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 (Stage II)/ 35

Dated: 24/02/2025

To,
Director (Environment) & Member Secretary,
Gujarat Coastal Zone Management Authority,
Forest & Environment Department,
Govt. of Gujarat,
Block No.14, 8th floor,
Sachivalaya, **Gandhinagar – 382 010.**

Sub: "Development of Integrated facilities (Stage II) within the existing Deendayal Port Trust (Erstwhile Kandla Port Trust) at District Kutch, Gujarat (1. Setting up of Oil Jetty no. 7, 2. Setting up of Barge Jetty at Jafrabadi, 3. Setting up of Barge Port at Veera, 4. Administrative office building at Tuna Tekra, 5. Road connecting from Veera Barge Jetty to Tuna gate by Deendayal Port Authority (Erstwhile Deendayal Port Trust)"– **Pointwise Compliances of the conditions stipulated in CRZ Recommendations reg.**

Ref.: 1) GCZMA CRZ recommendation vide letter No. ENV-10-2015-251-E (T cell) dated 29/06/2016
2) DPT letter EG/WK/4751/Part (Remaining 3 facilities)/53 dated 29/07/2021.
3 DPT letter EG/WK/4751/Part (Remaining 3 facilities)/144 dated 08/02/2022
4) DPT letter EG/WK/4751/Part (Stage II)/141 dated 01/07/2022
5) DPT letter EG/WK/4751/Part (Stage II)/292 dated 03/05/2023
6) DPT letter EG/WK/4751/Part (Stage II)/371 dated 03/10/2023
7) DPA letter EG/WK/4751/Part (Stage II)/109 dated 09/08/2024.

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

In this connection, it is to state that, the Gujarat Coastal Zone Management Authority vide above referred letter dated 29/6/2016 had recommended the aforesaid project of Deendayal Port Authority. Subsequently, the MoEF&CC, GOI had accorded the Environmental & CRZ Clearance vide letter dated 19/02/2020

Subsequently, DPA vide letter dated 22(24)/12/2020 has submitted compliance report of the stipulated conditions mentioned in the CRZ Recommendation letter 29/06/2016

..........Cont..........

Now, as directed under Specific Condition No. 28 mentioned in the CRZ Clearance letter dated 29/6/2016 i.e. ***A six monthly report on compliance of the conditions mentioned in this letter shall have to be furnished by the DPA on a regular basis to this Department and MoEF&CC, GoI***, please find enclosed herewith compliance report (for the period June 2024 to September 2024) of stipulated conditions along with necessary annexures, for kind information & record please **(Annexure I).**

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 via e-mail ID gczma.crz@gmail.com & direnv@gujarat.gov.in.

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

Thanking you.

Yours faithfully,

24/2/25

Dy.CE and EMC (I/c)

Deendayal Port Authority

Copy to:

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

ANNEXURE I
Point wise compliance

<u>Subject:</u> **Development of Integrated facilities (Stage-II) within the existing Deendayal Port Trust (Erstwhile Kandla Port Trust) at District Kutch, Gujarat. (1. Setting up of Oil Jetty No.7. 2. Setting up of Barge jetty at Jafarwadi 3. Setting up of Barge port at Veera; 4. Administrative office building at Tuna Tekra; 5. Road connecting from Veera barge jetty to Tuna gate by M/s Deendayal Port Trust (Erstwhile Kandla Port Trust)**

<u>CURRENT STATUS OF WORK – Upto September 2024</u>

Sr.No.	Name of Project	Status
1.	**Setting up of Oil Jetty No.7**	Under operation w.e.f January 2023.
2.	**Setting up of Barge jetty at Jafarwadi**	No construction activity started yet.
3.	**Setting up of Barge port at Veera**	No construction activity started yet.
4.	**Administrative office building at Tuna Tekra;**	No construction activity started yet.
5.	**Road connecting from Veera barge jetty to Tuna gate**	No construction activity started yet.

Subject: Point-wise Compliance Status Report for CRZ Clearance for Developing Integrated facilities (Phase-II)- within the existing Kandla Port at Kandla Dist: Kutch by M/s. Kandla Port Trust – Regarding (For the period up to September 2024)

1. **Setting up of Oil Jetty No.7**
2. **Setting up of Barge jetty at Jafarwadi**
3. **Setting up of Barge port at Veera**
4. **Administrative office building at Tuna Tekra**
5. **Road connecting from Veera barge jetty to Tuna gate**

Ref No: - GCZMA CRZ recommendation vide Letter No- <u>ENV-10-2015-251-E (T Cell)</u> dated 29.06.2016

S No	CRZ Conditions	Compliance Status
	SPECIFIC CONDITIONS	
1.	The provision of the CRZ notification 2011 shall be strictly adhered to by the KPT. No activity in contradiction to the provision of the CRZ notification shall be carried out by the KPT.	The work of project at Sr. No. 1 of EC i.e. ***"Setting up of Oil jetty no. 7"*** is Completed and it is under operation w.e.f January 2023. The Consent to Operate (CCA) from the Gujarat Pollution Control Board has already been obtained dated 20/1/2023 **<u>Copy submitted along with the compliance report submitted on 03/10/2023.</u>** However, for other projects mentioned at Sr. no. 2 to 5 (no construction activities started yet), it is assured that, the provisions of the CRZ Notification, 2011 will be strictly adhered to by DPA
2.	All necessary permissions under various laws/Rules/Notifications issued thereunder from different Government Department/agencies shall be obtained by M/s. KPT before commencing any enabling activities for proposed project.	The Consent to Establish (CTE) from the GPCB had already been obtained vide CTE No. 74134 granted by the GPCB vide letter no. PC/CCA-KUTCH 1319/GPCB ID 48573 dated 27/11/2015. In addition to this as the construction work for the project at Sr 1 is completed and it is under operation w.e.f January 2023 therefore CCA has obtained from the Gujarat Pollution Control Board vide GPCB/CCA- Kutch-1319/ID-48573/701442 dated 20/01/2023. **<u>Copy submitted along with the compliance report submitted on 03/10/2023.</u>**
3.	The KPT shall have to ensure that there shall not be any damage to the existing mangrove area.	The construction work for the project at Sr 1 is completed and it is under operation w.e.f January 2023. However, for other projects mentioned at Sr. no. 2 to 5 (no construction activities started yet), it is assured that, there shall not be any damage to the existing mangrove area
4.	The KPT shall effectively implement the mangrove Development, Protection & Management plan for control of indirect impacts on mangrove habitat	DPA had already undertaken Mangrove Plantation in an area of 1600 Ha. till date since the year 2005. A statement showing details of the mangrove plantation and the cost incurred is already submitted along with compliance report submitted on 09/08/2024. In addition to the above, DPA appointed M/s GUIDE, Bhuj, for "Regular Monitoring of Mangrove Plantation carried out by DPA" (period 15/9/2017 to 14/9/2018 vide work order dated 1/9/2017 and 24/5/2021 to 23/5/2022 vide work order dated 3/5/2021). The final report submitted by M/s GUIDE, Bhuj for the year 2021 to 2022. Submitted along with the compliance report submitted on 03/05/2023. 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. A copy Inception

		report is attached herewith as **Annexure A**
5.	The KPT shall have to make a provision that mangrove areas get proper flushing water and free flow of water shall not be obstructed	The construction work for the project at Sr 1 is Completed and it is under operation w.e.f January 2023. However, for other projects mentioned at Sr. no. 2 to 5 (no construction activities started yet), it is assured that, provision will be made for mangrove areas will get proper flushing of water and free flow of water is not obstructed.
6.	The KPT shall have to dispose of the dredged material only after scientific study to be carried out by the Institute of National repute and at a location suggested by them.	The work of project at Sr. No. 1 of EC i.e. "Setting up of Oil jetty no. 7" is Completed and it is under operation w.e.f January 2023. Capital Dredging at O.J. completed on 14/04/2023. It is submitted that, in compliance of specific condition no. xi of the EC dated 19/02/2020 DPA appointed IIT- Mumbai as an Independent agency for monitoring the dredging activities undertaken, vide work order no. HD/WK/1078/2022/OJ7/dredging/ENV610 dated 21/12/2022. However, for other projects mentioned at Sr. no. 2 to 5 (no construction activities started yet), it is assured that condition mentioned will be complied with.
7.	The KPT shall have to maintain the record for generation and disposal of capital dredging and maintenance dredging.	Point noted for the compliance.
8.	No dredging, reclamation or any other project related activities shall be carried out in the CRZ area categorized as CRZ I (i) and it shall have to be ensured that the mangrove habitats and other ecologically important and significant areas, if any, in the region are not affected due to any of the project activities	It is hereby assured that DPA will undertake only activities recommended by the GCZMA vide letter dated 29/06/2016 and EC & CRZ clearance accorded by the MoEF&CC, GOI vide letter dated 18/02/2020. DPA has already prepared a mangrove preservation plan for the entire Kandla area In addition to the above, DPA appointed M/s GUIDE, Bhuj, for "Regular Monitoring of Mangrove Plantation carried out by DPA" (period 15/9/2017 to 14/9/2018 vide work order dated 1/9/2017 and 24/5/2021 to 23/5/2022 vide work order dated 3/5/2021). The final report submitted by M/s GUIDE, Bhuj, for the years 2017 to 2018 has been submitted in the earlier compliance report, and the final report for the year 2021 to 2022 is Submitted along with the compliance report submitted on 03/05/2023. In continuation of same, DPA appointed M/s GUIDE, Bhuj, for "Monitoring of Mangrove Plantation 1600 ha carried out by DPA" (period 10/06/2024 to 09/06/2025 vide work order dated 10/6/2024.A copy is inception report is attached herewith as **Annexure A** Further, DPA had assigned the work to M/s GUIDE, Bhuj for "Regular Monitoring of Marine Ecology in and around the Deendayal Port Authority and Continuous Monitoring Programme covering all seasons on various aspects of the Coastal Environs covering Physico- chemical parameters of marine water and marine sediment samples coupled with biological indices, as per the requirements of EC & CRZ Clearances reg. (for three years (2021-2024)). The final reports has already been submitted along with compliance report submitted earlier. In continuation of the same, DPA had assigned the work to M/s GUIDE, Bhuj for "Regular Monitoring of Marine Ecology in and around the Deendayal Port Authority and

		Continuous Monitoring Programme covering all seasons on various aspects of the Coastal Environs covering Physico-chemical parameters of marine water and marine sediment samples coupled with biological indices as per the requirements of EC & CRZ Clearances reg. (for three years (2024-2027)) vide its work order dated 10/06/2024. Copy already submitted along with compliance report submitted on 09/08/2024 It is relevant to mention here that, DPA has already undertaken Mangrove Plantation in an area of 1600 Ha. till date since the year 2005. A statement showing details of the mangrove plantation already submitted along with compliance report submitted on 09/08/2024.
9.	The KPT shall participate financially for installing and operating the vessel traffic management system in the Gulf of Kutch and shall also take lead in preparing and operational sing the Regional Oil Spill Contingency plan in the Gulf of Kutch	DPA had already contributed an amount of Rs. 98.955 crore i.e 25% of the total project cost of 395.82 crore for installing and operating VTMS in Gulf of Kachchh
10.	The KPT shall strictly ensure that no creeks or rivers are blocked due to any activity at Kandla	The work of project at Sr. No. 1 of EC i.e. "Setting up of Oil jetty no. 7" is Completed and it is under operation w.e.f January 2023. However, for other projects mentioned at Sr. no. 2 to 5 (no construction activities started yet), it is assured that condition mentioned will be complied with
11.	Mangrove plantation in an area of 50 ha shall be carried out by the KPT within 2 years in a time bound manner on Gujarat coastline either within or outside the Kandla port Trust area and 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.	DPA has signed MoU with Gujarat Ecology Commission, Gandhinagar to carry out mangrove plantation through PPP mode for the year 2020-2021. DPA (Erstwhile KPT) had already undertaken Mangrove Plantation in an area of 1600 Ha. till date since the year 2005. A statement showing details of the mangrove plantation and the cost incurred has already been submitted along with compliance report submitted on 09/08/2024 In addition to the above, DPA appointed M/s GUIDE, Bhuj, for "Regular Monitoring of Mangrove Plantation carried out by DPA" (period 15/9/2017 to 14/9/2018 vide work order dated 1/9/2017 and 24/5/2021 to 23/5/2022 vide work order dated 3/5/2021). The final report submitted by M/s GUIDE, Bhuj, for the years 2017 to 2018 has been submitted in the earlier compliance report, and the final report for the year 2021 to 2022 is Submitted along with the compliance report submitted on 03/05/2023. In continuation of same, DPA appointed M/s GUIDE, Bhuj, for "Monitoring of Mangrove Plantation 1600 ha carried out by DPA" (period 10/06/2024 to 09/06/2025 vide work order dated 10/6/2024.A copy is inception report is attached herewith as **Annexure A**
12.	No activity other than those permitted by the competent authority under the CRZ Notification Shall be carried out in the CRZ area.	The construction work for the project at Sr 1 is completed and it is under operation. The work of project at Sr. No. 1 of EC i.e. "Setting up of Oil jetty no. 7" is Completed and it is under operation w.e.f January 2023. The Consent to Operate (CCA) from the Gujarat Pollution Control Board has already been obtained dated 20/1/2023 .Copy of same is already submitted in the earlier compliance report submitted on 03/10/2023. However, for other projects mentioned at Sr. no. 2 to 5 (no construction activities started yet), it is assured that, no activity other than those permitted by the competent authority under the CRZ Notification Shall be carried out

		in the CRZ area
13.	No ground water shall be tapped for any purpose during the proposed expansion/modernization activities.	The work of project at Sr. No. 1 of EC i.e. "Setting up of Oil jetty no. 7" is Completed and it is under operation w.e.f January 2023 required water supply is purchased from GWSSB. However, for other projects mentioned at Sr. no. 2 to 5 (no construction activities started yet), it is assured that condition mentioned will be complied with.
14.	All necessary permissions from different Government Departments/agencies shall be obtained by the KPT before commencing the expansion activities.	DPA had already obtained the necessary EC & CRZ clearance for the project on dated 19/02/2020. Further, Consent to establish from GPCB had already been obtained from GPCB for the same. Subsequently, DPA obtained EC to CTE (PCB ID 48573) vide GPCB Order dated 13/10/2020 after obtaining Environmental and CRZ Clearance from MoEF&CC, GoI vide F. No. 11- 13/2015-IA-III dated 19/02/2020 In addition to this as the construction work for the project at Sr 1 is completed and it is under operation w.e.f January 2023 therefore CCA has obtained from the Gujarat Pollution Control Board vide GPCB/CCA- Kutch-1319/ID-48573/701442 dated 20/01/2023. Copy of same is already submitted in the earlier Compliance report submitted on 03/10/2023.
15.	No effluent or sewage shall be discharged into the sea/creek or in the CRZ area and it shall be treated to confirm to the norms prescribed by the Gujarat Pollution Control Board and would be reused/recycled with in the plant premises.	In this regard, it is to state that, DPA is already having a sewage treatment plant capacity of 1.5MLD for the treatment of domestic sewage. The treated sewages from STP of DPA are utilized for plantation / Gardening. DPA has been conducting regular monitoring of Environmental parameters through NABL Accredited laboratory since the year 2016 in continuation of this DPA appointed M/s Gujarat Environment Management Institute (GEMI), Gandhinagar (NABL Accredited laboratory) for regular Monitoring of environmental parameters vide work order dated 15/02/2023. The work is in progress & DPA is submitting the monitoring data regularly to all the concerned authorities along with compliance reports submitted. The latest Environmental Monitoring Reports is enclosed herewith as **Annexure B.** Further, necessary provisions will be made for the projects at Sr. No. 2 – 5 to not discharge effluent or sewage into the sea/creek or in CRZ area
16.	All the recommendations and suggestions given by the Mantec Consultant Pvt. Ltd. New Delhi in their Comprehensive Environment Impact Assessment report for conservation/protection and betterment of environment shall be implemented strictly by the KPT.	DPA has installed Mist Canon at the Port area to minimize the dust Further, DPA has already installed continuous sprinkling system 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. DPA has been conducting regular monitoring of Environmental parameters through NABL Accredited laboratory since the year 2016 in continuation of this DPA appointed M/s Gujarat Environment Management Institute (GEMI), Gandhinagar (NABL Accredited laboratory) for regular Monitoring of environmental parameters vide work order dated 15/02/2023. The work is in progress & DPA is submitting the monitoring data regularly to all the

		concerned authorities along with compliance reports submitted. The latest Environmental Monitoring Reports is enclosed herewith as **Annexure B.** 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 DPA assigned work to M/s GUIDE, Bhuj, for regular monitoring of Marine Ecology since the year 2017 (From 2017 – 2021), and reports of the same are being submitted regularly to the Regional Office, MoEF&CC, GoI, Gandhinagar as well as to the MoEF&CC, GoI, New Delhi along with compliance reports submitted. The final report for the Holistic Marine Ecological Monitoring for the period up to May 2021 was submitted on 22.05.2021. Copy of the report was communicated vide earlier compliance report submitted vide letter dated 29/6/2021 Further, it is 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. The copy of the final reports has already been submitted along with compliance report submitted earlier. In continuation of the same, DPA had assigned the work to M/s GUIDE, Bhuj for "Regular Monitoring of Marine Ecology in and around the Deendayal Port Authority and Continuous Monitoring Programme covering all seasons on various aspects of the Coastal Environs covering Physico-chemical parameters of marine water and marine sediment samples coupled with biological indices as per the requirements of EC & CRZ Clearances reg. (for three years (2024-2027) vide its work order dated 10/06/2024. Copy of same is attached herewith as Annexure Dcopy already submitted along with compliance submitted on 09/08/2024 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 DPA has appointed Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May, 2022. The work completed. A copy of Final report is submitted along with the compliance report submitted on 03/10/2023. 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 and final report is attached herewith as **Annexure C** For dredged material management, 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 I n continuation of same, DPA had issued work order to GUIDE, Bhuj for "Study on dredged material for presence of Contaminants for year 2021-2024. The copy of 1st Season, 2nd season & 3rd reason report submitted by M/s GUIDE, Bhuj for the period 2023- 2024 is attached herewith as **Annexure- D** Further, Dredged Material will be disposed of at designated location as identified by the CWPRS, Pune Further, it is relevant to mention here that, DPA has commissioned a 45 kWP Solar Plant at Gandhidham on 7th July, 2022. DPA has installed 400 KWP solar plant and 600 KWP to be installed this year by PPP operator. DPA has installed 6 KWP solar plant at Jeev Seva Samiti, Gandhidham 4000 Acres of land has been identified for developing 150 MW Hybrid (Solar Cum Wind) Energy Park. 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. (Copy attached as Annexure)
17.	The construction and operational activities shall be carried out in such a way that there is no negative impact on mangrove and other coastal/marine habitats. The construction activities and dredging shall be carried out only under the constant supervision and guidelines of the Institute of National repute like NIOT	The construction work for the project at Sr 1 is completed and it is under operation w.e.f January 2023 and due care is being taken for so that, there is no negative impact on mangrove and other coastal/marine habitats. Further, for project at Sr. No. 2 to 5 (Construction not yet started); however, the specified condition will be complied with
18.	The KPT shall contribute financially for any common study or project that may be proposed by this Department for environmental management/conservation /improvement for the Gulf of Kutch	Point noted for the compliance.
19.	The construction debris and/or any other type of waste shall not be disposed of into the sea, creek or in the CRZ areas. The debris shall be removed from the construction site immediately after the construction is over.	The work of project at Sr. No. 1 of EC i.e. ***"Setting up of Oil jetty no. 7"*** is Completed and it is under operation w.e.f January 2023. The Consent to Operate (CCA) from the Gujarat Pollution Control Board has already been obtained dated 20/1/2023. Copy of same submitted along with compliance report submitted on 03/10/2023. However, for other projects mentioned at Sr. no. 2 to 5 (no construction activities started yet) DPA had already issued general circular vide dated 3/9/2019 regarding Construction and Demolition Waste Management for strict implementation in DPA.

		Copy is already submitted during the compliance report submitted on 03/05/2023
20.	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.	The work of project at Sr. No. 1 of EC i.e. ***"Setting up of Oil jetty no. 7"*** is Completed and it is under operation w.e.f January 2023. The Consent to Operate (CCA) from the Gujarat Pollution Control Board has already been obtained dated 20/1/2023 Copy of same is already submitted in the earlier compliance report submitted on 03/10/2023. However, for other projects mentioned at Sr. no. 2 to 5 (no construction activities started yet) the condition will be complied with
21.	The KPT shall regularly update their Local oil spill contingency and disaster management plan in consonance with the National oil Spill and Disaster Contingency plan and shall submit the same to this Department after having it vetted through the Indian Coast Guard.	DPA already has updated Disaster management plan and Local oil spill contingency plan. Copy of same is attached herewith as **Annexure E & Annexure F** DPA has also executed MOU with Oil companies, i.e., IOCL, HPCL, BPCL etc, for setting up of Tier I facility for combating the Oil Spill at Kandla.
22.	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 for the compliance.
23.	The KPT shall take up massive green belt development activities in and around Kandla and also within the KPT limits.	DPA assigned work for green belt development in an area of about 32 hectares to the Forest Department, Govt. of Gujarat, in August 2019 at the cost of Rs. 352.32 lakhs. The work is completed. Further, DPA also undertook massive green belt development in and around the Port area and at the Gandhidham area. DPA has appointed Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May, 2022. The work completed. A copy of Final report is submitted along with the compliance report submitted on 03/10/2023. 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 and copy of final report is attached herewith as **Annexure C**
24.	The KPT shall have to contribute financially for taking up the socio-economic upliftment activities in this region in consultation with the Forests and Environment Department and the District Collector/District development officer.	DPA has already been undertaking CSR activities. The details of CSR Activities implemented as well as proposed are enclosed herewith as **Annexure G.**
25.	A separate budget shall be earmarked for environmental management and socio-economic 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.	DPA has already kept Rs. 657 lakhs in B.E. 2024-25 under the scheme "Environmental Services & Clearance thereof". .

26.	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, DPA has also appointed an expert agency to provide Environmental Experts from time to time. Recently, DPA appointed M/s Precitech Laboratories, Vapi, vide work order dated 5/2/2021 Further, DPA has appointed a Manager Environment on a contractual basis for a period of 3+2 years. (Copy already submitted along with the compliance report submitted on 03/05/2022.)
27.	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&CC,GOI	DPA has been conducting regular monitoring of Environmental parameters through NABL Accredited laboratory since the year 2016 in continuation of this DPA appointed M/s Gujarat Environment Management Institute (GEMI), Gandhinagar (NABL Accredited laboratory) for regular Monitoring of environmental parameters vide work order dated 15/02/2023. The work is in progress & DPA is submitting the monitoring data regularly to all the concerned authorities along with compliance reports submitted. The latest Environmental Monitoring Reports is enclosed herewith as **Annexure B.** DPA has been submitting the environmental monitoring report along with the compliance report to IRO, MoEF&CC, GoI
28.	The KPT shall have to contribute financially to support the National Green Corps Scheme being implemented in Gujarat by the GEER foundation. Gandhinagar in consultation with Forests and Environment Department.	Point noted for the compliance.
29.	A six monthly report on compliance of the conditions mentioned in this letter shall have to be furnished by the KPT on regular basis to this Department/MoEF&CC,GOI	DPA has been regularly submitting a six-monthly report in compliance with the conditions mentioned to GCZMA and MoEF&CC, GOI. Last compliance submitted on 03/05/2023.
30.	Any other condition that may be stipulated by this Department and MoEF&CC,GoI from time to time for environmental protection / management purpose shall also have to be complied with by DPT.	Point noted.

ANNEXURE A
Inception Report

INCEPTION REPORT

For the Project entitled

Monitoring of Mangrove Plantation (1600 ha) carried out by Deendayal Port Authority, Kandla

DPA Work order No. EG/WK/4751/Part (Marine Ecology Monitoring)/70. Dt. 10.06.2024

Submitted by

Gujarat Institute of Desert Ecology

Mundra Road, Bhuj-370 001

Dist: Kachchh, Gujarat

Submitted to

DEENDAYAL PORT AUTHORITY KANDLA

Deendayal Port Authority

Gandhidham, Dist: Kachchh, Gujarat-370201

August-2024

Dr. V. Vijay Kumar
Director

Gujarat Institute of Desert Ecology

Certificate

This is to state that the **Inception report** of the work entitled, **"Monitoring of Mangrove Plantation (1600 ha) carried out by Deendayal Port Authority, Kandla"** has been prepared in line with the Work order issued by DPA vide No. EG/WK/4751/Part (Marine Ecology monitoring) / 70. Dt. 10.06.2024.

This work order is for a period of one year (10.06.2024 – 09.06.2025) for the above-mentioned study.

Authorized Signatory **Institute Seal**

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. Durga Prasad Behera, Scientist

Dr. L. Prabha Devi, Advisor

Mr. Dayesh Parmar, Senior Scientific Officer

Dr. Dhara Dixit, Project Scientist-I

Mr. Ketan Kumar Yogi, Junior Research Fellow

Mr. Arjan Rabari, Lab- Cum-Field Assistant

Mr. Jayanti Barot, Lab- Cum-Field Assistant

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1. Background

Mangroves are intricate ecosystems that shield coastal habitats from natural hazards. Mangrove forests, which account for less than 0.4% of the world's forests, are being destroyed at a rate of 1% per year. In some areas this could be higher with losses reaching up to between 2% -8 % (Friess *et al*., 2020). The decline in mangrove ecosystem by the 1970s was severe as a result of natural and human activities alike. Since the beginning of the 1980s around 20%-35% of global mangrove areas have been lost. The most quantity of mangrove loss has been recorded in developing countries where there is little space for coastal and maritime development activities of various forms including; aquaculture, tourism and trade among others (Das *et al*., 2022). This has prompted several researchers to target their restoration so as to recover their ecological and economical values. Gujarat state is no exception on this matter. The forests within these locations serve as one of the most productive and biologically diverse types on earth. Mangroves are found at different depths of saline environments; thus, they contain breathing roots or Pneumatophores. These roots provide shelter for various macro- and micro-faunal species. Thus, it is important to note that mangroves play a crucial role in carbon sequestration due to their ability to take up four times more carbon dioxide per unit area when compared with other terrestrial forest types (Akram *et al*., 2023). Mangroves also support fishing industries, ecotourism alongside sequestering carbon economically. Over time, the scientific community globally realized significance associated with ecological roles played by mangroves as well as services offered by them. Despite its benefits however, there has been over exploitation and degradation of mangroves for various reasons such that the area under mangrove cover declined at an alarming rate and also poorly restored. As a result researchers have eventually embarked on attempts to restore mangroves through plantation/conservation.

India has a total coastline length of 7516.6 km distributed among nine maritime states and four Union Territories where Gujarat is the longest one with 1650 km. For instance, Indian mangrove habitats contain forty-six species comprising fourteen families belonging to twenty-two genera. Approximately, about 3% of global mangrove vegetation is found in India (FSI, 2021). Gujarat is the second biggest state in India with respect to its extent of Mangrove cover (1175Km^2). Being woody habitats, the mangroves act as important carbon sinks in coastal areas. Although contentions exist around fifteen species are reported from thirteen coastal districts of Gujarat. Out of this Southern coast of Gulf of Kachchh (GoK) and South Gujarat are important districts for mangrove diversity. GoK coastal stretch in Gujarat accounts for most part of it with an extent 986 Km^2 out of 1140 Km^2. The north coast of GoK is composed of Kachchh District alone, which has 798 km^2 of mangroves, accounting to 70% of Gujarat's total area. Mangroves belong to a diverse taxonomic group, the majority of which are dominated by four genera: *Avicennia, Rhizophora, Sonneratia* and *Bruguiera*. However, the presence / restoration activities in Gujarat have been one of the most successful examples amongst any habitat restoration projects around the globe with respect to mangrove ecosystems being made up of mostly by single species of *Avicennia marina* in Kachchh District. Many mangrove species require periodic flooding with fresh water for their propagation. In view of topography and more specifically that associated with Kachchh region and Gujarat state as a whole, permanent sources of fresh water at all times are hard to find. The coastal belt along GoK is characterized by aridity which often makes other species than *A. marina* less promising for planting mangroves. This situation makes it difficult for plantation / restoration of mangroves especially in semi-arid regions like Kachchh.

1.2 Rationale

Deendayal Port Authority (DPA) is one of India's major ports that handles large amounts of cargo. The port encompasses a large coastal area with extensive mangroves (193.1 km2) and mudflats (312.9 km2). The port authorities are committed to preserving and enhancing these coastal habitats. However, the construction and operation of port facilities can have a substantial impact on the local ecology. Therefore, efforts are being made to conserve and protect the DPA mangrove area to maintain its ecological services. This has led DPA to undertake a 1600-hectare mangrove plantation project from 2005-2023 in locations like Sat Saida Bet, Nakti creek, Kantiyajal among others. Evaluation of this planting endeavor for which 1600 hectares the work order has been handed over to Gujarat Institute for Desert Ecology (GUIDE), Bhuj. The conservation measures have been undertaken with the involvement of state and central government departments as well as local communities towards restoring and protecting the mangrove stands.

The present study will mainly focus on the assessment of the present status of the mangrove at Sat Saida bet and Nakti creek in the Kandla (Kachchh) and Kantiyajal in the Bharuch district covering ten blocks occupying an area of 1400 ha, where plantation activities have been conducted during the period between 2005 and 2019. However, the present study (2024-2025) will also cover the additional 200 ha plantations carried out at Sat Saida bet (100 ha) and Kantiyajal (100 ha) during 2021 and 2023 with a total coverage area of 1600ha. The primary goal of this study is to assess the survival rate of mangrove plantations and the carbon sequestration potential of the planted mangroves and suggest achievable conservation measures. The details of the mangrove plantation work carried out in a phased manner by the DPA is presented in Table 1.

Table 1. Details of the implemented mangrove plantation activities by DPA

Location	**Year of Plantation**	**Area (ha)**	**Species planted**	**Implementing Agency**
Sat Saida Bet, Kachchh district	2005-2006	20	*A. marina*	Gujarat Institute of Desert Ecology, Bhuj
	2011-2012	200	*A. marina*	Forest Department, GoG
	2012-2013	300	*A. marina*	Forest Department, GoG
	2013-2014	330	*A. marina*	Forest Department, GoG
	2018-2019	50	*A. marina*	Gujarat Ecology Commission
	2022-2023	100	*A. marina*	Gujarat Ecology Commission
Nakti Creek, Kachchh district	2008-2009	50	*A. marina*	M/s. Patel Construction Co, Gandhidham
	2010-2011	100	*A. marina* *R. mucronata* *C. tagal*	Gujarat Ecology Commission
Kantiyajal,	2015-2016	150	*A. marina*	Gujarat Ecology

Bharuch District				Commission
	2016-2017	150	*A. marina* *R. mucronata*	Gujarat Ecology Commission
	2018-2019	50	*A. marina*	Gujarat Ecology Commission
	2021-2022	100	*A. marina*	Gujarat Ecology Commission
Total		**1600**		

1.3 Objectives of the Study

The present study is an attempt to analyse the rate of growth and survival, of the planted mangroves following the standard protocols and determinants of their health which are very much essential in conserving them. The Specific objectives are:

- To evaluate Gujarat Ecology Commission's (GEC) 1600 Ha mangrove plantations at Sat Saida Bet, Nakti creek in the Gulf of Kachchh and Kantiyajal in Bharuch district.
- To determine the extent of plantation, sapling health, survival rate of the planted species
- Evaluation of soil composition, bulk density
- To expound on the composition and distribution of natural mangrove
- To review the below ground carbon stock potential of the surviving ma grove plantation in view of the climate change.

2. Study area

The information of geological coordinates, maps and other details of sites of mangrove plantation by DPA in previous years, will be provided by DPA authorities. The sites are located in three different places, those are Kantiyajal (Bharuch), Sat saida Bet (Kachchh) and Nakti creek (Kachchh). The plantation sites will be confirmed by DPA authorities in the site visiting. At the time of evaluation, the team members from DPA will be available to confirm the sites and location of plantations Fig. 1.

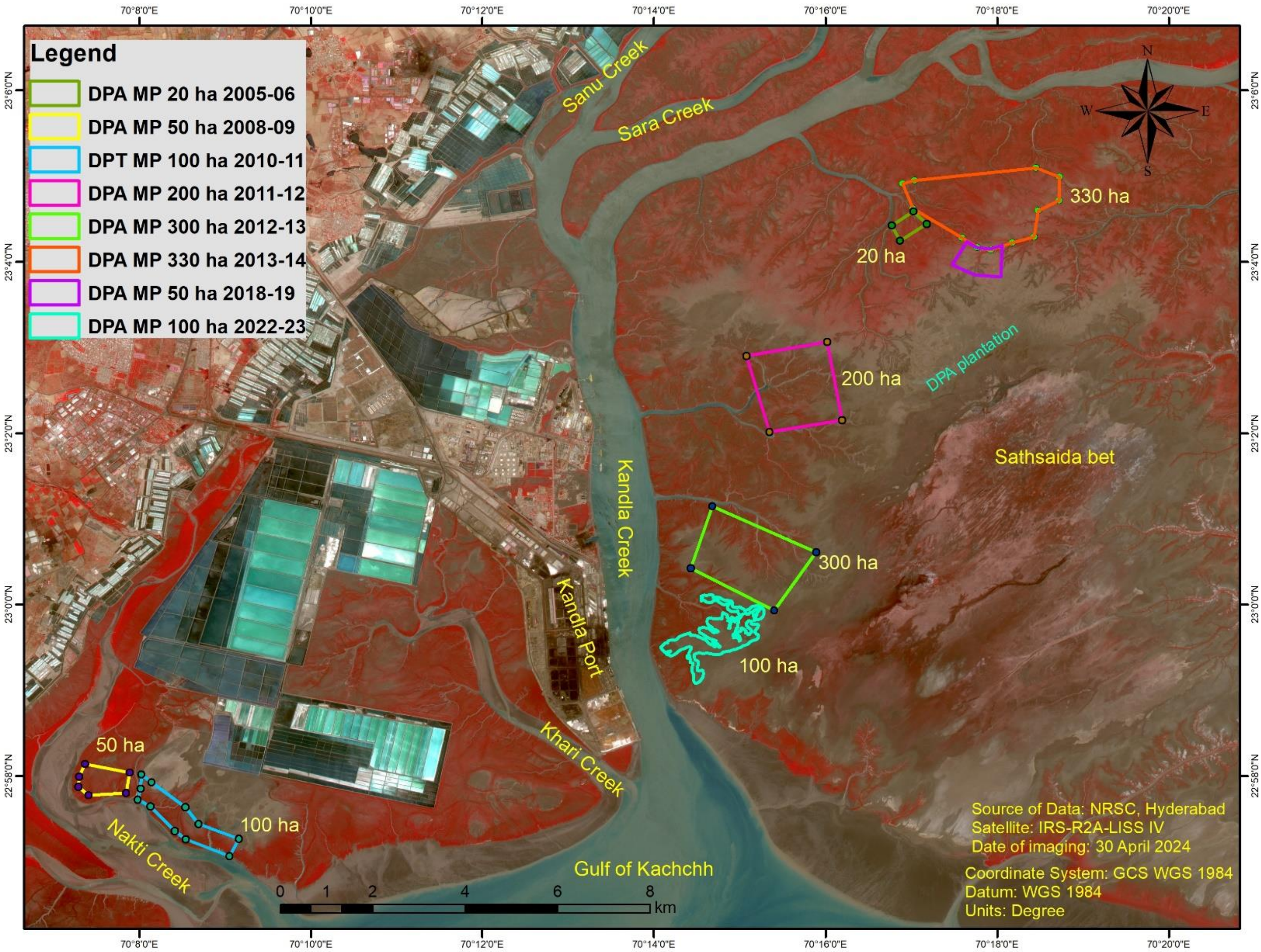

Fig. 1 Mangrove plantation Site in DPA environ

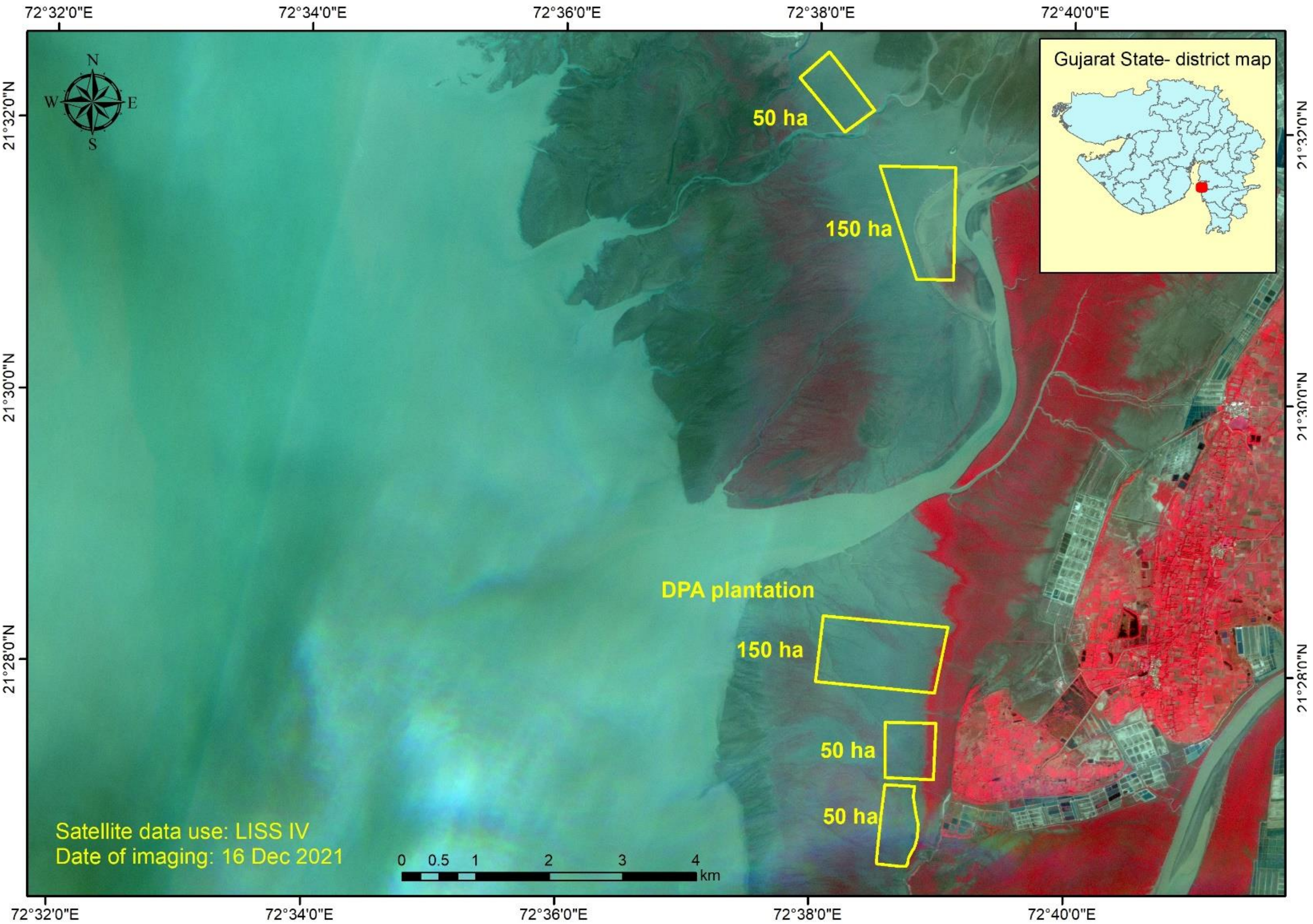

Fig. 2 Mangrove plantation Site in Kantiyajal, Bharuch

3. Methodology

3.1 Evaluation of mangrove plantation

To assess the overall plantation success at the plantation site at Sat Saida bet, Nakti creek and Kantiyajal, field surveys will be undertaken from September 2024 to April 2025. The mangrove plantation's survival percentage will be assessed by dividing the area into uniform grids. To show the survival status, density of transplanted saplings, and its grid number randomly selected areas will be counted for all surviving saplings, adopting quadrate method on the selected 10 × 10 m plots at the sampling sites. In all the selected sites, height and number of stems, canopy and other characteristics will be recorded. Before the survey takes place, all these plantation sites will be marked on Google map using their GIS Co-ordinates. Similarly, once with local maps as well as other relevant information will be obtained from the DPA officials or implementing agencies including Plantation registers, along with the personnel representatives involved in the plantation. A boat survey will be undertaken to evaluate around the study location and mangrove formations along creeks systems.

3.1.1 Analysis of Soil bulk density

Volume of known amount (20 g) of dry soil sample will be noted and to this a known volume of water (50 ml) will be added. At least 5 ml of water above the soil surface and kept in an undisturbed condition for 30 minutes. The final volume of soil plus water was noted and bulk density was calculated as follows:

Bulk density = weight of soil (g) / Volume of soil (g/ml)

3.1.2 Total Organic carbon in mangrove soil (El Wakeel and Riley, 1956)

Total organic carbon (TOC) (%) will be estimated following the Chromic acid digestion and Phenonthroline indicator (El Wakeel and Riley, 1956), wherein the organic matter is oxidized with a mixture of Potassium dichromate and concentrated Sulphuric acid, utilizing the heat of dilution of the acid to speed up the process. The unspent Potassium dichromate is back titrated against Ferrous sulphate solution.

The Total carbon calculation is as follows:

Ferrous ammonium sulphate (ml) (T) = Blank – Sample

Total organic carbon (TOC) in sediment soil (mgC/g) (X) = 1.14 x 0.6 x T)

Total organic carbon (TOC) in sediment soil (%) = X / 10)

Total carbon in sediment soil (%) = TOC ÷ 2

3.1.3 Calculation of carbon stock in sediment soil

Carbon stock in sediment soil up to 100 cm was calculated as follows:

Carbon stock in sediment (%) = Bulk density ($g.cm^{-3}$) × Total carbon (%) × Soil depth interval (cm)

3.2 Carbon Sequestration Potential of Planted Mangroves

3.2.1 Sampling of Soil and Plant Biomass

Sampling sites for soil/sediment and mangroves will be identified through reconnaissance survey. The survey and sampling involve (i) identification of sites for sampling in and around the study area, (ii) collection of soil/sediment and mangrove (iii) processing the samples for TOC (%), bulk density and plant biomass estimations.

3.2.2 Carbon content in Mangrove Biomass

The mangrove girth is generally measured at 1.3 m height for achieving tree diameter. However, since the present stands will be young the whole plant is uprooted for assessing biomass. Mangrove samples will be collected by complete uprooting of the individual at each site. Individual plants are then packed and labeled. The plant samples will be washed thoroughly under tap water several times with deionized water, drained, and then chopped and separated into root and shoot using a plant cutter. Fresh weight of the samples will be noted and subsequently oven dried till constant weight. Total biomass will be directly estimated by summing the dry weight from the wet biomass value.

3.2.3 Carbon biomass

The biomass is then converted into carbon biomass by multiplying by a factor of 0.42, i.e.

$$\text{Carbon biomass} = \text{Total biomass} \times 0.42$$

3.2.4 Carbon biomass per hectare

Carbon biomass was calculated per hectare by multiplying the carbon biomass with tree density per hectare, i.e.

$$\text{Carbon biomass (kg/ha)} = \text{carbon biomass x density of plants per hectare}$$

$$\text{Carbon biomass (Mg/ha)} = \text{(carbon biomass x density of plants per hectare) / 1000)}$$

3.2.5 Calculation of CO_2 equivalent

Carbon biomass value is converted into carbon dioxide equivalent by multiplying carbon biomass with 3.67

$$\text{i.e. } CO_2 \text{ equivalent (\%)} = \text{carbon biomass} \times 3.67$$

Table 2: Timeline Work plan for 12 months (Jun-24 –Jun-25)

Activity	Months											
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
• Review of literature related to the study • Planning of the project • Initiation of Inception study • Submission of Inception report												
• Survey of mangrove plantation site at Kantiyajal (450 Ha) and analysis all parameters												
• Survey of mangrove plantation site at Sat Saida bet, Nakti creek (1150 Ha) and analysis all parameters												
• Evaluation of Mangrove Plantation												
• Submission of Final Report for Comments and revisions, if any.												
• Submission of Final Report												

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ANNEXURE B
Latest 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: June-July 2024)

Document Ref No.: GEMI/DPA/782(2)(3)/2024-25/121

Submitted to:

Deendayal Port Authority (DPA), Kandla

GEMI

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"

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 (June-July 2024)"* is prepared.

- **Name of the Report:** *Environment Monitoring Report (June-July 2024)*
- **Date of Issue:** 10/09/2024
- **Version:** 1.0
- **Report Ref.:** GEMI/DPA/782(2)(3)/2024-25/121

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List of Abbreviations

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

CHAPTER 1: INTRODUCTION

1.1 Introduction

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

1.2 Green Ports Initiative

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

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

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

1.3 Importance of EMP

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

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

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

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

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

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

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

1.4 Objectives and scope of the Study

In line with the work order, the key objective of the study is to carry out the Environmental Monitoring and preparation the Management Plan for Kandla and Vadinar for a period of 3 years". Under the project, Environmental monitoring refers to systematic 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:

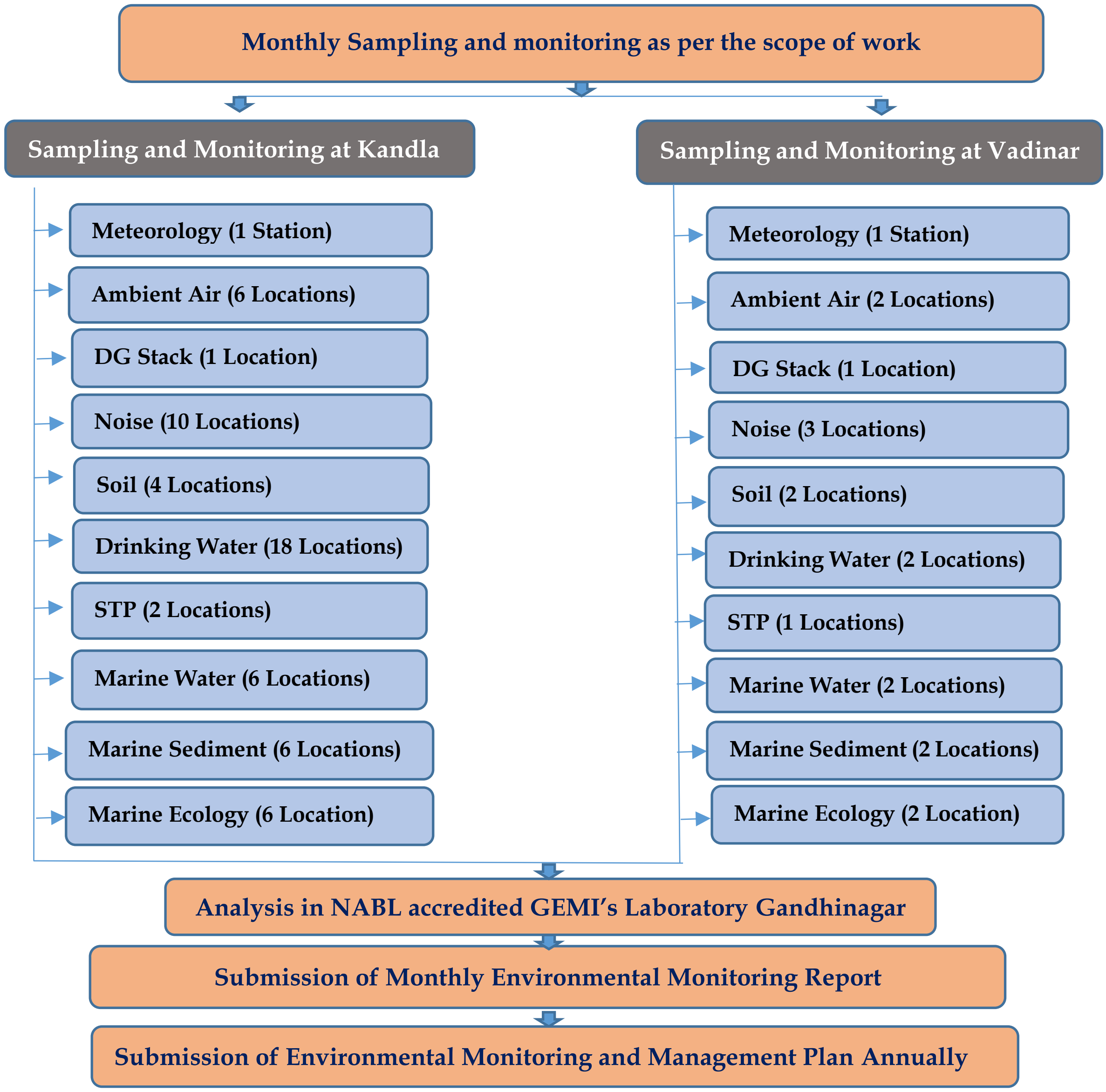


Figure 1: Methodology flow chart

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	°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.

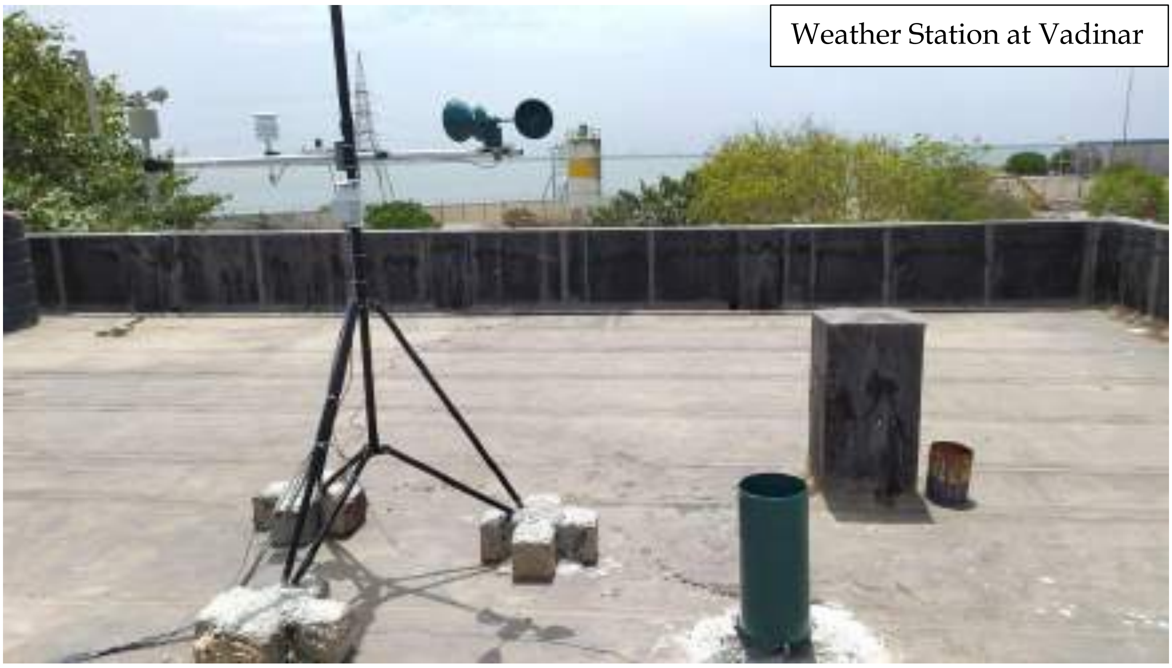


Figure 2: Photographs of Automatic Weather Monitoring Station at Kandla and Vadinar

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

<table>
<tr><th colspan="13">Details of Micro-meteorological data at Kandla Observatory</th></tr>
<tr><th>Monitoring Period</th><th colspan="3">Wind Speed (Km/h)</th><th colspan="3">Temperature (°C)</th><th colspan="3">Relative humidity (%)</th><th rowspan="2">Solar Radiation (W/m^2)</th><th rowspan="2">Wind Direction (°)</th><th rowspan="2">Rainfall (mm)</th></tr>
<tr><th>Stat.</th><th>Mean</th><th>Max.</th><th>Min</th><th>Mean</th><th>Max</th><th>Min</th><th>Mean</th><th>Max</th><th>Min</th></tr>
<tr><td>March-April, 2024</td><td>3.24</td><td>86</td><td>1.3</td><td>32.24</td><td>41.4</td><td>26.2</td><td>73.15</td><td>89.8</td><td>43.8</td><td>67.97</td><td>From West-South-West</td><td>3.96</td></tr>
<tr><th colspan="13">Details of Micro-meteorological data at Vadinar Observatory</th></tr>
<tr><th>Monitoring Period</th><th colspan="3">Wind Speed (Km/h)</th><th colspan="3">Temperature (°C)</th><th colspan="3">Relative humidity (%)</th><th rowspan="2">Solar Radiation (W/m^2)</th><th rowspan="2">Wind Direction (°)</th><th rowspan="2">Rainfall (mm)</th></tr>
<tr><th>Stat.</th><th>Mean</th><th>Max.</th><th>Min</th><th>Mean</th><th>Max</th><th>Min</th><th>Mean</th><th>Max.</th><th>Min</th></tr>
<tr><td>March-April, 2024</td><td>9.69</td><td>139.4</td><td>3.98</td><td>30.13</td><td>36</td><td>24.4</td><td>77.43</td><td>91.5</td><td>55.3</td><td>71.63</td><td>From South-West</td><td>0.43</td></tr>
</table>

3.3 Data Interpretation and Conclusion

- **Temperature**

a. **Kandla:** The ambient temperature for the monitoring period varies between the range of 26.2 – 41.4°C for Kandla, with average temperature of 32.24°C.
b. **Vadinar:** The ambient temperature for the monitoring period varies between the range of 24.4 -36°C for Vadinar, with average temperature of 30.13°C.

- **Relative Humidity**

a. **Kandla**: The Relative Humidity recorded between the range of 43.8 – 89.8%, with average Humidity of 73.15%.
b. **Vadinar:** During the study period, the Relative Humidity varies between 55.3 - 91.5%, with average Humidity of 77.43%.

- **Rainfall**

a. **Kandla:** 3.96 rainfall was observed at Kandla.
b. **Vadinar:** 0.43 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.

c. **Kandla:** Wind speed recorded ranges between 1.3 – 86, with average Wind Speed of 3.24 Km/hr.
a. **Vadinar:** During the monitoring period, the Wind speed recorded ranges between 3.98 – 139.4, with average Wind Speed of 9.69 Km/hr.

- **Solar Radiation:**

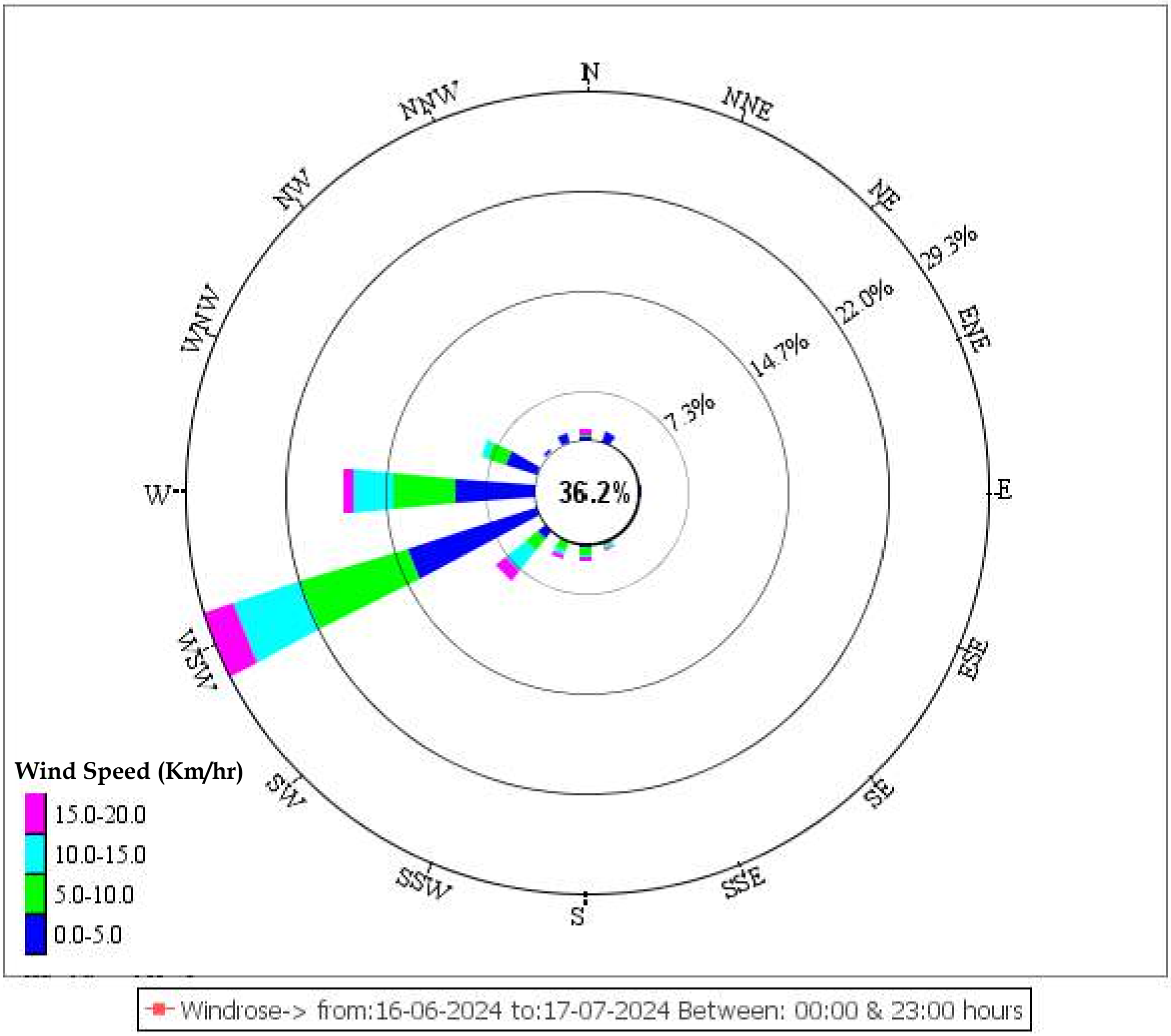
a. **Kandla:** The average Solar Radiation for the monitoring period was recorded as 67.97 W/m^2.
b. **Vadinar:** The average Solar Radiation was recorded as 71.63 W/m^2.

- **Wind rose diagram -**

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

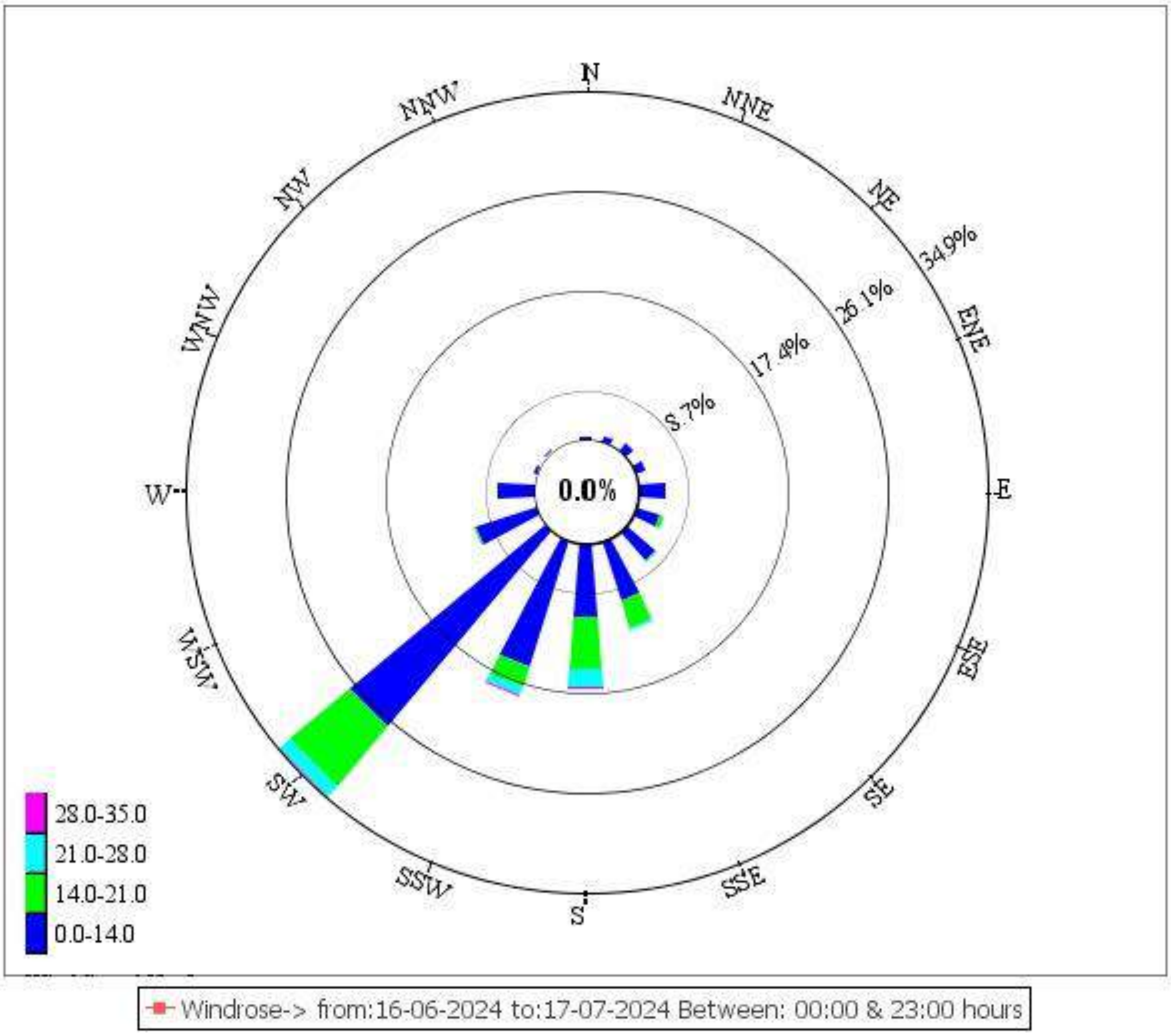
This Wind Rose Diagram reveals that at Kandla and Vadinar, during the monitoring period, the prevailing winds predominantly blow from the West South West direction at Kandla, whereas, high speed winds were also observed to blow from West direction. At Vadinar, the winds were observed to blow from From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

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



Modeler: Envirotech Instruments Pvt. Ltd. Delhi.

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



Modeler: Envirotech Instruments Pvt. Ltd. Delhi.

CHAPTER 4: AMBIENT AIR QUALITY MONITORING

4.1 Ambient Air Quality

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

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

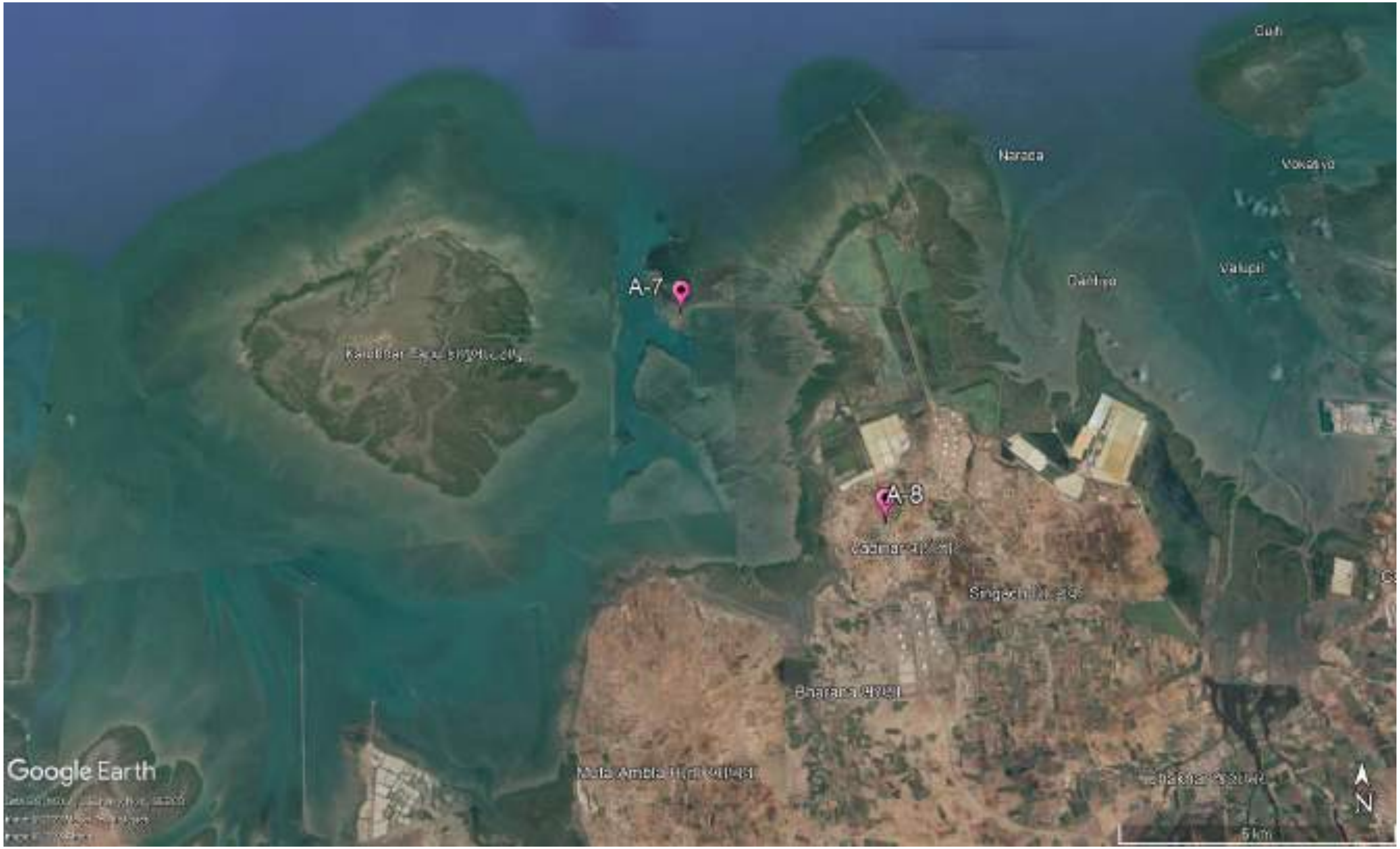

A-4: Marine Bhavan


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

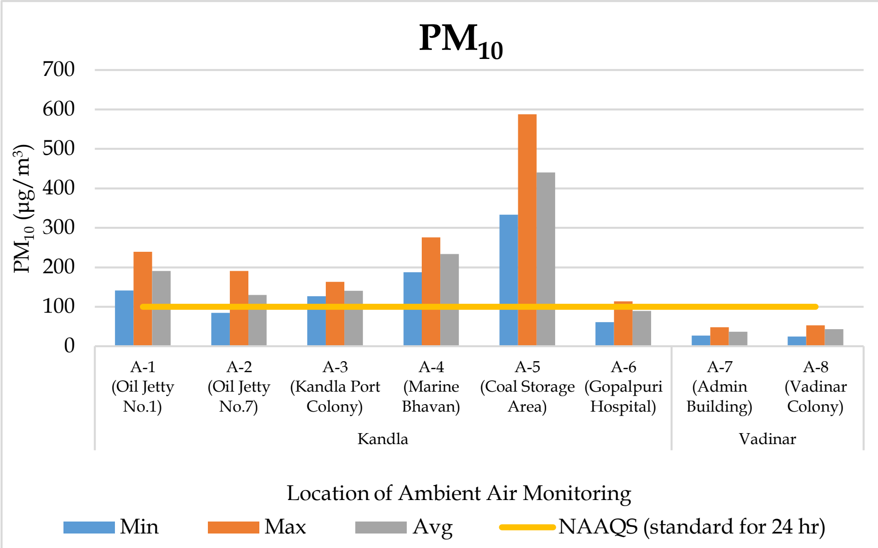
Station Code & Name	Unit of Average Concentration	Average Pollutant Concentration					
	Pollutants	**PM_{10} (µg/m³)**	**$PM_{2.5}$ (µg/m³)**	**SO_2 (µg/m³)**	**NO_X (µg/m³)**	**VOC (µg/m³)**	**CO (mg/m³)**
	Duration	**(24 hr)**				**(2 hr)**	**(1 hr)**
	NAAQS by CPCB / Monitoring days	**100**	**60**	**80**	**80**	**-**	**2**
A-1: Oil Jetty No.1,	17/06/2024	225.63	39.64	18.34	12.68	0.11	0.80
	19/06/2024	239.33	41.33	22.50	19.33	0.07	0.86
	24/06/2024	196.37	30.50	4.96	6.28	0.22	0.81
	27/06/2024	208.63	34.6	16.64	9.29	0.14	0.74

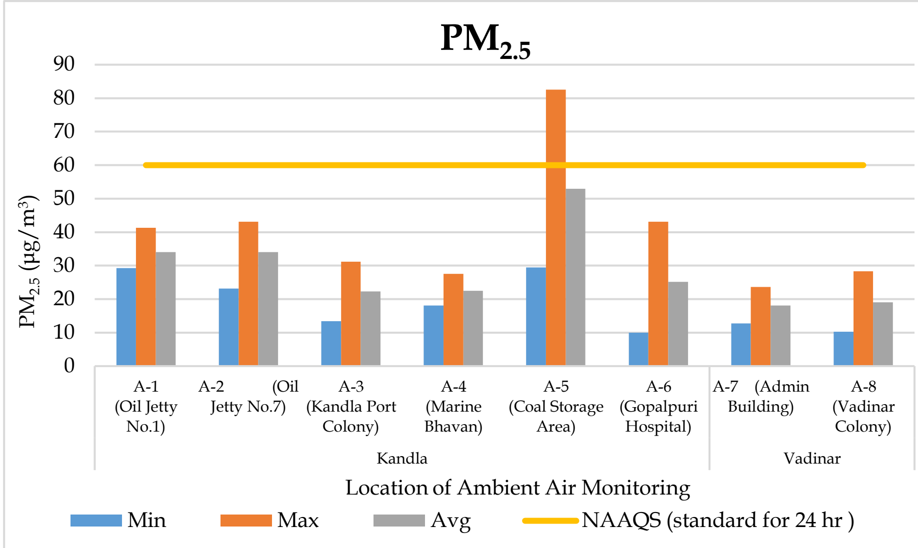
Station Code & Name	Unit of Average Concentration	Average Pollutant Concentration					
	Pollutants	**PM_{10} (µg/m³)**	**$PM_{2.5}$ (µg/m³)**	**SO_2 (µg/m³)**	**NO_X (µg/m³)**	**VOC (µg/m³)**	**CO (mg/m³)**
	Duration	**(24 hr)**				**(2 hr)**	**(1 hr)**
	NAAQS by CPCB / **Monitoring days**	**100**	**60**	**80**	**80**	**-**	**2**
Kandla	2/7/2024	188.37	31.19	23.83	11.51	0.18	0.66
	4/7/2024	141.41	29.24	4.88	<6	0.12	0.84
	8/7/2024	168.27	33.12	11.45	14.2	0.07	0.82
	10/7/2024	156.88	32.79	13.38	21.37	0.14	0.79
	Minimum	**141.41**	**29.24**	**11.45**	**6.28**	**0.07**	**0.66**
	Maximum	**239.33**	**41.33**	**23.83**	**21.37**	**0.22**	**0.86**
	Average	**190.61**	**34.05**	**17.69**	**13.52**	**0.13**	**0.79**
	Std. Deviation	**33.85**	**4.32**	**4.90**	**5.34**	**0.05**	**0.06**
A-2: Oil Jetty No.7, Kandla	17/06/2024	182.61	43.13	36.12	18.21	0.08	0.81
	19/06/2024	191.11	40.62	48.62	10.74	0.03	0.79
	24/06/2024	110.57	36.00	4.92	5.93	0.11	0.78
	27/06/2024	146.32	34.38	30.40	16.77	0.16	0.74
	2/7/2024	119.29	38.64	22.56	8.38	0.09	0.77
	4/7/2024	84.43	23.11	4.89	5.96	0.12	0.75
	8/7/2024	105.63	26.14	16.21	11.41	0.18	0.76
	10/7/2024	96.47	30.22	26.33	10.16	0.05	0.78
	Minimum	**84.43**	**23.11**	**4.89**	**5.93**	**0.03**	**0.74**
	Maximum	**191.11**	**43.13**	**48.62**	**18.21**	**0.18**	**0.81**
	Average	**129.55**	**34.03**	**23.76**	**10.95**	**0.10**	**0.77**
	Std. Deviation	**39.74**	**7.05**	**15.08**	**4.54**	**0.05**	**0.02**
A-3: Kandla Port Colony, Kandla	17/06/2024	146.07	13.39	4.87	5.78	0.20	0.87
	19/06/2024	129.49	14.12	4.96	5.84	0.13	0.86
	24/06/2024	134.77	28.61	29.38	12.34	0.19	0.84
	27/06/2024	163.17	31.16	21.16	9.46	0.12	0.82
	2/7/2024	141.42	27.42	10.27	19.7	0.16	0.85
	4/7/2024	150.52	24.32	4.79	5.94	0.11	0.82
	8/7/2024	126.63	18.38	16.83	12.75	0.27	0.83
	10/7/2024	131.31	21.15	14.77	22.87	0.32	0.86
	Minimum	**126.63**	**13.39**	**4.79**	**5.78**	**0.11**	**0.82**
	Maximum	**163.17**	**31.16**	**29.38**	**22.87**	**0.32**	**0.87**
	Average	**140.42**	**22.32**	**13.38**	**11.84**	**0.19**	**0.84**
	Std. Deviation	**12.40**	**6.67**	**8.92**	**6.52**	**0.07**	**0.02**
A-4: Marine Bhavan, Kandla	17/06/2024	272.90	22.25	4.84	5.76	0.16	0.89
	19/06/2024	253.03	18.10	4..93	5.72	0.21	0.86
	24/06/2024	275.72	22.69	4.89	5.83	0.04	0.84
	27/06/2024	264.42	27.55	27.57	12.25	0.09	0.88
	2/7/2024	218.13	23.41	19.38	14.07	0.11	0.87
	4/7/2024	193.37	25.45	4.97	5.85	0.23	0.85
	8/7/2024	187.73	21.76	13.49	16.19	0.21	0.84
	10/7/2024	203.38	18.93	17.38	23.89	0.25	0.87
	Minimum	**187.73**	**18.10**	**4.84**	**5.72**	**0.04**	**0.84**
	Maximum	**275.72**	**27.55**	**27.57**	**23.89**	**0.25**	**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	**233.59**	**22.52**	**13.22**	**11.20**	**0.16**	**0.86**
	Std. Deviation	**36.88**	**3.11**	**8.84**	**6.68**	**0.08**	**0.02**
A-5: Coal Storage Area, Kandla	17/06/2024	469.24	58.31	36.74	32.68	0.21	0.88
	19/06/2024	522.30	68.62	43.86	10.44	0.14	0.92
	24/06/2024	411.80	82.57	4.94	6.76	0.13	0.94
	27/06/2024	588.16	53.67	31.45	18.87	0.18	0.93
	2/7/2024	446.39	49.22	24.76	26.92	0.10	0.89
	4/7/2024	383.47	29.42	18.66	12.80	0.07	0.91
	8/7/2024	366.11	38.11	29.49	15.37	0.22	0.94
	10/7/2024	333.28	43.66	37.09	18.47	0.12	0.90
	Minimum	**333.28**	**29.42**	**4.94**	**6.76**	**0.07**	**0.88**
	Maximum	**588.16**	**82.57**	**43.86**	**32.68**	**0.22**	**0.94**
	Average	**440.09**	**52.95**	**28.37**	**17.79**	**0.15**	**0.91**
	Std. Deviation	**84.90**	**17.01**	**12.27**	**8.56**	**0.05**	**0.02**
A-6: Gopalpuri Hospital, Kandla	17/06/2024	113.68	43.07	4.97	5.87	0.11	0.73
	19/06/2024	95.01	10.01	4.88	5.92	0.22	0.67
	24/06/2024	78.76	21.78	4.79	5.68	0.19	0.67
	27/06/2024	105.1	29.38	16.23	8.37	0.13	0.7
	2/7/2024	98.34	36.44	11.74	11.33	0.08	0.75
	4/7/2024	61.27	16.27	4.85	5.94	0.16	0.85
	8/7/2024	78.58	25.71	23.58	11.96	0.24	0.78
	10/7/2024	83.67	18.87	9.68	9.79	0.20	0.82
	Minimum	**61.27**	**10.01**	**4.79**	**5.68**	**0.08**	**0.67**
	Maximum	**113.68**	**43.07**	**23.58**	**11.96**	**0.24**	**0.85**
	Average	**89.30**	**25.19**	**10.09**	**8.11**	**0.17**	**0.75**
	Std. Deviation	**16.91**	**10.86**	**6.88**	**2.63**	**0.06**	**0.07**
A-7: Admin Building, Vadinar	17/06/2024	44.86	15.69	15.82	11.76	0.12	0.71
	19/06/2024	47.70	12.78	4.98	5.98	0.10	0.70
	24/06/2024	38.91	13.49	6.68	12.09	0.19	0.68
	27/06/2024	29.72	23.66	4.88	6.33	0.14	0.69
	3/7/2024	27.40	19.44	4.93	5.89	0.04	0.72
	4/7/2024	34.3	21.66	19.73	9.63	0.09	0.7
	8/7/2024	27.08	17.55	22.32	5.91	0.23	0.73
	10/7/2024	42.52	20.69	4.85	5.73	0.11	0.72
	Minimum	**27.08**	**12.78**	**4.85**	**5.73**	**0.04**	**0.68**
	Maximum	**47.70**	**23.66**	**22.32**	**12.09**	**0.23**	**0.73**
	Average	**36.56**	**18.12**	**10.52**	**7.92**	**0.13**	**0.71**
	Std. Deviation	**8.10**	**3.92**	**7.49**	**2.79**	**0.06**	**0.02**
A-8: Vadinar Colony,	17/06/2024	49.61	13.63	9.37	16.18	0.13	0.74
	19/06/2024	52.72	10.30	4.84	5.91	0.18	0.75
	24/06/2024	51.67	28.30	8.37	19.38	0.23	0.72
	27/06/2024	35.58	25.44	4.93	6.52	0.07	0.73

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	3/7/2024	24.57	14.60	4.98	5.78	0.16	0.80
	4/7/2024	47.58	23.53	11.91	8.48	0.11	0.76
	8/7/2024	51.39	15.43	12.55	5.76	0.18	0.79
	10/7/2024	30.02	21.41	4.91	5.93	0.09	0.78
	Minimum	**24.57**	**10.30**	**4.84**	**5.76**	**0.07**	**0.72**
	Maximum	**52.72**	**28.30**	**12.55**	**19.38**	**0.23**	**0.80**
	Average	**42.89**	**19.08**	**7.73**	**9.24**	**0.14**	**0.76**
	Std. Deviation	**11.13**	**6.45**	**3.28**	**5.41**	**0.05**	**0.03**

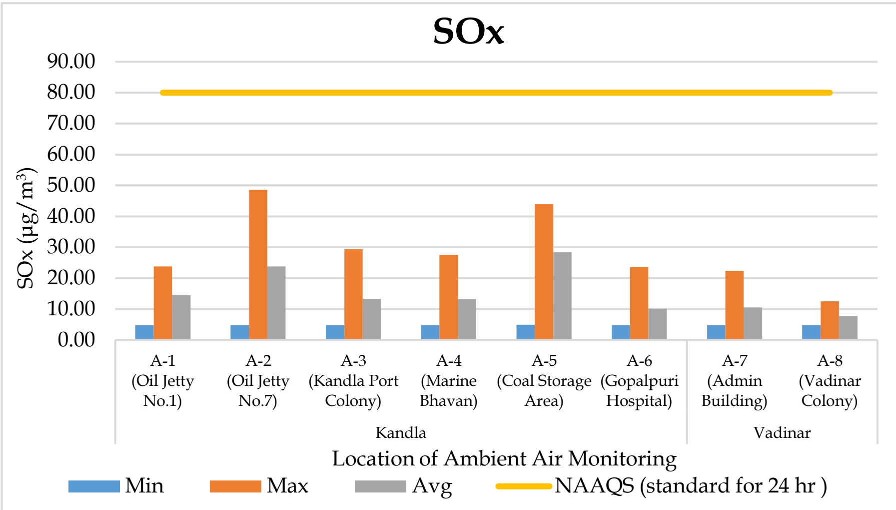
Graphs 1-6 shows spatial trend of ambient air parameter at all the eight-monitoring location (six at Kandla and 2 at Vadinar



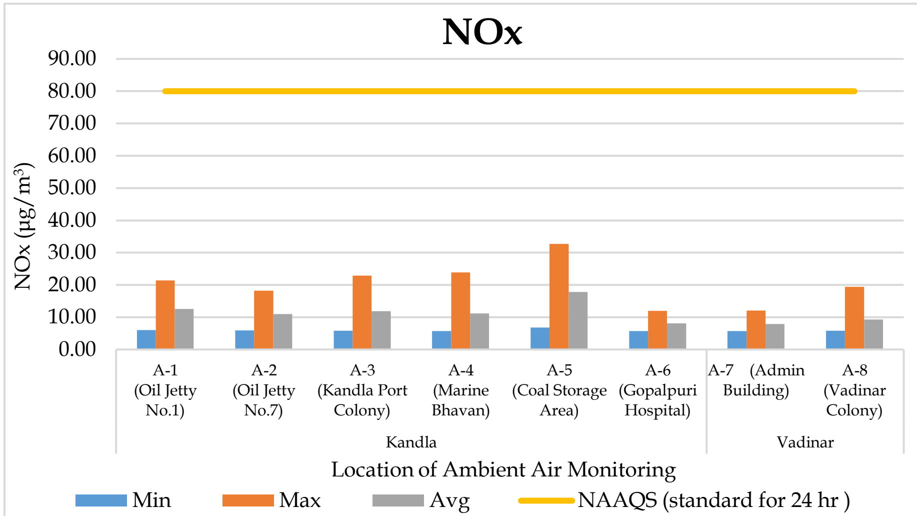


Graph 1: Spatial trend in Ambient PM_{10} Concentration

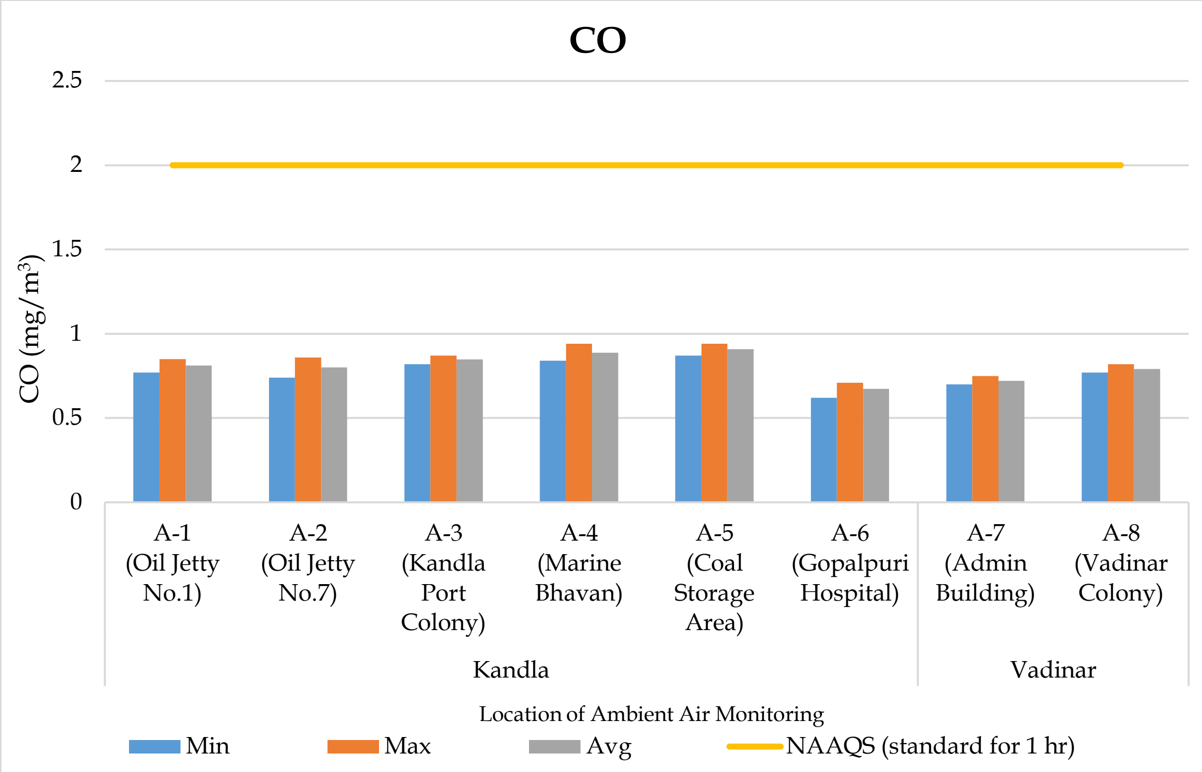
Graph 2: Spatial trend in Ambient $PM_{2.5}$ Concentration



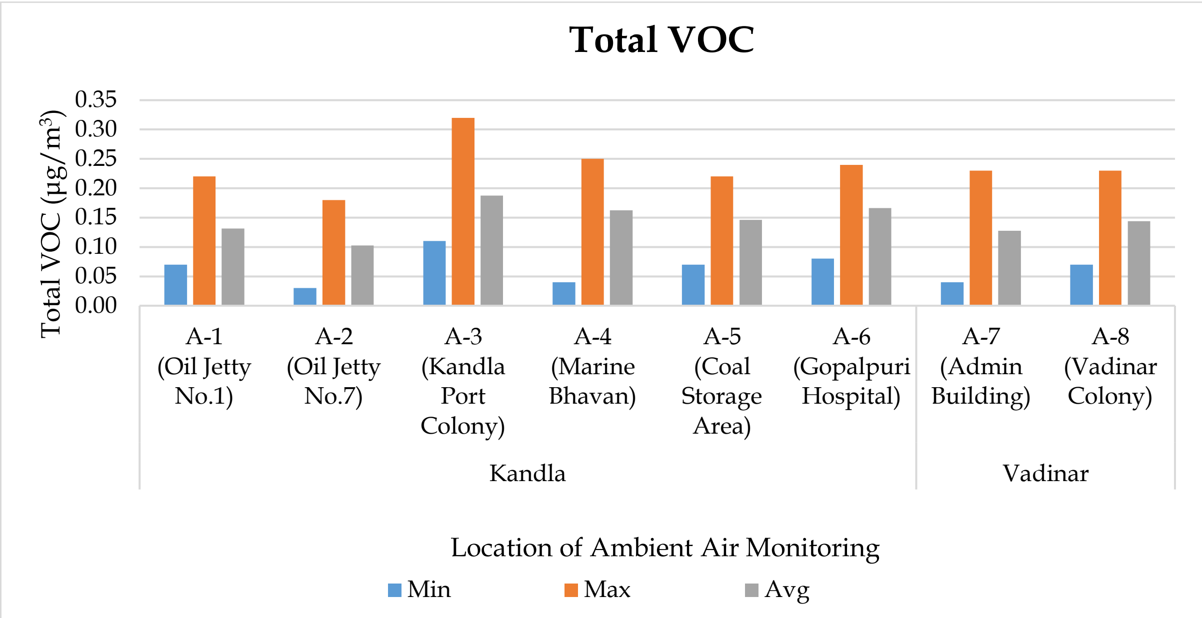
Graph 3: Spatial trend in Ambient SOx Concentration



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	0.25	0.44	0.48	0.60	0.43	0.46	0.01	0.04
2	Acenaphthylene	0.05	0.02	0.08	0.05	0.04	0.08	0.01	0.01
3	Acenaphthene	0.01	0.03	0.00	0.01	0.04	0.03	0.00	0.00
4	Fluorene	0.05	0.02	0.19	0.13	0.56	0.11	0.03	0.02
5	Anthracene	0.07	0.16	0.22	0.51	2.64	0.53	0.18	0.11
6	Phenanthrene	0.00	0.02	0.26	0.18	0.53	0.06	0.01	0.00
7	Fluoranthene	0.03	0.09	0.07	0.21	0.35	0.19	0.09	0.04
8	Pyrene	0.00	0.05	0.42	0.51	0.84	0.31	0.13	0.03
9	Chrycene	0.17	0.20	0.37	0.54	1.22	0.48	0.00	0.00
10	Banz(a)anthracene	0.11	0.06	0.06	0.23	0.58	0.20	0.05	0.02
11	Benzo[k]fluoranthene	0.03	0.01	0.20	0.15	0.36	0.10	0.00	0.00
12	Benzo[b]fluoranthene	0.03	0.05	0.10	0.17	0.32	0.11	0.00	0.00
13	Benzopyrene	0.03	0.04	0.00	0.14	0.84	0.25	0.02	0.04
14	Indeno [1,2,3-cd] fluoranthene	0.08	0.13	0.02	0.12	0.23	0.28	0.04	0.26
15	Dibenz(ah)anthracene	0.03	0.06	0.17	0.15	0.46	0.02	0.02	0.09
16	Benzo[ghi]perylene	0.00	0.01	0.00	0.00	0.00	0.00	0.07	0.18

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	1.11	1.08	1.63	1.24	1.43	1.69	1.53	1.27

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 61.27 to 588.16 µg/m³ with an average value of 203.93 µg/m³. PM_{10} exceeded NAAQS of all the monitoring locations in Kandla. Whereas, at Vadinar, the concentration varies from 24.57 to 52.72 µg/m³, with an average value of 39.73 µg/m³, and complies with the stipulated norm (100 µg/m³).
- The highest concentration of PM_{10} at locations A-5 i.e. Coal Storage 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 vary from 10.01 to 82.57 µg/m3, with an average of 31.84 µg/m3. While the **$PM_{2.5}$** concentrations at most locations in Kandla fall within the NAAQS limits, the concentration at location A-5, with a value of 82.57 µg/m3, exceeds the permissible limit. Whereas, at Vadinar its concentration varies from 10.30 to 28.30 µg/m^3 with average 18.60 µg/m^3 which falls within the limit of NAAQS of 60 µg/m^3.
- The concentration of **SO_x** varies from 4.79 to 48.62 µg/m^3 with average concentration as 17.22 µg/m^3 at Kandla and 4.84 to 22.32 µg/m^3 with average as 9.13 µg/m^3 at Vadinar. The average concentration of SO_x complies with the prescribed limit of NAAQS (80 µg/m^3) for both the monitoring site.
- The concentration of **NO_x** varies from 5.68 to 32.68 µg/m^3 with average 12.08 µg/m^3 at Kandla and 5.73 to 19.38 µg/m^3 with average 8.58 µg/m^3 at Vadinar. The concentration of **NO_x** falls within the prescribed limit of NAAQS i.e. 80 µg/m^3 at both the monitoring site of Kandla and Vadinar.
- The concentration of **CO** varies from 0.66 to 0.94 µg/m^3 with average 0.82 µg/m^3 at Kandla and 0.68 to 0.80 µg /m^3 with average 0.73 µg/m^3 at Vadinar. The concentration falls within the norm of 2 mg/m^3 specified by NAAQS at both the monitoring sites
- The concentration of **Total VOCs** levels was recorded in range of 0.03 to 0.32 µg/m^3 and 0.04 to 0.23 µg/m^3 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 1.08 to 1.69 µg/m³. While at Vadinar, the concentration of NM-VOC falls in the range of 1.27 to 1.53 µg/m³.

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	85.36	39.56
2.	Sulphur Dioxide (SO_2) (PPM)	100	6.31	N.D.
3.	Oxides of Nitrogen (NO_x) (PPM)	50	38.21	10.32
4.	Carbon Monoxide (CO) (%)	1	0.26	0.11
5.	Carbon Dioxide (CO_2) (%)	-	2.15	1.35

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	38.9	48.5	70	42.6	35.4	39.0
2	N-2	West Gate No.1	A	75	66.1	48.0	57.1	70	50.1	41.1	45.6
3	N-3	Canteen Area	B	65	60.2	44.2	52.2	55	49.2	36.7	43.0
4	N-4	Main Gate	A	75	58.4	46.9	52.7	70	45.4	36.2	40.8
5	N-5	Main Road	A	75	60.2	39.4	49.8	70	47.6	35.6	41.6
6	N-6	Marin Bhavan	B	65	61.9	39.5	50.7	55	42.0	34.6	38.3
7	N-7	Port & Custom Building	B	65	54.6	39.4	47.0	55	46.6	36.4	41.5
8	N-8	Nirman Building	B	65	54.5	42.6	48.6	55	48.1	37.1	42.6
9	N-9	ATM Building	B	65	58.1	41.6	49.9	55	45.9	35.9	40.9
10	N-10	Wharf Area/ Jetty	A	75	61.5	42.6	52.1	70	47.2	40.6	43.9
11	N-11	Near Main Gate	A	75	67.4	57.2	60.3	75	50.4	54.6	62.3
12	N-12	Near Vadinar Jetty	A	75	69.3	63.2	63.7	75	52.1	56.3	59.6
13	N-13	Port Colony Vadinar	C	55	53.5	45.1	45.3	55	43.3	44.7	52.1

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 47.0 dB(A) to 57.1 dB(A), while at Vadinar, the noise levels for the three-location ranged from 45.3 dB(A) to 63.7 dB(A). Whereas, during Night Time the average Noise Level ranged from 38.3 dB(A) to 45.6 dB(A) at Kandla and 52.1 dB(A) to 62.3 dB(A) at Vadinar, which was within the permissible limits for the industrial and commercial area, but exceeded slightly for location N-12, which is a residential zone. 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	-	7.34	7.3	8.64	8.45	7.74	8.14
2	Conductivity	µS/cm	45300	27200	226	219	102	272
3	Inorganic Phosphate	Kg/ha	2.06	2.22	3.14	3.03	0.59	0.55
4	Organic Carbon	%	0.56	0.5	0.29	0.23	0.1	0.52
5	Organic Matter	%	0.96	0.86	0.49	0.39	0.17	0.89
6	SAR	meq/L	24.88	10.06	0.39	0.38	0.09	0.17
7	Aluminium	mg/Kg	11277.15	14127.51	10350.29	7708.929	12783.28	13457.49
8	Chromium	mg/Kg	53.599	62.015	53.667	35.6	51.109	55.378
9	Nickel	mg/Kg	14.22	5.764	13.391	5.668	18.72	24.346
10	Copper	mg/Kg	83.233	123.235	14.591	14.22	63.292	67.75
11	Zinc	mg/Kg	146.081	45.517	32.38	17.203	37.242	55.477
12	Cadmium	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL
13	Lead	mg/Kg	15.314	5.068	2.698	1.591	BQL	BQL
14	Arsenic	mg/Kg	0.198	BQL	2.298	0.795	BQL	BQL
15	Mercury	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL
16	Water Holding Capacity	%	37.98	43.96	40	39.97	37.95	51.9
17	Sand	%	61.52	65.55	77.54	75.53	72.81	74.8
18	Silt	%	33.44	31.41	11.43	13.44	26.15	24.16
19	Clay	%	5.04	3.04	11.03	11.04	1.04	1.04
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 **7.3 to 8.64**, highest at location S-3 (Khori Creek) and lowest at S-2 (IFFCO Plant); while the average pH for Kandla was observed to be 7.93. Whereas, at Vadinar the pH was observed as 7.74 at S-5 i.e., Near SPM and 8.14 at S-6 i.e., Near Jetty Area. The pH in Kandla varies from the **Slightly alkaline to strongly 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 **219 to 45300 µs/cm**, highest at location S-1 (Oil Jetty 7) and lowest at S-4 (Nakti Creek), with the average as **18236.25** µs/cm. Whereas, at Vadinar the conductivity falls within the range of **102 to 272** µs/cm with an average value of **187 µs/cm.**

- At Kandla, the concentration of **Inorganic Phosphate** varied from **2.06 to 3.14 Kg/ha**, with average 2.61 Kg/ha. Whereas, at the locations of Vadinar, the Inorganic Phosphate was observed as 0.59 Kg/ha at S-5 (Near SPM) and 0.55 Kg/ha at S-6 (near Jetty Area), with the average 0.57 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 0.23 to 0.56% while the average TOC at Kandla was detected as 0.39%. Whereas, at Vadinar the average TOC was found to be 0.31% where the observed TOC value found at S-5 and S-6 to be 0.1% and 0.52% respectively.

- The **Sodium Adsorption Ratio** ranges from **0.38 to 24.88 meq/L** with an average value 8.92 meq/L at Kandla. Whereas, at Vadinar, the average SAR was found to be 0.13 meq/L where the observed SAR value found at S-5 (0.09 meq/L) and S-6 (0.17 meq/L).

- The **Water Holding Capacity** in the soil samples of Kandla and Vadinar varies from 37.98 to 43.96% and 37.95 to 51.9% respectively.

- The Soil Texture was observed as "Sandy loam" at all the monitoring locations in Kandla and Vadinar, except the location S-6 of Vadinar which is "loamy sand".

Heavy Metals

- For the sampling period, the concentration of **Aluminium** varied from **7708.929 to 14127.509 mg/kg** at Kandla, and **12783.28 to 13457.493 mg/kg** at Vadinar. Whereas, the average Aluminium concentration was observed to be 10865.97 and 13120.39 mg/kg at Kandla and Vadinar monitoring station respectively.

- The concentration of **Chromium** varied from **35.6 to 62.015 mg/kg** at Kandla and **51.109 to 55.378 mg/kg** at Vadinar and the average value was observed to be 51.22 and 53.24 mg/kg at Kandla and Vadinar monitoring station, respectively.

The concentration of **Nickel** varied from **5.668 to 14.22 mg/kg** at Kandla and **18.72 to 24.346 mg/kg** at Vadinar and the average value was observed to be 9.76 and 21.533 mg/kg at Kandla and Vadinar monitoring station, respectively.

- The concentration of **Zinc** varied from **17.203 to 146.081 mg/kg** at Kandla and **37.242 to 55.477 mg/kg** at Vadinar and the average value was observed to be 60.29 and 46.35 mg/kg at Kandla and Vadinar monitoring station, respectively.

- The concentration of **copper** varied from **14.22 to 123.235 mg/kg** at Kandla and **63.292 to 67.75 mg/kg** at Vadinar and the average value was observed to be 58.81 and 65.52 mg/kg at Kandla and Vadinar monitoring station, respectively.

- Concentration of **Lead** varied from **1.59 to 15.31 mg/kg** at Kandla with average value 6.16 mg/Kg, whereas for Vadinar, the values recorded 6.57 mg/Kg at S-5 and "Below Quantification Limit" at location at S-6 location.

- The concentration of **Arsenic** varied from **0.19 to 2.29 mg/kg** at Kandla with average value 1.09 mg/Kg, whereas for Vadinar, the values recorded 6.57 mg/Kg at S-5 and "Below Quantification Limit" at location at 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
18.	Nitrite	mg/L	APHA, 23rd Edition, 4500 NO2-B: 2017	

Sr. No.	Parameters	Units	Reference method	Instrument
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	-	8.34	6.41	7.67	8.78	7.63	8.26	8.48	8.50	7.79	8.15	7.87	7.88	7.90	8.10	7.85	7.01	6.99	6.91	7.58	7.30
2.	Colour	Hazen	5	15	1	1	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3.	EC	µS/ cm	-	-	15	44.56	677	48.7	1004	88.4	14.05	31	703	210	1041	57.9	123.7	173	169.9	165	158.6	68	499	113.9
4.	Salinity	PSU	-	-	0.02	0.21	0.33	0.03	0.49	0.05	0.02	0.02	0.34	0.10	0.51	0.03	0.06	0.09	0.08	0.08	0.08	0.04	0.24	0.06
5.	Turbidity	NTU	1	5	BQL	BQL	0.52	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	0.68	BQL
6.	Chloride	mg/L	250	1000	4.96	8.55	119.11	6.95	193.56	17.87	4.47	7.94	119.11	45.16	203.48	14.39	23.33	33.25	36.23	32.26	35.73	17.87	71.47	17.87
7.	Total Hardness	mg/L	200	600	2.5	8	165	13	200	7	BQL	3.5	170	20	210	4	25.0	40	12.5	25	7.5	12	130	20
8.	Ca Hardness	mg/L	-	-	1.5	6	100	10	115	5.5	1	2.5	85	5	125	3	12.5	15	7.5	12.5	2.5	5	60	5
9.	Mg Hardness	mg/L	-	-	1	2	65	3	85	1.5	BQL	1	85	15	85	1	12.5	25	5	12.5	5	7	70	15
10.	Free Residual Chlorine	mg/L	0.2	1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	4.96	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
11.	TDS	mg/L	500	2000	8	22	356	26	516	46	8	16	362	108	538	30	66	94	88	86	82	36	258	60
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	BQL	BQL	BQL	BQL	BQL	BQL	BQL	0.318	BQL	BQL	BQL	BQL	BQL	BQL	BQL	0.500	0.360
14.	Sulphate	mg/L	200	400	BQL	BQL	33.516	BQL	52.375	BQL	BQL	BQL	38.326	BQL	66.402	BQL	BQL	BQL	BQL	21.771	BQL	BQL	33.620	BQL
15.	Nitrate	mg/L	45	-	BQL	BQL	2.783	BQL	28.36	5.037	BQL	BQL	2.242	1.865	30.93	BQL	BQL	1.330	1.353	BQL	4.432	BQL	3.584	BQL
16.	Nitrite	mg/L	-	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	1.638	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
17.	Sodium	mg/L	-	-	BQL	BQL	72.16	BQL	109.19	16.59	BQL	BQL	78.98	28.79	109.58	10.72	16.16	19.30	27.45	21.13	28.99	13.51	54.54	17.05
18.	Potassium	mg/L	-	-	BQL	BQL	BQL	BQL	7.22	BQL	BQL	BQL	BQL	BQL	7.89	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
19.	Hexavalent Chromium	mg/L	-	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	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	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
24.	Iron	mg/L	**0.3**	-	BQL	BQL	BQL	0.119	BQL	BQL	BQL	BQL	BQL	0.126	BQL	0.872	BQL	0.121	BQL	0.252	BQL	0.109	0.128	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	0.059	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	3.964	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
30.	Total Coliform*	MPN/ 100ml	**Shall not be detected**		5110	380	695	BQL	3100	130	10	2018	1060	BQL	4250	BQL	35	BQL	3400	BQL	385	85	85	75

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 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 **6.41 to 8.78**, with an average pH of 7.80. In Vadinar, its values ranged from **7.30 to 7.58**, with an average pH of 7.44. Notably, the pH levels at both project sites fall within the acceptable range of 6.5 to 8.5, except the location DW-2 & DW-4, as specified under IS:10500:2012.
- **Colour:** The colour varies from 1 to 5 at the monitoring locations of Kandla. Only locations DW-3 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 **14.05 to 1041 µS/cm**, with an average value of 266.26 µS/cm. In Vadinar, the EC values showed variation from **113.9 to 499 µS/cm**, with an average value of 306.45 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.
- **Salinity:** Salinity at Kandla varies from **0.02 to 0.51 PSU** with an average of 0.14 PSU, while at Vadinar, salinity was observed to be 0.24 and **0.06 PSU** for locations DW-19 & DW-20 respectively.
- **Turbidity:** At the drinking water locations of Kandla, the turbidity was found BQL for all locations except locations DW-3 (0.52 NTU. Whereas, at Vadinar the value of turbidity was reported 0.68 NTU at DW-19 and BQL at DW-20 respectively.
- **Chlorides:** The chloride concentrations in Kandla varied from **4.47 to 203.48 mg/L**, with an average value of 51.34 mg/L. At Vadinar the locations DW-19 and DW-20, the chloride concentration was observed as 71.47 mg/L and 17.87 mg/L, with an average value of 44.67 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 **2.5 to 210 mg/L**, with an average concentration of 54.41 mg/L. At location DW-11, the total hardness was observed 210 mg/L, which exceeds the acceptable limit but falls within the permissible limit. While at Vadinar, the observed values were 130 & 20 mg/L; at locations DW-19 & D-20, with an average concentration of 75 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 8 to 538 mg/L, with an average concentration of 138.22 mg/L. At Locations DW-11, the TDS

value is 538 mg/L, which is more than the acceptable limit but within the permissible limit. while in Vadinar, it ranged from 60 to 258 mg/L, with an average of 159 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-11 (0.31 mg/L) at Kandla. While at Vadinar Fluoride concentration was reported to be 0.500 & 0.360 mg/L respectively 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-3(33.516 mg/L), DW-5 (52.375 mg/L), DW-9 (38.326 mg/L), DW-11 (66.402 mg/L), and DW-16 (21.771 mg/L). In Vadinar, the sulphate concentration was observed 33.620 mg/L at location DW-19 and BQL at location 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 **1.33 to 30.93 mg/L,** with the average concentration of 8.70 mg/L and locations DW-1, DW-2, DW-4, DW-7, DW-8, DW-12, DW-13, DW-16 and DW-18 were recorded as "BQL". While at Vadinar, the concentration recorded 3.584 mg/L at location DW-19 and BQL at location DW-20.
- **Nitrite:** Except locations DW-11 (1.638 mg/L), all monitoring locations showed the Nitrite concentration as BQL at Kandla & Vadinar.
- **Sodium:** During the monitoring period, at Kandla variation in the concentration of Sodium was observed to be in the range of **10.72 to 109.58 mg/L**, with the average concentration of 42.50 mg/L and Location DW-1, DW-2, DW-4, DW-7 & DW-8 showed the BQL concentration for Sodium. While at Vadinar, the concentration recorded 54.54 mg/L at DW-19 and 17.05 mg/L at DW-20.
- **Odour:** Odour values recorded 1 TON at all monitoring locations of Kandla and Vadinar.
- **Arsenic:** In Kandla & Vadinar, the Arsenic concentrations were recorded BQL for all of the locations.
- **Copper:** In Kandla & Vadinar, the Copper concentrations were recorded BQL for all of the locations.
- **Iron:** Except for locations DW-4 (0.119 mg/L), DW-10 (0.126 mg/L), DW-12 (0.872 mg/L), DW-14 (0.121 mg/L), DW-16 (0.252 mg/L), and DW-18 (0.109 mg/L), the other locations were observed to have concentrations Below the detection Limit at Kandla. Whereas, at Vadinar the Copper concentrations were recorded 0.128 mg/L & BQL for locations DW-19 and DW-20 respectively.
- **Lead:** In Kandla & Vadinar, the Lead concentrations were recorded BQL for all of the locations.
- **Manganese:** All of locations observed to have BQL concentration for both the monitoring locations at Kandla and Vadinar except the location DW-8 (0.059 mg/L).
- **Free Residual Chlorine:** Free Residual Chlorine concentrations at all monitoring locations, including Kandla and Vadinar, were observed to be below quantifiable limits (BQL) except at location DW-11, where a concentration of 4.96 mg/L was

recorded. According to health standards, concentrations exceeding 4 mg/L are considered unsafe for human health, potentially leading to adverse health effects.

- The parameters such as **Free Residual Chlorine, Toal Suspended Solid, Potassium 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 in higher number at location DW-1 (5110 MPN/100ml), DW-11 (4250 MPN/100ml), DW-15 (3400 MPN/100ml), DW-5 (3110 MPN/100ml) & DW-8 (2018 MPN/100ml). Whereas, TC were also detected at locations DW-2 (380 MPN/100ml), DW-3 (695 MPN/100ml), DW-6 (130 MPN/100ml), DW-7 (10 MPN/100 ml), DW-9 (1060 MPN/100 ml), DW-13 (35 MPN/100 ml), DW-17 (385 MPN/100 ml), DW-18 (85 MPN/100 ml), DW-19 (75 MPN/100 ml) and DW-20 (5 MPN/100 ml) and for the rest of the monitoring locations of Kandla and Vadinar were detected "Below the Quantification Limit (BQL)". Reporting such concentration of Coliforms indicates certain external influx may contaminate the source. Hence, it should be checked at every distribution point.

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:

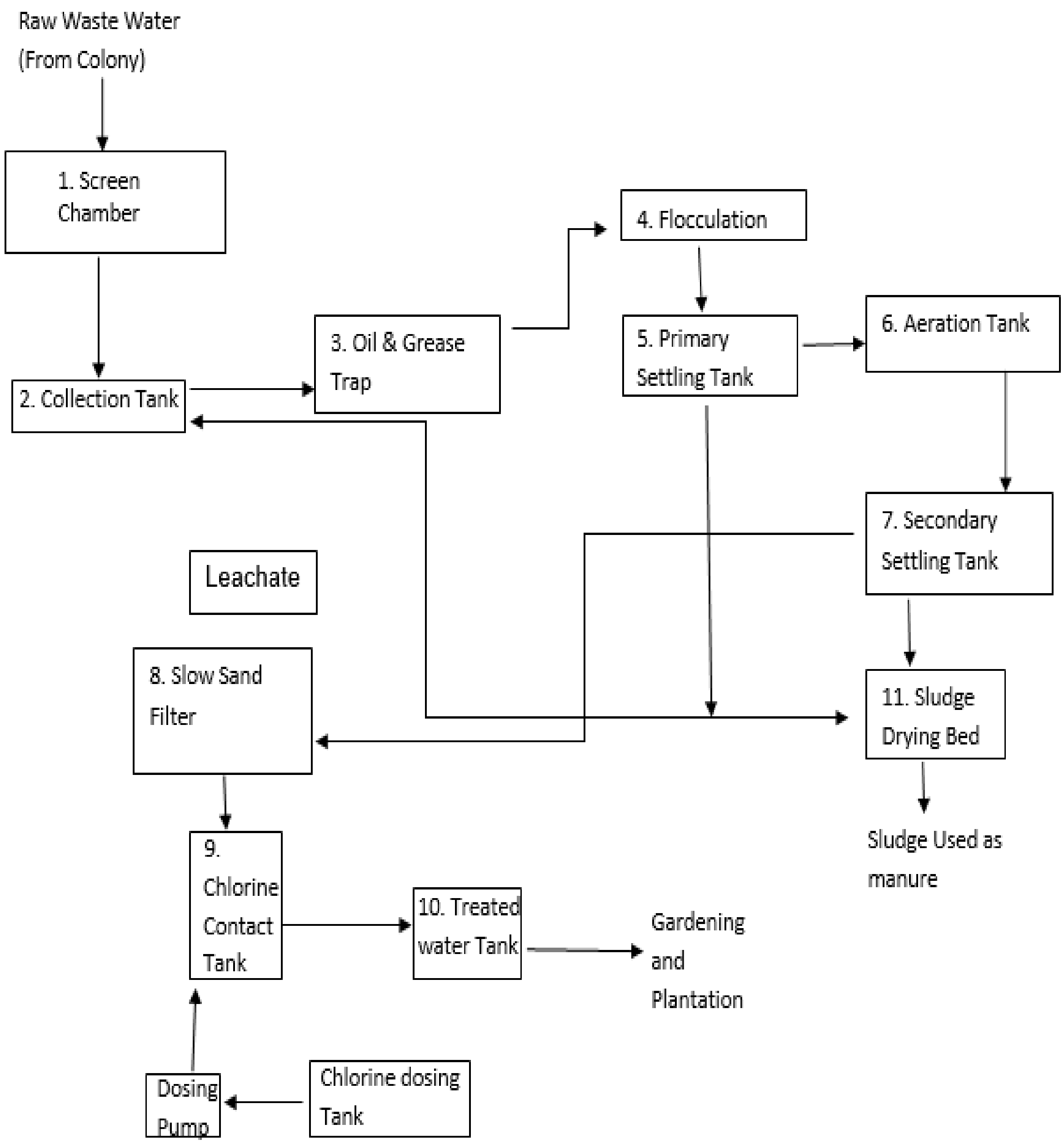


Figure 3: Process flow diagram of STP at Kandla

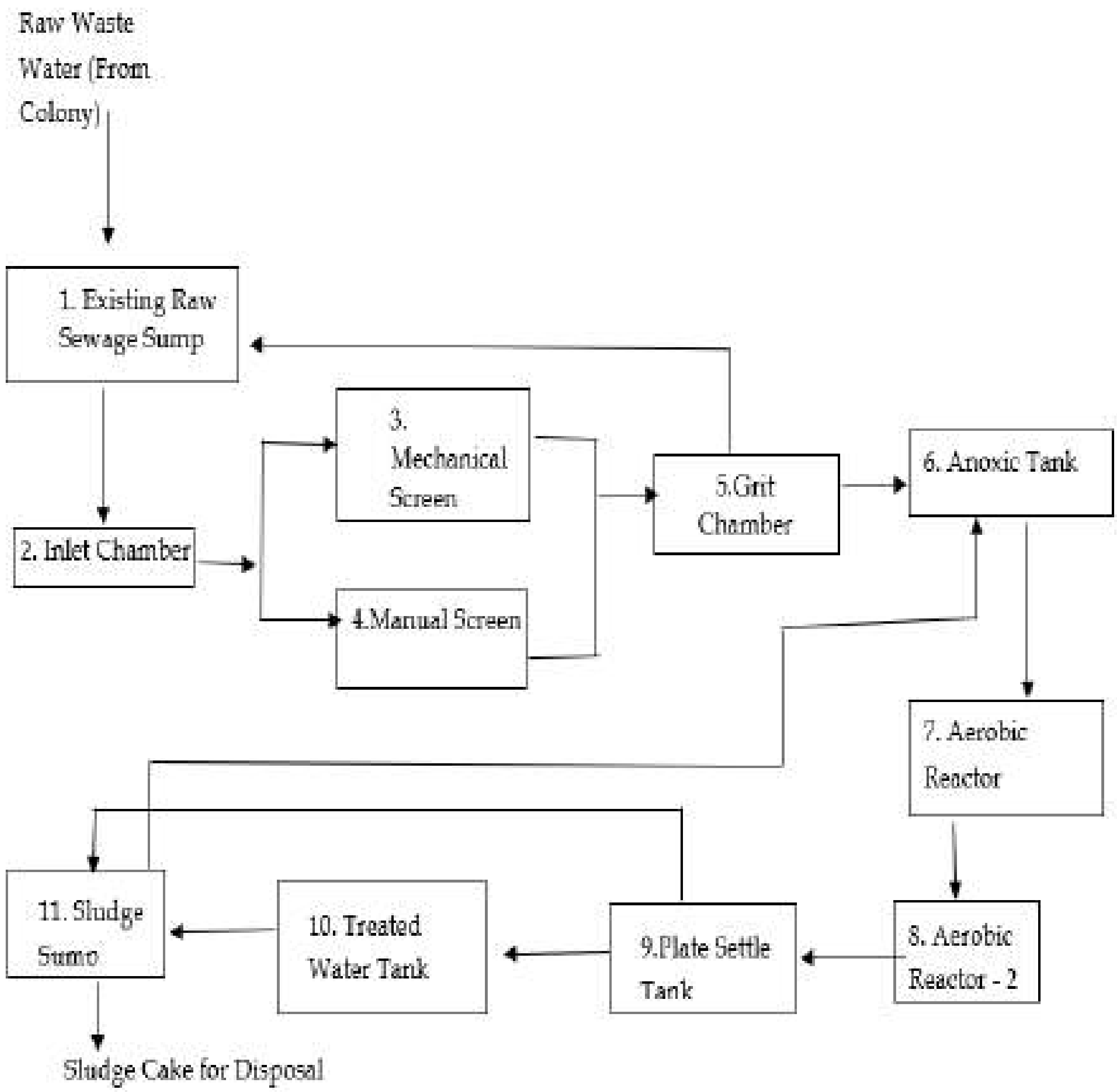


Figure 4: Process flow diagram of STP at Gopalpuri

<u>STP at Vadinar</u>

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

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

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

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

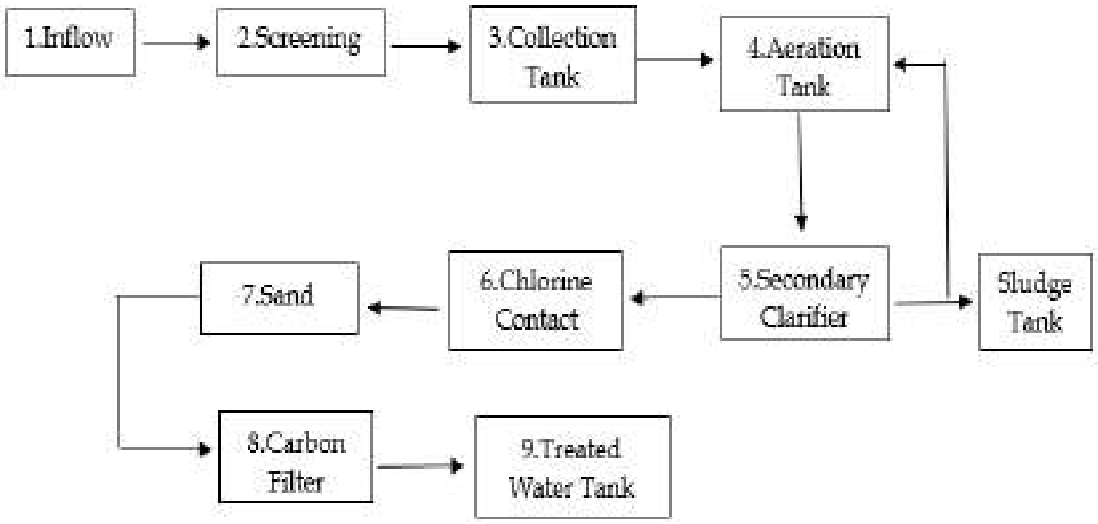


Figure 5: Process flowchart for the STP at Vadinar

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

Map 14: Locations for STP Monitoring at Kandla

Map 15: Locations for STP Monitoring at Vadinar

Methodology

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

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

Frequency

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

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

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

9.2 Result and Discussion

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

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

Sr No.	Parameter	Units	GPCB Norms (Kandla)	Kandla															
				Week 3 of June				Week 4 of June				Week 1 of July				Week 2 of July			
				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**	7.02	7.22	7.08	7.36	7.18	7.41	7.12	7.29	7.22	7.56	7.08	7.21	7.12	7.48	6.94	7.48
2.	TDS	mg/L	-	1896	1438	708	682	3948	3583	977	745	1869	1624	766	498	6643	3814	962	894
3.	TSS	mg/L	**100**	126	8	88	10	88	12	126	18	72	14	108	10	78	6	62	8
4.	COD	mg/L	-	249	92.4	257	52.2	229	66.47	236	42.7	173.7	66.21	385.7	54.7	233	71.2	184	52
5.	DO	mg/L	-	BQL	5	BQL	3	BQL	4.8	BQL	4.2	BQL	3.9	BQL	5.4	BQL	2.3	BQL	4
6.	BOD	mg/L	**30**	77.81	11.55	80.32	6.53	71.19	14.16	87.19	9.26	68.34	8.27	118.54	7.59	79.46	6.89	57.5	6.5
7.	SAR	meq/L	-	10.69	8.54	4	3.58	18.47	13.91	7.41	5.34	8.79	8.13	4.92	2.78	16.72	5.63	4.75	5.14
8.	Total Coliforms	MPN/ 100ml	**<1000**	1600	1600	1600	1600	1600	1600	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 June		Week 4 of June		Week 1 of July		Week 2 of July	
				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**	7.21	7.07	7.22	7.04	7.24	7.05	7.2	7.48
2.	TDS	mg/L	-	584	578	532	442	436	378	452	366
3.	TSS	mg/L	**20**	8	4	8	2	12	6	18	4
4.	COD	mg/L	**50**	116.9	36.3	149.2	52.4	132	52	148.6	36.1
5.	DO	mg/L	-	BQL	4.5	BQL	5.6	BQL	7	0.9	7.8
6.	BOD	mg/L	**10**	36.53	4.54	46.63	6.55	39.6	7.8	46.44	6.77
7.	SAR	meq/L	-	3.08	2.59	3.51	2.96	2.32	2.2	2.4	1.99
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 7.21-7.56 at Kandla and 7.04–7.48 at Vadinar respectively.
- The **TDS** of treated sewage at Kandla was ranges from 498 to 3814 mg/L, whereas for Vadinar it ranges from 366 to 578 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 42.7 to 92.4 mg/L. Whereas for Vadinar the value of COD falls within the range of 36.1 – 52.4 mg/L, and conforms the CCA norms of 50 mg/L, except the 4th & 1st week sample of June & July.
- The value of **DO** was observed in the range of 2.3 to 5.4 mg/L, whereas for Vadinar it was observed in the range of 4.5 to 7.8 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 2.78 to 13.91 meq/L, whereas for Vadinar, it was observed in the range of 1.99 to 2.96 meq/L.
- The **Total Coliforms** was observed to exceed the norms at the locations of the STP-1 & STP-2 for the treated effluent at Kandla and STP-3 at Vadinar.

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

9.4 Remedial Measures:

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

reagent (hydrogen peroxide and iron catalyst) and UV/H_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	

<table>
<tr><th>Sr. No</th><th>Parameters</th><th>Units</th><th>Reference method</th><th>Instrument</th></tr>
<tr><td>16.</td><td>Nitrite</td><td>mg/L</td><td>APHA, 23rd Edition, 4500 NO2- B: 2017</td><td></td></tr>
<tr><td>17.</td><td>Sodium</td><td>mg/L</td><td>APHA, 23rd Edition, 3500 Na-B: 2017</td><td rowspan="2">Flame photometer</td></tr>
<tr><td>18.</td><td>Potassium</td><td>mg/L</td><td>APHA, 23rd Edition, 3500 K-B: 2017</td></tr>
<tr><td>19.</td><td>Manganese</td><td>µg/L</td><td>APHA, 23rd Edition, ICP Method 3120 B: 2017</td><td rowspan="3">ICP-OES</td></tr>
<tr><td>20.</td><td>Iron</td><td>mg/L</td><td>APHA, 23rd Edition, ICP Method 3120 B: 2017</td></tr>
<tr><td>21.</td><td>Total Chromium</td><td>µg/L</td><td rowspan="2">APHA, 23rd Edition, 3500 Cr B: 2017</td></tr>
<tr><td>22.</td><td>Hexavalent Chromium</td><td>µg/L</td><td>UV- Visible Spectrophotometer</td></tr>
<tr><td>23.</td><td>Copper</td><td>µg/L</td><td rowspan="5">APHA, 23rd Edition, ICP Method 3120 B: 2017</td><td rowspan="6">ICP-OES</td></tr>
<tr><td>24.</td><td>Cadmium</td><td>µg/L</td></tr>
<tr><td>25.</td><td>Arsenic</td><td>µg/L</td></tr>
<tr><td>26.</td><td>Lead</td><td>µg/L</td></tr>
<tr><td>27.</td><td>Zinc</td><td>mg/L</td></tr>
<tr><td>28.</td><td>Mercury</td><td>µg/L</td><td>EPA 200.7</td></tr>
<tr><td>29.</td><td>Floating Material (Oil grease scum, petroleum products)</td><td>mg/L</td><td>APHA, 23rd Edition, 5520 C: 2017</td><td>Soxhlet Assembly</td></tr>
<tr><td>30.</td><td>Total Coliforms (MPN)</td><td>MPN/ 100ml</td><td>IS 1622: 2019</td><td>LAF/ Incubator</td></tr>
</table>

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	-	1.018	1.024	1.022	1.019	1.02	1.023	1.02	1.023
2.	pH	-	6.5-9.0	7.79	7.89	7.85	7.80	7.79	7.82	7.83	7.88
3.	Color	Hazen	No Noticeable	5	5	5	5	5	5	5	1
4.	EC	µS/cm	-	62,600	57,800	59,400	60,500	61,500	58,900	53,300	55,100
5.	Turbidity	NTU	-	>500	150	>500	323	>500	424	11.7	18.2
6.	TDS	mg/L	-	42,638	39,356	41,264	41,884	42,728	43,544	36,178	37,296
7.	TSS	mg/L	-	744	152	568	348	608	348	12	14
8.	COD	mg/L	-	68.1	58.7	89.4	60.4	88.5	80.9	57.9	46.8
9.	DO	mg/L	3.0 mg/L	5.7	6.2	5.5	5.6	5.6	5.8	6.5	7.8
10.	BOD	mg/L	5.0 mg/L	4.26	3.67	5.59	3.78	5.53	5.05	3.62	5.85
11.	Oil & Grease	mg/L	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12.	Sulphate	mg/L	-	3444.7	3473.1	3160.3	3452.6	3344	3045.9	3041.8	2772.6
13.	Nitrate	mg/L	-	4.144	3.599	4.578	3.678	5.200	3.834	2.963	2.371
14.	Nitrite	mg/L	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
15.	Phosphate	mg/L		0.901	BQL	BQL	BQL	BQL	BQL	BQL	BQL
16.	Silica	mg/L	-	4.23	3.67	3.15	3.75	4.74	3.94	1.80	1.60
17.	Sodium	mg/L	-	>10,000	>10,000	>10,000	>10,000	>10,000	>10,000	>10,000	>10,000
18.	Potassium	mg/L	-	444	336	454	428	419	441	382	384
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	-	4.477	0.970	3.887	2.861	4.058	2.876	BQL	0.225
25.	Lead	mg/L	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
26.	Manganese	mg/L	-	0.17	BQL	0.14	0.094	0.16	0.10	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	-	4.82	1.27	3.92	2.86	3.26	4.28	0.08	BQL
31.	Total Coliforms	MPN/ 100ml	500/100 ml	8	2	2	1600	13	4	BQL	9

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	1.018	1.024	1.022	1.019	1.02	1.023	1.02	1.023

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 **1.018 to 1.024 kg/m³**, with the average of 1.021 **kg/m³.** Whereas for the location of Vadinar, it was observed 1.02 **kg/m³** at MW-7 and 1.023 **kg/m³** at MW-8, with the average of 1.021 **kg/m³**.
- **pH** at Kandla was observed in the range of **7.79 to 7.89**, with the average pH as 7.89. Whereas for the locations of Vadinar, it was observed in the range of be **7.83 to 7.88**, with the average pH as 7.85. 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** at MW-7 and **1 Hazen** at MW-8 location.
- **Electrical conductivity (EC)** was observed in the range of **57,800 to 62,600 µS/cm**, with the average EC as 60116.7 µS/cm for the locations of Kandla, whereas for the locations of Vadinar, it was observed in the range of **53,300 to 55,100 µS/cm**, with the average EC as 54,200µS/cm.
- For all monitoring locations of Kandla the value of **Turbidity** was observed in the range of **150 to 424 NTU**, with average value of 299 NTU, and location MW-1, MW-3 & MW-5 exceeds the quantification limit of 500 NTU. For Vadinar it ranges from **11.7 to 18.2 NTU**, with average of 14.95 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 **39,356 to 43,544 mg/L**, with an average value of 41,902.3 mg/L. Similarly, at Vadinar, the TDS values ranged from **36,178 to 37,296 mg/L**, with an average value of 36,737 mg/L.

- **TSS** values in the studied area varied between **152 to 744 mg/L** at Kandla and **12 to 14 mg/L** at Vadinar, with the average value of 461.33 mg/L and 13 mg/L respectively for Kandla and Vadinar.
- **COD** varied between **58.7 to 89.4 mg/L** at Kandla and **46.8 to 57.9 mg/L** at Vadinar, with the average value as 74.33 mg/L and 52.35 mg/L respectively for Kandla and Vadinar.
- **DO** level in the studied area varied between **5.5 to 6.2 mg/L** at Kandla and **6.5 to 7.8 mg/L** at Vadinar, with the average value of 5.73 mg/L and 7.15 mg/L respectively for Kandla and Vadinar. Which represents that the marine water is suitable for marine life.
- **BOD** observed was observed in the range of **3.67 to 5.59 mg/L**, with average of 4.64 mg/L for the location of Kandla and for the locations of Vadinar, it was observed in the range of **3.62 to 5.85 mg/L**, with an average value of 4.73 mg/L.
- **Sulphate** concentration in the studied area varied between **3045.9 to 3473.1 mg/L** at Kandla and **2772.6 to 3041.8 mg/L** at Vadinar. The average value observed at Kandla was 3320.1 mg/L, whereas 2907.2 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 **3.59 to 5.2 mg/L**, with the average of 4.17 mg/L. Whereas for the Vadinar, recorded value was observed as 2.96 mg/L at MW-7 and 2.37 mg/L at MS-8.
- In the study area of Kandla the concentration of **Potassium** varied between **336 to 454 mg/L** and **382 to 384 mg/L** at Vadinar, with the average value as 420.33 mg/L and 383 mg/L respectively for Kandla and Vadinar.
- **Silica** in the studied area varied between **3.15 to 4.74 mg/L**, with the average of 3.91 mg/L, at Kandla. Vadinar, observed value was found to be 1.80 mg/L at MW-7 and 1.60 mg/L at MS-8 locations.
- **Sodium** in the study area at both Kandla & Vadinar the sodium concentration value recorded Above the quantification limit.
- **Odour** was observed 1 for all locations of Kandla and Vadinar.
- **Copper** at the Kandla site as well as both locations at the Vadinar site, had levels below the quantification limit (BQL)."
- **Iron** in the studied area varied between **0.97 to 4.47 mg/L**, with the average of 3.18 mg/L, at Kandla, and for Vadinar value were recorded BQL for location MW-7 and 0.225 mg/L for location MW-8.
- **Lead** concentration was observed BQL at both site of Kandla & Vadinar.
- **Manganese** in the studied area varied between **0.094 to 0.17 mg/L**, with the average of 0.13 mg/L, at Kandla. At Vadinar both location MW-7 and MW-8 observed BQL.
- **Particulate Organic Carbon** in the study area was observed in the range of **1.27 to 4.82**, with the average value of 3.40. Whereas for the Vadinar, the value observed was 0.08 at MW-7 and BQL 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, except the location MW-4, which is 1600 MPN/100ml.

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	2.12	2.41	3.64	2.88	3.42	1.71	1.85	1.06
2.	Phosphate	mg/Kg	288.72	329.62	467.84	363.18	319.45	213.507	217.339	339.31
3.	Organic Matter	%	1.12	1.36	1.02	1.28	0.94	1.43	1.13	1.52
4.	Sulphate as SO^{4-}	mg/Kg	170.55	146.88	133.90	122.57	189.41	169.42	145.05	126.34
5.	Calcium as Ca	mg/Kg	3680.00	3850.00	4600.00	4100.00	3740.00	3500.00	3400.00	3800.00
6.	Magnesium as Mg	mg/Kg	1928.00	2473.00	2541.00	2849.00	2473.00	1342.00	976.00	1865.00
7.	Silica	g/Kg	519.37	521.29	534.91	546.62	554.35	523.5	507.02	534.29
8.	Nitrite	mg/Kg	0.68	0.79	0.61	0.72	0.77	0.29	0.22	0.31
9.	Nitrate	mg/Kg	6.83	7.42	6.21	5.88	6.12	15.28	11.6	5.79
10	Sodium	mg/Kg	8190	10687	7526	13760	9149	11972	9548	12586
11	Potassium	mg/Kg	2671	2149	2375	3460	2549	6376	4447	1172
12	Aluminium	mg/Kg	7234.11	6841.64	8423.36	9864.22	7246.18	12327.688	10215.74	12643.2
13	Chromium	mg/Kg	49.21	53.46	52.15	56.51	48.72	50.009	48.941	86.61
14	Copper	mg/Kg	5.52	5.63	5.75	6.29	5.31	48.227	30.463	4.25
15	Nickel	mg/Kg	24.87	21.79	25.48	27.62	26.73	29.24	22.776	24.37
16	Zinc	mg/Kg	58.75	52.4	61.85	82.41	55.12	62.49	41.691	40.85
17	Cadmium	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
18	Lead	mg/Kg	6.08	6.41	6.19	6.77	6.28	6.54	2.97	4.494
19	Arsenic	mg/Kg	4.61	4.82	4.58	4.72	4.42	4.61	1.485	2.497
20	Mercury	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Texture	-	Sandy loam	Sandy loam	Silt loam	Sandy 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 June-July. The detailed interpretation of the parameters is given below:

- **Inorganic Phosphate** for the sampling period was observed in range of **2.12 to 3.64** Kg/ha for Kandla. Whereas for Vadinar the value observed at location MS-7 (Nakti creek) is 1.71 Kg/ha and MS-8 (Near Vadinar Jetty) is 1.85 Kg/ha. For Kandla and Vadinar the average value of Inorganic Phosphate was observed 2.81 and 1.78 Kg/ha respectively.

- The concentration of **Phosphate** was observed in range of **288.72 to 467.84 mg/Kg** for Kandla and for Vadinar the value observed at location MS-7 (Nakti creek) as 213.507 mg/Kg and MS-8 (Near Vadinar Jetty) as 217.339 mg/Kg. For Kandla and Vadinar the average concentration of Phosphate was observed 367.238 and 215.423 mg/Kg respectively.
- The **Organic Matter** for the sampling period was observed in the range of **0.94 to 1.36 %** for Kandla with the average value of 1.16% and for Vadinar the value recorded at location MS-7 and MS-8 was observed 1.43% & 1.13% respectively, with average concentration as 1.28 %.
- The concentration of **Sulphate** was observed in the range of **122.57 to 212.27 mg/Kg** for Kandla and for Vadinar the value observed at MS-7 is 169.42 mg/Kg and at MS-8 is 145.05 mg/Kg. For Kandla and Vadinar the average value of Sulphate was observed 162.596 and 157.235 mg/Kg respectively.
- The value of **Calcium** was observed in the range of 3680 **to 4900 mg/Kg** for Kandla and for Vadinar the value observed at MS-7 is 3500.00 mg/Kg and at MS-8, is 3400.00 mg/Kg. The average value of Calcium for the monitoring period was observed 4145 mg/Kg and 3450 mg/Kg at Kandla and Vadinar, respectively.
- The value of **Magnesium** for the sampling period was observed in the range of **1928 to 2849 mg/Kg** for Kandla and for Vadinar the value observed at MS-7 is 1342.00 mg/Kg and at MS-8, is 976.00 mg/Kg. For Kandla and Vadinar the average value of Magnesium was observed 2427 mg/Kg and 1159 mg/Kg respectively.
- For the sampling period **Silica** was observed in the range of **519.27 to 559.73 mg/Kg** for Kandla with average value 539.37 mg/Kg and for Vadinar the value observed to be 523.5 and 507.02 mg/Kg at MS-7 and MS-8, respectively with average 515.26 mg/Kg.
- The value of **Nitrate** was observed in the range of **5.88 to 8.19 mg/Kg** for Kandla with average value 6.77 mg/Kg and for Vadinar the value observed to be 15.28 and 11.6 mg/Kg at MS-7 and MS-8, respectively with average 13.44 mg/Kg.
- The value of **Nitrite** was observed in the range of **0.61 to 0.83 mg/Kg** for Kandla with average value 0.73 mg/Kg and for Vadinar the value observed to be 0.29 and 0.22 mg/Kg at MS-7 and MS-8, respectively with average 0.25 mg/Kg.
- The value of **Sodium** was observed in the range of **7526 to 13760 mg/Kg** for Kandla with average value 10327.66 mg/Kg and for Vadinar the value observed to be 11972 and 9548 mg/Kg at MS-7 and MS-8, respectively with average 10760 mg/Kg.
- The value of **Potassium** was observed in the range of **2149 to 3671 mg/Kg** for Kandla with average value 2812.5 mg/Kg and for Vadinar the value observed to be 6376 and 4447 mg/Kg at MS-7 and MS-8, respectively with average 5411.5 mg/Kg.
- The value of **Aluminium**, was observed in the range of **6841.64 to 10157.25 mg/Kg** for Kandla with average value 8294.46 mg/Kg and for Vadinar the value observed to be 12327.68 and 10215.74 mg/Kg at MS-7 and MS-8, respectively with average 11271.7 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, and MS-4 "**Silt loam"** at location MS-3, 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	4.61	4.82	4.58	4.72	4.42	4.61	1.485	2.497
2.	Copper	mg/Kg	5.52	5.63	5.75	6.29	5.31	48.227	30.463	4.25
3.	Chromium	mg/Kg	49.21	53.46	52.15	56.51	48.72	50.009	48.941	86.61
4.	Nickel	mg/Kg	24.87	21.79	25.48	27.62	26.73	29.24	22.776	24.37
5.	Lead	mg/Kg	6.08	6.41	6.19	6.77	6.28	6.54	2.97	4.494
6.	Zinc	mg/Kg	58.75	52.4	61.85	82.41	55.12	62.49	41.691	40.85
7.	Cadmium	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL

- **Arsenic** was observed in the range of **4.42 to 4.82 mg/Kg** for Kandla with average value 4.62 mg/Kg and for Vadinar the value observed to be 1.48 and 2.49 mg/Kg at MS-7 and MS-8, respectively with average 1.99 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 **5.31 to 6.54 mg/Kg** for Kandla with average value 5.84 mg/Kg and for Vadinar the value observed to be 48.22 and 30.46 mg/Kg at MS-7 and MS-8, respectively with average 39.74 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 **48.72 to 59.81 mg/Kg** for Kandla with average value 53.31 mg/Kg and for Vadinar the value observed to be 50 and 48.94 mg/Kg at MS-7 and MS-8, respectively with average 49.47 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 **21.79 to 29.24 mg/Kg** for Kandla with average value 25.95 mg/Kg and for Vadinar the value observed to be 22.77 and 24.37 mg/Kg at MS-7 and MS-8, respectively with average 38.1mg/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 **6.08 to 6.77 mg/Kg** for Kandla with average value 6.37 mg/Kg and for Vadinar the value observed to be 2.97 and 4.49 mg/Kg at MS-7 and MS-8, respectively with average 3.73 mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to lead falls in moderately polluted class.
- **Zinc** was observed in the range of **52.4 to 82.41 mg/Kg** for Kandla with average value 62.17 mg/Kg and for Vadinar the value observed to be 41.69 and 40.85 mg/Kg at MS-7 and MS-8, respectively with average 56 mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to zinc falls in non-polluted class.
- **Cadmium** was observed BQL for all locations at Kandla and Vadinar during sampling period. With reference to the guidelines mentioned in table 35, the sediment quality with respect to cadmium falls in non-polluted class.

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

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

CHAPTER 12: MARINE ECOLOGY MONITORING

12.1 Marine Ecological Monitoring

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

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

Table 37: Details of the sampling locations for Marine Ecological

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

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

Map 20: Locations of Marine Ecological Monitoring at Kandla

Map 21: Locations of Marine Ecological Monitoring at Vadinar

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

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

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

Methodology

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

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

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

- **Zooplankton Estimation**

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

- **Benthic Organisms Estimation**

  Benthic macroinvertebrates are small aquatic animals and the aquatic larval stages of insects. They include dragonfly and stonefly larvae, snails, worms, and beetles. Use of benthic macroinvertebrates has been in vogue as indicator organisms for water quality monitoring since long. Traditional methods of water quality monitoring incorporates mostly monitoring of physicochemical parameters. Benthic macroinvertebrates are majorly insects that dwell on the floor of water bodies. They are found in all water bodies, as they have a wide range of pollution tolerance among various species. The benthic macro-invertebrate's community structure depends on the exposure to pollution it receives. Benthic macroinvertebrates have been used as indicator organisms to measure the water quality of water bodies across the world. Evaluating the abundance and variety of benthic macroinvertebrates in a waterbody gives us an indication of the biological condition of that waterbody. Generally, waterbodies in healthy biological condition support a wide variety and high number of macroinvertebrate taxa, including many that are intolerant of pollution. Samples yielding only pollution–tolerant species or very little diversity or abundance may indicate a less healthy waterbody. Biological condition is the most comprehensive indicator of waterbody health. When the biology of a waterbody is healthy, the chemical and physical components of the waterbody are also typically in good condition.

- **Diversity Index**

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

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

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

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

Where, $\sum$ = Summation symbol,

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	158	220	92	147	130	108	115	158
2.	Net Primary Productivity	mg/L/hr	0.58	BQL	0.82	BQL	0.72	BQL	BQL	BQL
3.	Gross Primary Productivity	mg/L/hr	1.12	BQL	1.22	0.78	1.19	0.66	0.76	BQL
4.	Pheophytin	mg/m^3	0.88	4	0.78	0.84	1.12	0.97	1.32	BQL

Sr. No.	Parameters	Unit	Kandla						Vadinar	
			ME-1	ME-2	ME-3	ME-4	ME-5	ME-6	ME-7	ME-8
5.	Chlorophyll-a	mg/m^3	0.93	1.210	1.87	1.19	1.86	1.52	1.44	1.26
6.	Particulate Oxidisable Organic Carbon	mg/L	1.11	0.78	0.74	0.81	0.92	1.08	0.61	0.62
7.	Secchi Depth	ft	0.62	0.59	0.53	0.71	0.64	0.68	1.05	1.16

- **Biomass:**
  With reference to the **Table 39**, the concentration of **Biomass** reported from location ME-1 to ME-6 in range between **92-220mg/L** where lowest biomass presents in ME-3 (Near Coal Berth) and highest biomass present in ME-2 (Kandla Creek) during sampling period. In Vadinar, the value of biomass was observed 115 mg/L at ME-7 (Near SPM) and 158 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 **0.66 to 1.22 mg/L/48 Hr** where the highest value recorded for ME-3 and lowest recorded at ME-6 (Nakti Creek (near NH - 8A)). In Vadinar, the value of **GPP** was observed 0.76 at ME-7 (Near SPM) and BQL 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 between **0.58 to 0.82 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 **0.78 to 4 mg/m^3** where the highest value observed at ME-2 (Kandla Creek (near KPT Colony)) and the lowest value observed at ME-3 (Near Coal Berth). While in Vadinar, the value of Pheophytin was observed 1.32mg/m^3 at ME-7 and BQL at ME-8 monitoring station.

- **Chlorophyll-a**
  In the sub surface water, the value of Chlorophyll-a reported in range from **0.93 to 1.87 mg/m^3**. 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 1.44 mg/m^3 at ME-7 (Near SPM) and 1.26 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 **0.74 to 1.11 mg/L** from monitoring location ME-1 to ME-6 at Kandla, whereas for Vadinar, the value of POC observed 0.61 mg/L at ME-7 (Near SPM) and 0.62 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 **0.53 to 0.71 ft** whereas at Vadinar, the value recorded at ME-7 i.e. Near SPM is 1.05 ft and in Near Vadinar Jetty is 1.16 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.	-	253	-	-	258	155	-	-
Biddulphia sp.	219	-	377	116	-	-	129	211
Chaetoceros sp.	-	-	-	-	119	-	-	-
Chlamydomonas sp.	189	129	-	268	-	262	355	282
Cyclotella sp.	202	-	324	-	143	-	-	-
Coscinodiscus sp.	-	156	-	179	-	154	166	197
Ditylum sp	225	-	170	-	-	-	-	-
Fragilaria sp.	-	344	-	-	264	255	-	208
Bacteriastrum sp.	176	-	432	202	187	-	345	-
Pleurosigma sp.	-	181	-	-	-	192	-	-
Navicula sp.	281	-	186	-	246	-	-	149
Merismopedia sp.	-	191	-	161	-	164	250	-
Synedra sp.	217	-	-	-	266	-	-	-
Skeletonema sp.	-	131	-	153	-	238	-	294
Oscillatoria sp.	-	-	166	-	169	-	192	-
Thallassiosira	297	198	-	232	-	356	-	189
Gomphonema sp.	-	-	158	-	188	-	221	-
Density-Units/L	**1806**	**1583**	**1813**	**1311**	**1840**	**1776**	**1658**	**1530**
No. of genera	**8**	**8**	**7**	**7**	**9**	**8**	**7**	**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 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 1311 to 1840 units/L, while for Vadinar its density of phytoplankton observed 1658 units/L at ME-7 and 1530 units/L at ME-8. During the sampling, phytoplankton communities were dominated by *Thallassiosira* and *Cyclotella sp*. in Kandla, while *Chlamydomonas 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	9	8	7	7
Individuals	1806	1583	1813	1311	1840	1776	1658	1530
Shannon diversity	2.06	1.89	1.87	1.62	2.18	2.02	1.81	1.77
Simpson 1-D	0.87	0.86	0.83	0.85	0.88	0.86	0.84	0.85
Species Evenness	0.99	0.91	0.96	0.83	0.99	0.97	0.93	0.91
Margalef richness	0.93	0.95	0.80	0.84	1.06	0.94	0.81	0.82
Berger-Parker	0.16	0.22	0.24	0.20	0.14	0.20	0.21	0.19
Relative abundance	0.44	0.51	0.39	0.53	0.49	0.45	0.42	0.46

- **Shannon- Wiener's Index (H)** of phytoplankton communities was in the range of **1.62 to 2.18** between selected sampling stations from ME-1 to ME-6 with an average value of 1.94 at Kandla creek and its nearby creeks. While for Vadinar, Shannon Wiener's index of phytoplankton communities recorded to be **1.81** at location ME-7 and **1.77** at ME-8 with an average value of 1.79. 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 0.88** 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 0.84 at location ME-7 and 0.85 at ME-8 with an average of 0.85.

- **Margalef's diversity index** (Species Richness) of phytoplankton communities in Kandla and nearby creeks sampling stations was varying from **0.80 to 1.06** with an average of 0.92 during the sampling period. While for Vadinar, Margalef's diversity index (Species Richness) of phytoplankton communities observed 0.81 at ME-7 and 0.82 at ME-8 with an average value of 0.82.

- **Berger-Parker Index (d)** of phytoplankton communities was in the range of **0.14 to 0.24** between selected sampling stations from ME-1 to ME-6 with an average value of 0.19 at Kandla creek and nearby creeks. Berger-Parker Index (d) of phytoplankton communities in the sampling stations of Vadinar, was in the range of 0.19to 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 **0.83 to 0.99** for all the six-monitoring station of Kandla and for the Vadinar the species evenness is observed 0.93 at location ME-7 & 0.91 at ME-8 location.

- During the sampling period, **Relative Abundance** of phytoplankton communities was in range of **0.39 to 0.53** between selected sampling stations from ME-1 to ME-6 with an average value of 0.47 at Kandla creek and nearby creeks. Whereas for Vadinar the Index value 0.42 at ME-7 and 0.46 at ME-8 with an average value 0.44, 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.	-	2	1	-	1	-	-	1
Acrocalanus	1	-	-	1	-	2	1	-
Amoeba	-	1	1	-	-	1	-	-
Brachionus sp.	2	-	-	-	2	-	1	1
Calanus sp.	2	1	-	2	-	1	-	-
Cladocera sp.	-	-	2	-	1	-	2	2
Cyclopoid sp.	-	-	-	1	1	-	-	-
Copepod larvae	1	1	-	1	-	1	-	1
Diaptomus sp.	-	-	1	-	-	1	1	-
Eucalanus sp.	1	-	-	1	2	-	1	1
Mysis sp.	1	2	2	-	-	2	-	-
Paracalanus sp.	-	1	-	2	1	-	2	1
Density Unit/L	**8**	**8**	**7**	**8**	**8**	**8**	**8**	**7**
No. of genera	**6**	**6**	**5**	**6**	**6**	**6**	**6**	**6**

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 7 to 8 units/L, while for Vadinar its density of zooplankton observed 8 units/L at ME-7 and 8 units/L at ME-8. During the sampling, zooplankton communities were dominated by *Mysis sp.* in Kandla, while*, Cladocera* and *Paracalanus* 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	6	6	5	6	6	6	6	6
Individuals	8	8	7	8	8	8	8	7
Shannon diversity	1.73	1.73	1.47	1.73	1.73	1.73	1.73	1.65
Simpson (1-D)	0.93	0.93	0.9	0.93	0.93	0.93	0.93	0.95
Species Evenness	0.97	0.97	0.91	0.97	0.97	0.97	0.97	0.92
Margalef	2.4	2.4	2.06	2.4	2.4	2.4	2.4	2.57
Berger-Parker	0.25	0.25	0.29	0.25	0.25	0.25	0.25	0.29
Relative abundance	75	75	71.43	75	75	75	75	85.71

- **Shannon- Wiener's Index (H)** of zooplankton communities was in the range of **1.47 to 1.73** 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 1.73 at ME-7 and 1.65 at ME-8 with an average value of 1.69. 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 **0.9 to 0.93** at all sampling stations in the Kandla creek and nearby creeks, with an average of 0.92 Similarly, for Vadinar Simpson diversity index (1-D) of zooplankton communities was 0.93 at ME-7 and 0.95 at ME-8 with an average of 0.94.

- **Margalef's diversity index** (Species Richness) of zooplankton communities in Kandla and nearby creeks sampling stations was varying from **2.06 to 2.4** with an average of 2.34 during the sampling period. While for Vadinar, Margalef's diversity index (Species Richness) of zooplankton communities observed 2.4 at ME-7 and 2.57 at ME-8 with an average value of 2.48.

- **Berger-Parker Index (d)** of zooplankton communities was in the range of **0.25 to 0.29** between selected sampling stations from ME-1 to ME-6 with an average value of 0.25 at Kandla creek and nearby creeks. Berger-Parker Index (d) of zooplankton communities in the sampling stations of Vadinar, was in the range of 0.25 to 0.29 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 **0.91 to 0.97** for all the six-monitoring station of Kandla whereas, for the Vadinar the species evenness was observed in the range of 0.92 to 0.97, during the monitoring month.

- During the sampling period, **Relative Abundance** of zooplankton communities was in range of 71.43 to 75 between selected sampling stations from ME-1 to ME-6 with an average value of 74.40 at Kandla creek and nearby creeks. Whereas for Vadinar the Index value 75 at ME-7 and 85.71 at ME-8 with an average value 80.36, 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	-	-	-
Mollusca	-	1	1	-	-	2	1	-
Odonata	-	-	1	2	-	-	1	1
Lymnidae	1	-	-	1	1	-	-	-
Planorbidae	-	2	2	-	-	1	-	-
Talitridae	2	-	-	-	-	-	2	3
Trochidae	-	1	-	1	2	1	-	2
Atydae	1	-	1	2	-	-	1	3

Family/Class	ME-1	ME-2	ME-3	ME-4	ME-5	ME-6	ME-7	ME-8
Gammaridae	-	-	-	-	1	2	-	-
Portunidae	-	-	1	-	-	-	-	-
Turbinidae	2	1	1	1	1	1	1	-
Palaemonidae	-	-	-	-	1	-	1	-
No. of Family	**7**	**5**	**7**	**7**	**7**	**7**	**7**	**9**
No of Class	**5**	**4**	**6**	**5**	**6**	**5**	**6**	**4**

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, Portunidae sp.*, etc. The No. of Family of benthic fauna was varying from 5 to 9. The dominating benthic communities at Kandla Creek and nearby creek (Nakti and Khori creek) were represented Atydae, Turbinidae. While lowest number of benthic species was represented by Portunidae.

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	5	4	6	5	6	5	6	4
Individuals	7	5	7	7	7	7	7	9
Shannon diversity	1.55	1.19	1.75	1.55	1.75	1.55	1.75	1.36
Simpson 1-D	0.9	0.9	0.95	0.9	0.95	0.9	0.95	0.81
Species Evenness	0.96	0.86	0.98	0.96	0.98	0.96	0.98	0.98
Margalef	2.06	1.86	2.57	2.06	2.57	2.06	2.57	1.37
Berger-Parker	0.29	0.4	0.29	0.29	0.29	0.29	0.29	0.33
Relative abundance	71.43	80	85.71	71.43	85.71	71.43	85.71	44.44

- **Shannon- Wiener's Index (H)** of benthic organism was in the range of **1.19 to 1.75** between selected sampling stations from ME-1 to ME-6 with an average value of 1.55 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 & 1.36 at ME-8 location with an average value of 1.55. 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 **0.9 to 0.95** 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 0.81 at ME-8 location with an average of 0.88.

- **Margalef's diversity index** (Species Richness) of benthic organism in Kandla and nearby creeks sampling stations was varying from **1.86 to 2.57** with an average of 2.19 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 1.37 at ME-8 location with an average of 1.97.

- **Berger-Parker Index (d)** of benthic organism was in the range of **0.29 to 0.4** between selected sampling stations from ME-1 to ME-6 with an average value of 0.30 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 0.98 at both of the location.

- During the sampling period, **Relative Abundance** of Benthic organisms was in range of **71.43 to 85.71** between selected sampling stations from ME-1 to ME-6 with an average value of 77.61 at Kandla creek and nearby creeks. Whereas for Vadinar the Index value 85.71 at ME-7 and 44.44 at ME-8 location, with an average value 65.08, 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

Annexure 2: Photographs of the Environmental Monitoring conducted at Vadinar

Air Monitoring

Noise Monitoring

STP Monitoring

Drinking water Monitoring

Marine Monitoring

Soil Monitoring

Source: GEMI

Gujarat Environment Management Institute (GEMI)

(An Autonomous Institute of Government of Gujarat)

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

Head Office

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

Sector-25, Gandhinagar-382024

Laboratory

Plot No. B-64, G.I.D.C. Electronic Estate,

Opp. I.P.R., Sector-25, Gandhinagar-382025

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

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

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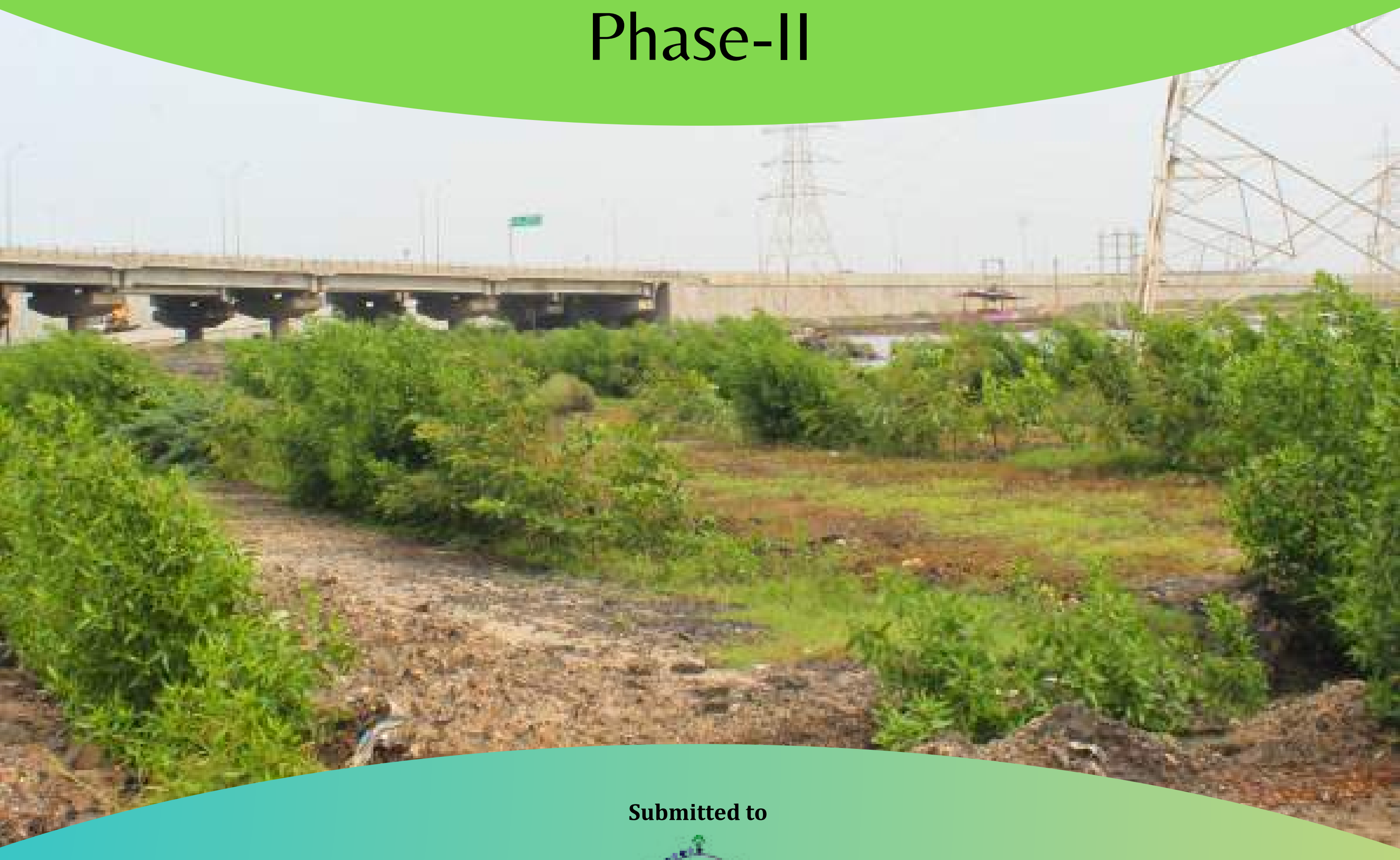
ANNEXURE C
Final Report Green Belt Development II

Final Report
on

Greenbelt Development in Deendayal Port Authority and its surrounding areas, Kandla Port

Phase-II



Submitted to

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

Submitted by

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

Final Report

on

Greenbelt Development in Deendayal Port Authority and its surrounding areas (Phase-II) Kandla Port

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, *Project Assistant-I*
Mr. Ajay Gohel, *Project Fellow*

Submitted by

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

Content

Introduction

The Greenbelt cover/forest has been the utmost necessity for the survival of human as well as for the wildlife with the current scenario of human explosion, industrial development and climate change. The greenbelt cover provides ecological services such as purifying air, reduce soil erosion, improving ground water table, reduce salinity. In addition, it also caters the services such as food, fodder and medicine, etc. along with playing a very vital role in providing habitats for wildlife and maintaining ecological balance, climate regulation, biodiversity conservation and maintaining pleasant micro climate of the region. Thus, green belt offers a number of benefits for population. Moreover, vegetation absorbs various pollutants from the environment and thus helps in effective pollution control. However, due to the various types and extent of economic development like industrialization, mining, infrastructural development, etc. has exerted pressure in reducing and fragmenting natural vegetation cover day-by day all over the world.

The infrastructural and industrial development leads to influence the life of all the living organisms in two directions: either upwards or downwards. In the upward mode, human being gets opportunities for luxuriant life with easy accessibility to the resources while in downward, the quality of ecosystem services gets affected. Most of the industrial and infra-structural developmental activities generate pollution of one or other types with varying magnitudes, which makes susceptible to all the organisms, nevertheless, the pre-eminence of resistance of each of the organisms helps themselves to overcome the hazards caused by such pollutants.

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

As per the National Forest Policy (NFP-1988), it is necessary to encourage the planting of trees alongside of roads, railway lines, rivers and streams and canals, and on other unutilized lands under state/corporate, institutional or private ownership. NFP give emphasis on the green belt developments. It says – Green belts should be raised in urban/industrial areas as well as in arid tracts. Such a programme will help to check erosion and desertification as well as improve the microclimate.

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

Rationale

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

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

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

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

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

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

In order to enhance and strengthen Greenbelt Development, the DPA has approached GUIDE to develop the greenbelt area within the port area in phase wise manner and raised 5000 plants at a suitable site during the first phase (2022-23). In continuation, 10,000 plants have been finalized during the 2nd phase 2023-24 and 800 plants as a deficient of first phase.

GUIDE team has visited the proposed Greenbelt development site at Kandla port with the officials from Kandla Port as part of selection of suitable and available locations for green belt development. Based on the observation of the project site and its landscape, environment and ecology of the area, suitable plant species for such area was worked out in order 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 RoB and another site opposite to 15-16th Birth along the wall have been selected on the peripheral boundary of two sites.

Fig. 1 Map of Plantation Area RoB

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 and with saline ground water. The area is very dry and hot during the summer. The highest temperature in Kandla is used to be recorded in this area.

Fig. 2 Map of Plantation Area 15-16 Birth Opp: Wall

Fig. 3 Map of Plantation Area 15-16 Birth Opp: Wall

Scope of Works

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

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

Approach and Methodology for Greenbelt Development

Following steps have been adopted for greenbelt development:

- Removal of exotic/unwanted plants plant species from the entire area demarcated for green belt development: The entire selected site has been cleared by removing unwanted weeds and material such as stones, plastics etc.by JCB and also with the help of labor forces.
- Landscaping of the area and land preparation Trench line of 2.5x 2.5 ft. have been dig out through JCB at RoB site and another site opposite to 15-16th Birth along the wall.
- Soil and moisture conservation work since the port area is highly saline, SMC work was very much essential for better survival of the plants. Agriculture fertile soil have been added in appropriate quantity.
- Identification of native species of plants for plantation in greenbelt as per the site suitability the site was very challenging for greenbelt development since the water and soil is highly saline with the extreme climatic condition, the selection of plant species for plantation has been made very carefully. 40 % of plants have been selected as native species for plantation where as 60% species of *Conocarpus* depends on high salinity level of the soil of the area.

- Procurement of sapling of identified species or Nursery management or seeding of tree/shrub species all the saplings were procured where of 3-4 ft. in height from reliable nursery. All saplings were of tree species.

- Installation of drip irrigation facilities was not feasible therefore activity was planned preferably through tankers. The watering of the plantation has been scheduled as per the seasons which is given in table. Regular watering as per the scheduled have been provided by the water tanker under the supervision of team expert

- Use of Manure, preferably organic fertilizer for enhancing soil fertility best quality organic manure have been provided to the saplings for better growth and survival. Weed management and trench repairing have been carried out periodically also as and when it required.

- Regular monitoring and management of the saplings by a qualified team from GUIDE the selected. The regular visit to the site has been made for monitoring and clearing the road for water tanker for irrigation. Gap fillings was also made during the period.

Plantation Techniques:

- Site development for a plantation includes clearance for weeds and it involves, bush cutting, soil and moisture conservation works and marking of pits for planting of saplings etc.

- After clearing the land sites for digging of pits, plantation have been marked on ground using a measuring tape to ensure the desired spacing.

- Pits of the size 45 cm x 45 cm and 45 cm depth have been dug for tree plantation. Pits have been deep enough to ensure that the roots of the plants do not curl up once the planting material is placed in it.

- Since the soil is highly saline, a fertile soil around 10 dumpers have been added for better survival of plants

- Organic manure has been added for better growth 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 level to the ground thus avoiding any water logging.

- The plantation has been carried out in two phases

- Around 4000 saplings have been planted during the first phase at available plantation area at RoB site.
- Around 4500 saplings have been planted during the first phase at available plantation area at opposite 15-16th Birth along the wall.
- The remaining 2500 saplings have been planted at opposite 15-16th Birth along the wall. Thus, a total of 11000 plantations have been completed at the end of the project.
- Along with the above, gap filling of 2500 plants were carried out in both the sites, thus covering a total of 13,500 plants have been planted to achieve the target of 11,000 plants.
- The assessment on survival of plants have been carried out during the 2nd week of August 2024 which shows the deficient of around 1000 plants hence the gap filling of 1200 plants have been made during 3rd to 7th September 2024.
- The verification of plantation has been made with the officials of Deendayal Port Authority on 22nd October 2024 and it has been verified and confirmed that 90% survival of plants for the plantation carried out during the 2nd Phase under the project.

Selection of Plant Species for Plantation:

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

Number of Sapling:

Approximate numbers of saplings to be required for the greenbelt are as follows;
Total plantations of 11,000 saplings were planted at RoB & 15-16 Birth (Opposite wall both sides) along with additional gap filling in the areas.

Management and Monitoring of Greenbelt:

The plantation within the identified site have been managed and monitored for a minimum period of one year from June 2023 to September 2024. The management of plantation includes appropriate irrigation of the plantation in regular intervals, during summer and winter periods along with dry spells during the monsoon.

The plants are growing very well and reached more than 4-6 ft. height. The survival of plants has been noted very high as 90% during September 2024. Watering have been made through tanker service at given schedule during the different seasons. (Table. 1)

Table-1 Time Schedule for Watering

Sr. No.	Month & Year	Number of Time
1	October 2023	7 times/ month
2	November 2023	7 times/ month
3	December 2023	7 times/ month
4	January 2024	7 times/ month
5	February 2024	7 times/ month
6	March 2024	9 times/ month
7	April 2024	10 times/ month
8	May 2024	10 times/ month
9	June 2024	8 times/ month
10	July 2024	8 times/ month
11	August 2024	3 times/ month
12	September 2024	5 times/ month

Annexure I

List of Plants for Plantation at site for Greenbelt Development

Site: Road Over Bridge

Sr. No.	Scientific Name	Local Name	No. of Plants
1	*Conocarpus*	Conocarpus	2500
2	*Peltophorum pterocarpum*	Peltofoum	200
3	*Millettia pinnata*	Karanj	100
4	*Delonix regia*	Gulmahor	200
5	*Alstromia schollaris*	Saptparni	100
6	*Terminalia catapa*	Badam	100
7	*Plumaria obtusa*	Chmapo	100
8	*Ceaslpinia pulcherima*	Galtoro	100
9	*Bauhinia racemosa*	Kachnar	200
10	*Tabubia rosea*	tabubia	100
11	*Terminalia arjuna*	Arjun	100
12	*Cassia fistula*	Garmalo	200
	Gap Fillings		2050

Site: Opposite 15-16th Berth

Sr. No.	Scientific Name	Local Name	No. of Plants
1	*Conocarpus*	Conocarpus	4000
2	*Peltophorum pterocarpum*	Peltofoum	450
3	*Millettia pinnata*	Karanj	400
4	*Delonix regia*	Gulmahor	400
5	*Mimusops elengi*	Borssalii	300
6	*Ceaslpinia pulcherima*	Galtoro	450
7	*Tabubia rosea*	tabubia	400
8	*Cassia fistula*	Garmalo	300
9	*Bauhinia racemosa*	Kachnar	300
	Gap fillings		1650

Fig. 4 Digging Out Trench for Plantation

Fig. 5 Transportation of Plants to Site

Fig. 6 Fertile Soil for Better Survival of Plants

Fig. 7 Soil Filling in Plantation Pits

Fig. 8 Organic Manure for Better Growth and Survival

Fig. 9 Regular Watering of the Plants by Tanker

Gap Filling (September 2024)

Current Status of plantation at RoB site

Current Status of plantation opp: 15-16 Berth

ANNEXURE D
Dredged material study s1, s2, s3

FIRST SEASON REPORT

(2023-24)

for the Project entitled

"Studies on Dredged Materials for the presence of Contaminants"

(As per EC & CRZ Clearance accorded by the MoEF & CC, GoI dated 19/12/2016- specific condition no. vii)

DPT Work order No. EG/WK/4751/Part (EC&CRZ-1)/84. Dt.18.09.2021

Submitted by

Gujarat Institute of Desert Ecology

P.B. No. 83, Mundra Road

Opp. Changleshwar temple

Bhuj - Kachchh, Gujarat – 370001, India

Submitted to

Deendayal Port Authority

Administrative Office Building

Post Box No. 50

Gandhidham (Kachchh)

Gujarat - 370201

Project Team

Project Co-Ordinator **:** Dr. V. Vijay Kumar, Director

S. No	Name and Designation	Role	Background
1.	Dr. K. Karthikeyan Assistant Director	Principal Investigator	M.Sc., Ph.D. in Environmental Science; 15 years of experience in Marine Environmental Monitoring and Pollution Assessment studies.
2.	Dr. G. Jayanthi Scientist	Co- Investigator	MSc., MPhil., PhD in Botany; 13 years of Research and teaching experience inclusive of Post-Doctoral experience for 5 years.
3.	Dr. Krushnakant. D. Baxi Scientific Officer	Co- Investigator	Ph.D in Zoology (Marine Biology) with 5 years of experience
4.	Ds. Monika Sharma Sr. Scientific Asst.	Team member	M.Sc. in Environmental Sciences; 7 years of experience in Marine water and sediment analysis
5.	Ms. Dipti Parmar Scientific Assistant	Team member	M.Sc. in Environmental Sciences; 6 years of experience in sediment and water analysis.

Dr. V. Vijay Kumar
Director

Gujarat Institute of Desert Ecology

Certificate

This is to state that the **First Season Report** of the work entitled, **"Studies on Dredged Material for the presence of contaminants"** has been prepared in line with the Work order issued by DPT vide No. EG/WK/4751/Part (EC & CRZ-1)/84. Dt.18.09.2021 as per the EC & CRZ Clearance accorded by the MoEF & CC, GoI dated 19/12/2016, Specific Condition No. vii. This work order is for a period of Three years from 2021 –2024 for the above-mentioned study.

Gujarat Institute of Desert Ecology Bhuj

Authorized Signatory **Institute Seal**

PO. Box No. 83, Opp. Changleshwar Temple, Mundra Road, Bhuj (Kachchh) - 370 001, Gujarat (India)
Tel : 02832 - 235025-29
www.gujaratdesertecology.com, E-mail : desert_ecology@yahoo.com

CONTENTS

Among the twelve major ports across the nation, Deendayal Port Authority, formerly known as Deendayal Port Trust, erstwhile called as Kandla Port Trust, holds a prominent position as a significant maritime gateway in India, situated within Gujarat's Kutch district. This stands out as the largest Creek-based port, positioned at the southwestern tip of the Gulf of Kachchh, on India's north-western coastline within the state of Gujarat. Deendayal Port Authority (DPA) serves as a pivotal hub for maritime trade, facilitating the transportation needs of several hinterland states. It boasts excellent connectivity through an extensive rail and road network, functioning as a crucial gateway for the export and import activities of northern and western Indian states, including Jammu & Kashmir, Delhi, Punjab, Himachal Pradesh, Haryana, Rajasthan, Gujarat, as well as parts of Madhya Pradesh, Uttaranchal, and Uttar Pradesh. This port ranks among the largest and most essential ports in the country, playing a vital role in India's international trade and maritime infrastructure. The administration and operations of the port are overseen by the Deendayal Port Trust (DPT), an autonomous entity established under the Major Port Trusts Act of 1963.

The Deendayal Port Trust is entrusted with the comprehensive management, development, and administration of the port. The authority is comprised of a dedicated team of professionals and experts who work diligently to ensure the efficient operation of the port and all related activities. About 35% of the country’s total export takes place through the ports of Gujarat in which the contribution by Deendayal port is considerable. The port handled a total cargo of 105 MMTPA during 2016-17, 110 MMTPA during 2017-18, 115 MMTPA during 2018-19, 122.5 MMTPA during 2019-2020, 117.5 MMTPA during 2020-21 and 137 MMTPA during 2022-23. DPA is the only major Indian port to handle more than 127 MMT cargo throughput, and it has also registered the highest cargo throughput in its history. The port has handled a total of 3151 vessels during FY 2021-22. Over the years, the port has witnessed significant growth and development, becoming a crucial gateway for India's international trade. Deendayal Port has a strategic location on the west coast of India, offering direct access to the Arabian Sea. It serves as a vital link for India's trade with countries in the Middle East, Africa, Europe, and Asia. The port handles a wide range of cargoes, including petroleum products, chemicals, coal, iron ore, fertilizers, salt, and general cargo.

Further, regular expansion of infrastructure and port facilities is under way to cater future logistic requirements. With such capacity, the Port ranks No. 1 among all the major ports in India for 12th Consecutive year. Further, a regular expansion of infrastructure and port facilities is under way to cater future logistic requirements. The port has high commercial importance in the Indian maritime trade as it handled 36.1 million tons (17%) of Cargo out of total Cargo of 213.1 million tons of the maritime Cargo of India during 2015. In addition, regular expansion of infrastructure and port facilities is under way to cater future logistic requirements.

Deendayal Port Authority (DPA) has taken up Development of 7 Integrated facilities, and the Ministry of Environment, Forest and Climate Change (MoEF & CC), has put up some conditions while according Environmental and CRZ clearance. One of the conditions is to carry out the *"Study on Dredged Material for presence of contaminants"* as accorded by the MoEF & CC, GoI dated 19/12/2016 - Specific condition no. vii)" which states that ***"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"***.

1.1 Need of the study

Considering the aforementioned condition, DPA has assigned the task of carrying out the study to Gujarat Institute of Desert Ecology (GUIDE), Bhuj. This study will be attempted three times in a year at two specified locations. Further, the study will envisage the evaluation of physico-chemical constituents in the dredged materials in the dumped locations in the study area. GUIDE has been entrusted with the project, which has duration of three years (01.11.2021 – 31.10.2024) as specified in the work order. Accordingly, the study was initiated to evaluate the dredged materials for potential contamination, employing a systematic investigation that encompasses the analysis of physical, chemical, and biological characteristics with special reference to pollutants including heavy metal, Petroleum hydrocarbon etc.

1.2. Scope of the study

a. To monitor the locations where dredged materials are dumped will be conducted.
b. Dredged materials in the area will be analyzed for the presence of contaminants in two different locations.
c. Detailed assessment of the dredged materials for physical, chemical and biological characteristics will be studied.
d. Suggesting suitable disposal options for the dredged material will be made.

1.3. Sampling locations for 2023-24

The study focused on investigating the presence of contaminants in the dredged materials during the year 2022-24. The specific locations for sampling can be found in Table 1 and Plate 1. The selection of these sampling sites was based on information supplied by the Hydraulic and Dredging Division to the Department of Port Administration (DPA), concerning the locations of dumping grounds. These location details were subsequently shared with the Gujarat Institute of Desert Ecology (GUIDE) via an email dated October 24, 2018. Three seasonal studies covering Location 1, Location 2 and Location 3 with the First season of the study was conducted during 22.01.2024 – 24.01.2024.

Table 1: GPS Co-ordinates of sampling locations

Station	Latitude (N)	Longitude (E)
Location 1 (Offshore)	22° 51' 00" N	70° 10’ 00" E
Location 2 (Cargo jetty)	22°56' 31" N	70 13' 00" E
Location 3 (Phang Creek)	23° 04' 28" N	70°13’ 28" E

1.4. Details of work done during 2nd Quarter (February 2024 – April 2024)

The First season sampling of the project was conducted in the 1st Quarter of the project period, i.e., 2023-24. The First season sampling was performed in the month of January 2024. During the sampling, the surface and bottom marine water samples and bottom marine sediment samples were collected from the three designated locations, *i.e.,* Offshore, Cargo Jetty and Creek systems which was pre-designated locations as earmarked by CPWRS was conducted.

After the collection, the samples were preserved using standard protocols and stored in an Ice box and brought to the laboratory within 2-3 hrs of collection Comprehensive analysis was performed on all the samples, both water (36 samples) and sediment (18 samples), to determine various physical, chemical, and biological characteristics. The analysis followed the standard methods prescribed by the Integrated Coastal and Marine Area Management (ICMAM) in 2012. All samples were analysed in triplicates, and the obtained data was compared against the marine water limits specified by the Central Pollution Control Board (CPCB) and other relevant standards.

Plate 1: Map showing locations of proposed sampling (2023-2024)

The sediment samples from the study area were collected for the purpose of characterization employing standard methodology and the analysis of the samples were also performed as per standard protocol and the data of sediment analysis is presented in this Chapter 1. The sediment samples were collected in pre-fixed stations using a Van-Veen type of grab sampler. After collection, the sediment samples were preserved with Rose Bengal and formalin to avoid decomposition of samples and processed for analysis and the samples after collection were brought to the laboratory on the same day of collection and air dried and used for further analysis for the test parameters (Table 2).

Table 2: Physico-chemical and biological characteristics of sediment samples

S. No.	Physico-chemical and biological parameters
1	pH (1: 10 suspension)
2	Salinity (ppt)
3	Sand (%)
4	Silt (%)
5	Clay (%)
6	Total organic carbon (%)
7	Phosphorus (mg/kg)
8	Sulphur (mg/kg)
9	Petroleum Hydrocarbon (µg/kg)
10	Cadmium (mg/kg)
11	Lead (mg/kg)
12	Chromium (mg/kg)
13	Copper (mg/kg)
14	Cobalt (mg/kg)
15	Nickel (mg/kg)
16	Zinc (mg/kg)
17	Magnesium (mg/kg)
18	Macrobenthos

2.1. pH and Salinity (1: 10 suspension)

The pH of the sediment suspension is a measure of the activity of H+ ions within the sediment-water system. It indicates whether the sediment is acidic, neutral or alkaline in nature. Since ions are the carrier of electricity, the electrical conductivity (EC) of the sediment-water system rises according to the content of soluble salts. The EC measurement directly corresponds to the concentration of soluble salts in the sediment at any particular temperature. To conduct the analysis, ten grams of the finely sieved sediment was dissolved in 100ml of distilled water to prepare leachate. This leachate was taken for shaking using a rotator shaker for one hour to ensure proper homogenization of the suspension. Following this, the suspension was allowed to settle for two hours, and the supernatant was collected after filtration for the subsequent analysis of pH and salinity using the pH and EC meter (Make: Systronics 361) and Refractometer (Make: Atago) respectively. Each sample was analyzed in triplicates to ensure accuracy, and the mean values were considered for further evaluation.

2.2. Textural analysis (Sand/Silt/Clay)

Sediment samples were collected using Van Veen grab whereas intertidal sediments will be collected using a handheld shovel. After collection, the scooped samples are transferred to polythene bags, labelled and stored under refrigerated conditions. The sediment samples are thawed, oven dried at 40ºC and ground to a fine powder before analyses.

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

2.3. Total organic carbon

Total organic carbon refers to the carbon content stored within sediment organic matter. It is derived from various sources such as the decomposition of plant and animal residues, root exudates, living and deceased microorganisms, sediment biota etc. To measure total organic carbon in sediment, a process of oxidation is employed using potassium dichromate in the presence of concentrated sulfuric acid. During the analysis, potassium dichromate generates nascent oxygen, which reacts with the carbon present in organic matter, resulting in the production of carbon dioxide (CO2). The excess volume of potassium dichromate is then titrated against a standardized solution of ferrous ammonium sulfate in the presence of phosphoric acid, using Ferroin indicator to detect the initial appearance of unoxidized ferrous iron. This titration allows the determination of the volume of potassium dichromate required to oxidize the organic carbon present in the sample.

Procedure

The determination of the percentage of total organic carbon in sediment involves oxidizing the organic matter within the sediment samples using chromic acid. The excess chromic acid is then estimated by titrating it against ferrous ammonium sulfate, with ferroin serving as an indicator. The step-by-step procedure is outlined as follows:

To begin, 1 gram of sediment sieved to a particle size of 0.5 mm is weighed and transferred into a 500 ml conical flask. Then, 10 ml of 1N $K_2Cr_2O_7$ is added to the flask with pipette followed by gentle swirling to ensure thorough mixing. Next, 20 ml of concentrated H2SO4 is added, and the sediment and reagents are mixed gently. This mixture is allowed to react for 30 minutes on a marble stone to avoid any damage caused by the release of intense heat from the sulfuric acid reaction. Afterward, 200 ml of distilled water is slowly added to the flask, along with 10 ml of concentrated orthophosphoric acid and approximately 0.2 grams of NaF. The sample and reagent mixture is left to stand for 1.5 hours, as the titration endpoint is better observed in a cooled solution. Just before the titration, 1 ml of ferroin indicator is added to the conical flask. The excess $K_2Cr_2O_7$ is then titrated with 0.5 N ferrous ammonium sulfate until the color changes from yellowish green to greenish, and finally to a brownish-red color indicating the endpoint. A blank test without the sediment sample is also performed simultaneously for reference. Through this procedure, the percentage of total organic carbon in the sediment can be accurately determined.

2.4. Total Phosphorus

The determination of total phosphorus in sediment is commonly conducted using Bray's extraction method. This method involves the formation of specific-colored compounds by adding appropriate reagents to the solution, with the intensity of the color being directly proportional to the concentration of phosphorus being estimated. The color intensity is measured spectrophotometrically. In the spectrophotometric analysis, a light source emitting light of a specific wavelength (usually within a band width of 0.1 to 1.0 nm) in the ultraviolet region of the spectrum is used. The photoelectric cells in spectrophotometer measure the light transmitted by the solution allowing for quantitative analysis.

Procedure

To perform the analysis, 50 ml of the Bray's extractant is added to a 100 ml conical flask containing 5 grams of sediment sample. The flask is shaken for 5 minutes and then filtered. Exactly 5 ml of the filtered sediment extract is transferred to a 25 ml measuring flask using a bulb pipette. Subsequently, 5 ml of the molybdate reagent is added using an automatic pipette, followed by dilution to 20 ml with distilled water and shaken well. Furthermore, 1 ml of dilute Stannous Chloride solution is added, and the volume is made up to the 25 ml mark. Thorough shaking is performed to ensure proper mixing. The mixture is then allowed to develop color, and after 10 minutes, readings are taken in the spectrophotometer at a wavelength of 660 nm. Prior to the readings, the instrument is zeroed using a blank prepared similarly but without the sediment.

2.5. Total Sulphur

Total sulphur in the sediment extract was determined using a turbidimetric method with a spectrophotometer. A series of standards containing sulphur at concentrations of 2, 4, 6, 8, and 10 ppm were prepared from a stock solution. Each flask in the series received 25 ml of the respective standard solution, and 2.5 ml of conditioning reagent solution was added. Additionally, 5 ml of extraction solution was added to the mixture. To facilitate the reaction, 0.2-0.3 grams of barium chloride were included and thoroughly mixed. The volume was adjusted to 25 ml with distilled water, and readings were taken at 340 nm using a spectrophotometer.

For the sample analysis, 5 grams of marine sediment were placed in a 100 ml conical flask. To this, 25 ml of a 0.15% $CaCl2$ solution was added and shaken for 30 minutes. The mixture was then filtered through Whatman No. 42 filter paper. Subsequently, 5 ml of the sample aliquot was transferred into a 25 ml volumetric flask. Conditioning reagent (2.5 ml) and 0.2 to 0.3 grams of barium chloride powder were added, followed by making up the volume to 25 ml with distilled water. The flask contents were shaken for 2 minutes, and the absorbance was measured using the same procedure as the standard solutions.

2.6. Petroleum Hydrocarbons

To analyze petroleum hydrocarbons in sediment, the following procedure will be conducted. First, the sediment will undergo reflux with a mixture of KOH and methanol, allowing for the extraction of petroleum hydrocarbons. This reflux process helps release the hydrocarbons from the sediment matrix. Next, the sediment will be subjected to extraction using hexane, which selectively dissolves the hydrocarbons present in the sediment. The excess hexane will be carefully removed, leaving behind a residue containing the concentrated hydrocarbons of interest. To further purify the sample and remove any impurities, a clean-up procedure will be performed using silica gel column chromatography. This column chromatography process helps separate the hydrocarbons from other compounds present in the residue, resulting in a cleaner sample for analysis. Finally, the hydrocarbon content in the sediment will be estimated by measuring fluorescence, following the standard method for petroleum hydrocarbon analysis. This fluorescence measurement allows for quantification and determination of the hydrocarbon levels present in the sediment sample. By following this procedure, accurate analysis of petroleum hydrocarbons in sediment can be achieved.

2.7. Heavy metals

Heavy metals, such as Cadmium (Cd), Lead (Pb), Chromium (Cr), Nickel (Ni), Cobalt (Co), Copper (Cu), Zinc (Zn), Manganese (Mn), and others, are of particular concern in relation to the environment. To release mineral elements from sediment samples, wet oxidation is commonly employed, utilizing oxidizing acids, such as tri/di-acid mixtures.

In the analysis procedure, a sediment sample weighing 1.0 gram is taken in a 100 ml beaker, which is covered with a watch glass. A mixture of Aqua regia (1:3 HNO_3:HCl) in the amount of 12 ml is added to the beaker. The beaker is then subjected to digestion for 3 hours at 100°C on a hot plate using a sand bath. Afterward, the samples are evaporated to near dryness, allowed to cool for 5 minutes, and then 20 ml of 2% nitric acid is added. The beaker is placed on a hot plate for digestion for 15 minutes, after which it is removed from the hot plate and allowed to cool. The mixture is then filtered using Whatman No. 42 mm filter paper. Finally, the volume is adjusted to 50 ml with 2% nitric acid to make up the final solution. The extracted sample is then aspirated into an Atomic Absorption Spectrometer (AAS) for analysis. By following this procedure, the heavy metal content in the sediment can be accurately analyzed using wet oxidation, filtration, and AAS techniques.

2.8. Results

2.8.1. pH (Hydrogen Ion)

When any characteristics study of water or sediment is concerned, pH is considered to be one of the major variable especially in marine sediments as it influences various biogeochemical processes and ecosystem dynamics. These values are influenced by various factors, including the carbon, oxygen, nitrogen, phosphate, silicate, sulphur, iron, and manganese cycles. They are closely associated with processes such as heterotrophic respiration, chemoautotrophic activity, photosynthesis, precipitation, and the dissolution of calcium carbonate in marine water and sediments. In our investigation, we conducted measurements of average pH values at different locations. The offshore area exhibited an average pH of 8.18±0.13, the cargo jetty had an average pH of 8.15±0.05, and the Phang Creek showed an average pH of 8.26±0.07. The data on individual values at all the locations and stations are given in Table 3.

2.8.2. Salinity

Salinity of seawater is subject to fluctuations influenced by temperature changes, following diurnal and seasonal cycles that correspond to variations in atmospheric temperature. Salinity levels in marine water and sediment exhibit a wide range, typically spanning from 0 to 36 in most estuaries. Semi-enclosed bays can experience hyper-salinity conditions. In the present study, it was observed that a broader range of salinity concentrations at different stations. The highest salinity concentration of 51.00 ppt was recorded at station 1A in the Offshore area, while the lowest salinity concentration of 19.50 ppt was found at station 2 Cargo Jetty. The mean ± standard deviation (SD) salinity values were determined to be 41.10±7.92 ppt, 35.25±11.84 ppt, and 31.44±4.04 ppt in the offshore, cargo jetty, and Phang creek, respectively. These findings are summarized in Tables 3-5, where all the data is presented.

2.8.3. Sediment Texture

Understanding the sediment texture at different stations provides valuable insights into the habitat characteristics and ecological dynamics of the marine environment. The sediment texture plays a significant role in determining the physical and chemical properties of the marine sediment, influencing the distribution and abundance of benthic organisms at the offshore station, the average percentage composition of sand, silt, and clay was found to be 28.65 %, 9.53 % and 61.82 %, respectively. The cargo jetty station exhibited average percentages of 44.92% for sand, 25.28 % for silt, and 29.80 % for clay. Similarly, at the Phang creek station, the average percentages were 40.60% for sand, 26.23% for silt, and 33.17% for clay. These findings are summarized in Tables 3-5, which presents the data from all the stations.

2.8.4. Total organic Carbon

Total Organic carbon in sediments primarily originates from the decomposition of animals, plants, and anthropogenic sources such as chemical waste, fertilizers, and organic-rich waste. These sources contribute to the enrichment of the marine environment with organic material, which subsequently settles to the bottom sediments from the water column. This pathway leads to an increase in Total Organic Carbon (TOC) values and can have implications for the faunal communities inhabiting the sediments. In our study, during this first season, it was investigated the TOC concentrations at different stations. The mean ± standard deviation (SD) TOC percentages were determined to be 0.48±0.19% at the offshore station, 0.89±0.20% at the cargo jetty station, and 0.57±0.08% at the Phang creek station. The TOC concentrations at all stations are presented in Tables 3-5. Understanding the dynamics of organic carbon in marine sediments is vital for assessing the health and ecological integrity of marine environments. It helps in monitoring anthropogenic influences and their potential impacts on the marine ecosystem.

2.8.5. Organic matter

Organic matter serves as the primary reservoir of organic carbon in marine sediments, encompassing the chemical, physical, and biological degradation processes that contribute to the formation of organic material in the marine environment. It consists of a mixture of materials derived from various planktonic and benthic species, forming the ecological foundation for primary producers and consumers in the overlying surface sediment.

In our study conducted during the First season, we investigated the levels of organic matter in different locations. The organic matter percentages ranged from 0.62% to 1.49% in the offshore location, 1.18% to 1.96% at the cargo jetty, and 0.77% to 1.93% in the Phang creek area and the findings are summarized in the below tables (3-5), which illustrates the variation in organic matter content across the studied locations. Understanding the presence and dynamics of organic matter in marine sediments is crucial for assessing the overall health and ecological functioning of marine ecosystems. It provides insights into the cycling of carbon and nutrients, as well as the interactions between different species and trophic levels within the sediment community. Monitoring and studying organic matter in marine sediments helps to comprehend the intricate processes that shape marine environments and their associated biota.

2.8.6. Phosphorus and Sulphur

Sulphur (S) is involved in dissimilatory sulfate reduction by microbial activity, which is a primary pathway for organic matter mineralization in anoxic sea beds. This process leads to the production of sulfide. Subsequently, chemical or microbial oxidation of the produced sulfide forms a complex network of pathways in the sulfur cycle, resulting in intermediate sulfur species and partial conversion back to sulfate. On the other hand, Phosphorus (P) is an essential nutrient for life and plays a crucial role in regulating primary productivity within marine systems. It serves as a key element in various biological processes. In marine sediments, phosphorus availability influences primary productivity, affecting the growth and development of marine organisms.

In the present study, the highest concentration of sulphur was recorded as 48.33 mg/kg was recorded at Offshore station, while the lowest concentration of 26.52 mg/kg was observed at Phang creek. The concentrations of phosphorus and sulphur at all stations are presented in Tables 3,4 and 5. Similarly, the highest phosphorus concentration was found to be 50.00 mg/kg at Phang creek location, while the lowest concentration of 6.81 mg/kg was observed at Offshore station. Further, understanding the levels of phosphorus and sulphur in marine sediments is crucial for comprehending nutrient dynamics and biogeochemical processes in marine ecosystems. These elements influence the availability of essential nutrients and can have implications for primary productivity and the overall functioning of marine ecosystems.

2.8.7. Petroleum hydrocarbon

Petroleum hydrocarbons in general have low solubility in marine water and tend to adsorb onto particulate matter, leading to their long-term persistence in sediment bottoms. This persistence can have significant negative impacts on benthic aquatic communities within the marine ecosystem. PHCs are a major source of contamination in marine environments, primarily comprising compounds from three classes: alkanes, olefins, and aromatics. In the present study, the levels of PHCs in different locations were measure. The range of PHC concentrations was found to be 0.48 – 1.39 µg/kg in the offshore area, 06.4 – 1.10 µg/kg at the cargo jetty and 0.53 – 1.22 µg/kg in the

Phang Creek. The highest concentration of PHCs with 1.39 µg/kg was observed at station 1C (Offshore), while the lowest concentration with 0.48 µg/kg was also found at a different point at the same station 1D (Offshore Creek). The presence of petroleum hydrocarbons in marine environments is of great concern due to their potential harmful effects on marine organisms and ecosystems. These contaminants can bioaccumulate in organisms and disrupt their physiological processes, as well as cause long-lasting damage to the benthic communities. Continuous monitoring and mitigation efforts are necessary to prevent and minimize the negative impacts of petroleum hydrocarbon contamination in marine ecosystems.

2.8.8. Magnesium

Understanding the distribution and dynamics of magnesium in marine sediments provides valuable insights into the geochemical processes occurring within the sediment column and their impact on the marine ecosystem. Continuous monitoring of magnesium levels is crucial for assessing the health and ecological integrity of marine environments. Dissolved magnesium flux from the overlying ocean into marine sediments is primarily driven by molecular diffusion. This process occurs as pore water magnesium is depleted during the formation of authigenic minerals within the sediment column. Additionally, direct burial of seawater occurs as sediment accumulates on the seafloor, contributing to the input of magnesium into the sediment. Its concentration in sediments can have implications for nutrient availability, sediment mineralogy, and the diverse organisms inhabiting the sediment environment.

In our study conducted during the First season at Deendayal Port, we determined the concentrations of magnesium at different stations. The average ± standard deviation (SD) magnesium concentrations were found to be 1548.42±227.70 mg/kg at the offshore station, 1450.67±365.58 mg/kg at the cargo jetty, and 1573.58±256.28 mg/kg at the Phang Creek station. The highest concentration of magnesium 1919.50 mg/kg was observed at station 2D (Cargo Jetty Creek), while the lowest concentration with 1008.00 mg/kg was found at Control point in the same location.

2.8.9. Heavy metals

The heavy metal concentration in the sediment samples were examined for the presence of heavy metals from the samples collected from various stations at different locations at Deendayal Port. The concentrations of Lead was found to be Below Detection Limit in all the three location. The highest concentration of nickel was found to be 54.50 mg/kg at Offshore and Cargo Jetty location, while the lowest concentration of Nickel was observed at Cargo Jetty (36.40 mg/kg). Among the three stations, site 2B (Cargo Jetty) recorded the highest concentration of zinc, with 55.95 mg/kg at and the Control site at the Cargo jetty location recorded the Below Detection Limit of Zinc.

In case of Manganese, the 2E site at Cargo jetty had the highest concentration of 825.50 mg/kg, while Control 2 in Cargo jetty recorded the lowest mean concentration of 184.00 mg/kg. The highest concentration of cadmium of 19.90 mg/kg was observed in Cargo Jetty station, whereas the lowest concentration of 0.85 mg/kg was found at station Offshore location (Site 1C). The data is presented in Tables 3-5.

Table 3: Physico-chemical characteristics of sediment samples collected from Offshore location

S. No	Parameters	1A	1B	1C	1D	1E	Control 1
1	pH (1: 10 suspension)	8.14	8.19	8.20	8.00	8.40	8.14
2	Salinity	33.00	30.20	44.41	45.29	51.00	42.67
3	Petroleum Hydrocarbon	0.988	0.9874	1.3915	0.48	0.6531	0.6512
4	Magnesium	1723.5	1383	1806	1507	1667.5	1203.5
5	Sand (%)	25.1	14.8	27.5	43.4	29.6	31.5
	Silt (%)	4.8	5.0	7.8	22.3	5.9	11.4
	Clay (%)	70.1	80.2	64.7	34.3	64.5	57.1
6	Organic matter (%)	0.67	0.62	0.77	1.49	0.67	0.72
7	Total organic carbon	0.39	0.36	0.45	0.87	0.39	0.42
8	Phosphorus	6.81	8.63	10.68	11.59	12.50	13.63
9	Sulphur	34.91	32.02	31.94	45.16	48.33	33.30
10	Nickel	41.35	54.5	36.4	37.65	47.25	BDL
11	Lead	BDL	BDL	BDL	BDL	BDL	BDL
12	Cadmium	9.95	14.9	0.85	14.8	12.4	12.1
13	Chromium	77.2	31.7	37.1	54.4	37.95	44.45
14	Zinc	BDL	50.35	34.75	49.8	49.65	43.7
15	Copper	5.6	5.2	11.55	26.65	13.6	11.95
16	Manganese	664	645.5	750.5	824	795	732.5
17	Cobalt	BDL	BDL	4.35	7.85	7.05	4.3

Table 4: Physico-chemical characteristics of sediment samples collected from Cargo jetty

S. No	Parameters	2A	2B	2C	2D	2E	Control 2
1	pH (1: 10 suspension)	8.13	8.2	8.16	8.06	8.13	8.2
2	Salinity	47.00	40.93	45.29	36.92	21.86	19.50
3	Petroleum Hydrocarbon	0.8864	1.0957	0.8895	0.837	0.6447	0.6573
4	Magnesium	1074.5	1465	1783.5	1919.5	1453.5	1008
5	Sand (%)	43.1	36.7	34.9	29.9	47.3	77.6
	Silt (%)	28.5	34.7	20.0	18.5	32.8	17.2
	Clay (%)	28.4	28.6	45.1	51.6	19.9	5.2
6	Organic matter (%)	1.96	1.91	1.29	1.60	1.24	1.18
7	Total organic carbon	1.14	1.11	0.75	0.93	0.72	0.69
8	Phosphorus	17.72	18.40	14.77	43.86	47.27	31.13
9	Sulphur	36.36	34.61	35.05	38.94	34.50	26.72
10	Nickel	41.35	54.5	36.4	37.65	47.25	BDL
11	Lead	BDL	BDL	BDL	BDL	BDL	BDL
12	Cadmium	9.8	17.4	19.9	5.25	17.7	6.75
13	Chromium	72.2	171.25	50.5	46.7	47.15	7.25
14	Zinc	42.55	55.95	31.45	51.4	44.45	BDL
15	Copper	18	28.95	16.7	18.2	20.2	BDL
16	Manganese	810.5	825	816.5	775.5	825.5	184
17	Cobalt	7.95	8.2	3.95	6.1	9.25	BDL

Table 5: Physico-chemical characteristics of sediment samples collected from Phang creek

S. No	Parameters	3A	3B	3C	3D	3E	Control 3
1	pH (1: 10 suspension)	8.18	8.32	8.17	8.33	8.28	8.30
2	Salinity	35.62	31.87	29.09	28.91	36.66	26.47
3	Petroleum Hydrocarbon	1.2217	1.1875	0.8305	0.542	1.0876	0.5261
4	Magnesium	1061	1630.5	1728.5	1673	1610	1738.5
5	Sand (%)	28.1	42.6	35.5	42.5	55.1	39.8
	Silt (%)	11.5	38.8	14.5	34.4	35.0	23.2
	Clay (%)	60.4	18.6	50.0	23.1	9.9	37.0
6	Organic matter (%)	0.82	0.98	1.08	1.03	0.77	1.13
7	Total organic carbon	0.48	0.57	0.63	0.6	0.45	0.66
8	Phosphorus	35.90	45.22	40.22	8.86	6.13	50.00
9	Sulphur	33.27	30.41	28.47	26.52	35.11	31.83
10	Nickel	32.55	38	36.45	40.55	53.45	36.65
11	Lead	BDL	BDL	BDL	BDL	BDL	BDL
12	Cadmium	15.35	9.2	10.15	16.6	18	16.85
13	Chromium	38.8	51.85	45.45	55.1	71.75	113.85
14	Zinc	41.7	39.75	47.35	18.9	25.65	23.2
15	Copper	9.95	18.55	13.85	19.2	23.05	20.4
16	Manganese	621.5	752.5	780	790.5	774	799.5
17	Cobalt	3.65	0.6	5.7	5.9	3.85	1.3

3.1. Introduction

"Planet Earth is dominated by the seas". One of the most important natural resources that cover much of the earth's surface is Ocean. Earth surface contains more than 97% of water in which the oceans show biggest part of the life. The five oceans together constitute approximately 71% of the world's water bodies. Indian Ocean is the third largest ocean in the world with average depth of 3,890 meters (12,760 ft). The Indian ocean's connection is a very large scale, including the Red Sea, East Africa, the Persian Gulf, Southern Arabia, India and Other Indian sub continental countries. This connection network connected people from all the coastal areas of the Indian Ocean and beyond, trading in aromatics, textiles, spices, precious stones, industrial productions, grain and an incredible range of other commodities and substances. Gujarat state of India shows longest coastline compare to other Indian states. Gujarat coastline is famous for various coastal ecosystems and habitats such as estuary, coral reefs, marshes, mangroves, and lagoons, rocky and sandy areas. The Kachchh, largest district of the country with an area of 45,652 sq. km. Deendayal Port Authority is (DPT) one among the 12 major ports of the country and it is located in India's western coastal region

Benthos

Benthos is nothing but water bottom communities or the organisms (floral and faunal) live in a benthic region regarding the sediment, rock and other substratum. They include mollusca (gastropods and bivalves), coral, sponges, worms (mostly polychaetes and nematode), crustacean crabs, other crustaceans, echinoderms, oysters etc. Benthic animals are considered as the organism which lives in the bottom layer of all types of ecosystems including saline water as well as in freshwater. However, this term 'benthos' is used as an expressive term for the entire bottom community. On the basis of distribution of benthos in water, they can be classified into three types which are, Endo-benthos, Epi-benthos (Pearson and Rosenberg, 1978) and Hyper-benthos (Mees and Jones,1997). Benthos could also recognize as one of the best indicators to assess the health and productivity of aquatic ecosystems. The benthic particularly macro benthic communities are an integral part of the coastal biotic components. They can serve as important food resource for the diverse groups of various organisms particularly bottom feeding animals. They are sensitive to wide range of environmental challenges including water movements, pollutants and living spaces (Martin et al., 2011), which make them to be considered as the important biological indicator species, which are used for monitoring marine environment. Based on size, Benthos mainly divided into 3 types namely, Macrobenthos (> 1 mm), Meiobenthos (< 1 mm or > 0.1 mm) and Microbenthos (< 0.1 mm).

3.2. Methodology

To study the benthic organisms, triplicate samples were collected at each station using Van-Veen grab which covered an area of $0.1m^2$. The wet sediment was sieved with varying mesh sizes (0.5 mm-macrofauna) for segregating the organisms. The organisms retained in the sieve were fixed in 5-7% formalin and stained further with Rose Bengal solution for easy spotting at the time of sorting. The number of organisms in each grab sample was expressed as number/ meter square (No/m^2). All the species were sorted, enumerated and identified to the advanced taxonomic level possible with the consultation of available literature. The works of Fauvel (1953), Day (1967) were referred for polychaetes; Barnes (1980) and Lyla *et al*. (1999) for crustaceans; Subba Rao *et al.* (1991) and Ramakrishna (2003) for molluscs.

Further, the data were treated with univariate statistical methods in PRIMER (Ver. 6.) statistical software (Clarke and Warwick, 1994)

a) Shannon – Wiener index

In the present study, the data were analyzed for diversity index (H') by following Shannon – Wiener's formula (1949):

$$H' = -\sum^{S} Pi \log 2\ Pi \ldots\ldots \quad i = 1$$

which can be rewritten as

$$H' = \frac{3.3219\ (N \ \log N - \sum ni - \log ni}{N}$$

where, H'= species diversity in bits of information per individual ni = proportion of the samples belonging to the ith species

(number of individuals of the ith species)

N = total number of individuals in the collection and

$\sum$ = sum

b) Species richness(S) was calculated using the following formula given by Margalef (1958)

c) Margalef index (d)

d = (S-1) / log N

d) Pielou's evenness index

The equitability (J') was computed using the following formula of Pielou (1966):

$$J' = \frac{H'}{\log_2 S} \text{ or } \frac{H'}{\ln S}$$

Where, J' = evenness; H' = species diversity in bits of information per individual and S = total number of species.

3.3. Results on Species Composition, Population density and Biomass of Macrofauna of selected sites

Species Composition, Population density and Biomass of Macrofauna at selected sites

1.Offshore

In Offshore region of Kandala port, total six sites were selected namely, (1A, 1B, 1C, 1D, 1E and 1- control). A total 4groups/species(of benthic community) of benthic animalswere observed in all stations at Offshore sites and they a Bivalves (Mollusca),Gastropods (Mollusca), Polychaeta worms (Annelida), Saccostrea sp (Bivalvia). All the data(Density and Biomass) expressed in (nos./m^2), (gm/m^2) respectively (Table 6). Crustacean animals (Bivalve), Placuna sp (Bivalvia), Pecten sp (Bivalvia), Razor clam (Bivalvia) and Scaphopoda (Mollusca) were totally absent in Offshore.

Highest population density of benthic organisms wasrecorded in station 1C-Offshore(975 nos/m^2), whereas lowest in station 1control-Offshore(125nos/m^2). The density range of all stations varied from 125 to 975nos./m^2. Bivalves and Polychaeta worms were more abundant among all the benthic organisms might be sandy-muddy or sandy substratum in bottom part of Offshore region. Low recorded benthos were Gastropods (Mollusca) and Saccostrea sp (Bivalvia) that indicated some part of substratum are hard (rocky) and algal growth association with animals. The highest biomass value (expressed wet weight) of benthic fauna was observed in station 1C-Offshore (3.11gm/m^2) and lowest value was 1control-Offshore(1.06 gm/m^2) (Table 6). Range of the Biomass was 1.06 to 3.11 gm/m^2 . Moderately Biomass values and also density values suggested mixing substratum, less availability of plenty food items and more predator pressure by higher animals. Intermediate association was also one responsible factor for the same. Variation in density and biomass in Offshore region because more influences by the Water Currents, Up welling - Down welling (Churning process of water) movements of water and Nutrients availability and Fluctuation in turbidity of water.

2. Cargo Jetty

In Cargo Jetty, frequently observed benthic groups were Bivalves, Gastropods, Crustacean animals and Saccostrea sp (Bivalvia). Less reported benthos were Placuna sp (Bivalvia), Pecten sp (Bivalvia) and Scaphopoda whereas Polychaeta worms (Annelida) was totally absent.The population density range noted between 100 to 3725(nos/m^2) among all the stations (Cargo Jetty-2A, 2B, 2C, 2D, 2E &2-Control) during the study period. Highest and Lowest density were recorded in station 2control- Cargo Jetty(1800nos./m^2) and 2D & 2E-Cargo Jetty (100 nos./m^2) respectively.

Pecten sp (Bivalvia) and Razor clams (Bivalve) were only seen in 2control-Offshore whereas Placuna sp (Bivalvia) only observed in 2A-Cargo Jetty.The Biomass value indicated a highestvalue in station 2control- Cargo Jetty (19.17gm/m^2) and lowest in 2D- Cargo Jetty (1.82gm/m^2) (Table 6).Average Biomass and Populationdensity value of all station were 7.74gm/m^2, 1083 nos./m^2 respectively which indicated the moderate favourable environment condition of biota, water quality as well as substratum (mostly rocky) and also substratum of cargo jetty not suitable for Annelids.

3. Phang creek

Six Stations of Phang creek were selected for the studynamely 3A, 3B, 3C, 3D, 3E and 3-control-Phang Creek.In this Phang Creek benthic organisms were mostly represented byGastropoda, Polychaeta worms (annelids) and Crustaceans.Other benthos like *Placuna sp, Pecten sp, Saccostrea sp* and Scaphopoda (Mollusca) were totally absent whereas Bivalves and Razor clams were rarely recorded.The population density was highest in station 3E-Phang Creek (2850nos./m^2) and on the other side, lowest density was recorded in 3C-Phang Creek (25nos./m^2).Station 3control-Phang Creek comprises highest wet wt (20.65 gm/m^2), whereas low value was recorded in3C-Phang Creek(0.03 gm/m^2).

Overall result (Offshore, Cargo Jetty and Phang creek) of macrofaunal community showed highest population density in 2control-Cargo Jetty (3725nos/m^2) and high biomasswas observed (20.65gm/m^2) in 3control-Phang creek. Table 6 showed highest population values of Bivalves in 2control- Cargo Jetty (2050nos/m^2) and same highest value of Gastropoda showed in 3E-Phang creek(1425nos/m^2).

The lowest value comprised by the *Pecten sp, Placuna sp,* Scaphopoda and Razor clam including some were totally absent in some sites.Some absent or less frequently observed benthosindicated extreme weather condition (may be suddenly change temperature of running season), more stress condition and unfavourable environment condition for their survival.Bivalves and Gastropods, dominant groups,werepreferred rocky, sandy or mix substratum, and any other hard substrata**.**Polychaete wormsare preferred sandy-muddy substratum or sandy habitat.

Table 6 showed that average population density and biomass higher in Offshore, Cargo Jetty and some sites of Phang Creek area wheremostly rocky, sandy or covered with muddy area providing a unique habitats for benthos.*Low density and biomass was observed in mostly Phang creek area nd some parts of Off shore and Cargo Jetty* (Table 6 and Figure 1) which indicated s*tressful environment, seasonal effect, more anthropogenic activities and also might be some chemical and biological changes in* *water*.The population density and biomass of benthic community largely affected by the symbiotic and intermediate relation between them or with other invertebrates and suitable rocky substratum or coral reef in bottom of sea. Availability of Plankton, as a food source, also affected the benthic animals (Table 6 and Fig. 1 & 2). Extremely hot weather condition (during April and May months) also more affected in Cargo Jetty and Phang creek regions of Kandla port area.

In benthic communities, recorded species at all sites were, *Pecten sp, Placuna sp, Umbonium vestiarium Tellina sp., Clypeomorus bifasciata, Trochus sp, Radix sp,Nassarius sp, Nerita sp, Donax sp, Turris sp,Marcia sp, Dosinia sp, Donax sp, Anadara sp, Turris sp, Solen, Nereis sp, Saccostrea sp, Optediceros breviculum,Euolica sp etc.The percentage of occurrence (Table 6) was revealed highest group present byBivalves- Mollusca (67%) next Gastropoda (61%) then following araePolychaeta worms (Annelida) (50%), Crustacean animals and Saccostrea sp (39%), Placuna sp (28%) and both Pecten sp and Scaphopoda (6%) respectively.Detail status of Population density, Group composition and biomass of the benthic community of all selected sites were depicted in (Table 6) and (Figure 1).*Among all the stations, highest percentage composition recorded by Bivalves(40%) followed by Gastropods (27%), Polychaeta worms &*Saccostrea sp* (10%), Crustaceans (7%), Razor clam (3%) and 1% by *Pecten sp*, Scaphopoda and *Placuna sp* (Figure.2).

Phytoplankton abundance and their size, zooplankton body composition, patchy distribution of zooplankton, water currents, ebb and flow tides, and water churning process, changing in structure of muddy, rocky and sandy habitats are the main reasonsfor biomass and density fluctuation in Benthic communities. In Crustacean most commonly observed species are Crabs and attached Barnacles. Main Mollucsa families recorded Trochidae, Cerithidea, Turritellidae, Tellinidae, Mitridae, Veneridae, Donacidae and Bucciniae etc. *Nereis sp* of anneliids was mostly observedin samples. More number of the broken bivalves, debris, plant items , broken gastropods, small pebbles and soil particles are frequently observed during benthic organism's study.

Diversity Indices of Benthic Community

Various diversity indices calculation, showed that Shannon Diversity Index ranging from (0.00-1.34) indicated very low diversity. Highest diversity indices were recorded in Station 2B-Cargojetty (1.34) where four groups/species of benthos presented where as Shannon indices nil (zero) observed in 3A & 3C- Phang creek where only one benthic group present and density value was very low. Comparatively less Shannon indices value very low in Phang creek area number of benthos group/species present between 1 to 4 nos. The evenness values ranged between (0.61 to 1). The highest evenness value (1) is observed in stations 2D & 2E (Cargo Jetty) and 3A,3B & 3C (Phang creek) where only 1 or 2 benthic groups were present with less population whereas the lowest evenness index value 0.61 was at 2control-Cargo Jetty. Evenness value "1" indicated all organisms occurred in same area or mostly same group.Simpson's Index value ranged between 0.00 to 0.73indicated to lower to very less moderate diversity. The Margalef value showed range of 0.00 to 0.61 indicated high variation in species/group numbers (Table 7).

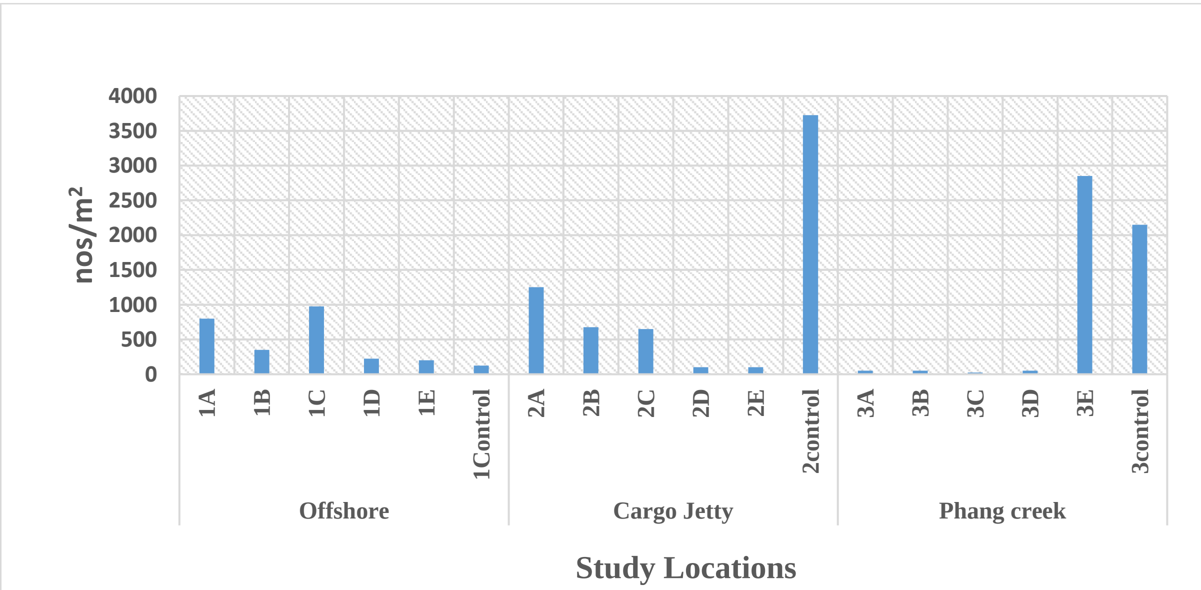


Figure 1. Population density of benthic organisms (nos/m^2) in various sites

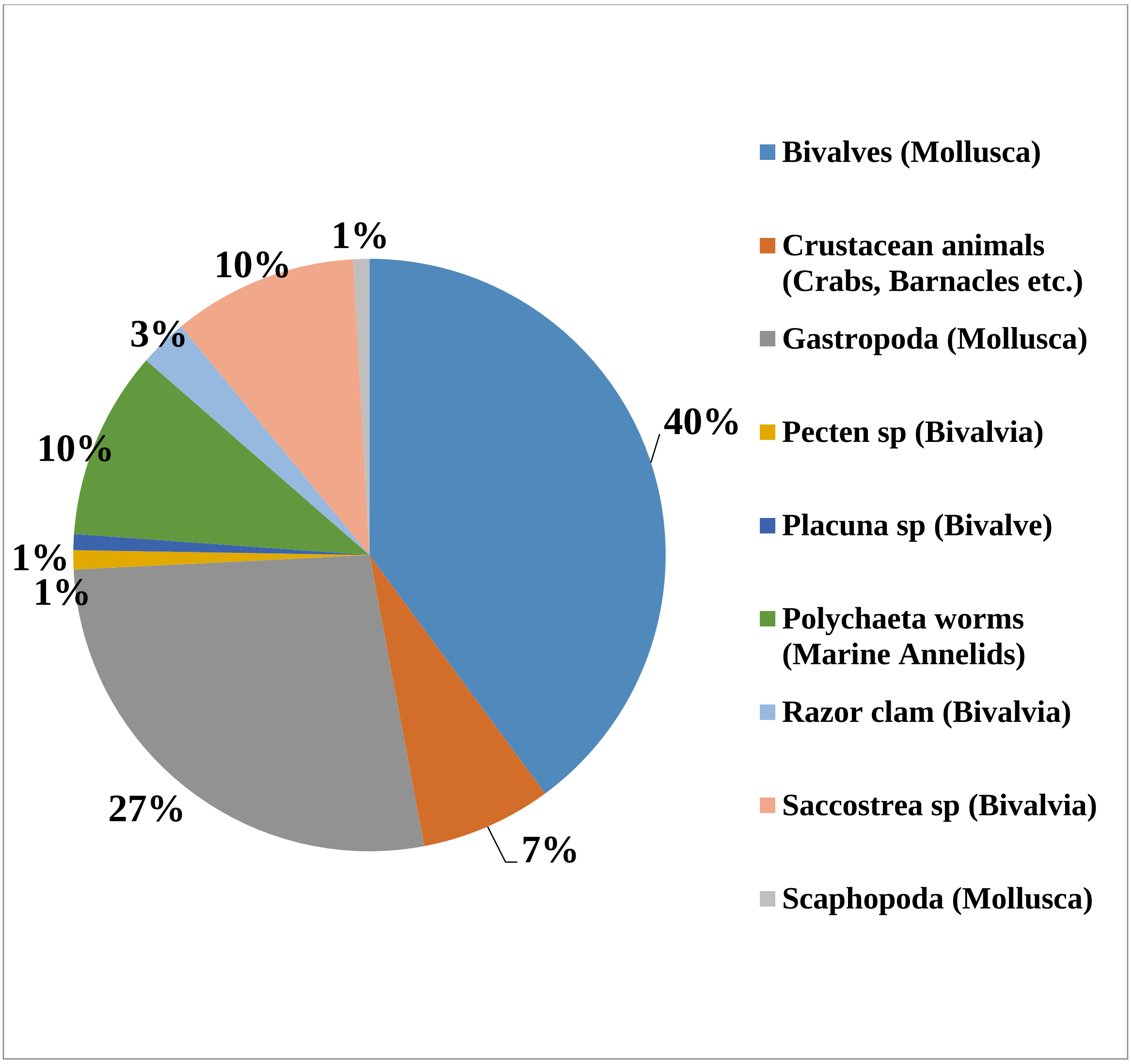


Figure 2. Percentage composition of benthic organisms in various sites

Table 6. Macrobenthos distribution in different sites of Deendayal Port

Name of Station	Offshore						Cargo Jetty						Phang creek						
	1A	1B	1C	1D	1E	1-Control	2A	2B	2C	2D	2E	2-Control	3A	3B	3C	3D	3E	3-Control	% of Occurrence
Name of Benthic Groups																			
Bivalves (Mollusca)	250	125	300	100	0	50	550	125	50	50	0	2050	0	0	0	0	1025	1050	67
Crustacean animals (Crabs, Mysis etc.)	0	0	0	0	0	0	0	175	300	50	50	0	0	0	0	25	300	125	39
Gastropoda (Mollusca)	50	100	25	0	0	0	325	250	50	0	50	750	0	25	0	0	1425	850	61
Pecten sp (Bivalvia)	0	0	0	0	0	0	0	0	0	0	0	150	0	0	0	0	0	0	6
Placuna sp (Bivalve)	0	0	0	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	28
Polychaeta worms (Marine Annelids)	500	125	650	0	50	25	0	0	0	0	0	0	50	25	25	25	0	0	50
Razor clam (Bivalvia)	0	0	0	0	0	0	0	0	0	0	0	150	0	0	0	0	100	125	17
Saccostrea sp (Bivalvia)	0	0	0	125	150	50	250	125	250	0	0	500	0	0	0	0	0	0	39
Scaphopoda (Mollusca)	0	0	0	0	0	0	0	0	0	0	0	125	0	0	0	0	0	0	6
Total Population Density Nos/m^2	800	350	975	225	200	125	1250	675	650	100	100	3725	50	50	25	50	2850	2150	
Biomass (wet weight) gm/m^2	2.06	2.14	3.11	1.28	1.38	1.06	11.14	7.2	5.24	1.82	1.88	19.17	0.56	0.96	0.03	0.6	15.65	20.65	

Table 7. Diversity indices of benthic faunal groups at various station of Deendayal Port

Variables	Offshore						Cargo Jetty						Phang Creek					
	1A	1B	1C	1D	1E	1-control	2A	2B	2C	2D	2E	2-contrl	3A	3B	3C	3D	3E	3cont
Taxa_S	3	3	3	2	2	3	4	4	4	2	2	6	1	2	1	2	4	4
Individuals (Nos./m^2)	800	350	975	225	200	125	1250	675	650	100	100	3725	50	50	25	50	2850	2150
Dominance_D	0	0	1	1	1	0	0	0	0	1	1	0	1	1	1	1	0	0.40
Shannon Diversity Index (H)	0.83	1.09	0.73	0.69	0.56	1.06	1.26	1.34	1.12	0.69	0.69	1.29	0.00	0.69	0.00	0.69	1.07	1.05
Simpson_1-D	0.51	0.66	0.46	0.49	0.38	0.64	0.69	0.73	0.63	0.50	0.50	0.63	0.00	0.50	0.00	0.50	0.61	0.60
Evenness_e^H/S	0.76	0.99	0.69	0.99	0.88	0.96	0.88	0.96	0.77	1.00	1.00	0.61	1.00	1.00	1.00	1.00	0.73	0.71
Menhinick	0.11	0.16	0.10	0.13	0.14	0.27	0.11	0.15	0.16	0.20	0.20	0.10	0.14	0.28	0.20	0.28	0.07	0.09
Margalef	0.30	0.34	0.29	0.18	0.19	0.41	0.42	0.46	0.46	0.22	0.22	0.61	0.00	0.26	0.00	0.26	0.38	0.39

4.1. Introduction

In recent decades, there has been a notable deterioration in aquatic ecosystems primarily caused by the presence of a diverse array of organic and inorganic contaminants. Among these pollutants, heavy metals (HMs) and microplastics (MPs) have emerged as significant contributors to this environmental degradation (Frew et al., 2020; Saha et al., 2016). These substances are recognized for their capability to infiltrate and accumulate within the aquatic food chain, making them hazardous pollutants in aquatic environments (Olojo et al., 2005). Of particular concern are heavy metals due to their toxic nature, long-lasting presence, resistance to degradation, the potential for bioaccumulation, and the ability to magnify up the food chain, all of which have raised global alarms (Begum et al., 2013; Cai et al., 2017).

Heavy metal pollution in aquatic ecosystems can be attributed to a variety of sources, including natural factors such as atmospheric deposition and weathering (Ebrahimpour and Mushrifah, 2010; Hamidian et al., 2016) as well as human activities like mining, agricultural runoff, sewage discharge, industrial effluent release, gasoline leaks from fishing vessels, and accidental chemical waste spills (Arulkumar et al., 2017). It is essential to recognize that certain heavy metals, such as copper (Cu), iron (Fe), nickel (Ni), cobalt (Co), zinc (Zn), manganese (Mn), and chromium (Cr), play vital roles in physiological processes and are necessary for the proper biological functioning of organisms in trace amounts. However, exposure to nonessential heavy metals can lead to various health concerns, including renal, cardiovascular, nervous, and bone diseases, as well as immune-related issues (Abadi et al., 2018; Madreseh et al., 2018). It is crucial to acknowledge that all heavy metals become toxic when their concentration exceeds a certain threshold level (Makedonski et al., 2017). In light of these concerns, it is imperative to assess the various characteristics of water in order to determine the extent of pollutant presence in aquatic environments.

4.2. Materials and Methods

In this study, marine water and sediment samples were collected following standard protocols, and their analysis was conducted using established methods for marine water and sediment analysis as prescribed by APHA (2012), NIO manual (1982), and ICMAM Manual (2012). For general analysis, surface water samples were collected using a clean polyethylene bucket, while water samples from the bottom were collected using a weighted Niskin sampler. Water samples at a depth of 1 meter below the surface were collected using a 1-liter glass bottle sampler. Parameters such as pH, temperature, and salinity were measured on-site using handheld meters and verified in the laboratory.

The collected water samples were stored under refrigerated conditions until further analysis of other parameters. According to the standard protocol, fixatives and preservatives were added to the samples for specific parameters. For example, Winkler A&B solution was immediately added to measure dissolved oxygen, concentrated H2SO4 was used to bring the pH below 2 for chemical oxygen demand analysis, and nitric acid was used for the preservation of heavy metals. Formalin was added to marine water samples for planktonic analysis. In general, all water and sediment samples were stored in sterile polythene bottles and Ziplock bags and kept in an icebox to maintain suitable conditions until they were transported to the laboratory. The parameters to be analyzed (Table 8) and the methods used for the sample analysis are described below.

Table 8: Physico-chemical and biological characteristics of marine water samples

S. No	Physico-chemical and Biological parameters
1	pH
2	Salinity (ppt)
3	Total Dissolved Solids (mg/L)
4	Turbidity (NTU)
5	Dissolved Oxygen (mg/L)
6	Bio-Chemical Oxygen Demand (mg/L)
7	Chemical Oxygen Demand (mg/L)
8	Phenolic compound (µg/L)
9	Petroleum Hydrocarbons (µg/L)
10	Oil and grease (mg/L)
11	Cadmium (mg/L)
12	Lead (mg/L)
13	Chromium (mg/L)
14	Copper (mg/L)
15	Cobalt (mg/L)

16	Nickel (mg/L)
17	Zinc (mg/L)
18	Magnesium (mg/L)
19	Chlorophyll (mg/m^3)
20	Phaeophytin (mg/m^3)
21	Phytoplankton Phytoplankton cell counts (no/L) Total Genera (no.) Major Genera
22	Zooplankton Biomass (ml/100m^3) Population (no/100m^3) Total Group (no.) and Major Groups

4.2.1. pH, Temperature and Salinity

pH and temperature measurements were conducted using a Thermo Fisher pH/EC/Temperature meter. Prior to use, the instrument was calibrated with standard buffers. For pH determination, an appropriate volume of the sample was titrated against silver nitrate (20 g/l), with potassium chromate serving as an indicator. The chlorinity of the sample was estimated, and salinity values were derived using a specific formula.

Total Dissolved Solids (TDS)

To confirm the readings obtained from the handheld meter, the samples underwent a gravimetric procedure. Approximately 100 ml of the water sample was taken in a beaker and filtered. The filtered sample was then completely dried in a hot air oven at 105°C. The TDS values were calculated by measuring the difference between the initial and final weight of the dried sample.

Turbidity

For turbidity measurement, a sample tube (Nephelometric cuvette) was filled with distilled water and inserted into the sample holder. The lid of the sample compartment was closed, and the meter reading was adjusted to zero by manipulating the 'SET ZERO' knob. The sample tube containing the 40 NTU standard solution was then placed in the tube, and the meter reading was set to 100. Similar measurements were carried out for other standard solutions. To determine the turbidity of the marine water sample, the sample tube was filled with the water sample, and the corresponding reading was recorded.

Dissolved Oxygen (DO)

To determine the Dissolved Oxygen (DO) levels in a water sample obtained from a marine environment, the following procedure was employed. Collect sea water sample, ensuring that the sampling container is clean and free from any potential contaminants that may affect the accuracy of the results. Subsequently, transfer the water sample into a Winkler's bottle or a suitable container, taking care to eliminate any trapped air bubbles. It is crucial to completely fill the bottle to minimize any headspace that could potentially alter the DO readings. Next, add the appropriate volumes of Winkler's reagents, such as manganese sulfate and alkali-iodide-azide, to the water sample as per the specific instructions of the Winkler's method. Gently and thoroughly mix the contents of the bottle to ensure uniform distribution of the reagents without introducing any air bubbles. Allow the bottle to stand undisturbed for a designated incubation period, typically around 30 minutes, to enable the necessary reactions to occur. After the incubation period, perform a titration using a standardized sodium thiosulfate (Na2S2O3) solution until a faint yellow color appears, indicating the complete consumption of dissolved oxygen in the sample. Record the volume of sodium thiosulfate solution used for titration, which represents the amount of dissolved oxygen present in the water sample. To account for any dissolved oxygen in the reagents, it is essential to conduct the same procedure with blank samples that do not contain the water sample. This allows for an accurate calculation of the DO levels in the original water sample. Finally, employ the appropriate formula provided by Winkler's method to calculate the DO concentration in the water sample.

Biochemical Oxygen Demand (BOD)

To determine the Biochemical Oxygen Demand (BOD), the following procedure was employed using the direct unseeded method. Collect representative sea water sample from the desired location, ensuring the sampling container is clean and uncontaminated. Fill a BOD bottle with the water sample, leaving minimal headspace to prevent air contact that could affect BOD measurements. It's important to completely fill the bottle to minimize air bubbles. Record the initial Dissolved Oxygen (DO) level in the water sample using a dissolved oxygen meter or appropriate measurement method. Seal the BOD bottle tightly with the stopper to prevent air exchange. Incubate the sealed BOD bottle in a controlled environment, such as a BOD incubator, at a specified temperature (typically 20°C), for a designated incubation period, usually around 5 days. Throughout the incubation period, keep the BOD bottle in darkness to minimize the impact of photosynthetic activity. After the incubation period, measure the final DO level in the water sample using the same method or instrument as the initial measurement. Calculate the BOD by subtracting the final DO level from the initial DO level, accounting for any necessary dilution or blank corrections. This difference represents the amount of oxygen consumed by the organic matter in the water sample during the incubation period.

Chemical Oxygen Demand (COD)

The Chemical Oxygen Demand (COD) test is a widely used method for quantifying the levels of organic and inorganic pollutants in water samples. The first step involves collecting representative water samples from the target site, ensuring proper labeling and record-keeping. Subsequently, these samples are placed into digestion vials or tubes, to which digestion reagents, typically potassium dichromate and sulfuric acid, are added. This step initiates the oxidation of organic matter in the sample. The sealed vials or tubes are then subjected to high-temperature heating, typically around 150-160°C, for a predetermined period, usually around 2 hours. This heating process breaks down complex organic compounds into simpler forms. After digestion, the samples are allowed to cool to room temperature. To determine the COD concentration, a colorimetric measurement is taken. A suitable reagent is added to the digested samples, reacting with any residual potassium dichromate, and generating a color change proportional to the COD concentration. This color intensity is measured using a colorimeter or spectrophotometer, and the results are calibrated using known COD standards. The final calculations yield the COD value, typically expressed in milligrams of oxygen per liter (mg/L) of the sample.

Phenolic compounds

To analyze phenolic compounds in water, the following procedure was followed. A 500 ml water sample containing phenols was treated with 4-aminoantipyrine, which converted the phenols into an orange-colored antipyrine complex. This complex was then extracted using 25 ml of chloroform. The absorbance of the extracted complex was measured at 460 nm using phenol as a standard for comparison. This measurement allowed for the quantification of phenolic compounds present in the water sample.

Petroleum Hydrocarbons (PHc)

The analysis of Petroleum Hydrocarbons (PHc) in a water sample involved the following protocol. One liter seawater sample was extracted using organic solvent, hexane. The mixture was then separated into an organic layer and an aqueous layer. The organic layer, containing the petroleum hydrocarbons, was isolated. To remove any remaining water, the organic layer was dried using anhydrous sulphate. The volume of the organic layer was subsequently reduced to 10 ml at a temperature of 30°C under low pressure. The fluorescence of the extracted organic compound was measured at 360 nm (with excitation at 310 nm) using Saudi Arabian crude residue as a standard. This residue was obtained by evaporating the lighter fractions of crude oil at 120°C. By comparing the fluorescence intensity of the extract with that of the standard, the concentration of petroleum hydrocarbons in the water sample could be determined.

Oil and Grease

To determine the content of Oil and Grease in a sample, the following procedure was followed. Approximately 500 ml of the sample was transferred to a separating funnel, and the sample bottle was rinsed with 30 ml of trichlorotrifluoroethane. The rinsing solvent was then added to the separating funnel. Next, 5 ml of 1:1 hydrochloric acid (HCl) was added to the mixture, and the contents were vigorously shaken for about 2 minutes. If a soluble emulsion was formed, the sample container was shaken for an additional 5 to 10 minutes. After shaking, the layers in the separating funnel were allowed to separate, and the lower layer (organic layer) was discarded.

The solvent layer was drained through a funnel containing a filter paper moistened with solvent, and it was collected in a clean distillation flask that had been pre-weighed. The solvent was then distilled from the flask using a water bath set at 70°C. The resulting residue was carefully transferred into a clean, pre-weighed, and dried beaker, using the minimum amount of solvent necessary. The beaker was placed on a water bath at 70°C for 15 minutes to evaporate off all the solvent. After the evaporation process, the beaker was cooled in a desiccator for 30 minutes to reach a consistent temperature, and its weight was then measured.

Heavy metals

Heavy metals are a significant concern, especially in coastal environments, since it is biomagnifying from lower organisms to higher organisms through water and sediment. Common heavy metals of concern include Cadmium (Cd), Lead (Pb), Chromium (Cr), Copper (Cu), Cobalt (Co), Nickel (Ni), Zinc (Zn), Magnesium (Mg) and Manganese (Mn). To release mineral elements from sediment and analyze them, a wet oxidation process is typically employed using oxidizing acids, such as a mixture of Tri / Di-acids.

The procedure begins by weighing 0.5 grams of the sediment sample and placing it in a 100 ml beaker, which is covered with a watch glass. Then, 12 ml of Aqua regia (a mixture of 1 part HNO3 and 3 parts HCl) is added to the beaker. The beaker is placed in a digestion apparatus and heated at 100°C for 3 hours on a hot plate using a sand bath. The sample is evaporated until it is nearly dry, and then allowed to cool for 5 minutes. Next, 20 ml of 2% nitric acid is added to the cooled sample in the beaker, and the mixture is further digested on the hot plate for 15 minutes. After digestion, the beaker is removed from the hot plate and allowed to cool. The sample is then filtered using a Whatman No. 42 mm filter paper to remove any solid particles. To make up the final volume, the filtrate is diluted with 2% nitric acid to a total volume of 50 ml. The resulting extracted sample is then aspirated into an Atomic Absorption Spectrometer (AAS) for analysis of the heavy metal concentrations.

Results

In this First season study conducted in the present year, we closely monitored three distinct locations: Offshore, Cargo Jetty, and Phang Creek. A comprehensive analysis of physico-chemical characteristics in marine water samples was conducted at each of these sites. The collected data is thoughtfully presented in Tables 9-11. These findings serve as a significant source of information regarding the precise physico-chemical conditions prevailing at each of these locations. Consequently, they play a pivotal role in enhancing the comprehension of the environmental factors that exert influence on the quality of marine water in these specific areas. The description of the data in each station is detailed as below.

Location 1 - Offshore location

In the offshore location (Location 1), the recorded data shows that the mean value of temperature was recorded as 33.10±0.30°C. The pH values ranged between 7.77 and 7.97, with an average pH value of 7.91±0.06. The salinity of the seawater recorded the mean value as 37.83±1.94 ppt, while the TDS which indicates the presence of various anions and cations, had an average value of 47097.67±2199.72 mg/L. Turbidity values ranged from 35.6 to 151.4 NTU. The maximum Dissolved Oxygen and Biochemical Oxygen Demand were in the order of 7.60 mg/L and 3.30 mg/L respectively. The average COD value was determined to be 44.33±4.08 mg/L. The concentrations of Phenolic compounds and Petroleum hydrocarbons varied between 3.5 to 42.88 µg/L, and 0.28 to 0.44 µg/L, respectively. The concentration of oil and grease ranged from 1.50 mg/L to 8.40 mg/L. Additionally, the maximum concentrations of heavy metals were observed for Magnesium (335.45 mg/L), Nickel (1.34 mg/L), Cadmium (2.89 mg/L), Manganese (2.41 mg/L), and Cobalt (0.81 mg/L), as shown in Table 9.

Location 2 – Cargo Jetty

At the Cargo Jetty location, the recorded data shows that the mean value of temperature was recorded as 32.53±0.846°C, and the mean value of pH was observed as 7.91±0.02. The average salinity of the seawater was 37.11±1.478 ppt reflecting the salt content, while the TDS which indicates the presence of various anions and cations, had an average value of 45412.5±2503.78 mg/L. Turbidity values ranged from 40.7 to 185.63 NTU, which is quite lower than the previous season sample data. The maximum values recorded for Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) were 8.2 mg/L and 3.0 mg/L respectively (as shown in Table 10). The average COD value was determined to be 42.00±7.03 mg/L. The concentrations of Phenolic compound were between 3.29 µg/L to 41.54 µg/L with an mean concentration of 21.23±11.91 µg/L. In case of Petroleum hydrocarbon, all the samples were well within the permissible limits set by CPCB and the maximum recorded concentration was 0.33 µg/L. The mean concentration of oil and grease in the marine water samples was 5.00±2.09 mg/L, which falls below the acceptable limit of 10 mg/L according to GPCB norms. Regarding heavy metal concentrations, the Mean±SD values for Magnesium, Nickel, Cadmium, Manganese and Cobalt were 237.658±92.402 mg/L, 1.293±0.839 mg/L, 2.263±0.770 mg/L, 1.560±1.193 mg/L, 0.705 respectively, whereas Chromium, Zinc and Copper recorded a Below Detection Limit (BDL) in all the sampling points in Station 2 as given in Table 10.

Location 3 - Phang Creek

During this winter sampling in the Phang creek near the port, all the samples were subjected for analysis for various characteristics (Table 11). The mean value of temperature was recorded as 33.20±0.89°C and the pH value was recorded between 7.93 to 8.04. The average salinity of the seawater in the vicinity was found to be 36.89±1.25 ppt, while the TDS which indicates the presence of various anions and cations, had an average value of 49053.83±4300.43 mg/L. Turbidity values ranged from 105.5 to 161.7 NTU. Pollution indices such as Dissolved Oxygen and Biochemical Oxygen Demand, Phenolic compounds, and Oil and grease concentrations had maximum values of 8.0 mg/L, 3.1 mg/L, 27.01 µg/L, and 7.6

mg/L, respectively. The average value of PHc was 0.294±0.020 µg/L. In case of heavy metals, the maximum concentrations of Magnesium, Nickel, Cadmium, Manganese and Cobalt recorded were 336.2 mg/L, 2.37 mg/L, 2.41 mg/L, 2.86 mg/L and 1.365 mg/L respectively. Few of the heavy metals such as Lead, Chromium, Zinc and Copper were in the Below Detection Limits.

Table 9: Physico-chemical characteristics of the marine water from sampling location 1 (Offshore)

S. No	Parameters	1A		1B		1C		1D		1E		Control 1	
		SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
1	Temperature (^{0}C)	32.8	33.3	33.5	33.2	33.5	33.0	33.3	32.8	32.8	33.3	32.6	33.1
2	pH	7.87	7.87	7.96	7.77	7.91	7.92	7.94	7.95	7.91	7.96	7.91	7.97
3	Salinity (ppt)	35.87	40.00	37.60	38.84	37.17	35.87	38.84	36.74	41.06	36.74	40.20	35.01
4	Total Dissolved Solids (mg/L)	46235.00	52374.00	44674.00	49270.00	45684.00	48723.00	48486.00	45392.00	45570.00	46097.00	46520.00	46147.00
5	Turbidity (NTU)	66.7	62.2	42.8	35.6	53.2	81.4	135.2	151.4	103.1	93	106.3	103.3
6	Dissolved Oxygen(mg/L)	7.6	7.4	7.5	7.3	7.3	7.2	7.6	7.4	7.5	7.2	7	6.6
7	Bio-Chemical Oxygen Demand (mg/L)	0.6	1.1	0.4	1.7	0.7	1.1	0.3	0.6	1.0	1.1	1.9	1.6
8	Chemical Oxygen Demand (mg/L)	52.00	50.00	48.00	44.00	46.00	42.00	44.00	42.00	40.00	38.00	44.00	42.00
9	Phenolic Compounds (µg/L)	33.50	16.49	3.50	14.63	42.88	20.92	36.49	25.46	20.10	30.30	15.25	32.16
10	Petroleum Hydrocarbons (µg/L)	0.3226	0.4381	0.3274	0.3363	0.3148	0.29	0.3079	0.308	0.2752	0.2892	0.2963	0.281
11	Oil and grease (mg/L)	1.5	3.2	5.2	3.6	6.0	4.0	6.0	4.0	5.6	7.2	8.4	4.0
12	Magnesium (mg/L)	88.8	222.7	297	148.75	335.45	216.45	116.15	40.43	83.2	201.35	160.15	40.27
13	Nickel (mg/L)	BDL	BDL	BDL	BDL	0.495	1.34	0.63	BDL	BDL	BDL	BDL	BDL
14	Lead (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
15	Cadmium (mg/L)	0.565	BDL	2.385	BDL	1.305	2.245	2.455	0.665	2.21	2.45	2.89	2.43
16	Chromium (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
17	Zinc (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
18	Copper (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19	Manganese (mg/L)	BDL	BDL	BDL	BDL	2.11	BDL	BDL	BDL	BDL	BDL	2.405	2.22
20	Cobalt (mg/L)	BDL	BDL	BDL	BDL	0.405	0.81	0.775	BDL	BDL	BDL	BDL	0.33

Note: BDL denotes Below Detection Limit.

Table 10: Physico-chemical characteristics of the marine water from sampling location 2 (Cargo Jetty)

S. No	Parameters	2A		2B		2C		2D		2E		Control 2	
		SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
1	Temperature (^{0}C)	33.1	33.1	30	32	32.9	32.8	32.8	32.7	32.8	32.6	32.8	32.8
2	pH	7.87	7.94	7.94	7.91	7.92	7.93	7.89	7.89	7.89	7.94	7.89	7.92
3	Salinity (ppt)	36.31	37.17	40.2	38.04	38.04	37.32	34.58	36.47	38.04	35.18	37.6	36.47
4	Total Dissolved Solids (mg/L)	48943	38489	46473	47007	45308	47425	45802	44846	44890	45207	45217	45343
5	Turbidity (NTU)	153.7	151.6	145.6	154.5	185.3	174.4	43.2	42.1	45.4	41.8	42.8	40.7
6	Dissolved Oxygen(mg/L)	5.8	7.5	8.2	7	6.1	6.2	6.7	7.8	6.4	7.1	5.5	6.5
7	Bio-Chemical Oxygen Demand (mg/L)	0.6	1.2	2	1.7	0.6	1	0.7	2.6	0.4	1.9	0.9	1.6
8	Chemical Oxygen Demand (mg/L)	48	44	52	50	44	40	32	30	48	36	42	38
9	Phenolic Compounds (µg/L)	33.29	23.91	29.89	33.81	41.54	26.08	16.28	9.7	16.28	10.82	9.89	3.29
10	Petroleum Hydrocarbons (µg/L)	0.2804	0.2884	0.2904	0.2977	0.2949	0.3322	0.2907	0.3112	0.3109	0.3325	0.3106	0.3039
11	Oil and grease (mg/L)	6	4.8	6.8	5.6	5.6	6.8	1.6	0.8	6.4	6.4	2.8	6.4
12	Magnesium (mg/L)	284.8	346.05	385.5	300.4	151.1	127.05	226.35	104.9	183.7	152.7	299.35	290
13	Nickel (mg/L)	0.3	1.32	BDL	BDL	BDL	BDL	BDL	1.05	2.51	BDL	1.995	0.585
14	Lead (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
15	Cadmium (mg/L)	2.195	3.04	2.83	1.275	BDL	2.22	2.665	1.14	3.02	2.16	1.175	3.175
16	Chromium (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
17	Zinc (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
18	Copper (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19	Manganese (mg/L)	BDL	2.45	2.025	BDL	BDL	BDL	BDL	0.205	BDL	BDL	BDL	BDL
20	Cobalt (mg/L)	0.705	0.705	0.705	0.705	0.705	0.705	0.705	0.705	0.705	0.705	0.705	0.705

Note: BDL denotes Below Detection Limit

Table 11. Physico-chemical characteristics of the marine water from sampling location 3 (Phang Creek)

S. No	Parameters	3A		3B		3C		3D		3E		Control 3	
		SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
1	Temperature (^{0}C)	32.8	32.6	32.7	32.5	32.7	32.5	32.6	32.4	34.4	34.4	34.4	34.4
2	pH	7.99	7.94	7.98	7.93	8.04	7.98	8.01	7.95	8.03	7.98	7.97	7.97
3	Salinity (ppt)	39.9	36.47	36.47	36.47	35.61	38.61	37.75	36.04	36.04	36.9	36.47	36.04
4	Total Dissolved Solids (mg/L)	52643	47285	54530	46275	46001	46775	47722	43492	51862	58269	46465	47327
5	Turbidity (NTU)	161.7	140.7	146.6	105.5	140.1	150.1	109.2	115.4	115.8	120.3	138.1	124.5
6	Dissolved Oxygen(mg/L)	7	8	7	6.5	6.4	6.3	6	7.4	6.7	6.6	5.5	5.5
7	Bio-Chemical Oxygen Demand (mg/L)	1.8	2.0	2	1.6	1.3	1.1	0.2	1.2	1.6	1.1	0.1	0.7
8	Chemical Oxygen Demand (mg/L)	42	38.0	40	36	42	38	42	38	40	36	48	40
9	Phenolic Compounds (µg/L)	23.19	1.96	10.1	13.6	15.46	20.51	9.79	10.51	15.56	27.01	11.44	20
10	Petroleum Hydrocarbons (µg/L)	0.3003	0.3122	0.3097	0.2989	0.3164	0.2959	0.2992	0.2955	0.284	0.297	0.2835	0.2379
11	Oil and grease (mg/L)	2.4	4.4	5.2	3.2	4.8	6.4	5.6	4.4	7.6	3.2	2.8	4.8
12	Magnesium (mg/L)	272.85	231.75	206.05	336.2	274.45	60.95	234.25	42.48	320.65	328.7	214.95	195.7
13	Nickel (mg/L)	BDL	BDL	0.46	BDL	BDL	BDL	BDL	0.52	2.11	2.235	2.37	BDL
14	Lead (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
15	Cadmium (mg/L)	2.155	2.41	1.845	1.74	1.37	0.64	0.255	0.77	2.205	0.555	BDL	0.42
16	Chromium (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
17	Zinc (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
18	Copper (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19	Manganese (mg/L)	BDL	BDL	BDL	2.28	BDL	0.175	BDL	BDL	0.005	2.86	BDL	2.085
20	Cobalt (mg/L)	BDL	BDL	BDL	BDL	0.34	0.035	BDL	1.075	1.35	0.93	1.365	0.76

Note: BDL denotes Below Detection Limit

5.1. Introduction for Plankton

Plankton are divided in two parts which are phytoplankton and zooplankton (Brink. 1993). Phytoplanktons are the primary producers in marine ecosystems and form the basis of the food web. The animal portion of plankton is known as Zooplankton. Size is very important to understanding about the classification of both zooplankton and phytoplankton. Based on size, various categories of plankton are smallest one Picoplankton (0.2-2 µm), Nanoplankton (2-20 µm), Microplankton (20-200 µm), Mesoplankton (200 µm-2 mm), Macroplankton (2-20 mm) and Megaplakton(> 20 mm) . The population of plankton diversity is largely related to Seasonal and Monthly variability in Physical, Chemical and Biological parameters; Interspecific competition among the Zooplankton; Inter-relationship for prey and predator between zooplankton and their mostly predator animals; Grazing ratio of Zooplankton; Suspension of sediment; Fluctuation in Phytoplankton abundance; Waves, Currents and Tidal turbulence effect; Fluctuation in Chlorophyll a and Nutrients; Input of Organic and other Pollution creating sources; Fish potential ratio; Monsoon effect; Suddenly changes in atmosphere; Peak time of every seasons and it's effect; Vertical migration of Zooplankton; Food selection pattern of predator; Collection time and number of collected samples, mixing of water column, high surface action, Seasonal upwelling and down welling process in water column.

Population always remains either stable or fluctuating, depending on environment conditions surrounding it (Taylor, 1988; Garzke et al. 2017). Population of plankton and other marine living organisms on which the whole aquatic life depends directly or indirectly is largely governed by the interaction of a number of biological, chemical and physical processes and tolerance to one or more of these conditions (Reid and Wood 1976).

Phytoplankton

The meaning of the term phytoplankton is the plants which are made to wander (the word 'phyto' means plant and 'planktos' means are made to wander). These are single celled marine algae, among those a few can show movement by using their flagella while others drift with currents (Zohari et al, 2014). As a photosynthetic organism they are dependent on sunlight for photosynthesis and play the most important components of natural aquatic systems as the main primary producers.

Major phytoplankton in sea water is Diatoms (Tiwari and Nair, 1998; Thakur et al, 2015), Cocolithophores, Sillicoflagellates, Blue green algae (Cyanobacteria) and Dinoflagellates. Zooplankton comprises the second level in the food chain and includes Tintinnids, Foramonifers, Radiolarians, Amphipoda, Copepoda, Calanoida, Chaetognaths, larvae of benthic invertebrates and fish larvae etc. (Gajbhiye and Abidi, 1993; Thirunavukkarosu, 2013; Chakrabarty et al. 2017).

Diatoms are divided into two main types based on their shape- the Centric diatoms or Centrales, and the Pennate diatoms or Pennales (Tabassum, 2012). Dinoflagellates have plant like mechanisms such as photosynthetic activity, storage of energy (by synthesis of carbohydrates) etc. The Cyst-forming Dinoflagellates mostly occurred in all marine habitats. They are the most primitive eukaryotes. Some Dinoflagellates are responsible for Harmful Algal Blooms (multiplication of dinoflagellates cells) in sea which causes death of fishes in large numbers

Zooplankton

Most of the zooplankton are microscopic which can drift with the currents. Although most of them can swim, they have no ability to progress against water currents (Alcaraz and Calbet, 2003). They also play important role in food web by indirectly supporting a few large ocean predators such as tuna, sharks etc, which feed upon the small planktivorous fish. In this way they are the major link in the marine life in between phytoplankton and fish including commercially important species, their study is the important part for getting knowledge of the functioning of marine ecosystems (Alcaraz and Calbet, 2003).

Nearly all fish depend on zooplankton for food in both larval stages and entire life period (Madin et al., 2001). Holoplanktons are those which live permanently in the planktonic form, while meroplanktons are the temporary members in this form. The potential of zooplankton to respond quickly to environment changes and short generation life span, make them important bioindicator of water pollution and all variation occurred in their living environment. Their study is the important part for getting knowledge of the functioning of marine ecosystems (Mees and Jones, 1997).

Zooplankton comprises the second level in the food chain and includes Tintinnids, Foramonifers, Radiolarians, Amphipoda, Copepoda, Calanoida, Chaetognaths, larvae of benthic invertebrates and fish larvae etc. (Gajbhiye and Abidi, 1993; Thirunavukkarosu, 2013; Chakrabarty et al. 2017). The zooplankton may be classified according to their habitat and depth, distribution, size and duration of planktonic life period (Omori and lkeda, 1984). There are the two main classification on the bases of habitat which are Marine plankton or Haliplankton and Freshwater plankton or Limnoplankton. Metazooplankton copepods are considered the most numerous group among the various animal species; therefore, information about their biology and physiology is key to understanding the different metazooplankton functions in the marine ecosystems (Ikeda et al., 2001).

5.2. Methodology

5.2.1 Estimation of Chlorophyll and Phaeophytin

Estimating Chlorophyll and Phaeophytin was done using known volume of water (500 ml) was filtered through a 0.45μm Millipore membrane filter paper and the pigments retained on the filter paper were extracted in 90% acetone overnight at 50°C. The extinction of the acetone extract was measured using fluorimeter before and after treatment with dilute acid (0.1N HCI).

5.2.2. Phytoplankton sampling and analysis

Phytoplankton samples were collected in the ten prefixed sampling sites using a standard plankton net with a mesh size of 51 μm. Plankton nets are with a square mouth covering an area of 0.900 cm^2 (30 cm square mouth) fitted with a flow meter (Hydrobios). Nets were towed from a moving boat for 10 minutes and the plankton adhering to the net was concentrated in the net bucket. Plankton soup from the net bucket was transferred to a pre-cleaned and rinsed container and preserved with 5%

neutralized formaldehyde. The containers were appropriately labelled. The initial and final flow meter reading was noted down for calculating the amount of water filtered to estimate plankton density. As per flow meter reading, a total amount of 165m^3 of water was filtered by the net. One liter of water was separately collected for density estimation to counter check density estimation obtained by the flow meter reading. Quantitative analysis of phytoplankton (cell count) was carried out using a sedge wick-Rafter counting chamber. One ml of soup added to a Sedgwick counting chamber was observed under an inverted compound microscope. The number of cells present in individual cells of the counting chambers (1/1000) was noted and identified up to a generic level. Several observations were fixed to represent the entire quantity of the soup (generally more than30 times) and the recorded data were used to calculate the density (No/l) using the formula, N = n×v/V (where N is the total no/l; n is an average number of cells in 1 ml; v is the volume of concentrate; V is the total volume of water filtered). The phytoplankton diversity richness and evenness were past software.

5.3. Phytopigments

The concentration of phytopigments is inversely proportional to the turbidity of the waters and in general, waters owing to the high turbidity restricts sunlight penetration essential for nutrient uptake by phytoplankton and thus inhibiting primary production. The concentration of chlorophyll pigment in the water samples ranged from 0.52 -0.78 mg/m^3 with a mean ± SD being 0.67±0.08 mg/m^3 in the Offshore (Table 12), 0.5 to 0.78 mg/m^3 with mean ± SD of 0.67±0.08 mg/m^3 in the Cargo Jetty (Table 13) and 0.47 to 0.72 mg/m^3 with mean ± SD being 0.61±0.08 mg/m^3 in the Phang creek location (Table 14).

Another phytopigment estimated was Phaeophytin, which is one of the breakdown products of Chlorophyll was also estimated in the water samples collected from all the three locations and the concentration of Phaeophytin in the marine water samples were in the concentrations such as 0.27-0.66 mg/m^3 with a Mean±SD of 0.55±0.12 mg/m^3 in the Offshore location (Table 12). In case of Cargo Jetty location, the concentration of the secondary pigment was in the range of 0.4 - 0.72 mg/m^3 with a Mean±SD of

0.579±0.098 mg/m^3 (Table 13) and in case of the creek location, the concentration of phaeophytin was almost similar when compared to the other two locations and was ranging between 0.36 – 0.69 mg/m^3 with a Mean±SD of 0.484±0.087 mg/m^3 (Table 14). An optimum ration of Chlorophyll to Phaeophytin of above 1.5 as expected for natural estuarine and coastal waters.

Table 12: Chlorophyll and Phaeophytin concentration observed in the Offshore site

Parameters	1A		1B		1C		1D		1E		1 Control	
	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
Chlorophyll	0.65	0.72	0.75	0.78	0.52	0.65	0.59	0.71	0.64	0.59	0.74	0.750
Phaeophytin	0.270	0.560	0.640	0.660	0.480	0.580	0.480	0.650	0.550	0.430	0.640	0.640

Table 13: Chlorophyll and Phaeophytin concentration observed in the Cargo Jetty site

Parameters	2A		2B		2C		2D		2E		2 Control	
	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
Chlorophyll	0.740	0.780	0.742	0.600	0.650	0.620	0.720	0.620	0.500	0.750	0.650	0.720
Phaeophytin	0.680	0.720	0.630	0.550	0.400	0.580	0.440	0.580	0.480	0.660	0.580	0.650

Table 14: Chlorophyll and Phaeophytin concentration observed in the Phang Creek site

Parameters	3A		3B		3C		3D		3E		3 Control	
	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
Chlorophyll	0.520	0.680	0.720	0.720	0.600	0.570	0.479	0.660	0.620	0.530	0.720	0.580
Phaeophytin	0.480	0.480	0.52	0.570	0.480	0.430	0.370	0.470	0.480	0.360	0.690	0.480

Phytoplankton

The study was conducted at 3 sites (or regions) at Kandla Port and near area where dredging activities is going on Creek and the stations are Offshore, Cargo Jetty and Phang Greek.

Offshore

In this site, frequently observed species were *Actinocyclus sp, Coscinodiscus centralis, Coscinodiscus wailesii, Ditylum brightwelli, Thalassionema frauenfeldii colony, Trieres mobiliensis, Pleurosigma sp, Rhizosolenia setigera, Odontella sinensis, Thalassiosira sp etc.* whereas less observed species were *Amphiprora sp, Biddulphia sp, Coscinodiscus granii, Entomoneis sp, Fragilariopsis sp colonies, Paralia sp chain, Planktoniella sol, Rhizosolenia clevei var.communi and some unidentified.*

Total 44 Phytoplankton were recorded in this Offshore area. Highest population density was recorded at site 1A-Offshore (375520nos./m^3) and lowest density was recorded at site 1B-Offshore (55840nos./m^3). The maximum number of species observed in site 1A-Offshore (30 nos.) followed by 1E (28nos.), 1Control (24 nos.), 1B&1C-Offshore (19nos.), 1D-Offshore(17nos.). The population density greatly varied between (55840nos./m^3 to 375520nos./m^3). *Biddulphia sp, Synedra ulna, Ulnaria ulna, Fragilariopsis sp colony, Pleurosigma sp, Nitzschia sp, Oocystis sp.* were recorded which are sometimes considering for pollution indicator species in water. Green algae sp and *Oocystis sp* were also recorded in some location of Offshore which may be indication of freshwater or polluted water mixing with seawater. Some Dinoflagellates were also like *Tripos furca, Tripos muelleri* . Golden brown naked biflagellate algae *Pyrophacus sp* also recorded in site 1A-Offshore. Highest population density contributor species was *Thalassionema frauenfeldii colonies (range 10240 to 90400* nos./m^3)

Cargo jetty

Total 48 Phytoplankton were recorded in this Cargo Jetty area. The population density greatly varied between 37280 Nos/m³ to 72960 Nos/m^3.Highest density value recorded at 2control-Cargo Jetty (72960 nos./ m^3) and lowest value was at 2A-Cargo

Jetty (37280 nos./m^3). The lowest number of species noted in the site 2A-Cargo Jetty(19 nos.) whereas highest in 2control-CargoJetty (29 nos.).

In this Cargo Jetty station commonly or frequently observed species were *Actinocyclus sp, Coscinodiscus centralis, Coscinodiscus radiatus, Coscinodiscus wailesii, Gyrosigma sp, Nitzschia sp, Oocystis sp, Planktoniella blanda, Pleurosigma sp, Thalassionema frauenfeldii colony, Trieres mobiliensis, Tripos furca, Tripos muelleri* etc. The rarely found species were *Amphiprora sp, Biddulphia sp, Cerataulina sp, Chaetoceros sp, Noctiluca sp, Planktoniella sol, Proboscia sp, Pyrophacus sp, Thalassionema nitzschioides colony, Trachyneis sp etc.* The Dinoflagellates *like Noctiluca sp*(mostly consider deep sea species), *Tripos furca, Tripos muelleri* and *Protoperidinium sp* were also observed during microscopic analysis that may be indication of water circulation from deep water to upper surface. *Pyrophacus sp*. are golden brown naked bi-flagellates also recorded. Some unidentified species and *Silicoflagellates (protists)* were also recorded.

Phang Creek

The population density of phytoplankton ranged from 72480 nos./m^3 to 253280 nos./m^3 same way species availability ranged from 14 to 26 nos. Maximum and Minimum value of population density were recorded in site 3Control-Phang Creek (253280nos./m^3) and 3A-Phang Creek (72480 nos./m^3) respectively. Highest number of species recorded in site 3D & 3control-Phang Creek (26 nos.) and lowest in site 3C-Phang Creek (14 nos.). Total recorded phytoplankton was 45 in this creek area. *Actinocyclus sp, Coscinodiscus centralis, Coscinodiscus granii, Coscinodiscus radiatus, Nitzschia sp, Rhizosolenia sp , Synedra ulna, Thalassionema frauenfeldii colony, Thalassiosira sp, Trieres mobiliensis, Tripos muelleri etc.* were frequently noticed during microscopic work whereas less observed species were *Bellerochea sp chain, Green algae (unidentified), Paralia sp chain, Planktoniella sol, Protoperidinium sp, Silicoflagellates (protists), Tripos furca etc.* Green algae *were also recorded*, which are generally found in fresh water and estuarine area. Silicoflagellates (protists) generally recorded deep sea but also observed in creek area may be because of water circulation pattern.

Overall view of Phytoplankton showed that a total 62 species of Marine phytoplankton were identified during winter season of the year 2024. Among them,31-Centric diatoms, 19-Pennate diatoms, 7-Dinoflagellates, 1-Blue green algae, 2-Green algae and 1-silicoflagellates and some are not identified phytoplankton was included in unidentified. Some species like *Amphiprora sp, Bellerochea sp chain, Noctiluca sp, Paralia sp chain, Planktoniella sol, Rhizosolenia imbricata, Triceratium favus, Tripos furca* and *Trichodesmium sp* etc., were rarely recorded during sample analysis. Input of the fresh water indicated by the presence of some common fresh water species like *Green algae* and blue green algae - *Trichodesmium sp.*

Presence of *Dinoflagellates (Noctiluca sp, Protoperidinium sp, Pyrophacus sp and different type of Tripos sp.)* indication of bottom water circulation up to surface water layer in some level. Noctiluca genus is also considering bioluminescent organisms and deep water species. Silicoflagellates was also recorded in some sites Kandala region. Highest phytoplankton density was observed at the site 1A-Offshore (375520nos./m^3) and lowest was observed at site 2A-Cargo Jetty (37280 nos./m^3) (Table 15). Total number of highest species observed at site 1A-Offshore (30nos.) and lowest in site 3C-Phang Creek (17 Nos.).

The high population density composed by species like *Coscinodiscus centralis, Coscinodiscus radiatus, Planktoniella blanda, Odontella sinensis, Rhizosolenia sp, Rhizosolenia setigera, Synedra ulna, Thalassionema frauenfeldii colony, Trieres mobiliensis* and *Tripos muelleri* (Table 15). This result indicated that genus *Coscinodiscus sp. Rhizosolenia sp, Thalassiosira sp, Trieres sp* and *Tripos sp* were very common with good numbers in all sites. In some sites, least number of species and low density of phytoplankton might be responsible due to some factors like extreme cool weather because of winter season, high pre-predation ratio, marine pollution (anthropogenic pressure), high turbidity, total suspended solids, water current and suddenly changes in environment conditions etc. Diatoms, type of phytoplankton, constitute major part in total phytoplankton composition The individual density of species of sites viz. has been depicted in Table 15. All values of phytoplankton density, list of phytoplankton and others shown in (Table 15).

Diversity Indices of Phytoplankton

According to Table 16, diversity indices calculation for phytoplankton showed that the Shannon Index ranged from (0.86 to 2.85) indicated low level to moderate level of diversity status. High Shannon Index was recorded at 1E-Offshore (2.85) where 28 species were recorded and low at 1B-Cargo Jetty (0.86) where 19 species were recorded. Lowest evenness recorded at site 1B – Offshore (0.12) whereas highest was in at 2A-Cargo Jetty (0.69). Dominance D index ranged from 0.08 to 0.72where higher value in 1B-Offshore (0.72) and lowest was at in 1E- Offshore (0.08). Value of Margalef D (1.06 to 2.45) showed more variation in species numbers (Table 16.).

Table 15. Density of Phytoplankton at different sites of Deendayal Port

Name of Sites	Offshore						Cargo Jetty						Phang Creek					
	1A	**1B**	**1C**	**1D**	**1E**	**1 control**	**2A**	**2B**	**2C**	**2D**	**2E**	**2 control**	**3A**	**3B**	**3C**	**3D**	**3E**	**3 control**
Genus of Phytoplankton																		
Actinocyclus sp	52000	320	4480	8320	960	7200	800	4160	800	6080	800	1600	6720	9120	14400	8320	11200	10240
Amphiprora sp	800	0	0	0	0	0	0	0	0	0	0	640	0	0	0	0	0	1120
Bacillaria paxillifera colonies	640	320	0	0	1280	0	640	0	0	800	960	480	0	0	0	1440	640	0
Bellerochea sp chain	960	0	0	0	640	640	0	640	960	0	0	0	0	0	0	800	0	0
Biddulphia sp	0	0	640	0	0	640	0	0	0	0	0	640	0	0	0	0	160	0
Cerataulina sp	0	0	0	0	0	0	0	0	0	480	0	0	0	0	0	0	0	0
Chaetoceros decipiens	0	0	0	0	0	0	0	1120	0	0	480	0	0	0	0	0	0	0
Chaetoceros sp	5120	640	320	0	0	1120	800	0	0	0	0	800	0	0	0	0	0	0
Coscinodiscus centralis	16320	480	5280	6080	6560	7520	4960	5920	9120	3360	6400	10560	13920	59200	15840	11520	8800	19360
Coscinodiscus granii	64000	0	0	0	0	0	0	0	0	0	0	0	7200	88800	83200	50400	83200	48000
Coscinodiscus radiatus	68000	800	4320	5440	8320	8800	5920	4160	9120	6880	7520	15520	16800	65600	60800	69600	57600	63200
Coscinodiscus sp.	0	0	5920	0	3680	1440	1120	0	0	0	1600	1600	1600	3360	0	0	0	0
Coscinodiscus wailesii	0	1600	4480	4480	5120	3200	0	3360	4320	2720	6560	5920	0	0	0	0	0	0
Cyclotella sp	0	320	0	0	0	1120	0	0	0	0	0	0	0	0	0	0	0	0
Ditylum brightwelli	7520	480	960	1440	1440	0	640	1440	0	0	1280	0	800	0	640	0	0	0
Entomoneis sp	0	0	0	0	320	0	0	0	0	0	0	0	0	0	0	0	0	0
Fragilariopsis sp colonies	0	0	0	0	640	0	0	0	0	1120	0	0	0	0	0	640	0	640
Green algae (unidentified)	0	0	0	480	0	480	0	0	0	0	0	0	0	0	320	0	0	960
Gyrosigma sp.	1280	0	320	0	640	640	0	480	480	480	480	640	0	800	0	640	800	1280
Hemiaulus sp chain	0	0	0	0	0	0	480	0	0	0	0	0	0	0	0	0	0	0
Melosira sp colony	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	800
Navicula sp	0	0	0	0	0	0	0	0	0	0	0	0	0	640	0	480	0	640
Nitzschia sigmoidea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	480	0	0	640
Nitzschia sp	320	0	480	0	0	3200	0	480	960	1120	1120	1120	800	960	0	2720	800	1440
Noctiluca sp	0	0	0	0	0	0	0	0	0	480	0	0	0	480	0	0	0	0
Odontella sinensis	12800	320	800	640	0	1120	0	640	1120	0	0	1600	1280	0	0	1920	0	320
Odontella mobiliensis	0	320	0	0	0	0	0	0	0	640	1280	0	0	1600	480	2080	2240	0
Oocystis sp	6400	320	0	0	0	0	2080	0	480	2240	1920	1280	1760	0	0	0	1600	0
Paralia sp chain	480	0	0	0	0	0	0	0	0	0	0	0	0	0	0	320	0	0
Pinnularia sp	0	0	0	0	0	0	0	0	0	0	0	480	0	1120	0	0	0	
Planktoniella blanda	800	0	0	0	1600	1120	480	320	640	640	0	640	0	1760	0	1920	2400	640
Planktoniella sol	800	0	0	0	0	0	0	640	320	0	0	0	0	0	0	0	320	0

Pleurosigma angulatum	0	0	0	0	640	0	0	480	0	0	0	0	0	0	0	480	800	0
Pleurosigma sp.	1440	320	0	960	800	1760	1120	800	1600	0	1280	1120	800	480	0	0	3360	1440
Proboscia sp	640	640	0	2400	0	0	0	0	0	0	1600		0	0	0	0	0	0
Protoperidinium sp	0	0	0	0	0	0	0	0	0	640	320	800	480	0	0	0	960	0
Pseudo-nitzschia sp chain	0	0	0	0	480	0	0	0	0	0	1120	0	0	0	0	0	0	0
Pyrophacus sp	640	0	0	0	0	0	0	0	0	640	0	0	0	0	0	0	0	0
Rhizosolenia bergonii	0	0	0	0	0	0	0	0	0	1440	320	0	0	0	0	0	0	0
Rhizosolenia clevei var.communis	0	0	0	0	0	800	0	0	0	0	0	0	0	0	0	0	0	0
Rhizosolenia imbricata	6720	480	0	0	2080	0	2080	0	640	960	0	1280	0	0	0	0	960	0
Rhizosolenia setigera	5120	0	640	960	1440	320	2400	0	1280	800	2400	1600	0	0	1600	1760	2080	2080
Rhizosolenia sp	0	320	960	2240	4000	960	0	0	1120	3200	4160	2720	2560	3840	0	3200	2400	2240
Silicoflagellates (protists)	0	0	0	0	1120	960	0	0	0	0	0	480	0	0	0	640	0	0
Surirella sp	0	0	0	0	0	0	0	0	0	0	0	0	480	480	0	0	480	0
Synedra sp	0	0	0	0	0	0	0	0	640	0	0	0	800	800	0	1120	0	1120
Synedra ulna	1600	320	480	320	1120	1440	960	800	480	480	640	1120	0	960	640	1760	2400	960
Thalassionema frauenfeldii colonies	90400	47200	30400	30400	10240	15200	7360	8320	8320	14560	12320	12960	12320	8320	14720	46400	28800	17920
Thalassionema nitzschioides colonies	0	0	0	0	0	0	0	0	0	640	0	0	0	0	0	0	0	0
Thalassiosira aculeata	8160	0	0	960	2400	1920	0	1280	0	0	0	1120	0	0	0	0	960	2400
Thalassiosira sp.	6080	0	640	3200	1760	4640	1600	1760	800	0	0	1600	960	800	6880	11520	9120	3200
Trachyneis sp	0	0	0	0	0	0	0	480	0	0	0	0	0	0	0	0	0	0
Triceratium favus	0	0	0	0	0	0	0	0	0	0	0	0	0	320	0	0	0	0
Triceratium sp	2240	0	0	0	480	1600	0	0	0	0	0	640	0	0	0	0	1760	1440
Trichodesmium sp	0	0	0	0	0	0	0	0	0	0	1920	0	0	0	0	0	0	0
Trieres mobiliensis	7520	320	800	1440	2560	0	1120	1760	1120	1280	960	1280	1120	1440	2880	1920	2880	1440
Tripos azoricus	0	0	0	0	0	0	0	480	0	0	960	0	0	0	0	0	0	0
Tripos furca	5120	0	480	640	480	0	960	1120	1120	0	800	1600	0	0	0	2560	0	0
Tripos fusus	0	0	0	0	0	0	0	0	0	0	0	0	0	960	0	0	0	0
Tripos muelleri	1120	320	800	0	480	0	1760	960	800	960	960	1120	1760	1440	1920	1600	0	1120
Ulnaria (Synedra) ulna	480	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unidentified	0	0	0	0	320	0	0	0	0	160	2400	0	320	0	0	640	0	320
Density of Phytoplankton (diff. sites wise.)(no/m^3)	375520	55840	63200	70400	61600	67840	37280	41600	46240	52800	62560	72960	72480	253280	204800	226400	226720	184960
Total= 2176480 no/m^3																		
Total No Of Genus/Species=**62**																		

Table 16. Diversity Indices of Phytoplankton at different sites at Deendayal Port

Variables	Offshore						Cargo jetty						Phang Creek					
	1A	**1B**	**1C**	**1D**	**1E**	**1-control**	**2A**	**2B**	**2C**	**2D**	**2E**	**2-contrl**	**3A**	**3B**	**3C**	**3D**	**3E**	**3-control**
Taxa_S	30	19	19	17	28	24	19	23	22	25	27	29	19	23	14	26	25	26
Individuals (Nos/m^2)	375520	55840	63200	70400	61600	67840	37280	41600	46240	52800	62560	72960	72480	253280	204800	226400	226720	184960
Dominance_D	0.14	0.72	0.26	0.22	0.08	0.10	0.10	0.10	0.13	0.12	0.09	0.11	0.14	0.25	0.27	0.19	0.22	0.21
Shannon Diversity Index (H)	2.33	0.86	1.94	2.04	2.85	2.64	2.58	2.68	2.47	2.58	2.80	2.68	2.27	1.74	1.63	2.07	1.98	2.03
Simpson_1-D	0.86	0.28	0.74	0.78	0.92	0.90	0.90	0.90	0.87	0.88	0.91	0.89	0.86	0.75	0.73	0.81	0.78	0.79
Evenness_e^H/S	0.34	0.12	0.37	0.45	0.62	0.58	0.69	0.63	0.54	0.53	0.61	0.51	0.51	0.25	0.36	0.30	0.29	0.29
Menhinick	0.05	0.08	0.08	0.06	0.11	0.09	0.10	0.11	0.10	0.11	0.11	0.11	0.07	0.05	0.03	0.05	0.05	0.06
Margalef	2.26	1.65	1.63	1.43	2.45	2.07	1.71	2.07	1.96	2.21	2.35	2.50	1.61	1.77	1.06	2.03	1.95	2.06

Zooplankton

The study was conducted at 3 sites in Kandla Port and nearby areas where dredging activities are going on. The three selected study stations are Offshore, Cargo Jetty and Phang Greek.

Offshore

Calanoida (unidentified), Euterpina sp (Harpacticoida), Foraminifera (unidentified), Nauplius larva of Copepoda, Nauplius larvae of Barnacles, Ophiopluteus Larva (Echinodermata), Ostracoda, *Paracalanus sp* (Calanoida), Sponge Spicules, Zoea larva of Crab etc. were the mostly common zooplankton and throughout observed in all sites of Offshore area. Highest population density was recorded at site 1A-Offshore (144000 nos./100m^3) where number of species was highest (32 nos.) and lowest density in 1C-Offshore (26080 nos./100m^3) where number of species recorded lowest numbers (23 nos.). High biomass was observed in the site 1E-Offshore (44.92 ml/100m^3) and low biomass was recorded in site 1D-Offshore (15.24 ml/100m^3). The range of the population density, biomass and number of species were (26080 to 144000 nos./100m^3), (15.24 to 44.92 ml/100m^3) and (23 32 to 31 nos.) respectively in all sites.

Less observed species were Animal egg (Unidentified), *Appendicularia sp* (Tunicata), *Bestiolina sp* (Calanoida), Egg development stage, Jellyfish (small), *Leprotintinnus sp* (Tintinnida), Narcomedusae (Hydrozoa:Cnidaria), Protozoa and Zoothamnium sp (ciliate colony) in this station. Total 58 zooplankton was recorded in Offshore area adding that more composition of zooplankton by the Phylum Arthropoda (Crustacea), Tintinnids and Foraminifera and Sponge Spicules (Porifera).

Cargo Jetty

The population density of zooplankton varied from 33440 nos./100m^3 to 65440 nos./100m^3. Maximum density was noticed in site 2E-Cargo Jetty (65440 nos./100m^3) and minimum was at site 2D-Cargo Jetty (33440 nos./100m^3). Maximum number of species (29nos.) found 2E & 2C - Cargo Jetty minimum number of species was observed in site 2control-Cargo Jetty (25nos.). Biomass ranged between 8.22 to 66.67

ml/100m^3 where highest biomass noted in site2E-Cargo Jetty and lowest in 2D-Cargo Jetty. Frequently observed species were Calanoida (unidentified), *Clausocalanus sp* (Calanoida), *Corycaeus sp* (Calanoida), *Euterpina sp* (Harpacticoida), Medusa of Obelia sp (Hydrozoa), Mysids (shrimp like), Ophiopluteus Larva (Echinodermata), Polychaete larvae (Annelids), Protozoaea larva (Crustacea), Sagitta sp (arrow worm), Sponge Spicules, Zoea larva of Crab etc. whereas less observed species were Animal egg (Unidentified), *Bolivina sp* (Foraminifera), Cyclops sp (Cyclopoida), Harpacticoida (unidentified), Leprotintinnus sp (Tintinnida), Microsetella sp (Harpacticoida), *Pontella sp* (Calanoida), *Spiroloculina sp* (Foraminifera), *Temora sp* (Calanoida), *Tortanus sp* (Calanoida) etc. Some Unidentified species and larval stages were also reported. Total recorded zooplanktons were 47 in Cargo Jetty.

Phang Creek

This Creek area was represented by the zooplankton fauna majority of them were Acartia sp (Calanoida), Calanoida (unidentified), *Clausocalanus sp* (Calanoida), Foraminifera (unidentified), Nauplius larvae of Barnacles, *Sagitta sp* (arrow worm), *Subeucalanus sp* (Calanoida), Veliger larvae of Bivalve, Zoea larva of Crab.Very less time or rarely recorded species were *Acrocalanus sp* (Calanoida), *Cyclops sp* (Cyclopoida), Cyphonautes larva (Bryozoan), *Favella sp* (Tintinnida), Gnathiid isopoda larvae, Larva Of Isopoda, *Leprotintinnus simplex* (Tintinnida), Medusa of Obelia sp (Hydrozoa), *Oncaea sp* (Cyclopoida), *Pontella sp* (Calanoida), Radiolaria skeleton etc. The range of zooplankton biomass was between 8.06 to 20.97 ml/100m^3. Highest Biomass was recorded in site 3D-Phang creek (20.97 ml/100m^3) and lowest in site 3A-Phang creek (8.06 ml/100m^3). Maximum and Minimum species count was at in site 3B-Phang creek (31nos.) and 3D-Phang Creek (08nos.) respectively. Population density was maximum recorded in site 3B-Phang Creek (40320 nos./100m^3) and minimum in site 3D-Phang Creek (8000 nos./100m^3). In site 3D-Phang creek comparatively low density according to other sites may be because of high predator pressure or some environment changes.

Overall assessment of zooplankton showed that the total number of 79 Zooplankton recorded during winter season. Out of these (79) zooplankton, 58 zooplankton recorded in Offshore region, 47 zooplankton at Cargo Jetty and 48 zooplankton in Phang Creek region. The recorded zooplankton of all 3 stations mainly representing Phylum Arthropoda (Crustacea), Protozoa (mainly foraminifera and tintinnids), Porifera (sponge spicules). Crustacean zooplankton was the dominant due to the dominance of different larval stages and Copepods which mainly feed phytoplankton. More larval stage of crustacean and other animals observed in samples that indicated reproduction and development season of animals from larval to mature animal.Generally zooplankton population dynamics and studies emphasize is given up to group level rather than to species level because of microscopic size of zooplankton so owing to the difficulty in identifying the zooplankton as some species are considered as a group or genus level. The most dominant or frequently observed species(all 3 station) were Calanoida (unidentified), *Clausocalanus sp* (Calanoida), *Euterpina sp* (Harpacticoida), Foraminifera (unidentified), Nauplius larva of Copepoda, Nauplius larvae of Barnacles, Nauplius larvae of Crustacea, Ophiopluteus Larva (Echinodermata), Ostracoda, *Paracalanus sp* (Calanoida), Sponge Spicules, Veliger larvae of Bivalve, Zoea larva of Crab etc. Foraminifera belonging to the meroplankton were present at all three stations.

Overall range of Population density, Biomass and Number of species were (8000 to 144000no/100 m^3), (8.06 to 66.67 ml/100m^3) and (08 to 32 nos) respectively. Average high biomass noted at Cargo Jetty (31.42 ml/100m^3) followed by Offshore (26.16 ml/100m^3) than Phang Creek (13.56 ml/100m^3) (Table 17, 18, 19). Highest population density was recorded in site 1A-Offshore (144000 Nos/100m^3) and lowest was recorded in site 3D-Phang Creek (8000 No/100m3). Among all recorded zooplankton, majority dominance occurrence was by the Copepoda, Crustacean larvae, Spong Spicules, Foraminifera (Protozoa), Tintinnids (Protozoa), Zoea larva of Crab, Mysids (shrimp like),Egg capsules of Littorinids (Mollusca).

Maximum zooplankton faunal composition was dominated by the Phylum Arthropoda, Mollusca, Protozoa, Porifera. The Fish larva (Ichthyoplankton) was also recorded in all 3 locations. The Zooplankton of Chaetognatha, Tunicata, Cnidaria, Amoebozoa were only represented by the species namely *Sagitta sp (arrow worm),* *Appendicularioa sp, Narcomedusae (Hydrozoa), Arcella sp.* respectively. Veliger larva of Bivalve and Gastropoda shells include in Phylum Mollusca. The Echinodermata phylum represented by the Ophiopluteus larva and Gastrula larva of Sea star.

In Offshore**,** maximum Occurrence (%) was by the Nauplius larva of Barnacles (11.14%) and minimum by the Hydrozoa larva (Cnidaria) (0.05%). In Cargo Jetty, maximum Percentage of Occurrence (%) by the Nauplius larva of Copepoda (9.27%) and minimum by some unidentified species (0.06%). In Phang Creek, maximum occurrence by the Nauplius larva of Copepoda (9.89%) and minimum (0.19%) by the *Acrocalanus sp* (Calanoida), Cyphonautes larva (Bryozoan), Gnathiid isopoda larvae, Harpacticoida (unidentified), *Oncaea sp* (Cyclopoida), Zoea larva of Procelain crab and some Unidentified species (Table 17, 18, 19).

During microscopic sample analysis more number of species varieties of Foraminifera, Sponge spicules, Crustacean larva and Tintinnidswere observed. These all three are very important for paleontological study aspects and also for evolutionary, ecological and environmental rebuilding. Some species of Ostracoda, Foraminifera and Sponge spicules are considered in microfossils materials. Some deep sea species also recorded that is indication of water circulation pattern. Data on zooplankton density, list of zooplankton is shown in Table 17, 18 and 19.

Plankton identification, both zooplankton and phytoplankton, were done by using relevant identification and taxonomic keys and with standard literatures, monographs and research articles.(Kasturirangan, 1963; APHA, 1992; Mitra et al., 2003;Goswami, 2005; Carling et al., 2004; Mandal, 2004; Hussain & Kalaiyarasi, 2013; Guglielmo et al., 2015; Hussain et al., 2016; Sreenivasulu et al., 2017; NIO,1998; NIO,2002) ,etc

Diversity Indices of Zooplankton

Table 20 *shows* diversity indices of zooplankton.The Shannon-wiener diversity index (H') fluctuated between 1.82 to 3.17 indicated moderate to quite high range of diversity added indication of healthy body of water with a maximum value in site 1D-Offshore (3.17) where maximum number of species noted (31 nos.) after 1D-Offshore

(32 nos.) and minimum value in site 3D-Phang Creek (1.82) where species number was 8.Range of the evenness was 0.50 to 0.82 where lowest and highest recorded in site 1A-Offshore (0.50) and 2A-Cargo Jetty (0.82) respectively. Range of Simpson index was 0.80 to 0.95. The range value of Margalef indices was 0.78 to 2.83 that means high species number variations. (Table 20).

Table 17.Density of Zooplankton at Offshore site of Deendayal Port

Name of Genera/Group	1A	1B	1C	1D	1E	1 Control	Individual total density (no/100m^3)	% of Occurrence (Site-wise)
Acartia sp (Calanoida)	1120	480	0	480	480	0	2560	0.75
Animal egg (Unidentified)	0	160	0	480	0	0	640	0.19
Appendicularia sp (Tunicata)	0	0	0	0	0	320	320	0.09
Arcella sp (Amoebozoa)	800	0	0	1280	4000	0	6080	1.77
Bestiolina sp (Calanoida)	0	480	0	0	0	0	480	0.14
Bolivina sp (Foraminifera)	0	0	320	0	0	0	320	0.09
Calanoida (unidentified)	5600	4320	800	1760	2400	7360	22240	6.48
Centropages sp (Calanoida)	0	480	0	0	0	480	960	0.28
Clausocalanus sp (Calanoida)	2560	2880	0	0	0	3040	8480	2.47
Copepoda eggs sac(egg pouch)	0	480	0	320	640	0	1440	0.42
Cyclopoida (unidentified)	2560	1440	640	640	0	0	5280	1.54
Cyclops sp (Cyclopoida)	23520	0	0	640	0	0	24160	7.04
Cyphonautes larva (Bryozoan)	640	640	0	320	0	0	1600	0.47
Egg capsules of Littorinids	640	0	0	480	0	800	1920	0.56
Egg development stage	640	0	0	0	0	0	640	0.19
Euchaeta sp (Calanoida)	0	0	0	0	480	640	1120	0.33
Euterpina sp (Harpacticoida)	2240	800	0	640	960	1920	6560	1.91
Fish larva	320	320	0	0	320	320	1280	0.37
Foraminifera (unidentified)	9120	800	800	1600	640	800	13760	4.01
Gastrula larva of Sea star	640	0	0	640		0	1280	0.37
Globigerina sp (Foraminifera)	0	0	640	0	1600	0	2240	0.65
Heteropoda shells (gastropods)	960	0	0	1280	480	0	2720	0.79
Hydrozoa larva (Cnidaria)	0	0	0	0	0	160	160	0.05
Jellyfish (small)	0	0	0	320	0	0	320	0.09
Leprotintinnus pellucidus (Tintinnida)	0	0	480	0	0	0	480	0.14
Leprotintinnus sp (Tintinnida)	0	0	0	0	0	640	640	0.19
Microsetella sp (Harpacticoida)	4960	0	960	0	0	0	5920	1.72
Mysids (shrimp like)	1120	1440	960	0	0	480	4000	1.16
Mysis larva of Lucifera sp	0	0	0	0	0	480	480	0.14
Mysis larva of Prawn	0	0	0	0	800	1600	2400	0.70
Narcomedusae (Hydrozoa:Cnidaria)	0	480	0	0	0	0	480	0.14
Nauplius larva of Copepoda	8160	4800	2880	3520	2400	6400	28160	8.20
Nauplius larvae of Barnacles	7200	7360	2560	5120	6560	9440	38240	11.14
Nauplius larvae of Crustacea	10400	3040	640	0	0	0	14080	4.10
Ophiopluteus Larva	800	320	800	800	480	640	3840	1.12

(Echinodermata)								
Ostracoda	4480	800	800	640	640	800	8160	2.38
Paracalanus sp (Calanoida)	3200	3200	2560	2400	1600	2400	15360	4.47
Parvocalanus sp (Calanoida)	0	2720	2080	0	1280	1920	8000	2.33
Polychaete larvae (Annelids)	2560	800	960	640	640	480	6080	1.77
Pontellid nauplius larva (Calanoida)	0	0	320	0	0	0	320	0.09
Protozoa	0	320	0	0	0	0	320	0.09
Protozoaea larva (Crustacea)	0	0	0	640	0	480	1120	0.33
Radiolaria skeleton	0	0	0	640	0	0	640	0.19
Sagitta sp (arrow worm)	2240	0	1440	640	1600	0	5920	1.72
Spirillina limbata	960	0	0	0	0	0	960	0.28
Sponge Spicules	1120	1120	1600	800	1760	2720	9120	2.66
Subeucalanus sp (Calanoida)	3520	2560	0	2560	0	2880	11520	3.36
Tardigrade (Water bear)	0	0	0	0	0	320	320	0.09
Tintinnids (unidentified)	0	480	0	0	0	0	480	0.14
Tintinnopsis beroidea (Tintinnida)	0	0	640	960	0	0	1600	0.47
Tintinnopsis cylindrica (Tintinnida)	3840	320	480	640	0	0	5280	1.54
Tintinnopsis orientalis (Tintinnida)	33600	0	0	640	0	0	34240	9.97
Tintinnopsis sp (Tintinnida)	0	0	0	2400	0	0	2400	0.70
Veliger larvae of Bivalve	1440	480	0	480	960	320	3680	1.07
Zoea larva of Crab	2400	960	2400	1600	6240	6560	20160	5.87
Zoea larva of Procelain crab	0	0	320	480	0	0	800	0.23
Zoothamnium sp(ciliate colony)	640	0	0	0	0	0	640	0.19
Unidentified larva	0	160	0	0	800	0	960	0.28
Total No. Of Genera/Groups=58								
Site-wise Total Density (no/100m^3)	144000	44640	26080	36480	37760	54400	**Total Density =343360**	**100%**
Biomass (ml/100m^3)	**17.86**	**19.29**	**18.99**	**15.24**	**44.92**	**40.63**		

Table 18. Density of Zooplankton at Cargo Jetty site of Deendayal Port

Name of Genera/Group	2A	2B	2C	2D	2E	2 Control	Individual total density (no/100m^3))	% of Occurrence (Site-wise)
Acartia sp (Calanoida)	640	0	1280	0	2560	1440	5920	2.20
Ammonia sp (Foraminifera)	320	0	0	480	0	640	1440	0.54
Animal egg (Unidentified)	0	320	0	0	0	0	320	0.12
Bolivina sp (Foraminifera)	0	0	320	0	0	160	480	0.18
Calanoida (unidentified)	2080	3200	2720	0	8160	4800	20960	7.79
Clausocalanus sp (Calanoida)	1920	3040	480	1760	1920	2080	11200	4.16
Corycaeus sp (Calanoida)	2400	3360	640	960	4160	1440	12960	4.82
Cyclops sp (Cyclopoida)	480	0	0	0	0	0	480	0.18
Cyphonautes larva (Bryozoan)	0	960	320	0	320	0	1600	0.59
Egg capsules of Littorinids	0	640	320	800	480	480	2720	1.01
Euterpina sp (Harpacticoida)	1440	2240	800	2720	2720	1600	11520	4.28
Fish larva	640	640	0	0	0	0	1280	0.48
Foraminifera (unidentified)	1280	960	0	0	320	1600	4160	1.55
Globigerina sp (Foraminifera)	800	0	800	320	640	0	2560	0.95
Harpacticoida (unidentified)	0	0	0	0	320	0	320	0.12
Heteropoda shells (gastropods)	1280	1760	0	640	0	0	3680	1.37
Leprotintinnus sp (Tintinnida)	0	0	0	320	0	0	320	0.12
Medusa of Obelia sp (Hydrozoa)	320	4320	1600	0	4160	2080	12480	4.64
Microsetella sp (Harpacticoida)	0	0	0	640	0	0	640	0.24
Mysids (shrimp like)	1600	1440	2240	0	3520	2240	11040	4.10
Mysis larva of Lucifera sp	0	320	320	0	0	0	640	0.24
Nauplius larva of Copepoda	1760	4800	2720	4000	7520	4160	24960	9.27
Nauplius larvae of Barnacles	3520	0	4160	2400	0	2400	12480	4.64
Nauplius larvae of Crustacea	1920	0	0	960	0	0	2880	1.07
Ophiopluteus Larva (Echinodermata)	480	800	320	640	1280	960	4480	1.66
Ostracoda	800	480	320	480	640	320	3040	1.13
Paracalanus sp (Calanoida)	960	1120	640	800	1280	0	4800	1.78
Parvocalanus sp (Calanoida)	0	0	1120	0	4000	1600	6720	2.50
Polychaete larvae (Annelids)	640	2240	4160	1120	320	1600	10080	3.75
Pontella sp (Calanoida)	0	0	0	0	480	0	480	0.18
Pontellid nauplius larva (Calanoida)	0	320	0	160	320	480	1280	0.48
Prawn brood eggs	0	10080	0	0	0	0	10080	3.75

Prawn larvae (premature stage)	0	3680	1920	1600	4160	6240	17600	6.54
Protozoaea larva (Crustacea)	1600	480	1600	960	2560	0	7200	2.68
Sagitta sp (arrow worm)	480	1440	320	320	2880	1600	7040	2.62
Spirillina sp (Foraminifera)	0	0	0	480	480	0	960	0.36
Spiroloculina sp (Foraminifera)	0	0	0	0	0	320	320	0.12
Sponge Spicules	640	3200	800	960	1920	640	8160	3.03
Subeucalanus sp (Calanoida)	1120	3520	640	1760	0	0	7040	2.62
Tardigrade (Water bear)	0	0	480	0	0	640	1120	0.42
Temora sp (Calanoida)	0	0	960	0	0	0	960	0.36
Tintinnopsis radix (Tintinnida)	0	0	0	0	320	0	320	0.12
Tortanus sp (Calanoida)	0	320	0	0	0	0	320	0.12
Veliger larvae of Bivalve	1120	320	800	800	1280	0	4320	1.61
Zoea larva of Crab	3360	0	2240	6720	6400	5280	24000	8.92
Unidentified	0	0	0	160	0	0	160	0.06
Unidentified larva	0	0	640	480	320	160	1600	0.59
Total No. Of Genera/Groups=47								
Site-wise Total Density (no/100m^3)	33600	56000	35680	33440	65440	44960	**Total Density =269120**	**100%**
Biomass (ml/100m^3)	**19.09**	**24.59**	**32.89**	**8.22**	**66.67**	**37.04**		

Table 19. Density of Zooplankton at Phang Creek site of Deendayal Port

Name of Genera/Group	3A	3B	3C	3D	3E	3 Control	Total density (no/100m3)	% of Occurrence (Site-wise)
Acartia sp (Calanoida)	1920	1280	1760	0	2560	2240	9760	5.74
Acrocalanus sp (Calanoida)	0	0	320	0	0	0	320	0.19
Arcella sp (Amoebozoa)	0	0	0	2080	480	0	2560	1.51
Calanoida (unidentified)	4160	2240	3040	480	4160	960	15040	8.85
Clausocalanus sp (Calanoida)	2720	2560	1120	0	1280	480	8160	4.80
Corycaeus sp (Calanoida)	1440	1120	1280	0	0	1440	5280	3.11
Cyclopoida (unidentified)	0	320	480	0	800	0	1600	0.94
Cyclops sp (Cyclopoida)	320	0	0	0	0	320	640	0.38
Cyphonautes larva (Bryozoan)	0	320	0	0	0	0	320	0.19
Egg capsules of Littorinids	0	480	800	0	320	800	2400	1.41
Euchaeta sp (Calanoida)	0	1440	1120	0	1280	0	3840	2.26
Euterpina sp (Harpacticoida)	1440	1760	1600	0	1120	0	5920	3.48
Favella sp (Tintinnida)	0	0	640	0	0	0	640	0.38
Fish larva	0	800	0	0	320	0	1120	0.66
Foraminifera (unidentified)	1120	960	640	320	960	1280	5280	3.11
Globigerina sp (Foraminifera)	0	480	0	0	0	0	480	0.28
Gnathiid isopoda larvae	320	0	0	0	0	0	320	0.19
Harpacticoida (unidentified)	0	160	160	0	0	0	320	0.19
Heteropoda shells (gastropods)	1280	2400	1440	0	640	0	5760	3.39
Larva Of Isopoda	0	0	0	640	0	0	640	0.38
Larva of Stomatopoda (Arthropoda)	0	320	480	0	0	0	800	0.47
Leprotintinnus simplex (Tintinnida)	0	0	0	0	480	0	480	0.28
Leprotintinnus sp (Tintinnida)	0	640	480	2400	0	640	4160	2.45
Medusa of Obelia sp (Hydrozoa)	1760	0	0	0	0	320	2080	1.22
Mysids (shrimp like)	480	1120	0	0	320	0	1920	1.13
Mysis larva of Lucifera sp	640	320	0	0	320	0	1280	0.75
Nauplius larva of Copepoda	4320	4320	3360	0	1600	3200	16800	9.89
Nauplius larvae of Barnacles	3040	800	3840	0	2400	1440	11520	6.78
Nauplius larvae of Crustacea	0	0	0	640	0	0	640	0.38
Oncaea sp (Cyclopoida)	0	0	0	0	320	0	320	0.19
Ophiopluteus Larva (Echinodermata)	640	0	800	0	0	320	1760	1.04
Ostracoda	480	320	480	0	640	640	2560	1.51
Paracalanus sp (Calanoida)	0	960	0	0	320	640	1920	1.13
Parvocalanus sp (Calanoida)	0	1280	800	0	1120	0	3200	1.88
Polychaete larvae (Annelids)	0	960	960	0	1440	1120	4480	2.64

Pontella sp (Calanoida)	0	0	0	0	480	0	480	0.28
Prawn larvae (premature stage)	640	1600	0	0	0	0	2240	1.32
Protozoaea larva (Crustacea)	1440	1760	1280	0	800	1120	6400	3.77
Radiolaria skeleton	0	800	0	0	0	0	800	0.47
Sagitta sp (arrow worm)	1440	3040	1120	0	2240	800	8640	5.08
Small Gastropoda shells	800	0	480	0	0	320	1600	0.94
Sponge Spicules	640	480	800	1120	480	320	3840	2.26
Subeucalanus sp (Calanoida)	1440	0	1600	0	1760	1280	6080	3.58
Tintinnids (unidentified)	0	0	0	0	0	480	480	0.28
Veliger larvae of Bivalve	2080	2240	800	0	320	320	5760	3.39
Zoea larva of Crab	2400	3040	1600	0	1120	480	8640	5.08
Zoea larva of Procelain crab	0	0	0	0	0	320	320	0.19
Unidentified	0	0	0	320	0	0	320	0.19
Total No. Of Genera/Groups=48								
Site-wise Total Density (no/100m^3)	36960	40320	33280	8000	30080	21280	**Total density =169920**	**100%**
Biomass (ml/100m^3)	**8.06**	**15**	**10.71**	**20.97**	**8.46**	**18.18**		

Table 20. Diversity indices of Zooplankton at different sites of Deendayal Port

Variables	Offshore						Cargo jetty						Phang Creek					
	1A	**1B**	**1C**	**1D**	**1E**	**1-control**	**2A**	**2B**	**2C**	**2D**	**2E**	**2-contrl**	**3A**	**3B**	**3C**	**3D**	**3E**	**3-control**
Taxa_S	32	30	23	32	23	27	26	27	29	27	29	25	24	31	28	8	28	24
Individuals (nos. /m^2)	144000	44640	26080	36480	37760	54400	33600	56000	35680	33440	65440	44960	36960	40320	33280	8000	30080	21280
Dominance_D	0.10	0.07	0.06	0.06	0.09	0.09	0.05	0.07	0.06	0.08	0.07	0.07	0.06	0.05	0.06	0.20	0.06	0.07
Shannon Diversity Index(H)	2.77	2.92	2.92	3.15	2.74	2.72	3.06	2.89	3.04	2.87	2.93	2.86	2.95	3.17	3.10	1.82	3.05	2.94
Simpson_1-D	0.90	0.93	0.94	0.94	0.91	0.91	0.95	0.93	0.94	0.92	0.93	0.93	0.94	0.95	0.94	0.80	0.94	0.93
Evenness	0.50	0.62	0.80	0.73	0.67	0.56	0.82	0.67	0.72	0.65	0.65	0.70	0.79	0.77	0.79	0.77	0.76	0.78
Menhinick	0.08	0.14	0.14	0.17	0.12	0.12	0.14	0.11	0.15	0.15	0.11	0.12	0.12	0.15	0.15	0.09	0.16	0.16
Margalef	2.61	2.71	2.16	2.95	2.09	2.38	2.40	2.38	2.67	2.50	2.53	2.24	2.19	2.83	2.59	0.78	2.62	2.31

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Second Season Report
(2023 - 2024)

Studies on Dredged Materials for the presence of Contaminants and suggesting suitable disposal options

(As per EC & CRZ Clearance accorded by the MoEF & CC, GoI dated 19/12/2016 - Specific Condition No. vii)

DPA Work order No. EG/WK/4751/Part (EC&CRZ-1) / 84. Dt. 18.09.2021.

<u>Submitted by</u>

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

Submitted to

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

Project Team

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

S. No	Name and Designation	Role	Background
1.	Dr. K. Karthikeyan Assistant Director	Principal Investigator	M.Sc., Ph.D. in Environmental Science; 15 years of experience in Marine Environmental Monitoring and Pollution Assessment studies.
2.	Dr. G. Jayanthi Scientist	Co-Investigator	MSc., MPhil., PhD in Botany; 13 years of Research and teaching experience inclusive of Post-Doctoral experience for 5 years.
3.	Dr. Krushnakant. D. Baxi Scientific Officer	Co-Investigator	Ph.D in Zoology (Marine Biology) with 5 years of experience
4.	Ds. Monika Sharma Sr. Scientific Asst.	Team member	M.Sc. in Environmental Sciences; 7 years of experience in Marine water and sediment analysis
5.	Ms. Dipti Parmar Scientific Assistant	Team member	M.Sc. in Environmental Sciences; 6 years of experience in sediment and water analysis.

Dr. V. Vijay Kumar
Director

Gujarat Institute of Desert Ecology

Certificate

This is to state that the **Second Season Report** of the work entitled, **"Studies on Dredged Material for the presence of contaminants"** has been prepared in line with the Work order issued by DPT vide No. EG/WK/4751/Part (EC & CRZ-1)/84. Dt.18.09.2021 as per the EC & CRZ Clearance accorded by the MoEF & CC, GoI dated 19/12/2016, Specific Condition No. vii.

This work order is for a period of Three years from 2021 –2024 for the above-mentioned study.

Gujarat Institute of Desert Ecology
Bhuj

Authorized Signatory **Institute Seal**

CONTENTS

Among the twelve major ports across the nation, Deendayal Port Authority, formerly known as Deendayal Port Trust, erstwhile called as Kandla Port Trust, holds a prominent position as a significant maritime gateway in India, situated within Gujarat's Kutch district. This stands out as the largest Creek-based port, positioned at the southwestern tip of the Gulf of Kachchh, on India's north-western coastline within the state of Gujarat. Deendayal Port Authority (DPA) serves as a pivotal hub for maritime trade, facilitating the transportation needs of several hinterland states. It boasts excellent connectivity through an extensive rail and road network, functioning as a crucial gateway for the export and import activities of northern and western Indian states, including Jammu & Kashmir, Delhi, Punjab, Himachal Pradesh, Haryana, Rajasthan, Gujarat, as well as parts of Madhya Pradesh, Uttaranchal, and Uttar Pradesh. This port ranks among the largest and most essential ports in the country, playing a vital role in India's international trade and maritime infrastructure. The administration and operations of the port are overseen by the Deendayal Port Trust (DPT), an autonomous entity established under the Major Port Trusts Act of 1963.

The Deendayal Port Trust is entrusted with the comprehensive management, development, and administration of the port. The authority is comprised of a dedicated team of professionals and experts who work diligently to ensure the efficient operation of the port and all related activities. About 35% of the country’s total export takes place through the ports of Gujarat in which the contribution by Deendayal port is considerable. The port handled a total cargo of 105 MMTPA during 2016-17, 110 MMTPA during 2017-18, 115 MMTPA during 2018-19, 122.5 MMTPA during 2019-2020, 117.5 MMTPA during 2020-21 and 137 MMTPA during 2022-23. DPA is the only major Indian port to handle more than 127 MMT cargo throughput, and it has also registered the highest cargo throughput in its history. The port has handled a total of 3151 vessels during FY 2021-22. Over the years, the port has witnessed significant growth and development, becoming a crucial gateway for India's international trade.

Deendayal Port has a strategic location on the west coast of India, offering direct access to the Arabian Sea. It serves as a vital link for India's trade with countries in the Middle East, Africa, Europe, and Asia. The port handles a wide range of cargoes, including petroleum products, chemicals, coal, iron ore, fertilizers, salt, and general cargo.

Further, regular expansion of infrastructure and port facilities is under way to cater future logistic requirements. With such capacity, the Port ranks No. 1 among all the major ports in India for 12th Consecutive year. Further, a regular expansion of infrastructure and port facilities is under way to cater future logistic requirements. The port has high commercial importance in the Indian maritime trade as it handled 36.1 million tons (17%) of Cargo out of total Cargo of 213.1 million tons of the maritime Cargo of India during 2015. In addition, regular expansion of infrastructure and port facilities is under way to cater future logistic requirements.

Deendayal Port Authority (DPA) has taken up Development of 7 Integrated facilities, and the Ministry of Environment, Forest and Climate Change (MoEF & CC), has put up some conditions while according Environmental and CRZ clearance. One of the conditions is to carry out the *"Study on Dredged Material for presence of contaminants"* as accorded by the MoEF & CC, GoI dated 19/12/2016 - Specific condition no. vii)" which states that ***"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"***.

1.1 Need of the study

Considering the aforementioned condition, DPA has assigned the task of carrying out the study to Gujarat Institute of Desert Ecology (GUIDE), Bhuj. This study will be attempted three times in a year at two specified locations. Further, the study will envisage the evaluation of physico-chemical constituents in the dredged materials in the dumped locations in the study area. GUIDE has been entrusted with the project, which has duration of three years (01.11.2021 – 31.10.2024) as specified in the work order. Accordingly, the study was initiated to evaluate the dredged materials for potential contamination, employing a systematic investigation that encompasses the analysis of physical, chemical, and biological characteristics with special reference to pollutants including heavy metal, Petroleum hydrocarbon etc.

1.2. Scope of the study

a. To monitor the locations where dredged materials are dumped will be conducted.
b. Dredged materials in the area will be analyzed for the presence of contaminants in two different locations.
c. Detailed assessment of the dredged materials for physical, chemical and biological characteristics will be studied.
d. Suggesting suitable disposal options for the dredged material will be made.

1.3. Sampling locations for 2023-24

The study focused on investigating the presence of contaminants in the dredged materials during the year 2023-24. The specific locations for sampling can be found in Table 1 and Plate 1. The selection of these sampling sites was based on information supplied by the Hydraulic and Dredging Division to the Department of Port Administration (DPA), concerning the locations of dumping grounds. These location details were subsequently shared with the Gujarat Institute of Desert Ecology (GUIDE) via an email dated October 24, 2018. Three seasonal studies covering Location 1, Location 2 and Location 3 with the second season of the study was conducted during 10.06.2024 – 12.06.2024.

Table 1: GPS Co-ordinates of sampling locations

Station	Latitude (N)	Longitude (E)
Location 1 (Offshore)	22° 51' 00" N	70° 10’ 00" E
Location 2 (Cargo jetty)	22°56' 31" N	70 13' 00" E
Location 3 (Phang Creek)	23° 04' 28" N	70°13’ 28" E

1.4. Details of work done during 3rd Quarter (May 2024 – July 2024)

The second season sampling of the project was conducted in the 1st Quarter of the project period, i.e., 2023-24. The second season sampling was performed in the month of January 2024. During the sampling, the surface and bottom marine water samples and bottom marine sediment samples were collected from the three designated locations, *i.e.,* Offshore, Cargo Jetty and Creek systems which was pre-designated locations as earmarked by CPWRS was conducted.

After the collection, the samples were preserved using standard protocols and stored in an Ice box and brought to the laboratory within 2-3 hrs of collection Comprehensive analysis was performed on all the samples, both water (36 samples) and sediment (18 samples), to determine various physical, chemical, and biological characteristics. The analysis followed the standard methods prescribed by the Integrated Coastal and Marine Area Management (ICMAM) in 2012. All samples were analysed in triplicates, and the obtained data was compared against the marine water limits specified by the Central Pollution Control Board (CPCB) and other relevant standards.

Plate 1: Map showing locations of proposed sampling (2023-2024)

Chapter 2 Physico-Chemical Characteristics of the Sediment

The sediment samples from the study area were collected for the purpose of characterization employing standard methodology and the analysis of the samples were also performed as per standard protocol and the data of sediment analysis is presented in this Chapter 1. The sediment samples were collected in pre-fixed stations using a Van-Veen type of grab sampler. After collection, the sediment samples were preserved with Rose Bengal and formalin to avoid decomposition of samples and processed for analysis and the samples after collection were brought to the laboratory on the same day of collection and air dried and used for further analysis for the test parameters (Table 2).

Table 2: Physico-chemical and biological characteristics of sediment samples

S. No	Physico-chemical and biological parameters
1	pH (1: 10 suspension)
2	Salinity (ppt)
3	Sand (%)
4	Silt (%)
5	Clay (%)
6	Total organic carbon (%)
7	Phosphorus (mg/kg)
8	Sulphur (mg/kg)
9	Petroleum Hydrocarbon (µg/kg)
10	Cadmium (mg/kg)
11	Lead (mg/kg)
12	Chromium (mg/kg)
13	Copper (mg/kg)
14	Cobalt (mg/kg)
15	Nickel (mg/kg)
16	Zinc (mg/kg)
17	Magnesium (mg/kg)
18	Macrobenthos

2.1. pH and Salinity (1: 10 suspension)

The pH of the sediment suspension is a measure of the activity of H+ ions within the sediment-water system. It indicates whether the sediment is acidic, neutral or alkaline in nature. Since ions are the carrier of electricity, the electrical conductivity (EC) of the sediment-water system rises according to the content of soluble salts. The EC measurement directly corresponds to the concentration of soluble salts in the sediment at any particular temperature. To conduct the analysis, ten grams of the finely sieved sediment was dissolved in 100ml of distilled water to prepare leachate. This leachate was taken for shaking using a rotator shaker for one hour to ensure proper homogenization of the suspension. Following this, the suspension was allowed to settle for two hours, and the supernatant was collected after filtration for the subsequent analysis of pH and salinity using the pH and EC meter (Make: Systronics 361) and Refractometer (Make: Atago) respectively. Each sample was analyzed in triplicates to ensure accuracy, and the mean values were considered for further evaluation.

2.2. Textural analysis (Sand/Silt/Clay)

Sediment samples were collected using Van Veen grab whereas intertidal sediments will be collected using a handheld shovel. After collection, the scooped samples are transferred to polythene bags, labelled and stored under refrigerated conditions. The sediment samples are thawed, oven dried at 40ºC and ground to a fine powder before analyses.

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

2.3. Total organic carbon

Total organic carbon refers to the carbon content stored within sediment organic matter. It is derived from various sources such as the decomposition of plant and animal residues, root exudates, living and deceased microorganisms, sediment biota etc. To measure total organic carbon in sediment, a process of oxidation is employed using potassium dichromate in the presence of concentrated sulfuric acid. During the analysis, potassium dichromate generates nascent oxygen, which reacts with the carbon present in organic matter, resulting in the production of carbon dioxide (CO2). The excess volume of potassium dichromate is then titrated against a standardized solution of ferrous ammonium sulfate in the presence of phosphoric acid, using Ferroin indicator to detect the initial appearance of unoxidized ferrous iron. This titration allows the determination of the volume of potassium dichromate required to oxidize the organic carbon present in the sample.

2.3.1. Procedure

The determination of the percentage of total organic carbon in sediment involves oxidizing the organic matter within the sediment samples using chromic acid. The excess chromic acid is then estimated by titrating it against ferrous ammonium sulfate, with ferroin serving as an indicator. The step-by-step procedure is outlined as follows:

To begin, 1 gram of sediment sieved to a particle size of 0.5 mm is weighed and transferred into a 500 ml conical flask. Then, 10 ml of 1N $K_2Cr_2O_7$ is added to the flask with pipette followed by gentle swirling to ensure thorough mixing. Next, 20 ml of concentrated H2SO4 is added, and the sediment and reagents are mixed gently. This mixture is allowed to react for 30 minutes on a marble stone to avoid any damage caused by the release of intense heat from the sulfuric acid reaction. Afterward, 200 ml of distilled water is slowly added to the flask, along with 10 ml of concentrated orthophosphoric acid and approximately 0.2 grams of NaF. The sample and reagent mixture is left to stand for 1.5 hours, as the titration endpoint is better observed in a cooled solution. Just before the titration, 1 ml of ferroin indicator is added to the conical flask. The excess $K_2Cr_2O_7$ is then titrated with 0.5 N ferrous ammonium sulfate until the color changes from yellowish green to greenish, and finally to a brownish-red color indicating the endpoint. A blank test without the sediment sample is also performed simultaneously for reference. Through this procedure, the percentage of total organic carbon in the sediment can be accurately determined.

2.4. Total Phosphorus

The determination of total phosphorus in sediment is commonly conducted using Bray's extraction method. This method involves the formation of specific-colored compounds by adding appropriate reagents to the solution, with the intensity of the color being directly proportional to the concentration of phosphorus being estimated. The color intensity is measured spectrophotometrically. In the spectrophotometric analysis, a light source emitting light of a specific wavelength (usually within a band width of 0.1 to 1.0 nm) in the ultraviolet region of the spectrum is used. The photoelectric cells in spectrophotometer measure the light transmitted by the solution allowing for quantitative analysis.

2.4.1. Procedure

To perform the analysis, 50 ml of the Bray's extractant is added to a 100 ml conical flask containing 5 grams of sediment sample. The flask is shaken for 5 minutes and then filtered. Exactly 5 ml of the filtered sediment extract is transferred to a 25 ml measuring flask using a bulb pipette. Subsequently, 5 ml of the molybdate reagent is added using an automatic pipette, followed by dilution to 20 ml with distilled water and shaken well. Furthermore, 1 ml of dilute Stannous Chloride solution is added, and the volume is made up to the 25 ml mark. Thorough shaking is performed to ensure proper mixing. The mixture is then allowed to develop color, and after 10 minutes, readings are taken in the spectrophotometer at a wavelength of 660 nm. Prior to the readings, the instrument is zeroed using a blank prepared similarly but without the sediment.

2.5. Total Sulphur

Total sulphur in the sediment extract was determined using a turbidimetric method with a spectrophotometer. A series of standards containing sulphur at concentrations of 2, 4, 6, 8, and 10 ppm were prepared from a stock solution. Each flask in the series received 25 ml of the respective standard solution, and 2.5 ml of conditioning reagent solution was added. Additionally, 5 ml of extraction solution was added to the mixture. To facilitate the reaction, 0.2-0.3 grams of barium chloride were included and thoroughly mixed. The volume was adjusted to 25 ml with distilled water, and readings were taken at 340 nm using a spectrophotometer.

For the sample analysis, 5 grams of marine sediment were placed in a 100 ml conical flask. To this, 25 ml of a 0.15% $CaCl_2$ solution was added and shaken for 30 minutes. The mixture was then filtered through Whatman No. 42 filter paper. Subsequently, 5 ml of the sample aliquot was transferred into a 25 ml volumetric flask. Conditioning reagent (2.5 ml) and 0.2 to 0.3 grams of barium chloride powder were added, followed by making up the volume to 25 ml with distilled water. The flask contents were shaken for 2 minutes, and the absorbance was measured using the same procedure as the standard solutions.

2.6. Petroleum Hydrocarbons

To analyze petroleum hydrocarbons in sediment, the following procedure will be conducted. First, the sediment will undergo reflux with a mixture of KOH and methanol, allowing for the extraction of petroleum hydrocarbons. This reflux process helps release the hydrocarbons from the sediment matrix. Next, the sediment will be subjected to extraction using hexane, which selectively dissolves the hydrocarbons present in the sediment. The excess hexane will be carefully removed, leaving behind a residue containing the concentrated hydrocarbons of interest. To further purify the sample and remove any impurities, a clean-up procedure will be performed using silica gel column chromatography. This column chromatography process helps separate the hydrocarbons from other compounds present in the residue, resulting in a cleaner sample for analysis. Finally, the hydrocarbon content in the sediment will be estimated by measuring fluorescence, following the standard method for petroleum hydrocarbon analysis. This fluorescence measurement allows for quantification and determination of the hydrocarbon levels present in the sediment sample. By following this procedure, accurate analysis of petroleum hydrocarbons in sediment can be achieved.

2.7. Heavy metals

Heavy metals, such as Cadmium (Cd), Lead (Pb), Chromium (Cr), Nickel (Ni), Cobalt (Co), Copper (Cu), Zinc (Zn), Manganese (Mn), and others, are of particular concern in relation to the environment. To release mineral elements from sediment samples, wet oxidation is commonly employed, utilizing oxidizing acids, such as tri/di-acid mixtures.

In the analysis procedure, a sediment sample weighing 1.0 gram is taken in a 100 ml beaker, which is covered with a watch glass. A mixture of Aqua regia (1:3 HNO_3:HCl) in the amount of 12 ml is added to the beaker. The beaker is then subjected to digestion for 3 hours at 100°C on a hot plate using a sand bath. Afterward, the samples are evaporated to near dryness, allowed to cool for 5 minutes, and then 20 ml of 2% nitric acid is added. The beaker is placed on a hot plate for digestion for 15 minutes, after which it is removed from the hot plate and allowed to cool. The mixture is then filtered using Whatman No. 42 mm filter paper. Finally, the volume is adjusted to 50 ml with 2% nitric acid to make up the final solution. The extracted sample is then aspirated into an Atomic Absorption Spectrometer (AAS) for analysis. By following this procedure, the heavy metal content in the sediment can be accurately analyzed using wet oxidation, filtration, and AAS techniques.

2.8. Results

2.8.1. pH (Hydrogen Ion)

When any characteristics study of water or sediment is concerned, pH is considered to be one of the major variable especially in marine sediments as it influences various biogeochemical processes and ecosystem dynamics. These values are influenced by various factors, including the carbon, oxygen, nitrogen, phosphate, silicate, sulphur, iron, and manganese cycles. They are closely associated with processes such as heterotrophic respiration, chemoautotrophic activity, photosynthesis, precipitation, and the dissolution of calcium carbonate in marine water and sediments. In our investigation, we conducted measurements of average pH values at different locations. All three locations show slightly alkaline pH levels in sediments. Offshore has the lowest average pH (7.46 ± 0.14), followed by Cargo Jetty (7.50 ± 0.11) and Phang Creek (7.51 ± 0.08). The differences are minimal, indicating relatively stable and similar pH conditions across all locations. The data on individual values at all the locations and stations are given in Table 3.

2.8.2. Salinity

Salinity of seawater is subject to fluctuations influenced by temperature changes, following diurnal and seasonal cycles that correspond to variations in atmospheric temperature. Salinity levels in marine water and sediment exhibit a wide range, typically spanning from 0 to 36 in most estuaries. Semi-enclosed bays can experience hyper-salinity conditions. In the present study, it was observed that a broader range of salinity concentrations at different stations. Phang Creek shows the highest average salinity (37.36 ± 11.41 ppt), followed by Cargo Jetty (22.65 ± 6.35 ppt) and Offshore (20.77 ± 7.15 ppt), respectively. These findings are summarized in Tables 3-5, where all the data is presented.

2.8.3. Sediment Texture

Understanding the sediment texture at different stations provides valuable insights into the habitat characteristics and ecological dynamics of the marine environment. The sediment texture plays a significant role in determining the physical and chemical properties of the marine sediment, influencing the distribution and abundance of benthic organisms at the offshore station. The sediment composition across the three locations—Offshore, Cargo Jetty, and Phang Creek—shows distinct patterns in the distribution of sand, silt, and clay. In terms of sand content, the Cargo Jetty has the highest percentage at 53.60% ± 16.99%, which indicates a more dynamic, high-energy environment. This could be due to the influence of strong currents or wave action that tends to carry away finer particles, leaving behind coarser sand. Offshore has a lower sand content at 41.73% ± 7.85%, while Phang Creek lies in between with 49.38% ± 20.40%. The silt content is fairly consistent between Offshore and the Cargo Jetty, with 22.32% ± 15.55% and 21.88% ± 14.11%, respectively. Phang Creek, however, shows a notably lower silt percentage at 13.62% ± 4.26%. Clay content is highest in Phang Creek at 37.00% ± 21.57%. Offshore also has a significant clay percentage at 35.95% ± 20.85%, while the Cargo Jetty has the lowest clay content at 24.52% ± 14.72%. These findings are summarized in Tables 3-5, which presents the data from all the stations.

2.8.4. Total organic Carbon

Total Organic carbon in sediments primarily originates from the decomposition of animals, plants, and anthropogenic sources such as chemical waste, fertilizers, and organic-rich waste. These sources contribute to the enrichment of the marine environment with organic material, which subsequently settles to the bottom sediments from the water column. This pathway leads to an increase in Total Organic Carbon (TOC) values and can have implications for the faunal communities inhabiting the sediments. In our study, during this second season, it was investigated the TOC concentrations at different stations. The mean ± standard deviation (SD) TOC percentages were determined to be Total Organic Carbon which is reported as 0.60±0.10% at the offshore station, 0.39±0.12% at the cargo jetty station, and 0.79±0.45% at the Phang creek station. The TOC concentrations at all stations are presented in Tables 3-5. Understanding the dynamics of organic carbon in marine sediments is vital for assessing the health and ecological integrity of marine environments. It helps in monitoring anthropogenic influences and their potential impacts on the marine ecosystem.

2.8.5. Organic matter

Organic matter serves as the primary reservoir of organic carbon in marine sediments, encompassing the chemical, physical, and biological degradation processes that contribute to the formation of organic material in the marine environment. It consists of a mixture of materials derived from various planktonic and benthic species, forming the ecological foundation for primary producers and consumers in the overlying surface sediment. In our study conducted during the second season, we investigated the levels of organic matter in different locations. The organic matter percentages ranged 1.06± 0.22% in the offshore location, 0.67% ± 0.21% at the cargo jetty, and 1.41% ± 0.88% in the Phang creek area and the findings are summarized in the below tables (3-5), which illustrates the variation in organic matter content across the studied locations. Understanding the presence and dynamics of organic matter in marine sediments is crucial for assessing the overall health and ecological functioning of marine ecosystems. Phang Creek shows the highest organic matter suggesting higher inputs of organic material, possibly from terrestrial sources or higher productivity. The Cargo Jetty area shows the lowest organic matter, which might be due to higher energy conditions preventing organic matter accumulation.

2.8.6. Phosphorus and Sulphur

Sulphur (S) is involved in dissimilatory sulfate reduction by microbial activity, which is a primary pathway for organic matter mineralization in anoxic sea beds. This process leads to the production of sulfide. Subsequently, chemical or microbial oxidation of the produced sulfide forms a complex network of pathways in the sulfur cycle, resulting in intermediate sulfur species and partial conversion back to sulfate. On the other hand, Phosphorus (P) is an essential nutrient for life and plays a crucial role in regulating primary productivity within marine systems. It serves as a key element in various biological processes. In marine sediments, phosphorus availability influences primary productivity, affecting the growth and development of marine organisms. In the present study, the highest concentration of sulphur was recorded as Phang Creek shows the highest average sulphur content (54.98 ± 2.63 mg/kg), followed by Cargo Jetty (43.37 ± 8.43 mg/kg) and Offshore (39.10 ± 8.40 mg/kg). The concentrations of phosphorus and sulphur at all stations are presented in Tables 3,4 and 5. The offshore has the highest average phosphorus content (11.15 ± 2.89 mg/kg), followed by Cargo Jetty (10.72 ± 4.33 mg/kg) and Phang Creek (6.98 ± 1.03

mg/kg). This could reflect differences in nutrient inputs or cycling across the locations.

Phosphorus levels are highest in the offshore and cargo jetty areas. This could indicate different sources of phosphorus, such as upwelling in offshore areas or anthropogenic inputs near the cargo jetty. The lower levels in Phang Creek might be due to higher uptake by organisms or different sediment characteristics that don't retain phosphorus as effectively. Phang Creek shows the highest sulphur content with the least variability. This could indicate more reducing conditions in the sediments, possibly due to higher organic matter content and limited oxygen penetration. The lower levels in offshore and cargo jetty areas might reflect more oxidizing conditions due to better water circulation. These elements influence the availability of essential nutrients and can have implications for primary productivity and the overall functioning of marine ecosystems.

2.8.7. Petroleum hydrocarbon (PHC)

Petroleum hydrocarbons in general have low solubility in marine water and tend to adsorb onto particulate matter, leading to their long-term persistence in sediment bottoms. This persistence can have significant negative impacts on benthic aquatic communities within the marine ecosystem. PHCs are a major source of contamination in marine environments, primarily comprising compounds from three classes: alkanes, olefins, and aromatics. In the present study, the levels of PHCs in different locations were measure.

Phang Creek has the highest average petroleum hydrocarbon content (5.82 ± 3.81 μg/kg), followed by Cargo Jetty (5.05 ± 4.00 μg/kg) and Offshore (2.36 ± 1.32 μg/kg). This suggests more anthropogenic oil-related inputs in the nearshore areas. The presence of petroleum hydrocarbons in marine environments is of great concern due to their potential harmful effects on marine organisms and ecosystems. These contaminants can bioaccumulate in organisms and disrupt their physiological processes, as well as cause long-lasting damage to the benthic communities. The higher levels of petroleum hydrocarbons in Phang Creek and Cargo Jetty compared to the offshore location suggest more significant anthropogenic inputs in these areas. This could be due to boat traffic, urban runoff, or industrial activities near these locations. The offshore area, being further from these sources, shows lower contamination levels.

2.8.8. Magnesium

Understanding the distribution and dynamics of magnesium in marine sediments provides valuable insights into the geochemical processes occurring within the sediment column and their impact on the marine ecosystem. Continuous monitoring of magnesium levels is crucial for assessing the health and ecological integrity of marine environments. Dissolved magnesium flux from the overlying ocean into marine sediments is primarily driven by molecular diffusion. This process occurs as pore water magnesium is depleted during the formation of authigenic minerals within the sediment column. Additionally, direct burial of seawater occurs as sediment accumulates on the seafloor, contributing to the input of magnesium into the sediment. Its concentration in sediments can have implications for nutrient availability, sediment mineralogy, and the diverse organisms inhabiting the sediment environment.

In our study conducted during the second season at Deendayal Port, we determined the concentrations of magnesium at different stations. Phang Creek shows the highest average magnesium content (5018.75 ± 1443.26 mg/kg), followed by Offshore (4324.83 ± 957.00 mg/kg) and Cargo Jetty (3508.50 ± 1786.51 mg/kg). Highest magnesium content in sediments of Phang Creek could be due to differences in sediment sources, with Phang Creek possibly receiving more magnesium-rich materials from terrestrial sources. The high variability in the Cargo Jetty area suggests a more heterogeneous sediment composition, possibly due to varied inputs from both marine and terrestrial sources.

2.8.9. Heavy metals

The heavy metal concentration in the sediment samples were examined for the presence of heavy metals from the samples collected from various stations at different locations at Deendayal Port. The analysis of sediment samples from three locations *viz*., offshore, cargo jetty, and Phang Creek revealed varying concentrations of heavy metals. In the offshore samples, Nickel ranged from 14.20 to 70.55 mg/kg (mean 49.75 mg/kg), while Chromium, Zinc, and Copper showed moderate levels with 10.15 ± 0.49; 22.53 ± 28.89; 23.87 ± 4.17. Manganese was notably high, averaging 639.88 ± 223.92 mg/kg. The concentration of cobalt was found to be 19.21 ± 1.81 mg/kg. Lead and Cadmium were consistently below detectable limits in offshore location. The cargo jetty location exhibited below detectable limits with lead, chromium, cadmium but showed a high variability in copper levels (11.65 to 123.90 mg/kg). The concentration of zinc, manganese, cobalt was found to be 6.83 ± 5.48 mg/kg; 622.15 ± 184.51 mg/kg; 12.72 ± 6.21 mg/kg. The concentration of nickel showed 13.94 ± 8.45 mg/kg. The Phang Creek location demonstrated the highest variability in Nickel (4.55 to 105.70 mg/kg) and contained below detectable limits with lead and cadmium. Manganese concentrations were consistently high across all three locations, with Phang Creek showing the highest average at 723.92 ± 17.13 mg/kg. Cobalt levels were relatively consistent across sites, ranging from 8.20 to 37.95 mg/kg. These results indicate site-specific variations in metal contamination, with some metals showing notably high concentrations in certain areas. The concentration of chromium, zinc and copper is 29.48 ± 10.78 mg/kg; 16.72 ± 14.12 mg/kg; 31.27 ± 23.13 mg/kg. The data is presented in Tables 3-5.

Table 3: Physico-chemical characteristics of sediment samples collected from Offshore location

S. No	Parameters	1A	1B	1C	1D	1E	Control 1
1	pH (1: 10 suspension)	7.44	7.33	7.41	7.39	7.45	7.73
2	Salinity	21.10	23.40	24.20	27.60	21.30	7.00
3	Petroleum Hydrocarbon	2.30	0.80	1.56	BDL	2.88	4.25
4	Magnesium	2993.5	3830.5	4445	4989	5730	3961
5	Sand (%)	49.9	37.2	28.9	40.7	48.1	45.6
	Silt (%)	30.6	9.3	10.6	20.3	13.4	49.7
	Clay (%)	19.5	53.5	60.5	39.0	38.5	4.7
6	Organic matter (%)	1.08	1.13	1.03	0.93	1.42	0.77
7	Total organic carbon	0.63	0.66	0.6	0.54	0.73	0.45
8	Phosphorus	15.97	10.41	9.95	11.34	12.03	7.17
9	Sulphur	32.90	33.24	37.55	52.13	46.71	32.06
10	Nickel	70.55	14.2	63.65	49.3	51.05	BDL
11	Lead	BDL	BDL	BDL	BDL	BDL	BDL
12	Cadmium	BDL	BDL	BDL	BDL	BDL	BDL
13	Chromium	9.8	BDL	BDL	BDL	10.5	BDL
14	Zinc	BDL	BDL	42.95	2.1	BDL	BDL
15	Copper	27.25	17.55	21.9	25.25	27.4	BDL
16	Manganese	727	717	741.5	754	716	183.8
17	Cobalt	19.2	20.05	19.3	16.3	21.2	BDL

Table 4: Physico-chemical characteristics of sediment samples collected from Cargo jetty

S. No	Parameters	2A	2B	2C	2D	2E	Control 2
1	pH (1: 10 suspension)	7.4	7.33	7.53	7.59	7.6	7.54
2	Salinity	16.60	25.20	13.60	24.50	25.20	30.80
3	Petroleum Hydrocarbon	1.02	BDL	2.88	3.54	11.25	6.58
4	Magnesium	5105	3491.5	5950	1710	1463.5	3331
5	Sand (%)	60.7	43.8	82.6	36.2	41.6	56.7
	Silt (%)	10.0	46.2	14.8	30.9	18.5	10.9
	Clay (%)	29.3	10.0	2.6	32.9	39.9	32.4
6	Organic matter (%)	0.41	0.72	0.41	0.88	0.72	0.88
7	Total organic carbon	0.24	0.42	0.24	0.51	0.42	0.51
8	Phosphorus	7.17	14.35	3.93	13.65	10.87	14.35
9	Sulphur	31.29	40.91	37.51	46.06	50.53	53.89
10	Nickel	BDL	9	BDL	10.95	26.55	9.25
11	Lead	BDL	BDL	BDL	BDL	BDL	BDL
12	Cadmium	BDL	BDL	BDL	BDL	BDL	BDL
13	Chromium	BDL	BDL	BDL	BDL	BDL	BDL
14	Zinc	BDL	2.95	BDL	10.7	BDL	BDL
15	Copper	123.9	22.25	BDL	22	11.65	17.8
16	Manganese	618	730.5	254.9	718.5	720	691
17	Cobalt	BDL	17.6	3.25	11.3	12.5	18.95

Table 5: Physico-chemical characteristics of sediment samples collected from Phang creek

S. No	Parameters	3A	3B	3C	3D	3E	Control 3
1	pH (1: 10 suspension)	7.40	7.43	7.54	7.61	7.53	7.57
2	Salinity	29.90	41.80	35.87	24.30	57.30	35.00
3	Petroleum Hydrocarbon	3.56	2.85	BDL	BDL	5.62	11.25
4	Magnesium	6075	2798	5030	6825	4024.5	5360
5	Sand (%)	67.2	72.5	62.8	34.9	24.7	34.2
	Silt (%)	13.8	13.9	17.2	12.8	18.0	6.0
	Clay (%)	19.0	13.6	20.0	52.3	57.3	59.8
6	Organic matter (%)	1.29	2.22	2.71	1.13	0.62	0.51
7	Total organic carbon	0.75	1.29	1.36	0.65	0.36	0.3
8	Phosphorus	8.56	6.94	6.25	7.87	6.01	6.25
9	Sulphur	55.53	56.18	57.32	54.50	56.41	49.96
10	Nickel	21.05	64.5	105.7	13.4	BDL	4.55
11	Lead	BDL	BDL	BDL	BDL	BDL	BDL
12	Cadmium	BDL	BDL	BDL	BDL	BDL	BDL
13	Chromium	BDL	BDL	37.1	BDL	BDL	21.85
14	Zinc	BDL	BDL	32.2	13.4	BDL	4.55
15	Copper	44.3	38.75	66.45	15.1	2.35	20.65
16	Manganese	739.5	725.5	734.5	703.5	702	738.5
17	Cobalt	23.1	20.25	37.95	14.25	8.2	15.05

3.1. Introduction

Earth surface contains more than 97% of water in which the oceans show biggest part of the life. The five oceans together constitute approximately 71% of the world's water bodies. Indian Ocean is the third largest ocean in the world with average depth of 3,890 meters (12,760 ft). As having at long coastline of almost 8000 km, India has vast marine resources. The Indian Ocean's connection is a very large scale, including the Red Sea, East Africa, the Persian Gulf, Southern Arabia, India and Other Indian sub continental countries Gujarat state of India shows longest coastline in India which is famous for various coastal ecosystems. Gujarat coasts having different coastal ecosystems like mangrove, sandy shores, muddy shores, rocky shores, mixed shores, wet sand shore, coral reefs and intertidal mudflats (Brink, 1993; Parasharya and Patel, 2014). Gujarat state is the only state in India bestowed with two gulfs, Gulf of Kachchh and Gulf of Khambhat. The Kachchh, largest district of the country with an area of 45,652 sq. km. Deendayal Port Authority is (DPT) one among the 12 major ports of the country and it is located in India's western coastal region.

3.1.1. Benthos

Benthos is nothing but water bottom communities or the organisms (floral and faunal) live in a benthic region regarding the sediment, rock and other substratum. They include mollusca (gastropods and bivalves), coral, sponges, worms (mostly polychaetes and nematode), crustacean crabs, other crustaceans, echinoderms, oysters etc. The faunal benthic organisms are called as zoo-benthos, while floral benthic organisms are called as phyto-benthos. They play an important role in conversion of organic detritus from the sedimentary storage into the dissolved nutrients. Their distribution in water bodies can be varies and, on that basis, they can be classified into three types which are Endo-benthos, Epi-benthos (Pearson and Rosenberg, 1978) and Hyper-benthos (Mees and Jones,1997). They are the food source of diverse groups of various organisms including the bottom feeding animals. They are one of the best indicators to assess the health and productivity of aquatic ecosystems. They are sensitive to wide range of environmental challenges including water movements, pollutants and living spaces (Martin et al., 2011). Their variations to tolerate changes in various environmental factors make them to be considered as an important bio-indicator for monitoring and research of marine environment.

3.2. Methodology

To study the benthic organisms, triplicate samples were collected at each station using Van-Veen grab which covered an area of $0.1m^2$. The wet sediment was sieved with varying mesh sizes (0.5 mm-macrofauna) for segregating the organisms. The organisms retained in the sieve were fixed in 5-7% formalin and stained further with Rose Bengal solution for easy spotting at the time of sorting. The number of organisms in each grab sample was expressed as number/ meter square (No/m^2). All the species were sorted, enumerated and identified to the advanced taxonomic level possible with the consultation of available literature. The works of Fauvel (1953), Day (1967) were referred for polychaetes; Barnes (1980) and Lyla *et al*. (1999) for crustaceans; Subba Rao *et al.* (1991) and Ramakrishna (2003) for molluscs.

Further, the data were treated with univariate statistical methods in PRIMER (Ver. 6.) statistical software (Clarke and Warwick, 1994)

a) Shannon – Wiener index

In the present study, the data were analyzed for diversity index (H') by following Shannon – Wiener's formula (1949):

$H' = -\sum^{S} Pi \log 2\, Pi \ldots\ldots \quad i = 1$

which can be rewritten as

$$H' = \frac{3.3219\,(N \log N - \sum ni - \log ni}{N}$$

where, H'= species diversity in bits of information per individual

ni = proportion of the samples belonging to the ith species

(number of individuals of the ith species)

N = total number of individuals in the collection and

$\sum$ = sum

b) Species richness(S) was calculated using the following formula given by Margalef (1958).

c) Margalef index (d)

$$d = (S-1) / \log N$$

d) Pielou's evenness index

The equitability (J') was computed using the following formula of Pielou (1966):

$$J' = \frac{H'}{\log_2 S} \text{ or } \frac{H'}{\text{In}S}$$

Where, J' = evenness; H' = species diversity in bits of information per individual and S = total number of species.

3.3. Results on Species Composition, Population density and Biomass of Macrofauna of selected sites

3.3.1.Offshore

In Offshore region of Kandala port, total six sites were selected namely, (1A, 1B, 1C, 1D, 1E and 1- control). A total 6 groups/species(of benthic community) of benthic animals were observed in all stations at Offshore sites and they a Bivalves (Mollusca),Gastropods (Mollusca), Placuna sp (Bivalvae), Crustacean animals, Polychaeta worms (Annelida), Saccostrea sp (Bivalvia). All the data (Density and Biomass) expressed in (nos./m^2), (gm/m^2) respectively (Table 6). Pecten sp (Bivalvia), Worm snails and Scaphopoda (Mollusca) were totally absent in Offshore.

Highest population density of benthic organisms was recorded in station 1A-Offshore(675 nos/m^2), whereas lowest in station 1C-Offshore (75nos/m^2). The density range of all stations varied from 75 to 675nos./m^2. Bivalves and Gastropods were more abundant among all the benthic organisms might be sandy-muddy or rocky substratum in bottom part of Offshore region. Low recorded benthos were Polychaeta worms and Saccostrea sp (Bivalvia) that indicated less part of substratum are muddy and not suitable attachement. The highest biomass value (expressed wet weight) of benthic fauna was observed in station 1D-Offshore (4.36gm/m^2) and lowest value was

1C-Offshore (0.06 gm/m^2) (Table 6). Range of the Biomass was 0.06 to 4.36 gm/m^2 . Moderately Biomass values and also density values suggested mixing substratum, less availability of plenty food items and more predator pressure by higher animals. Intermediate association was also one responsible factor for the same. Variation in density and biomass in Offshore region because more influences by the Water Currents, Up welling - Down welling (Churning process of water) movements of water and Nutrients availability and Fluctuation in turbidity of water.

3.3.2.Cargo Jetty

In Cargo Jetty, frequently observed benthic groups were Bivalves, Gastropods, *Placuna sp* (Bivalvae), *Pholas sp* and less reported benthos were Razor clam, *Saccostrea sp* , Worm snail and Scaphopoda. Crustacean animal group was totally absent. The population density range noted between 150 to 3300(nos/m^2) among all the stations (Cargo Jetty-2A, 2B, 2C, 2D, 2E &2-Control) during the study period. Highest and Lowest density were recorded in station 2C- Cargo Jetty(3300nos./m^2) and 2E-Cargo Jetty (150nos./m^2) respectively.

Biomass value indicated a highest value in station 2C- Cargo Jetty (40.9gm/m^2) and lowest in 2control- Cargo Jetty (2.27gm/m^2) (Table 6). Average Biomass and Population density value of all station were 12.08gm/m^2, 1020 nos./m^2 respectively which indicated the moderate favourable environment condition of biota, water quality as well as substratum (mostly rocky).

3.3.3. Phang creek

Six Stations of Phang creek were selected for the study namely 3A, 3B, 3C, 3D, 3E and 3-control-Phang Creek. In this Phang Creek benthic organisms were mostly represented by Polychaeta worms (annelids). Only three groups were present namely Polychaeta worms, Bivalve and Gastropods whereas Other were totally absent. The population density was highest in station 3A and 3B -Phang Creek (75nos./m^2) and on the other side, lowest density was recorded in 3D-Phang Creek (25nos./m^2). Station

3B-Phang Creek comprises highest wet wt (0.86gm/m^2), whereas low value was recorded in3D & 3E-Phang Creek(0.03 gm/m^2).

Overall result (Offshore, Cargo Jetty and Phang creek) of macrofaunal community showed highest population density in 2C-Cargo Jetty (3300nos/m^2) and high biomass was observed (40.9gm/m^2) in 2C-Cargo Jetty . Table 6 showed highest population values of Bivalves in 2C- Cargo Jetty (1750nos/m^2) and same highest value of Gastropoda showed in 2C- Cargo Jetty (625nos/m^2).

The lowest value comprised by the *Pecten sp, Placuna sp, Pholas sp,* Scaphopoda , Worm snails, Razor clam including some were totally absent in some sites. Some absent or less frequently observed benthos indicated extreme weather condition (may be suddenly change temperature of running season), more stress condition and unfavourable environment condition for their survival. Bivalves and Gastropods, dominant groups were preferred rocky, sandy or mix substratum, and any other hard substrata**.** Polychaete worms are preferred sandy-muddy substratum or sandy habitat mostly in Phang creek.

Table 6 showed that average population density and biomass higher in Cargo Jetty and after Offshore where mostly rocky, sandy or covered with muddy area and algal growth providing a unique habitats for benthos. Low density and biomass was observed in mostly Phang creek area and some parts of Off shore (Table 6 and Figure 1) which indicated stressful environment, seasonal effect, more anthropogenic activities and also might be some chemical and biological changes in water. The population density and biomass of benthic community largely affected by the symbiotic and intermediate relation between them or with other invertebrates and suitable rocky substratum or coral reef in bottom of sea. Availability of Plankton, as a food source, also affected the benthic animals (Table 6 and Fig. 1 & 2). Extremely mix weather condition (during May and June months) also more affected in Offshore and Phang creek regions of Kandla port area.

In benthic communities, recorded species at all sites were, *Pecten sp, Placuna sp, Umbonium vestiarium Tellina sp., Clypeomorus bifasciata, Trochus sp, Radix* *sp,Nassarius sp, Nerita sp, Donax sp, Turris sp,Marcia sp, Dosinia sp, Donax sp, Anadara sp, Turris sp, Solen, Nereis sp, Saccostrea sp, Optediceros breviculum,Euolica sp etc.* The percentage of occurrence (Table 6) was revealed *highest group present by Bivalves and Gastropoda (72%)* then following area *Polychaeta worms (Annelida) (56%), Placuna sp (33%) and then others. Detail status of Population density,* Group composition and biomass of the benthic community of all selected sites were depicted in (Table 6) and (Figure 1). *Among* all the stations, highest percentage composition recorded by Bivalves (43%) followed by Gastropods (22%), *Placuna sp* (14%) and others (Figure.2).

Phytoplankton abundance and their size, zooplankton body composition, patchy distribution of zooplankton, water currents, ebb and flow tides, and water churning process, changing in structure of muddy, rocky and sandy habitats are the main reasons for biomass and density fluctuation in Benthic communities. In Crustacean most commonly observed species are Crabs and attached Barnacles. Main Mollucsa families recorded Trochidae, Cerithidea, Turritellidae, Tellinidae, Mitridae, Veneridae, Donacidae and Bucciniae etc. *Nereis sp* of anneliids was mostly observedin samples. More number of the broken bivalves, debris, plant items, broken gastropods, small pebbles and soil particles are frequently observed during benthic organism's study.

3.4. Diversity Indices of Benthic Community

The data in table 7 showed various diversity indices calculation, showed that Shannon Diversity Index ranging from (0.00-1.52) indicated very low diversity. Highest diversity indices was recorded in Station 2B-Cargojetty (1.52) where six groups/species of benthos presented where as Shannon indices nil (zero) observed in 3C, 3D, 3E, 3Control- Phang creek where only one benthic group present and density value was very low. Comparatively less Shannon indices value very low in Phang creek area number of benthos group/species present between 1 to 2 nos. The evenness values ranged between (0.53 to 1). The highest evenness value (1) is observed in stations 3C, 3D, 3E and 3 Control (Phang creek) where only 1 or 2 benthic groups.

Evenness value "1" indicated all organisms occurred in same area or mostly same group. Simpson's Index value ranged between 0.00 to 0.75 indicated to lower to very less moderate diversity. The Margalef value showed range of 0 - 0.86 indicated high variation in species/group numbers (Table 7).

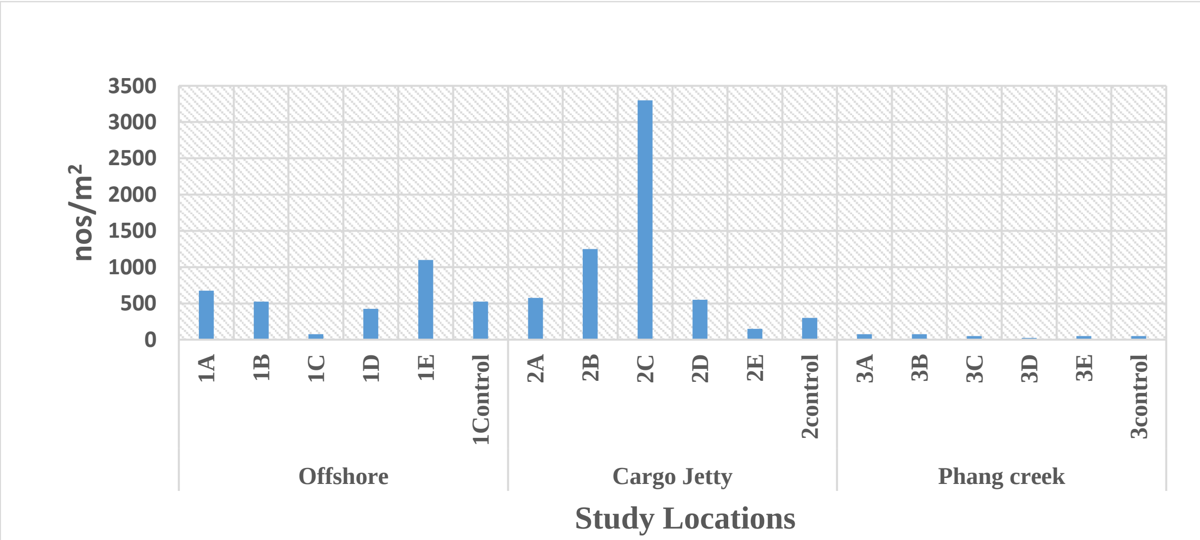

Figure 1. Population density of benthic organisms (nos/m^2) in various sites

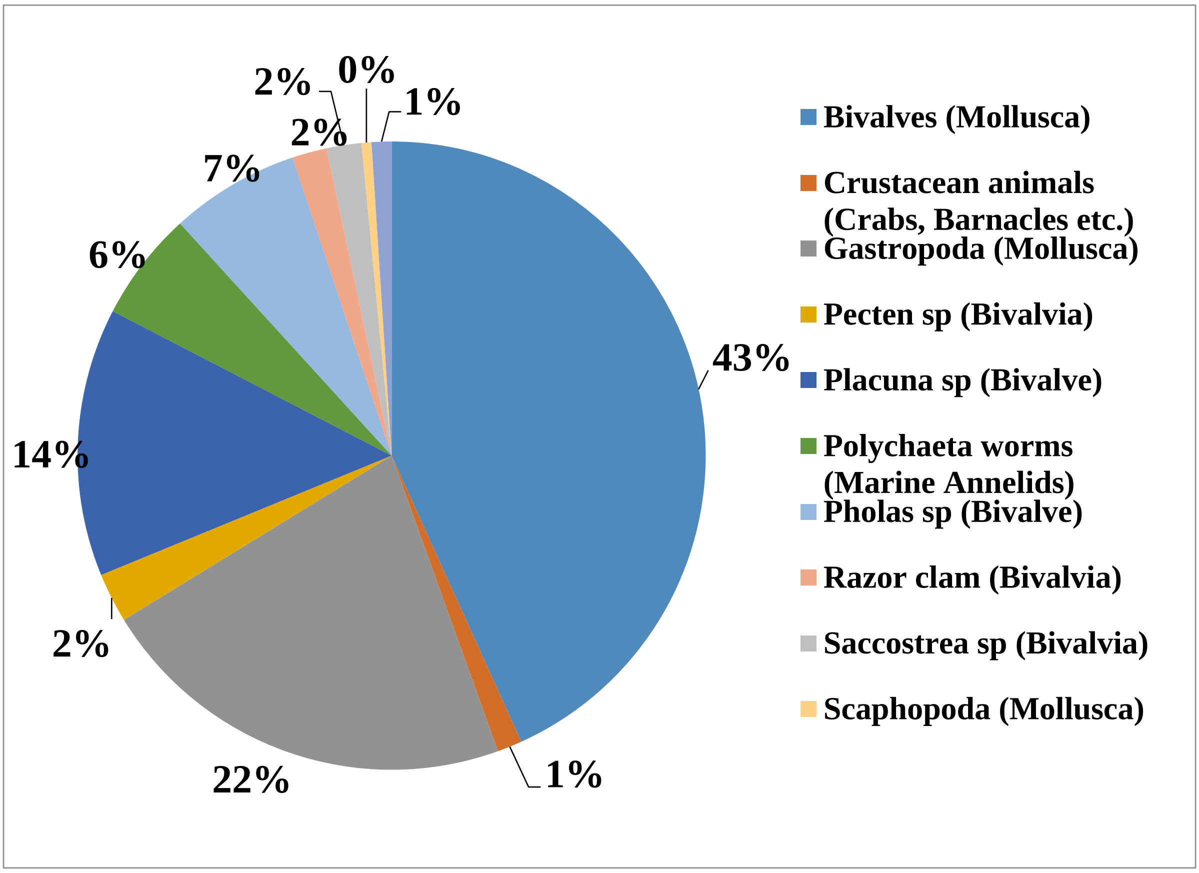

Figure 2. Percentage composition of benthic organisms in various sites

Table 6. Macrobenthos distribution in different sites of Deendayal Port

Name of Station	Offshore						Cargo Jetty						Phang creek						
	1A	1B	1C	1D	1E	1-Control	2A	2B	2C	2D	2E	2-Control	3A	3B	3C	3D	3E	3-Control	% of Occurrence
Name of Benthic Groups																			
Bivalves (Mollusca)	350	225	50	250	500	175	125	250	1750	250	100	175	25	0	0	0	0	0	72
Crustacean animals (Crabs, Mysis etc.)	0	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Gastropoda (Mollusca)	175	125	25	50	175	225	175	150	625	175	50	125	0	50	0	0	0	0	72
Pecten sp (Bivalvia)	0	0	0	0	0	0	0	0	250	0	0	0	0	0	0	0	0	0	6
Placuna sp (Bivalve)	150	175	0	0	300	0	175	250	300	0	0	0	0	0	0	0	0	0	33
Polychaeta worms (Marine Annelids)	0	0	0	125	0	50	0	50	0	75	0	0	50	25	50	25	50	50	56
Pholas sp (Bivalve)	0	0	0	0	0	0	50	500	50	50	0	0	0	0	0	0	0	0	22
Razor clam (Bivalvia)	0	0	0	0	0	0	0	0	175	0	0	0	0	0	0	0	0	0	6
Saccostrea sp (Bivalvia)	0	0	0	0	0	75	0	0	100	0	0	0	0	0	0	0	0	0	11
Scaphopoda (Mollusca)	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	6
Worm snail (Vermitidae)	0	0	0	0	0	0	50	50	0	0	0	0	0	0	0	0	0	0	11
Total Population Density Nos/m^2	675	525	75	425	1100	525	575	1250	3300	550	150	300	75	75	50	25	50	50	
Biomass (wet weight) gm/m^2	4.24	2.02	0.06	4.36	2.94	1.02	14.32	7.34	40.9	5.1	3.2	2.27	0.76	0.86	0.07	0.03	0.03	0.08	

Table 7. Diversity indices of benthic faunal groups at various station of Deendayal Port –Kandla (Benthos)

Variables	Offshore						Cargo Jetty						Phang Creek					
	1A	1B	1C	1D	1E	1-control	2A	2B	2C	2D	2E	2-contrl	3A	3B	3C	3D	3E	3cont
Taxa_S	3	3	2	3	4	4	5	6	8	4	2	2	2	2	1	1	1	1
Individuals (Nos./m^2)	675	525	75	425	1100	525	575	1250	3300	550	150	300	75	75	50	25	50	50
Dominance_D	0.39	0.35	0.56	0.45	0.32	0.32	0.25	0.26	0.34	0.33	0.56	0.51	0.56	0.56	1.00	1.00	1.00	1.00
Shannon Diversity Index (H)	1.03	1.07	0.64	0.92	1.25	1.23	1.48	1.52	1.45	1.21	0.64	0.68	0.64	0.64	0.00	0.00	0.00	0.00
Simpson_1-D	0.61	0.65	0.44	0.55	0.68	0.68	0.75	0.74	0.66	0.67	0.44	0.49	0.44	0.44	0.00	0.00	0.00	0.00
Evenness_e^H/S	0.93	0.97	0.94	0.84	0.87	0.86	0.88	0.76	0.53	0.84	0.94	0.99	0.94	0.94	1.00	1.00	1.00	1.00
Menhinick	0.12	0.13	0.23	0.15	0.12	0.17	0.21	0.17	0.14	0.17	0.16	0.12	0.23	0.23	0.14	0.20	0.14	0.14
Margalef	0.31	0.32	0.23	0.33	0.43	0.48	0.63	0.70	0.86	0.48	0.20	0.18	0.23	0.23	0.00	0.00	0.00	0.00

Chapter 4 Physico-Chemical Characteristics of Marine Water

4.1. Introduction

In recent decades, there has been a notable deterioration in aquatic ecosystems primarily caused by the presence of a diverse array of organic and inorganic contaminants. Among these pollutants, heavy metals (HMs) and microplastics (MPs) have emerged as significant contributors to this environmental degradation (Frew et al., 2020; Saha et al., 2016). These substances are recognized for their capability to infiltrate and accumulate within the aquatic food chain, making them hazardous pollutants in aquatic environments (Olojo et al., 2005). Of particular concern are heavy metals due to their toxic nature, long-lasting presence, resistance to degradation, the potential for bioaccumulation, and the ability to magnify up the food chain, all of which have raised global alarms (Begum et al., 2013; Cai et al., 2017).

Heavy metal pollution in aquatic ecosystems can be attributed to a variety of sources, including natural factors such as atmospheric deposition and weathering (Ebrahimpour and Mushrifah, 2010; Hamidian et al., 2016) as well as human activities like mining, agricultural runoff, sewage discharge, industrial effluent release, gasoline leaks from fishing vessels, and accidental chemical waste spills (Arulkumar et al., 2017). It is essential to recognize that certain heavy metals, such as copper (Cu), iron (Fe), nickel (Ni), cobalt (Co), zinc (Zn), manganese (Mn), and chromium (Cr), play vital roles in physiological processes and are necessary for the proper biological functioning of organisms in trace amounts. However, exposure to nonessential heavy metals can lead to various health concerns, including renal, cardiovascular, nervous, and bone diseases, as well as immune-related issues (Abadi et al., 2018; Madreseh et al., 2018). It is crucial to acknowledge that all heavy metals become toxic when their concentration exceeds a certain threshold level (Makedonski et al., 2017). In light of these concerns, it is imperative to assess the various characteristics of water in order to determine the extent of pollutant presence in aquatic environments.

4.2. Materials and Methods

In this study, marine water and sediment samples were collected following standard protocols, and their analysis was conducted using established methods for marine water and sediment analysis as prescribed by APHA (2012), NIO manual (1982), and ICMAM Manual (2012). For general analysis, surface water samples were collected using a clean polyethylene bucket, while water samples from the bottom were collected using a weighted Niskin sampler. Water samples at a depth of 1 meter below the surface were collected using a 1-liter glass bottle sampler. Parameters such as pH, temperature, and salinity were measured on-site using handheld meters and verified in the laboratory.

The collected water samples were stored under refrigerated conditions until further analysis of other parameters. According to the standard protocol, fixatives and preservatives were added to the samples for specific parameters. For example, Winkler A&B solution was immediately added to measure dissolved oxygen, concentrated H2SO4 was used to bring the pH below 2 for chemical oxygen demand analysis, and nitric acid was used for the preservation of heavy metals. Formalin was added to marine water samples for planktonic analysis. In general, all water and sediment samples were stored in sterile polythene bottles and Ziplock bags and kept in an icebox to maintain suitable conditions until they were transported to the laboratory. The parameters to be analyzed (Table 8) and the methods used for the sample analysis are described below.

Table 8: Physico-chemical and biological characteristics of marine water samples

S. No	Physico-chemical and Biological parameters
1	pH
2	Salinity (ppt)
3	Total Dissolved Solids (mg/L)
4	Turbidity (NTU)
5	Dissolved Oxygen (mg/L)
6	Bio-Chemical Oxygen Demand (mg/L)
7	Chemical Oxygen Demand (mg/L)
8	Phenolic compound (µg/L)
9	Petroleum Hydrocarbons (µg/L)
10	Oil and grease (mg/L)
11	Cadmium (mg/L)
12	Lead (mg/L)
13	Chromium (mg/L)
14	Copper (mg/L)
15	Cobalt (mg/L)
16	Nickel (mg/L)
17	Zinc (mg/L)
18	Magnesium (mg/L)
19	Chlorophyll (mg/m^3)
20	Phaeophytin (mg/m^3)
21	Phytoplankton Phytoplankton cell counts (no/L) Total Genera (no.) Major Genera
22	Zooplankton Biomass ($ml/100m^3$) Population ($no/100m^3$) Total Group (no.) and Major Groups

4.2.1. pH, Temperature and Salinity

pH and temperature measurements were conducted using a Thermo Fisher pH/EC/Temperature meter. Prior to use, the instrument was calibrated with standard buffers. For pH determination, an appropriate volume of the sample was titrated against silver nitrate (20 g/l), with potassium chromate serving as an indicator. The chlorinity of the sample was estimated, and salinity values were derived using a specific formula.

4.2.2. Total Dissolved Solids (TDS)

To confirm the readings obtained from the handheld meter, the samples underwent a gravimetric procedure. Approximately 100 ml of the water sample was taken in a beaker and filtered. The filtered sample was then completely dried in a hot air oven at 105°C. The TDS values were calculated by measuring the difference between the initial and final weight of the dried sample.

4.2.3. Turbidity

For turbidity measurement, a sample tube (Nephelometric cuvette) was filled with distilled water and inserted into the sample holder. The lid of the sample compartment was closed, and the meter reading was adjusted to zero by manipulating the 'SET ZERO' knob. The sample tube containing the 40 NTU standard solution was then placed in the tube, and the meter reading was set to 100. Similar measurements were carried out for other standard solutions. To determine the turbidity of the marine water sample, the sample tube was filled with the water sample, and the corresponding reading was recorded.

4.2.4. Dissolved Oxygen (DO)

To determine the Dissolved Oxygen (DO) levels in a water sample obtained from a marine environment, the following procedure was employed. Collect sea water sample, ensuring that the sampling container is clean and free from any potential contaminants that may affect the accuracy of the results. Subsequently, transfer the water sample into a Winkler's bottle or a suitable container, taking care to eliminate any trapped air bubbles. It is crucial to completely fill the bottle to minimize any headspace that could potentially alter the DO readings. Next, add the appropriate volumes of Winkler's reagents, such as manganese sulfate and alkali-iodide-azide, to the water sample as per the specific instructions of the Winkler's method. Gently and thoroughly mix the contents of the bottle to ensure uniform distribution of the reagents without introducing any air bubbles. Allow the bottle to stand undisturbed for a designated incubation period, typically around 30 minutes, to enable the necessary reactions to occur. After the incubation period, perform a titration using a standardized sodium thiosulfate ($Na_2S_2O_3$) solution until a faint yellow color appears, indicating the complete consumption of dissolved oxygen in the sample. Record the volume of sodium thiosulfate solution used for titration, which represents the amount of dissolved oxygen present in the water sample. To account for any dissolved oxygen in the reagents, it is essential to conduct the same procedure with blank samples that do not contain the water sample. This allows for an accurate calculation of the DO levels in the original water sample. Finally, employ the appropriate formula provided by Winkler's method to calculate the DO concentration in the water sample.

4.2.5. Biochemical Oxygen Demand (BOD)

To determine the Biochemical Oxygen Demand (BOD), the following procedure was employed using the direct unseeded method. Collect representative sea water sample from the desired location, ensuring the sampling container is clean and uncontaminated. Fill a BOD bottle with the water sample, leaving minimal headspace to prevent air contact that could affect BOD measurements. It's important to completely fill the bottle to minimize air bubbles. Record the initial Dissolved Oxygen (DO) level in the water sample using a dissolved oxygen meter or appropriate measurement method. Seal the BOD bottle tightly with the stopper to prevent air exchange. Incubate the sealed BOD bottle in a controlled environment, such as a BOD incubator, at a specified temperature (typically 20°C), for a designated incubation period, usually around 5 days. Throughout the incubation period, keep the BOD bottle in darkness to minimize the impact of photosynthetic activity. After the incubation period, measure the final DO level in the water sample using the same method or instrument as the initial measurement. Calculate the BOD by subtracting the final DO level from the initial DO level, accounting for any necessary dilution or blank corrections. This difference represents the amount of oxygen consumed by the organic matter in the water sample during the incubation period.

4.2.6. Chemical Oxygen Demand (COD)

The Chemical Oxygen Demand (COD) test is a widely used method for quantifying the levels of organic and inorganic pollutants in water samples. The first step involves collecting representative water samples from the target site, ensuring proper labeling and record-keeping. Subsequently, these samples are placed into digestion vials or tubes, to which digestion reagents, typically potassium dichromate and sulfuric acid, are added. This step initiates the oxidation of organic matter in the sample. The sealed vials or tubes are then subjected to high-temperature heating, typically around 150-160°C, for a predetermined period, usually around 2 hours. This heating process breaks down complex organic compounds into simpler forms. After digestion, the samples are allowed to cool to room temperature. To determine the COD concentration, a colorimetric measurement is taken. A suitable reagent is added to the digested samples, reacting with any residual potassium dichromate, and generating a color change proportional to the COD concentration. This color intensity is measured using a colorimeter or spectrophotometer, and the results are calibrated using known COD standards. The final calculations yield the COD value, typically expressed in milligrams of oxygen per liter (mg/L) of the sample.

4.2.7. Phenolic compounds

To analyze phenolic compounds in water, the following procedure was followed. A 500 ml water sample containing phenols was treated with 4-aminoantipyrine, which converted the phenols into an orange-colored antipyrine complex. This complex was then extracted using 25 ml of chloroform. The absorbance of the extracted complex was measured at 460 nm using phenol as a standard for comparison. This measurement allowed for the quantification of phenolic compounds present in the water sample.

4.2.8. Petroleum Hydrocarbons (PHc)

The analysis of Petroleum Hydrocarbons (PHc) in a water sample involved the following protocol. One liter seawater sample was extracted using organic solvent, hexane. The mixture was then separated into an organic layer and an aqueous layer. The organic layer, containing the petroleum hydrocarbons, was isolated. To remove any remaining water, the organic layer was dried using anhydrous sulphate. The volume of the organic layer was subsequently reduced to 10 ml at a temperature of 30°C under low pressure. The fluorescence of the extracted organic compound was measured at 360 nm (with excitation at 310 nm) using Saudi Arabian crude residue as a standard. This residue was obtained by evaporating the lighter fractions of crude oil at 120°C. By comparing the fluorescence intensity of the extract with that of the standard, the concentration of petroleum hydrocarbons in the water sample could be determined.

4.2.9. Oil and Grease

To determine the content of Oil and Grease in a sample, the following procedure was followed. Approximately 500 ml of the sample was transferred to a separating funnel, and the sample bottle was rinsed with 30 ml of trichlorotrifluoroethane. The rinsing solvent was then added to the separating funnel. Next, 5 ml of 1:1 hydrochloric acid (HCl) was added to the mixture, and the contents were vigorously shaken for about 2 minutes. If a soluble emulsion was formed, the sample container was shaken for an additional 5 to 10 minutes. After shaking, the layers in the separating funnel were allowed to separate, and the lower layer (organic layer) was discarded.

The solvent layer was drained through a funnel containing a filter paper moistened with solvent, and it was collected in a clean distillation flask that had been pre-weighed. The solvent was then distilled from the flask using a water bath set at 70°C. The resulting residue was carefully transferred into a clean, pre-weighed, and dried beaker, using the minimum amount of solvent necessary. The beaker was placed on a water bath at 70°C for 15 minutes to evaporate off all the solvent. After the evaporation process, the beaker was cooled in a desiccator for 30 minutes to reach a consistent temperature, and its weight was then measured.

4.2.10. Heavy metals

Heavy metals are a significant concern, especially in coastal environments, since it is biomagnifying from lower organisms to higher organisms through water and sediment. Common heavy metals of concern include Cadmium (Cd), Lead (Pb), Chromium (Cr), Copper (Cu), Cobalt (Co), Nickel (Ni), Zinc (Zn), Magnesium (Mg) and Manganese (Mn). To release mineral elements from sediment and analyze them, a wet oxidation process is typically employed using oxidizing acids, such as a mixture of Tri / Di-acids.

The procedure begins by weighing 0.5 grams of the sediment sample and placing it in a 100 ml beaker, which is covered with a watch glass. Then, 12 ml of Aqua regia (a mixture of 1 part HNO3 and 3 parts HCl) is added to the beaker. The beaker is placed in a digestion apparatus and heated at 100°C for 3 hours on a hot plate using a sand bath. The sample is evaporated until it is nearly dry, and then allowed to cool for 5 minutes. Next, 20 ml of 2% nitric acid is added to the cooled sample in the beaker, and the mixture is further digested on the hot plate for 15 minutes. After digestion, the beaker is removed from the hot plate and allowed to cool. The sample is then filtered using a Whatman No. 42 mm filter paper to remove any solid particles. To make up the final volume, the filtrate is diluted with 2% nitric acid to a total volume of 50 ml. The resulting extracted sample is then aspirated into an Atomic Absorption Spectrometer (AAS) for analysis of the heavy metal concentrations.

4.3. Results

In this second season study conducted in the present year, we closely monitored three distinct locations: Offshore, Cargo Jetty, and Phang Creek. A comprehensive analysis of physico-chemical characteristics in marine water samples was conducted at each of these sites. The collected data is thoughtfully presented in Tables 9-11. These findings serve as a significant source of information regarding the precise physico-chemical conditions prevailing at each of these locations. Consequently, they play a pivotal role in enhancing the comprehension of the environmental factors that exert influence on the quality of marine water in these specific areas. The description of the data in each station is detailed as below.

4.3.1. Location 1 - Offshore location

The offshore water samples exhibited moderate levels of salinity (40.90 ± 5.06 ppt) and total dissolved solids (42,279.25 ± 1,658.75 mg/L). The water was relatively warm (30.49° ± 0.22°C) with a slightly alkaline pH (7.87 ± 0.07). Turbidity was notable (141.13 ± 57.37 NTU), which could be due to suspended particles or plankton. Dissolved oxygen levels (5.48 ± 0.41 mg/L) were adequate for marine life but the lowest BOD (1.70 ± 0.44 mg/L), suggesting less biodegradable organic matter. However, it shows the highest levels of COD (34.50 ± 5.92 mg/L). The presence of petroleum hydrocarbons (17.12 ± 8.10 μg/L) indicating potential anthropogenic inputs from marine activities and phenolic compounds (22.93 ± 9.68 μg/L) suggests some level of anthropogenic influence. Nutrient indicators like chlorophyll (0.51 ± 0.10 mg/m^3) and phaeophytin (0.32 ± 0.06 μg/L) were present in low concentrations. The mean value of Oil and Grease exhibited 6.10 ± 1.41 mg/L. Most heavy metals were either below detectable limits or present in low concentrations, with cadmium (1.72 ± 1.11 μg/L) showing the highest levels among the detected metals. Lead, zinc and copper showed Below Detectable Limit (BDL). The concentration of heavy metals observed for Magnesium (301.91 ± 109.91 mg/L); Nickel (1.84 ± 0.82 mg/L); Chromium (0.23 ± 0.30 mg/L); Manganese (0.32 ± 0.27 mg/L); Cobalt (0.92 ± 0.70 mg/L) were shown in Table 9. Overall, the offshore waters showed signs of moderate anthropogenic impact but maintained conditions generally suitable for marine life.

4.3.2. Location 2 – Cargo Jetty

At the Cargo Jetty location, the recorded data shows that the mean value of temperature was recorded as 30.82 ± 0.10°C, and the mean value of pH was observed as 7.93 ± 0.03. The average salinity of the seawater was 39.35 ± 2.44 ppt reflecting the salt content, while the TDS which indicates the presence of various anions and cations, had an average value of 44,775.08 ± 4,693.04 mg/L. Turbidity values ranged from 130.76 ± 19.35 NTU. The maximum values recorded for Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) were 5.75 ± 0.36 mg/L and 2.08 ±

0.65 mg/L respectively (as shown in Table 10). The average COD value was determined to be 32.00 mg/L ± 4.26 mg/L. The concentrations of Phenolic compound with mean concentration is 18.90 ± 6.99 μg/L. In case of Petroleum hydrocarbon, all the samples were well within the permissible limits set by CPCB and the maximum recorded concentration was 15.80 ± 8.34 μg/L. The mean concentration of oil and grease in the marine water samples was 7.67 ± 3.34 mg/L, which falls below the acceptable limit of 10 mg/L according to GPCB norms. Regarding heavy metal concentrations, the Mean values for Magnesium, Nickel, Cadmium, Manganese and Cobalt were 279.89 ± 130.92 mg/L, 2.15 ± 1.48 mg/L, 0.98 ± 0.81 mg/L, 0.30 ± 0.12 mg/L, 1.39 ± 0.58 mg/L respectively. The concentration of Chromium was found to be 0.055 mg/L with only one detectable value. The concentration of lead, Zinc and Copper recorded a Below Detection Limit (BDL) in all the sampling points in Station 2 as given in Table 10.

4.3.3. Location 3 - Phang Creek

During this winter sampling in the Phang creek near the port, all the samples were subjected for analysis for various characteristics (Table 11). The mean value of temperature was recorded as 31.46 ± 0.28°C and the pH value was recorded between 7.88 ± 0.05. The average salinity of the seawater in the vicinity was found to be 39.95 ± 2.40 ppt while the TDS which indicates the presence of various anions and cations, had an average value of 42,749.17 ± 3,004.49 mg/L. Turbidity values ranged 329.73 ± 25.94 NTU. Pollution indices such as Dissolved Oxygen and Biochemical Oxygen Demand, Phenolic compounds, and Oil and grease concentrations had maximum values of 5.34 ± 0.21 mg/L, 2.49 ± 0.29 mg/L, 13.23 ± 4.59 μg/L, and 6.18 ± 2.90 mg/L, respectively. The average value of Petroleum hydrocarbon was 13.80 ± 7.02 μg/L. The average COD value was determined to be 30.50 ± 4.83 mg/L. In case of heavy metals, the maximum concentrations of Magnesium, Nickel, Cadmium, Manganese and Cobalt recorded were 276.17 ± 167.43 mg/L, 2.34 ± 1.66 mg/L, 0.98 ± 0.38 μg/L, 0.20 ± 0.22 μg/L and 1.74± 0.55 mg/L respectively. The mean value of Chromium is 0.29 ± 0.31 μg/L. Few of the heavy metals such as Lead, Zinc and Copper were in the Below Detection Limits.

Table 9: Physico-chemical characteristics of the marine water from sampling location 1 (Offshore)

S. No	Parameters	1A		1B		1C		1D		1E		Control 1	
		SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
1	Temperature (^{0}C)	30.6	30.5	30.3	30.3	30.3	30.3	30.3	30.5	30.5	30.5	30.9	30.9
2	pH	7.79	7.72	7.86	7.88	7.90	7.80	7.92	7.88	7.93	7.91	7.92	7.93
3	Salinity (ppt)	38.61	38.61	38.18	42.47	39.04	38.61	55.35	41.61	44.19	40.33	36.47	37.32
4	Total Dissolved Solids (mg/L)	41818	44920	41748	42724	41091	41275	41098	39817	43694	43052	45168	40946
5	Turbidity (NTU)	225	260.2	151.6	152	150.1	145.8	86	88.5	49.8	130.1	127.7	126.7
6	Dissolved Oxygen(mg/L)	5.9	5.8	5.3	5.2	6.2	6.1	5.3	5	5.2	5.1	5.4	5.2
7	Bio-Chemical Oxygen Demand (mg/L)	1.40	1.30	1.30	1.20	2.00	1.80	1.40	1.30	1.80	2.10	2.40	2.40
8	Chemical Oxygen Demand (mg/L)	36.00	32.00	34.00	30.00	32.00	30.00	36.00	32.00	48.00	44.00	32.00	28.00
9	Phenolic Compounds (µg/L)	14.20	32.29	36.40	32.91	33.30	32.70	17.18	13.02	15.72	17.50	10.31	19.58
10	Petroleum Hydrocarbons (µg/L)	12.56	10.85	25.23	18.65	22.21	10.56	11.52	10.28	32.65	28.54	12.50	9.86
11	Oil and grease (mg/L)	5.6	2.8	7.6	5.6	7.2	7.6	5.2	6.8	6.4	7.6	5.2	5.6
12	Magnesium (mg/L)	339.45	414.50	237.55	93.9	234	291	218.95	349.15	269.5	449.5	245.85	479.55
13	Nickel (mg/L)	BDL	2.305	BDL	BDL	0.44	BDL	1.795	BDL	BDL	2.185	2.455	BDL
14	Lead (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
15	Cadmium (mg/L)	BDL	BDL	1.52	2.055	2.75	BDL	2.875	2.285	0.16	2.925	0.42	0.515
16	Chromium (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.57	BDL	0.05	0.06	BDL
17	Zinc (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
18	Copper (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19	Manganese (mg/L)	BDL	BDL	BDL	0.335	0.105	0.92	0.51	0.35	0.21	0.29	0.11	0.02
20	Cobalt (mg/L)	BDL	1.655	BDL	0.39	0.225	BDL	0.7	0.365	0.41	1.945	1.87	0.73

Note: BDL denotes Below Detection Limit.

Table 10: Physico-chemical characteristics of the marine water from sampling location 2 (Cargo Jetty)

S. No	Parameters	2A		2B		2C		2D		2E		Control 2	
		SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
1	Temperature (^{0}C)	30.6	30.9	30.9	30.8	30.8	30.7	30.8	30.7	30.9	30.9	30.9	30.9
2	pH	7.89	7.87	7.92	7.92	7.94	7.95	7.96	7.95	7.93	7.94	7.95	7.96
3	Salinity (ppt)	36.28	42.9	39.47	40.33	38.61	36.28	40.33	37.75	42.47	39.04	36.28	42.47
4	Total Dissolved Solids (mg/L)	41756	43689	46079	50188	36643	41043	51710	51507	42176	41859	42913	47738
5	Turbidity (NTU)	130.8	125.7	101.5	115.2	135.7	140	104.8	110.8	153.9	152.7	140.9	157.1
6	Dissolved Oxygen(mg/L)	6.2	5.8	5.6	5.2	5.8	5.6	5.6	5.3	6.3	5.4	6.1	6.1
7	Bio-Chemical Oxygen Demand (mg/L)	2.6	2.9	1.1	1.1	1.9	1.2	2.4	2.3	2.9	2.5	2	2.1
8	Chemical Oxygen Demand (mg/L)	36	30	28	22	32	32	34	34	36	30	38	32
9	Phenolic Compounds (µg/L)	6.56	17.39	17.81	13.85	29.06	14.47	21.66	15.72	28.54	23.95	14,27	19,27
10	Petroleum Hydrocarbons (µg/L)	10.85	9.26	25.87	19.82	10.52	9.52	15.46	10.42	35.28	22.22	10.85	9.56
11	Oil and grease (mg/L)	7.2	6.4	4.8	8.8	16	6.4	12	5.2	5.6	7.2	8	4.4
12	Magnesium (mg/L)	BDL	209.2	131.55	132.95	387.4	453.9	149	247.7	341.3	164.3	439.45	422
13	Nickel (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	4.365	1.495	1.3	1.435
14	Lead (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
15	Cadmium (mg/L)	0.735	0.365	BDL	1.75	BDL	0.9	BDL	0.77	0.17	0.53	2.595	BDL
16	Chromium (mg/L)	0.055	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
17	Zinc (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
18	Copper (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19	Manganese (mg/L)	0.325	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.425	0.1	0.35	0.285
20	Cobalt (mg/L)	BDL	BDL	BDL	0.605	BDL	BDL	BDL	0.96	2.305	1.58	1.46	1.435

Note: BDL denotes Below Detection Limit

Table 11. Physico-chemical characteristics of the marine water from sampling location 3 (Phang Creek)

S. No	Parameters	3A		3B		3C		3D		3E		Control 3	
		SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
1	Temperature (^{0}C)	31	31.1	31.1	31.3	31.5	31.6	31.6	31.5	31.6	31.5	31.9	31.8
2	pH	7.86	7.83	7.82	7.8	7.88	7.91	7.9	7.92	7.93	7.91	7.92	7.92
3	Salinity (ppt)	38.61	39.04	36.61	41.61	37.75	42.9	38.61	41.61	36.47	40.76	42.04	43.33
4	Total Dissolved Solids (mg/L)	42690	40452	43570	42072	43750	43943	43651	44879	38455	37123	43840	48565
5	Turbidity (NTU)	263.3	353.2	330.2	336.6	373	325.9	338.6	341.5	315	322	326.8	330.7
6	Dissolved Oxygen(mg/L)	5.2	5	5.5	5.1	5.4	5.7	5.4	5.1	5.5	5.3	5.5	5.4
7	Bio-Chemical Oxygen Demand (mg/L)	2	2.1	2.4	2.6	2.3	2.4	2.4	2.5	2.6	2.7	2.9	3
8	Chemical Oxygen Demand (mg/L)	32	28.0	36	30	28	22	36	32	28	24	38	32
9	Phenolic Compounds (µg/L)	19.79	16.56	20.83	16.35	14.89	5.72	11.77	10.41	8.43	11.77	13.02	9.27
10	Petroleum Hydrocarbons (µg/L)	25.25	13.84	20.85	18.57	12.58	10.87	21.25	10.85	9.85	5.62	2.30	BDL
11	Oil and grease (mg/L)	12.0	7.2	4.4	4.8	5.2	6.4	4.4	5.2	2.0	5.6	10.8	4.8S
12	Magnesium (mg/L)	56.55	350.75	BDL	70.3	108.8	557.5	244.8	407.6	276.95	474	151.3	339.35
13	Nickel (mg/L)	1.91	1.77	BDL	2.06	4.125	BDL	BDL	0.295	3.235	4.93	BDL	0.37
14	Lead (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
15	Cadmium (mg/L)	BDL	BDL	0.815	BDL	0.87	1.535	BDL	BDL	BDL	BDL	BDL	0.69
16	Chromium (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	0.115	BDL	0.175	0.09	0.22	0.84
17	Zinc (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
18	Copper (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19	Manganese (mg/L)	0.255	0.1	0.12	0.02	0.205	0.075	0.03	0.425	0.07	0.735	BDL	BDL
20	Cobalt (mg/L)	2.425	1.515	1.42	1.195	1.725	1.95	0.69	2.255	1.695	2.535	BDL	1.725

Note: BDL denotes Below Detection Limit

5.1. Introduction for Plankton

Plankton is defined as all those living organisms which are suspended and drifting in water. The planktonic communities encompass of aquatic organisms which drift passively and also have limited mobility to move contrary of the water mass. Plankton are divided in two parts which are phytoplankton and zooplankton (Brink. 1993). The tiny flora or plants are called as Phytoplankton, and weak swimming tiny fauna or animals are called as Zooplankton. Phytoplankton are the primary producers in marine ecosystems and form the basis of the food web. Zooplankton are pelagic animals play a role in the food chain in aquatic ecosystem to provide a food resource to various organisms. Major phytoplankton in sea water is Diatoms (Tiwari and Nair, 1998; Thakur et al, 2015), Cocolithophores, Sillicoflagellates, Blue green algae (Cyanobacteria) and Dinoflagellates. Zooplankton comprises the second level in the food chain and includes Tintinnids, Foramonifers, Radiolarians, Amphipoda, Copepoda, Calanoida, Chaetognaths, larvae of benthic invertebrates and fish larvae etc. (Gajbhiye and Abidi, 1993; Thirunavukkarosu, 2013; Chakrabarty et al. 2017). Size is very important to understanding about the classification of both zooplankton and phytoplankton. Based on size, various categories of plankton are smallest one Picoplankton (0.2-2 µm), Nanoplankton (2-20 µm), Microplankton (20-200 µm), Mesoplankton (200 µm-2 mm), Macroplankton (2-20 mm) and Megaplakton(> 20 mm) . The population of plankton diversity is largely related to seasonal and monthly variability in Physical, Chemical and Biological parameters; Interspecific competition among the Zooplankton; Inter-relationship for prey and predator between zooplankton and their mostly predator animals; Grazing ratio of primary-secondary consumers; Suspension of sediment; Fluctuation in Phytoplankton abundance; Waves, Currents and Tidal turbulence effect; Fluctuation in Chlorophyll a and Nutrients; Input of Organic and other Pollution creating sources; Fish potential ratio; Monsoon effect; Suddenly changes in atmosphere; Peak time of every seasons and it's effect; Vertical migration of Zooplankton; Food selection pattern of predator; Collection time and number of collected samples, mixing of water column, high surface action, Seasonal up welling and down welling process in water column.

5.1.1. Phytoplankton

Phytoplankton are single celled marine algae with great difference in shape, size and form, either use flagella for movement in water or just drift with currents (Zohari et al, 2014). These photosynthetic organisms need sunlight for photosynthesis. With trapping carbon in the process of photosynthesis, they can control the atmospheric carbon dioxide and help in combating the global climate change. With this, they have significant role in the management of nutrients cycles in the ocean systems. Their role as primary producers in aquatic ecosystem, in the process of nutrients cycling in the ocean systems, also in calcification, silicification, nitrogen-fixing, etc. made them important marine component for marine life study. Their sensitiveness for various anthropogenic activities in the marine environment such as Eutrophication, introduction of invasive species, overfishing etc, make them one of the best indicators to analyse these activities.

5.1.2. Zooplankton

The faunal species particularly microscopic fauna, living inside the water bodies are known as zooplankton. Zooplankton is tiny-small animals found in all water bodies particularly the pelagic and littoral zone in the ocean. They are classified by size and or by development stages. Zooplankton community is composed of both primary consumers (which eat phytoplankton) and secodanry (which feed on the other zooplankton). Nearly all fish depend on zooplankton for food in both larval stages and entire life period (Madin et al., 2001). They are attractive, various and plentiful group of faunal species which can swim or generally drift with water currents but have no potential to swim against water currents (Alcaraz and Calbet, 2003). The important role of them is to be a major link in the marine life in between marine microalgae or phytoplankton and fish. Although they can be classified according to their habitat and depth, distribution, size and duration of planktonic life period (Omori and lkeda, 1984), generally, it is considered as there are two types of zooplanktons.

Holoplanktons are those which live permanently in the planktonic form, while meroplanktons are the temporary members in this form. The potential of zooplankton to respond quickly to environment changes and short generation life span, make them important bioindicator of water pollution and all variation occurred in their living environment. Their study is the important part for getting knowledge of the functioning of marine ecosystems (Mees and Jones, 1997).

5.2. Methodology

5.2.1 Estimation of Chlorophyll and Phaeophytin

Estimating Chlorophyll and Phaeophytin was done using known volume of water (500 ml) was filtered through a 0.45μm Millipore membrane filter paper and the pigments retained on the filter paper were extracted in 90% acetone overnight at 50°C. The extinction of the acetone extract was measured using fluorimeter before and after treatment with dilute acid (0.1N HCI).

5.2.2. Phytoplankton sampling and analysis

Phytoplankton samples were collected in the ten prefixed sampling sites using a standard plankton net with a mesh size of 51 μm. Plankton nets are with a square mouth covering an area of 0.900 cm^2 (30 cm square mouth) fitted with a flow meter (Hydrobios). Nets were towed from a moving boat for 10 minutes and the plankton adhering to the net was concentrated in the net bucket. Plankton soup from the net bucket was transferred to a pre-cleaned and rinsed container and preserved with 5% neutralized formaldehyde. The containers were appropriately labelled. The initial and final flow meter reading was noted down for calculating the amount of water filtered to estimate plankton density. As per flow meter reading, a total amount of 165m^3 of water was filtered by the net. One liter of water was separately collected for density estimation to counter check density estimation obtained by the flow meter reading. Quantitative analysis of phytoplankton (cell count) was carried out using a sedge wick-Rafter counting chamber. One ml of soup added to a Sedgwick counting chamber was observed under an inverted compound microscope. The number of cells present in individual cells of the counting chambers (1/1000) was noted and identified up to a generic level. Several observations were fixed to represent the entire quantity of the soup (generally more than30 times) and the recorded data were used to calculate the density (No/l) using the formula, $N = n \times v/V$ (where N is the total no/l; n is an average number of cells in 1 ml; v is the volume of concentrate; V is the total volume of water filtered). The phytoplankton diversity richness and evenness were past software.

5.3. Phytopigments

The concentration of phytopigments is inversely proportional to the turbidity of the waters and in general, waters owing to the high turbidity restricts sunlight penetration essential for nutrient uptake by phytoplankton and thus inhibiting primary production. The concentration of chlorophyll pigment in the water samples ranged from 0.35 -0.68 mg/m^3 with a mean ± SD being 0.51±0.10 mg/m^3 in the Offshore (Table 12), 0.274 to 0.62 mg/m^3 with mean ± SD of 0.41±0.12 mg/m^3 in the Cargo Jetty (Table 13) and 0.31 to 0.71 mg/m^3 with mean ± SD being 0.45±0.11 mg/m^3 in the Phang creek location (Table 14).

Another phytopigment estimated was Phaeophytin, which is one of the breakdown products of Chlorophyll was also estimated in the water samples collected from all the three locations and the concentration of Phaeophytin in the marine water samples were in the concentrations such as 0.24-0.42 mg/m^3 with a Mean±SD of 0.32±0.06 mg/m^3 in the Offshore location (Table 12). In case of Cargo Jetty location, the concentration of the secondary pigment was in the range of 0.12- 0.32 mg/m^3 with a Mean±SD of 0.228±0.059 mg/m^3 (Table 13) and in case of the creek location, the concentration of phaeophytin was almost similar when compared to the other two locations and was ranging between 0.24-0.55 mg/m^3 with a Mean±SD of 0.35±0.08 mg/m^3 (Table 14). An optimum ration of Chlorophyll to Phaeophytin of above 1.5 as expected for natural estuarine and coastal waters.

Table 12: Chlorophyll and Phaeophytin concentration observed in the Offshore site

Parameters	1A		1B		1C		1D		1E		1 Control	
	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
Chlorophyll	0.520	0.530	0.660	0.500	0.490	0.460	0.480	0.470	0.680	0.590	0.382	0.350
Phaeophytin	0.250	0.370	0.310	0.280	0.280	0.380	0.310	0.250	0.410	0.420	0.280	0.240

Table 13: Chlorophyll and Phaeophytin concentration observed in the Cargo Jetty site

Parameters	2A		2B		2C		2D		2E		2 Control	
	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
Chlorophyll	0.520	0.350	0.320	0.280	0.450	0.313	0.341	0.347	0.530	0.274	0.580	0.620
Phaeophytin	0.320	0.280	0.210	0.120	0.280	0.210	0.290	0.200	0.230	0.180	0.260	0.160

Table 14: Chlorophyll and Phaeophytin concentration observed in the Phang Creek site

Parameters	3A		3B		3C		3D		3E		3 Control	
	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
Chlorophyll	0.348	0.580	0.460	0.420	0.560	0.710	0.380	0.310	0.420	0.510	0.430	0.360
Phaeophytin	0.360	0.372	0.32	0.350	0.470	0.550	0.240	0.280	0.370	0.320	0.374	0.280

5.4. Phytoplankton

The study was conducted at 3 sites (or regions) at Kandla Port and near area where dredging activities is going on Creek and the stations are Offshore, Cargo Jetty and Phang Greek.

5.4.1. Offshore

In this site, frequently observed species were *Actinocyclus sp, Coscinodiscus centralis, Coscinodiscus wailesii, Ditylum brightwelli, Fragilaria sp, Thalassionema frauenfeldii colony, Thalassionema nitzschioides colonies, Trieres mobiliensis, Odontella sinensis, etc.* whereas less observed species were *Amphiprora sp, Bacillaria paxillifera colonies, Gyrosigma sp, Protoperidinium sp, Rhizosolenia sp etc.* Total 30 Phytoplankton were recorded in this Offshore area. Highest population density was recorded at site 1E-Offshore (431680nos./m^3) and lowest density was recorded at site 1B-Offshore (160000nos./m^3). The maximum number of species observed in site 1Control-Offshore (20 nos.) followed by 1D (18nos.), 1E and 1A (16nos.), 1B(13nos.), 1C-Offshore(12nos.). The population density greatly varied between (160000nos./m^3 to 431680nos./m^3). *Synedra ulna, Fragilaria sp colony, Nitzschia sp, Thalassiosira sp* were recorded which are sometimes considering for pollution indicator species in water. Green algae was also recorded in some location of Offshore which may be indication of freshwater or polluted water mixing with seawater. Some Dinoflagellates were also recorded like *Protoperidinium sp*, Highest population density contributor species was *Coscinodiscus wailesii (range 88000 to 120000*nos./m^3)

5.4.2. Cargo jetty

Total 27 Phytoplankton were recorded in this Cargo Jetty area. The population density greatly varied between 104800 Nos/m^3 to 393440 Nos/m^3. Highest density value recorded at 2control-Cargo Jetty (393440nos./ m^3) and lowest value was at 2C-Cargo Jetty (104800nos./m^3). The lowest number of species noted in the site 2C and 2E-Cargo Jetty (09 nos.) whereas highest in 2A-CargoJetty (15 nos.). In this Cargo Jetty station commonly or frequently observed species were *Actinocyclus sp, Coscinodiscus centralis, Coscinodiscus radiatus, Coscinodiscus wailesii, Odontella sinensis, Thalassionema frauenfeldii colony* etc. The rarely found species were Climacosphenia sp, *Chaetoceros sp, Planktoniella blanda, Rhizosolenia imbricata, Triceratium favus etc.* The Dinoflagellates *like Tripos muelleri* was also observed during microscopic analysis that may be indication of water circulation from deep water to upper surface. *Dictyocha sp (Silicoflagellates)* was also recorded.

5.4.3. Phang Creek

The population density of phytoplankton ranged from 64000nos./m^3 to 121120nos./m^3 same way species availability ranged from 11 to 20 nos. Maximum and Minimum value of population density were recorded in site 3Control-Phang Creek (121120nos./m^3) and 3A-Phang Creek (64000 nos./m^3) respectively. Highest number of species recorded in site 3B-Phang Creek (20nos.) and lowest in site 3C-Phang Creek (13nos.). Total recorded phytoplankton was 27 in this creek area. *Actinocyclus sp, Coscinodiscus centralis, Coscinodiscus wailesii, Coscinodiscus radiatus, Odontella sinensis Thalassionema frauenfeldii colonies Rhizosolenia sp , Synedra ulna, Thalassionema frauenfeldii colonies, Thalassionema nitzschioides colonies, Thalassiosira sp etc.* were frequently noticed during microscopic work whereas less observed species were Biddulphia sp, Fragilaria sp Gyrosigma sp and some unidentified phytoplankton. Green algae *were also recorded,* which are generally found in fresh water and estuarine area.

Overall view of Phytoplankton showed that a total 40 species of Marine phytoplankton were identified during summer season of the year 2024. Among them,20-Centric diatoms, 15-Pennate diatoms, 2-Dinoflagellates, 1-Green algae and 1-silicoflagellates and some are not identified phytoplankton's was included in unidentified. Some species like *Bacillaria paxillifera colonies, Chaetoceros sp, Climacosphenia sp, Dictyocha sp (Silicoflagellates) Planktoniella blanda, Rhizosolenia gracillima, Trachyneis sp* were rarely recorded during sample analysis. Input of the fresh water indicated by the presence of some common fresh water species like *Green algae*. Presence of *Dinoflagellates (,Tripos muelleri Protoperidinium sp)* indication of bottom water circulation up to surface water layer in some level. *Dictyocha sp* (Silicoflagellates) was also recorded in Cargo Jetty region. Highest phytoplankton density was observed at the site 1E-Offshore (431680nos./m^3) and lowest was observed at site 3A-Phang creek (64000 nos./m^3) (Table 15). Total number of highest species observed at site 1control-Offshore and 3B-Phang creek (20nos.) and lowest in site 2C and 2E-Cargo jetty (09nos.).

The high population density composed by species like Actinocyclus sp, *Coscinodiscus centralis, Coscinodiscus radiates, Coscinodiscus wailesii, Thalassionema frauenfeldii colonies, Thalassionema nitzschioides colonies* (Table 15). This result indicated that genus *Coscinodiscus sp. Actinocyclus sp, Thalassionama sp* were very common with good numbers in all sites. In some sites, least number of species and low density of phytoplankton might be responsible due to some factors like extreme cool weather because of winter season, high pre-predation ratio, marine pollution (anthropogenic pressure), high turbidity, total suspended solids, water current and suddenly changes in environment conditions etc. Diatoms, type of phytoplankton, constitute major part in total phytoplankton composition The individual density of species of sites and all the values of phytoplankton density, list of phytoplankton and others shown in (Table 15).

5.5. Diversity Indices of Phytoplankton

According to Table 16, diversity indices calculation for phytoplankton showed that the Shannon Index ranged from (0.73 to 2.34) indicated low level to moderate level of diversity status. High Shannon Index was recorded at 3Control-Phang creek (2.34) where 18 species were recorded and low at 2E-Cargo Jetty(0.73) where 09 species were recorded. Lowest evenness recorded at site 2A and 2E-Cargo Jetty(0.23)whereas highest was in at 3B-Phang creek (0.65). Dominance_D index ranged from 0.10 to 0.72 whereas higher value in 2E-Cargo Jetty (0.72) and lowest was at in 3B- Phang creek (0.10). Value of Margalef D (0.64 to 1.67) showed more variation in species numbers. (Table 16.).

Table 15. Density of Phytoplankton at different sites of Deendayal Port

Name of Sites	Offshore						Cargo Jetty						Phang Creek					
	1A	1B	1C	1D	1E	1 control	2A	2B	2C	2D	2E	2 control	3A	3B	3C	3D	3E	3 control
Genus of Phytoplankton																		
Actinocyclus sp	20000	9600	24000	16000	163200	22400	12000	4000	9600	24000	4000	4000	0	8000	0	3200	14400	8000
Amphiprora sp	0	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	0	0
Bacillaria paxillifera colonies	4000	0	0	3200	0	0	0	0	0	800	0	0	0	0	0	0	0	0
Biddulphia sp	0	0	0	0	0	0	0	0	0	0	0	0	0	1600	0	0	480	0
Chaetoceros sp	0	0	0	0	0	0	0	0	0	800	0	0	0	0	0	0	0	0
Coscinodiscus centralis	16000	8000	4000	16800	57600	20800	16800	8000	16000	0	8000	8000	4000	12000	9600	16800	10400	14400
Coscinodiscus radiatus	20000	24000	19200	32000	40800	17600	20000	16000	20000	48000	16000	41600	16000	12000	12000	20000	17600	25600
Coscinodiscus sp.	0	0		0	0	0	0	0	0	0	0	0	8000	3200	0	16000	6400	16000
Coscinodiscus wailesii	120000	88000	79200	64000	120000	88000	160000	80000	49600	16000	240000	320000	20000	17600	24800	32160	24000	24000
Climacosphenia sp	0	0	0	0	0	0	0	0	800	0	0	0	0	0	0	0	0	0
Ditylum brightwelli	0	2400	4000	4000	1600	0	2400	0	0	2400	0	2400	0	1600	0	0	0	2400
Dictyocha sp (Silicoflagellates)	0	0	0	0	0	0	2400	0	0	0	0	0	0	0	0	0	0	0
Fragilaria sp	4800	3200	0	4000	16000	12000	0	0	0	0	0	0	0	0	0	800	0	0
Green algae (unidentified)	4000	0	0	0	0	1600	0	3200	0	0	0	0	0	1600	1600	1600	0	800
Gyrosigma sp.	0	800	0	0	0	1600	0	3200	0	0	0	0	1600	1600	0	0	0	800
Navicula sp	0	0	0	0	800	0	0	0	0	0	0	0	0	800	3200	480	1600	0
Nitzschia sp	0	2400	0	800	0	1120	0	0	0	0	0	0	1600	0	0	0	320	640
Odontella sinensis	1600	8000	7200	7200	10400	4800	1600	3200	3200	8000	4000	2400	800	5600	4000	4800	0	960
Pinnularia sp	0	0	0	0	0	0	0	0	0	0	0	0	0	1600	0	0	0	0
Planktoniella blanda	0	0	0	0	0	0	0	0	1600	0	3200	0	0	0	0	0	0	0
Planktoniella sol	4000	2400	0	3200	0	0	2400	0	0	0	0	0	0	0	0	0	0	0

Pleurosigma sp.	640	0	0	0	1600	2400	0	0	0	0	0	0	0	1600	0	1600	800	3200
Protoperidinium sp	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhizosolenia gracillima	0	0	0	0	0	0	0	0	0	3200	0	0	0	0	0	0	0	0
Rhizosolenia imbricata	0	0	0	640	800	0	0	0	800	0	0	0	0	0	0	0	0	0
Rhizosolenia setigera	0	0	0	0	0	800	0	0	0	0	0	0	0	0	0	0	0	0
Rhizosolenia sp	0	2400	0	0	0	1600	0	800	0	800	0	2400	0	0	0	0	0	0
Surirella sp	0	0	0	0	0	800	1600	3200	0	0	0	0	0	320	0	0	320	0
Synedra sp	0	0	1600	3200	0	0	0	4000	0	0	0	0	0	0	4000	320	8000	4000
Synedra ulna	4000	0	0	4000	1600	4000	4000	800	0	0	0	640	2400	3200	2400	2400	5600	320
Thalassionema colonies frauenfeldii	3200	0	0	8000	1600	7200	1920	2400	3200	0	4000	2400	2400	4000	4000	4800	4000	3200
Thalassionema nitzschioides colonies	800	4000	7200	4000	4800	7200	1600	0	0	4000	0	2400	0	4000	0	4800	3200	4800
Thalassiosira aculeata	8000	0	0	0	0	800	0	0	0	0	0	0	0	0	0	1600	0	0
Thalassiosira sp.	8000	0	0	4800	0	10400	800	0	0	0	4000	0	3200	4000	5600	2400	4000	2400
Thalassiosira ferelineta	0	0	3200	0	0	0	0	0	0	0	0	1600	0	0	0	1600	0	4000
Trachyneis sp	0	0	0	0	480	0	0	0	0	0	0	0	0	0	800	0	0	0
Triceratium favus	3200	0	1600	4000	0	2400	2400	2400	0	0	0	2400	0	800	0	1600	0	0
Trieres mobiliensis	0	4800	6400	8000	7200	1280	0	0	0	0	1600	3200	0	1600	1600	2400	0	5600
Tripos muelleri	0	0	0	0	0	0	800	0	0	0	0	0	0	0	0	0	0	0
Unidentified	0	0	0	0	0	0	0	0	0	0	0	0	4000	0	1600	0	0	0
Density of Phytoplankton (diff. sites wise.)(no/m^3)	222240	160000	160800	187840	431680	208800	230720	131200	104800	108000	284800	393440	64000	86720	75200	119360	101120	121120
Total= 3191840 no/m^3																		
Total No Of Genus/Species=**40**																		

Table 16. Diversity Indices of Phytoplankton at different sites at Kandla Port

	Offshore						Cargo jetty						Phang Creek					
	1A	**1B**	**1C**	**1D**	**1E**	**1-control**	**2A**	**2B**	**2C**	**2D**	**2E**	**2-contrl**	**3A**	**3B**	**3C**	**3D**	**3E**	**3-control**
Variables																		
Taxa_S	16	13	12	18	16	20	15	13	9	10	9	13	11	20	13	19	15	18
Individuals (Nos/m^2)	222240	160000	160800	187840	431680	208800	230720	131200	104800	108000	284800	393440	64000	86720	75200	119360	101120	121120
Dominance_D	0.32	0.34	0.29	0.17	0.25	0.22	0.50	0.40	0.29	0.28	0.72	0.67	0.19	0.10	0.17	0.15	0.14	0.13
Shannon Diversity Index (H)	1.76	1.64	1.72	2.24	1.70	2.09	1.25	1.51	1.53	1.59	0.73	0.79	1.95	2.56	2.12	2.28	2.22	2.34
Simpson_1-D	0.68	0.66	0.71	0.83	0.75	0.78	0.50	0.60	0.71	0.72	0.29	0.33	0.81	0.90	0.83	0.85	0.86	0.87
Evenness_e^H/S	0.36	0.39	0.47	0.52	0.34	0.40	0.23	0.35	0.51	0.49	0.23	0.17	0.64	0.65	0.64	0.51	0.62	0.58
Menhinick	0.03	0.03	0.03	0.04	0.02	0.04	0.03	0.04	0.03	0.03	0.02	0.02	0.04	0.07	0.05	0.06	0.05	0.05
Margalef	1.22	1.00	0.92	1.40	1.16	1.55	1.13	1.02	0.69	0.78	0.64	0.93	0.90	1.67	1.07	1.54	1.22	1.45

5.5. Zooplankton

The study was conducted at 3 sites in Kandla Port and nearby areas where dredging activities are going on. The three selected study stations are Offshore, Cargo Jetty and Phang Greek.

5.5.1. Offshore

Acartia sp, Calanoida (unidentified), Euterpina sp (Harpacticoida), Foraminifera (unidentified), Nauplius larva of Copepoda, Ostracoda, *Paracalanus sp* (Calanoida), Sponge Spicules, Zoea larva of Crab etc. were the mostly common zooplankton and throughout observed in all sites of Offshore area. Highest population density was recorded at site 1C-Offshore (125440 nos./100m^3) where number of species was (24 nos.) and lowest density in 1A-Offshore (90080 nos./100m^3) where number of species was recorded (20 nos.). High biomass was observed in the site 1E-Offshore (27.78 ml/100m^3) and low biomass was recorded in site 1D-Offshore (5.95 ml/100m^3). The range of the population density, biomass and number of species were (93120 to 196000 nos./100m^3), (5.95 to 27.78 ml/100m^3) and (20 to 27 nos.) respectively in all sites.

Less observed species were Amphipoda (Crustacea), Arcella sp (Amoebozoa), Centropages sp (Calanoida), Corycaeus sp (Calanoida), Fish larva, Fish egg *Leprotintinnus sp* (Tintinnida), Triloculina sp (Foraminifera) etc in this station. Total 49 zooplankton was recorded in Offshore area adding that more composition of zooplankton by the Phylum Arthropoda (Crustacea), Tintinnids and Foraminifera and Sponge Spicules (Porifera).

5.5.2. Cargo Jetty

The population density of zooplankton varied from 53600 nos./100m^3 to 105920 nos./100m^3. Maximum density was noticed in site 2E-Cargo Jetty (65440nos./100m^3) and minimum was at site 2A-Cargo Jetty (105920nos./100m^3). Maximum number of species (27nos.) found 2A - Cargo Jetty minimum number of species was observed in site 2C-Cargo Jetty (17nos.). Biomass ranged between 7.50 to 122.95 ml/100m^3 where highest biomass noted in site2Control-Cargo Jetty and lowest in 2D-Cargo Jetty. Frequently observed species were *Acartia sp (Calanoida)*, Calanoida (unidentified), *Clausocalanus sp* (Calanoida), Copepoda eggs sacs, *Leprotintinnus sp* (Tintinnida), Ostracoda, Polychaete larvae (Annelids), *Tintinnopsis orientalis* (Tintinnida) Sponge Spicules, Zoea larva of Crab etc. whereas less observed species were Ammonia sp (Foraminifera), *Centropages sp* (Calanoida), Corycaeus sp (Calanoida), Cyphonautes larva (Bryozoan), Euchaeta sp (Calanoida), Mysis larva of Prawn, Harpacticoida (unidentified), *Spiroloculina sp* (Foraminifera),etc. Some Unidentified larval stages were also reported. Total recorded zooplanktons were 47 in Cargo Jetty.

5.5.3. Phang Creek

This Creek area was represented by the zooplankton fauna majority of them were Acartia sp (Calanoida), Calanoida (unidentified), Copepoda eggs sac *Clausocalanus sp* (Calanoida), Foraminifera (unidentified), Veliger larvae of Bivalve, Sponge spicules, *Leprotintinnus sp* (Tintinnida).Very less time or rarely recorded species were, Calcarina sp (Foraminifera), Centropages sp (Calanoida) Cyclopoida (unidentified), Fish larva, Leprotintinnus nordqvistii (Tintinnida), Nauplius larva of Copepoda, *Paracalanus sp* (Calanoida), Tintinnopsis cylindrica (Tintinnida), Zoea larva of Crab. The range of zooplankton biomass was between 17.86 to 74.63 ml/100m^3. Highest Biomass was recorded in site 3A-Phang creek (74.63 ml/100m^3) and lowest in site 3C-Phang creek (17.86 ml/100m^3). Maximum and Minimum species count was at in site 3E-Phang creek (23nos.) and 3D-Phang Creek (15nos.) respectively. Population density was maximum recorded in site 3A-Phang Creek (110080 nos./100m^3) and minimum in site 3D-Phang Creek (57600 nos./100m^3). In site 3D-Phang creek comparatively low density according to other sites may be because of high predator pressure or some environment changes.

Overall assessment of zooplankton showed that the total number of 66 Zooplankton recorded during summer season. Out of these (79) zooplankton, 49 zooplankton recorded in Offshore region, 47 zooplankton at Cargo Jetty and 41 zooplankton in

Phang Creek region. The recorded zooplankton of all 3 stations mainly representing Phylum Arthropoda (Crustacea), Protozoa (mainly foraminifera and tintinnids), Porifera (sponge spicules). Crustacean zooplankton was the dominant due to the dominance of different larval stages and Copepods which mainly feed phytoplankton. More larval stage of crustacean and other animals observed in samples that indicated reproduction and development season of animals from larval to mature animal.Generally zooplankton population dynamics and studies emphasize is given up to group level rather than to species level because of microscopic size of zooplankton so to the difficulty in identifying the zooplankton as some species are considered as a group or genus level. The most dominant or frequently observed species(all 3 station) were Acartia sp (Calanoida) Calanoida (unidentified), *Clausocalanus sp* (Calanoida), Copepoda eggs sac, Foraminifera (unidentified), Globigerina sp (Foraminifera), Ostracoda, Sponge Spicules, Veliger larvae of Bivalve, Zoea larva of Crab etc. Foraminifera and Ostracoda belonging to the meroplankton were present at all three stations.

Overall range of all three sites Population density, Biomass and Number of species were (53600 to 196000no/100 m^3), (5.95 to 122.95ml/100m^3) and (15 to 27nos) respectively. Average high biomass noted at Cargo Jetty (35.64 ml/100m^3) followed by Phang creek (33.84 ml/100m^3) than Offshore (20.05 ml/100m^3) (Tables 17-19). Highest population density was recorded in site 1E-Offshore (196000 nos/100m^3) and lowest was recorded in site 2C-Cargo Jetty (53600no/100m3). Among all recorded zooplankton, majority dominance occurrence was by the Copepoda, Crustacean larvae, Spong Spicules, Foraminifera (Protozoa), Tintinnids (Protozoa), Zoea larva of Crab..

Maximum zooplankton faunal composition was dominated by the Phylum Arthropoda, Mollusca, Protozoa, Porifera, Foraminifera. The Fish larva and Fish egg (Ichthyoplankton) was also recorded in sites of Offshore. The Zooplankton of Chaetognatha,, Amoebozoa were only represented by the species namely *Sagitta sp (arrow worm), Arcella sp.* respectively. Veliger larva of Bivalve and Heteropods shells include in Phylum Mollusca. The Echinodermata phylum represented by the Ophiopluteus larva and Gastrula larva of Sea star.

In Offshore**,** maximum Occurrence (%) was by the Foraminifera (unidentified) (13.24%) and minimum by the Amphipoda (Crustacea) (0.04%). In Cargo Jetty, maximum Percentage of Occurrence (%) by the Foraminifera (unidentified) (12.42%) and minimum by the Centropages sp (Calanoida) (0.06%). In Phang Creek maximum Occurrence by the Foraminifera(unidentified) (25.49%) and minimum (0.07%) by the Nematoda and some unidentified zooplankton (Tables 17 - 19).

During microscopic sample analysis more number of species varieties of Foraminifera, Sponge spicules, Crustacean larva and Tintinnidswere observed. These all three are very important for paleontological study aspects and also for evolutionary, ecological and environmental rebuilding. Some species of Ostracoda, Foraminifera and Sponge spicules are considered in microfossils materials. Some deep sea species also recorded that is indication of water circulation pattern. Data on zooplankton density, list of zooplankton is shown in Tables (17, 18 and 19).

Plankton identification, both zooplankton and phytoplankton, were done by using relevant identification and taxonomic keys and with standard literatures, monographs and research articles (Kasturirangan, 1963; APHA, 1992; Mitra et al., 2003; Goswami, 2005; Carling et al., 2004; Mandal, 2004; Hussain & Kalaiyarasi, 2013; Guglielmo et al., 2015; Hussain et al., 2016; Sreenivasulu et al., 2017; NIO,1998; NIO,2002) ,etc

5.6. Diversity Indices of Zooplankton

The data in the Table 20 shows diversity indices of zooplankton. *The Shannon*-wiener diversity index (H') fluctuated between 2.19 to 3.03 indicated moderate to quite high range of diversity added indication of healthy body of water with a maximum value in site 1Control-Offshore (3.03) where maximum number of species noted (27 nos.) and minimum value in site 3A-Phang Creek (2.19) where species number was 19. Range of the evenness was 0.47 to 0.83 where lowest and highest recorded in site 3A-Phang creek (0.47) and 1C-Offshore (0.83) respectively. Range of Simpson index was 0.78 to 0.94. The range value of Margalef indices was 1.43 to 2.25 that means high species number variations. (Table 20).

Table 17. Density of Zooplankton at Offshore site of Deendayal Port

Name of Genera/Group	1A	1B	1C	1D	1E	1 Control	Individual total density (no/100m^3)	% of Occurrence (Site-wise)
Acartia sp (Calanoida)	4000	4000	4000	0	2400	3200	17600	2.33
Ammonia sp (Foraminifera)	3200	0	0	2400	3200	4000	12800	1.69
Amphipoda (Crustacea)	0	320	0	0	0	0	320	0.04
Arcella sp (Amoebozoa)	0	0	0	3200	0	0	3200	0.42
Bolivina sp (Foraminifera)	0	4000	2400	0	0	2400	8800	1.16
Calanoida (unidentified)	0	5600	9600	8000	0	16000	39200	5.19
Centropages sp (Calanoida)	0	3200	0	0	0	0	3200	0.42
Clausocalanus sp (Calanoida)	3200	0	4000	2400	3200	4000	16800	2.22
Copepoda eggs sac	12000	4800	5600	16000	24000	8000	70400	9.32
Corycaeus sp (Calanoida)	0	0	0	0	0	1600	1600	0.21
Cyclopoida (unidentified)	0	4000	12000	0	8000	8000	32000	4.24
Euterpina sp (Harpacticoida)	1600	0	3200	2400	1600	1600	10400	1.38
Fish larva	0	0	0	0	2400	1600	4000	0.53
Fish egg	0	0	0	0	2400	0	2400	0.32
Foraminifera (unidentified)	20000	16000	8000	12000	32000	12000	100000	13.24
Gastrula larva of Echinodermata	480	0	0	0	1600	0	2080	0.28
Globigerina sp (Foraminifera)	5600	0	5600	9600	2400	0	23200	3.07
Globigerinoides sp (Foraminifera)	0	4000	5600	0	0	0	9600	1.27
Heteropoda shells (gastropods)	0	3200	0	0	0	0	3200	0.42
Leprotintinnus simplex (Tintinnida)	0	0	0	1600	0	0	1600	0.21
Leprotintinnus sp (Tintinnida)	0	0	0	2400	0	2400	4800	0.64
Leprotintinnus nordqvistii (Tintinnida)	0	0	0	0	4000	0	4000	0.53
Lucifer sp (small prawn)	1600	0	0	0	0	0	1600	0.21
Microsetella sp (Harpacticoida)	0	0	4000	0	1600	1600	7200	0.95
Mysids (shrimp like)	0	0	3200	0	0	0	3200	0.42
Mysis larva of Prawn	0	2400	0	0	0	0	2400	0.32
Nauplius larva of Copepoda	0	3200	3200	3200	0	2080	11680	1.55
Nauplius larvae of Barnacles	0	0	0	4000	0	2400	6400	0.85
Nauplius larvae of Crustacea	0	0	11200	16000	17600	0	44800	5.93
Oithona sp (Cyclopoida)	0	0	0	0	20000	0	20000	2.65
Ophiopluteus Larva (Echinodermata)	0	0	0	0	0	800	800	0.11
Ostracoda	7200	4000	8000	8000	10400	2400	40000	5.29
Paracalanus sp (Calanoida)	0	0	1600	3200	3200	0	8000	1.06
Parvocalanus sp (Calanoida)	1600	0	3200	2400	4000	3200	14400	1.91
Polychaete larvae (Annelids)	2400	8000	0	4000	7200	3200	24800	3.28
Rotallida (Foraminifera)	0	0	0	0	4000	7200	11200	1.48
Sagitta sp (arrow worm)	1600	0	0	0	0	0	1600	0.21
Spirillina sp (Foraminifera)	800	4000	0	1600	1600	1600	9600	1.27
Spiroloculina sp (Foraminifera)	0	0	0	4000	0	0	4000	0.53
Sponge Spicules	4000	3200	9600	4000	12000	13600	46400	6.14
Subeucalanus sp (Calanoida)	2400	2400	2400	3200	3200	5600	19200	2.54

Tintinnopsis cylindrica (Tintinnida)	0	0	0	1600	0	0	1600	0.21
Tintinnopsis orientalis (Tintinnida)	0	12800	8000	0	10400	6400	37600	4.98
Tintinnopsis radix (Tintinnida)	5600	800	0	0	0	4000	10400	1.38
Tintinnopsis sp (Tintinnida)	8000	0	6400	0	8000	0	22400	2.96
Triloculina sp (Foraminifera)	0	0	640	0	0	7200	7840	1.04
Veliger larvae of Bivalve	0	0	1600	2400	3200	0	7200	0.95
Zoea larva of Crab	3200	3200	2400	3200	2400	4000	18400	2.44
Unidentified larva	1600	0	0	0	0	0	1600	0.21
Total No. Of Genera/Groups=49								
Site-wise Total Density (no/100m^3)	90080	93120	125440	120800	196000	130080	**755520**	**100%**
Biomass (ml/100m^3)	**16.23**	**17.97**	**26.14**	**5.95**	**27.78**	**26.25**		

Table 18: Density of Zooplankton at Cargo Jetty site of Deendayal Port

Name of Genera/Group	2A	2B	2C	2D	2E	2 Control	Individual total density (no/100m^3))	% of Occurrence (Site-wise)
Acartia sp (Calanoida)	1600	3200	0	12000	2400	1600	20800	4.19
Ammonia sp (Foraminifera)	4000	0	0	0	0	0	4000	0.81
Arcella sp (Amoebozoa)	1600	0	0	800	0	0	2400	0.48
Calanoida (unidentified)	8000	12000	0	12000	8000	0	40000	8.07
Centropages sp (Calanoida)	0	320	0	0	0	0	320	0.06
Clausocalanus sp (Calanoida)	1600	0	1600	3200	3200	4000	13600	2.74
Copepoda eggs sac	2400	4000	1600	3200	2400	8000	21600	4.36
Corycaeus sp (Calanoida)	0	0	0	0	1600	0	1600	0.32
Cyclopoida (unidentified)	0	4000	8000	0	0	4000	16000	3.23
Cyclops sp (Cyclopoida)	0	0	0	4800	4000	0	8800	1.77
Cyphonautes larva (Bryozoan)	0	0	800	0	0	0	800	0.16
Euchaeta sp (Calanoida)	0	0	0	3200	0	0	3200	0.65
Euterpina sp (Harpacticoida)	1600	0	1600	0	1600	0	4800	0.97
Fish larva	800	0	800	0	0	0	1600	0.32
Foraminifera (unidentified)	32000	0	0	4000	16000	9600	61600	12.42
Globigerina sp (Foraminifera)	6400	3200	4000	0	3200	0	16800	3.39
Harpacticoida (unidentified)	0	0	0	0	1600	0	1600	0.32
Heteropoda shells (gastropods)	2400	0	0	0	0	0	2400	0.48
Hydrocaulus & Hydrotheca(Hydrozoa)	0	1600	0	0	0	0	1600	0.32
Lagena sp (Foraminifera)	0	0	800	0	0	0	800	0.16
Leprotintinnus simplex (Tintinnida)	0	1600	0	0	4000	1600	7200	1.45
Leprotintinnus sp (Tintinnida)	0	3200	1600	1600	2400	1600	10400	2.10
Microsetella sp (Harpacticoida)	0	3200	0	800	0	1600	5600	1.13
Mysis larva of Prawn	0	0	0	0	0	16000	16000	3.23
Nauplius larva of Copepoda	1120	0	4000	2400	4000	0	11520	2.32
Nauplius larvae of Barnacles	2400	0	0	3200	0	0	5600	1.13
Nauplius larvae of Crustacea	0	4800	0	16000	3200	3200	27200	5.49
Nauplius larvae of Cyclopoida	800	0	0	0	0	0	800	0.16
Oithona sp (Cyclopoida)	7200	0	0	4000	4800	3200	19200	3.87
Ophiopluteus Larva (Echinodermata)	0	800	0	640	0	0	1440	0.29
Ostracoda	1600	3200	3200	3200	2400	0	13600	2.74
Paracalanus sp (Calanoida)	1600	2400	4000	3200	1600	0	12800	2.58
Parvocalanus sp (Calanoida)	1600	0	0	0	2400	3200	7200	1.45
Polychaete larvae (Annelids)	4800	4800	4000	1600	2400	4000	21600	4.36
Pontellid nauplius larva (Calanoida)	0	0	1600	0	0	0	1600	0.32
Protozoaea larva (Crustacea)	0	0	0	1600	0	0	1600	0.32
Quinqueloculina sp (Foraminifera)	3200	1600	0	0	1600	0	6400	1.29
Sagitta sp (arrow worm)	800	0	800	0	0	800	2400	0.48
Spiroloculina sp (Foraminifera)	0	0	0	0	0	800	800	0.16
Sponge Spicules	800	4800	3200	3200	0	4000	16000	3.23
Subeucalanus sp (Calanoida)	1600	1600	0	0	2400	0	5600	1.13
Tintinnopsis beroidea (Tintinnida)	0	0	0	0	800	0	800	0.16
Tintinnopsis orientalis (Tintinnida)	9600	12000	12000	2560	8000	0	44160	8.91
Tintinnopsis sp (Tintinnida)	0	0	0	4000	0	0	4000	0.81
Veliger larvae of Bivalve	2400	4000	0	2400	2400	3200	14400	2.90
Zoea larva of Crab	3200	2400	0	2400	0	3200	11200	2.26
Unidentified larva	800	0	0	0	0	1600	2400	0.48
Total No. Of Genera/Groups=47								

Site-wise Total Density ($no/100m^3$)	105920	78720	53600	96000	86400	75200	**495840**	**100%**
Biomass ($ml/100m^3$)	**11.54**	**22.22**	**25.25**	**7.50**	**24.39**	**122.95**		

Table 19: Density of Zooplankton at Phang Creek site of Deendayal Port

Name of Genera/Group	3A	3B	3C	3D	3E	3 Control	Total density (no/100m3)	% of Occurrence (Site-wise)
Acartia sp (Calanoida)	2400	2400	3200	0	2400	2400	12800	2.65
Ammonia sp (Foraminifera)	0	4000	1600	0	3200	3200	12000	2.48
Arcella sp (Amoebozoa)	3200	0	1600	800	800	0	6400	1.32
Bolivina sp (Foraminifera)	1600	0	1600	0	0	0	3200	0.66
Calanoida (unidentified)	4000	0	9600	5600	8000	8000	35200	7.28
Calcarina sp (Foraminifera)	4000	0	0	0	0	0	4000	0.83
Centropages sp (Calanoida)	0	1600	0	0	0	0	1600	0.33
Clausocalanus sp (Calanoida)	800	160	2400	3200	0	4000	10560	2.18
Copepoda eggs sac	4000	4000	0	2400	8000	12000	30400	6.29
Cyclopoida (unidentified)	0	0	4000	1600	0	0	5600	1.16
Euterpina sp (Harpacticoida)	2400	0	0	1600	0	1600	5600	1.16
Fish larva	0	480	0	0	0	0	480	0.10
Foraminifera (unidentified)	48000	15200	12000	16000	22400	9600	123200	25.49
Gastrula larva of Echinodermata	1600	0	0	3200	0	0	4800	0.99
Globigerina sp (Foraminifera)	12000	4000	4800	0	4000	0	24800	5.13
Leprotintinnus simplex (Tintinnida)	0	2400	0	2400	4000	0	8800	1.82
Leprotintinnus sp (Tintinnida)	3200	3200	2400	3200	4000	1600	17600	3.64
Leprotintinnus nordqvistii (Tintinnida)	1600	0	0	0	0	0	1600	0.33
Microsetella sp (Harpacticoida)	0	0	1600	0	3200	1600	6400	1.32
Mysids (shrimp like)	0	8000	4000	0	0	0	12000	2.48
Mysis larva of Prawn	960	2400	0	0	320	0	3680	0.76
Nauplius larva of Copepoda	0	0	0	1600	0	0	1600	0.33
Nauplius larvae of Barnacles	0	0	1600	0	0	0	1600	0.33
Nauplius larvae of Crustacea	0	0	0	4800	4800	1920	11520	2.38
Nematoda	0	0	0	0	0	320	320	0.07
Ostracoda	7200	0	4800	0	1600	4800	18400	3.81
Paracalanus sp (Calanoida)	0	0	0	0	2400	0	2400	0.50
Parvocalanus sp (Calanoida)	0	0	2400	2400	2400	640	7840	1.62
Polychaete larvae (Annelids)	0	800	3200	3200	2400	0	9600	1.99
Prawn larvae (premature stage)	0	5600	0	0	0	0	5600	1.16
Reussella sp (Foraminifera)	0	0	5600	0	1600	0	7200	1.49
Rotallida (Foraminifera)	0	0	0	0	4000	0	4000	0.83
Rosalina sp (Foraminifera)	4000	3200	0	0	8000	0	15200	3.14
Sponge Spicules	4000	3200	3200	5600	12000	12000	40000	8.28
Subeucalanus sp (Calanoida)	0	0	2400	0	0	2400	4800	0.99
Tintinnopsis cylindrica (Tintinnida)	0	0	0	0	800	0	800	0.17
Tintinnopsis orientalis (Tintinnida)	4000	4000	0	0	4800	3200	16000	3.31
Triloculina sp (Foraminifera)	0	1600	0	0	0	0	1600	0.33
Veliger larvae of Bivalve	1120	800	640	0	0	800	3360	0.70
Zoea larva of Crab	0	0	480	0	0	0	480	0.10
Unidentified	0	0	0	0	320	0	320	0.07
Total No. Of Genera/Groups=41								
Site-wise Total Density (no/100m^3)	110080	67040	73120	57600	105440	70080	**169920**	**100%**
Biomass (ml/100m^3)	**74.63**	**26.67**	**17.86**	**43.21**	**22.00**	**18.66**		

Table 20: Diversity indices of Zooplankton at different sites of Deendayal Port

	Offshore						Cargo jetty						Phang Creek					
	1A	**1B**	**1C**	**1D**	**1E**	**1-control**	**2A**	**2B**	**2C**	**2D**	**2E**	**2-contrl**	**3A**	**3B**	**3C**	**3D**	**3E**	**3-control**
Variables																		
Taxa_S	20	20	24	24	27	27	27	21	17	24	24	19	19	19	21	15	23	17
Individuals (nos. /m^2)	90080	93120	125440	120800	196000	130080	105920	78720	53600	96000	86400	75200	110080	67040	73120	57600	105440	70080
Dominance_D	0.10	0.08	0.06	0.07	0.08	0.06	0.12	0.08	0.11	0.08	0.07	0.10	0.22	0.10	0.08	0.12	0.09	0.11
Shannon Diversity Index(H)	2.62	2.75	3.00	2.90	2.87	3.03	2.69	2.79	2.51	2.85	2.92	2.63	2.19	2.60	2.79	2.41	2.73	2.46
Simpson_1-D	0.90	0.92	0.94	0.93	0.92	0.94	0.88	0.92	0.89	0.92	0.93	0.90	0.78	0.90	0.92	0.88	0.91	0.89
Evenness	0.69	0.78	0.83	0.76	0.65	0.76	0.54	0.77	0.72	0.72	0.77	0.73	0.47	0.71	0.77	0.75	0.67	0.69
Menhinick	0.07	0.07	0.07	0.07	0.06	0.07	0.08	0.07	0.07	0.08	0.08	0.07	0.06	0.07	0.08	0.06	0.07	0.06
Margalef	1.67	1.66	1.96	1.97	2.13	2.21	2.25	1.77	1.47	2.01	2.02	1.60	1.55	1.62	1.79	1.28	1.90	1.43

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Third Season Report

Studies on Dredged Materials for the presence of Contaminants and suggesting suitable disposal options

(As per EC & CRZ Clearance accorded by the MoEF & CC, GoI dated 19/12/2016 - Specific Condition No. vii)

DPA Work order No. EG/WK/4751/Part (EC&CRZ-1) / 84. Dt. 18.09.2021.

Submitted by

Gujarat Institute of Desert Ecology
Mundra Road, Bhuj - Kachchh,
Gujarat – 370001.

Submitted to

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

2024

Project Team

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

S. No	Name and Designation	Role	Background
1.	Dr. K. Karthikeyan Assistant Director	Principal Investigator	M.Sc., Ph.D. in Environmental Science; 15 years of experience in Marine Environmental Monitoring and Pollution Assessment studies.
2.	Dr. G. Jayanthi Scientist	Co-Investigator	MSc., MPhil., PhD in Botany; 13 years of Research and teaching experience inclusive of Post-Doctoral experience for 5 years.
3.	Dr. Krushnakant. D. Baxi Scientific Officer	Co-Investigator	Ph.D in Zoology (Marine Biology) with 5 years of experience
4.	Ds. Monika Sharma Sr. Scientific Asst.	Team member	M.Sc. in Environmental Sciences; 7 years of experience in Marine water and sediment analysis
5.	Ms. Dipti Parmar Scientific Assistant	Team member	M.Sc. in Environmental Sciences; 6 years of experience in sediment and water analysis.

Dr. V. Vijay Kumar
Director

Gujarat Institute of Desert Ecology

CERTIFICATE

This is to state that the **Third Season Report** of the work entitled, **"Studies on Dredged Material for the presence of contaminants"** has been prepared in line with the Work order issued by DPT vide No. EG/WK/4751/Part (EC & CRZ-1)/84. Dt.18.09.2021 as per the EC & CRZ Clearance accorded by the MoEF & CC, GoI dated 19/12/2016, Specific Condition No. vii.

This work order is for a period of Three years from 2021 –2024 for the above-mentioned study.

Authorized Signatory **Institute Seal**

PO. Box No. 83, Opp. Changleshwar Temple, Mundra Road, Bhuj (Kachchh) - 370 001, Gujarat (India)
Tel : 02832 - 235025-26
www.gujaratdesertecology.com, E-mail : desert_ecology@yahoo.com

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Chapter 1 Background

Deendayal Port Authority, formerly known as Deendayal Port Trust, erstwhile called as Kandla Port Trust is one of the Major Twelve Ports of the Country, holds a prominent position as a significant maritime gateway in India, situated within Gujarat's Kutch district. This stands out as the largest Creek-based port, positioned at the southwestern tip of the Gulf of Kachchh, on India's north-western coastline within the state of Gujarat. Deendayal Port Authority (DPA) serves as a pivotal hub for maritime trade, facilitating the transportation needs of several hinterland states. It boasts excellent connectivity through an extensive rail and road network, functioning as a crucial gateway for the export and import activities of northern and western Indian states, including Jammu & Kashmir, Delhi, Punjab, Himachal Pradesh, Haryana, Rajasthan, Gujarat, as well as parts of Madhya Pradesh, Uttaranchal, and Uttar Pradesh. This port ranks among the largest and most essential ports in the country, playing a vital role in India's international trade and maritime infrastructure. The administration and operations of the port are overseen by the Deendayal Port Trust (DPT), an autonomous entity established under the Major Port Trusts Act of 1963.

The Deendayal Port Trust is entrusted with the comprehensive management, development, and administration of the port. The authority is comprised of a dedicated team of professionals and experts who work diligently to ensure the efficient operation of the port and all related activities. About 35% of the country's total export takes place through the ports of Gujarat in which the contribution by Deendayal port is considerable. The port handled a total cargo of 105 MMTPA during 2016-17, 110 MMTPA during 2017-18, 115 MMTPA during 2018-19, 122.5 MMTPA during 2019-2020, 117.5 MMTPA during 2020-21 and 137 MMTPA during 2022-23. DPA is the only major Indian port to handle more than 127 MMT cargo throughput, and it has also registered the highest cargo throughput in its history. The port has handled a total of 3151 vessels during FY 2021-22. Over the years, the port has witnessed significant growth and development, becoming a crucial gateway for India's international trade.

Deendayal Port has a strategic location on the west coast of India, offering direct access to the Arabian Sea. It serves as a vital link for India's trade with countries in the Middle East, Africa, Europe, and Asia. The port handles a wide range of cargoes, including petroleum products, chemicals, coal, iron ore, fertilizers, salt, and general cargo.

Further, regular expansion of infrastructure and port facilities is under way to cater future logistic requirements. With such capacity, the Port ranks No. 1 among all the major ports in India for 12th Consecutive year. Further, a regular expansion of infrastructure and port facilities is under way to cater future logistic requirements. The port has high commercial importance in the Indian maritime trade as it handled 36.1 million tons (17%) of Cargo out of total Cargo of 213.1 million tons of the maritime Cargo of India during 2015. In addition, regular expansion of infrastructure and port facilities is under way to cater future logistic requirements.

Deendayal Port Authority (DPA) has taken up Development of 7 Integrated facilities, and the Ministry of Environment, Forest and Climate Change (MoEF & CC), has put up some conditions while according Environmental and CRZ clearance. One of the conditions is to carry out the *"Study on Dredged Material for presence of contaminants"* as accorded by the MoEF & CC, GoI dated 19/12/2016 - Specific condition no. vii)" which states that ***"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"***.

1.1 Need of the study

Considering the aforementioned condition, DPA has assigned the task of carrying out the study to Gujarat Institute of Desert Ecology (GUIDE), Bhuj. This study will be attempted three times in a year at two specified locations. Further, the study will envisage the evaluation of physico-chemical constituents in the dredged materials in the dumped locations in the study area. GUIDE has been entrusted with the project, which has duration of three years (01.11.2021 – 31.10.2024) as specified in the work order. Accordingly, the study was initiated to evaluate the dredged materials for potential contamination, employing a systematic investigation that encompasses the analysis of physical, chemical, and biological characteristics with special reference to pollutants including heavy metal, Petroleum hydrocarbon etc.

1.2. Scope of the study

a. To monitor the locations where dredged materials are dumped will be conducted.
b. Dredged materials in the area will be analyzed for the presence of contaminants in two different locations.
c. Detailed assessment of the dredged materials for physical, chemical and biological characteristics will be studied.
d. Suggesting suitable disposal options for the dredged material will be made.

1.3. Sampling locations for 2023-24

The study focused on investigating the presence of contaminants in the dredged materials during the year 2023-24. The specific locations for sampling can be found in Table 1 and Plate 1. The selection of these sampling sites was based on information supplied by the Hydraulic and Dredging Division to the Department of Port Administration (DPA), concerning the locations of dumping grounds. These location details were subsequently shared with the Gujarat Institute of Desert Ecology (GUIDE) via an email dated October 24, 2018. Three seasonal studies covering Location 1, Location 2 and Location 3 with the Third season of the study was conducted during 01.08.2024 – 03.08.2024.

Table 1: GPS Co-ordinates of sampling locations

Station	Latitude (N)	Longitude (E)
Location 1 (Offshore)	22° 51' 00" N	70° 10’ 00" E
Location 2 (Cargo jetty)	22°56' 31" N	70 13' 00" E
Location 3 (Phang Creek)	23° 04' 28" N	70°13’ 28" E

1.4. Details of work done during 3rd Quarter (May 2024 – July 2024)

The Third season sampling of the project was conducted in the 3rd Quarter of the project period, *i.e.*, 2023-24. During the sampling, the surface and bottom marine water samples and bottom marine sediment samples were collected from the three designated locations, *i.e.*, Offshore, Cargo Jetty and Creek systems which was pre-designated locations as earmarked by CPWRS was conducted.

After the collection, the samples were preserved using standard protocols and stored in an Ice box and brought to the laboratory within 2-3 hrs of collection Comprehensive analysis was performed on all the samples, both water (36 samples) and sediment (18 samples), to determine various physical, chemical, and biological characteristics. The analysis followed the standard methods prescribed by the Integrated Coastal and Marine Area Management (ICMAM) in 2012. All samples were analysed in triplicates, and the obtained data was compared against the marine water limits specified by the Central Pollution Control Board (CPCB) and other relevant standards.

Plate 1: Map showing locations of proposed sampling (2023-2024)

Chapter 2 Physico-Chemical Characteristics of the Sediment

The sediment samples from the study area were collected for the purpose of characterization employing standard methodology and the analysis of the samples were also performed as per standard protocol and the data of sediment analysis is presented in this Chapter 1. The sediment samples were collected in pre-fixed stations using a Van-Veen type of grab sampler. After collection, the sediment samples were preserved with Rose Bengal and formalin to avoid decomposition of samples and processed for analysis and the samples after collection were brought to the laboratory on the same day of collection and air dried and used for further analysis for the test parameters (Table 2).

Table 2: Physico-chemical and biological characteristics of sediment samples

S. No	Physico-chemical and biological parameters
1	pH (1: 10 suspension)
2	Salinity (ppt)
3	Sand (%)
4	Silt (%)
5	Clay (%)
6	Total organic carbon (%)
7	Phosphorus (mg/kg)
8	Sulphur (mg/kg)
9	Petroleum Hydrocarbon (µg/kg)
10	Cadmium (mg/kg)
11	Lead (mg/kg)
12	Chromium (mg/kg)
13	Copper (mg/kg)
14	Cobalt (mg/kg)
15	Nickel (mg/kg)
16	Zinc (mg/kg)
17	Magnesium (mg/kg)
18	Macrobenthos

2.1. pH and Salinity (1: 10 suspension)

The pH of the sediment suspension is a measure of the activity of H+ ions within the sediment-water system. It indicates whether the sediment is acidic, neutral or alkaline in nature. Since ions are the carrier of electricity, the electrical conductivity (EC) of the sediment-water system rises according to the content of soluble salts. The EC measurement directly corresponds to the concentration of soluble salts in the sediment at any particular temperature. To conduct the analysis, ten grams of the finely sieved sediment was dissolved in 100ml of distilled water to prepare leachate. This leachate was taken for shaking using a rotator shaker for one hour to ensure proper homogenization of the suspension. Following this, the suspension was allowed to settle for two hours, and the supernatant was collected after filtration for the subsequent analysis of pH and salinity using the pH and EC meter (Make: Systronics 361) and Refractometer (Make: Atago) respectively. Each sample was analyzed in triplicates to ensure accuracy, and the mean values were considered for further evaluation.

2.2. Textural analysis (Sand/Silt/Clay)

Sediment samples were collected using Van Veen grab whereas intertidal sediments will be collected using a handheld shovel. After collection, the scooped samples are transferred to polythene bags, labelled and stored under refrigerated conditions. The sediment samples are thawed, oven dried at 40ºC and ground to a fine powder before analyses.

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

2.3. Total organic carbon

Total organic carbon refers to the carbon content stored within sediment organic matter. It is derived from various sources such as the decomposition of plant and animal residues, root exudates, living and deceased microorganisms, sediment biota etc. To measure total organic carbon in sediment, a process of oxidation is employed using potassium dichromate in the presence of concentrated sulfuric acid. During the analysis, potassium dichromate generates nascent oxygen, which reacts with the carbon present in organic matter, resulting in the production of carbon dioxide (CO2). The excess volume of potassium dichromate is then titrated against a standardized solution of ferrous ammonium sulfate in the presence of phosphoric acid, using Ferroin indicator to detect the initial appearance of unoxidized ferrous iron. This titration allows the determination of the volume of potassium dichromate required to oxidize the organic carbon present in the sample.

2.3.1. Procedure

The determination of the percentage of total organic carbon in sediment involves oxidizing the organic matter within the sediment samples using chromic acid. The excess chromic acid is then estimated by titrating it against ferrous ammonium sulfate, with ferroin serving as an indicator. The step-by-step procedure is outlined as follows:

To begin, 1 gram of sediment sieved to a particle size of 0.5 mm is weighed and transferred into a 500 ml conical flask. Then, 10 ml of 1N $K_2Cr_2O_7$ is added to the flask with pipette followed by gentle swirling to ensure thorough mixing. Next, 20 ml of concentrated H2SO4 is added, and the sediment and reagents are mixed gently. This mixture is allowed to react for 30 minutes on a marble stone to avoid any damage caused by the release of intense heat from the sulfuric acid reaction. Afterward, 200 ml of distilled water is slowly added to the flask, along with 10 ml of concentrated orthophosphoric acid and approximately 0.2 grams of NaF. The sample and reagent mixture is left to stand for 1.5 hours, as the titration endpoint is better observed in a cooled solution. Just before the titration, 1 ml of ferroin indicator is added to the conical flask. The excess $K_2Cr_2O_7$ is then titrated with 0.5 N ferrous ammonium sulfate until the color changes from yellowish green to greenish, and finally to a brownish-red color indicating the endpoint. A blank test without the sediment sample is also performed simultaneously for reference. Through this procedure, the percentage of total organic carbon in the sediment can be accurately determined.

2.4. Total Phosphorus

The determination of total phosphorus in sediment is commonly conducted using Bray's extraction method. This method involves the formation of specific-colored compounds by adding appropriate reagents to the solution, with the intensity of the color being directly proportional to the concentration of phosphorus being estimated. The color intensity is measured spectrophotometrically. In the spectrophotometric analysis, a light source emitting light of a specific wavelength (usually within a band width of 0.1 to 1.0 nm) in the ultraviolet region of the spectrum is used. The photoelectric cells in spectrophotometer measure the light transmitted by the solution allowing for quantitative analysis.

2.4.1. Procedure

To perform the analysis, 50 ml of the Bray's extractant is added to a 100 ml conical flask containing 5 grams of sediment sample. The flask is shaken for 5 minutes and then filtered. Exactly 5 ml of the filtered sediment extract is transferred to a 25 ml measuring flask using a bulb pipette. Subsequently, 5 ml of the molybdate reagent is added using an automatic pipette, followed by dilution to 20 ml with distilled water and shaken well. Furthermore, 1 ml of dilute Stannous Chloride solution is added, and the volume is made up to the 25 ml mark. Thorough shaking is performed to ensure proper mixing. The mixture is then allowed to develop color, and after 10 minutes, readings are taken in the spectrophotometer at a wavelength of 660 nm. Prior to the readings, the instrument is zeroed using a blank prepared similarly but without the sediment.

2.5. Total Sulphur

Total sulphur in the sediment extract was determined using a turbidimetric method with a spectrophotometer. A series of standards containing sulphur at concentrations of 2, 4, 6, 8, and 10 ppm were prepared from a stock solution. Each flask in the series received 25 ml of the respective standard solution, and 2.5 ml of conditioning reagent solution was added. Additionally, 5 ml of extraction solution was added to the mixture. To facilitate the reaction, 0.2-0.3 grams of barium chloride were included and thoroughly mixed. The volume was adjusted to 25 ml with distilled water, and readings were taken at 340 nm using a spectrophotometer.

For the sample analysis, 5 grams of marine sediment were placed in a 100 ml conical flask. To this, 25 ml of a 0.15% $CaCl_2$ solution was added and shaken for 30 minutes. The mixture was then filtered through Whatman No. 42 filter paper. Subsequently, 5 ml of the sample aliquot was transferred into a 25 ml volumetric flask. Conditioning reagent (2.5 ml) and 0.2 to 0.3 grams of barium chloride powder were added, followed by making up the volume to 25 ml with distilled water. The flask contents were shaken for 2 minutes, and the absorbance was measured using the same procedure as the standard solutions.

2.6. Petroleum Hydrocarbons

To analyze petroleum hydrocarbons in sediment, the following procedure will be conducted. First, the sediment will undergo reflux with a mixture of KOH and methanol, allowing for the extraction of petroleum hydrocarbons. This reflux process helps release the hydrocarbons from the sediment matrix. Next, the sediment will be subjected to extraction using hexane, which selectively dissolves the hydrocarbons present in the sediment. The excess hexane will be carefully removed, leaving behind a residue containing the concentrated hydrocarbons of interest. To further purify the sample and remove any impurities, a clean-up procedure will be performed using silica gel column chromatography. This column chromatography process helps separate the hydrocarbons from other compounds present in the residue, resulting in a cleaner sample for analysis. Finally, the hydrocarbon content in the sediment will be estimated by measuring fluorescence, following the standard method for petroleum hydrocarbon analysis. This fluorescence measurement allows for quantification and determination of the hydrocarbon levels present in the sediment sample. By following this procedure, accurate analysis of petroleum hydrocarbons in sediment can be achieved.

2.7. Heavy metals

Heavy metals, such as Cadmium (Cd), Lead (Pb), Chromium (Cr), Nickel (Ni), Cobalt (Co), Copper (Cu), Zinc (Zn), Manganese (Mn), and others, are of particular concern in relation to the environment. To release mineral elements from sediment samples, wet oxidation is commonly employed, utilizing oxidizing acids, such as tri/di-acid mixtures.

In the analysis procedure, a sediment sample weighing 1.0 gram is taken in a 100 ml beaker, which is covered with a watch glass. A mixture of Aqua regia (1:3 HNO_3:HCl) in the amount of 12 ml is added to the beaker. The beaker is then subjected to digestion for 3 hours at 100°C on a hot plate using a sand bath. Afterward, the samples are evaporated to near dryness, allowed to cool for 5 minutes, and then 20 ml of 2% nitric acid is added. The beaker is placed on a hot plate for digestion for 15 minutes, after which it is removed from the hot plate and allowed to cool. The mixture is then filtered using Whatman No. 42 mm filter paper. Finally, the volume is adjusted to 50 ml with 2% nitric acid to make up the final solution. The extracted sample is then aspirated into an Atomic Absorption Spectrometer (AAS) for analysis. By following this procedure, the heavy metal content in the sediment can be accurately analyzed using wet oxidation, filtration, and AAS techniques.

2.8. Results

2.8.1. pH (Hydrogen Ion)

When any characteristics study of water or sediment is concerned, pH is considered to be one of the major variable especially in marine sediments as it influences various biogeochemical processes and ecosystem dynamics. These values are influenced by various factors, including the carbon, oxygen, nitrogen, phosphate, silicate, sulphur, iron, and manganese cycles. They are closely associated with processes such as heterotrophic respiration, chemoautotrophic activity, photosynthesis, precipitation, and the dissolution of calcium carbonate in marine water and sediments. In our investigation, we conducted measurements of average pH values at different locations. All three locations show slightly alkaline pH levels in sediments. Offshore has the average pH (8.42 ± 0.12), followed by Cargo Jetty (8.44 ± 0.28) and Phang Creek (8.64±0.12). The differences are minimal, indicating relatively stable and similar pH conditions across all locations. The data on individual values at all the locations and stations are given in Table 3.

2.8.2. Salinity

Salinity of seawater is subject to fluctuations influenced by temperature changes, following diurnal and seasonal cycles that correspond to variations in atmospheric temperature. Salinity levels in marine water and sediment exhibit a wide range, typically spanning from 0 to 36 in most estuaries. Semi-enclosed bays can experience hyper-salinity conditions. In the present study, it was observed that a broader range of salinity concentrations at different stations. Phang Creek shows the average salinity (18.82±3.26 ppt), followed by Cargo Jetty (16.19±7.06 ppt) and Offshore (25.07± 7.22 ppt), respectively. These findings are summarized in Tables 3-5, where all the data is presented.

2.8.3. Sediment Texture

Understanding the sediment texture at different stations provides valuable insights into the habitat characteristics and ecological dynamics of the marine environment. The sediment texture plays a significant role in determining the physical and chemical properties of the marine sediment, influencing the distribution and abundance of benthic organisms at the offshore station. The sediment composition across the three locations such as Offshore, Cargo Jetty, and Phang Creek—shows distinct patterns in the distribution of sand, silt, and clay. In terms of sand content, the Offshore location has the highest percentage at 83.80±20.31%, which indicates a more dynamic, high-energy environment. This could be due to the influence of strong currents or wave action that tends to carry away finer particles, leaving behind coarser sand. Offshore has a lower clay content at 10.80±3.69%, while Phang Creek lies in between with 74.7±9.46%. The silt content is fairly consistent between Offshore and the Cargo Jetty, with 50.6±17.15% and 31.4±20.06%, respectively. Phang Creek, however, shows a notably lower silt percentage at 21.37±6.32%. Clay content is highest in Phang Creek at 63.4±9.46%. Offshore also recorded a lowest clay percentage at 7.00±3.69% and the data of all the field stations are summarized in Tables 3-5.

2.8.4. Total organic Carbon

Total Organic carbon in sediments primarily originates from the decomposition of animals, plants, and anthropogenic sources such as chemical waste, fertilizers, and organic-rich waste. These sources contribute to the enrichment of the marine environment with organic material, which subsequently settles to the bottom sediments from the water column. This pathway leads to an increase in Total Organic Carbon (TOC) values and can have implications for the faunal communities inhabiting the sediments. In our study, during this third season, it was investigated the TOC concentrations at different stations. The mean ± standard deviation (SD) TOC percentages were determined to be Total Organic Carbon which is reported as 1.35±0.08% at the offshore station, 0.73±0.09% at the cargo jetty station, and 0.52±0.06% at the Phang creek station. The TOC concentrations at all stations are presented in Tables 3-5. Understanding the dynamics of organic carbon in marine sediments is vital for assessing the health and ecological integrity of marine environments. It helps in monitoring anthropogenic influences and their potential impacts on the marine ecosystem.

2.8.5. Organic matter

Organic matter serves as the primary reservoir of organic carbon in marine sediments, encompassing the chemical, physical, and biological degradation processes that contribute to the formation of organic material in the marine environment. It consists of a mixture of materials derived from various planktonic and benthic species, forming the ecological foundation for primary producers and consumers in the overlying surface sediment. In our study conducted during the third season, we investigated the levels of organic matter in different locations. The organic matter percentages ranged 2.32±0.13% in the offshore location, 1.26±0.15% at the cargo jetty, and 0.89±0.11% in the Phang creek area and the findings are summarized in the below tables (3-5), which illustrates the variation in organic matter content across the studied locations. Understanding the presence and dynamics of organic matter in marine sediments is crucial for assessing the overall health and ecological functioning of marine ecosystems. Phang Creek shows the highest organic matter suggesting higher inputs of organic material, possibly from terrestrial sources or higher productivity. The Cargo Jetty area shows the lowest organic matter, which might be due to higher energy conditions preventing organic matter accumulation.

2.8.6. Phosphorus and Sulphur

In the present study, the highest concentration of sulphur was recorded at Offshore followed by Cargo Jeety and Phang Creek with average sulphur content at Offshore was (62.61±3.19 mg/kg), followed by Cargo Jetty (44.53±6.57 mg/kg) and Phang creek (41.53±4.49 mg/kg). The concentrations of phosphorus and sulphur at all stations are presented in Tables 3,4 and 5.

On the other hand, Phosphorus (P) is an essential nutrient for life and plays a crucial role in regulating primary productivity within marine systems. It serves as a key element in various biological processes. In marine sediments, phosphorus availability influences primary productivity, affecting the growth and development of marine organisms The Cargo jetty recorded the highest phosphorus content (38.27 mg/kg), followed by Offshore (29.64 mg/kg) and Phang Creek (27.62 mg/kg). This could reflect differences in nutrient inputs or cycling across the locations as Sulphur (S) is involved in dissimilatory sulfate reduction by microbial activity, which is a primary pathway for organic matter mineralization in anoxic sea beds. This process leads to the production of sulfide. Subsequently, chemical or microbial oxidation of the produced sulfide forms a complex network of pathways in the sulfur cycle, resulting in intermediate sulfur species and partial conversion back to sulfate. Phosphorus levels are highest in the offshore and cargo jetty areas. This could indicate different sources of phosphorus, such as upwelling in offshore areas or anthropogenic inputs near the cargo jetty.

The lower levels be due to higher uptake by organisms or different sediment characteristics that don't retain phosphorus as effectively. Phang Creek shows the highest sulphur content with the least variability. This could indicate more reducing conditions in the sediments, possibly due to higher organic matter content and limited oxygen penetration. The lower levels in offshore and cargo jetty areas might reflect more oxidizing conditions due to better water circulation. These elements influence the availability of essential nutrients and can have implications for primary productivity and the overall functioning of marine ecosystems.

2.8.7. Petroleum hydrocarbon (PHC)

Petroleum hydrocarbons in general have low solubility in marine water and tend to adsorb onto particulate matter, leading to their long-term persistence in sediment bottoms. This persistence can have significant negative impacts on benthic aquatic communities within the marine ecosystem. PHCs are a major source of contamination in marine environments, primarily comprising compounds from three classes: alkanes, olefins, and aromatics. In the present study, the levels of PHCs in different locations were measure. Offshore location has recorded the highest average petroleum hydrocarbon content (13.19± 3.61 µg/kg), followed by Phang creek (9.18±3.80 µg/kg) and Cargo jetty site (6.85±3.30 µg/kg). This suggests more anthropogenic oil-related inputs in the nearshore areas.

The presence of petroleum hydrocarbons in marine environments is of great concern due to their potential harmful effects on marine organisms and ecosystems. These contaminants can bioaccumulate in organisms and disrupt their physiological processes, as well as cause long-lasting damage to the benthic communities. The higher levels of petroleum hydrocarbons in Phang Creek and Cargo Jetty compared to the offshore location suggest more significant anthropogenic inputs in these areas.

This could be due to boat traffic, urban runoff, or industrial activities near these locations. The offshore area, being further from these sources, shows lower contamination levels.

2.8.8. Magnesium

In the present study conducted during the third season at Deendayal Port, we determined the concentrations of magnesium at different stations. Phang Creek shows the highest average magnesium content (20991.67±580.01 mg/kg), followed by Offshore (20541.67±698.15mg/kg) and Cargo Jetty (20133.33±787.82 mg/kg).

Highest magnesium content in sediments of Phang Creek could be due to differences in sediment sources, with Phang Creek possibly receiving more magnesium-rich materials from terrestrial sources. The high variability in the Cargo Jetty area suggests a more heterogeneous sediment composition, possibly due to varied inputs from both marine and terrestrial sources. Understanding the distribution and dynamics of magnesium in marine sediments provides valuable insights into the geochemical processes occurring within the sediment column and their impact on the marine ecosystem. Continuous monitoring of magnesium levels is crucial for assessing the health and ecological integrity of marine environments. Dissolved magnesium flux from the overlying ocean into marine sediments is primarily driven by molecular diffusion. This process occurs as pore water magnesium is depleted during the formation of authigenic minerals within the sediment column. Additionally, direct burial of seawater occurs as sediment accumulates on the seafloor, contributing to the input of magnesium into the sediment. Its concentration in sediments can have implications for nutrient availability, sediment mineralogy, and the diverse organisms inhabiting the sediment environment.

2.8.9. Heavy metals

The heavy metal concentration in the sediment samples were examined for the presence of heavy metals from the samples collected from various stations at different locations at Deendayal Port. The analysis of sediment samples from three locations *viz*., offshore, cargo jetty, and Phang Creek revealed varying concentrations of heavy metals. In the offshore samples, Nickel ranged from 31.9 to 43.65 mg/kg (mean 37.21 mg/kg), while the mean concentrations of Chromium was 65.91±29.69, 44.01±7.86 and 54.24±39.08 at Offshore, Cargo jetty and Phang creek locations respectively. The concentration of cobalt was comparatively less when compared the concentration of other metals where mean cobalt concentrations of 5.37±2.78 mg/kg, 4.42±1.32 mg/kg and 4.76±1.48 mg/kg as observed at Offshore, Cargo jetty and Phang creek locations respectively. Manganese was notably high with no major variation in the concentrations in the samples which was observed as 821.50 mg/kg, 817.50 mg/kg and 807.50 mg/kg at Offshore, Cargo jetty and Phang creek locations respectively. The data of all the heavy metal concentrations from all the locations are presented in Tables 3-5.

Table 3: Physico-chemical characteristics of sediment samples collected from Offshore location

S. No	Parameters	1A	1B	1C	1D	1E	Control 1
1	pH (1: 10 suspension)	8.41	8.38	8.23	8.44	8.58	8.48
2	Salinity	23.50	26.50	25.60	30.80	32.10	11.90
3	Petroleum Hydrocarbon	12.21	10.95	BDL	10.82	19.52	12.45
4	Magnesium	20250	21400	19850	20650	19800	21300
5	Sand (%)	32.3	34.7	34.9	33.8	34.9	83.8
	Silt (%)	59.9	56.1	59.7	55.4	56.7	15.8
	Clay (%)	7.8	9.2	5.4	10.8	8.4	0.4
6	Organic matter (%)	2.48	2.43	2.17	2.27	2.37	2.17
7	Total organic carbon	1.44	1.41	1.26	1.32	1.38	1.26
8	Phosphorus	20.43	16.11	16.40	21.87	20.40	29.64
9	Sulphur	61.18	63.55	66.88	65.18	60.66	58.22
10	Nickel	36.65	38.35	35.5	43.65	31.9	BDL
11	Lead	BDL	BDL	BDL	BDL	BDL	BDL
12	Cadmium	9.95	14.9	0.85	14.8	12.4	12.1
13	Chromium	57.05	80.5	49.45	77.1	108.8	22.55
14	Zinc	54.4	60.95	51.45	51.8	57.7	11.65
15	Copper	24.95	35.65	19.6	23.75	31.1	BDL
16	Manganese	815	821.5	764	761	802.5	818.5
17	Cobalt	3.5	7.5	8.7	5.2	6.25	1.05

Table 4: Physico-chemical characteristics of sediment samples collected from Cargo jetty

S. No	Parameters	2A	2B	2C	2D	2E	Control 2
1	pH (1: 10 suspension)	8.79	8.77	8.43	8.13	8.22	8.31
2	Salinity	13.21	11.60	30.30	12.50	13.60	15.90
3	Petroleum Hydrocarbon	BDL	12.25	5.62	3.48	7.24	5.68
4	Magnesium	20600	20200	21050	20550	18950	19450
5	Sand (%)	22.6	22.2	23.5	14.6	18.9	21.7
	Silt (%)	17.0	49.8	63.1	24.4	16.5	17.6
	Clay (%)	60.4	28.0	13.4	61.0	64.6	60.7
6	Organic matter (%)	1.39	1.24	1.44	1.29	1.16	1.03
7	Total organic carbon	0.81	0.72	0.84	0.75	0.66	0.6
8	Phosphorus	33.09	38.27	20.14	17.84	19.85	17.84
9	Sulphur	40.37	44.40	57.29	43.03	38.22	43.85
10	Nickel	9.1	16.35	31.85	9.9	BDL	24.05
11	Lead	BDL	BDL	BDL	BDL	BDL	BDL
12	Cadmium	9.8	17.4	19.9	5.25	17.7	6.75
13	Chromium	42.9	42.6	55.3	37.4	34.8	51.05
14	Zinc	43.9	47.75	57.6	52.25	45.6	74.15
15	Copper	4.95	11.65	20.7	6.65	5.25	19
16	Manganese	770.5	773.5	784	756.5	711.5	817.5
17	Cobalt	6.35	4.3	2.65	5.45	3.55	4.2

Table 5: Physico-chemical characteristics of sediment samples collected from Phang creek

S. No	Parameters	3A	3B	3C	3D	3E	Control 3
1	pH (1: 10 suspension)	8.55	8.70	8.69	8.43	8.71	8.73
2	Salinity	24.60	19.20	19.90	16.40	15.80	17.00
3	Petroleum Hydrocarbon	6.28	4.28	10.28	BDL	11.58	13.48
4	Magnesium	21450	20300	20850	21350	20350	21650
5	Sand (%)	13.3	10.6	10.3	13.4	27.4	16.4
	Silt (%)	27.7	14.7	25.7	12.6	21.7	25.8
	Clay (%)	59.0	74.7	64.0	74.0	50.9	57.8
6	Organic matter (%)	0.98	0.82	0.93	0.72	1.03	0.87
7	Total organic carbon	0.57	0.48	0.54	0.42	0.6	0.51
8	Phosphorus	15.53	27.62	21.87	12.94	20.14	24.74
9	Sulphur	34.96	42.22	44.66	42.44	37.70	47.18
10	Nickel	BDL	2.45	BDL	15.2	14.85	BDL
11	Lead	BDL	BDL	BDL	BDL	BDL	BDL
12	Cadmium	15.35	9.2	10.15	16.6	18	16.85
13	Chromium	69.5	33.75	15.1	124.9	48.65	33.55
14	Zinc	41.7	39.75	47.35	18.9	25.65	23.2
15	Copper	6.55	2.2	6.8	19.35	11.85	7.1
16	Manganese	785.5	774	712	774	807.5	801.5
17	Cobalt	3.3	4.8	3.85	7.25	3.75	5.6

3.1. Introduction

Earth's total volume of water is estimated at 1.386 billion km^3, among that, the salty water contributes almost 97.5% and the rest 2.5% contains freshwater. The existence of oceans on the Earth makes appearing it as blue planet from the space. Indian Ocean is the 3rd largest ocean in the world which (with its sub seas) surrounds to India on three sides with average depth of 3,890 meters (12,760 ft). As having at long coastline of almost 8000 km, India has vast marine resources. The Indian ocean's connection is a very large scale, including the Red Sea, East Africa, the Persian Gulf, Southern Arabia, India and Other Indian sub continental countries. This connection network connected people from all the coastal areas of the Indian Ocean and beyond, trading in aromatics, textiles, spices, precious stones, industrial productions, grain and an incredible range of other commodities and substances. Gujarat state of India shows longest coastline compare to other Indian states. Gujarat coastline is famous for various coastal ecosystems and habitats such as estuary, coral reefs, marshes, mangroves, and lagoons, rocky and sandy areas. Gujarat coasts having different coastal ecosystems like mangrove, sandy shores, muddy shores, rocky shores, mixed shores, wet sand shore, coral reefs and intertidal mudflats (Brink, 1993; Parasharya and Patel, 2014). Gujarat state is the only state in India bestowed with two gulfs, Gulf of Kachchh and Gulf of Khambhat. The Kachchh, largest district of the country with an area of 45,652 sq.km. Deendayal Port Authority is (DPT) one among the 12 major ports of the country and it is located in India's western coastal region

3.1.1. Benthos

Benthic animals are considered as the organism which lives in the bottom layer of all types of ecosystems including saline water as well as in freshwater. Benthos is nothing but water bottom communities or the organisms (floral and faunal) live in a benthic region regarding the sediment, rock and other substratum. They include mollusca (gastropods and bivalves), coral, sponges, worms (mostly polychaetes and nematode), crustacean crabs, other crustaceans, echinoderms, oysters etc. They play an important role in conversion of organic detritus from the sedimentary storage into the dissolved nutrients. Their distribution in water bodies can be varies and, on that basis, they can be classified into three types which are Endo-benthos, Epi-benthos (Pearson and Rosenberg, 1978) and Hyper-benthos (Mees and Jones,1997). Benthos could also recognize as one of the best indicators to assess the health and productivity of aquatic ecosystems. The benthic particularly macro benthic communities are an integral part of the coastal biotic components. They can serve as important food resource for the diverse groups of various organisms particularly bottom feeding animals. They are sensitive to wide range of environmental challenges including water movements, pollutants and living spaces (Martin et al., 2011). Their variations to tolerate changes in various environmental factors make them to be considered as an important bio-indicator for monitoring and research of marine environment.

3.2. Methodology

To study the benthic organisms, triplicate samples were collected at each station using Van-Veen grab which covered an area of $0.1m^2$. The wet sediment was sieved with varying mesh sizes (0.5 mm-macrofauna) for segregating the organisms. The organisms retained in the sieve were fixed in 5-7% formalin and stained further with Rose Bengal solution for easy spotting at the time of sorting. The number of organisms in each grab sample was expressed as number/ meter square (No/m^2). All the species were sorted, enumerated and identified to the advanced taxonomic level possible with the consultation of available literature. The works of Fauvel (1953), Day (1967) were referred for polychaetes; Barnes (1980) and Lyla *et al*. (1999) for crustaceans; Subba Rao *et al.* (1991) and Ramakrishna (2003) for molluscs.

Further, the data were treated with univariate statistical methods in PRIMER (Ver. 6.) statistical software (Clarke and Warwick, 1994)

a) Shannon – Wiener index

In the present study, the data were analyzed for diversity index (H’) by following Shannon – Wiener’s formula (1949):

$H' = -\sum^{S} Pi \log 2\ Pi \ldots\ldots \quad i = 1$

which can be rewritten as

$$H' = \frac{3.3219\ (N\ \log N - \sum ni - \log ni}{N}$$

where, H'= species diversity in bits of information per individual

ni = proportion of the samples belonging to the ith species

(number of individuals of the ith species)

N = total number of individuals in the collection and

$\sum$ = sum

b) Species richness(S) was calculated using the following formula given by Margalef (1958).

c) Margalef index (d)

d = (S-1) / log N

d) Pielou's evenness index

The equitability (J') was computed using the following formula of Pielou (1966):

$$J' = \frac{H'}{\log_2 S} \text{ or } \frac{H'}{\mathrm{InS}}$$

Where, J' = evenness; H' = species diversity in bits of information per individual and S = total number of species.

3.3. Results on Species Composition, Population density and Biomass of Macrofauna of selected sites

<u>3.3.1. Species Composition, Population density and Biomass of Macrofauna at selected sites</u>

3.3.1.1. ffshre

In Offshore region of Kandala port, total six sites were selected namely, (1A, 1B, 1C, 1D, 1E and 1- control). A total 6 groups/species(of benthic community) of benthic animals were observed in all stations at Offshore sites and they a Bivalves (Mollusca),Gastropods (Mollusca), Crustacean animals, Polychaeta worms

(Annelida), Saccostrea sp (Bivalvia), *Pirenella cingulata* (gastropoda). All the data(Density and Biomass) expressed in (nos./m^2), (gm/m^2) respectively (Table 6).

Highest population density of benthic organisms was recorded in station 1control-Offshore(1600nos/m^2), whereas lowest in station 1B-Offshore(325nos/m^2). The density range of all stations varied from 325 to 1600nos./m^2. Bivalves and Gastropods were more abundant among all the benthic organisms might be sandy-muddy or rocky substratum in bottom part of Offshore region. Low recorded benthos were Crustacean animals and *Pirenella cingulata* that indicated less part of substratum are muddy and not suitable rock attachement. The highest biomass value (expressed wet weight) of benthic fauna was observed in station 1control-Offshore (17.46gm/m^2) and lowest value was 1B-Offshore(2.19 gm/m^2) (Table 6). Range of the Biomass was 2.19 to 17.46 gm/m^2 . Moderately Biomass values and also density values suggested mixing substratum, less availability of plenty food items and more predator pressure by higher animals. Intermediate association was also one responsible factor for the same. Variation in density and biomass in Offshore region because more influences by the Water Currents, Up welling - Down welling (Churning process of water) movements of water and Nutrients availability and Fluctuation in turbidity of water. Variation in substratum is also a one responsible factor.

3.3.1.2. Cargo Jetty

In Cargo Jetty, frequently observed benthic groups were Crustacean animals and Gastropods less reported benthos were Bivalves, *Pirenella cingulta* and Polychaeta worms. The population density range noted between 50 to 275(nos/m^2) among all the stations (Cargo Jetty-2A, 2B, 2C, 2D, 2E &2-Control) during the study period. Highest and Lowest density were recorded in station 2D- Cargo Jetty(275nos./m^2) and 2C-Cargo Jetty (50nos./m^2) respectively.

Biomass value indicated a highest value in station 2D- Cargo Jetty (4.81gm/m^2) and lowest in 2C- Cargo Jetty (0.36gm/m^2) (Table 6).Average Biomass and Population density value of all station were 2.48gm/m^2, 167nos./m^2 respectively which indicated the low to moderate environment condition of biota, water quality as well as substratum (mostly rocky).

3.3.1.3. Phang creek

Six Stations of Phang creek were selected for the studynamely 3A, 3B, 3C, 3D, 3E and 3-control-Phang Creek.In this Phang Creek benthic organisms were mostly represented byPolychaeta worms (annelids). Only four groups were present namely Polychaeta worms, Bivalve, Crustacean animals, Gastropods whereas *Pirenella cingulata* and *Saccostrea sp* were totally absent. Crustacean animals was only noted in 3D-Phang creek. Polychaeta worms ware more abundant because of suitable muddy environment. The population density was highest in station 3D -Phang Creek (150nos./m^2) and on the other side, lowest density was recorded in 3B-Phang Creek (50nos./m^2).Station 3D-Phang Creek comprises highest wet wt (0.26gm/m^2), whereas low value was recorded in3B & 3control-Phang Creek(0.05 gm/m^2).

Overall result (Offshore, Cargo Jetty and Phang creek) of macrofaunal community showed highest population density in 1control-Offshore (1600nos/m^2) and high biomass was observed (17.46gm/m^2) in 1control-Offshore. Table 6 showed highest population values of Bivalves in 1control- Offshore (800nos/m^2) and same highest value of Gastropoda showed in 1D- Cargo Jetty (475nos/m^2). The lowest value comprised by the *Pirenella cingulata and Saccostrea sp (Bivalves)* including some were totally absent in some sites. Some absent or less frequently observed benthos indicated extreme weather condition (may be suddenly change temperature of running season), more stress condition and unfavourable environment condition for their survival. Bivalves and Gastropods, dominant groups were preferred rocky, sandy or mix substratum, and any other hard substrata**.** Polychaete worms are preferred sandy-muddy substratum or sandy habitat mostly in Phang creek.

Table 6 showed that average population density and biomass higher in Offshore and after Cargo jetty where mostly rocky, sandy or some part covered with muddy area and algal growth providing a unique habitats for benthos. *Low density and biomass was observed in mostly Phang creek area (Table 6 and Figure 1) which indicated* *stressful environment, seasonal effect (rainy time), more anthropogenic activities and also might be some chemical and biological changes in water.* The population density and biomass of benthic community largely affected by the symbiotic and intermediate relation between them or with otherinvertebrates and suitable rocky substratum or coral reef in bottom of sea. Availability of Plankton, as a food source, also affected the benthic animals (Table 6 and Fig. 1 & 2). Extremely mix weather condition (during June and July months) also more affected in Cargo jetty and Phang creek regions of Deendayal port area.

In benthic communities, recorded species at all sites were *Clypeomorus bifasciata, Trochus sp, Radix sp, Donax sp, Turris sp,Marcia sp, Dosinia sp, Donax sp, Anadara sp, Turris sp, Solen, Nereis sp, Saccostrea sp, Optediceros breviculum etc. The percentage of occurrence (Table 6) was revealed highest group present by Gastropoda (72%) then following are Polychaeta worms (56%), Bivalves and Crustacean animals (39%), Placuna sp (33%), Saccostrea sp (17%) and and then others. Detail status of Population density, Group composition and biomass of the benthic community of all selected sites were depicted in (Table 6) and (Figure 1).* Among all the stations, highest percentage composition recorded by Gastropoda (35%) followed by Bivalves (24%), *Saccostrea sp* (16%), Polychaeta worms (13%) and others (Figure.2).

Phytoplankton abundance and their size, zooplankton body composition, patchy distribution of zooplankton, water currents, ebb and flow tides, and water churning process, changing in structure of muddy, rocky and sandy habitats are the main reasons for biomass and density fluctuation in Benthic communities. In Crustacean most commonly observed species are Crabs and attached Barnacles. Main Mollucsa families recorded Trochidae, Cerithidea, Turritellidae, Tellinidae, Donacidae and Bucciniae etc. *Nereis sp* of anneliids was mostly observedin samples. More number of the broken bivalves, debris, plant items , broken gastropods, small pebbles and soil particles are frequently observed during benthic organism’s study.

3.4. Diversity Indices of Benthic Community

Table 7 showed various diversity indices calculation, showed that Shannon Diversity Index ranging from (0.00-1.45) indicated very low diversity. Highest diversity indices was recorded in Station 2D-Cargojetty (1.45) whereas Shannon indices nil (zero) observed in 1A, 2A, 2B, 3B. Comparatively less Shannon indices value very low in Phang creek area number of benthos group/species present between 1 to 3 nos. The evenness values ranged between (0.47 to 1). The highest evenness value (1) is observed in stations Offshore (1A), Cargo jetty (2A and 2B) and Phang creek (3B). Evenness value "1" indicated all organisms occurred in same area or mostly same group. Simpson's Index value ranged between 0.00 to 0.73 indicated to lower to very less moderate diversity. The Margalef value showed range of 0.00 to 0.56 indicated high variation in species/group numbers (Table 7).

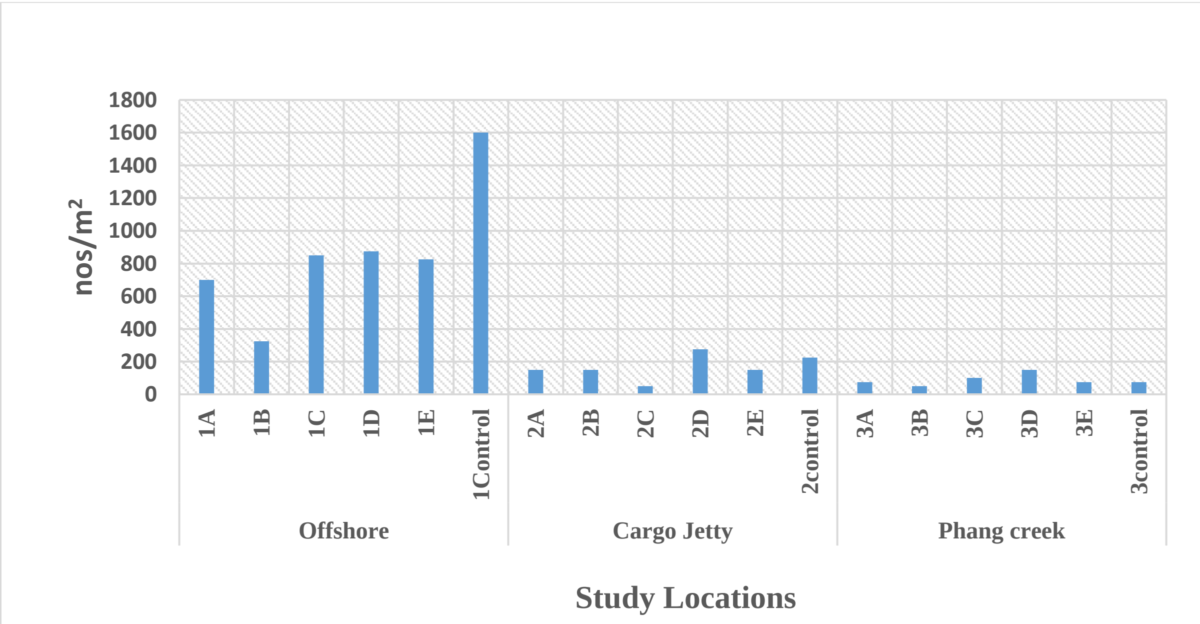

Figure 1. Population density of benthic organisms (nos/m^2)in various sites

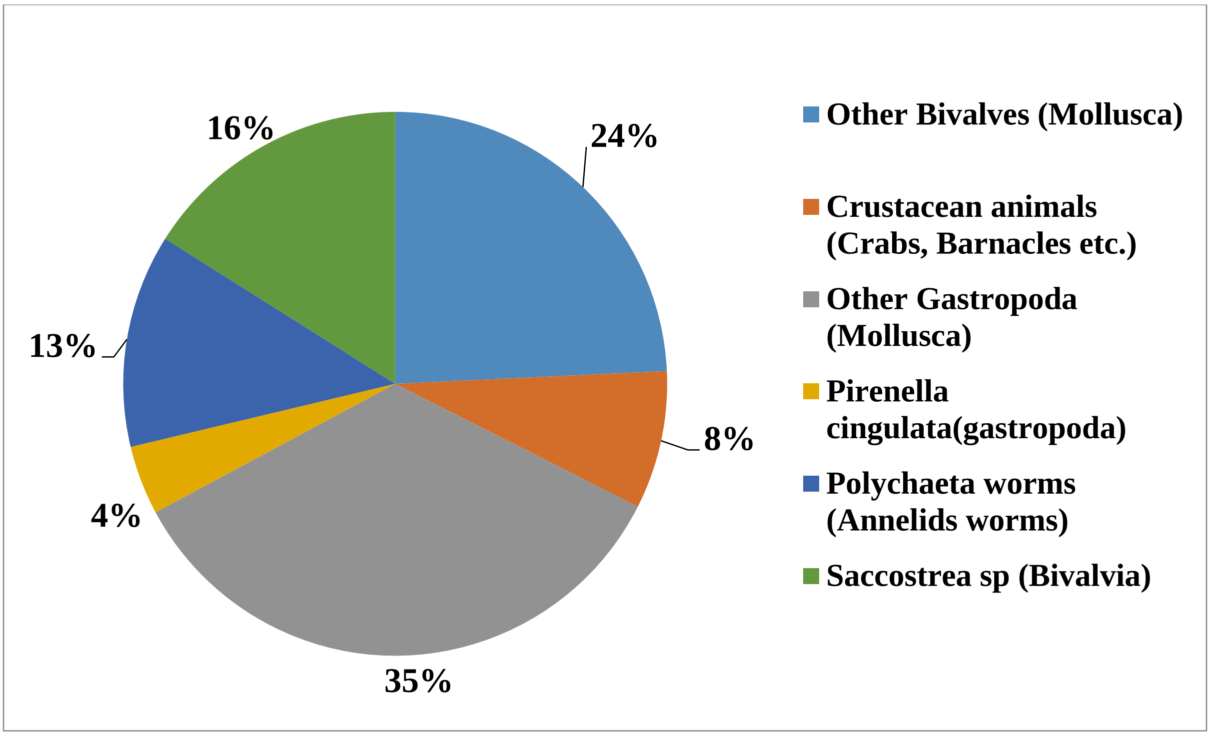

Figure 2. Percentage composition of benthic organisms in various sites.

Table 6. Macrobenthos distribution in different sites of Deendayal Port

Name of Station	Offshore						Cargo Jetty						Phang creek						
	1A	1B	1C	1D	1E	1-Control	2A	2B	2C	2D	2E	2-Control	3A	3B	3C	3D	3E	3-Control	% of Occurrence
Nameof Benthic Groups																			
Other Bivalves (Mollusca)	0	100	0	300	350	800	0	0	25	0	0	0	25	0	0	25	0	0	39
Crustacean animals (Crabs, Mysis etc.)	175	50	0	0	0	0	150	50	25	0	0	50	0	0	0	50	0	0	39
Other Gastropoda (Mollusca)	250	175	175	475	425	250	0	0	0	125	150	175	0	0	50	25	25	25	72
Pirenella cingulata(gastropoda)	0	0	125	0	0	0	0	0	0	150	0	0	0	0	0	0	0	0	11
Polychaeta worms (Marine Annelids)	0	0	300	100	50	0	0	100	0	0	0	0	50	50	50	50	50	50	56
Saccostrea sp (Bivalvia)	275	0	250	0	0	550	0	0	0	0	0	0	0	0	0	0	0	0	17
Total Population Density Nos/m^2	700	325	850	875	825	1600	150	150	50	275	150	225	75	50	100	150	75	75	39
Biomass (wet weight) gm/m^2	6.36	2.19	7.31	14.19	7.23	17.46	2.12	1.75	0.36	4.81	1.16	4.66	0.08	0.05	0.17	0.26	0.15	0.05	

Table 7: Diversity indices of benthic faunal community observed at all the locations during the third season

	Offshore						Cargo Jetty						Phang Creek					
	1A	**1B**	**1C**	**1D**	**1E**	**1-control**	**2A**	**2B**	**2C**	**2D**	**2E**	**2-contrl**	**3A**	**3B**	**3C**	**3D**	**3E**	**3cont**
Variables																		
Taxa_S	1	2	3	5	4	2	1	1	5	5	4	5	3	1	3	3	4	3
Individuals (Nos./m^2)	50	75	200	3225	900	400	50	25	1400	1225	1800	2125	425	50	2300	2225	2250	2800
Dominance_D	1.00	0.56	0.38	0.39	0.41	0.63	1.00	1.00	0.32	0.27	0.33	0.28	0.45	1.00	0.74	0.72	0.67	0.68
Shannon Diversity Index (H)	0.00	0.64	1.04	1.23	1.06	0.56	0.00	0.00	1.27	1.45	1.21	1.41	0.92	0.00	0.49	0.54	0.64	0.56
Simpson_1-D	0.00	0.44	0.63	0.61	0.59	0.38	0.00	0.00	0.68	0.73	0.67	0.72	0.55	0.00	0.26	0.28	0.33	0.32
Evenness_e^H/S	1.00	0.94	0.94	0.69	0.72	0.88	1.00	1.00	0.71	0.85	0.84	0.82	0.84	1.00	0.54	0.57	0.47	0.58
Menhinick	0.14	0.23	0.21	0.09	0.13	0.10	0.14	0.20	0.13	0.14	0.09	0.11	0.15	0.14	0.06	0.06	0.08	0.06
Margalef	0.00	0.23	0.38	0.50	0.44	0.17	0.00	0.00	0.55	0.56	0.40	0.52	0.33	0.00	0.26	0.26	0.39	0.25

Chapter 4 Physico-Chemical Characteristics of Marine Water

4.1. Introduction

In recent decades, there has been a notable deterioration in aquatic ecosystems primarily caused by the presence of a diverse array of organic and inorganic contaminants. Among these pollutants, heavy metals (HMs) and microplastics (MPs) have emerged as significant contributors to this environmental degradation (Frew et al., 2020; Saha et al., 2016). These substances are recognized for their capability to infiltrate and accumulate within the aquatic food chain, making them hazardous pollutants in aquatic environments (Olojo et al., 2005). Of particular concern are heavy metals due to their toxic nature, long-lasting presence, resistance to degradation, the potential for bioaccumulation, and the ability to magnify up the food chain, all of which have raised global alarms (Begum et al., 2013; Cai et al., 2017).

Heavy metal pollution in aquatic ecosystems can be attributed to a variety of sources, including natural factors such as atmospheric deposition and weathering (Ebrahimpour and Mushrifah, 2010; Hamidian et al., 2016) as well as human activities like mining, agricultural runoff, sewage discharge, industrial effluent release, gasoline leaks from fishing vessels, and accidental chemical waste spills (Arulkumar et al., 2017). It is essential to recognize that certain heavy metals, such as copper (Cu), iron (Fe), nickel (Ni), cobalt (Co), zinc (Zn), manganese (Mn), and chromium (Cr), play vital roles in physiological processes and are necessary for the proper biological functioning of organisms in trace amounts. However, exposure to nonessential heavy metals can lead to various health concerns, including renal, cardiovascular, nervous, and bone diseases, as well as immune-related issues (Abadi et al., 2018; Madreseh et al., 2018). It is crucial to acknowledge that all heavy metals become toxic when their concentration exceeds a certain threshold level (Makedonski et al., 2017). In light of these concerns, it is imperative to assess the various characteristics of water in order to determine the extent of pollutant presence in aquatic environments.

4.2. Materials and Methods

In this study, marine water and sediment samples were collected following standard protocols, and their analysis was conducted using established methods for marine water and sediment analysis as prescribed by APHA (2012), NIO manual (1982), and ICMAM Manual (2012). For general analysis, surface water samples were collected using a clean polyethylene bucket, while water samples from the bottom were collected using a weighted Niskin sampler. Water samples at a depth of 1 meter below the surface were collected using a 1-liter glass bottle sampler. Parameters such as pH, temperature, and salinity were measured on-site using handheld meters and verified in the laboratory.

The collected water samples were stored under refrigerated conditions until further analysis of other parameters. According to the standard protocol, fixatives and preservatives were added to the samples for specific parameters. For example, Winkler A&B solution was immediately added to measure dissolved oxygen, concentrated H2SO4 was used to bring the pH below 2 for chemical oxygen demand analysis, and nitric acid was used for the preservation of heavy metals. Formalin was added to marine water samples for planktonic analysis. In general, all water and sediment samples were stored in sterile polythene bottles and Ziplock bags and kept in an icebox to maintain suitable conditions until they were transported to the laboratory. The parameters to be analyzed (Table 8) and the methods used for the sample analysis are described below.

Table 8: Physico-chemical and biological characteristics of marine water samples

S. No	Physico-chemical and Biological parameters
1	pH
2	Salinity (ppt)
3	Total Dissolved Solids (mg/L)
4	Turbidity (NTU)
5	Dissolved Oxygen (mg/L)
6	Bio-Chemical Oxygen Demand (mg/L)
7	Chemical Oxygen Demand (mg/L)
8	Phenolic compound (µg/L)
9	Petroleum Hydrocarbons (µg/L)
10	Oil and grease (mg/L)
11	Cadmium (mg/L)
12	Lead (mg/L)
13	Chromium (mg/L)
14	Copper (mg/L)
15	Cobalt (mg/L)
16	Nickel (mg/L)
17	Zinc (mg/L)
18	Magnesium (mg/L)
19	Chlorophyll (mg/m^3)
20	Phaeophytin (mg/m^3)
21	Phytoplankton Phytoplankton cell counts (no/L) Total Genera (no.) Major Genera
22	Zooplankton Biomass ($ml/100m^3$) Population ($no/100m^3$) Total Group (no.) and Major Groups

4.2.1. pH, Temperature and Salinity

pH and temperature measurements were conducted using a Thermo Fisher pH/EC/Temperature meter. Prior to use, the instrument was calibrated with standard buffers. For pH determination, an appropriate volume of the sample was titrated against silver nitrate (20 g/l), with potassium chromate serving as an indicator. The chlorinity of the sample was estimated, and salinity values were derived using a specific formula.

4.2.2. Total Dissolved Solids (TDS)

To confirm the readings obtained from the handheld meter, the samples underwent a gravimetric procedure. Approximately 100 ml of the water sample was taken in a beaker and filtered. The filtered sample was then completely dried in a hot air oven at 105°C. The TDS values were calculated by measuring the difference between the initial and final weight of the dried sample.

4.2.3. Turbidity

For turbidity measurement, a sample tube (Nephelometric cuvette) was filled with distilled water and inserted into the sample holder. The lid of the sample compartment was closed, and the meter reading was adjusted to zero by manipulating the 'SET ZERO' knob. The sample tube containing the 40 NTU standard solution was then placed in the tube, and the meter reading was set to 100. Similar measurements were carried out for other standard solutions. To determine the turbidity of the marine water sample, the sample tube was filled with the water sample, and the corresponding reading was recorded.

4.2.4. Dissolved Oxygen (DO)

To determine the Dissolved Oxygen (DO) levels in a water sample obtained from a marine environment, the following procedure was employed. Collect sea water sample, ensuring that the sampling container is clean and free from any potential contaminants that may affect the accuracy of the results. Subsequently, transfer the water sample into a Winkler's bottle or a suitable container, taking care to eliminate any trapped air bubbles. It is crucial to completely fill the bottle to minimize any headspace that could potentially alter the DO readings. Next, add the appropriate volumes of Winkler's reagents, such as manganese sulfate and alkali-iodide-azide, to the water sample as per the specific instructions of the Winkler's method. Gently and thoroughly mix the contents of the bottle to ensure uniform distribution of the reagents without introducing any air bubbles. Allow the bottle to stand undisturbed for a designated incubation period, typically around 30 minutes, to enable the necessary reactions to occur. After the incubation period, perform a titration using a standardized sodium thiosulfate ($Na2S2O3$) solution until a faint yellow color appears, indicating the complete consumption of dissolved oxygen in the sample. Record the volume of sodium thiosulfate solution used for titration, which represents the amount of dissolved oxygen present in the water sample. To account for any dissolved oxygen in the reagents, it is essential to conduct the same procedure with blank samples that do not contain the water sample. This allows for an accurate calculation of the DO levels in the original water sample. Finally, employ the appropriate formula provided by Winkler's method to calculate the DO concentration in the water sample.

4.2.5. Biochemical Oxygen Demand (BOD)

To determine the Biochemical Oxygen Demand (BOD), the following procedure was employed using the direct unseeded method. Collect representative sea water sample from the desired location, ensuring the sampling container is clean and uncontaminated. Fill a BOD bottle with the water sample, leaving minimal headspace to prevent air contact that could affect BOD measurements. It's important to completely fill the bottle to minimize air bubbles. Record the initial Dissolved Oxygen (DO) level in the water sample using a dissolved oxygen meter or appropriate measurement method. Seal the BOD bottle tightly with the stopper to prevent air exchange. Incubate the sealed BOD bottle in a controlled environment, such as a BOD incubator, at a specified temperature (typically 20°C), for a designated incubation period, usually around 5 days. Throughout the incubation period, keep the BOD bottle in darkness to minimize the impact of photosynthetic activity. After the incubation period, measure the final DO level in the water sample using the same method or instrument as the initial measurement. Calculate the BOD by subtracting the final DO level from the initial DO level, accounting for any necessary dilution or blank corrections. This difference represents the amount of oxygen consumed by the organic matter in the water sample during the incubation period.

4.2.6. Chemical Oxygen Demand (COD)

The Chemical Oxygen Demand (COD) test is a widely used method for quantifying the levels of organic and inorganic pollutants in water samples. The first step involves collecting representative water samples from the target site, ensuring proper labeling and record-keeping. Subsequently, these samples are placed into digestion vials or tubes, to which digestion reagents, typically potassium dichromate and sulfuric acid, are added. This step initiates the oxidation of organic matter in the sample. The sealed vials or tubes are then subjected to high-temperature heating, typically around 150-160°C, for a predetermined period, usually around 2 hours. This heating process breaks down complex organic compounds into simpler forms. After digestion, the samples are allowed to cool to room temperature. To determine the COD concentration, a colorimetric measurement is taken. A suitable reagent is added to the digested samples, reacting with any residual potassium dichromate, and generating a color change proportional to the COD concentration. This color intensity is measured using a colorimeter or spectrophotometer, and the results are calibrated using known COD standards. The final calculations yield the COD value, typically expressed in milligrams of oxygen per liter (mg/L) of the sample.

4.2.7. Phenolic compounds

To analyze phenolic compounds in water, the following procedure was followed. A 500 ml water sample containing phenols was treated with 4-aminoantipyrine, which converted the phenols into an orange-colored antipyrine complex. This complex was then extracted using 25 ml of chloroform. The absorbance of the extracted complex was measured at 460 nm using phenol as a standard for comparison. This measurement allowed for the quantification of phenolic compounds present in the water sample.

4.2.8. Petroleum Hydrocarbons (PHc)

The analysis of Petroleum Hydrocarbons (PHc) in a water sample involved the following protocol. One liter seawater sample was extracted using organic solvent, hexane. The mixture was then separated into an organic layer and an aqueous layer. The organic layer, containing the petroleum hydrocarbons, was isolated. To remove any remaining water, the organic layer was dried using anhydrous sulphate. The volume of the organic layer was subsequently reduced to 10 ml at a temperature of 30°C under low pressure. The fluorescence of the extracted organic compound was measured at 360 nm (with excitation at 310 nm) using Saudi Arabian crude residue as a standard. This residue was obtained by evaporating the lighter fractions of crude oil at 120°C. By comparing the fluorescence intensity of the extract with that of the standard, the concentration of petroleum hydrocarbons in the water sample could be determined.

4.2.9. Oil and Grease

To determine the content of Oil and Grease in a sample, the following procedure was followed. Approximately 500 ml of the sample was transferred to a separating funnel, and the sample bottle was rinsed with 30 ml of trichlorotrifluoroethane. The rinsing solvent was then added to the separating funnel. Next, 5 ml of 1:1 hydrochloric acid (HCl) was added to the mixture, and the contents were vigorously shaken for about 2 minutes. If a soluble emulsion was formed, the sample container was shaken for an additional 5 to 10 minutes. After shaking, the layers in the separating funnel were allowed to separate, and the lower layer (organic layer) was discarded.

The solvent layer was drained through a funnel containing a filter paper moistened with solvent, and it was collected in a clean distillation flask that had been pre-weighed. The solvent was then distilled from the flask using a water bath set at 70°C. The resulting residue was carefully transferred into a clean, pre-weighed, and dried beaker, using the minimum amount of solvent necessary. The beaker was placed on a water bath at 70°C for 15 minutes to evaporate off all the solvent. After the evaporation process, the beaker was cooled in a desiccator for 30 minutes to reach a consistent temperature, and its weight was then measured.

4.2.10. Heavy metals

Heavy metals are a significant concern, especially in coastal environments, since it is biomagnifying from lower organisms to higher organisms through water and sediment. Common heavy metals of concern include Cadmium (Cd), Lead (Pb), Chromium (Cr), Copper (Cu), Cobalt (Co), Nickel (Ni), Zinc (Zn), Magnesium (Mg) and Manganese (Mn). To release mineral elements from sediment and analyze them, a wet oxidation process is typically employed using oxidizing acids, such as a mixture of Tri / Di-acids. The procedure begins by weighing 0.5 grams of the sediment sample and placing it in a 100 ml beaker, which is covered with a watch glass. Then, 12 ml of Aqua regia (a mixture of 1 part HNO3 and 3 parts HCl) is added to the beaker. The beaker is placed in a digestion apparatus and heated at 100°C for 3 hours on a hot plate using a sand bath. The sample is evaporated until it is nearly dry, and then allowed to cool for 5 minutes. Next, 20 ml of 2% nitric acid is added to the cooled sample in the beaker, and the mixture is further digested on the hot plate for 15 minutes. After digestion, the beaker is removed from the hot plate and allowed to cool. The sample is then filtered using a Whatman No. 42 mm filter paper to remove any solid particles. To make up the final volume, the filtrate is diluted with 2% nitric acid to a total volume of 50 ml. The resulting extracted sample is then aspirated into an Atomic Absorption Spectrometer (AAS) for analysis of the heavy metal concentrations.

4.3. Results

In this third season study conducted in the present year, we closely monitored three distinct locations: Offshore, Cargo Jetty, and Phang Creek. A comprehensive analysis of physico-chemical characteristics in marine water samples was conducted at each of these sites. The collected data is thoughtfully presented in Tables 9-11. These findings serve as a significant source of information regarding the precise physico-chemical conditions prevailing at each of these locations. Consequently, they play a pivotal role in enhancing the comprehension of the environmental factors that exert influence on the quality of marine water in these specific areas. The description of the data in each station is detailed as below.

4.3.1. Location 1 - Offshore location

The offshore water samples exhibited moderate levels of salinity (35.86 ± 1.47 ppt) and total dissolved solids (44788.17 ± 5796.20 mg/L). The water was relatively warm (29.21 ± 0.13°C) with a slightly alkaline pH (7.41 ± 0.10). Turbidity was notable (96.32 ± 18.88 NTU), which could be due to suspended particles or plankton. Dissolved oxygen levels (6.01 ± 0.63 mg/L) were adequate for marine life but the lowest BOD (2.27 ± 0.28 mg/L), suggesting less biodegradable organic matter. However, it shows the highest levels of COD (33.83 ± 6.00 mg/L). The presence of petroleum hydrocarbons (24.99 ± 8.56 µg/L) indicating potential anthropogenic inputs from marine activities and phenolic compounds (6.70 ± 1.77 µg/L) suggests some level of anthropogenic influence. Nutrient indicators like chlorophyll (0.59 ± 0.09 mg/m^3) and phaeophytin (0.32 ± 0.08 µg/L) were present in low concentrations. The mean value of Oil and Grease exhibited 5.93 ± 2.23 mg/L. The heavy metals concentration of Nickel was seen only in control site with 3.02 µg/L. Whereas Manganese showed 2.11 µg/L in 1C site. Chromium and zinc showed Below Detectable Limit (BDL) with 0.36 ± 0.22 µg/L and 0.17 ± 0.16 µg/L. The concentration of heavy metals observed for Magnesium is 4727.92 ± 102.01 mg/L (Table 9). Overall, the offshore waters showed signs of moderate anthropogenic impact but maintained conditions generally suitable for marine life.

4.3.2. Location 2 – Cargo Jetty

At the Cargo Jetty location, the recorded data shows that the mean value of temperature was 29.44 ± 0.17°C, and the mean value of pH was observed as 7.77 ± 0.03. The average salinity of the seawater was 36.75 ± 1.53 ppt reflecting the salt content, while the Total Dissolved Solids (TDS), which indicates the presence of various anions and cations, had an average value of 44,517.00 ± 6,516.71 mg/L. Turbidity values were notably high, averaging 289.14 ± 76.54 NTU. The Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) showed mean values of 6.33

± 0.50 mg/L and 1.17 ± 0.72 mg/L respectively (as shown in Table 10). The average Chemical Oxygen Demand (COD) value was determined to be 30.00 ± 5.53 mg/L. The concentrations of Phenolic compounds showed a mean concentration of 6.43 ± 1.93 µg/L. Petroleum hydrocarbons were present with a mean concentration of 17.06 ± 6.88 µg/L, and the mean concentration of oil and grease in the marine water samples was 7.80 ± 2.09 mg/L, which falls below the acceptable limit of 10 mg/L according to GPCB norms. In terms of heavy metals, magnesium showed the highest concentration at 4,757.50 ± 63.08 mg/L. Whereas Lead (0.19 ± 0.15 mg/L), nickel (1.29 ± 1.02 mg/L) and manganese (0.19 ± 0.15 mg/L) was present in the sampling point 2C and 2D. While cobalt was detected at 0.135 mg/L in a single sample at 2C. Other detected metals included chromium (1.15 ± 0.25 mg/L, cadmium (1.62 ± 1.07 mg/L), zinc (0.34 ± 0.14 mg/L). Notably, copper showed Below Detection Limit (BDL) values across all sampling points in Station 2 as given in Table 10.

4.3.3. Location 3 - Phang Creek

At the Phang Creek location near the port, all the samples were subjected for analysis for various characteristics (Table 11). The mean temperature recorded as 29.37 ± 0.14°C and pH values averaging 7.94 ± 0.03. The average salinity of the seawater was measured at 38.11 ± 2.98 ppt, while the TDS showed an average value of 43,467.33 ± 6,176.51 mg/L which indicates the presence of various anions and cations. Turbidity values averaged 248.95 ± 46.94 NTU. The average value of water quality parameters revealed Dissolved Oxygen levels of 5.73 ± 0.18 mg/L, Biochemical Oxygen Demand of 2.41 ± 0.22 mg/L, and Chemical Oxygen Demand of 30.50 ± 6.45 mg/L. Phenolic compounds were present with 24.81 ± 2.88 µg/L, while mean value of petroleum hydrocarbons showed concentrations of 16.54 ± 5.99 µg/L, and oil and grease levels were recorded at 6.33 ± 1.29 mg/L. The heavy metal analysis revealed significant magnesium presence at 4,713.75 ± 84.59 mg/L, with chromium showing concentrations of 1.97 ± 0.18 mg/L. Other detected metals included nickel at 1.58 ± 0.86 mg/L, cadmium at 1.22 ± 1.00 mg/L, and zinc at 0.30 ± 0.11 mg/L. The Lead (0.345 mg/L) were detected only at control sampling point, whereas cobalt (0.03 mg/L) were detected at single sampling point 3E. Both copper and manganese consistently remained Below Detection Limit (BDL) at this location.

Table 9: Physico-chemical characteristics of the marine water from sampling location 1 (Offshore)

S. No	Parameters	1A		1B		1C		1D		1E		Control 1	
		SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
1.	Temperature (^{0}C)	29.3	29.1	29.3	29.2	29.3	29.0	29.3	29.2	29.3	29.1	29.4	29.0
2.	pH	7.22	7.21	7.40	7.38	7.44	7.43	7.48	7.45	7.50	7.49	7.45	7.42
3.	Salinity (ppt)	35.18	34.75	36.90	36.04	36.04	37.33	36.90	33.46	33.89	35.18	36.04	38.61
4.	Total Dissolved Solids (mg/L)	46259	49478	40953	53420	48775	40325	49195	40245	32569	43647	49842	42750
5.	Turbidity (NTU)	81.6	84.5	86.2	80.5	84.4	75.2	93.6	93.5	132.2	123.3	120.3	100.5
6.	Dissolved Oxygen(mg/L)	6.1	5.8	5.5	5.5	5.3	5.1	6	5.8	7.1	6.6	6.8	6.5
7.	Bio-Chemical Oxygen Demand (mg/L)	2.20	1.50	2.60	2.30	2.20	2.30	2.20	2.20	2.50	2.40	2.30	2.50
8.	Chemical Oxygen Demand (mg/L)	42.00	38.00	36.00	32.00	40.00	34.00	42.00	28.00	26.00	24.00	32.00	32.00
9.	Phenolic Compounds (µg/L)	6.80	3.70	9.60	5.70	6.50	7.10	5.20	8.30	9.10	5.40	5.20	7.80
10.	Petroleum Hydrocarbons (µg/L)	25.25	12.86	13.58	20.58	32.58	28.52	40.58	32.85	20.89	25.42	30.89	15.87
11.	Oil and grease (mg/L)	5.2	3.6	4.8	6.0	3.6	4.4	10.8	9.2	7.6	6.0	5.6	4.4
12.	Magnesium (mg/L)	4800	4815	4815	4865	4830	4695	4645	4595	4650	4775	4555	4695
13.	Nickel (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	3.02	BDL
14.	Lead (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
15.	Cadmium (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
16.	Chromium (mg/L)	0.14	BDL	0.24	0.08	0.28	0.28	0.57	0.75	0.51	0.21	0.27	0.63
17.	Zinc (mg/L)	0.02	BDL	0.045	BDL	BDL	BDL	0.06	0.17	0.295	BDL	0.425	BDL
18.	Copper (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19.	Manganese (mg/L)	BDL	BDL	BDL	BDL	2.11	BDL	BDL	BDL	BDL	BDL	BDL	BDL
20.	Cobalt (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Note: BDL denotes Below Detection Limit.

Table 10: Physico-chemical characteristics of the marine water from sampling location 2 (Cargo Jetty)

S. No	Parameters	2A		2B		2C		2D		2E		Control 2	
		SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
1.	Temperature (^{0}C)	29.3	29.1	29.5	29.3	29.5	29.4	29.7	29.5	29.5	29.3	29.6	29.6
2.	pH	7.77	7.75	7.78	7.78	7.81	7.79	7.77	7.76	7.78	7.79	7.73	7.7
3.	Salinity (ppt)	36.47	39.47	35.18	38.61	34.75	36.04	37.32	36.47	36.04	38.18	37.75	34.75
4.	Total Dissolved Solids (mg/L)	47920	48323	42634	46611	52769	57974	41006	37746	35442	38480	42722	42577
5.	Turbidity (NTU)	320	335	320	334	357	334	282.8	317	145.2	190.7	168	366
6.	Dissolved Oxygen(mg/L)	6.5	6.4	6.6	6.5	6.5	5.9	5.9	5.5	7.1	7.1	6.2	5.8
7.	Bio-Chemical Oxygen Demand (mg/L)	1.9	1.5	0.6	0.4	1.2	0.4	0.9	0.4	2.6	2	0.9	1.2
8.	Chemical Oxygen Demand (mg/L)	28	22	36	28	32	26	40	28	36	32	22	30
9.	Phenolic Compounds (µg/L)	6.1	6.8	4	5.7	6.2	5.1	6	4.5	7.6	7	11.6	6.6
10.	Petroleum Hydrocarbons (µg/L)	18.50	12.50	23.85	20.78	15.28	9.87	11.58	13.58	25.68	30.85	12.87	9.42
11.	Oil and grease (mg/L)	9.6	9.6	6	10	10	9.6	7.6	7.6	3.6	6.8	8	5.2
12.	Magnesium (mg/L)	4670	4800	4745	4840	4790	4760	4635	4770	4815	4805	4775	4685
13.	Nickel (mg/L)	BDL	BDL	BDL	BDL	2.005	BDL	0.565	BDL	BDL	BDL	BDL	BDL
14.	Lead (mg/L)	BDL	BDL	BDL	BDL	0.29	0.255	0.02	BDL	BDL	BDL	BDL	BDL
15.	Cadmium (mg/L)	BDL	BDL	2.9	BDL	0.275	2.485	1.37	BDL	1.075	BDL	BDL	BDL
16.	Chromium (mg/L)	1.115	0.85	0.89	0.805	0.985	1.245	1.425	1.11	1.22	1.055	1.615	1.45
17.	Zinc (mg/L)	BDL	BDL	0.235	BDL	0.465	0.52	0.37	BDL	0.225	BDL	0.395	0.14
18.	Copper (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19.	Manganese (mg/L)	BDL	BDL	BDL	BDL	0.29	0.255	0.02	BDL	BDL	BDL	BDL	BDL
20.	Cobalt (mg/L)	BDL	BDL	BDL	BDL	0.135	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Note: BDL denotes Below Detection Limit

Table 11. Physico-chemical characteristics of the marine water from sampling location 3 (Phang Creek)

S. No	Parameters	3A		3B		3C		3D		3E		Control 3	
		SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
1.	Temperature (^{0}C)	29.5	29.2	29.5	29.3	29.4	29.5	29.5	29.1	29.4	29.3	29.5	29.2
2.	pH	7.92	7.93	7.9	7.9	7.98	7.96	7.98	7.99	7.93	7.95	7.91	7.94
3.	Salinity (ppt)	36.9	36.9	34.75	37.75	37.32	43.76	36.47	38.18	39.47	37.75	34.32	43.76
4.	Total Dissolved Solids (mg/L)	30332	36506	43126	41006	53783	47623	43605	45653	50187	43362	40155	46270
5.	Turbidity (NTU)	274.5	300	272	324	238	302	219	259	179.1	186.7	213.1	220
6.	Dissolved Oxygen(mg/L)	5.7	5.5	5.7	5.6	6.1	5.7	6	5.7	5.7	5.7	5.8	5.5
7.	Bio-Chemical Oxygen Demand (mg/L)	2.5	2.3	2.9	2.4	2.3	2.1	2.7	2.4	2.2	2.2	2.5	2.4
8.	Chemical Oxygen Demand (mg/L)	42	38.0	36	34	32	28	24	20	32	24	30	26
9.	Phenolic Compounds (µg/L)	22.8	22	24.1	25.4	19.3	27.2	30.2	25.1	25.2	24	28.3	24.1
10.	Petroleum Hydrocarbons (µg/L)	22.20	18.50	12.50	9.50	13.58	10.58	22.42	19.52	12.35	BDL	28.20	12.58
11.	Oil and grease (mg/L)	8.4	6.0	5.6	7.6	5.6	7.2	7.6	4.4	5.6	7.6	4.8	5.6
12.	Magnesium (mg/L)	4675	4865	4590	4585	4740	4660	4760	4685	4665	4795	4770	4775
13.	Nickel (mg/L)	1.855	1.47	1.74	0.85	1.595	0.75	1.49	0.11	2.79	0.925	3.005	2.37
14.	Lead (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.345	BDL
15.	Cadmium (mg/L)	BDL	0.76	2.875	BDL	0.27	BDL	0.825	BDL	BDL	1.375	BDL	BDL
16.	Chromium (mg/L)	1.955	1.535	2.005	2.21	2.055	2.08	2.08	1.89	1.835	1.97	2.18	1.87
17.	Zinc (mg/L)	0.315	0.19	0.195	0.345	0.465	0.27	0.38	0.2	0.26	0.195	0.535	0.235
18.	Copper (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19.	Manganese (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
20.	Cobalt (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.03	BDL	BDL	BDL

Note: BDL denotes Below Detection Limit

Chapter 5 Biological Characteristics of Marine Water

5.1. Introduction for Plankton

Plankton is defined as all those living organisms which are suspended and drifting in water. Phytoplanktons are the primary producers in marine ecosystems and form the basis of the food web. The animal portion of plankton is known as Zooplankton, which are pelagic animals and unable to maintain their position by swimming against the physical movement of water. Size is very important to understanding about the classification of both zooplankton and phytoplankton. Based on size, various categories of plankton are smallest one Picoplankton (0.2-2 µm), Nanoplankton (2-20 µm), Microplankton (20-200 µm), Mesoplankton (200 µm-2 mm), Macroplankton (2-20 mm) and Megaplakton(> 20 mm) . The planktonic communities encompass of aquatic organisms which drift passively and also have limited mobility to move contrary of the water mass. Plankton are divided in two parts which are phytoplankton and zooplankton (Brink. 1993).The tiny flora or plants are called as Phytoplankton, and weak swimming tiny fauna or animals are called as Zooplankton. Phytoplankton are the primary producers in marine ecosystems and form the basis of the food web. Zooplankton are pelagic animals play a role in the food chain in aquatic ecosystem to provide a food resource to various organisms. Major phytoplankton in sea water is Diatoms (Tiwari and Nair, 1998; Thakur et al, 2015), Cocolithophores, Sillicoflagellates, Blue green algae (Cyanobacteria) and Dinoflagellates. Zooplankton comprises the second level in the food chain and includes Tintinnids, Foramonifers, Radiolarians, Amphipoda, Copepoda, Calanoida, Chaetognaths, larvae of benthic invertebrates and fish larvae etc. (Gajbhiye and Abidi, 1993; Thirunavukkarosu, 2013; Chakrabarty et al. 2017). Interspecific competition among the Zooplankton; Inter-relationship for prey and predator between zooplankton and their mostly predator animals; Grazing ratio of primary-secondary consumers; Suspension of sediment; Fluctuation in Phytoplankton abundance; Waves, Currents and Tidal turbulence effect; Fluctuation in Chlorophyll a and Nutrients; Input of Organic and other Pollution creating sources; Fish potential ratio; Monsoon effect; Suddenly changes in atmosphere; Peak time of every seasons and it's effect; Vertical migration of Zooplankton; Food selection pattern of predator; Collection time and number of collected samples, mixing of water column, high surface action, Seasonal up welling and down welling process in water column

5.1.1. Phytoplankton

Phytoplankton are single celled marine algae with great difference in shape, size and form, either use flagella for movement in water or just drift with currents (Zohari et al, 2014). These photosynthetic organisms need sunlight for photosynthesis. Diatoms dominate the phytoplankton biomass in highly productive areas of the ocean. The diatoms are one of the most important phytoplankton as a primary producer of marine ecosystem. They are estimated to produce 20-25 % of the world total net primary production (Werner, 1977).

With trapping carbon in the process of photosynthesis, they can control the atmospheric carbon dioxide and help in combating the global climate change. With this, they have significant role in the management of nutrients cycles in the ocean systems. Their role as primary producers in aquatic ecosystem, in the process of nutrients cycling in the ocean systems, also in calcification, silicification, nitrogen-fixing,etc. made them important marine component for marine life study. Their sensitiveness for various anthropogenic activities in the marine environment such as Eutrophication, introduction of invasive species, overfishing etc, make them one of the best indicators to analyse these activities.

5.1.2. Zooplankton

The faunal species particularly microscopic fauna, living inside the water bodies are known as zooplankton. Zooplankton is tiny-small animals found in all water bodies particularly the pelagic and littoral zone in the ocean. They are classified by size and or by development stages. Zooplankton community is composed of both primary consumers (which eat phytoplankton) and secodanry (which feed on the other zooplankton). Crustaceans zooplankton are Arthropods whose body is covered with chitinous exoskeleton for protection. Nearly all fish depend on zooplankton for food in both larval stages and entire life period (Madin et al., 2001). They are attractive, various and plentiful group of faunal species which can swim or generally drift with water currents but have no potential to swim against water currents (Alcaraz and Calbet, 2003). The important role of them is to be a major link in the marine life in between marine microalgae or phytoplankton and fish. Although they can be classified according to their habitat and depth, distribution, size and duration of planktonic life period (Omori and lkeda, 1984), generally, it is considered as there are two types of zooplanktons. Holoplanktons are those which live permanently in the planktonic form, while meroplanktons are the temporary members in this form. The potential of zooplankton to respond quickly to environment changes and short generation life span, make them important bioindicator of water pollution and all variation occurred in their living environment. Their study is the important part for getting knowledge of the functioning of marine ecosystems (Mees and Jones, 1997).

5.2. Methodology

5.2.1 Estimation of Chlorophyll and Phaeophytin

Estimating Chlorophyll and Phaeophytin was done using known volume of water (500 ml) was filtered through a 0.45μm Millipore membrane filter paper and the pigments retained on the filter paper were extracted in 90% acetone overnight at 50°C. The extinction of the acetone extract was measured using fluorimeter before and after treatment with dilute acid (0.1N HCI).

5.2.2. Phytoplankton sampling and analysis

Phytoplankton samples were collected in the ten prefixed sampling sites using a standard plankton net with a mesh size of 51 μm. Plankton nets are with a square mouth covering an area of 0.900 cm^2 (30 cm square mouth) fitted with a flow meter (Hydrobios). Nets were towed from a moving boat for 10 minutes and the plankton adhering to the net was concentrated in the net bucket. Plankton soup from the net bucket was transferred to a pre-cleaned and rinsed container and preserved with 5%

neutralized formaldehyde. The containers were appropriately labelled. The initial and final flow meter reading was noted down for calculating the amount of water filtered to estimate plankton density. As per flow meter reading, a total amount of 165m^3 of water was filtered by the net. One liter of water was separately collected for density estimation to counter check density estimation obtained by the flow meter reading. Quantitative analysis of phytoplankton (cell count) was carried out using a sedge wick-Rafter counting chamber. One ml of soup added to a Sedgwick counting chamber was observed under an inverted compound microscope. The number of cells present in individual cells of the counting chambers (1/1000) was noted and identified up to a generic level. Several observations were fixed to represent the entire quantity of the soup (generally more than30 times) and the recorded data were used to calculate the density (No/l) using the formula, $N = n \times v/V$ (where N is the total no/l; n is an average number of cells in 1 ml; v is the volume of concentrate; V is the total volume of water filtered). The phytoplankton diversity richness and evenness were past software.

5.3. Phytopigments

The concentration of phytopigments is inversely proportional to the turbidity of the waters and in general, waters owing to the high turbidity restricts sunlight penetration essential for nutrient uptake by phytoplankton and thus inhibiting primary production. The concentration of chlorophyll pigment in the water samples ranged from 0.48 -0.74 mg/m^3 with a mean ± SD being 0.59±0.09 mg/m^3 in the Offshore (Table 12), 0.48 to 0.77 mg/m^3 with mean ± SD of 0.59±0.09 mg/m^3 in the Cargo Jetty (Table 13) and 0.43 to 0.99 mg/m^3 with mean ± SD being 0.707±0.159 mg/m^3 in the Phang creek location (Table 14).

Another phytopigment estimated was Phaeophytin, which is one of the breakdown products of Chlorophyll was also estimated in the water samples collected from all the three locations and the concentration of Phaeophytin in the marine water samples were in the concentrations such as 0.25-0.48 mg/m^3 with a Mean±SD of 0.32±0.08 mg/m^3 in the Offshore location (Table 12). In case of Cargo Jetty location, the concentration of the secondary pigment was in the range of 0.22- 0.44 mg/m^3 with a Mean±SD of 0.32±0.088 mg/m^3 (Table 13) and in case of the creek location, the concentration of phaeophytin was almost similar when compared to the other two locations and was ranging between 0.23-0.77 mg/m^3 with a Mean±SD of 0.46±0.16 mg/m^3 (Table 14). An optimum ration of Chlorophyll to Phaeophytin of above 1.5 as expected for natural estuarine and coastal waters.

Table 12: Chlorophyll and Phaeophytin concentration observed in the Offshore site

Parameters	**1A**		**1B**		**1C**		**1D**		**1E**		**1 Control**	
	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
Chlorophyll	0.650	0.580	0.580	0.480	0.670	0.480	0.640	0.620	0.740	0.520	0.670	0.480
Phaeophytin	0.320	0.280	0.250	0.280	0.250	0.320	0.480	0.320	0.340	0.280	0.460	0.260

Table 13: Chlorophyll and Phaeophytin concentration observed in the Cargo Jetty site

Parameters	**2A**		**2B**		**2C**		**2D**		**2E**		**2 Control**	
	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
Chlorophyll	0.770	0.650	0.640	0.520	0.580	0.480	0.620	0.560	0.520	0.700	0.480	0.650
Phaeophytin	0.440	0.420	0.230	0.310	0.250	0.260	0.230	0.420	0.320	0.350	0.220	0.440

Table 14: Chlorophyll and Phaeophytin concentration observed in the Phang Creek site

Parameters	**3A**		**3B**		**3C**		**3D**		**3E**		**3 Control**	
	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
Chlorophyll	0.430	0.610	0.580	0.840	0.810	0.990	0.820	0.630	0.570	0.650	0.680	0.870
Phaeophytin	0.390	0.400	0.64	0.460	0.740	0.770	0.320	0.230	0.420	0.490	0.350	0.410

5.4. Phytoplankton

The study was conducted at 3 sites (or regions) at Deendayal Port and near area where dredging activities is going on Creek and the stations are Offshore, Cargo Jetty and Phang Greek.

5.4.1. Offshore

In this site, frequently observed species were *Actinocyclus sp, Coscinodiscus centralis, Coscinodiscus wailesii, Coscinodiscus rediatus, Ditylum brightwelli, Thalassionema frauenfeldii colony, Thalassionema nitzschioides colonies, Odontella sinensis, etc.* whereas less observed species were *Amphiprora sp*, Green algae, *Navicula sp, Bacillaria paxillifera colonies, Gyrosigma sp, Protoperidinium sp etc.* Total 23 Phytoplankton were recorded in this Offshore area. Highest population density was recorded at site 1control-Offshore (36000nos./m^3) and lowest density was recorded at site 1C-Offshore (19840nos./m^3). The maximum number of species observed in site 1E and 1A-Offshore (13 nos.) followed by 1control (12nos.), 1B and 1C (11nos.), 1D(09nos.). The population density greatly varied between (19840nos./m^3 to 36000nos./m^3). *Synedra ulna, Navicula sp, Green algae Thalassiosira sp* were recorded which are sometimes considering for pollution indicator species in water. Green algae was also recorded in some location of Offshore which may be indication of freshwater or polluted water mixing with seawater. Some Dinoflagellates were also recorded like *Protoperidinium sp.* Highest population density contributor species was *Coscinodiscus wailesii* (range 5120 to 12000nos./m^3)

5.4.2. Cargo jetty

Total 24 Phytoplankton were recorded in this Cargo Jetty area. The population density greatly varied between 27040 nos/m^3 to 38240 nos/m^3.Highest density recorded at 2control-Cargo Jetty (38240nos./ m^3) and lowest value was at 2A and 2C-Cargo Jetty (27040nos./m^3). The lowest number of species noted in the site 2D-Cargo Jetty(09 nos.) whereas highest in 2control-CargoJetty (20nos.). In this Cargo Jetty station commonly or frequently observed species were *Actinocyclus sp, Coscinodiscus centralis, Coscinodiscus radiatus, Coscinodiscus wailesii, Odontella sinensis, Thalassiosira sp* etc. The rarely found species were Green algae, *Protoperidinium sp, Thalassiosira aculeata, Triceratium favus etc.* The Dinoflagellates like *Protoperidinium sp* was also observed during microscopic analysis that may be indication of water circulation from deep water to upper surface. *Silicoflagellates* were also recorded which are normally found in deep sea.

5.4.3. Phang Creek

The population density of phytoplankton ranged from 36800nos./m^3 to 86080nos./m^3 same way species availability ranged from 13 to 21 nos. Maximum and Minimum value of population density were recorded in site 3Control-Phang Creek (86080nos./m^3) and 3B-Phang Creek (36800 nos./m^3) respectively. Highest number of species recorded in site 3control-Phang Creek (21nos.) and lowest in site 3B and 3C-Phang Creek (13nos.). Total recorded phytoplankton was 29 in this creek area. *Actinocyclus sp, Coscinodiscus centralis, Coscinodiscus wailesii, Coscinodiscus radiatus, Odontella sinensis Thalassionema frauenfeldii coloniesRhizosolenia sp , Synedra ulna, Thalassionema frauenfeldii colonies,Thalassionema nitzschioides colonies, Thalassiosira sp etc.* were frequently noticed during microscopic work whereas less observed species were *Biddulphia sp, Pinnularia sp, Trieres mobiliensis Thalassiosira aculeata* and some unidentified phytoplanktons. Green algae *were also recorded*, which are generally found in fresh water and estuarine area.

Overall view of Phytoplankton showed that a total 37 species of Marine phytoplankton were identified during summer season of the year 2024. Among them,14-Centric diatoms, 18-Pennate diatoms, 2-Dinoflagellates, 2-Green algae and 1-silicoflagellates and some are not identified phytoplankton's was included in unidentified. Some species like Biddulphia sp ,*Bacillaria paxillifera colonies, Dictyocha sp (Silicoflagellates) Protoperidinium sp Trachyneis sp , Tripos muelleri* were rarely recorded during sample analysis. Input of the fresh water indicated by the presence of some common fresh water species like *Green algae* and *Oocystis sp.*

Presence of *Dinoflagellates (Tripos Muelleri Protoperidinium sp)* indication of bottom water circulation up to surface water layer in some level. *Dictyocha sp* (Silicoflagellates) was also recorded in Phang creek region. Highest phytoplankton density was observed at the site 3control-Phang creek (86080nos./m^3) and lowest was observed at site 1C-Offshore (19840 nos./m^3) (Table 15). Total number of highest species observed at site 3control-Phang creek (21nos.) and lowest in site 1D-Offshore and 2D-Cargo jetty (09nos.).

The high population density composed by species like Actinocyclus sp, *Coscinodiscus centralis, Coscinodiscus radiates, Coscinodiscus wailesii, Thalassionema frauenfeldii colonies, Thalassionema nitzschioides colonies, Thalassiosira sp* (Table 15). This result indicated that genus *Coscinodiscus sp. Actinocyclus sp, Thalassionama sp* were very common with good numbers in all sites. In some sites, least number of species and low density of phytoplankton might be responsible due to some factors like extreme cool or hot weather because of rainy season, mixing of water, high pre-predation ratio, marine pollution (anthropogenic pressure), high turbidity, total suspended solids, water current and suddenly changes in environment conditions etc. Diatoms, type of phytoplankton, constitute major part in total phytoplankton composition The individual density of species of sites viz. has been depicted in Table 15.

5.5. Diversity Indices of Phytoplankton

According to Table 16, diversity indices calculation for phytoplankton showed that the Shannon Index ranged from (1.79 to 2.54) indicated low level to moderate level of diversity range. High Shannon Index was recorded at 3A-Phang creek (2.34) where 17 species were recorded and low at 2D-Cargo Jetty(0.73) where 09 species were recorded. Lowest evenness recorded at site 2B-Cargo Jetty(0.59) whereas highest was in at 1control-Offshore (0.81). Dominance_D index ranged from 0.09 to 0.21 where higher value in 2D-Cargo Jetty (0.21) and lowest was at in 2control-Cargo jetty (0.09). Value of Margalef D (0.76 to 1.80) showed more to moderate variation in species numbers as shown in Table 16.

Table 15. Density of Phytoplankton at different sites of Deendayal Port

Name of Sites	**Offshore**						**Cargo Jetty**						**Phang Creek**					
	1A	**1B**	**1C**	**1D**	**1E**	**1 control**	**2A**	**2B**	**2C**	**2D**	**2E**	**2 control**	**3A**	**3B**	**3C**	**3D**	**3E**	**3 control**
Genus of Phytoplankton																		
Actinocyclus sp	2400	800	1120	2400	2400	4000	4000	640	3200	1600	4000	1600	0	4000	3200	4800	7200	10400
Amphiprora sp	800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bacillaria paxillifera colonies	0	0	0	0	0	1600	0	0	0	0	0	0	0	0	0	0	0	0
Biddulphia sp	0	0	0	0	0	0	0	0	0	0	0	0	1600	480	0	0	800	0
Campylodiscus sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	640
Coscinodiscus centralis	2400	2080	1600	2400	7200	2400	3200	8000	3840	9600	3200	3200	7200	4160	7200	10400	5600	12000
Coscinodiscus radiatus	5600	3360	4320	4800	4800	4800	1920	7200	6400	11200	8800	3200	9600	9600	10400	11200	10400	14400
Coscinodiscus sp.	1440	1920	0	0	0	0	0	0	0	0	0	0	0	1760	0	2080	0	0
Coscinodiscus wailesii	7200	8000	5120	12000	6400	9600	8000	9600	3360	7200	8800	8800	1760	2080	4800	1920	20000	19200
Ditylum brightwelli	800	1600	1600	2400	1600	2400	0	800	800	320	1600	3200	1600	0	0	0	0	800
Dictyocha sp (Silicoflagellates)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	640
Diploneis sp	0	0	0	0	800	0	0	0	0	0	0	0	0	0	0	0	0	0
Green algae (unidentified)	800	640	0	0	0	0	0	0	1600	0	0	800	0	0	0	480	0	960
Gyrosigma sp.	0	0	0	0	800	1600	0	0	0	0	0	640	1600	0	2400	2400	0	800
Navicula sp	0	0	480	1600	0	0	0	0	0	0	800	0	800	0	480	2400	1600	
Nitzschia sp	0	0	0	0	0	0	0	0	0	0	0	0	1600	0	0	0	0	1600
Odontella sinensis	1600	2400	0	2400	2400	0	0	2400	800	0	320	1600	3200	4000	2400	3200	0	1600
Oocystis sp	0	0	0	0	800	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinnularia sp	0	0	0	0	0	0	480	0	0	1600	0	0	800	0	1600	0	0	1600
Planktoniella sol	0	0	0	0	1600	2400	0	0	0	0	0	1600	0	0	0	0	3200	0
Pleurosigma sp.	480	0	0	0	0	0	1600	0	1440	0	0	0	0	480	0	2400	800	800
Pleurosigma angulatum	0	0	0	0	0	0	0	0	0	0	0	1600	0	0	0	0	0	0
Protoperidinium sp	0	0	640	0	0	0	0	0	800	0	0	0	0	0	0	0	0	0
Silicoflagellates	0	0	0	0	0	0	320	0	0	0	0	800	0	0	0	0	0	0
Surirella sp	0	0	0	0	0	0	0	0	0	0	0	1600	1600	0	1600	0	800	2400
Synedra sp	0	0	0	0	0	0	0	0	0	0	0	800	0	0	0	0	0	4000
Synedra ulna	1600	1920	1440	1600	0	1600	0	640	0	1600	2400	0	2400	3200	800	640	4000	800

Thalassionema frauenfeldii colonies	0	1760	2080	2400	2400	2400	3200	2400	0	0	1600	1600	2400	3200	2400	3200	3200	4800
Thalassionema nitzschioides colonies	0	0	0	0	0	0	0	0	0	0	0	1600	0	0	0	2400	0	0
Thalassiosira eccentrica	0	0	0	0	0	0	0	0	0	0	0	800	1600	0	0	0	0	0
Thalassiosira aculeata	0	0	0	0	0	0	320	800	0	0	0	800	0	800	0	800	0	1600
Thalassiosira sp.	1120	1600	1120	0	1600	1600	1600	2400	800	1600	1600	2400	2400	2400	4000	4000	10400	4800
Trachyneis sp	0	0	0	0	0	0	0	320	800	0	0	0	0	0	0	0	0	0
Triceratium favus	800	0	0	0	1600	0	0	0	1600	2400	0	800	1600	640	4000	0	0	1600
Trieres mobiliensis	0	0	0	0	0	1600	2400	320	1600	0	1600	800	0	0	0	1600	960	640
Tripos muelleri	0	0	0	0	0	0	0	0	0	0	0	0	800	0	0	0	0	0
Unidentified	0	0	320	0	0	0	0	0	0	0	0	0	0	0	0	0	320	0
Density of Phytoplankton (diff. sites wise.)(no/m^3)	27040	26080	19840	32000	34400	36000	27040	35520	27040	37120	34720	38240	42560	36800	45280	53920	69280	86080
Total= 708960 no/m^3																		
Total No Of Genus/Species=**37**																		

Table 16. Diversity Indices of Phytoplankton at different sites at Deendayal Port

Variables	Offshore						Cargo jetty						Phang Creek					
	1A	1B	1C	1D	1E	1-control	2A	2B	2C	2D	2E	2-contrl	3A	3B	3C	3D	3E	3-control
Taxa_S	13	11	11	9	13	12	11	12	13	9	11	20	17	13	13	16	14	21
Individuals (Nos/m^2)	27040	26080	19840	32000	34400	36000	27040	35520	27040	37120	34720	38240	42560	36800	45280	53920	69280	86080
Dominance_D	0.14	0.15	0.15	0.20	0.12	0.13	0.16	0.18	0.12	0.21	0.16	0.09	0.11	0.13	0.12	0.11	0.15	0.12
Shannon Diversity Index (H)	2.22	2.15	2.11	1.92	2.31	2.28	2.06	1.96	2.31	1.79	2.05	2.70	2.54	2.26	2.31	2.45	2.14	2.43
Simpson_1-D	0.86	0.85	0.85	0.80	0.88	0.87	0.84	0.82	0.88	0.79	0.84	0.91	0.89	0.87	0.88	0.89	0.85	0.88
Evenness_e^H/S	0.71	0.78	0.75	0.76	0.77	0.81	0.71	0.59	0.77	0.67	0.70	0.74	0.74	0.73	0.77	0.72	0.61	0.54
Menhinick	0.08	0.07	0.08	0.05	0.07	0.06	0.07	0.06	0.08	0.05	0.06	0.10	0.08	0.07	0.06	0.07	0.05	0.07
Margalef	1.18	0.98	1.01	0.77	1.15	1.05	0.98	1.05	1.18	0.76	0.96	1.80	1.50	1.14	1.12	1.38	1.17	1.76

5.5. Zooplankton

The study was conducted at 3 sites in Deendayal Port and nearby areas where dredging activities are going on. The three selected study stations are Offshore, Cargo Jetty and Phang Greek.

5.5.1. Offshore

Acartia sp, Calanoida (unidentified), Copepoda eggs sac, Egg capsules of Littorinids, Polychaete larvae (Annelids), Zoea larva of Crab, Foraminifera (unidentified), Nauplius larva of Copepoda, Sponge Spicules, Zoea larva of Crab etc. were the mostly common zooplankton and throughout observed in all sites of Offshore area. Highest population density was recorded at site 1D-Offshore (48000 nos./100m^3) where number of species was (24 nos.) and lowest density in 1A-Offshore (26560nos./100m^3) where number of species was recorded (18nos.). High biomass was observed in the site 1A-Offshore (66.67 ml/100m^3) and low biomass was recorded in site 1E-Offshore (13.51 ml/100m^3). The range of the population density, biomass and number of species were (26560 to 48000 nos./100m^3), (13.51 to 66.67 ml/100m^3) and (16 to 25 nos.) respectively in all sites.

Less observed species were Animal Development stage, Arcella sp (Amoebozoa), Dynamena pumila colony (Hydroid), Gastropoda shells, Spirillina sp (Foraminifera) etc. in this station. Total 44 zooplankton was recorded in Offshore area adding that more composition of zooplankton by the Phylum Arthropoda(Crustacea), Foraminifera and Sponge Spicules (Porifera).

5.5.2. Cargo Jetty

The population density of zooplankton varied from 26560 nos./100m^3 to 77760 nos./100m^3. Maximum density was noticed in site 2C-Cargo Jetty (77760nos./100m^3) and minimum was at site 2A-Cargo Jetty (26560nos./100m^3). Maximum number of species (28nos.) found 2control - Cargo Jetty minimum number of species was observed in site 2A-Cargo Jetty (15nos.). Biomass ranged between 16.67 to 31.82 ml/100m^3 where highest biomass noted in site2D-Cargo Jetty and lowest in 2B-Cargo Jetty.

Frequently observed species were *Acartia sp (Calanoida), Ammonia sp (Foraminifera), Bolivina sp (Foraminifera), Egg capsules of Littorinids* Calanoida (unidentified), Foraminifera (unidentified), Globigerina sp (Foraminifera), Ostracoda, Polychaete larvae (Annelids), Sponge Spicules, Zoea larva of Crab etc. whereas less observed species were Egg (unidentified), Gastropoda shells, Leprotintinnus nordqvistii (Tintinnida), Sagitta sp (arrow worm), *Subeucalanus sp* (Calanoida), *Triloculina sp* (Foraminifera) etc. Some Unidentified larval stages were also reported.Total recorded zooplanktons were 44 in Cargo Jetty.

5.5.3. Phang Creek

This Creek area was represented by the zooplankton fauna majority of them were Calanoida (unidentified), *Clausocalanus sp* (Calanoida), Copepoda eggs sacs, Foraminifera (unidentified), Gastrula larva of Echinodermata, Globigerina sp (Foraminifera), Ostracoda , Sponge spicules, *Leprotintinnus sp* (Tintinnida). Very less time or rarely recorded species were Egg (unidentified) , Euterpina sp (Harpacticoida), Fish larva, Globigerinoides sp (Foraminifera), *Leprotintinnus nordqvistii* (Tintinnida), *Nonion sp* (Foraminifera), Sagitta sp (arrow worm), *Tintinnopsis orientalis* (Tintinnida).

The range of zooplankton biomass was between 20.71 to 40.98 ml/100m^3. Highest Biomass was recorded in site 3A-Phang creek (40.98 ml/100m^3) and lowest in site 3B-Phang creek (20.71 ml/100m^3). Maximum and Minimum species count was at in site 3E-Phang creek (26nos.) and 3A-Phang Creek (18nos.) respectively. Population density was maximum recorded in site 3C-Phang Creek (88480 nos./100m^3) and minimum in site 3B-Phang Creek (53600 nos./100m^3). In site 3B-Phang creek comparatively low density according to other sites may be because of high predator pressure or some environment changes.

Overall assessment of zooplankton showed that the total number of 64 Zooplankton recorded during this season. Out of these (64) zooplankton, 44 zooplankton recorded in Offshore region, 44 zooplankton at Cargo Jetty and 48 zooplankton in Phang Creek region. The recorded zooplankton of all 3 stations mainly representing Phylum Arthropoda (Crustacea), Protozoa (mainly foraminifera and tintinnids), Porifera (sponge spicules). Crustacean zooplankton was the dominant due to the dominance of different larval stages and Copepods which mainly feed phytoplankton. More larval stage of crustacean and other animals observed in samples that indicated reproduction and development season of animals from larval to mature animal. Generally zooplankton population dynamics and studies emphasize is given up to group level rather than to species level because of microscopic size of zooplankton so to the difficulty in identifying the zooplankton as some species are considered as a groupor genus level. The most dominant or frequently observed species(all 3 station) were Acartia sp (Calanoida) Calanoida (unidentified), *Clausocalanus sp* (Calanoida), Copepoda eggs sac, Foraminifera (unidentified), Leprotintinnus sp (Tintinnida), Ostracoda, Polychaete larvae (Annelids) Globigerina sp (Foraminifera), Ostracoda, Sponge Spicules, Zoea larva of Crab etc. Foraminifera and Ostracoda belonging to the meroplankton were present at all three stations.

Overall range of all three sites Population density, Biomass and Number of species were (26560 to 88480no/100 m^3), (13.51 to 66.67ml/100m^3) and (15 to 26nos) respectively. Average high biomass noted at Offshore (35.65 ml/100m^3) followed by Phang creek (30.15 ml/100m^3) than Cargo Jetty (22.70 ml/100m^3) (Tables 17-19). Highest population density was recorded in site 3C-Phang creek (88480 nos/100m^3) and lowest was recorded in site 2A-Cargo Jetty and 1A-Offshore (26560no/100m3). Among all recorded zooplankton, majority dominance occurrence was by the Copepoda, Crustacean larvae, Spong Spicules, Foraminifera (Protozoa), Ostracoda, Tintinnids (Protozoa), Zoea larva of Crab. Jelly fish (Hydrozoa: Cnidaria) was also recorded in Offshore and Phang creek region.

Maximum zooplankton faunal composition was dominated by the Phylum Arthropoda, Mollusca, Protozoa, Porifera, Foraminifera. The Fish larva and Fish

(Ichthyoplankton) was also recorded in some sites of Offshore and Cargo jetty. The Zooplankton of Chaetognatha,, Amoebozoa were only represented by the species namely *Sagitta sp (arrow worm), Arcella sp.* respectively. Veliger larva of Bivalve and Heteropods shells include in Phylum Mollusca. The Echinodermata phylum represented by the Ophiopluteus larva and Gastrula larva of Sea star.

In Offshore**,** maximum Occurrence (%) was by the Zoea larva of Crab (9.04%) and minimum by the Dynamena pumila colony (Hydroid) and Nematoda (0.14%). In Cargo Jetty, maximum Percentage of Occurrence (%) by the Foraminifera (unidentified) (16.4%) and minimum by the *Brachionus sp* (Rotifera) (0.09%). In Phang Creek maximum. Occurrence by the Foraminifera (unidentified) (16.65%) and minimum (0.08%) by the Egg (unidentified) and some unidentified zooplankton (Table 17 - 19).

During microscopic sample analysis more number of species varieties of Foraminifera, Sponge spicules, Crustacean larva, Copepoda and Tintinnids were observed. These all three are very important for paleontological study aspects and also for evolutionary, ecological and environmental rebuilding. Some species of Ostracoda, Foraminifera and Sponge spicules are considered in microfossils materials. Some deep sea species also recorded that is indication of water circulation pattern. Data on zooplankton density, list of zooplankton is shown in Tables (17-19).

Plankton identification, both zooplankton and phytoplankton, were done by using relevant identification and taxonomic keys and with standard literatures, monographs and research articles.(Kasturirangan, 1963; APHA, 1992; Mitra et al., 2003;Goswami, 2005; Carling et al.,2004; Mandal, 2004; Hussain & Kalaiyarasi, 2013; Guglielmo et al., 2015; Hussain et al., 2016; Sreenivasulu et al., 2017; NIO,1998; NIO,2002) ,etc

5.6. Diversity Indices of Zooplankton

Table 20 shows *diversity indices of zooplankton. The* Shannon-wiener diversity index (H’) fluctuated between 2.39 to 3.17 indicated moderate to quite high range of diversity added indication of healthy body of water with a maximum value in site 3A-

Phang creek (2.39) where number of species noted (28 nos.) and minimum value in site 3A-Phang Creek (2.19) where species number was 18nos.Range of the evenness was 0.60 to 0.92 where lowest and highest recorded in site 3A and 3D-Phang creek (0.60) and 1A-Offshore (0.92) respectively. Range of Simpson index was 0.84 to 0.95. The range value of Margalef indices was 1.37 to 2.25 that means high species number variations. (Table 20).

Table 17.Density of Zooplankton at Offshore site of Deendayal Port

Name of Genera/Group	1A	1B	1C	1D	1E	1 Control	Individual total density (no/100m^3)	% of Occurrence (Site-wise)
Acartia sp (Calanoida)	0	1600	0	1600	640	0	3840	1.74
Animal Development stage	0	0	0	0	3200	0	3200	1.45
Ammonia sp (Foraminifera)	800	960	0	0	0	1600	3360	1.52
Arcella sp (Amoebozoa)	0	0	1600	0	0	0	1600	0.72
Brachionus sp (Rotifera)	0	0	0	0	0	1600	1600	0.72
Calanoida (unidentified)	1600	4800	1600	4000	4000	1600	17600	7.96
Clausocalanus sp (Calanoida)	2400	0	0	2400	0	0	4800	2.17
Copepoda eggs sac	960	1920	800	2400	800	480	7360	3.33
Corycaeus sp (Calanoida)	0	800	0	480	0	0	1280	0.58
Cyclopoida (unidentified)	0	3520	960	0	0	0	4480	2.03
Cyclops sp (Cyclopoida)	0	0	0	0	2400	0	2400	1.09
Dynamena pumila colony (Hydroid)	0	0	0	320	0	0	320	0.14
Egg capsules of Littorinids	1600	1280	800	4000	0	3200	10880	4.92
Euterpina sp (Harpacticoida)	0	1600	0	800	0	800	3200	1.45
Fish larva	0	0	0	800	0	800	1600	0.72
Foraminifera (unidentified)	1600	1600	0	4800	2720	5600	16320	7.38
Gastropoda shells	0	0	0	1600	0	0	1600	0.72
Globigerina sp (Foraminifera)	0	960	0	2400	0	0	3360	1.52
Harpacticoida (unidentified)	0	1600	0	0	0	0	1600	0.72
Heteropoda shells (gastropods)	640	960	0	0	0	800	2400	1.09
Jelly fish (Hydrozoa: Cnidaria)	3200	1600	0	1120	4000	0	9920	4.49
Leprotintinnus sp (Tintinnida)	0	2400	0	2400	800	0	5600	2.53
Microsetella sp (Harpacticoida)	320	1600	1600	0	0	0	3520	1.59
Mysis larva of Prawn	1600	0	800	0	0	0	2400	1.09
Nauplius larva of Copepoda	1600	0	1600	1600	1600	800	7200	3.26
Nauplius larvae of Barnacles	1600	800	0	0	1600	0	4000	1.81
Nauplius larvae of Crustacea	0	0	4000	3200	1600	0	8800	3.98
Nematoda	0	0	0	0	0	320	320	0.14
Oithona sp (Cyclopoida)	1600	0	0	0	0	3200	4800	2.17
Ophiopluteus Larva (Echinodermata)	0	1120	0	0	800	1600	3520	1.59
Ostracoda	0	800	480	1600	0	2400	5280	2.39
Paracalanus sp (Calanoida)	0	1600	1600	800	0	0	4000	1.81
Parvocalanus sp (Calanoida)	0	800	1600	0	1600	0	4000	1.81
Polychaete larvae (Annelids)	1440	1600	4000	1600	2400	3200	14240	6.44
Sagitta sp (arrow worm)	1120	640	0	0	0	0	1760	0.80

Spirillina sp (Foraminifera)	0	0	0	0	0	1600	1600	0.72
Spiroloculina sp (Foraminifera)	0	0	0	0	0	480	480	0.22
Sponge Spicules	0	1600	4000	1280	0	3200	10080	4.56
Subeucalanus sp (Calanoida)	0	0	0	0	1600	0	1600	0.72
Thermocyclops sp (Cyclopoida)	1280	0	1600	0	1600	0	4480	2.03
Tintinnopsisorientalis (Tintinnida)	0	0	0	1600	800	1600	4000	1.81
Veliger larvae of Bivalve	0	1120	0	800	0	1600	3520	1.59
Zoea larva of Crab	1600	5600	5600	5600	1600	0	20000	9.04
Unidentified larva	1600	0	0	800	0	800	3200	1.45
Total No. Of Genera/Groups=44								
Site-wise Total Density (no/100m^3)	26560	42880	32640	48000	33760	37280	**221120**	**100%**
Biomass (ml/100m^3)	**66.67**	**37.04**	**16.30**	**23.26**	**13.51**	**57.14**		

Table 18. Density of Zooplankton at Cargo Jetty site of Deendayal Port

Name of Genera/Group	2A	2B	2C	2D	2E	2 Control	Individual total density (no/100m^3))	% of Occurrence (Site-wise)
Acartia sp (Calanoida)	0	800	800	800	0	1600	4000	1.16
Ammonia sp (Foraminifera)	960	2400	0	2400	8800	2400	16960	4.93
Brachionus sp (Rotifera)	0	320	0	0	0	0	320	0.09
Bolivina sp (Foraminifera)	640	800	1600	800	2400	1600	7840	2.28
Calanoida (unidentified)	1120	800	0	1600	1600	1120	6240	1.81
Calcarina sp (Foraminifera)	0	0	800	1600	0	0	2400	0.70
Clausocalanus sp (Calanoida)	800	2400	4000	0	1600	1600	10400	3.02
Copepoda eggs sac	0	0	0	2400	2400	1600	6400	1.86
Cyclops sp (Cyclopoida)	0	1600	800	0	0	0	2400	0.70
Cyphonautes larva (Bryozoan)	800	0	800	0	0	0	1600	0.46
Egg capsules of Littorinids	0	4000	4000	0	5600	2400	16000	4.65
Egg (unidentified)	0	0	0	800	0	0	800	0.23
Euterpina sp (Harpacticoida)	0	0	800	800	0	1600	3200	0.93
Fish (small)	0	0	0	0	800	0	800	0.23
Foraminifera (unidentified)	4000	4000	16000	11200	12800	7200	55200	16.04
Gastrula larva of Echinodermata	640	0	480	0	800	0	1920	0.56
Gastropoda shells	0	0	800	0	0	0	800	0.23
Globigerina sp (Foraminifera)	2400	4000	4000	1600	3200	0	15200	4.42
Globigerinoides sp (Foraminifera)	0	1600	0	3200	2400	1600	8800	2.56
Harpacticoida (unidentified)	0	800	0	800	0	0	1600	0.46
Heteropoda shells (gastropods)	1600	4000	2400	0	0	800	8800	2.56
Leprotintinnus sp (Tintinnida)	3200	4800	4800	8800	8000	3200	32800	9.53
Leprotintinnus nordqvistii (Tintinnida)	0	0	0	0	0	800	800	0.23
Microsetella sp (Harpacticoida)	0	1600	0	800	0	0	2400	0.70
Nauplius larva of Copepoda	0	1600	2400	800	0	2400	7200	2.09
Nauplius larvae of Crustacea	0	0	0	0	2080	1600	3680	1.07
Nonion sp (Foraminifera)	800	1600	0	0	0	1600	4000	1.16
Ostracoda	1600	1600	5760	4000	640	2400	16000	4.65
Paracalanus sp (Calanoida)	1600	0	0	0	1600	1600	4800	1.39
Parvocalanus sp (Calanoida)	0	0	4000	3200	0	1600	8800	2.56
Polychaete larvae (Annelids)	1600	1600	2080	3200	800	1600	10880	3.16
Reussella sp	0	0	0	1600	1600	0	3200	0.93

(Foraminifera)								
Rotallida (Foraminifera)	0	0	11200	0	1600	800	13600	3.95
Sagitta sp (arrow worm)	0	800	0	0	0	800	1600	0.46
Spirillina sp (Foraminifera)	0	0	1760	1600	800	1600	5760	1.67
Spiroloculina sp (Foraminifera)	0	0	1920	2400	0	1600	5920	1.72
Sponge Spicules	4800	4800	4160	8000	6400	4000	32160	9.34
Subeucalanus sp (Calanoida)	0	0	0	0	0	480	480	0.14
Tintinnopsis orientalis (Tintinnida)	0	1600	0	0	1600	1600	4800	1.39
Tintinnopsis sp (Tintinnida)	0	1600	0	0	800	0	2400	0.70
Triloculina sp (Foraminifera)	0	1600	800	0	0	0	2400	0.70
Veliger larvae of Bivalve	0	0	1600	800	1600	0	4000	1.16
Zoea larva of Crab	0	2400	0	0	0	1600	4000	1.16
Unidentified	0	0	0	800	0	0	800	0.23
Total No. Of Genera/Groups=44								
Site-wise Total Density (no/100m^3)	26560	53120	77760	64000	69920	52800	**344160**	**100%**
Biomass (ml/100m^3)	**18.38**	**16.67**	**20.62**	**31.82**	**21.55**	**27.17**		

Table 19. Density of Zooplankton at Phang Creek site of Deendayal Port

Name of Genera/Group	3A	3B	3C	3D	3E	3 Control	Total density (no/100m3)	% of Occurrence (Site-wise)
Acartia sp (Calanoida)	0	1600	1600	0	1600	0	4800	1.15
Ammonia sp (Foraminifera)	0	4000	2400	0	5600	800	12800	3.06
Arcella sp (Amoebozoa)	0	0	4000	1600	1600	800	8000	1.91
Bolivina sp (Foraminifera)	1600	1600	1600	0	0	1600	6400	1.53
Calanoida (unidentified)	3200	1920	2400	6400	4000	4800	22720	5.43
Clausocalanus sp (Calanoida)	0	1600	1600	800	0	800	4800	1.15
Copepoda eggs sac	800	1600	0	0	2400	1600	6400	1.53
Cyclops sp (Cyclopoida)	1600	0	1440	1120	1600	0	5760	1.38
Egg capsules of Littorinids	3200	1440	0	5600	1600	2400	14240	3.41
Egg (unidentified)	0	0	0	320	0	0	320	0.08
Euterpina sp (Harpacticoida)	0	0	800	800	0	0	1600	0.38
Favella sp (Tintinnida)	0	0	0	0	640	0	640	0.15
Fish larva	0	0	0	0	800	0	800	0.19
Foraminifera (unidentified)	20800	9600	17600	12800	4000	4800	69600	16.65
Gastrula larva of Echinodermata	1600	1600	1600	0	2400	1600	8800	2.10
Globigerina sp (Foraminifera)	2400	2400	3200	0	6400	3200	17600	4.21
Globigerinoides sp (Foraminifera)	0	0	4000	0	0	4800	8800	2.10
Harpacticoida (unidentified)	0	1600	0	2400	0	0	4000	0.96
Heteropoda shells (gastropods)	0	1600	3200	0	0	0	4800	1.15
Hydrocaulus & Hydrotheca(Hydrozoa)	0	0	640	0	800	0	1440	0.34
Jelly fish (Hydrozoa: Cnidaria)	800	0	0	320	0	0	1120	0.27
Lagena sp (Foraminifera)	1600	0	0	0	0	0	1600	0.38
Leprotintinnus sp (Tintinnida)	4000	10400	8800	10400	12000	11200	56800	13.59
Leprotintinnus nordqvistii (Tintinnida)	0	0	0	0	0	640	640	0.15
Microsetella sp (Harpacticoida)	0	0	0	0	800	1600	2400	0.57
Nauplius larva of Copepoda	0	0	0	1600	1600	1600	4800	1.15
Nauplius larvae of Barnacles	0	0	0	0	1600	0	1600	0.38
Nauplius larvae of Crustacea	0	0	0	2240	8000	4000	14240	3.41
Nonion sp (Foraminifera)	0	0	0	1600	0	0	1600	0.38
Ophiopluteus Larva (Echinodermata)	0	0	0	1600	800	0	2400	0.57
Ostracoda	2400	0	9600	8800	2400	9600	32800	7.85
Paracalanus sp (Calanoida)	1600	1440	3200	800	800	0	7840	1.88
Parvocalanus sp (Calanoida)	0	0	1600	0	0	800	2400	0.57
Polychaete larvae	2400	800	0	2400	1600	1600	8800	2.10

(Annelids)								
Quinqueloculina sp (Foraminifera)	0	0	3200	640	0	0	3840	0.92
Reussella sp (Foraminifera)	0	800	0	0	0	0	800	0.19
Rotallida (Foraminifera)	0	2400	3200	0	2400	0	8000	1.91
Rosalina sp (Foraminifera)	800	0	0	0	0	0	800	0.19
Sagitta sp (arrow worm)	0	0	0	800	800	0	1600	0.38
Spirillina sp (Foraminifera)	1600	0	0	0	0	1120	2720	0.65
Spiroloculina sp (Foraminifera)	0	0	1600	0	0	0	1600	0.38
Sponge Spicules	4800	4000	8000	7200	6400	8800	39200	9.38
Tintinnopsis cylindrica (Tintinnida)	0	0	0	0	0	800	800	0.19
Tintinnopsis orientalis (Tintinnida)	0	0	1600	0	0	0	1600	0.38
Tintinnopsis sp (Tintinnida)	0	0	0	1120	0	1600	2720	0.65
Triloculina sp (Foraminifera)	0	1600	0	0	0	0	1600	0.38
Veliger larvae of Bivalve	2400	1600	1600	0	1440	1600	8640	2.07
Unidentified larva	0	0	0	800	0	0	800	0.19
Total No. Of Genera/Groups=48								
Site-wise Total Density (no/100m^3)	57600	53600	88480	72160	74080	72160	**418080**	**100%**
Biomass (ml/100m^3)	**40.98**	**20.71**	**23.53**	**39.06**	**23.36**	**33.33**		

Table 20. Diversity indices ofZooplankton at different sites of Deendayal Port

	Offshore						Cargo jetty						Phang Creek					
	1A	**1B**	**1C**	**1D**	**1E**	**1-control**	**2A**	**2B**	**2C**	**2D**	**2E**	**2-contrl**	**3A**	**3B**	**3C**	**3D**	**3E**	**3-control**
Variables																		
Taxa_S	18	25	16	24	18	21	15	25	24	24	23	28	18	20	24	23	26	24
Individuals (nos. /m^2)	26560	42880	32640	48000	33760	37280	26560	53120	77760	64000	69920	52800	57600	53600	88480	72160	74080	72160
Dominance_D	0.07	0.06	0.09	0.06	0.07	0.07	0.10	0.06	0.09	0.09	0.09	0.05	0.16	0.10	0.08	0.10	0.07	0.08
Shannon Diversity Index(H)	2.80	3.03	2.55	2.96	2.75	2.82	2.49	3.04	2.75	2.78	2.74	3.17	2.39	2.67	2.81	2.63	2.90	2.80
Simpson_1-D	0.93	0.94	0.91	0.94	0.93	0.93	0.90	0.94	0.91	0.91	0.91	0.95	0.84	0.90	0.92	0.90	0.93	0.92
Evenness	0.92	0.83	0.80	0.80	0.87	0.80	0.81	0.83	0.65	0.67	0.67	0.85	0.60	0.73	0.69	0.60	0.70	0.68
Menhinick	0.11	0.12	0.09	0.11	0.10	0.11	0.09	0.11	0.09	0.09	0.09	0.12	0.08	0.09	0.08	0.09	0.10	0.09
Margalef	1.67	2.25	1.44	2.13	1.63	1.90	1.37	2.21	2.04	2.08	1.97	2.48	1.55	1.75	2.02	1.97	2.23	2.06

6.0. References

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ANNEXURE E
Oil Spill Contingency Plan

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY

OIL SPILL RESPONSE CONTINGENCY PLAN

DPA KANDLA AND OOT VADINAR

INDEX

Contingency Planning Compliance Checklist

NAME OF PORT / OIL HANDLING AGENCY		DPA KANDLA AND OOT VADINAR / SADHAV SHIPPING LIMITED

DESCRIPTION		COMPLIED YES / NO	REMARKS
1	Whether the facility procedures / handles / uses / imports / stores any type of petroleum product	YES	Page-28, Para- 2.1.2.
2	Whether risk assessment is done	YES	Page-25, Para-2.1
3	Who did the risk assessment	Environ Software Pvt. Ltd.	Page-94, Para- 8, Annexure-26
4	whether maximum volume of oil spill that can occur in the worst-case scenario is considered	YES	Page-32, Para- 2.2 Annexure-11
5	Whether relative measure of the probability and consequences of various oil spills including worst case scenario are considered	YES	Page -33, Para-2.4
6	Whether all types of spills possible in the facility are considered including Grounding, Collision, Fire, Explosion, Rupture of hoses.	YES	Page -31, Para-2.1.3
7	Please specify the list of oils considered for risk assessment	YES	Heavy oils & Crude oil, Furnace oil. Page-32, Para-2.2
8	Whether the vulnerable areas are estimated by considering maximum loss scenario and weather condition.	YES	Page -33, Para-2.2.1, Annexure -15
9	Whether impacts on the vulnerable areas are made after considering the Marine protected areas, population, fishermen, saltpans, mangroves, corals, and other resources within the area	YES	Shoreline Maps Attached Page – 36, Para-2.5.3
10	Whether measures for reduction of identified high risks are included by reducing the consequences through spill mitigation measures.	YES	Page – 33, Para- 2.3.

11	Whether steps have been considered to reduce risks to the exposed population by increasing safe distances by acquiring property around the facility, if possible	YES	No Population along the coast at least about 10 Km
12	Whether risk levels are established for each month after consideration the probability with tide and current and consequences of each such spill	YES	Page 115, Annexure 15
13	Whether prevention and mitigation measures are included in the plan	YES	Page 33, Para 2.3, Annexure-7
14	Whether the spill may affect the shoreline.	YES	Annexure -15 Page -115
15	Whether time taken the oil spill to reach ashore in each quantity of spill in various months are mentioned in the plan	YES	Annexure-15, Page - 115
16	Whether sensitivity mapping has been carried out	YES	Page 147, Annexure-26
17	Does the sensitivity mapping clearly identify the vulnerable areas along with MPAs, corals, fishermen community, saltpans, mangroves and other socio-economic elements in the area	YES	Page 147, Annexure-26
18	Do the sensitivity maps indicate area to be protected on priority	YES	Page 39, Para – 2.7
19	Does the map indicate boom deployment locations	YES	Page 39, Para – 2.7
20	Whether any Marine Protected Area will be affected	YES	Annexure– 15, Para 2.5.3, Page - 36
21	Whether total number of fishermen likely to be affected is mentioned in the plan	YES	Page 30, Para 2.6.2
22	Whether any saltpan in the area is going to be affected	YES	Page 30, Para 2.6.2
23	Whether any mangroves in the area will be affected by a spill	YES	Page 30, Para 2.6.2

Preparedness:

24	Whether any containment equipment is Available	YES	Annexure– 7. Page-105.
25	Whether any recovery equipment is Available	YES	Annexure– 7 Page-105
26	Whether the facility is having any temporary storage capacity	YES	Page - 105, Para 7 Annexure– 7
27	Whether location of the oil spill response equipment is mentioned in the plan	YES	Annexure– 7 Page-105
28	Whether suitable vessels Available for deploying the boom, skimmer etc.	YES	Annexure-7 Page-106.
29	Whether OSD held with facility	YES	3000 Liters Annexure -7 Page-105
30	Whether the OSD held with the facility is approved for use in Indian Water	YES	YES
31	Whether the facility has MOU with other operators for Tier-1 preparedness	YES	MOU With IOCL & NAYARA Energy. Annexure – 25, Page No. 140
32	Whether the list of oil spill response equipment Available with each agency in MOU is deliberated	YES	Annexure– 25. Page-144
33	Whether the facility has MOU with private OSRO	NO	NO
34	Whether the procedure for evoking the mutual aid is clearly described in the plan	YES	Page – 141 of MoU, Para-1
35	Whether additional manpower is Available	YES	Page –144
36	Whether list of approved recyclers is mentioned in the plan	YES	Annexure-22, Page-136
37	Whether NEBA (Net Environmental Benefit Analysis) has been undertaken	YES	Annexure-15, Detailed Report of NEBA carried out by National Institute of Oceanography is enclosed
38	Whether the areas from priority protection have identified in the plan	YES	Page – 36 Para – 2.5.3
39	Whether relevant authorities and stakeholders were consulted for NEBA and during the areas for priority protection	YES	YES
40	Whether District administration has been appraised of the risk impact of oil spills?	YES	YES

	Action Plan		
41	Whether the plan outlines procedure for reporting of oil spills to Coast Guard	YES	Page – 57, Para. – 7.1
42	Whether the oil spill response action is clearly mentioned	YES	Page – 71, Para. – 8.1.
43	Whether the action plan includes all duties to be attended in connection with an oil spill	YES	Page – 71, Para. –9.1.
44	Whether the action plan includes key personnel by their names and designation viz. C/C, S/C	YES	Page-76, Para-9.1
45	Whether alternate coverage is planned to take care of the absence of a particular person (in case where action plan is developed basis names)	YES	Page-76, Para-9.1
46	Whether the plan includes assignment of all key coordination's viz, the communication Controller, Safety Coordinator, Emergency management team, Administration and Communication Coordinator and Safety Coordinator	YES	Page-76, Para-9.1 Page-48, Para-5.1
47	Whether contact directory containing numbers of key response and management personnel is intimated in the plan	YES	Annexure-1, Page – 96 Annexure-3, Page- 98 Annexure-18, Page-121
48	whether approved recyclers are identified for processing recovered oil and oily debris	YES	Annexure -23, Page - 136
49	Whether the shoreline likely to be affected is identified	YES	Page – 115, Annexure -15
50	Whether final report on the incident is submitted to CGHQ as per NOS-DCP 2014	NA	NA
51	Whether the spill incident and its consequences are informed to fishermen and other NGOs for environment protection through media.	NA	NA

Training and Exercises:

52	Whether mock Drill / emergency response drills are specified in the plan	YES	Page-53, Para 5.6.2
53	Whether the mock drills cover all types of probable oil spills	YES	YES
54	Whether the plan mentions list of trained manpower	YES	Page-136-137, Annexure-23-24
55	Whether the plan to updated according to the findings in mock drills and exercises	YES	YES
56	Whether the records for periodic mock drills are maintained in a well-defined format	YES	Also, entry is made in monthly log book.
57	What is the frequency of updating / revise of contingency plan?	YES	As and when required
58	Periodicity of joint exercise with mutual aid partners	YES	Once In 3 Months
59	Frequency of mock drills for practice	YES	Once In 6 Months

I hereby, declare that all the information appended above is true and correct to my knowledge or belief.

Date: Dy. Conservator, DPA

Verified:

Date (District Commander ICG)
Or his representative

Date (Regional Commander ICG)
Or his representative

Certificate of Endorsement

I hereby certify that:

1. The oil spill contingency plan for the facility under my charge has been prepared with due regard to the relevant international best practices, international conventions, and domestic legislation.

2. The nature and size of the possible threat including the worst-case scenario, and the resources consequently at risk have been realistically assessed bearing in mind the probable movement of any oil spill and clearly stated.

3. The priorities for protection have been agreed, considering the viability of the various protections and clean up options and clearly spelt out.

4. The strategy for protecting and cleaning the various areas have been agreed and clearly explained.

5. The necessary organization has been outlined, the responsibilities of all those involved have been clearly stated and all those who have a task to perform are aware of what is expected of them.

6. The levels of equipment, materials and manpower are sufficient to deal with the anticipated size of spill. If not, back-up resources been identified and, where necessary, mechanisms for obtaining their release and entry to the country have been established.

7. Temporary storage sites and final disposal routes for collected oil and debris have been identified.

8. The alerting and initial evaluation procedures are fully explained are fully explained as well as arrangement for continual review of the progress and effectiveness of the clean-up operation.

9. The arrangements for ensuring effective communication between shore, sea and air have been described.

10. All aspects of plan have been tested and nothing significant found lacking.

11. The plan is compatible with plans for adjacent areas and other activities.

12. The above is true to the best of my knowledge and belief.

13. I undertake to keep the plan updated at all times and keep the Indian Coast Guard informed of any changes through submissions of a fresh certificate of endorsement.

Seal	Signature :
	Name :
	Designation: Dy. Conservator
	Organization: Deendayal Port Authority
Place: Gandhidham	Date :

DISCLAIMER

The task of preparation of OSCP has been done by Sadhav Shipping Limited at the request of DPA.

Conclusion and recommendations resulting from the consulting services has been informed in good faith and on the basis of the best information Available from sources believed to be reliable.

Sadhav Shipping Limited provides no Warranty, express or implied, as for the accuracy, completeness or correctness of the analysis and report preparation work.

Sadhav Shipping Limited accepts no liability arising out of or in connection with the results, recommendations, or omissions. It is concluded that any usage / implementation / interpretation of the recommendation is at the client's risk. In particular, the recommendations should not be considered as certified, legal, or otherwise.

IMPORTANT NOTE

The oil spill contingency plan outlines the steps required for the management of responses to marine oil spills that are the responsibility of the Deendayal Port Authority (DPA), KANDLA and OOT VADINAR

This document should be read / referred to in conjunction with the National Oil Spill Disaster Contingency Plan (NOS-DCP).

This document is prepared in three Parts:

Parts- I Including Strategy.

Parts- II Including Action and Operations.

Parts- III Includes Data Directory.

ABBREVIATIONS

COT	Crude Oil Tank farm
CRZ	Coastal Regulatory Zone
DPC	Duty Port Captain
DPA	Deendayal Port AUTHORITY
DWT	Dead Weight Tonnage
NBTSL	NAYARA Bulk Terminal SALAYA Limited
ECT	Emergency Control Team
ERDMP	Emergency Response Disaster Management plan
ESD	Emergency Shutdown
FCA	Forest Conversation Act
HS&F	Health, Safety & Fire
HSEF	Health, Safety, Environment & Fire
ICG	Indian Coast Guard
IOCL	Indian Oil Corporation Limited
ITOPF	International Tanker Owners Pollution Federation
ICMAM	Integrated Coastal and Marine Area Management
IPIECA	International Petroleum Industry Environmental Conservation Association
KPT	Kandla Port AUTHORITY
LFP	Land Fall Point
MTCB	Marine Terminal Control Building
NOSDCP	National Oil spill Disaster Contingency plan
OSC	On Scene Commander
OOT	Offshore Oil Terminal
OSR	Oil Spill Response
OHC	Occupational Health Centre
P & I	Protection and Indemnity
PIT	Product Intermediate Tank Farm
PMC	Pollution Management Cell
PO	Port Officer
SPM	Single Point Mooring
SIC	Shift In-charge
VLCC	Very Large Crude Carrier
VOTL	Vadinar Oil Terminal Limited
WLPA	Wild Life Protection Act

DEENDAYAL PORT AUTHORITYOSCP ACTION FLOWCHART

On Observation of Oil/HNS Spill

OBSERVER ON VESSEL

- Inform Vessel Master.
- Take necessary steps to safely stop the release of Oil/HNS

OBSERVER ON WHARF

- Inform nearest Supervisor or Person In Charge.
- Take necessary steps to safely stop the release of Oil/HNS

VESSEL MASTER

- Verify report and obtain details
- Report to:
  - DC / COM
  - VTS, DPA
  - Monitor slick and keep the above informed.

SUPERVISOR/PERSON IN CHARGE

- Verify report and obtain details.
- Report to DC / COM
- Stop/Contain/Monitor slick/spill and keep the DC / COM informed.

DC / COM

- Obtain all information Available
- Authorize for urgent responses required to:
  - Ensure safety of Personnel and protection of Port.
  - Contain the Spill
  - Protect sensitive resources at imminent risk
- Inform other vessels in the area of oil spill and advise of any hazards
- Communicate incident to Berth operator
- If a hazardous substance is involved contact specialized agencies/ contractor/Berth operator for assistance
- Prepare a POLREP and send to:
  - Duty Officer Coast Guard
- Consult On-Scene Commander (OSC) for appropriate action.
- Initiate response
- Monitor the development and keep in constant touch with relevant authorities.
- Maintain a log of events.

DC / COM

- On receipt of initial information ensure that Indian Coast Guard, Maritime Rescue Coordination Centre (MRCC)/District Headquarters has been duly informed.
- On receipt of POLREP, the DC / COM will initiate communication/coordination with the advice and provide support to the designated Chief Incident Controller DC / COM on the issues including the following points.
  - Priority of the response Tier,
  - Location of EOC,
  - Additional human resources etc.

IMT Members

- Initiate resource mobilization on receipt of instruction.
- Deployment of members to EOC or muster point.
- Response actions as per instructions.
- Maintain a Log of Events.

PART – I

STRATEGY

1. INTRODUCTION

A. CONTINGENCY PLANNING:

In spite of best intentions to avoid oil spills through best and safe practices and rigid enforcement of good intentions in work place, the spills still occur and will keep on occurring. The next best post spill activity, then, is to address them in terms of containment and recovery within shortest possible time and through best Available means that need to be planned and kept ready in advance and spelled through a Contingency Plan for the facility or area handling oil, oil products or other pollutants.

Increase in density of marine traffic, especially oil tankers and petroleum-based installations along the Indian coast has increased the risks for occurrence of spills in harbor, coastal waters and during terminal operations apart from spills that could occur from collision, grounding of vessels and stranding. To address the fallout of incidents and accidents that could lead to pollution of marine environment, all countries handling polluting agents are required to have capabilities and create infrastructure and set up means that could handle the pollution response activity in case of any spill. The working parameters and strategy to address the response activities are spelled through a Contingency Plan.

B. PURPOSE AND OBJECTIVES:

India being signatory to number of international agreements and conventions aimed at controlling marine pollution through measures and rules applicable to marine facilities or surface units, is under an obligation to honor and implement the same through municipal legislation and through adopting means, practices and rules in accordance with Article I of the Convention 73 and Protocol 78 i.e. MARPOL 73/78.

The article has placed an obligation on the parties to the convention including India "to give effect to the provisions of the present convention and those Annexes there to by which they are bound, in order to prevent the pollution of the marine environment by the discharge of harmful substances or effluents containing such substances in contravention of the convention".

Apart from the specific obligations imposed by MARPOL, being a signatory to UN Convention on the Laws of the Sea (UNCLOS), India has an obligation to protect and preserve the marine environment in addition to obligations under International Convention on Oil Pollution Preparedness, Response and Co-operation 1990 (OPRC Convention).

Accordingly, India too had to formulate rules or administrative directions giving effect to international procedures through structures to be developed by ports and facilities handling vessels and oil cargo.

While, regulatory procedures are expected to be put in place through rules- implementing the various provisions and annexure of MARPOL 73/78, the practical aspects of marine pollution to set up a mechanism on the ground are dealt by OPRC – National Oil Spill Disaster Contingency Plan being an instrument for the same.
NOS-DCP has its origin in IMO convention OPRC – 1990, ratified by India. As per the convention it is imperative upon each signatory state to have laws and mechanisms to respond to oil spills in its waters.

National Oil Spill Disaster Contingency Plan is aimed at coordination of resource agencies to combat an oil spill in Indian waters and also spells the actions required of oil handling facilities i.e. to prepare contingency plans for respective facilities and to develop Tier I response capabilities and also to report oil spills. NOSDCP mandates a number of resource agencies comprising of 03 ministries and 15 departments apart from oil industry, off shore terminals etc. to an obligation to Render resources for pollution response when called for, Report Oil Spills,

prepare contingency plans for respective spill scenario, Set up Tier I response facilities and Use of Oil Spill dispersants (OSD) in accordance with Plan.
Of the three tiers of response envisaged and planned to handle a spill situation in consonance with quantum of spill, Tier 1 is the primary and first step of responses, to be mounted by the facility where the spill takes place.

While, NOS-DCP outlines the response activities as per Tier system of addressable of spill, the facility plan is the instrument to address the spill scenario at local level. Tier 1 being the first and primary response level has to be executed and undertaken by the facility handling polluting cargo, for which purpose drafting of a CP is the primary requirement.

The National Oil Spill Disaster Contingency Plan was first drafted in India by Coast Guard during 1996 with an objective to put in place the machinery and mechanisms to combat oil spills in Maritime zones of India. The Plan has since been updated in 2002.

C. AIMS & OBJECTIVES:

The aims and objectives of the Oil Spill Response Contingency Plan (here after termed the Plan or CP) of a port or facility are to draw a methodology and strategy to indicate actions required to be taken by responders to:

- Ensure Availability of timely, measured and effective response to incident so oil spill in waters under jurisdiction of the porter facility,
- Take measures to control the spill within minimum area,
- Minimize volume of spill by securing the source in most appropriate way,
- Minimize extent of movement of released oil from the source by timely containment,
- Minimize environmental impact by timely containment and recovery response,
- Maximize effectiveness of recovery actions through selection of appropriate equipment and techniques,
- Maximize response effectiveness through trained and competent, operational and response teams,
- Guide response personnel through the process of managing a spill originating within their area of operation, Mitigate consequences of oil pollution incidents,
- Allow those involved in response to rapidly disseminate information to parties involved and to ensure optimum deployment of Available equipment.

1.1 AUTHORITIES & RESPONSIBILITIES

This OSCP has been prepared and issued in accordance with:
The provisions of Merchant Shipping Act, 1958 as amended and /Major Ports AUTHORITYs Act, 1963 as amended.

Stakeholders identified as a part of this plan are DPA, individual Terminal Operators within its jurisdictional limit and other members as per Mutual Aid Plan. The institutional mechanism has been proposed for ensuring the effective participating of identified stakeholders for oil spill preparedness and response for achieving the objectives of Facility Level Oil Spill Contingency Plan for DPA at KANDLA and Vadinar.

1.1.1 Deendayal Port Authority will

- Maintain an adequate response preparedness (Tier-1 level) in Port by (Pollution response equipment preparedness)
- Providing equipment
- Providing PPE to the personnel
- Actively participate in the local, district, state, and national level committees / forums for Oil Spill Response contingency.

- Make all responsible efforts to act as early as possible on occurrence of oil spill and becomes the "First Response Agency" in the DPA.

1.1.2 Berth Operators, Associated staff, and Ship's crew

- It is the responsibility of berth operators, associated staff, stevedores, and ship's crew to report all identified Oil / HNS spills.
- Take all steps necessary to effectively prevent spills or limit the spread of spills that have occurred.

1.1.3. Other Government Agencies and CMG

- The roles and responsibilities of other relevant Government agencies and CMG group are detailed in NOS-DCP (8.6.2.5)

1.2 a. COORDINATING COMMITTEE DPA KANDLA

Chairman
Deputy Chairman
Management Team DPA, KANDLA

1) Deputy Conservator
2) Harbour Master
3) Lead HSEF
4) Shift in charges
5) Lead Diving team
6) Support Team Outsourced Agency.

b. COORDINATING COMMITTEE DPA OOT VADINAR

Chairman
Deputy Chairman
Management Team DPA, OOT Vadinar

1) Chief Operations Manager
2) Marine engineer
3) Lead HSEF
4) Shift in charges
5) Lead Diving team
6) Support Team Outsourced Agency.

The callout system for an oil spill incident is identical to any other emergency as contained in disaster management plan of DPA. Emergency Control Team (ECT) will arrange mobilization of additional resource like Emergency Response Team (ERT) as and when, required.

HEAD VOTL

Responsibilities: a) Liaise with Mutual Aid Organizations
b) Liaise with corporate communication for press statements release.
c) Liaise with Coast Guard Monitor as appropriate
d) Confirm / amend initial classification
e) Manage the VOTL response
f) Authorize expenditure

Note: Port Captain will take the charge till the Head VOTL arrives, after that he will assist the Head VOTL.

MARINE ENGINEER

Responsibilities: a) Observe or receive report of oil spill incident
b) Initiate measures to prevent/reduce further spillage
c) Maintain communication with all other vessels
d) Act as per instruction of SIC

Lead HSEF
Responsibilities: a) Initially access the situation and initiate action
b) Verify classification
c) Provide accurate situation to Head VOTL
d) Manage the pollution prevention response & Resources

SHIFT IN-CHARGE
Responsibilities: **a)** Initially assess situation and initiate action
b) Verify classification
c) Provide accurate situation reports to Head VOTL/Port Captain
d) Collect evidence and / or statements
e) Liaise with Lead HSEF (as applicable)
f) Liaise with incident vessel regarding status of oil spill (if applicable)

LEAD DIVING
Responsibilities: **a)** Observe and Initiate action upon information
b) Provide accurate situation reports to PMC
c) Assist in Collecting evidence and / or statements
d) Liaise with incident vessel regarding status of oil spill (if applicable)

1.3 STATUTORY REQUIREMENTS:

1.3.1 MARPOL 73/78:

India being signatory to number of international agreements and conventions aimed at controlling marine pollution through measures and rules applicable to marine facilities or surface units, is under an obligation to honor and implement the same through municipal legislation and through adopting means, practices and rules in accordance with Article I of the Convention 73 and Protocol 78 i.e. MARPOL 73/78.
BROAD CLASSIFICATION OF OILS AS PER MARPOL 73/78 is placed at **Annexure- 6**

1.3.2 International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC), 1990:

Apart from the specific obligations imposed by MARPOL, being a signatory to UN Convention on the Laws of the Sea (UNCLOS), India has an obligation to protect and preserve the marine environment in addition to obligations under International Convention on Oil Pollution Preparedness, Response and Co-operation 1990(OPRC Convention).

NOS-DCP has its origin in IMO convention OPRC – 1990, ratified by India. As per the convention it is imperative upon each signatory state to have laws and mechanisms to respond to oil spills in its waters.

1.3.3 National Regulations includes:

- Indian Port Act, 1908
- Coastguard Act, 1978
- Merchant Shipping Act, 1958
- Major Port Act, 1963
- Water (Prevention & Control of Pollution) Act, 1974, amended in 1988
- Environmental Protection Act, 1986 (amended 1991)
- Coastal Regulation Zones Notification – 1991

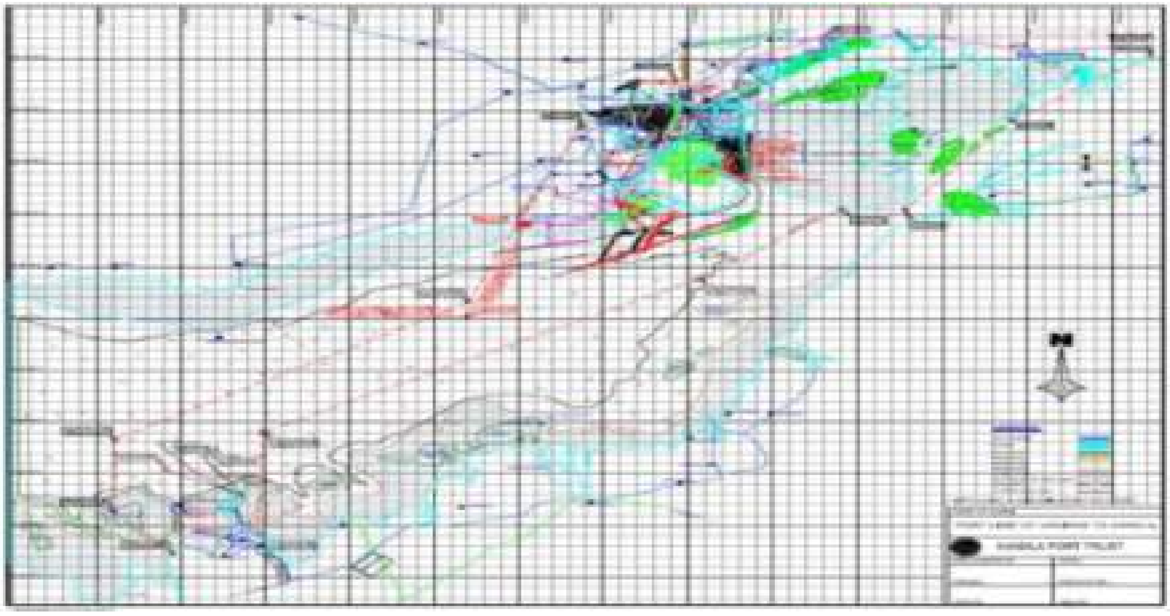
1.4 MUTUAL AID AGREEMENTS:

Refer Annexure – 25, Page -138

1.5 GEOGRAPHICAL LIMITS OF PLAN:

Deendayal Port Authority is located along the west bank of the Kandla creek situated at the north-east head of Gulf of Kutch which is at the west coast of India. Ships calling at Deendayal Port Authority therefore have to traverse across the GOK. This plan is limited to Deendayal Port Authority and up to anchorage area.

The plan contains details of contingency arrangements required for responding to the actual or threatened oil pollution incidents within the marine terminal area, as below. BETWEEN POINT A, B, C & D MENTIONED BELOW PIC



Response strategy for the DPA KANDLA plan has been developed taking into account the spill risks, and possible sources of spillage associated with Marine Terminal operations including those at the SPM and Jetty berths and other facilitates within the Port.

The geographical area of operations is bound by, but not limited to, one mile either side of the line joining following coordinates.

POINT A COORDINATES: LAT 23° 3'7.00"N, LONG 70°13'3.17"E
POINT B COORDINATES: LAT 23° 3'6.71"N, LONG 70°13'34.73"E
POINT C COORDINATES: LAT 22°57'59.87"N, LONG 70°13'38.65"E
POINT D COORDINATES: LAT 22°58'49.71"N, LONG 70°14'21.28"E

OIL JETTY –I LAT, 23°01.6’ N LONG 70°13.3'E
OIL JETTY –II LAT, 23°01.7’ N LONG 70°13.3'E
OIL JETTY –III LAT, 23°01.9’ N LONG 70°13.3'E
OIL JETTY –IV LAT, 23°02.0’ N LONG 70°13.3'E
OIL JETTY –V LAT, 23°02.2’ N LONG 70°13.3'E
OIL JETTY –VI LAT, 23°02.4’ N LONG 70°13.3'E

DRY DOCK: LAT, 23°00.9’ N LONG 70°13.3'E
SNA JETTY: LAT, 23°00.6’ N LONG 70°13.3'E

CARGO JETTY STARTING FROM NORTH TO SOUTH IN STRAIGHT LINE STARTING FROM NORTHERN END OF CARGO JETTY 1 LAT, 23°00.4’ N LONG 70°13.4'E TO END OF LAST CARGO JETTY NO. 16’S SOUTHERN END LAT, 22°58.4’ N LONG 70°13.8'E DISTANCE 2.030NAUTICAL MILES.

DPA KANDLA AND OOT VADINAR Port is located along the west bank of the Kandla creek situated at the north-east head of Gulf of Kutch which is at the west coast of India. Ships calling at DPA KANDLA AND OOT VADINAR port therefore have to traverse across the GOK. This plan is limited to DPA KANDLA AND OOT VADINAR port and up to anchorage area, which is 4 nautical miles from port.

The plan contain details of contingency arrangements required for responding to the actual or threatened oil pollution incidents within the marine terminal area, as below.

Response strategy for the DPA KANDLA AND OOT VADINAR plan has been developed taking into account the spill risks, and possible sources of spillage associated with Marine Terminal operations including those at the SPM and Jetty berths and other facilitates within the Port.

Note: Deendayal Port Authority port limit extends from Kandla to Vadinar and IOCL & Nayara Energy installations are located at Vadinar under port limits.

The geographical area of operations is bound by, but not limited to, one mile either side of the line joining following coordinates.

SPM1:	22°30’14” N/69°39’35” E
LFP:	22°27’59” N/69°43’26” E
Berth B (North End):	22° 27’ 15” N 069° 40’ 10” E
Berth A (South End):	22°26’ 54” N 069° 40’ 11” E
Sea Water Intake:	22°26’ 11” N 069° 40’ 32” E
LO- LO/ RO-RO Jetty:	22°26’ 24” N 069° 40’ 29” E
SPM2 (proposed):	22°31’ 48” N 069° 40’ 18” E
Berth C (proposed):	22°27’ 21 N 069° 40’ 09” E
Berth D (proposed):	22°27’ 27 N 069° 41’ 10” E

1.6. INTERFACE WITH ROSDCP & NOSDCP

Oil company and port oil spill contingency Plans (Kandla)

The companies whose installations are located in nearby area have individually prepared their own contingency plans, which detail their response to tier one incident. Agreement dated 28.12.2019 of Mutual Aid- Scheme for Oil Spill Response and control by oil handling Member Organization Between IOCL, BPCL, HPCL, strengthens Oil Spill response capability in the area, the agreement is valid for five years.

Sl. No	Owner
1	Indian Oil Corporation Limited, KANDLA
2	Kesar enterprises Ltd.
3	J.R Enterprises
4	IFFCO Kandla unit
5	BPCL
6	Friends oil & chemical terminals Pvt Ltd.
7	Indo Nippon co Ltd.
8	HPCL
9	IMC Ltd.
10	Mother diary fruit & vegetables Pvt Ltd.
11	Parker agro hem product ltd.

Oil Company and port oil spill contingency Plans (OOT Vadinar)

The companies whose installations are located in nearby area have individually prepared their own contingency plans, which detail their response to tier one incident. Agreement dated 28.12.2019 of Mutual Aid- Scheme for Oil Spill Response and control by oil handling Member Organization Between VOTL, IOCL, BORL, RIL, EBTSL & Cairn India Ltd, strengthens Oil Spill response capability in the area, the agreement is valid for five years.

Sl. No	Owner
1	Indian Oil Corporation Limited, Vadinar
2	Reliance Industries Ltd, Sikka
3	Bharat Oman Refinery Ltd, Sikka
4	Cairn India Limited, Bhogat
5	Vadinar Oil Terminal Limited, NAYARA ENERGY

District Plans
In the event of actual or threatened spread of oil extent of which is or is likely to be beyond the mitigating resources Available with DPA, then the **ICG Oil Pollution plan** may be implemented. In such case nominated officer of ICG will assume the function of On Scene Commander

National Oil Spill Disaster Contingency Plan (NOS – DCP)
In the event of an oil spill incident which calls for a Tier-III response, the coast guard will implement the NOS – DCP. DPA and all Mutual Aid Partners will continue to deploy their anti-pollution resources, as directed by the Coast Guards on scene commander

2. RISK ASSESSMENT

As required of a Contingency Plan, this Plan has tried to compare the hazard and vulnerability in a particular location to see the kind of risk that are posed and then to addresses those problems by determining how best to control the spill, how to prevent certain ecological elements or environments from exposure to oil, and how best to advise the local civil authority of the dangers that could be posed by the spill and how to address them and to repair the damage done by the spill.

2.1. IDENTIFICATION OF ACTIVITIES AND RISK:

In spite of best intentions to conduct cargo work under best practices, a spill could still occur at a port or terminal during cargo work because of the failure of pipelines, loading arms, flanges or equipment. The potential accidents associated with a plant, port, terminal or pipeline can be divided into two categories in terms of Generic and Specific operating failures.

Generic failures are associated with mechanical component of the facility or terminal like vessels, pipelines, pumps or compressors. The failures under this category could be caused by factors as corrosion, vibration or external impact. A small event like a leak may escalate into a bigger event by itself causing a bigger failure.

Specific operating failures is the prime cause of human errors but they can also include accidents.

Every significant mechanical component that could fail with its operating conditions, contents and inventory, is a contributor to failure identification. The study of Generic failures requires consideration of each component under their normal operating conditions.

The possible range of failures being large in number are generally considered under the following heads and incidents
For vessel/ storage tanks
Rupture (Full bore)
- Large leaks (20%mm equivalent leaks)
- Medium and small leaks (due to corrosion, impact and other such cases)

For pipelines
- Full bore ruptures
- Large, medium and small leaks

2.1.1 Failure frequencies - Pipelines

The failure frequency of pipelines is subject to a number of factors like rate of corrosion, age of pipeline, duration of use, size of damage and length etc. Different value of any of these will give different figures for failure frequency. The data as per table 1 gives the failures frequencies in relation to type or size of leak and represents the chances of occurrence of mentioned type of leak per unit length of pipeline per unit diameter.

TYPE	% of cross sectional	Frequency per year
Small leak	< 1	$2.8\text{x}10^{-7}$ L/D
Big leak	5	$1.2\text{x } 10^{-7}$ L/D
Catastrophic leak	20	$5.0\text{x}10^{-7}$ L/D
Rupture(guillotine failure)	100	$2.2\text{x}10^{-7}$ L/D

Table1. – Pipe leak frequencies as per size of leak.

With respect to causes of leak as per the failure of different systems, the frequencies are as per table 2

The following scenarios are identified for probable oil spills in marine operations of DPA KANDLA AND OOT VADINAR:

I. Spill due to floating hose failure at SPM.
II. Spill due to rupture of subsea crude oil pipeline from SPM to LFP (iii) Spill due to collision at SPM & tanker route.
III. Spill due to overflow from tanker while transfer of Oil at Jetty.
IV. Spill due to Loading arm failure at Jetty.
V. Spills due to tanker collision / grounding in the vicinity of Jetty.

Kandla Port established under Major Ports Act, 1963 is now renamed as Deendayal Port Authority one of the busiest major multi-product port of India located in the Kachchh district of Gujarat. Kandla has 16 dry cargo berths with a total of 2.57 km in a straight-line and 6 dedicated LIQUID CARGO berths for handling EDIBLE OILS, PETROLEUM, POL and chemicals.

During 2019 - 20 the port handled 115 MMT of cargo and thereby retaining number one position for volume of cargo handled among the Major Ports of India. Deendayal Port is located in inner most eastern part of Gulf of Kutch, It is connected by Road by national Highway, Port is also connected with Rail connectivity Nearest Railway Stations are Kandla and Gandhidham, Port handles various types and sizes of the ships, tankers and container ships, Maximum DWT permitted at Deendayal Port is 75000mt, Max draft permitted is 14 Mtrs, Max draft permitted is 13.5 Mtrs.

DPA's Satellite Port, Vadinar Oil Terminal is located close to Jamnagar. It is connected by road through SH-25. 12.5 km spur line connects the rail gantry of Vadinar Terminal to Jodhpur railway station. Nearest railway station is Jamnagar. Oil Jetties can handle up to a maximum size of vessel 56,000 DWT. SPM handle Very Large Crude Oil Vessels (VLCC) with a maximum pumping capacity of 10000 tons per hour. Hence, it should be inferred that the area is having high density of potential sources. Images of KPT & Vadinar Terminal are given in
Figure 2.1

DPA Kandla **DPA Kandla oil jetty**

Figure2.1. Layout of Deendayal Port & Vadinar Terminal

The port has been achieved the first position among all major ports of India, of so last decade. Presently, the port can handle dry bulk, break-bulk; liquid bulk and container cargo. Important commodities handled at the port are Coal, Petroleum Oil PRODUCTS and Lubricants (POL), Food Grains and Container Cargo, Ports, various Chemicals Oil handling facilities & Ships in and around the Deendayal Port Limit are the other potential sources of oil spill. The location map of Ports, SPMs & Captive Jetties of Gulf of Kachchh is given as

Figure 2.2. Majority of Installations are located within the DPA limit or very close to it.

Figure2.2. Location of Ports and allied Facilities in Gulf of Kachchh

2.1.2. Existing Facilities at Kandla Port

Deendayal Port has 16 berths, 7 oil jetties, 1 maintenance jetty, 1 dry-dock and a few small jetties for small vessels. Adjacent to all these terminals and jetties there are storage facilities for covering cargo received by pipelines, containers to petroleum products.

There is an existing steel **floating dry dock** within the port caters the need of port crafts as well as outside organizations and has capacity to accommodate vessels of following parameters.

- Length Overall (LOA) - maximum up to 95meters.
- Breadth - maximum up to 20meters.
- Draft - maximum up to 4.5meters.
- Lift displacement - maximum up to 2700tones.

Port's Chemical and Liquid Handling Complex has total storage capacity for 21.9 lakh kiloliters. Private sector storage terminals have capacity for 9.8 lakh kiloliters.

Port consists of 185 hectares of custom bonded port area. Port offers an excellent and vast Dry Cargo Storage Facilities inside the Custom Bonded Area for storage of Import and Export cargoes, on very competitive rates. Also, it has the largest capacity in India for storing liquid cargoes, and it is served by a modern pipeline network. The storage facility for liquefied petroleum gas has capacity for 30 thousand cubic meters. The container handling facilities include 545 m of quays equipped with four rail-mounted quay cranes and two harbor or mobile cranes. The container facilities include an almost 11- hectare container yard, a 6.5 thousand square meter container freight station, and 90 reefer points for refrigerated containers.

2.1.2. Offshore Oil Terminal (OOT), Vadinar

DPA had commissioned offshore oil terminal facilities at Vadinar in 1978, jointly with Indian Oil Corporation. It has capacity of 58 MMTP and handle crude oil and petroleum products. Vadinar one of the deepest natural draft terminals in India and it does not require any maintenance dredging. The facilities consist of three offshore Single Point Mooring (SPM), two jetties for handling liquid petroleum products, tanks for storage of crude oil and petroleum products and rail and road gantries for dispatch of petroleum products.

The features of the OOT Vadinar is as presented below:

- A draft of up to 33 m at SPMs and Lighterage Point Operations(LPO)
- Handling VLCCs of 300000 DWT and more.
- Providing crude oil for the refineries of Koyali (Gujarat), Mathura (Uttar Pradesh), Panipat (Haryana) and NAYARA Refinery, Jamnagar(Gujarat)
- Simultaneous handling of three VLCCs possible at the SPMs with vast crude tank age facility.
- Two nos. of 50 Tons state-of-art B.R SRP Pull-back tugs are Available for smooth and simultaneous shipping operations on the SPMs and product jetty.
- One oil and debris recovery tug for oil pollution control has been acquired and stationed at Vadinar.
- Excellent infrastructure facilitating transshipment operations, even during the monsoon.

2.1.3. Traffic Handled at Kandla

Deendayal Port has shown buoyant growth in cargo handling in the recent past. The port's share in traffic handled by all major ports has risen steadily over the years. The past traffic profile of the port is shown in **Figure 2.3.** During 2018-19 & 2019-20 total traffic handled are 115.40 MMT and 122.61 MILLION METRIC TONNES respectively

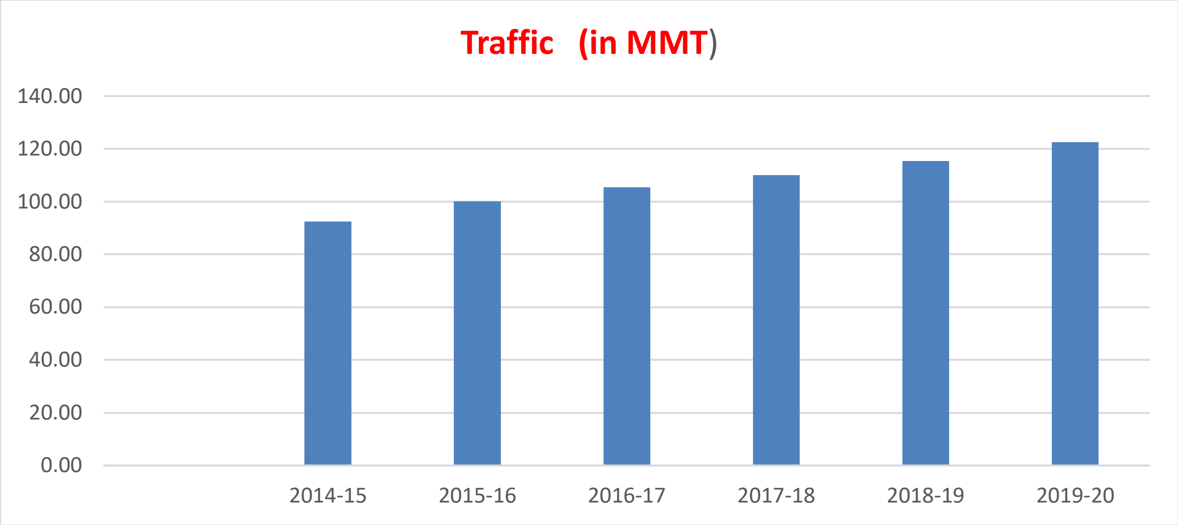
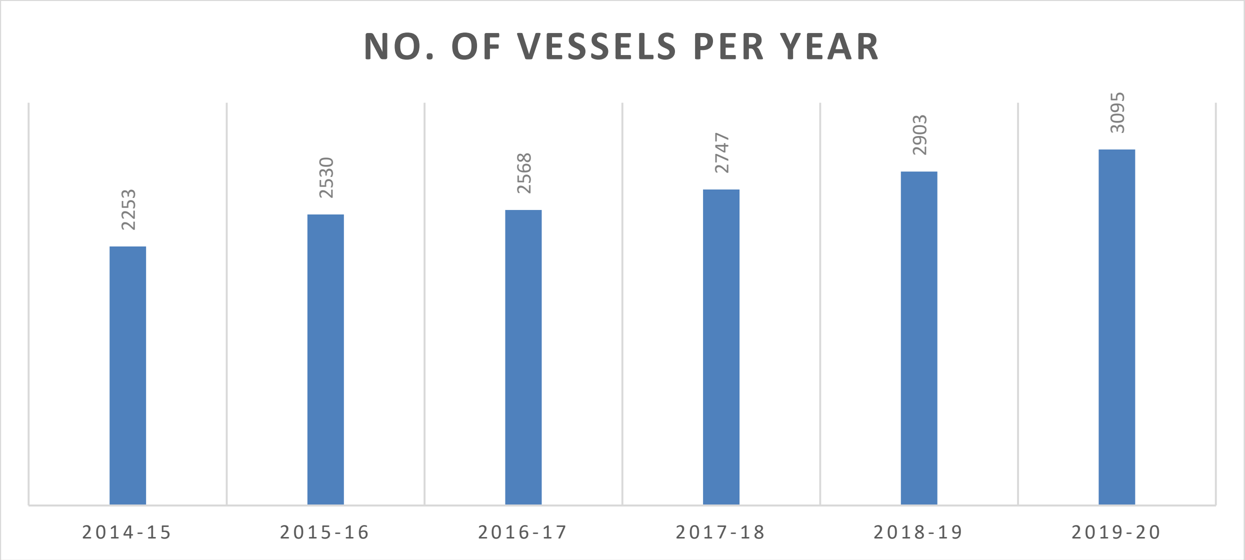


Figure2.3 Traffic Profile OF DEENDAYAL PORT AUTHORITY

Total number of ships visited KPT during the year 2014-2020 are given as shown in **Figure.2.4.** Among them almost 75 % visited KPT and remaining 25 % visited Vadinar.



Total number of ships handled at DPA commodity wise during the period of 2014-2020 is as presented in **Figure2.5**

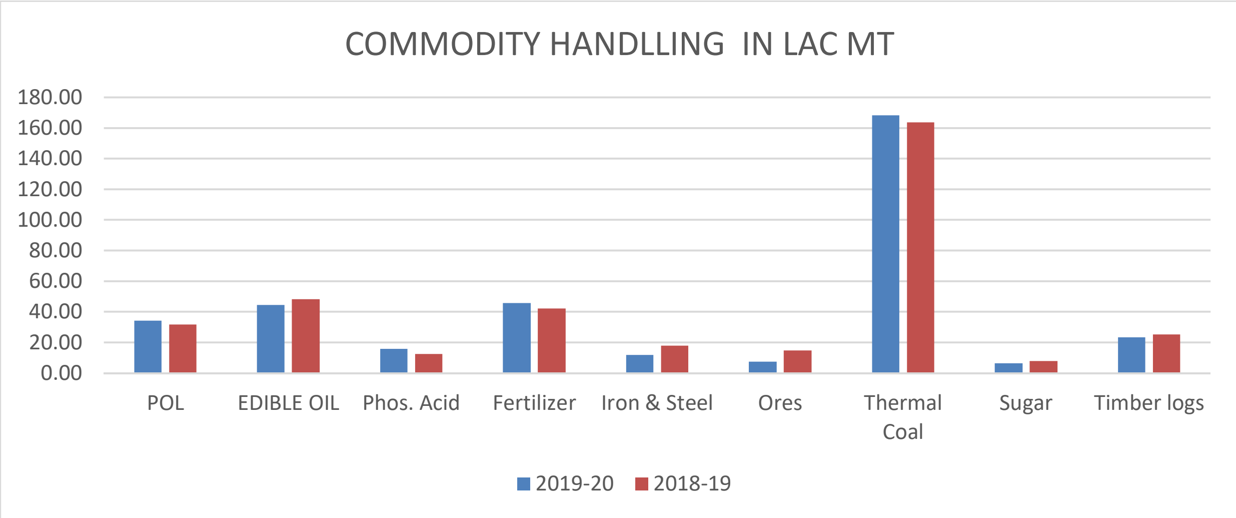


Figure2.5. COMMODITY Handled at DPA

Risk Assessment Summary for Maximum Oil Spillages:

Cause	Assessed Risk	Spill Quantity
SPM – Floating Hose Failure	Rare Phenomenon	153 T
Overflow from tanker while transfer of oil at Jetty	Rare Phenomenon	56 T
Jetty Berths –Loading Arm Failure	Extremely Low	10 Liter.
Rupture of subsea crude Rare Phenomenon oil pipeline from SPM to shore tanks	Very rare, Not Likely	1-2 Liter

2.1.4. Cargo Ops or Transfer Spill Frequencies

Transfer spill is defined as an event where the oil is released to sea due to failure or error during loading/ unloading of cargo or fuel oil. This includes loading in port and ship-to-ship transfer also. Typical causes for this spill include overflow, hose failure, errors in setting valves etc.

As per figures compiled by DNV, during 2000-10, ten transfer spills on oil tankers with known quantities were reported. The oil tanker exposure during this period was 74,471 ship years. Based on an Average of 80 port visits per ship year, a total of 5.6 million cargo transfers were undertaken. This figure gives a transfer spill frequency of 1.7x 10^{-6} per cargo transferred.

2.1.5. Spill Volume Calculations – Pipelines

The quantity of oil spilled can be calculated in terms of total rapture and also for pin hole leaks using software taking into account the diameter of hole and flow rate. The formula for total rapture calculation is:

Volume of Spill = 2 Pie X Radius of Pipeline X Length of Pipeline X Flow Volume. (Refer Annexure-11)

2.2. TYPES OF OIL LIKELY TO BE SPILLED: Characteristics of different classes of oils is placed at an Annxure-9

No	Oil Type	Specific Gravity	Genre	Characteristics	Examples
1	Light oil	< 0.84	White oils	Non-persistent, Volatile	Aviation fuel, Kerosene, Motor spirit, Naphtha, HSD.
2	Crude oil	>0.84	Black oils	Persistent, Viscous, Emulsion. Fresh oil amenable to dispersants	Arabian Light, Arabian Heavy etc.
3	Heavy oil	>0.95	Black oils	Persistent, Viscous, Emulsion, Generally not amenable to dispersants	Fuel Oils, LSWR

Table 3

Flammability (Nf) 3 – Liquids and solids that can be ignited under almost all ambient temperature conditions
2– Materials that must be moderately heated or exposed to relatively high ambient Temperatures before ignition can occur

Health (NH) **0** - Materials which on exposure under fire conditions would offer no hazard beyond that of Ordinary combustible material
1 – Materials which on exposure would cause irritation but only minor residual injury if no Treatment is given

Reactivity (Nr) **0** – materials which in themselves are normally stable, even under fire exposure conditions and which are not reactive with water

It is apparent that risks to human life caused by most of the hydrocarbons in terms of flammability, health and reactivity are not very significant and can be handled with some degree of expertise.

2.2.1. CAUSES OF OIL SPILL

The common causes of spill are:

- Cargo operations- loading, discharge
- Ship collision, or grounding
- Bunker/ fueling operations
- Ship distress / sinking

Pipeline ruptures /accidental spills from sub-sea/over the sea/shore approach (in the tidal zone) pipelines Location of spill within the scope of this Plan. Based on the location of vessel at the particular time of incident within the area of operation, the likely spill could occur at any of the following locations.

I. Sea or in channel due collision etc. during passage
II. Close shore due grounding or
III. Alongside at jetty or at the terminal during cargo operations
IV. Iv. Sea or at landfall point from interbreed pipelines.

Notwithstanding the above locations, it is possible that an eventuality occurring at sea like a collision or mechanical failure could lead to a situation where the consequences would be felt in some other location at a coastal location.

2.3. SPILLED OIL MITIGATION

DPA KANDLA AND OOT VADINAR is prepared to mitigate Oil Spills of Importance from routine operations, while oil spill situations of higher magnitude are dealt with neighboring industries viz. IOCL, NAYARA ENERGY, Indian coast Guard cooperation and external intervention. However, accidental leakages are arrested immediately with Remote operating controls/QSD valves by automated sensors. The exact quantities from each incident is difficult to predict due to the variables of operating conditions and the length of risk exposure, optimum risks associated with the events has been considered while devising the oil spill contingency plan

2.4. DEVELOPMENT OF OIL SPILL SCENARIOS INCLUDING WORST CASE DISCHARGE CONSIDERING MAXIMUM LOSS AND WEATHER CONDITION

DPA KANDLA AND OOT VADINAR is operating 02Nos.Berths (A & B) which can accommodate vessels ranging from 25,000 to 100,000 DWT for oil handling & one SPM which can accommodate vessels ranging from 87,000 to 350,000 DWT for crude oil. Marine Terminal is located within an area which has been declared as a Marine National Park/ Marine Sanctuary. The mean tidal range is approximate 6 meters and current speed in excess of 2 knots may be experienced alongside the jetty.

2.5. SHORELINE SENSITIVITYMAPPING:

The quantity of the spill reaching to the coast and affected areas for various seasons for various hydrological and meteorological conditions and predicted BY use of Hyrodyn-OILSOFT software is as follows.

2.5.1. Main Approach Channel

The least depth in the main approach channel to the tanker jetty is 14 meters; the maximum acceptable draft alongside jetty berths is 14 meters. A minimum under keel clearance of 6% of vessel's maximum sea going draft plus 0.60 meters is applied to all vessels under way.
While the risk of grounding is low, it cannot be totally eliminated. The most likely cause is steering or propulsion system failure which could result in grounding on the channel margins with consequent damage to the bottom and/or the mid body plating. The potential spill quantities depend upon the size / type of tanker and the area of impact damage. The vessels calling the product terminal, in bound and out bound will be escorted by minimum two tugs in fair weather condition. This considerably reduces the risk of the vessel running aground in the channel.

Deendayal Port located in the northern plank of the GOK, in an area with irregular and dissected configurations, with numerous creeks surrounded by marshy lands on the bank of Kandla creek. Located at the juncture of Kathiawar and Saurashtra peninsula, i.e., at a transition zone between arid and semi-arid zone having striking characteristics of the arid area.

The port limits extend from Navlakhi at the head of GOK to NARARA Bet in the southern arm. While from Tuna in the north coast to Kalumbhar Bet in the southern arm. The limit is bounded by Kachchh in the North & North-East, Morbi at East and Devbhoomi Dwarka and parts of Jamnagar district towards South & South- East respectively. Along the coast there are numerous coastal villages with people engaged in traditional occupation of fishing hosting large and small fish landing centers. Also, being the adjoining land masses of ports, many of them have been developed into port towns and subsequently developed as industrial pockets.

Sathsaida bet, flamingo flats, IFFCO Intake location, Fishermen Residence, Saltpans surrounding port are important sensitive areas of DPA. Important organisms include algae, mangroves, corals, sponges, mollusks, prawns, fishes, reptiles, birds and mammals. In order to protect the rich biodiversity of the GOK, several intertidal mudflats and coral reefs along its southern shore are declared as Marine National Park and Marine Sanctuary (MNPS). There are also are as declared as Important Bird and Biodiversity Areas (IBAs) and Important Within the port limit is one of the most productive and diversified habitats along the West coast of India. The high tidal influx covers vast low-lying areas comprising a network of creeks, marshy tidal flats and rocky regions, which provide congenial environment to a wide variety of marine biota. The northern shore is predominantly sandy or muddy confronted by numerous shoals, creeks and sustains large stretches of mangroves. There are vast mudflats towards the Mundra coast. There are narrow beaches along the coast behind the mudflats. Towards the southern limit, shoreline is comprised of numerous islands and inlets, which harbor vast areas of mangroves and coral reefs with living corals Coastal and Marine Biodiversity Areas (ICMBAs).

Thus, the peculiarities of Deendayal Port area which are to be duly considered with respect to oil spill sensitivity can be briefed as follows:

- An all-weather Major Port with several oil handling facilities including SPMs within port limits
- Dry Weather and Mild Monsoon
- High tidal ranges and strong tidal currents
- Extensive creek system acting as tidal channels
- Valuable ecological resources such as Corals, Mangroves, Mudflats and bird flocking areas around the vast creek system

Association (IPIECA), & International Association of Oil & Gas Producers (OGP). NOS-DCP-2015 put forwards the same scheme for the preparation oil spill contingency plan at various levels in the Indian context.

- ESI index is based on three parameters including Extensive socio-economic activities including Special Economic Zone (SEZ), saltpans, fishing areas and intake points of shore-based industries.

Environmental Sensitivity Index (ESI) is an international scheme used for classifying as well as ranking the shoreline based on their sensitivity towards oil spill. This methodology was prepared by National Oceanic and Atmospheric Administration (NOAA) further promulgated jointly by IMO, The International Petroleum Industry Environmental Conservation:

- Shoreline Classification, which takes sensitivity of the shore habitats, natural persistence of oil and ease of cleanup.
- Biological Resources including oil-sensitive animals, rare plants
- Human-Use Resources that have sensitivity because of their typical use, such as beaches, parks and

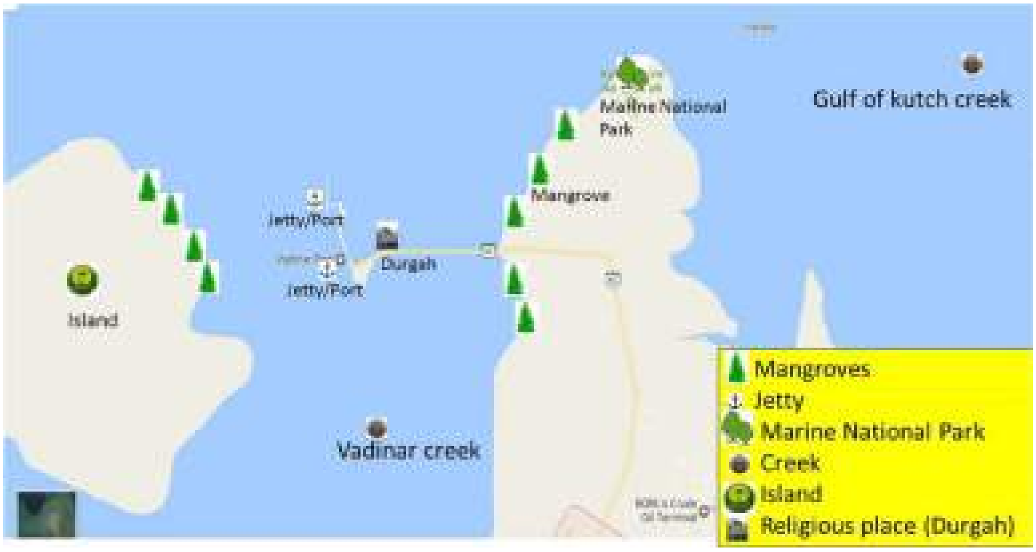
marine sanctuaries, water intakes, and archaeological sites.

While preparing the ESI maps, the sensitivity of the shore is represented by color-codes along the coast while, biological and human-use resources are represented by symbols. The coastal area has been studied and the ecological resources have been mapped for the Deendayal Port Area.

2.5.2. Approach to SPM

Tankers bound for SPM will follow the deep-water route. Berthing and unberthing of the tankers on to the SPM will be done by DPA Pilots. Charted depth at SPM location is 34.5 meters. Grounding of Tankers in the SPM area is considered as very remote.

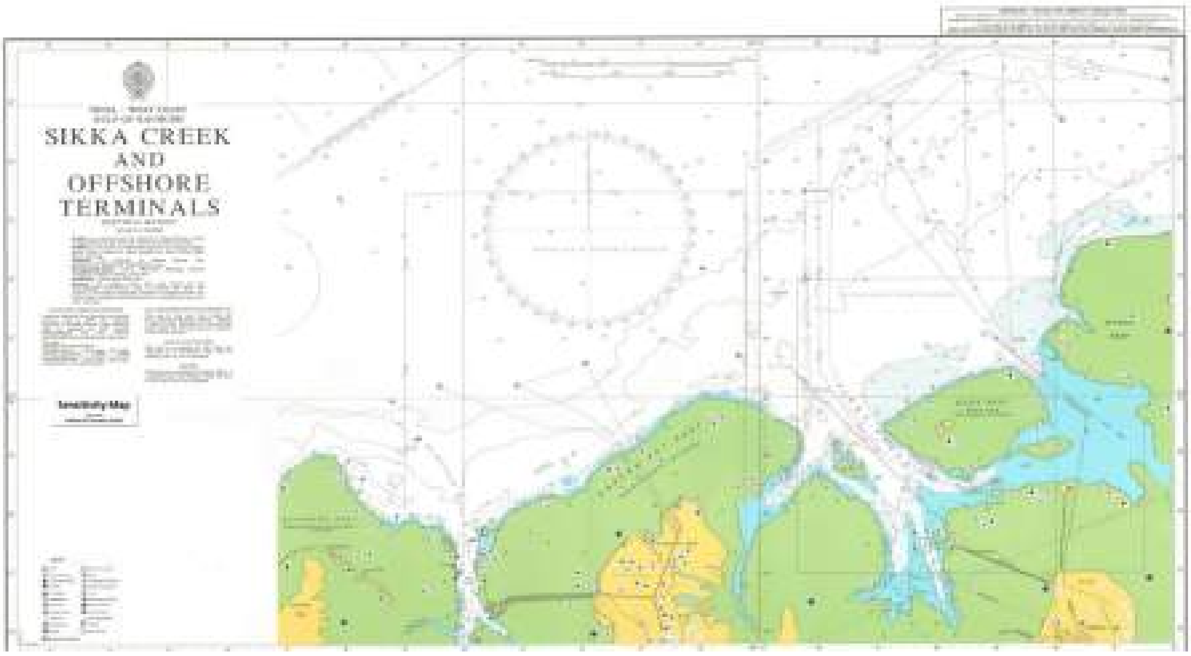
A detailed shore line sensitive mapping has been carried out. The Sensitivity chart is attached below for reference. Further CZMP map is showing sensitive shoreline is attached as Annex – 06 for our area. Map showing sensitive areas i.e. Saltpans, Mangroves, Fishing Grounds Landing ground, Boat jetty etc.



Map-1
Sensitive areas - Overview

AREA CHART OF DPA KANDLA AND OOT VADINAR PORT

Map-2



2.5.3 ENVIRONMENTAL SENSITIVITY INFORMATION (Refer Annexure15)

This section summarizes the environmental sensitivity information derived from a variety of studies. It should be consulted, in conjunction with the Spill Response Guidelines to identify priority Areas for protection and the most appropriate response technique(s).

The Marine Terminal is located within an area which has been designated a National Marine Park / Marine Sanctuary. The Authorities have listed the following as their priorities for protection, in descending order, from spilled oil;

1. Marine National Park
2. Marine Sanctuary
3. Salt works
4. Forest Areas
5. NAYARA refinery intake location
6. Mangroves area

2.6. SHORELINE RESOURCES, PRIORITIES FOR PROTECTION:

2.6.1. SHORELINE RESOURCES

The adequate shoreline clean up equipment Available to deploy and effective clean up shall be done. **Annexure-7**

Deendayal Port is located inside extensive creek system surrounded by bets including intertidal and high tidal mudflats, while its limit extends to the Port. Because of its geographical extent, the area is described as two zones- Kandla Zone for the areas in Northern side of the port limit and Vadinar Zone is located towards the southern side of port limit. The inner portion of Gulf area has more uniform and stable environmental conditions. The important shoreline features of the port limit are given as **Table 2.1.** Deendayal Port limit is free from significant wave disturbances while the Vadinar has marine meteorological conditions dominated by tides and monsoons.

Table 2.1. Important Shoreline Features of the Port Limit

Sl. No.	Nature of Coast	Coastal Stretch	Length(km)	Major Feature
1	Mix- Wave & Tide dominating Coast	Mundra - Tuna	45	Mudflat, Paleo-mudflat/ Salt Pan, Ebb Delta/ Sand Ridges
2	Tide Dominating Coast	Tuna – Kandla	15	Mudflat including Hard Mudflats bordering LRK, Paleo-mudflat/ Salt Pan, Mangrove
3	Tide Dominating Coast	Kandla – Vadinar	60	Islands of southern arm such as Kalumbhar and NARARA with Corals, Mangroves & Mudflats.

2.6.2. PRIORITIES FOR PROTECTION AND CLEAN-UP

In the event of a major oil spill, large stretches of the coastline may be threatened and, ultimately, impacted by oil. The response to such a spill can be divided into two aspects:
a) Protection
b) Clean-up
The priority shall be given as per sensitivity mapping as shown in Map-1, like Marine national park and marine sanctuary where corals and mangroves are surviving.

Prioritization of resources is an integral part of sensitivity mapping since it will be helpful in determining the response priorities, achieving optimal resource use and essentially ensure maximum resource protection. This was done by giving ranks to each resource types which has been already described under the heads of Environmental sensitivity i.e. Sensitivity to Oil Pollution, Environmental Value, Cultural & Social values and Economic values (Kandla et al, 2008). Ranks between 10 were assigned for the resource. Same rank was given to different resource when the occupied same position in different heads. Two resources may take a same value as required by the circumstance. Hence, it is not necessary that all the values must be present under one category at a time. Intake points considered here are only of industrial use. Weight ages were given to each head i.e., Sensitivity to Oil Pollution (30), Environmental Value (30), Cultural & Social values (20) and Economic values (20). Priority Index (PI) was worked out based on this. Details of Prioritization of Resources are given as **Table 2.2.** below.

Table 2.2. Prioritization of Resources

Resources	Sensitivity for Oil Pollution (1-10) Weight (30%)	Cultural & Social Values (10%)	Scientific Values (20%)	Environmental Importance (30%)	Economic Considerations (10%)	Total Relative Response of Sensitivity	Risk Value	Priority	
								Index	Order
Rocky Coast	3	1	2	2	1	2.1	1	2.1	D
Port/ Harbor/ Jetties	1	7	2	4	8	3.4	2	6.8	C
Intake Locations	10	2	1	1	2	3.9	3	11.7	B
Salt Pans	3	8	2	6	5	4.4	1	4.4	D
Sandy Beach	6	8	3	5	2	4.9	2	9.8	D
Fishing Grounds	7	8	5	6	8	6.2	2	12.4	B
Sub tidal Coral Reefs	2	9	10	9	6	6.8	1	6.8	C
Intertidal Mudflats	7	4	7	8	3	6.6	2	13.2	B
Mangroves	9	10	8	10	8	9.1	3	27.3	A
Intertidal Corals	10	9	10	9	9	9.5	3	28.5	A

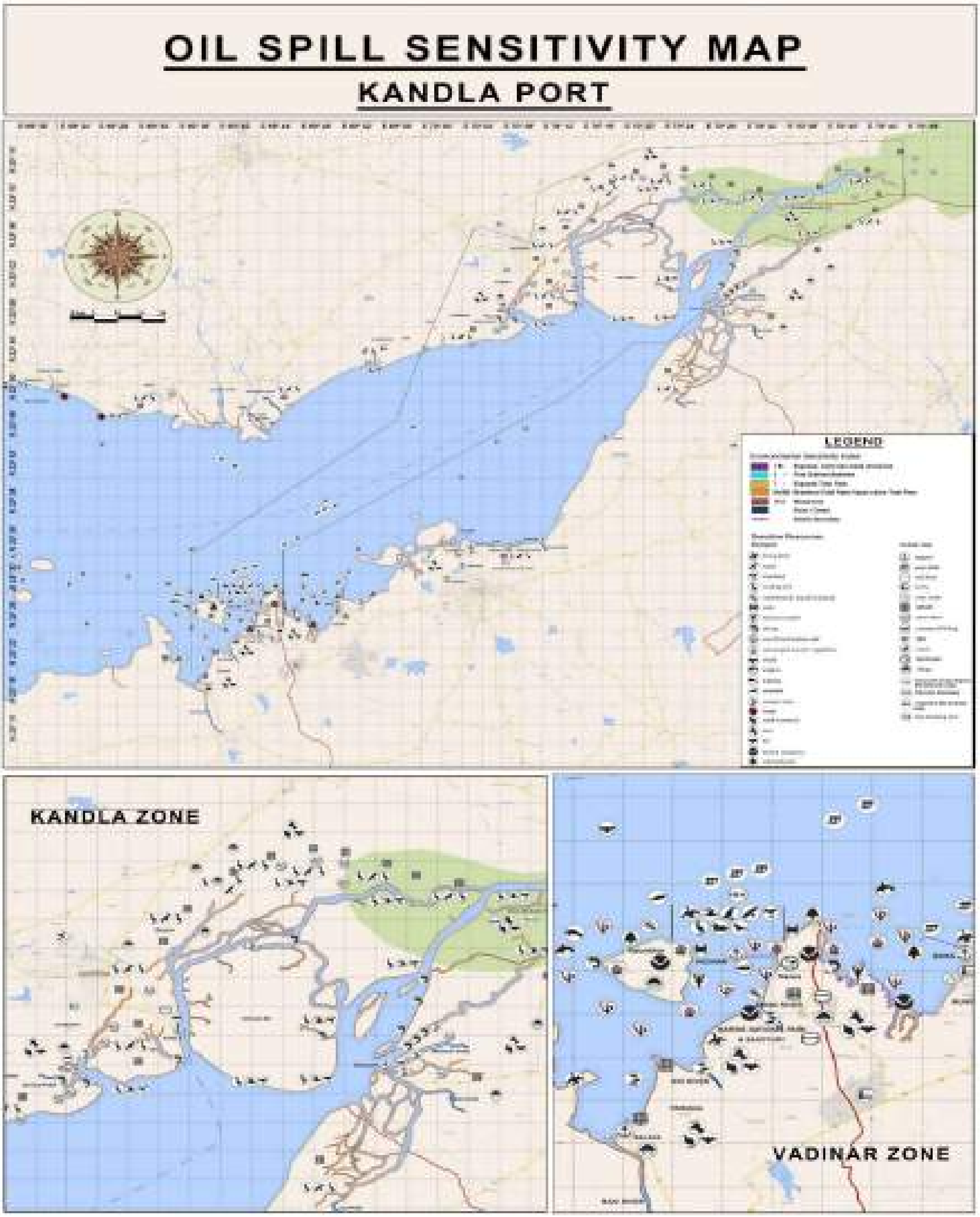
Areas requiring special consideration include presence of protected areas such as SATHSAIDA BET, MANGROVES, birding areas and other animal frequenting areas, estuaries, mangroves & fish breeding areas, tourist areas including recreational & heritage areas, industrial water intake points, resource extraction areas such as salt pans and aquaculture ponds and multi-featured areas - especially in the coral islands with variable features within a short distance from the shoreline along the southern arm.

2.7. SPECIAL LOCAL CONSIDERATION

Marine National Park/Marine Sanctuary in Gulf of Kutch is located in close vicinity of DPA KANDLA AND OOT VADINAR. Special consideration be made for handling of crude & product oil in the area.
The area identified in this region is mangroves habitat, corals reef and mudflats which needs a special consideration.

The Authorities have listed the following as their priorities for protection, in descending order,

a) Marine National Park
b) Marine Sanctuary
c) Salt pans
d) Forest Areas
e) NAYARA refinery intake location



AREA CHART OF DPA DEENDAYAL PORT

2.8. FATE AND EFFECTS

Oil spilled on water undergoes a progressive series of changes in physical and chemical properties which are referred to as weathering. The weathering of oil starts immediately after it has been spilled and proceeds at a rate which varies according to the type of oil involved and ambient climatic conditions. Weathering rates are not constant throughout the duration of an oil spill, and are usually highest in the first few hours. The process of weathering occurs simultaneously with the spreading and movement of an oil slick. Major processes which contribute to the weathering of oil spilled on water include evaporation, dissolution, oxidation, emulsification, and microbial degradation. In effect, weathering is the loss of certain components of the oil through a series of natural processes which begin when the spill occurs and continue indefinitely while oil remains in the environment. The lighter and more volatile components of the spilled oil are lost most rapidly. Consequently, the rate of weathering is highly dependent on the type of oil spilled light crude and fuel oils typically weather at a much faster rate than heavy crude or heavy fuel oils which contain a smaller proportion of light fractions.
Indefinitely while oil remains in the environment. The lighter and more volatile components of the spilled oil are lost most rapidly. Consequently, the rate of weathering is highly dependent on the type of oil spilled; light crude and fuel oils typically weather at a much faster rate than heavy crude or heavy fuel oils which contain a smaller proportion of light fractions.

Movement of Oil on Water

In large oil slicks, the waves will be partly suppressed and wave transport will be reduced. The movement of an oil slick on the surface of water is determined mainly by the current and wind velocity in the area.
Current velocities depend on wind velocities, geographical latitude, eddy viscosity, position in the water column, water depth, and proximity to coasts. Surface currents are directed to the right decreasing and turning more to the right with depth.
Winds can be broadly divided into prevailing winds, which vary over time periods of weeks to seasons, and short-term winds which vary over time periods of hours to weeks. High winds are also generated infrequently by summer tropical storms and cyclones.
When wind and currents are in different directions, they can interact in a complex manner to break up an oil slick into windrows. Windrows are long, narrow columns of relatively thick oil separated by wide bands of relatively oil-free water. In most mathematical models of oil slick drift, the oil is assumed to drift with the same velocity as the surface current. A floating oil slick is dragged along the water surface by wind friction whereas oil dispersed into the water column is not. When wind and current are not in the same direction, each tends to drive the slick in a different direction at a different speed.
The spilled crude oil and products such as FO (Fuel Oil), HSD (High Speed Diesel) and MS
(Motor Sprit) undergo a number of physical and chemical changes (weathering).

2.9 Weathering Processes:

WEATHERING PROCESSES AND TIME SCALES

Refer Annexure-10

3. RESPONSE STRATEGY:

3.1 PHILOSOPHY AND OBJECTIVES:

Within the scope of this Plan, a response action required to be mounted could be at any of these locations

I. Sea or channel, incident due collision etc. during passage,
II. Close shore due grounding or stranding,
III. Alongside at jetty or at the terminal during cargo operations.

It is feasible that a casualty occurring at sea like a collision or mechanical failure could lead to a situation where the consequences would be felt in some other location or at a coastal location due movement of pollutants from the site of incident.

The factors that would dictate immediate and long-term strategies to deal with the spill are

I. Location of discharge,
II. Spill movement and likely fate of spilled oil,
III. Time window Available for response before hitting the coastline,
IV. Nature of shoreline and priority for protection.

Keeping in account the location of spill, the response will be required to be initiated either at the jetty / terminal or at sea and guided by this OPERATIONS MANUAL. The actions required to be initiated would be immediate and long term, depending on a study and analysis of spill movement.

3.2 LIMITING AND ADVERSE CONDITION:
Weather and Time play very important role in conducting the Oil Spill Response activities. However other factors also play important role in OSR operation:

i. **Weather:** Weather, sea conditions and time factor play an important role in oil spill response operations. While, operations could continue at terminal or at the jetty most of the time, operations at sea would be largely restricted during night hours and sea conditions. The area of operations of this CP is subject to rough and severe weather conditions during SW monsoon i.e. June to September. An appreciable weather change in the area is subject to heavy rains, high winds and waves. The sea conditions being rough, it is not possible to mount sustained operations or deploy equipment at the Harbor mouth or in the channel. However, it is possible to continue operations at DPA and KPT, though at a restricted scale. Best use of good weather windows would be required to be made to mount operations.

ii. **Terrain**: A large portion of the area being mudflats is not accessible from sea and is constrained by Availability of depths for vessels to approach.

iii. **Site approach:** Certain areas especially mudflats and mangrove vegetation stretching long distances are not approachable by road or tracks from the shore.

iv. **Other limitations**: that might need consideration while planning response activity could include the Following:

- Safety factors including vessel limits, night movements, risk of fire and explosion, toxicity (oil contact/inhalation/ingestion) and hazardous environments such as fast flowing rivers and steep terrain.

- Environmental conditions that can influence logistics including inclement weather, hazardous terrain and accessibility including condition of roads.

3.3 OIL SPILL RESPONSE IN OFFSHORE ZONES:
Containment and recovery will be the strategy for offshore zones. Immediately on noticing the oil slick/oil spill, all endeavors will be to contain the spill by deploying suitable Oil Spill Response equipment and then efforts will be made to recover the oil as soon as possible.
Allowing the oil slick to hit the shores and then initiate shore cleanup measures will be the last resort, as it leads to excessive manpower requirements and also time-consuming effort.
The strategies for responding to Offshore Oil Spills are as follows:
a) Monitor and Evaluate
b) Containment & Recovery
c) Dispersant Spraying

3.4 OIL SPILL RESPONSE IN COASTALZONES:
The strategies for responding to Offshore Oil Spills are as follows:
a) Monitor and Evaluate
b) Containment & Recovery
c) Dispersant Spraying

Containment of Oil
Booms are the primary method used to contain, deflect, or exclude oil floating on the water. Booms are typically classified according to form or location of use and have the following characteristics:
1. A flotation unit or freeboard designed to contain or divert the oil as well as to resist oil splashing over the top;
2. A skirt or curtain to prevent oil from being carried beneath the boom;
3. A longitudinal strength member (usually, cable, chain, or high tensile strength fabric) that serves to join boom sections and provide anchoring points; and
4. A ballast unit or weight designed to hold the skirt perpendicular to the current flow. Containment booming encircles and contains the floating oil so that it can be collected and recovered. A simple spill in calm weather and with minimal current movement can be contained by stretching a boom across a waterway perpendicular to the path of the spill.

Deflection booming attempts to intercept, deflect, or shunt a slick towards a more desirable recovery site. Deflection booming is used when swift currents render containment booming ineffective.
Exclusion booming is largely a protective measure. Instead of being deployed to contain or intercept the oil slick, exclusionary boom is used to protect sensitive areas such as marshlands, water intakes, and shorelines by keeping oil out of an area. Exclusionary booming may have to be coupled with deflection booming to provide the best overall defense.

Mechanical Recovery of Oil
In offshore areas, mechanical clean-up with skimmers is usually begun immediately after containment measures have been implemented. Oil skimmers are used to recover oil from the surface of the water. Skimmers come in a variety of designs and sizes. Small skimming units can be used successfully on spills ranging from minor spills to major offshore disasters. Large skimming vessels are generally used on larger, open-water spills. They are usually self-propelled and are much more expensive to purchase and maintain than small skimming units.
In shoreline areas, clean-up efforts are not subject to the same time constraints imposed upon protection efforts. As a result, planning may be conducted with greater attention to detail, damage assessment, selection of techniques, and cost effectiveness. Shoreline cleanup, however, should be implemented as rapidly as possible to reduce the effects of oil migrating to adjacent clean shorelines.

In Situ Burning

In situ burning involves the containment of oil with fire-proof boom so it can be ignited. In order for in situ burning to be effective in most situations, the burn must take place within a few hours after the spill, or the oil will have dispersed too much to be burned successfully.

Use of Dispersants

Dispersants are chemicals that reduce the interfacial tension between oil and water. This enables waves to break an oil slick into tiny droplets and suspend them in the water column. As a result, the oil will present less of a threat to shorelines and coastal resources. Once the oil is dispersed into the water, chemical and biological processes convert it to carbon dioxide, oxygen, salts and other materials. High sea states which prevent oil spill containment and clean-up with booms and skimmers will mix the oil and dispersant together, providing excellent conditions for dispersant effectiveness. Chemical dispersants are effective in areas where environmental or logistical considerations will not allow the deployment of clean-up equipment and personnel. Dispersants are most effective if used within 24 hours after the spill occurs, and will:

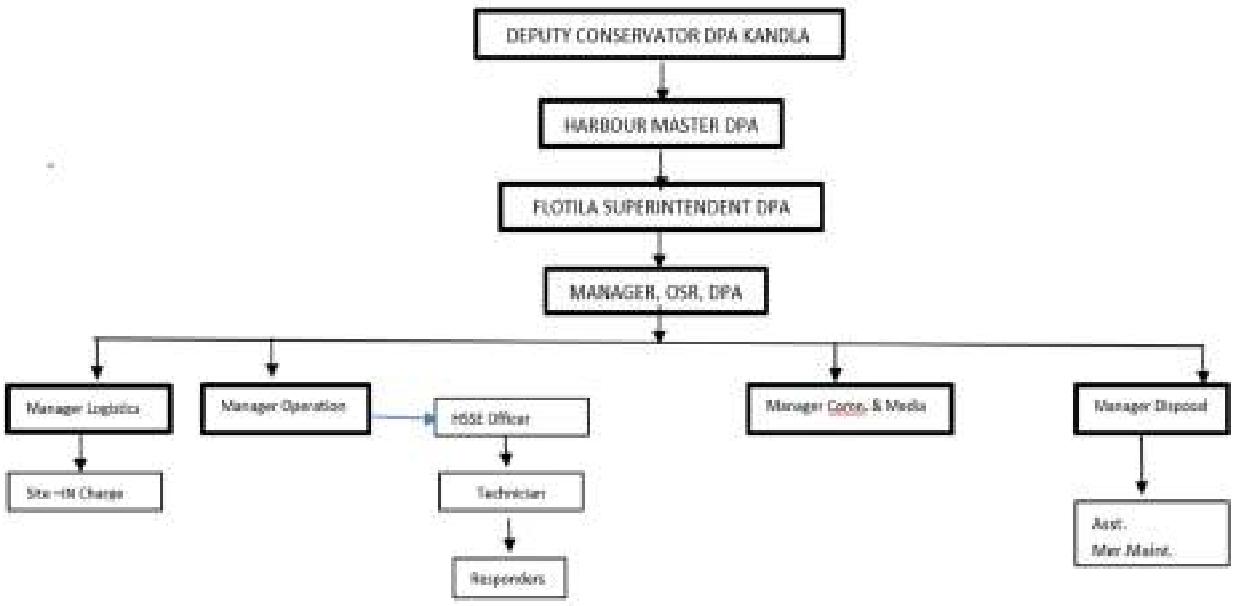
1. Remove oil slicks from the water surface;
2. Break the slick into tiny droplets which expedites biodegradation and decomposition of the oil spill;
3. Reduce the overall level of effort and manpower requirements necessary for responding to major spills; and
4. Prevent or reduce adverse effects on birds and mammals.

However, dispersants are not effective for oil spills in waters with low temperatures, low salinity, broken ice, or high energy. They accelerate the transfer of oil into the water column and thereby temporarily create high localized concentrations of dispersant/oil mixtures which could be toxic to some marine life.

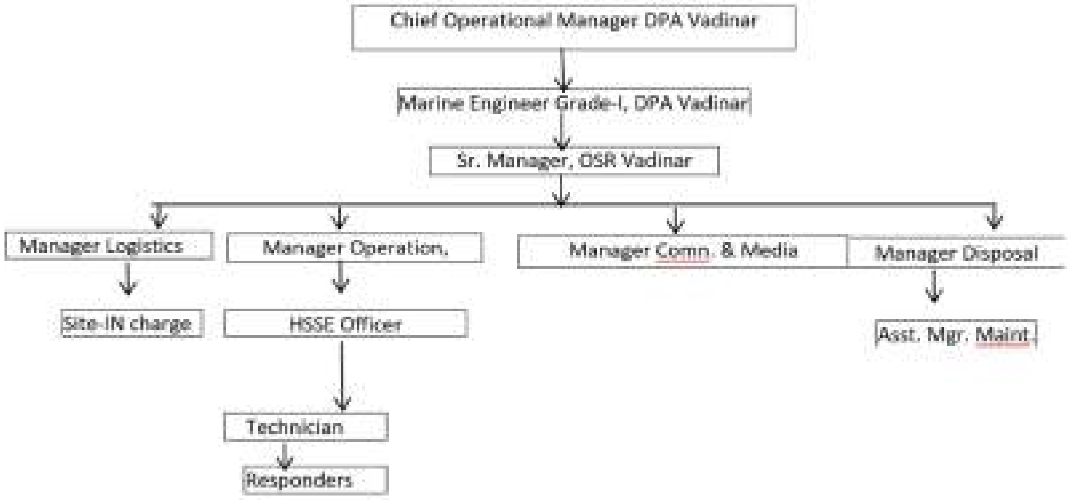
The use of dispersants at and in the vicinity of our site is prohibited. The decision to use the dispersants rests with the ICG. Reference is made of Policy and Guidelines for use of oil spill Dispersants (OSD) in Indian Water.

Refer Annexure- 20

Pollution Management Cell under the chairman ship of Chairman, DPA / Dy. Chairman, will be established at MTCB to manage the initial response to the incident.



3.5. SHORELINE OIL SPILL RESPONSE: ORGANIZATION CHART



The Vadinar Oil Terminal Port (DPA KANDLA AND OOT VADINAR) is situated in the middle of the most ecological sensitive marine environment. In order to conserve and protect this precious marine environment, Government has the area around it as Marine National Park and Marine Sanctuary
The response to shoreline oiling, clean-up effectiveness, and eventually, to conduct final evaluations of shorelines to ensure they meet clean-up end points.

Shoreline oil spill response process includes eight basic steps:

1. Conduct reconnaissance survey(s).
2. Segment the shoreline.
3. Assign teams.
4. Develop clean-up guidelines and endpoints.
5. Monitor effectiveness of cleanup.
6. Conduct post-cleanup inspections.
7. Conduct final evaluation of cleanup activities.

Manual recovery is the most common method of shoreline cleanup, involving teams of workers using rakes, shovels and the like to pick up oil and debris. The oily materials are collected in buckets and drums for transfer to a processing station. Workers may also use suction hoses, pumps and vacuum trucks to recover spilled oil. While manual cleanup is a slow, painstaking process, it generates less waste than other techniques.

Monitor Only: Spill clean-up operations inevitably have their own environmental impacts. For example, heavy equipment can damage sensitive plants and disrupt wildlife habitats. When the potential harm caused by a spill is less than the potential harm caused by attempts to remove it, spilled petroleum products are allowed to degrade naturally. Technicians periodically monitor the breakdown of the spill to be sure there is no unforeseen threat to sensitive ecosystems and/or groundwater supplies.

Wildlife Cleanup: Oiled fish, birds and animals may absorb potentially lethal toxins through their skin. Following spills, birds, otters, seals and walruses may be collected for cleaning and treatment, and then returned to the environment. This is an expensive, time-consuming undertaking and, although techniques have improved greatly in the past few years, recovery rates are often poor. Many other species cannot be rehabilitated because they are either too difficult to capture, or the stress of captivity is likely to have more negative effect than the oiling.

3.5.1. PORT- VESSEL POLLUTION EMERGENCY INTERPHASE: For appropriate action & responsibility to be initiated as per table placed at an**Annexure-13**

The spilled oil contained on the terminal/ jetty will be handled manually. While, use of vacuum pumps could be made, the absorbents will be required to be used to collect the spilled oil. In respect of oil released or introduced into water, response as per water body procedures are to be initiated. (Refer Annexure-13).

3.5.2. Water Response:

The spill at sea could occur at anchorage or in channel due any eventuality or accident. An oil spill occurring due damage to vessel is a point source spill which would need to be addressed earliest. Taking into account the fact that a multiple response may be required, the vessel and responders will have to mount a rapid reaction.

3.5.3. Vessel Response

While, the first action is expected of the vessel operator in containing the spill by way of plugging of leak as far as possible, the first action of the response team is to be to contain the spill by placing booms attached to ship's hull to isolate the damaged area. Recovery of spilled oil would also be required to be undertaken simultaneously.

OSR Response

The response team being stationed afloat with equipment placed on response vessel, would deploy the equipment to contain the spill. In the event of a spill originating from the ship side, containment will be handled by placing booms along the ship side.
In case of a large spill, the actions to lighter the ship or transfer the cargo will be initiated by the port authority or ship owners.
While, Containment and recovery would be the preferred option, the other alternatives like dispersion could also be put to use subject to local restriction

3.6. REFINERIES AVAILABLE IN GUJRAT & IN INDIA

The details of Refineries Available near DPA KANDLA AND OOT VADINAR, In Gujarat State and in India are placed as an **annexure- 8**

3.7. STORAGE AND DISPOSAL OF OIL AND OILY WASTE:

3.7.1. Storage:

Initially, when the skimmer recovers the oil, it is to be stored in the floating storage tank onboard Oil Spill Response Vessel and OSRO Centre, specially designed for the purpose.

3.7.2. Disposal:

Disposal of recovered oily waste is an integral part of the Operation Manual and is explained in detail in "WASTE DISPOSAL PLAN". The purpose of disposal is not only to direct the recovered oil and waste to a final processing facility but also to bring to attention of responders, the methods to minimize the amount of waste generated during operations.
All disposal is to be undertaken keeping in view the provisions of different statutes and legal parameters like 'The Environmental Protection Act 1986' and the Hazardous Waste (Management & Handling and Trans boundary Movement) Rules 2008. Disposal of certain waste like solids and debris etc. that cannot be processed by participating oil companies will be required to be undertaken in close consultation with local administrative authority. In the event, where, spill originates from any unit of the participating oil companies, the custody of waste and recovered oil is to be handed over to the company for transportation, storage and disposal.
Any dispute arising on this account will be settled by respective CMT, whose decision will be final and binding.
The details of refineries Available in Gujarat & in India are placed as below:
Refer Annexure – 23

LIST OF DISPERSANTS APPROVED FOR APPLICATION BY COAST GUARD

The NIO and Coast Guard approved list of oil spill dispersants (OSD) are enumerated below.

Type II - Water dilutable (1 part of dispersant: 10 parts of sea water is to be used in the ratio 1 part of diluted dispersant: 2-3 parts of oil)

COREXIT-9500 - (JAN 2003)
BG Exploration & Production India Ltd.,
1st Floor, Mitlas Sahar Plaza
Kondivita, M/ Road, Andheri (E), Mumbai - 400 059
Phone : 022-28395841 Fax : 022-28395201

Gold Crew - (Feb 2003)
MS Conterprise
Mayurpankh, 5th Floor
Agiary Lan, Jambli Naka, Thana (W) - 400 601
Phone : 022-25401518/25971690 Fax: 022-25373940

FireChem - (Feb 2003)
M/s Fire Chem Private Ltd
B-4, Rana Commercial Complex
Sector-20 B, Near Ajronda, Faridabad - 121 007
Phone : 0129-25288186/25288187 Fax : 0129-25288700

Spilcare-O - (Dec 2004)
Spilcare - O Metaclean Pvt. Ltd
AB-148, 3rd Main Road, Anna Nagar,
Chennai - 600 040, Phone : 044-26200482 Fax : 044-26281457

Type III - Concentrate (to be used neat in the ratio 1 part of dispersant : 25 parts of oil)

COREXIT-9500 - (JAN 2003)
BG Exploration & Production India Ltd.
1st Floor, Mitlas Sahar Plaza
Kondivita, M/ Road, Andheri (E) Mumbai -400 059
Phone : 022-28395841 Fax : 022-28395201

Challenger-OSD EF III - (Aug 2003)
Challenger Chemicals & Polymers Private Ltd.
PR No. 0917, 3 Balasundaram Lay Out
Siddhanaidu School Road
New Siddhanaidu, Coimbatore - 641 044
Phone : 044-2218224 Fax : 0422-2213181

Spilcare-O - (Dec 2004)
Spilcare - O Metaclean Pvt. Ltd
AB-148, 3rd Main Road, Anna Nagar,
Chennai - 600 040
Phone : 044-26200482 Fax : 044-26281457

NOVA CHEMICALS - (JUNE 2005)
Pragji Vrindavan CHS
Room No.50, 4th floor, 20/24 Old Hanuman Lane
Kalbadevi, Mumbai - 400 002, Phone/Fax : 022-56347397

ICG requirements for selection of OSD :

Physical State	:	Flowing clear and homogenous liquid free from suspended solid.
Stability	:	Between 100-90%
Efficiency	:	Above 60% for Type-II Above 50% for Type-III after dilution
Flash Point	:	60°C Minimum
Cloud Point	:	0 to -5°C
Shelf Life	:	5 to 10 years
Validity	:	Should be in possession of valid NIO evaluation certificate
Date of Manufacture	:	Within 3 months of date of supply

4. EQUIPMENT:

4.1. Marine Oil Spill Response Equipment:

The typical response equipment required for mounting an operation consists of equipment for water response and shoreline operations and could include:

Off Shore

Control Station
Booms
Skimmers
Absorbents
Sprayers & dispersants
Radio communication Equipment
Boats / tugs / response vessel
Pumps / hoses
Aircraft Transportation

4.2 INSPECTION, MAINTAINANCE AND TESTING:

Inspection & maintenance are being carried out as per manufacturer's manuals.

(Annexure- 4)

4.3. SHORELINE EQUIPMENT, SUPPLIES AND SERVICES:

General provisions

1) Control Station
2) Protective clothing for everybody (including boots and gloves), spare clothing cleaning material, rags, soap, detergents, brushes
3) Equipment to clean clothes, machinery etc. with jets of hot water
4) Plastic bags (heavy duty) for collecting oily debris.
5) Heavy duty plastic sheets for storage areas especially
6) temporary storage pits
7) Spades, shovels, scrapers, buckets, rakes
8) Ropes and lines
9) Anchors, buoys
10) Lamps and portable generators
11) Whistles
12) First Aid Material
13) Special equipment which may be used
14) Workboats
15) Trucks / cars (fours wheel drive)
16) Radio transmitter/ receivers
17) Workshop / repair facilities
18) Bulldozers, mechanical scrapers and similar earthmoving Equipment
19) Vacuum trucks Tank trailers
20) Life vests
21) Explosive meters

5. MANAGEMENT:

5.1 CRISIS MANAGEMENT AND FINANCIAL AUTHORITIES CHART: ReferAnnexure-15

5.1.1 Crisis Management Team:

	DESIGNATION	APPOINTED MEMBER
1	Chief Incident Controller (CIC)	Dy. Conservator
2	On Scene Commander	Sr. Manager OSR/ Harbour Master
3	Member Admin & Finance	FA&CAO
4	Member HSE & Media	Port safety and Fire officer
5	Member legal	Secretary
6	Member Tech	Chief Mechanical Engineer
7	OSRO/ Response Specialist	To be appointed by OSRO, in case response being undertaken by OSRO

	DESIGNATION	APPOINTED MEMBER
1	Chief Incident Controller (CIC)	Chief Operations Manager
2	On Scene Commander	Sr. Manager OSR/ ME Gr.– I
3	Member Admin & Finance	Accounts Officer OOT
4	Member HSE & Media	Port safety and Fire officer
5	Member legal	Secretary
6	Member Tech	XEN (E&M)
7	OSRO/ Response Specialist	To be appointed by OSRO, in case response being undertaken by OSRO

CMT is the primary unit for incident management and is composed of senior managers from various departments for providing advice and resources and take 'on the spot decisions' to meet any immediate requirements arising during the response.

The major functions that would need to be carried out by CMT to discharge the Plan are as per table below:

Field Operations	• Initiation, Control of Operations and response activity • Emergency Control room functions • Implementing tired response and disposal • Shoreline cleaning (when initiated through this CP) • Planning and strategy
	• Victuals • Transport • Additional Manpower and Equipment • Security
Technical matters	• Cargo ops, Availability of response items, repairs • Communication- operational and with other • Government / non govt. authorities, Media
Legal	• Documentation of damages, claims and compensation, notifications

Health and safety	• Medical assistance

TABLE 12 Major functions of Crisis Management Team

5.1.2 Financial Authorities:

The Financial Authorities of DPA is as per the existing organization structure. At the time of the crisis, the need of the hour will be understood and requirements of OSC /ERT will be met at a faster rate than normal. Since all Head of Departments (HODs) would be Available, immediate on the spot approval will be accorded.

5.2 Incident Organization chart:

CMT is the primary unit for incident management and is composed of senior managers from various departments for providing advice and resources and take 'on the spot decisions' to meet any immediate requirements arising during the responses. Organization Chart is as follows: Refer **Annexure -14**

INCIDENT ORGANIZATION CHART:

INCIDENT AND SPILL INFORMATION

↓

Port Control / COM / DC
Communication and Ops Centre

↓

ASSESS SPILL QUANTUM —Major→ CONVIENE CMT
(Assess enhanced Tier Response)

↓ Minor

Tier I
Inform OSC / OSRO ← Take over Operation (As per CP)

Undertake response ops. Inform Coast Guard

Resource agencies close out

Responsibilities: -

Liaise with Mutual Aid Organizations
Liaise with corporate communication for press statements release
Liaise with Coast Guard Monitor as appropriate
Confirm / amend initial classification
Manage the DPA KANDLA AND OOT VADINAR response
Authorize expenditure

Alert

Indian Coast Guard, Mutual Aid Partners, OISD and other External organizations.

Support Services

- Weather, Tides, currents.
- Topography & shoreline Character.
- Environmental sensitivity data Spill trajectory modeling, oil data (character, behavior)
- Documentation & Information control,
- Logistical implications of Strategies/Tactics

Operation Team

- Practical input into Strategies and Tactics suggested.
- Operation Plans,
- Type and quantity of equipment and personal needed.
- Details of any restrictions or constraints.

Incident Controller Planning Meeting

HSE

- Fire Fighting Plan
- Security Plan

Administration & Communication

- Cost implications of Strategies/Tactics.
- Information on any legal issues.
- Communications Plan
- Available & Future resources.
- Personnel/services contracted or needed.
- Transport Available/needed.

Incident Action Plan

5.2.1 Functional Designations:

Following functional designations stand identified and notified through the Plan, to give effect to this Plan:

(i) Crisis Management Team
(ii) Chief Incident Controller
(iii) Incident Controller (On Scene Commander)
(iv) Incident Manager / OSRO Manager
(v) On Scene Coordinator / Response Specialist
(vi) Responders

5.3 Manpower Availability (on-site, on-call):

Terminal Area is manned on 24x7 hours basis; manpower is Available at site to meet any exigency. However, DPA department will provide assistance of water craft, vehicles, cranes etc. for movement of men and material.

5.3.1 Afloat Operations and Response Team/ Teams

Incident operations and response team comprises of CMT or part thereof, as decided by CIC as per the magnitude of spill (Reference 9.2.1 Note v). While, the CMT would be activated to meet in the event of a major accident, a comparatively small incident may need only limited action of CMT to be performed by a part of team.

I. **Chief Incident Controller (CIC)** - DC / COM is nominated permanent Chief Incident Controller irrespective of the magnitude of spill. While, in the event of a large spill, major decisions and duties are expected of him to be discharged along with CMT, in the event where the spill can be handled by response team alone, the incident will be handled by Incident Controller (IC). The appointed IC will carry out the functions of On Scene Commander for the operation. However, the CIC is to keep account of the operation and ensure to be kept informed.

II. **Incident Manager (IM) –** is a member appointed by DC / COM or respective CMT leader to undertake the responsibilities associated with administration of operations and giving effect to decisions arrived at by CMT. He is to ensure timely execution of demands and decisions with a view to provide continuity to operations. To facilitate ease of operations and administration, a permanent IM is to stand nominated at all times by DC / COM or CMT leader.
In the event, the response activity is assigned by the port to an OSRO; the OSRO will appoint a manager in addition to Incident Manager to undertake the responsibility of meeting the demands of response teams.

III. **Operations Response Team (OSRO specialist/ Responder / OSC)** - the response team is to have a permanent status and is to be nominated by CIC on behalf of CMT. The team would comprise of persons specifically nominated on account of their experience of response operations, their qualification or expertise in the matter. The nominated members could be employee of the port or any department in addition to nomination to response team. Being of permanent status, the details of identified members are to be Available at Communication and Operations Center at all times and is to be inserted as a temporary enclosure to this plan. All responders are to be qualified in terms of having undergone IMO Level I course are to be inserted as a temporary enclosure to this plan.

The functions of response team can be assigned to an identified and qualified OSRO also. (The details of National & International OSRO are placed at an **Annexure-2** in such an event of nomination, all functions with respect to response team and On Scene Co-coordinator will be carried out by the OSRO or OSRO representative, while, CMT and CIC will continue to function hitherto.
Response resources like equipment to be deployed having been identified in terms of quantity and location, additional resources like spill response vessel (SRV) and work boat etc. along with responders would be as per identification and notification by CMT leader. In the event of an OSRO being assigned the responsibility to provide resources, OSRO will have to mobilize the different units.

5.4 AVAILABILITY OF ADDITIONAL MANPOWER:
The response team is to comprise of a Manager, Specialists, responders and response workers apart from the crew of the vessel or work boat assigned to response duties. The team and additional resource composition is

(i) Incident Manager / OSRO Manager
(ii) OSC- Incident Controller/On Scene Coordinator
(iii) SR Vessel and Captain
(iv) Responders
(v) Vessel crew
(vi) Work boat, master and crew

Additional responders or additional teams could be assembled during response ops as the requirement demands.

5.5 ADVISORS AND EXPERTS (Contact details are placed at an**Annexure-1) – SPILL RESPONSE, WILDLIFE, AND MARINE ENVIRONMENT:**

The following Authorities and Organization have been consulted during the preparation of this plan:
1. Indian Coast Guard
2. Integrated Marine Facilities at Kandla & Vadinar.

Oil Industry Safety Directorate (OISD) has decided that, all the Ports and Oil companies should create Tier 1 facilities for maintenance and combating oil spills, Therefore, DPA KANDLA AND DPA OOT VADINAR has established Tier-1 facilities.
This report presents the methodology and results of an assessment of the risk of a significant oil spill occurring at DPA KANDLA AND DPA OOT VADINAR in or around SPM, channel route, along pipeline corridor at product jetty and in the area proposed for expansion in the Gulf of Kutch. The assessment has considered low to moderate frequency with low to moderate impact events, i.e. Tier-I spills.
5.6 TRAINING / SAFETY SCHEDULES AND DRILL / EXERCISE PROGRAMME:

5.6.1 Training:
Oil Spill Response Requires Specialist Training which should be developed at all levels of the response. Also, the Management of an oil spill incident is a major task and has a crucial bearing on the outcome of an oil spill response, issues such as the control of crisis situations, political interest, media pressure, public environmental awareness and legal and financial implications can add substantial burdens to the oil spill response team and must be effectively handled if the overall response has to be successful. Effective Training hence becomes crucial for the response team in order to handle the situation aptly and correctly. There is no denying the fact that oil spill combating in any capacity is a rare event for most people and therefore, it is important to keep in touch with skills and knowledge gained as a part of ongoing personnel Training. This too, will help in ensuring that all those involved in the response operation understand each other’s role in an oil spill incident.
At present Organization has 10 employees trained in IMO Level-I Oil spill response and 04 employees trained in IMO Level-II Oil spill response.

5.6.2 Exercises and Drills

The purpose of exercises and drills is to test the knowledge of persons and members associated with response activity and maintain them in the highest state of readiness and professional competence. The exercises would aim to assess acquaintance of response teams with operation ability and initiation of Plan and also the knowledge of operational parameters.
For this purpose, it is required to conduct both in house training and evaluation exercises and also multi agency co-ordination exercises are being conducted at regular intervals.
In addition to classroom training, the responders would need to go through regular internal and external exercises that would include deployment of equipment to demonstrate level of proficiency. With respect to management of operations in consonance with the plan, it is desirable to conduct real time CP exercises with all industrial stake holders involved. Such an exercise conducted at a large magnitude would need to incorporate the staff from DPA, Participating Oil Companies and the Indian Coast Guard and scheduled as mutually agreed.

The purpose of exercises and drills would be to check the following:

1. **Organizational and Planning**
   (a) Knowledge of Contingency Plan and Procedures
   (b) Personnel Notifications and Staff Mobilization
   (c) Ability to operate as per CP and Operations Manual

2. **Operational Response**
   (a) Oil spill assessment
   (b) Response equipment selection
   I Containment strategies
   (d) Spilled oil recovery techniques
   (e) Disposal of recovered oily water and contaminated material

3. **Response Support**
   (a) Communications
   (b) Logistics
   (c) Personnel support
   (d) Documentation

5.6.3 SAFETY-**Refer Page-64**
5.6.4 Types of exercise:
Exercise requirement as per contract is to conduct internal and external exercise. In addition to classroom training, Exercises are to include deployment of equipment to demonstrate satisfactory levels of proficiency. External exercises are to incorporate with the staff from DPA, participating oil companies and the Indian Coast Guard.

(i) **Type A:** Internal exercises lasting approx. One day for ensuring OSR readiness of all equipment, services and personnel.
ii. Type **B**: Emergency Response Exercise (Tier-I) is to be conducted once a year.
iii. **Type C:** These exercises designed to test either specific scenarios or emergency plans and include external participation (i.e. mutual aid, govt. agencies)

6. COMMUNICATION

6.1 INCIDENT CONTROL ROOM AND FACILITIES:

Communications plan

Communications between the MTCB, COT and PIT Control Room and Marine personnel during the response to any oil spill within the local area will be primarily by VHF private channel radio.
Communications between the MTCB and other vessels will be established on VHF
Radio Channel 16**/12.**
Use of cellular telephones is to be kept to minimum. Cellular phones are **NOT** to be used in the vicinity of spill.

Contact details OOT Vadinar:

Port Control	Landline - DPA	02882573005
	VHF - DPA	Marine channel 12, 16 Marine Channel 13
COC/ME Gr-I	Landline number	02882573033
	Mobile	9979126681
	VHF	Marine Channel 12 and 13,16
COM /CIC	Landline- KPT	02882573001
	Mobile	9819999227
Marine Engineer Grade - I	Mobile	9979126681

Table 13

Contact details Kandla:

Port Control	Landline - Kandla/Gandhidham	Kandla-02836-270529/270194 Gandidham-02836-233585
	VHF - Kandla	Marine channel, 08,10,12,16
COC/HM	Landline number	02836270201
	Mobile	8976741054
	VHF	Marine Channel 08 and 10,16
DC / CIC	Landline- DPA	02836233585
	Mobile	9603123449
Flotilla Superintendent	Mobile	9825227610

Table 14

6.2 FIELD COMMUNICATION EQUIPMENT:

6.2.1 Equipment:

The communication center is to be provided the following equipment

i. VHF – 2 numbers
ii. Walkie-talkies – as per the number of response teams and functional team leaders
iii. Telephone (landline or wireless) – 1
iv. Computer and printer with internet and projector facility

6.2.2 Publications: NOS-DCP

6.3 REPORTS, MANUALS, MAPS CHARTS AND INCIDENT LOGS:

For Reports use formats described

1) Map of Local Area
2) Geographical limit and sensitivity map
3) Sensitivity Mapping CZMP as annexure -
4) Refer the logs maintain by MTCB & Individuals log if any

The Log Incident Report form as per **Annexure-17** sample has to be developed to ensure that the basic information required to formulate a response to an Oil Spill Emergency is obtained during the notification (if required). Port Control / COM /Communication and Ops Centre will complete the form and dispatch to the concerned authorities by the fastest means. In all cases, the original status report forms will be handed over to ECT, who, in turn, would maintain record of all such documents.

The personal log form and continuation sheets have to be as per **Annexure -18** to allow all personnel involved on the emergency response to maintain a personal log of event. The personal log forms and the continuation sheets are to be used during the oil spill response to record the contacts and activities carried out during such emergency.

Incident Logs are for logging of all the events taking place. This will help in preparing a comprehensive Incident Report on a day to day basis as well as on completion of operation.

After the response work is over, the personal log form as per sample at annexure-18and the continuation sheets are to be numbered, signed and handed over to the COM.

PART II

ACTIONS
AND
OPERATIONS

7. INITIAL PROCEDURS

7.1 NOTIFICATION OF OIL SPILL TO CONCERNED AUTHORITIES

Any INFORMATION RECEIVED WITH RESPECT TO A SPILL, BEING OF IMPORTANCE TO ARRIVE AT A DECISION FOR ACTIVATION OF CMT and RESPONSE REQUIRED TO BE TAKEN, HAS TO BE RECORDED WITH CARE AND WITH ALL POSSIBLE DETAILS.

Correct knowledge of the quantity of spill is a factor that would facilitate the CMT and other responders to decide on the scale of response action and also the requirements to decide on Tier responsibility. The information has to contain the following details

- Authority reporting spill (with all details)
- Time and position of spill
- Type of oil
- Assessed quantum of spill

INCIDENT AND INFORMATION FLOW CHART

<u>INCIDENT AND SPILL INFORMATION</u>

Port Control /COM / DC

Communication and Ops Centre

ASSESS SPILL QUANTUM → (Major) CONVIENE CMT (Assess enhanced Tier Response)

Minor

Inform OSC / OSRO ← (Tier I) Take over Operations (As per CP)

Undertake response ops.

Inform Coast Guard

Resource agencies

close out

Notification matrix

The matrix gives the primary telephone contact number; alternative telephone and facsimile numbers are included in **Annexure-19**

7.1.1 ADDITIONAL INFORMATION:

In addition to the above information, following info is also to be recorded and provided to the responder or OSRO,

- Detailed weather conditions – wind, direction and speed
- Sea conditions

7.2 PRELIMINARY ESTIMATE OF RESPONSETIER:

The moment oil spill takes place or is detected**,** immediately the time and place of the spill started and stopped should be ascertained from the originator of the oil spill. The information about diameter of pipe, rate of pumping /flow of oil would help in determining the quantity of oil that has spilled into water. In case, accident is due to collision the sounding of the tank would talk about the quantum of oil spilled into the water and then only magnitude of spill could be established. The notification as per NOSDCP will be adopted for declaring Tier I, II or Tier III spill or spill of a minor nature.

7.3 NOTIFYING KEY TEAM MEMBERS AND AUTHORITIES:

The Key Team Members are – COM, Marine ENGG GR -I, Fire Officer, Sr. Manager OSRC and other HODs. These members can be informed over Phone /Mobile phone, and same be also logged at ECR.

7.4 MANNING CONTROL ROOM:

Marine Terminal Control Building (MTCB) will be the control room, unless otherwise location nominated by the Head DPA KANDLA AND OOT VADINAR

7.5 COLLECTING INFORMATION (OIL TYPE, SEA / WIND FORECASTS, AERIAL SURVEILLANCE, BEACH REPORTS):

Samples to be collected from various points, clearly marked and sealed. Samples to be stored for further investigations, as required. The following equipment shall be held for the purpose of storing samples
a) At least 6 sampling bottles,
b) One seal tag for each sampling bottle
c) Prognosis and Synopsis weather reports
d) Any other relevant matter

The moment oil spill is reported /intimated to the various departments, the action by

i. Marine department will provide all the relevant data for that day to ECR i.e. Tide conditions at that time, Tide timings, Current, Wind direction /speed, Weather forecast, Vessel movements, Vessel position in DPA Port, Water crafts Availability for pollution response activities. Relevant Navigation Charts and any other important data /information Available may also be provided. Also number of Security Personnel Available at that time will be made Available.
ii. Traffic department to provide information regarding Availability of type and number of vehicles Available for transportation of men and equipment. Also, number of Casual Labors Available at that time will be made Available.

iii. Fire department to indicate readiness about FIRE CONTINGENCY including OIL FIRE and also number of spare Life Jackets Available.
iv. ECT Ensure that no individual is working / supervising / observing OSR operations/ Exercise Without Life Jackets “ON”.

OSC is to collect following information immediately in case of oil spill:

- Time of oil spill occurred.
- Position with reference to prominent land mark and also, if possible, in latitude and longitude.
- Visual appearance, apparent thickness of oil and extent of area covered.
- Percentage covers of various thickness of oil.
- Existing weather condition and weather forecast
- Current and tide conditions
- Immediate Availability of support vessel, equipment and manpower.
- Estimate oil spill trajectory and likely area and time of its landfall.

7.5.1Information Display:

The following latest information is to remain displayed at all times on wall boards in the Control and Operations Center:

- Vessels working cargo in port – quantity of cargo, location and expected times of completion
- Prevailing weather conditions and future forecast
- Vessels expected to arrive and depart port in next 24 hrs., cargo and quantity
- Important contact numbers of CMT, OSRO and other CP aid agencies

  Continuous watch on working frequencies used by ships, port and terminal for POL cargo ops
- Watch on Ch 16 at all times
- Log all information in respect of an oil spill (with maximum details) received through keeping watch or from any other source
- In case of first receipt of information, pass all the details regarding spill to CMT leader to facilitate complete or partial activation of team or response actions by OSRO
- Pass all information regarding spill to OSRO and duty vessel or tug assigned response duties.
- Remain in constant touch with designated response team leader and response / support vessels as per working channel decided for operations
- Collect latest information from MET dept. on weather conditions in the area including wind direction & speed, tide condition and other weather parameters (all received information is to be logged)
- Provide weather data to operational teams as demanded

7.6 ESTIMATED FATE OF SLICK&PLANNING MEDIUM-TERM OPERATIONS (24-48 AND 78 HOURS):

The likelihood of oil spill taking place are from two factors mostly, during vessel operations and secondly due to collision. Since, during vessel operations, OSRO personnel as well as ship's staff present at the site, any mishap taking place could be tackled immediately as reaction time will be very less and damage control could be done very fast. Therefore, quantity of oil spilling into water is expected to be minimum and the spill could be neutralized quiet easily. Here in this case dispersants, sorbents may be used and whole operation is likely not to last more than 24 hours. In fact, OSR items are kept handy in OSRV to use any time.
However, in case of oil spill occurring due to Collision, it is certainly going to be at a higher magnitude. As, when the collision takes place, everybody's attention is likely to be toward safety of the vessel i.e. to Avoid vessel getting grounded, Avoid colliding with other vessels, preventive action against fire or carryout firefighting, damage control action against flooding and so on. It is anticipated that in case of collision the oil spill is likely to occur due to rupture of or crack in fuel tanks. It should be clearly understood that

i. In case of rupture of fuel tanks a sudden gush of oil will be there, and for some time it will be uncontrollable. By the time any effective damage control action is taken, a substantial amount of oil would have already gone overboard. This would necessitate immediate oil containment measures, as well as starting of oil recovery action. This oil spill recovery action may go well beyond 48 hours, keeping weather and sea conditions in mind, because one does not know at what time of the Day or Night accident takes place which will determine the time delay in appreciation of the situation and mobilization of OSR team and equipment. It may clearly be understood that appreciation of oil slick between sunset and sunrise is quite difficult and at times it may be fully incorrect, hence slight time delay may be anticipated.

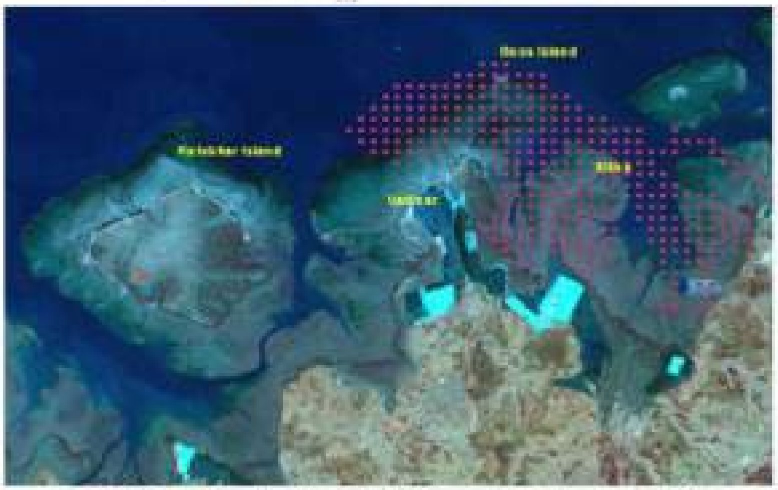
Such accidents don't happen quite often, but very rarely. Hence readiness of OSR team and Equipment shall be maintained at all times.

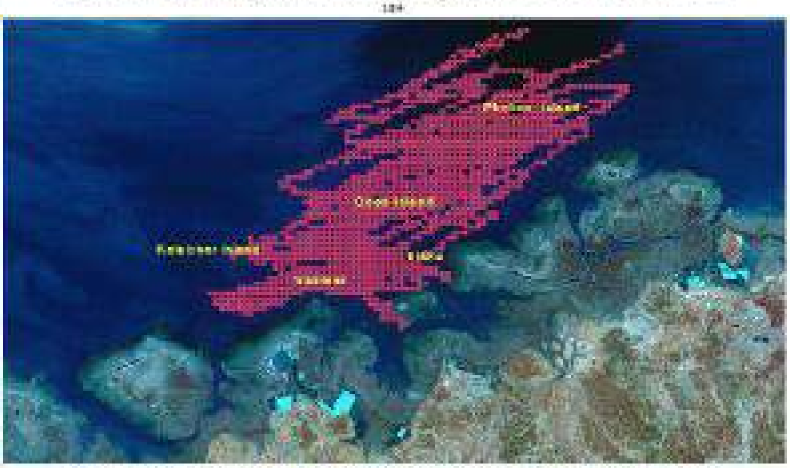
ii. The oil spill scenario through cracked fuel tank /tanks is not very different than the previous one, because due to cracked/fractured /material failure occurred in the fuel oil tank/tanks, oil would continue leaking in a small /moderate rate. But it would be difficult to locate the source/point of oil leak and by the time source /point of leak is detected, suitable action is initiated and leak is arrested, a sizeable quantity of oil would have already been over board. Detection of oil leak will become more difficult if the crack /fracture develops after some time due Collision related structural stress and ship is secured alongside jetty with the damaged /leaking side situated between shipside and jetty. The problem will become more compounded if the accident takes place after sunset during severe monsoon conditions and detection of oil slick in the night would be really quiet difficult. Like above serial (i), here also one cannot deploy OSR men and equipment preciously and reaction time to deploy OSR men and equipment, subsequently recovery of spilled oil is going to take more or less the same time.

Here the vessels taken on consideration are visiting ships of various sizes in all weather conditions but not the minor vessels or tug boats.

7.7.1 ESTIMATED FATE OF SLICK: (24, 48 AND 72 HOURS):

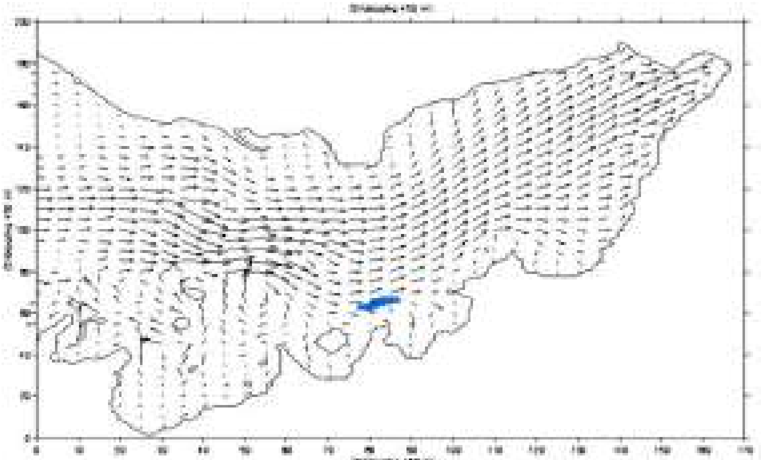
Please refer to the picture below and apply the prevailing factors deduced from the weather reports.

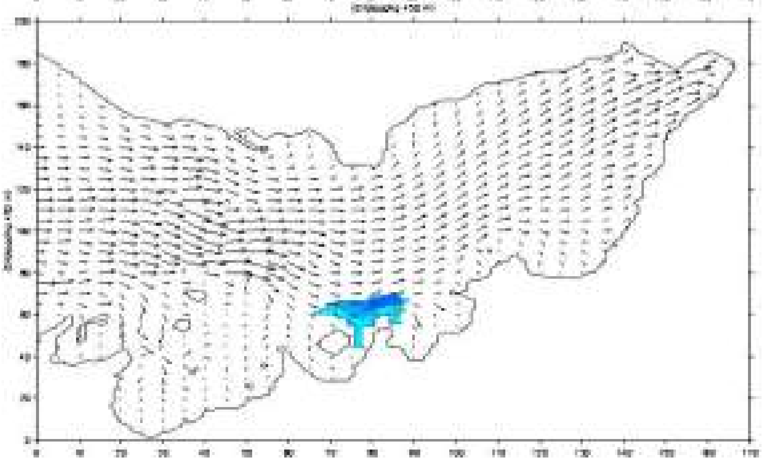




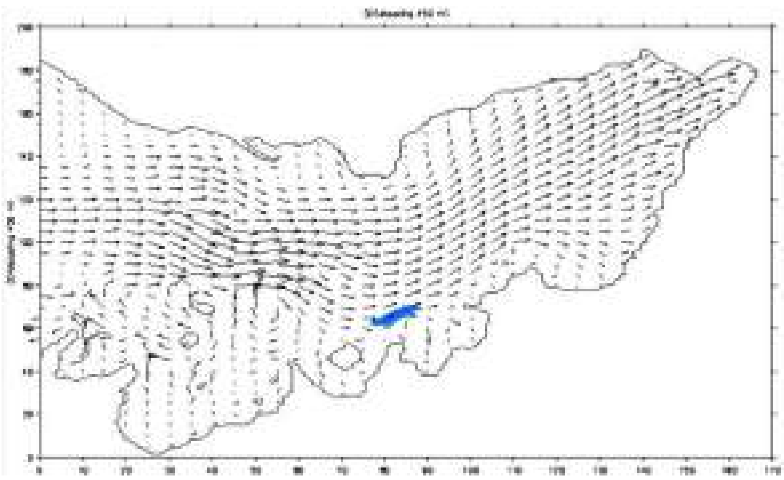
Estimating fate of slick.

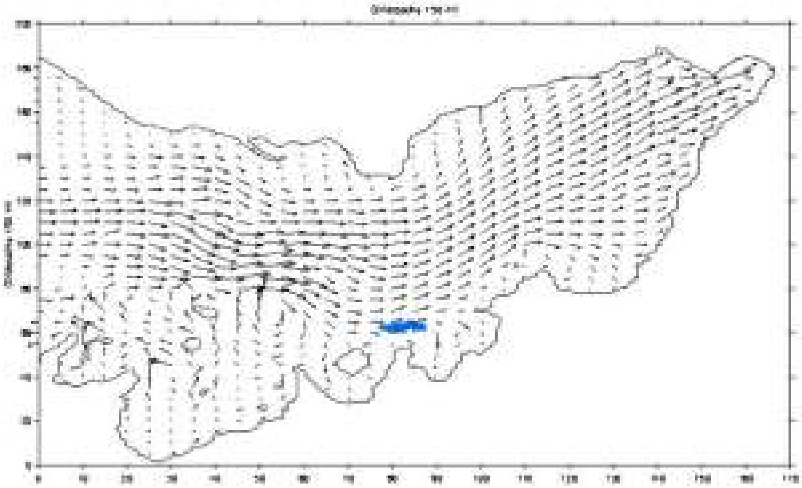
Oil trajectories at the end of 2 hour and 24 hours for scenario I: No wind condition:



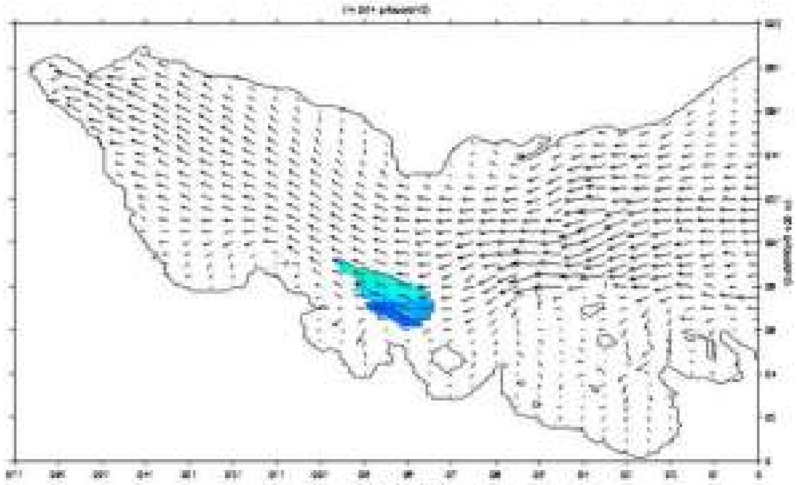


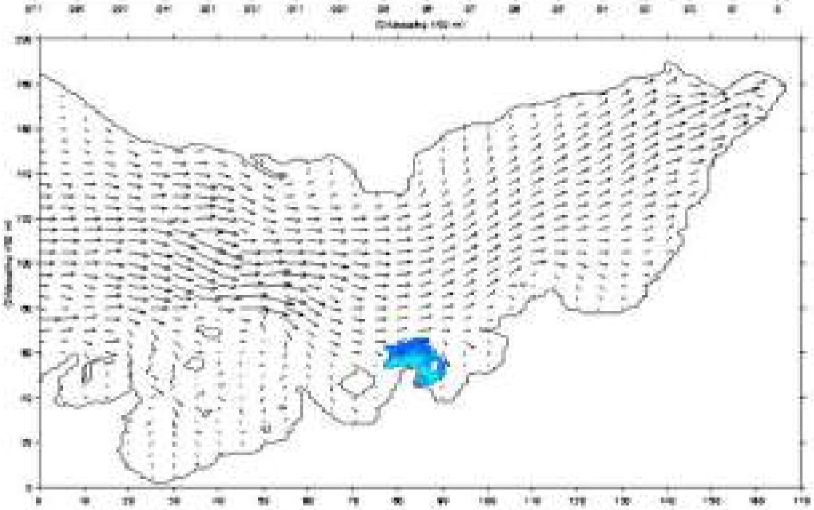
Oil trajectories at the end of 2 hour and 24 hours for scenario II: 5m/s wind from 240 degree N





Oil trajectories at the end of 2 hour and 24 hours for scenario III: m/s wind from 330 degree N





7.6 IDENTIFYING RESOURCES IMMEDIATELY AT RISK, INFORMINGPARTIES:

There are no resources which will be immediately at risk except Marine national park & ESSR intake. No population along the coast up to about 10 km, the mangroves are at about 5 km. salt pans are at about 7-8 km. The mangroves and salt pans are likely to be affected only at highest high water during NE monsoon . Depending upon the place of spill, the resources at risk will be assessed.

7.7. Surveillance

The aim of surveillance is to detect, characterize and preferably quantify spilled oil that may be present in a range of settings (on-water, in-water and onshore). This is of critical importance in enabling the incident command to effectively determine the scale and nature of the oil spill scenario, make decisions on where and how to respond, control various response operations and, over time, confirm whether or not the response ineffective. Irrespective of the final response strategy selected monitoring of oil spill will commence immediately after the oil spill and will continue until the response operation is terminated. The information gathered through monitoring and evaluation will be used by the IMT to steer the response, and ensure that the most effective and efficient response strategies are being adopted.

Five monitoring and evaluation methods are discussed in this section:

- Aerial Surveillance
- Vessel Surveillance
- Satellite Surveillance
- Surface Plume Tracking
- Spill Trajectory Modeling.

7.7.1 Aerial Surveillance

Aerial surveillance is the first response for any ongoing reportable incident as it allows the Incident Management Team to quickly gather initial information about the incident and formulate tactical plans to combat the spill. Aerial surveillance can be carried out throughout the incident management process to provide feedback to the command Centre on daily progress and to help evaluate the success of the response strategies.

A written or verbal flight task is given to the aerial observer detailing the purpose of the mission, such as:

- Confirming the location of the spill using ladder or spiral search path
- Quantifying the amount of oil on the water and verifying the results from modeling
- Directing response operations such as directing vessels/aerial dispersant application planes onto the thickest part of the oil
- Conducting shoreline surveys to identify areas that may have been, or may be impacted.

Followed by the aerial surveillance and preliminary shoreline survey substantiated by notes, sketches, photographs and videos supported by GPS readings. In case considerable part of oil spill sunk due to environmental conditions, oil characteristics or both, under water survey may be required. The survey may be undertaken using visual assessment, divers, remotely operated vehicles, acoustic sensors or sorbents. Environmentally hazardous areas must be marked specifically based on the secondary data already Available so that many accidents resulting in loss of life and property can be Averted.

7.7.2 Vessel Surveillance

Before the arrival of aircraft for aerial surveillance, vessels Available on the scene can help to conduct initial visual surveillance by following the leading edge of the slick. This location in formation can then be communicated to the Incident Management Team to guide the aerial surveillance aircraft to the slick. This is only a temporary measure as the vessel's visibility ranges restricted and there is a risk of secondary contamination of the vessel.

7.7.3 Satellite Surveillance

Surveillance of oil spill is also possible through satellites with sensors such as SAR (Synthetic Aperture RADAR–an active sensor that send out a micro wave pulse and reads there turn) and Optical sensors– (Relies on reflected energy). RADAR imagery is the preferred option as the active pulse from space reacts with surface textures giving all-weather day / night imaging. This service may be gauged through Space Application Centre, Ahmedabad.

7.8. SAMPLING

Identification of the responsible source for an oil spill incident is essential because of its legal implication. Laboratory analysis of the oil samples is thus required following a spill incident. From the same it is possible to identify differences between one type of oil & the other and also to determine the similarities between spilled oil and its source. Source of the oil could be identified by the comparison of the spilled with the potential source samples. Sampling is as important as laboratory analysis and investigation.

Sampling of both biotic and abiotic resources from spill affected area is the first and foremost part of the oil spill testing. Resources can be water, oil, sediment, air or biota. Samples should be representative, since they are used to quantify the oil, predict its weathering characteristics and to identify the source.

Improper samples or sampling will lead to wrong results and conclusions that will not stand up in legal examination and subsequently laboratory analysis and investigations will become mere wastage. Personnel who are supposed to collect the samples should be given minimum training and practice to do better response in a real spill situation. A sampling plan shall be adopted that will describe the sampling procedures in brief and will ensure that all the required operations are taking place accurately and sequentially without any missing.

Sampling of oil from different environment site, from vessel engine to water body or even from an organism will be required. Also they can be of varied forms mainly of heterogeneous nature some of which are given below.

- Oil, oily water, heavily emulsified oil, tar balls or lumps on the water surface
- Mixtures of oil, sorbents or other materials which are soaked with oil
- Oiled animals on the water surface or on beaches mainly in the intertidal area
- Oil in tanks on ships, offshore constructions or land facilities
- Oily water bilges and slop tanks on ships, offshore constructions or land facilities
- Oily sludge in the sludge tanks on ships, offshore oil installations/ drilling rigs or land facilities.

Sampling equipment shall be pre cleaned to remove any oil residues including finger oils that may mix with the oil collected and interfere with the laboratory analysis. Oil contaminated sampling containers should be Avoided. Sampling equipment if not purchased preleased shall be cleaned with a detergent wash, rinsed with distilled water and then rinsed with solvents like dichloromethane, hexanes. Pre cleaned supplies can be wrapped in aluminum foil to prevent contamination while being stored or transported to the spill.

Table 7.1: Details for Oil Spill Sampling

Sl. No	Sample Type	Sample Container	Quantity of Sample	
1	Oil	Glass Bottle 500 ml Clean. Colored (dark) glass is preferred for water samples. Preferably supplied by laboratory. Top should be sealed with aluminum foil under the cap.	Pure Oil Source Sample	30-50 ml
			Contaminated Oil (Emulsified Oil, oil from the sea or shore, sandy tar ball)	10-20 g
			Debris with oil, oil stained sand	Sufficient quantity that oil content is approx.10g
2	Water		Water sample with visible oil	1 liter
			Water sample with no visible oil	3-5 liter
3	Sediment	Fine: Silt - Pebble	Glass Jar 250 ml Clean. Colored (dark) glass is preferred for water containing samples. Preferably supplied by laboratory. Top should be sealed with aluminum foil under the cap.	
		Coarse: Cobble	Wrapped in aluminum foil Once wrapped they can be stored in plastic bags.	
4	Biota	Glass Jar same as Glass Bottle/ Jar	Oiled feather	5-10 feathers depending on the quantity of oil present
		Wrapped in aluminum foil Whole specimens. Once wrapped they can be stored in plastic bags.	Fish, shellfish (flesh and organs)	Multiple individuals of the same species totaling 30g

A sampling kit may be arranged for this with necessary sampling equipment's as described in the **Table 7.2** given below.

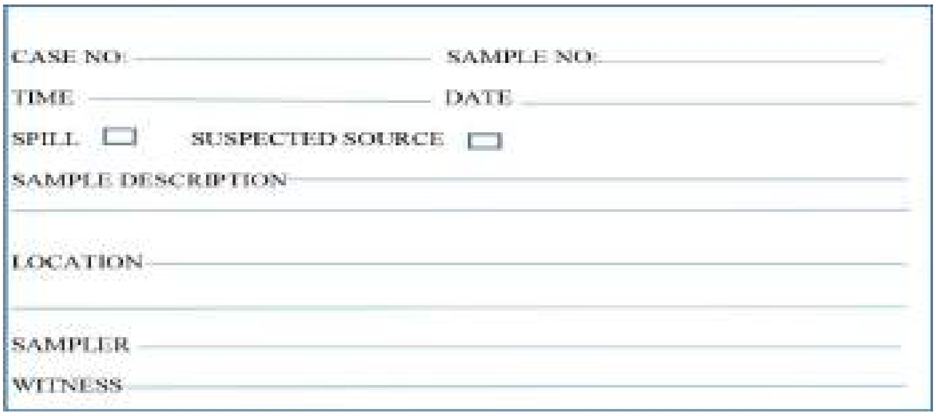
Table 7.2 Components of the Sampling Kit

Sl. No	Item	Details
1	Sample jars (250 ml or other size)	Pre cleaned, Teflon or aluminum cap or Alf oil barrier as required. Plastic should not be used
2	Slick/pooled oil sampling equipment	Wooden spatulas/tongue depressors or stainless-steel spatulas/spoons.
3	Sheen sampling equipment	TFE fluorocarbon polymer nets or small squares of sorbent. Polymer nets or bags with rings and extension poles, TFE polymer sheets of mesh fabric can also be used.
4	Disposable gloves	100% nitrile medical examination gloves
5	Sorbent padding for storage cooler.	
6	Sample storage coolers with pre-frozen freezer blocks.	
7	Waterproof plastic envelope.	
8	Sample identification labels	>1/sample. White Adhesive 5cm to 10cm water and oil resistant
9	Sample Log Sheets.	
10	Chain of Custody Forms.	
11	Decontamination equipment if needed,	
12	Cardboards Shipping Tubes, &Fiber board boxes	(25cm x 25cm x 25cm), For packing sample jars for shipment
	Sorbent material	
	Grease proof plastic bags 50cm x 65cm	
13	Tape for sealing jars, shipment tubes and fiberboard box 2 to 10 cm wide	
14	Towels absorbent cloth or paper, twine	
15	Tongue depressors or pre-cleaned metal scoop	To aid collecting samples of heavy oil or tar Balls
16	Sediment Sampler	
17	Onsite Probes	e.g. DO, Turbidity, Conductivity, Odor, Ambient Hydrocarbon Detector, Multi Wavelength Fluor meter etc.
18	Kit/ Pouch to hold all sampling equipment to spill location	

7.8.1. Sample Identification and Security

Sample identification, labeling and security are very important part of oil spill sampling, especially when it has a forensic value. The sample jar is to be sealed using tape to seal the lid to the jar, before placing the labels on the jar. While placing the labels on the jar, two labels should be kept one for the purpose of sample identification and the other for chain of custody. Writings on the jar should be legible and written using indelible ink. A sample identification label has been shown in **Figure7.1.** Below.

Figure7.1. Sample Identification Label


CASE NO: ____________ SAMPLE NO: ____________

TIME ____________ DATE ____________

SPILL ☐ SUSPECTED SOURCE ☐

SAMPLE DESCRIPTION ____________

LOCATION ____________

SAMPLER ____________

WITNESS ____________

7.8.2. LABELING AND SEALING

All necessary information required for identification of the sample shall be there on the label such as geographic location, signature on suspected source sample from master or crew man, dates sealed and who sealed sample, etc., should be a part of the label.

Case number is a unique number as signed by investigator to help keep track of spills overtime. Sample number stands for serial number given for each sample 1, 2, 3 etc. Sample description used to distinguish one sample from another sample. For water samples the description should have information relating the sample to a fixed point like name of creek, distance from a bridge pier or any other identifiable structure. For sample from suspected vessels, the description should have the name of the vessel and specific location of the sample such as engine oil bilge. Samples taken from a shore facility should include the name of the facility including a city, location of the sample on the facility (IMO).

7.8.3. SAMPLE LOG

For each sampling operation a sample log should be prepared and transferred along with along with sampling jars and kept in safe custody. It should contain all the Available details regarding the sample including the necessary things given below.

A. Sample number or code (Optional, but advisable for multiple sampling at a single location).
B. Sample description (oil, debris, thick slick, film, sediment, air and biotitic).
C. Time and Date (24 hr. Clock, Day/Month/Year).
D. Location (GPS coordinates or other description).
E. Name of person taking the sample.
F. Witness (If a sample for legal purposes).
G. Identification and description of samples and locations.
H. Subcontractor information and name(s) of on-site personnel.
I. Dates and times of sample collections and chain-of-custody information.
J. Records of photographs.
K. Site sketches of sample location including identification of nearest roads and surrounding developments.
L. Calibration results

7.8.4. CHAIN OF CUSTODY (COC)

8. After sampling it is important that samples are to be kept in a person's custody or possession so that either he can see them or they are locked up. The sample description here should be exactly same as that of sample label. All persons who have control of the samples need to sign in the signature part of the COC as well as the chain of custody label on the sample. COC document should be sent with the samples to the laboratory. Format for chain of custody is attached as **Table 7.3**.

Table 7.3. Format for Chain of Custody

Chain of Custody Record			
Organization's name			
Address:			
Spill	Source	Sample no	Description of samples for case no:
Person Assuming Responsibility for Samples			Time/ Date

Chain of Custody Record					
Sample number	Relinquished by:	Time/ date	Received by	Time/ date	Reason for change of custody
Sample number	Relinquished by:	Time/ date	Received by	Time/ date	Reason for change of custody
Sample number	Relinquished by:	Time/ date	Received by	Time/ date	Reason for change of custody

Page of _

7.8.5. HANDLING THE SAMPLES

Samples must be handled, stored and transported with care so that they remain uncontaminated, intact and fit for purpose. Handling procedures should also be documented such that sample integrity can be demonstrated. Containers should be filled as full as possible toe clued air and Avoid vocative losses of light hydro carbons. All samples should be labeled immediately. Labels should not be placed inside the sample container. Labels should be applied to containers after the sample has been sealed. This will allow the container' exterior to be cleaned and dried before the label is attached. While sampling care should be taken that there is no contamination from exhausts of engines or cooling water of sampling vehicles.

7.8.6. Storing the Samples

Samples should be held overnight or for any extended time in a secure room, with in a suitable containerize. a refrigerator. A sample room may be established and a sample room controller may be appointed and log may also be kept for the room. Samples should have a Chain of Custody record attached to track the location and handling of samples. Samples are stored in a cool dark room. Weathering may be accelerated in the presence of heat and sunlight. The samples may be placed in an insulated pouch or Stay of a cooler's closed vehicle is no desirable especially in summer even when a cooler issued. Hence it is better to Avoid such journeys or for the optimum condition i.e., keep the samples in an explosion proof refrigerator at 2 to 7°C. Samples should not be freeze and hence the temperature should be maintained above - 4°C. The preservation methods are given **Table 7.5**below.

Table 7.5. Preservation Methods for Different Types of Samples

Sl. No.	Sample Type	Preservation Method
1	Sediment	Chilled to < 4 °C- but not frozen
2	Oil	Chilled to < 4 °C- but not frozen
3	Soft Marine Fauna/Fish	10 % formalin in sea water Or freshwater if sample is from fresh water
4	Crustaceans/ Fish	Freezing (for large fish and crustaceans)

All areas where samples are handled or stored must be decontaminated before and after use, designated to be NO smoking areas, isolated from combustion engines, exhausts or other sources of hydrocarbon contamination. Samples will be transferred to the sample intake team to be frozen as soon as possible especially for sediment and tissue chemistry samples. Water samples will be analyzed immediately due to holding time limitations, while sediment and tissue samples collected for VOC and PAH analyses will be archived. Sediment samples collected for nutrient analyses will be analyzed within the 28-day holding time. (*MC252OilSpill–Jean Lafitte National Historic Park and Preserve Submerged Aquatic Vegetation NRDA*)

7.8.7. Shipping of Samples

The guidelines for this are laid down by International Air Transport Association (IATA). This ensures safe, intact arrival of samples and prevents damage to other parcels. Packaging and Shipping of the mis regulated under IATA's Dangerous Goods Regulations. Most of the samples belongs to the following to categories Flammable Liquid, packaging group II consists of oils with flash points less than 23°C e.g. gasoline, naphtha and most of the crude oil. Flammable Liquid, packaging group with flashpoints more than 23°C but less than 60.5°C e.g. Kerosene, jet fuels, turbine fuels, No.1 fuel oils etc.

8. OPERATIONS PLANNING

8.1 ASSEMBLING FULL RESPONSE TEAM

Area of operation of this Plan being confined to DPA Port. All responses and actions would get limited to coastal zone and within the estuary.

8.1.1 Crisis Management Team/s (CMT)

The core operational team discharging the functions of incident control, administration and management is designated as Crisis Management Team/s (CMT) operating from the identified control center located in the Port Administrative building.

8.1.2CMG:

Apart, from the designated CMT, another senior level team designated as Core Management Group (CMG), headed by the respective head of DPA, will get activated in times of major spill crisis that may require liaison with senior level state, center authorities or other agencies. The other team members of CMG will be the heads of departments. The functions of CMG will be the same as CMT with a view to provide support to operations in terms of administrative requirements. CMG will assemble on the recommendation of Chief Incident Controller.

This Plan formulates the policies and strategies to be followed in case of a response and to be executed on the ground by CMT along with response team or Oil Spill Response Organization (OSRO).

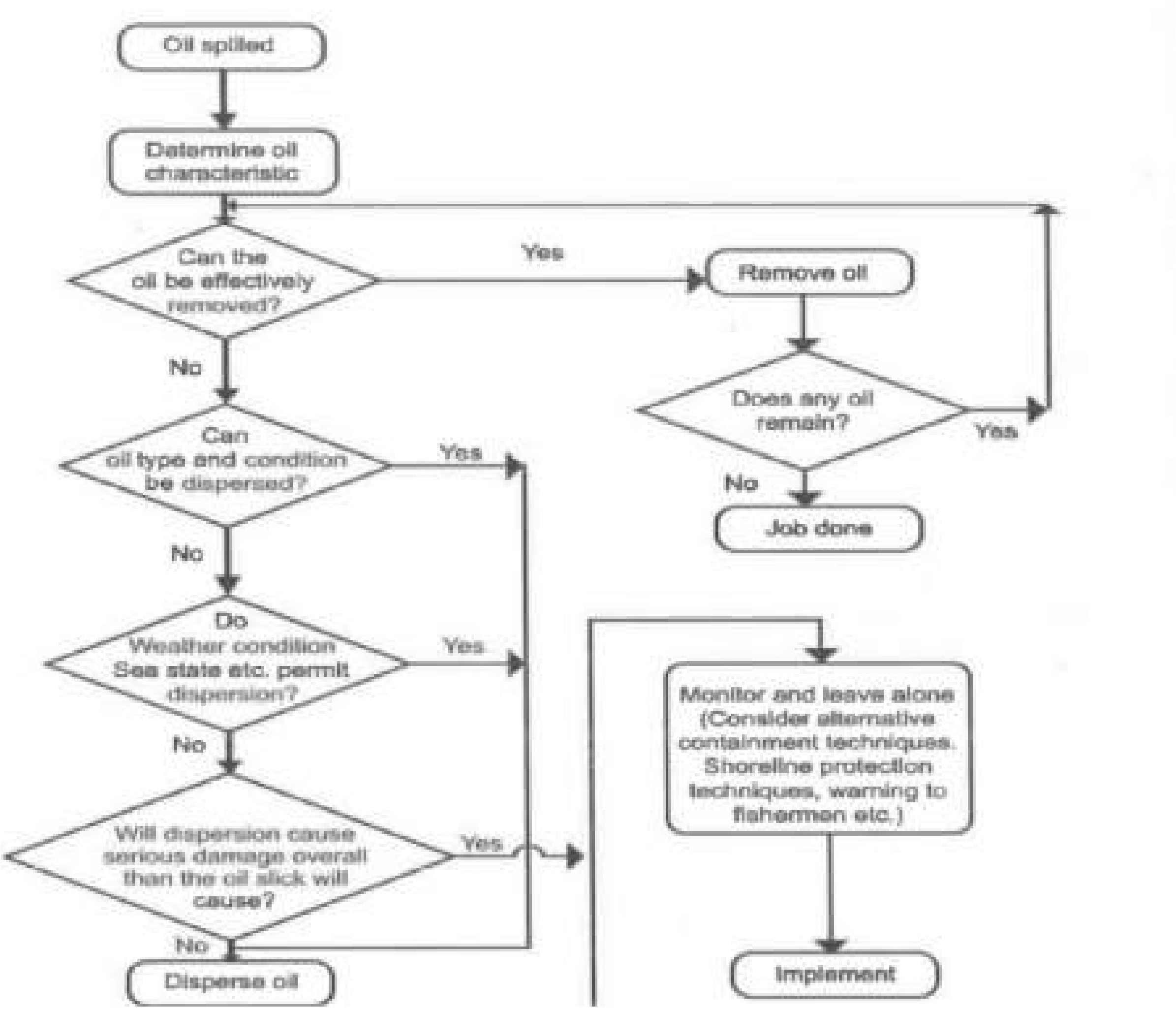
The operational spill prevention provisions of this CP will be discharged by three CMTs - headed by Chief Incident Controller, one each for the area of jurisdiction of DPA, NAYARA, Reliance. Duties and responsibilities of all the three teams would largely remain the same- as spelled in this CP, with additions and amendments undertaken by each team as per operational situation and requirements particular to their area of operation. Each team would be responsible for operations in their respective area of Jurisdiction.

8.2 IDENTIFYING IMMEDIATE RESPONSE PRIORITIES

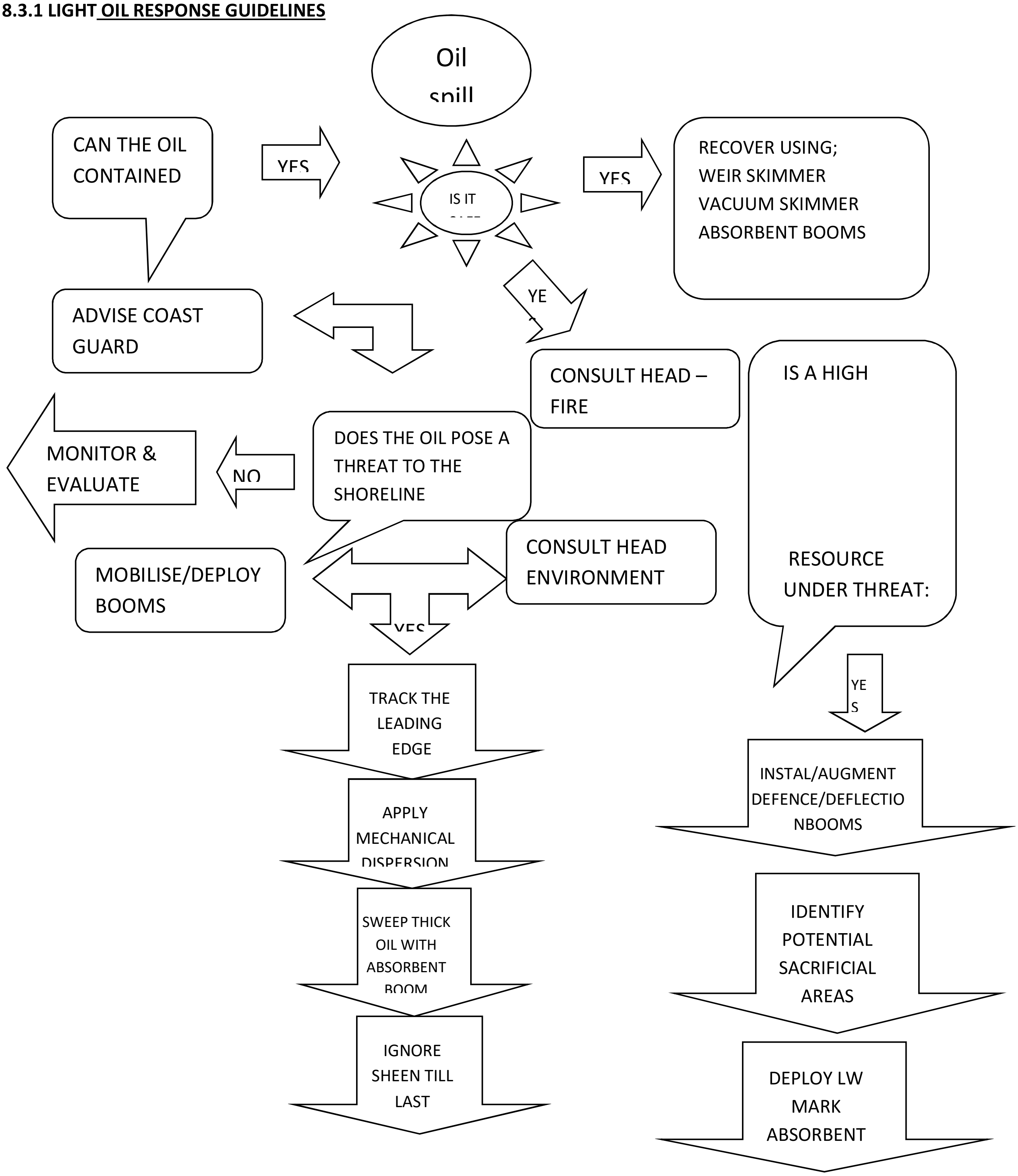
Major actions that would be required to be taken when a spill occurs are mentioned below. While, some actions like containment are required to be initiated immediately following a spill, some actions like shore line clean up etc. will get initiated in due time. The purpose of fast response is to minimize hazards to human health and environment. The following response is accordingly addressed through the Contingency Plan and Operations Manual:

- Stoppage of discharge and containing spill within a limited area.
- Defining size, position and content of spill, direction and speed of movement and likelihood of Affecting sensitive habitats.
- Notification to private companies or government agencies responsible for cleanup actions.
- Movement of trained personnel and equipment to site.
- Initiation of Response activity.
- Ensuring safety of response personnel and public.
- Oil removal and disposal.

8.3 MOBILIZING IMMEDIATE RESPONSE:



8.3.1 LIGHT OIL RESPONSE GUIDELINES



8.4 MEDIA BRIEFING:

Release of Information to media is to be as per 'Media policy' of the respective organization heading the CMT for particular operation. Refer **Annexure-5**

Media Holding Statement (Tier 1 incident)

Timed at:	…………hrs. ………….day		………… Date
At	…………..hrs.	on	………… Date
	…………day		

An oil spill current at (location) …………………

The estimated quantity of oil (state type) spilled is………liters/tones or

The quantity of oil (state type) spilled is not yet known.

DPA KANDLA AND OOT VADINAR has initiated spill response measures and is investigating the cause. The Indian Coast Guard and all other concerned authorities have been informed

NEXT PRESS STATEMENTS AT ……………. HRS IST

8.5 PLANNING MEDIUM-TERM OPERATIONS (24-48 AND 78 HOURS):

The likelihood of oil spill taking place are from two factors mostly, during vessel operations and secondly due to collision.

Since, during vessel operations, OSRO personnel as well as ship's staff present at the site, any mishap taking place could be tackled immediately as reaction time will be very less and damage control could be done very fast. Therefore, quantity of oil spilling into water is expected to be minimum and the spill could be neutralized quiet easily. Here in this case dispersants, sorbents may be used and whole operation is likely not to last more than 24 hours. In fact, OSR items are kept handy in OSRV to use any time.

However, in case of oil spill occurring due to Collision, it is certainly going to be at a higher magnitude. As, when the collision takes place, everybody's attention is likely to be toward safety of the vessel i.e. to Avoid vessel getting grounded, avoid colliding with other vessels, preventive action against fire or carryout firefighting, damage control action against flooding and so on. It is anticipated that in case of collision the oil spill is likely to occur due to rupture of or crack in fuel tanks. It should be clearly understood that

i. In case of rupture of fuel tanks, a sudden gush of oil will be there, and for some time it will be uncontrollable. By the time any effective damage control action is taken, a substantial amount of oil would have already gone overboard. This would necessitate immediate oil containment measures, as well as starting of oil recovery action. This oil spill recovery action may go well beyond 48 hours, keeping weather and sea conditions in mind, because one does not know at what time of the Day or Night accident takes place which will determine the time delay in appreciation of the situation and mobilization of OSR team and equipment. It may clearly be understood that appreciation of oil slick between sunset and sunrise is quite difficult and at times it may be fully incorrect, hence slight time delay may be anticipated. Such accidents don't happen quite often, but very rarely. Hence readiness of OSR team and Equipment shall be maintained at all times.

ii. The oil spill scenario through cracked fuel tank /tanks is not very different than the previous one, because due to cracked/fractured /material failure occurred in the fuel oil tank/tanks, oil would continue leaking in a small /moderate rate. But it would be difficult to locate the source/point of oil leak and by the time source /point of leak is detected, suitable action is initiated and leak is arrested, a sizeable quantity of oil would have already been over board. Detection of oil leak will become more difficult if the crack /fracture develops after some time due Collision related structural stress and ship is secured alongside jetty with the damaged /leaking side situated between shipside and jetty. The problem will become more compounded if the accident takes place after sunset during severe monsoon conditions and detection of oil slick in the night would be really quite difficult. Like above serial (i), here also one cannot deploy OSR men and equipment preciously and reaction time to deploy OSR men and equipment, subsequently recovery of spilled oil is going to take more or less the same time.

Here the vessels taken on consideration are visiting ships of various sizes in all weather conditions but not the minor vessels or tug boats.

8.6 DECIDING TO ESCALATE RESPONSE TO HIGHER LEVEL:

If oil spill is larger magnitude and is beyond spill combating capabilities of DPA KANDLA AND OOT VADINAR, in such case Head DPA KANDLA AND OOT VADINAR in consent with senior management, will inform Indian Coast Guard accordingly and shall provide all further assistance required by ICG.

8.6.1 NEBA May be Considered while deciding to escalate if required. Refer **Annexure -15**

8.7 MOBILIZING OR PLACING ON STANDBY RESOURCES REQUIRED

To be decided by the On-scene commander and Head DPA KANDLA AND OOT VADINAR considering the control on spillage, mitigation progress and weather forecast. It should be borne in mind that mobilization of resources from out stations is a time consuming and cumbersome process, therefore the anticipated arrival time of the Pollution Response Equipment should be calculated well before hand on account of:

(i) Transportation time by rail /road /sea/air.
(ii) Time taken by Custom /Government formalities.
(iii) Time taken in loading/unloading.
(iv) Availability of specialized loading /unloading machineries and accessories.

8.8 ESTABLISHING FIELD COMMAND POST AND COMMUNICATIONS

The OSC will be equipped with VHF (Walkie-Talkie) and mobile phone. The OSR team leaders would also be having hand held VHF sets. (They can also be provided with mobile phones). Therefore, establishing Field Command Post is considered not necessary, unless the spill is of large magnitude.

9. CONTROL OF OPERATIONS

9.1 ESTABLISHING A MANAGEMENT TEAM WITH EXPERTS AND ADVISORS: -

The members of the DPA Executive Advisory Committee are:

NAME	DESIGN.	ALTERNATE	DESIGN
Capt. Pradeep Mohanty	Deputy Conservator	Shri Lalji Meena	Harbour Master
Shri A. Ramasamy	Chief Operations Manager	Shri Narendra Naik	ME Gr-I
Shri B Ratna Shekhar Rao	Traffic Manager	Shri Sudipto Mukherjee	Sr. Dy. Traffic Manager
Shri Sushil Chandra Nahak	Chief Mechanical Engineer	Shri Rajdeo Kumar	ME Gr-I
Shri B. Bhagyanath	FA&CAO	Shri Hitesh Thakkar	Dy. CAO

9.2 UPDATING INFORMATION (SEA/WIND/WEATHER FORECASTS, AERIAL SURVEILLANCE, BEACH REPORTS):

VTMS, (Port Control) is entrusted the responsibility of providing initial information pertaining to wind direction & speed, water current, tide position at the time of oil spill, high water & low water timings, sea condition, swell /wave heights, weather forecasts & existing weather warning, navigational warnings, any Coast Guard or Naval aircraft or helicopter sighted /in contact, any other relevant information Available. The moment information about OIL SPILL is received all these data / information is to be provided to ECR. This information is to be automatically updated as and when received. Regular inputs must be obtained from local sources regarding health of the surrounding coastal areas.

9.3 REVIEWING AND PLANNINGOPERATIONS:

The ongoing operations should be assessed and reviewed as and when the ECT considers it necessary or suggested by OSC. This is necessary to upgrade the level of operations or scale down the operations due to different prevailing factors /compulsions. Review of operations is an ongoing process and accordingly the planning is to be reoriented to maximize the utilization of men and machinery without compromising on safety of both. Here operational rest to men and machinery should also be kept in mind because response teams can be rotated at regular intervals but continuous running machinery also needs rest after certain stipulated continuous running hours.

9.4 OBTAINING ADDITIONAL EQUIPMENT, SUPPLIES ANDMANPOWER

The equipment maintained on the vessel will be the first to be deployed for containment and would be augmented by movement of additional equipment as required by the situation. In the event of a decision being taken by the team managing the spill, the equipment held with the participating units will be made Available to response teams.

In the event of an ongoing spill or a spill that requires declaring of Tier 2 or 3 responses, the additional equipment and manpower held with any other OSRO or facility will be sourced in an accelerating manner including resourcing from the international spill handling companies. Contact details of companies holding equipment in India and International OSROs are as follows:

9.5 PREPARING DAILY INCIDENT LOG AND MANAGEMENT REPORT:
To maintain detailed daily log of activities undertaken by OSR Manager / Responders/Control Room and their team including deployment of equipment, advice rendered or demands rose. The log is to mention action taken daily (in narrative form) and observations made as per **Annexure-16 & 17.**

IC/ OSC / VESSEL MASTER DAILY LOG

INCIDENT TITLE: ------------------------------------- NUMBER-------------------------------------

----

DATE:

Incident Severity – Minor / Major / Tier I / Tier II / Tier III

1. RESPONSE RESOURCES AVAILABLE

VESSEL BOAT

EQUIPMENT

2. ACTION INITIATED

CONTAINMENT

EQUP DEPLOYED

POLLUTION COLLECTED AND DISPOSED TODAY

TODAY TONS: ----------------------

TOTAL TONS: ------------------------

3. REPORTING AUTHORITY (DESIGNATION)

9.6 PREPARING OPERATIONS ACCOUNTING AND FINANCING REPORTS:
This will be done by Finance and Legal Department. As one of their members is always in the ECR they would find it easier to take stock of the situation and prepare the accounts and reports on a day-to-day basis.

9.7 PREPARING RELEASES FOR PUBLIC AND PRESS CONFERENCES:
Information to media is to be released by the person identified through respective Media policy of the organization. In the event of non-authorization of any one person, the Media release will be made by CIC or by a person nominated by him after authorization by head of the Organization.
The daily report of actions taken on a particular day as prepared by COC and OSC is to be shared with the person nominated to brief the media. Each press brief is too cleared by CIC prior being provided to media.
While, providing factual details and information to media assists in passing the situational report to public likely to be affected by a spill, it is advisable not to sensualist the information with unwanted figures or actions that could shock or distress the public.
Most of the factual information like precautions required by public to be taken with respect to fishing activity, closure of beaches, demand for beach cleaning volunteers could be disseminated through media.

9.8 BRIEFING LOCAL AND GOVERNMENT OFFICIALS:
Consequent upon releases cleared by Chairman, local and government officials are to be briefed by the PRO or any other person authorized to do so.

10. TERMINATION OF OPERATIONS

10.1. DECIDING FINAL AND OPTIMAL LEVELS OF BEACH CLEAN-UP

The coastal stretches off DPA are varied in terms of ecological sensitivity; with large stretches of mangroves inter spread with sandy beaches and rocky shores. DPA harbor estuary shows differences in physical environment, the degree of exposure to waves and energy levels and currents. Geomorphic features like the terrain greatly influence the distribution and persistence of oil.

While, the first priority would be to stop the ingress of oil onto the coast, still the requirement of coastal or beach cleaning operations cannot be ruled out. The local administration being responsible for shore cleaning activity is to be notified in time about the movement of spill and advised about the strategy to be adopted.

Tactical beach cleaning ops are to be conducted as per the physical properties of the terrain with respect to retention of oil. Operations are to be guided as per OPERATIONAL MANUAL parameter.

10.2. STANDING-DOWN EQUIPMENT, CLEANING, MAINTAINING, AND REPLACING

Once the Pollution Response Operations are over, the equipment and machineries are to be accounted for, consumables are to be accounted for, checked for their serviceability and then stored in their respective places.

All equipment and machineries are to be thoroughly washed with fresh water as per the OEM‟s guidelines, necessary maintenance carried out and then equipment is to be secured.

10.3. PREPARING FORMAL DETAILED REPORT

After the operations are complete, the OSC will prepare a detailed report covering all the aspects of the oil spill cleanup, which will include success and failures as well, lesson learnt recommendations about equipment, man power, plans etc. The report will be forwarded to Deputy Conservator for submission to ECT.
Detailed report for the incident will be prepared by Head-DPA KANDLA AND OOT VADINAR as per prescribed format.

INVESTIGATION

Every oil pollution incidence is followed by investigation both by the Company as well as Nodal agencies
In order to assist such investigations complete and accurate records, as specified below, shall be maintained,

a. Certificates and records of equipment issued by regulatory authorities,
b. Log Book showing weather and details of the incidents,
c. Chronological record of loading / discharging bunkering including agreed plans of such loading / discharging / bunkering,
d. Brief report on spill including:
    i. Time,
    ii. Location,
    iii. Cause and Type of oil.
e. Samples of spilled oil shall be taken as per procedures described g) Estimate of amount spilled and the process of such estimation,
f. Copies of notification & update reports,
g. Record relating to direction and rate of spread,
h. Weather reports and recorded weather in log book and
i. Where possible photographic evidence shall also be collected. Such photographic records shall be identified with date, time and location.

Where any original evidence is demanded by Nodal Authorities, photocopies of such evidence be retained and the concerned authority shall request to certify the same as true copy of the original

10.4 REVIEWING PLANS AND PROCEDURES FROM LESSONS LEARNT:

Contingency Plan being a sequence and layout of dynamic operating procedures and parameters is subject to revision due changes in operational parameters of port, cargo, equipment innovations and changing response strategies. Exercises and real time drills being operational tasks might also necessitate a review of plan to be undertaken to incorporate the observations made, apart from the above mentioned.

Accordingly, a study in detail of observations made during every response operation would be undertaken by CMT with a view to incorporate the observations into the Plan for easy and flaw less implementation.

ROLES AND RESPONSIBILITIES OIL TERMINAL LIMITED (DPA KANDLA AND OOT VADINAR)

DPA KANDLA AND OOT VADINAR has responsibility for dealing with oil spills which occur within the Marine Terminal Local Area.

Responsibility for management of the response remains with DPA KANDLA AND OOT VADINAR unless the slick migrates outside the Local Area or more than 500 meters from the spill source/marine facilities of the company. In the event that the oil migrates to the port area administered by Deendayal Port AUTHORITY, the AUTHORITY will assume responsibility for leading the pollution response.

Should the spill migrate to other areas, or to other areas in addition the Deendayal Port AUTHORITY harbour area, the Coast Guard Monitor will assume the position of On Scene Commander and will direct the response effort. In both cases, DPA KANDLA AND OOT VADINAR will act and deploy their resources as required by the relevant On Scene Commander.

Deendayal Port AUTHORITY (DPA)

The Statutory Port Authority responsible for administering the area embraced by the
Deendayal port AUTHORITY limits. The IOC Terminal along with DPA KANDLA AND OOT VADINAR Marine facilities at Vadinar is located within the port limits.

Indian Coast Guard (ICG)

The Indian Coast Guard has a statutory duty to protect the maritime and other national interests of India in the Maritime Zones of India and to prevent and control marine pollution. Coast Guard is also the Central Co-ordination Authority for marine pollution control in the country. The Indian Coast guard is responsible for implementation and enforcement of the relevant marine pollution laws.

The coast guard will assume the role of On-Scene commander in the event of oil spill exceeding the capability and jurisdiction of DPA (Deendayal Port AUTHORITY)

Gujarat Pollution Control Board

The Gujarat Pollution Control Board is responsible for, and controls, waters up to 5 km from the shoreline. They require to be advised of all pollution incidents.

Gujarat Maritime Board

Gujarat Maritime Board is required to be informed of all pollution incidents; however, DPA KANDLA AND OOT VADINAR facility is not under the jurisdiction of GMB.

Ministry of Environment, Gujarat

The Ministry requires to be informed of all pollution incidents.

Oil Industry Safety Directorate (OISD)

OISD is required to be informed of all oil spill incidents.

Oil Pollution Management cell

Pollution Management Cell (PMC) is the nomenclature used to describe the command-and-control team established for a spill incident within the Marine Terminal Local Area.

The PMC will convene at the MTCB, under the chairmanship of the Head -DPA KANDLA AND OOT VADINAR and will consist of a Management Team and a Support Team.

Nearest Bird Handlers Details:

1. Nature Conservation society, Lakota Nature club Jamnagar,
Contact no. +919377526667, +919879516990

2. "Sir Peter Scott Bird Hospital", Saat Rasta, Jamnagar, Contact No. 7574000108.

11 HEALTH AND SAFETY PLAN

11.1 Introduction

Full account must be taken of the health and safety requirements for all personnel involved in oil spill response activities. The site-Specific Health and safety Plan Assessment Form list site characteristics, site hazards and personnel protective equipment and site facility needs. This plan is intended to act as an aide–memoir to ensure that all applicable health and safety requirements are considered and appropriate action are taken.
The applicable requirements noted in the **Company's HSEF Procedures** must also be observed.
Following Section gives guidance on specific oil spill clean-up tasks and hazards.

11.2. SITE HAZARDS

11.2.1. Bird Handling

Handling or birds must be undertaken by properly trained personnel to ensure the protection of both bird and handler; wild birds have no way of understanding human intentions. Even a greatly weakened bird can inflict serious injury to handlers, especially to their eyes. Open wounds on hands and arms from such injuries can present opportunities for oily contaminants and disease to enter the handler's blood stream.
Handling of oiled birds is usually best left to experts, or to volunteers who have received some training. Chasing and man handling birds puts them under additional stress.

11.2.2. Equipment Required:

a) thick gloves (able to withstand nasty pecks),
b) Overalls
c) Safety footwear
d) Cardboard Box with lid of a suitable size to give the bird some room for movement
e) Goggles to protect eyes,
f) Optional long – handled net to help catch bird

11.2.3. Procedures:

a) Do not let the bird get close to your head, as it may try to peck your eyes.
b) Catch the bird by hand or with the aid of a long-handled net. Do not put the birds under any more stress than necessary. Only attempt capture if it can be done quickly and efficiently.
c) Hold the bird with both hands to hold the wings in.
d) Put the bird in a cardboard box lined with absorbent material (e.g. newspaper), with a lid.
e) Do not wrap the bird up in anything it may get too hot and too stressed.
f) Take the bird to a cleaning station as soon as possible. Let them know where and when the bird was caught.
g) Keep a note of all birds caught and sent to cleaning station. Make a note of species if possible.

11.2.4. Tug & Work Boat Safety

a) Boat operators must familiarize themselves and passengers with safety features and Equipment on their boats.
b) Boats must be operated by qualified individuals.
c) Lifejackets must be worn by personnel on boats.
d) Use of cold-water immersion suits is particularly critical under conditions of cold stress.
e) Boats should generally not be used after sunset for oil recovery. If this is required or poses minimal risk, areas of operation should be carefully prescribed, and individual boat operators should maintain a communication schedule with a shore base. Each boat should be fully equipped with appropriate navigation lights.
f) Distress signals should be carried on all vessels.

g) Boat operators must keep their supervisors informed of their area of operation, especially when they change their work area (if plans call for a boat to move to another location during a shift, the operator should advise the supervisor of his actual time of departure)

h) Portable fuel tanks should be filled outside of the boat. All sources of ignition in the area of refuelling should be isolated.

Personnel working in or operating boats should wear appropriate non-slip footwear.

a) Fixed ladders or other substantial access/egress should be provided at boat transfer locations from low water line to platform.

b) Workers should be cautioned about using their arms or legs to fend off during berthing or getting their hands, arms, or legs between vessels and docks or fixed structures.

11.2.5. Chemical Hazards

Attach appropriate Material Safety Data Sheets for all hazardous substances likely to be used at a spill site.

11.2.6. Cold Stress

Cold stress can occur among responders as a result of prolonged exposure to low environmental air temperatures or from immersion in low temperature water. It can lead to a number of adverse effects including frostbite, chilblain and hypothermia. This single most important aspect of life-threatening hypothermia is the fall in the deep core temperature of the body.

11.2.7. Drum Handling / Manual Handling

Drum handing at a spill site will primarily involve drums of waste and contaminated clothing. Several types of drums and containers may be used ranging from 25 to 200 litters in size. All drums and containers must be properly labelled. If in doubt as to the contents of a drum – seek advice.

Manual lifting and moving of drums should be kept to a minimum. A guide to manual handling is as allows:

(a) Wear gloves.
(b) Assess the weight of the load and get help if it is beyond your capability.
(c) Where appropriate, use mechanical aids provided.
(d) Size up the job – remove any obstructions; note any snags and make sure there is a clear space where the load has to be set down. Ensure that you can see over the load when carrying it.
(e) Look out for any splinters, projecting nails or sharp edges or wire.
(f) Stand close to the object and with your feet 20 to 30 c apart, place one foot in advance of the other, pointing in the direction you intend to move.
(g) Bend your knees to a crouch position, keeping your back straight.
(h) Get a firm grip at opposite corners of the load with the palm of the hand and the roots of the fingers, arms as close to the body as possible.
(i) Lift with your thing muscles by looking up and straightening your legs.
(j) Bend your knees to a crouch position, keeping your back straight.
(k) Get a firm grip at opposite corners of the load with the palm of the hand and the roots of the fingers, arms as close to the body as possible.
(l) Lift with your thigh muscles by looking up and straightening your legs.

AIR TEMPERATURE CELSIUS

Relative Humidity	21º	24º	26º	30º	32º	35º	38º	40º	44º	46º
20%	19º	22º	25º	28º	31º	34º	37º	41º	45º	49º
40%	20º	24º	26º	30º	34º	39º	*44º	*51º	**58º	**66º
60%	21º	25º	28º	32º	38º	*46º	**56º	**65		
80%	22º	26º	30º	36º	*45º	**58º				
? Heat cramps or exhaustion likely. Heat stroke										

12. Response to HNS Incidents

12.1. RESPONSE OPTIONS

In many cases, particularly if the release involves a chemical that evaporates or dissolves rapidly, it will not be possible to physically contain or recover the spilled product from the sea. In these cases, the response options may be limited to monitoring and measures designed to mitigate the potential hazards, for example communication to advise local residents to remain indoors or prohibition of fishing.

Following the identification of the hazards posed by the release, including consideration of the effects of fire and potential reactivity, the response operation must evaluate which techniques can be used. It is important to rapidly establish which response techniques are feasible in order to reduce or if possible, eliminate the impacts of the hazardous substance on humans and the environment.

In most chemical incidents the rapid communication of relevant information, both internal and external to the response activities is likely to be the most important action that response agencies need to carry out. The polluter will, therefore, maintain continuous liaison with the chemical/ HNS manufacturer and repositories of data (such as the French Centre of Documentation, Research and Experimentation, or CEDRE) regarding HNS properties and response and promptly provide such data to the responders.

12.2. MONITORING

Many chemical spills will be difficult or impossible to observe with the naked eye and it is essential that an appropriate monitoring strategy is put in place to ensure the safety of responders and to confirm predictions of the spread and dispersion of the slick. The type of monitoring implemented will depend on the specific properties and hazards posed by the substance involved.

12.2.1 MONITORING GASES IN AIR

It is essential to systematically monitor the concentrations of chemicals in air throughout any incident involving gases or vapors. Key aspects of monitoring include:

- **Oxygen concentrations** any atmosphere having <19.5% oxygen i.e., an oxygen-deficient atmosphere, should be entered only by personnel wearing self-contained breathing apparatus, monitoring is carried out using oxygen cells.
- **Combustible or explosive gas levels** to identify areas where flammable air/fuel mixtures exist; a value below 10% of the Lower Explosive Limit may be considered safe. Typical instruments are combustible gas detectors and explosion meters. Continuous monitoring must be carried out as the situation and the concentration of gas can change rapidly raising the value over 10% LEL.
- **Toxic substances** to identify areas where toxic substances are present and to establish safe outer limits where it is reasonably safe for unprotected personnel. Instruments must be capable of measuring at ppm level and include gas detection tubes, flame ionization detectors, photo- ionization devices, IR trace gas detection (these instruments typically provide only approximate levels) and portable gas chromatographs and portable mass spectrometers (these instruments typically require specialist personnel to operate them).

12.2.2 MONITORING THE WATER COLUMN

Monitoring the concentration of chemicals in the water column typically involves two main techniques:

- **Collecting water samples** – these are then transferred for analysis at fixed or mobile laboratories;
- **Use of towed probes** – a number of monitoring devices can be towed through the water column to establish the extent of a slick and to provide real-time data. Typical measurements include: pH, light absorption, electrical conductivity.

12.2.3 MONITORING SURFACE SLICKS

Thin films on the sea surface can damp capillary waves. A number of techniques have been developed that make use of the altered properties of the sea surface:

- **Side-Looking Airborne Radar** (SLAR) makes use of the reduced intensity of the backscatter and the surface slick appears as a darker area on the SLAR image;
- **UV scanners** can identify changes in the UV reflectivity of the sea surface;
- **IR scanners** and **Forward-Looking Infrared Imagers** (FLIR) identify changes in the radiation Temperature of the sea surface.

The effectiveness of these techniques differs depending on the properties of the chemical involved and the environmental conditions. Understanding the Available resources and their applicability is a key part of the contingency planning process.

12.2.4 MONITORING SUNKEN SPILLS

When a pool of liquid chemical collects on the seabed, there will be a phase boundary between the chemical and the sea water. It may be possible to use echo sounders to locate this phase boundary and hence to identify the area affected by the spill. Monitoring of the concentration of the spilt substance at different depths may also be useful to delineate the area affected.

12.3 RESPONSE TECHNIQUES

12.3.1 RESPONSE TO GASES AND EVAPORATORS

Plume modeling, air monitoring and defensive strategies such as water sprays are commonly used to respond to gas leaks. When applied as a fine droplet, i.e., as a mist and in calm conditions, they can:

- knock down water soluble gases;
- stop, steer or disperse sparingly soluble or insoluble gas clouds;
- Reduce the risk of fire and explosion in flammable clouds of gases, by cooling hot surfaces, putting out sparks and suppressing flame formation.

When applying water sprays, it is also important to be aware of consequences such as high volume waste streams and, in extreme cases, contributing to the instability of the vessel.

12.3.2 RESPONSE TO FLOATING CHEMICALS

A chemical that floats on the water surface will spread and form a large contact surface with the air. Depending on its vapor pressure, it may evaporate and give rise to a vapor cloud above the slick. Monitoring of air concentrations is important in these situations to assess fire and explosion risks and health risks. The selection of response technique must also take account of these hazards and the overall objective of the response. It is possible to attempt to contain and recover spills of floaters, but only of those substances that evaporate or dissolve slowly i.e., category F substances. Typical techniques involve:

- **Covering the slick with foam** – for flammable substances, this reduces evaporation and hence reduces possible fire and explosion risks (taking care to use the type of foam appropriate to the chemical involved).

It also restricts spread over the water surface and hence can increase the effectiveness of containment and recovery operations. In this case, consideration must be given to the toxicity of the foam to marine life.

- **Application of sorbents** either loose, as mats or in "sausages". As many low viscosity chemical spills rapidly spread to cover a large surface area, these techniques are most applicable if the spread of the chemical can be confined.
- **Bubble curtains** created by releasing compressed air through a perforated hose may be used to contain floating slicks in shallow, slow-flowing waters.
- **Conventional oil spill response booms and skimmers** may be used to contain and recover spills of floating chemicals. The effectiveness of these techniques depends on the physical properties of the substance involved, as the equipment may not be able to deal with the thin films and low viscosity of some floating chemicals. Compatibility of the equipment with the chemical must also be considered.

12.3.3. RESPONSE TO DISSOLVED CHEMICALS

The potential to contain and recover spills of chemicals that dissolve is extremely limited. Response techniques are generally restricted to forecasting their spread, monitoring and mitigation of their effects. In the case of spills in shallow or confined waters, treating agents can include:

- Neutralizing agents;
- Flocculation agents
- Oxidizing agents;
- Reducing agents
- Gelling agents
- Activated carbon; and
- Ion exchangers.

In practice though, the use of these treating agents is often ineffective as the dosage is difficult to estimate and recovery of the substance may be difficult. Curtain barriers may also be used to contain dissolved chemical spills in shallow and almost stagnant waters. Response to sunken chemicals must consider not only the recovery of the chemical itself, but the removal and treatment of contaminated sediments. The principal technique is that of dredging.

12.4 HNS RESPONSE EQUIPMENT INVENTORY

It is submitted that no HNS being handled at KANDLA. No HNS Inventory held with port however, if at all an importer handling agent has been instructed to maintain required equipment as per MOU/Permission granted for handling.

12.5 DISPOSAL

Before commencing any actions that may lead to the recovery of spilled chemical, it is essential that an appropriate and legal disposal route has been identified for both the recovered chemical and any waste generated. Even temporary storage must take proper account of the physical properties of the chemical and its potential to evaporate or leak. Waste streams may be subject to transportation regulations covering hazardous waste, so relevant national regulations must be identified.

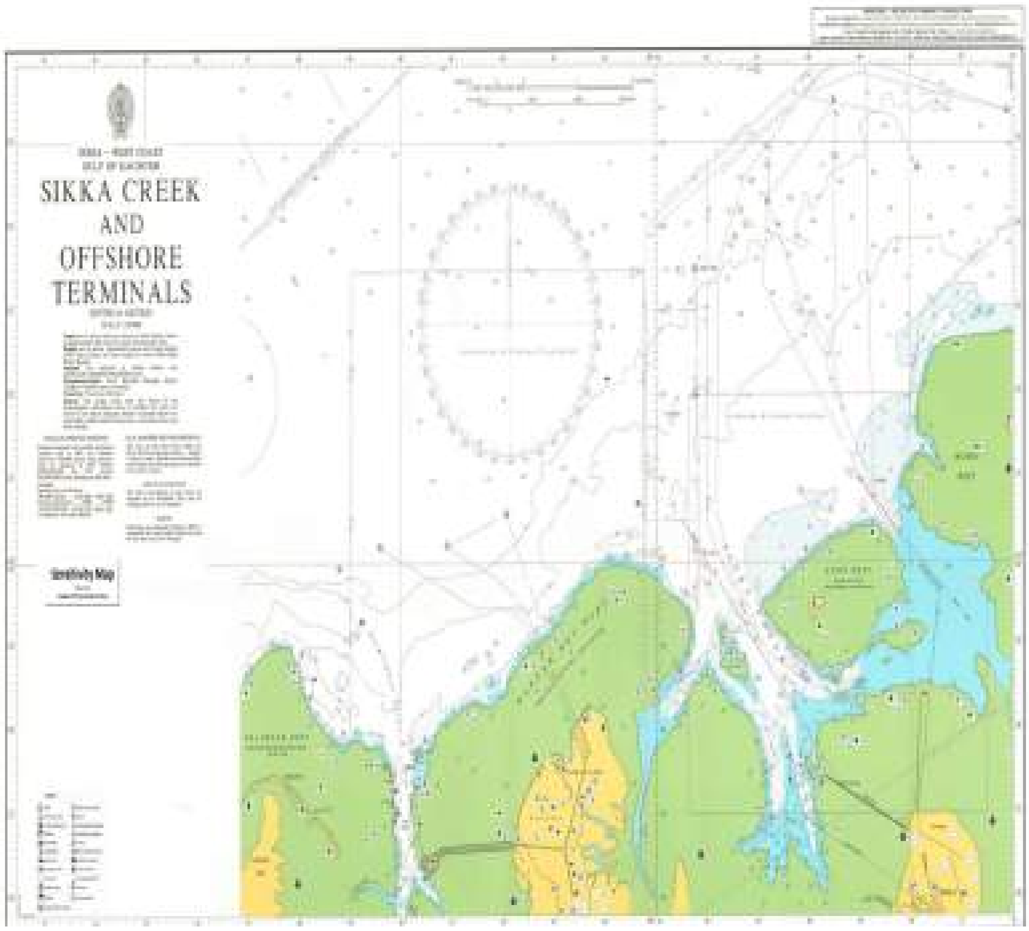
NOTE: It is submitted that no HNS being handled at OOT Vadinar.

PART – III

DATA DIRECTORY

COATAL CHARTS, TIDAL INFORMATION, CURRENTS (RANGES AND STREAMS) PREVAILING WINDS

1.1COASTAL CHART:



REPORTS, MANUALS, MAPS, CHARTS AND INCIDENT LOGS.

A copy of the relevant manual is kept with DPA Office at Vadinar. Maps/charts of creak & the Costal Charts, currents, tidal information prevailing wind are Available with survey section of port.

1.1.1. COASTAL FACILITIES, ACCESS ROADS.

DPA includes jetty area and oil terminal. The distance between these two is about 500 m. These terminals are connected by road as well as by sea.

1.1.2. TIDAL INFORMATION

The dominant tide in the DPA KANDLA AND OOT VADINAR is the semi-diurnal tide with a period of 12 hours and 40 minutes. The following are the particulars of tidal levels related to Chart Datum.

Month	High Tide		Low Tide	
	Max	Min	Max	Min
January	5.87	4.11	2.45	0.15
February	5.89	4.04	2.50	0.29
March	5.77	3.75	2.35	0.43
April	5.74	3.79	2.16	0.31
May	5.72	3.94	2.05	0.32
June	5.62	4.17	2.19	0.41
July	5.76	4.37	2.34	0.30
August	5.90	4.28	2.37	0.22
September	5.90	4.08	2.28	0.31
October	5.90	3.89	2.15	0.13
November	5.84	3.79	2.07	0.16
December	5.68	3.82	2.29	0.32

YEAR	**Tide (Mtrs.)**	
	Max.	Min.
2015	7.27	-0.02
2016	7.27	-0.02
2017	7.19	-0.16
2018	7.25	-0.06
2019	7.25	-0.02

The dominant tide in the DPA KANDLA is the semi-diurnal tide with a period of 4 years 2015-2019 The following are the particulars of tidal levels related to Chart Datum.

1.1.3. CURRENTS:

The currents in DPA and the near shore zones are tide induced with reversal at high and low waters. The current strength ranges from 1.5 to 3 knots.

Current speeds and directions within the Bay and associated tributaries are largely due to the tidal movements and show little variation from non-monsoon to monsoon. The maximum current speed in the outer Bay exceeds 1 m/s and the variation in the water column at any given time is not significant.

Lateral variations in the speed however occur with current in the eastern area being somewhat stronger. The maximum current speeds decrease in the inner creek and are typically around 8.0 m/s, decreasing markedly during neap tide.
As characterized for a tide dominated system, the alongshore components are fairly strong with the dominance of seaward component while cross shore components are relatively weak. Their relative magnitude and directions are indicative of net seaward movement over a tidal cycle though shoreward drift can be significant around the change of tide.

Excursion lengths and Average current speeds observed for the Bay based on the Available drogue trajectories are as per table below:

YEAR	WAVE LENGTH PATTERN AT OTP	
	Significant wave length	Maximum wave length
2015	2.20 mt.	3.70 mt.
2016	2.20 mt.	3.70 mt.
2017	2.20 mt.	3.70 mt.
2018	2.20 mt.	3.70 mt.
2019	2.20 mt.	3.70 mt.
2020	2.20 mt.	3.70 mt.

October	6.5
November	6.2
December	6.5
Total / Average	6.4

Table 15

1.1.4. WIND:

General direction of wind is from the North to the West Quarter, with seasonal variations as shown below:
Seasonal wind Variations

YEAR	Wind Speed	
	Max.	Avg.
2015	46 KMPH(July)	9 KMPH
2016	36 KMPH(June)	9 KMPH
2017	32 KMPH(July)	9 KMPH
2018	32 KMPH(April)	9 KMPH
2019	34 KMPH(July)	9 KMPH
2020	39 KMPH (JULY)	10 KMPH

Month	Wind speed max (Km/hrs.)	Wind speed min (Km/hrs.)
January	28.00	4.00
February	22.00	2.00
March	22.00	2.00
April	22.00	4.00
May	28.00	6.00
June	32.00	8.00
July	38.00	10.00
August	28.00	4.00

September	24.00	4.00
October	14.00	2.00
November	16.00	4.00
December	34.00	4.00
Total/Average	25.66	4.5

Table 16

The physical and chemical characteristics of spilled oil change almost immediately when spilled in the marine environment due to evaporation, dispersion, emulsification, dissolution, oxidation, sedimentation and biodegradation. All of these processes that set in together are collectively referred to as oil weathering and decide the final fate of spilled oil and quantities that would need to be removed physically. An uncertainty in a trajectory fore-cast builds over time due to these processes that the spilled oil goes through.
If the oil is persistent and does not vaporize immediately or disperses and comes ashore, then the costs in terms of cleanup, damages and economic loses can be considerable.

1.1.5 POINT SYMBOLS FOR BIOLOGICAL RESOURCES

Refer **Annexure -12**

2. Risk Locations and probable fate of oil

The Following are the Risk Locations near/vicinity of DPA KANDLA, Gujarat

1) Mangroves inside / Surrounding Port Area
2) Sathsaida bet, consist of 10 sq. Km mangroves & marshy area.
3) IFFCO Intake
4) Fishermen hutments & Basti & fishing boat parking area north of Dry Dock
5) Salt pans
6) Flamingo flat

The Following are the Risk Locations near/vicinity of DPA OOT VADINAR, Gujarat

1) Marine National Park
2) Marine Sanctuary
3) NAYARA Refinery Intake
4) Mangroves
5) Salt pans
6) Forest Areas

The physical and chemical characteristics of spilled oil change almost immediately when spilled in the marine environment due to evaporation, dispersion, emulsification, dissolution, oxidation, sedimentation and biodegradation. All of these processes that set in together are collectively referred to as oil weathering and decide the final fate of spilled oil and quantities that would need to be removed physically. An uncertainty in a trajectory fore-cast builds over time due to these processes that the spilled oil goes through.
If the oil is persistent and does not vaporize immediately or disperses and comes ashore, then the costs in terms of cleanup, damages and economic loses can be considerable.

OIL THICKNESS AND APPEARANCE OF SLICK:

Oil slicks form very thin films on open water. Depending on the properties of the product, the thickness can range from a tenth of a micron to hundreds of microns. The color of oil film post spreading is a good measure of quantity of oil that may be contained within the slick.

When direct light from the sun contacts a very thin oil film (<0.1 micron; µ), much of the light is reflected back to the observer as gray or silver sheen.

If the film is thicker (0.1 to 3 µ), the light passes through the film and is reflected off the oil-water interface and back to the viewer. The observer will then see a film that can range from rainbow to darker-colored sheens.

For very thick films (> 3 µ), the light is absorbed and the slick appears dark- colored (i.e., black or brown) to the observer. However, the viewer can no longer deter- mine film thickness based on color. If the slick is dark-colored, the observer cannot tell whether the film is 3 µ or 100 µ thick.

In order to quantify oil thickness, the following is used as guidelines

Appearance	Thickness
Silver Sheen	0.0001mm
Rainbow sheen	0.003 mm
Light brown/ Black slick	0.1 mm
Dark brown/ Black slick	more than 1 mm

To determine an approximate quantity of spilled oil, the following formula is used:

L (Length of slick) meters X W (Width) X Thickness (mm) = Cubic meters100

The extent of spread in terms of length and breadth along with % of area showing a particular color as per thickness can be used for calculation of quantity of spill through spill calculation software. Calculation of spill quantity as per slick characteristics are placed at **Annexure-12**

3. Shoreline Resources for priority Protection Held At DPA KANDLA AND OOT VADINAR:

ANTI – POLLUTION RESOURCES (Local Area) DPA KANDLA AND OOT VADINAR are placed at **Annexure-7&19**

3.1 LIST OF REFINERIES

Refer **Annexure -8**

4. Shoreline Types:

SHORELINE TYPES AND RANKING

Vulnerability index of shores in order of increasing vulnerability to oil spill damage as per Gundlach and Hayes 1978

1. Exposed rocky headlands	Wave reflection keeps most of the oil offshore. No cleanup necessary.
2. Eroding wave- cut platforms	Most oil removed by natural processes within wave swept weeks.
3.Fine-grained sand beaches	Oil does not usually penetrate into the sediment, facilitating mechanical removal if necessary. Otherwise, oil may persist several months. (Some evidence suggests that penetration can occur)
4. Coarse-grained beaches	Oil may sink and/or be buried rapidly, making clean-up difficult. Under moderate to high-energy condition, oil will be removed naturally from up difficult. Under moderate to high-energy conditions, oil will be removed naturally from most of the

	beach face. Most oil will not adhere to, nor penetrate into, the Compacted tidal flat. Clean-up is usually unnecessary

5. Mixed sand and gravel beaches Oil may penetrate the beach rapidly and become buried. Under moderate to low energy conditions, oil may persist for years.
6. Gravel beaches same as above. Clean-up should concentrate on high-tide/swash area. A solid asphalt pavement may form under heavy oil accumulations.

7. Sheltered rocky coasts	Areas of reduced wave action. Oil may persist for
8. Sheltered tidal flats	Concentration is very heavy.
9. Salt marshes/mangroves	Areas of great biological activity and low wave Most productive of aquatic environments. Oil may persist for years. Cleaning of salt marshes by burning or cutting should be undertaken only if heavily soiled. Protection of these environments by booms or absorbing material should receive first priority

5. Sea Zones and Response Strategies:

Within the scope of this Plan, a response action required to be mounted could be at any of these locations
(i) Sea or channel, incident due collision etc. during passage,
(ii) Close shore due grounding or stranding,
(iii) Alongside at jetty or at the terminal during cargo operations.

Notwithstanding the above locations, it is possible that an eventuality occurring at sea like a collision or mechanical failure could lead to a situation where the consequences would be felt in some other location at a coastal location.

6. Shorelines Zones and Clean-up Strategies:

A number of shoreline response strategies are Available as per table below, but shorelines should be assessed so see whether these are suitable. This will depend on:

- Rate and likelihood of natural cleaning
- Access for personnel and machinery
- Nature and distribution of the Oil / HNS
- Shoreline character
- Availability of personnel and machinery
- Safety issues
- Environmental sensitivity to Oil / HNS and cleanup methods.

	PRIMARY CLEANUP					FINAL CLEANUP						
	Pumping / skimming	Mechanical removal	Manual removal	Natural recovery	Comments	Low pressure flushing	High Pressure washing / Sand blasting	Dispersants	Natural organic sorbents	Batch recovery	Natural recovery	Comments
Rocks, Boulders and artificial structures	V	NA	V	+	Poor access may prevent pumping / skimming. Exposed / remote shorelines best left to natrual recovery	NA	V	+	+	NA	V	Avoid excessive abrasion of rocks / artificial structures. Cleanup of boulders difficult and often gives poor results.
Cobbles, Pebbles and shingle	V	X	V	+	Exposed / remote shorelines bestg left to natural recovery	V	X	+	+	+	+	If load bearing character good, consider pushing oiled material to surf zone to enhance natural recovery
Sand	V	+	V	+	Heavy equipment only applicable on firm beaches	V	X	+	NA	+	+	Solid oil can be recovered using beach cleaning machines. Enhance natural recovery by ploughing / harrowing
Mud flats marshes and mangroves	+	X	+	V	Operation preferably carried out on the water from small, shallow drought vessels.	+	X	X	+	NA	V	Operations should preferably be carried out on the water from small, shallow-drought vessels.

Table : Application of techniques to different shoreline types

V : Viable   + = Possibly useful   X = Not recommended   NA : Not Appicable

7. Oil and Waste Storage / Disposal sites:

An efficient and monitored disposal of waste includes immediate classification, segregation, packaging and labeling at source. List of Approved Recyclers –Placed at Annexure -23

	Packaging	Storage Capacity (m^3)
ON WATER	On board Storage	100 to >1,000
	Barges	10 to 10000
	Flexible / towable bladders or tanks	500 to 15000
SHORELINE	Plastic bags or sacks	0.25 to 15,000
	Super sacks	0.5 to 2.5
	Barrels or drums	~0.2
	Portable tanks	1 to 5
	Skips or dumpsters	10 to 40
	Lined pits	Up to 200
	Vacuum trucks	7.5 to 20

HW: Hazardous Waste, MTA: Metric Tons per Annum, TSDF: Treatment, Storage and Disposal Facility

WASTE DISPOSAL OPTIONS

WASTE	PRIMARY OPTION	SECONDARY OPTION	ALTERNATE OPTION
Fresh Oil	Refining	Fuel Blending	Ex Situ burning
Weathered	Fuel blending	Land Treatment	Landfill
Emulsions	Fuel Blending	Land Treatment	Landfill
Hydraulic Fuels	Refining		
Oil debris	Incineration	Open burning	Landfill
Oily PPE	Incineration	Landfill	
Oily Sand / Gravel	Ex situ burning	Land treatment	Landfill
Oily sorbents	Fuel blending	Incineration	Landfill
Oily Waste water	Electro coagulation treatment		
Animal carcasses	For research	Incineration	
Domestic waste	Incineration	Landfill	
Non oily debris	Incineration	Landfill	
Pallets	Recycle / reuse	Open burning	Landfill
Paper board	Recycle / reuse	Open burning	Landfill
Drums	Recycle / reuse	Landfill	
Hazardous wastes	Social handling, storage treatment		

8. SENSITIVITY MAPS/CHARTS.

The Gulf abounds in marine wealth and is considered as one of the biologically richest marine habitats along the west coast of India. It is endowed with a great diversity of natural ecosystems, of which the major systems are salt pans, intertidal zones, marine algae (seaweeds), sea grass and sand dunes, mangroves, coral reefs, creeks, and Open Ocean. The Risk Assessment Studies for Marine Oil Spill for Jetties and SPMs and sensitive mapping of (Gulf of Kutch) has been carried out by NAYARA Energy Limited, Vadinar recently in February 2024 through Environ Software Pvt. Ltd., and is placed as an **Annexure -26**.

B. LIST OF EQUIPMENT AND MANPOWER REQUIREMENT

1) AUXILIARY EQUIPMENT:

a) OSR DUMP BARGE: ANURADHA
b) Harbor Tugs
c) Pilot Vessels, launches and others

ReferAnnexure-21

2) SUPPORT EQUIPMENT:

a) Computer and printer with internet
b) Walkie-talkie Sets
c) Telephone Lines
d) Mobile Sets

3) SOURCES OF MANPOWER

In the event of oil spill, Traffic, Mechanical as well as Civil department of DPA shall provide required facility with regard to catering, housing, transportation, field sanitation and shelter etc.

The Following are the Sources of Manpower to combat any oil spill incident in DPA KANDLA AND OOT VADINAR:

A. OSR Manager
B. OSR Operational Managers
C. OSR responders
D. DPA Fire Brigade Department

A: OSR Manpower: Following qualified OSR man power are presently available at DPA Kandla & OOT Vadinar:

1. IMO Level - III
2. IMO Level -II
3. IMO Level -I

ReferAnnexure-23 & 24

4) LOCAL AND NATIONAL GOVT. CONTACTS:

Refer Annexure-3

5) CONTACT DETAILS OF LOCAL ADMINISTRATION.

Refer Annexure-18

6) CONTACT DETAILS OF EXPERTS AND ADVISORS

Refer Annexure- 01

ANNEXURE -1
(Page-77, Refer Para 6)

CONTACT DETAILS OF EXPERTS AND ADVISORS:

The Management group will seek assistance from experts indicated in the following:

Name of Body	Telephone No.	Fax
Nautical Advisor	022-2613651-54	9122-22613655
DG Shipping, Mumbai	022-22613651-54, 022-226131156	22-22613655
Indian Register of Shipping	022-30519400	022-25703611
IIT- Gujarat	079 2395 2800	022-25723480
Cyclone Detection Radar	022-22150431/ 22174707	-
Area Cyclone Warning Centre (ACWC)-Colaba, Mumbai	022-22150431	022-22160824
Ministry of Environment and Forest (MOEF)	011-24360721, 011-24361896	011-24362746
The National Environmental Engineering & Research Institute (NEERI)	0712-2249999/66	0712-2244900
Directorate of Maharashtra Fire Services	022-26670438/39	022-266600287
Ministry of Petroleum & Natural Gas	011-23387404	011-23383100
National Institute of Ocean Technology (NIOT)	044-667893300	044-22460275/ 22460645
National Ship Design and Research Centre	07386677846	
Department of Explosives	0712-2510248 022-27575946 27575946,27564941	
Inspectorate Dock Safety, Mumbai	022-22692180/ 56565511/56565558 9757222853	022-22613391
GPCB, GUJRAT	079 2323 2152	079 2323 2156
GPCB, JMNAGAR	0288 2752366	0288 2753540
Meteorological Observatory, Ahmedabad	079-22865165	22865449

ANNEXURE-2
(Refer 5.3, Page 40)

LIST OF ADDITIONAL RESOURCES AND INTERNATIONAL OSROs

1. SADHAV Shipping LTD.
Oil Spill Response Unit,
618, Laxmi Plaza
New Link Road, Andheri (West)
Mumbai-400053
Tel- 022-400053, Fax-022-40003366.
Mail- Shipping@SADHAV.com . Web - www.SADHAV.com

2. Australian Marine Oil Spill Centre
PO Box 305
Victoria 3214
Australia
Tel + 61 3 5272 1555 Fax + 61 3 5272 1839
Mail: amose@amosc.com.au Web: http://www.aip.com.au

3. Fast Oil Spill Team
C/o PIM 40 G 23 Tour Elf
92078 Paris- La Defense Cedex France
Tel: + 33 1 4744 5636 Fax : + 33 1 4744 2677 Mail :
giefost@club-internet.fr

4. Oil Spill Response Ltd
Oil Spill Services Centre
Lower William Street Northam
Southampton SOI 1 QE, UK
Tel: + 44 1703 331 551 Fax: + 44 1703 331 972
Mail: osrl@osrl.co.uk Web: http://www.oilsillresponse.com

5. Petroleum association of Japan
Oil Spill response Department Keidanren Building
9-4, 1 – Chome, Ohtemachi Chiyoda Ku,
Tokyo 100, Japan
Tel: + 81 3 3279 3819 Fax: + 81 3 3242 5688
Mail: mail@pcs.gr.ip Web :http://www.pcs.gr.ip

ANNEXURE-3
(Ref Para-4 Page-77)

LOCAL AND NATIONAL GOVT. CONTACTS:

1. The Commander
   Coast Guard Region (North West)
   Gandhinagar, Gujarat
   Tel 079 23243315, 23243316
   Fax: 079 23243305
   Email ID: rhq-nw@indiancoastguard.nic.in

2. The Commander Coast Guard Dist. HQ -15,Okha
   Tel -02892262260, 61223421
   Email ID: cgs-okh@indiancoast.nic.in

3. The Commanding Officer,
   Indian Coast Guard Station, Vadinar.
   Tel 02833256333
   Email ID: vdr@indiancoastguard.nic.in

4. Coast Guard Pollution Response Team (NW)
   Tel- 079 23243315, 23243316
   Ops- 079 23243264, 3283,3292
   Fax 079 23243305
   EmailID-prt-nw@indiancoastguard.nic.in

2. FISHERIES

Nature Conservation society, Lakota Nature club Jamnagar,
Contact no. +919377526667, +919879516990

3. STATE POLLUTION CONTROL BOARD – REGIONAL OFFICES

Sardar Patel Commercial Complex,
Rameshwar Nagar
Kasturba Gandhi Vikas Gruh Marg, Bedi Bandar Road
Jamnagar- 361 008
Tel-(0288) 2752366

CONTACT DETAILS OF STATE GOVERNMENT

DEPARTMENT	DESIGNATION	TELEPHONE	FAX
Gujarat Maritime board, Gandhinagar	Chairman GMB	079-23234696	23234703
	Chief Engineer	079-23234699	23244132
	Traffic manager	079-23246726	23234705
	Dy Secretary Control Room GBM	079-23234706	23234706
	Nautical Officer	079-23234716	23234716
	Officer on Special duty	079-23234698	23240274
Forest & Environment	Principal Chief Conservator of Forests	079-2354100	
	Director Environment, Govt. of Gujarat Gandhinagar	079-23251062	23252156

CONTACT DETAILS OF PORTS

NAME OF PORT	DESIGNATION	TELEPHONE	FAX
Okha	Port officer	02892-262008	262002
Vadinar	Chief Operation Manager	02882573001	
		9819999227	
Bedi Port	Port Supervisor	0288-2755207	
Sikka Port	Port Supervisor	0288-2344230	
Salaya Port	Port Supervisor	02833-285526	
Jakhau Port	Traffic Inspector	02834-223033	230033
Sangchi Port	Port Officer	02831-287233	274115
Kandla Port	Dy Conservator	02836-220235	02836-233585
	VTS GOK	02836-270110	02836-270110
	Harbor Master	02836-270624	270427
	Signal Station Port Officer	02836-270194	270624
Old Port Mundra GMB	Traffic Inspector	02838-222136	222136
Mandvi Port GMB	Port Officer	02834-230033	230033
Tuna Port	Superintendent	02836-299510	271465

CONTACT DETAILS OF OHA

NAME	DESIGNATION	TELEPHONE	FAX
Vadinar			
IOCL	CGM, IOCL	02833-256464	256543
	Manager Marine	07894407768	
Nayara energy	Head VOTL	09909908611	
RIL	Head Security	0288-4011911	4010000,4011253
BORL	Vice President	02833-256499,08238069222	256499
	Port Control Room	9726701985,07069073711	
HPCL-MITTAL, Mundra	DGM Pipe line	02838-271050	271050
APSEZL, Mundra	Marine Services	02838-255671,9825228673	02838-255110

DISTRICT ADMINISTRATION

OFFICE	DESIGNATION	TELEPHONE	FAX
Devbhoomi-Dwarka	District Collector & District Magistrate	02833 232803,	232102
Jamnagar	Office of the Collector	0288-2555869	2555869
Kachchh	District Collector	02832-252347	02832-250020
Morvi	District Collector	02822-240701	02822-243703

ANNEXURE- 4
(Page-36,41, Ref Para-4.2,5.6)

WEEKLY MAINTENANCE / TRAINING PROGRAMME, DPA

Date	Event of the Day	Duty Staff
Monday	Tool Box Meeting General cleaning and maintenance of equipment Training/Starting of Power pack and DBD Skimmer Lecture/Discussion on HSE	
Tuesday	Tool Box Meeting General cleaning and maintenance of equipment Training/Starting of Spate 75 pump and Mini Max skimmer Lecture/Discussion on OSD	
Wednesday	Tool Box Meeting General cleaning and maintenance of equipment Training/Power pack & Terminator Skimmer and Discussion on Firefighting appliances	
Thursday	Tool Box Meeting General cleaning and maintenance of equipment Training and Maintenance of Equipment -Onboard OSR Dumb barge Anuradha. OSD pump and spraying system Training/Instruction on OPRC IMO Level I	
Friday	Tool Box Meeting General cleaning and maintenance of equipment Training/Ro Boom, Anchor and anchor chain Discussion on Booms/Skimmers	
Saturday	Tool Box Meeting. General cleaning and maintenance of equipment Training/Maintenance of Skimmer Disc/brush Davit and OSD back pack sprayer. • Discussion on safety of Men and Materials during loading/unloading of OSR Equipment/items	

ANNEXURE - 5
(Refer Para-8.4, Page-57)

MEDIA COMMUNICATIONS GUIDELINES

The degree of interest from the press in a specific oil pollution incident is unpredictable but normally closely related to the number of other news items at the time of the incident. Experience shows that even quite extensive pollution does not always attract the attention from the media, while minor, rather insignificant pollution can create a media storm when there is little else to report.

The media can be an effective means of ensuring that the public is kept informed of the incident, its effects and what is being done. Therefore, proper attention to the media and providing the correct information is very important.

The responsibilities of First Responders do not include dealing with the media. Though, it is advisable to refer all and any questions to the media liaison officer identified through the Contingency Plan, still the response leaders on all levels should be prepared to answer questions from the press because of media's persistence for news.

The lesson to be learned is that - unless otherwise instructed, it should always be remembered that even precise information can be misinterpreted or misunderstood. It is therefore recommended to obtain the name and telephone number of members of the press who have received information in order to verify or correct wrong news stories based on misunderstood information.

The basic questions from the press are likely to be:

- What happened?
- Why did it happen?
- What are the measures being taken by the authorities with respect to the pollution?
- What is being done to prevent such an incident happening again?

How to deal with these approaches is a matter of experience but the following guidelines can be used by First Responders:

- Tell the truth. If there is something you do not know, then say so to Avoid getting chased by the press,
- comment only about your area of responsibility and do not speculate on other topics, avoid offering opinions,
- Emphasize the positive points of the operation like outcome of operations, objectives going to be achieved etc.,
- Never make assumptions, your information must be verified and solid before released,
- Do not offer a personal opinion,
- Beware of language (e.g. it is better to say that two ships collided than one crashed

into the other if it is not clear which was at fault),

- Be polite, patient and never get personal or sarcastic (you will normally be treated in the same way you treat a person and aggressive behavior from your side can cause you a lot of unnecessary problems),
- Insist that the press observe local safety regulations.

ANNEXURE -6
(Refer 1.3.1Page -20)

BROAD CLASSIFICATION OF OILS AS PER MARPOL 73/78

Asphalt solutions	Gasoline blending s
Blending stocks	Alkylates- fuel
Roofers flux	Reformates
Straight run residue	Polymer - fuel
Clarified	Casing head (natural)
Crude oil	Automotive
Mixtures containing crude oil	Aviation
Diesel oil	straight run
Fuel no. 4,5 and 6	Fuel oil no.1 (Kerosene)
Residual fuel oil	Fuel oil no. 1-D
Road oil	Fuel oil no. 2
	Jet fuels
Transformer oil	Fuel oil no. 2-D
Aromatic oil (excluding vegetable oil)	
Lubricating oils and blending stocks	JP-1 (Kerosene)
Mineral oil	JP- 3, 4
Motor oil	JP–5 (Kerosene, heavy)
	naphtha
Penetrating oil	Mineral spirit
Spindle oil	
Turbine oil	Solvent
	Petroleum
Straight run	Heart cut distillate oil

ANNEXURE-7
(Refer Para-3, Page -74)

ANTI – POLLUTION RESOURCES (Local Area) DPA KANDLA AND OOT VADINAR

Equipment List as per NOSDCP 2018	List of Equipment available at DPA Kandla	List of Equipment available at DPA OOT Vadinar	Total List of Equipment available with DPA	Requirement	Shortfall/ Excess (if any)
Inflatable Booms	1200	2000	3200 Mtrs.	1000 Mtrs.	+2200
Fence boom (Material: Neoprene rubber/Neoprene rubber/ PU/ PV)	200	Nil	200 Mtrs.	1000 mtrs	-800
Skimmer (20TPH 50% weir type, 50vo Brush type)	02 Nos.	03 Nos.	05 Nos.	06 Nos.	-01
OSD Applicator with Spray arms type along with 02 Nozzles system and 02 hand lancers (No')	03 Nos.	05 Nos	08 Nos.	07 Nos.	+01
Oil Spill Dispersant (Chemical Dispersant) (liters)	5000 ltrs.	3000 Ltrs.	8000 Ltrs.	5000 Ltrs.	+3000 Ltrs.
Bio-remediation (liters)	Nil	Nil	Nil	3000 Ltrs.	-3000 Ltrs.
Flex Barge 10 Tons (no.)	5 Nos.	4 Nos.	09 Nos.	07 Nos.	+2 Nos.
Weir Boom 100 meters with minimum 02 weirs with power pack and accessories (no's) or integrated containment cum recovery system with power pack and accessories (no's	Nil	02 Nos.	02 Nos.	03 Nos.	-1 Nos.
Sorbent boom size min. 5 inch Dia, min. length 5 feet (no')	Nil	500 Nos.	500 Nos.	700 Nos.	-200 Nos.
Sorbent Pads min. 20 inch x 20 inch (no.)	Nil	2000 Nos.	2000 Nos.	2200 Nos.	-200 Nos.
Mini Vacuum pumps	01 Nos.	04 Nos.	05 Nos.	07 Nos.	-02 Nos.
Portable Oil temporary storage facility capacity 10 m3	Nil	05 Nos.	05Nos.	08 Nos.	-03 Nos.
200 meters Shoreline sealing boom with power pack and accessories (material: Rubber/Neoprene rubber) (nos.)	Nil	Nil	Nil	04 Nos.	-04 Nos.
VOC Portable Monitor	Nil	Nil	Nil	02 Nos.	-02 Nos.
Level A protection: Positive pressure, full faces	Nil	05 Nos.	05 Nos.	08 Nos.	-03 Nos.

piece self-contained breathing apparatus (SCBA) or passive pressure air respirator with escape SCBA; Totally encapsulated chemical and vapor protective suit; Inner and outer chemical resistant gloves; and .Disposable protective suit gloves, and boots					
Level B protection: . Positive pressure, full face piece self-contained breathing apparatus (SCBA) or posiWe pressure supplied air respirator with escape SCBA; . Inner and outer chemical-resistant gloves; . Face shield; . Hooded chemical resisantdathing; .overall; and . Outer chemical-resistant boot.	Nil	Nil	Nil	16 Nos.	-16 Nos.
Level C protection: .Full face air purifying respirators; .inner and outer chemical-resistant gloves; ' Hard hat; ' Escape mask; and . disposable chemical{resistant outer boots"	10 Nos.	20 Nos.	30 Nos.	Nil Nil 05 Nil Nil	30 30 25 30 30
OSR Vessels					
Work Boats	2	2	4	4	NIL
Tugs	4	4	8	4	+4

ANNEXURE – 8
(Refer Para-3.6,page-34)

LIST OF REFINERIES

NEARBY AND IN GUJRAT STATE

Reliance Industries Ltd. (Domestic Tariff Area) (RIL-DTA) (Private Sector). JAMNAGAR (Gujarat)

Reliance Industries Limited – SEZ (RIL-SEZ) (Private Sector). Jamnagar

Nayara Oil Limited (EOL) (Private Sector), Vadinar, Gujarat

REFINERIES AVAILABLE IN INDIA:

Guwahati Refinery (Assam) – Indian Oil Corporation Limited (IOCL)

Barauni Refinery (Bihar) - Indian Oil Corporation Limited (IOCL)

Koyali Refinery (Gujarat) - Indian Oil Corporation Limited (IOCL)

Haldia Refinery (West Bengal) - Indian Oil Corporation Limited (IOCL)

Mathura Refinery (Uttar Pradesh) - Indian Oil Corporation Limited (IOCL)

Digboi Refinery (Assam) – Indian Oil Corporation Ltd (IOCL)

Panipat Refinery (Haryana) - Indian Oil Corporation Ltd (IOCL)

Bongaigaon Refinery (Assam) – Indian Oil Corporation Limited (IOCL)

Visakha Refinery (Andhra Pradesh)- Hindustan Petroleum Corporation Limited (HPCL)

Kochi Refinery (Kerala) – Bharat Petroleum Corporation Limited (BPCL)

Manali Refinery (Tamil Nadu) – Chennai Petroleum Corporation Ltd (CPCL)

Basin Refinery (Nagapattinam-Tamil Nadu) – Chennai Petroleum Cauvery Corporation (CPCL)

NumaligarhRefinery (Assam) - Numaligarh Refinery Limited (NRL)

Mangolare Refinery (Karnataka) – Manglore Refinery Limited (MRL)

Tatipaka Refinery (Andhra Pradesh) – Oil & Natural Gas Corporation Limited (ONGC)

Reliance Industries LTD.(Domestic Tariff Area) (RIL-DTA) (Private Sector).JAMNAGAR (Gujarat)

Reliance Industries Limited – SEZ (RIL-SEZ) (Private Sector). Jamnagar

NAYARA Oil Limited (EOL) (Private Sector), Vadinar, Gujarat

Bina Refinery – Bharat Oman Refineries Limited (BORL) (Madhya Pradesh)

Guru Gobind Singh Refinery – HPCL – Mittal Energy Limited (HMEL), Bhatinda (Punjab)

ANNEXURE-9
(Refer Para-2.2, Page-25)

CHARASTRISTICS OF DIFFERENT CLASS OF OILS

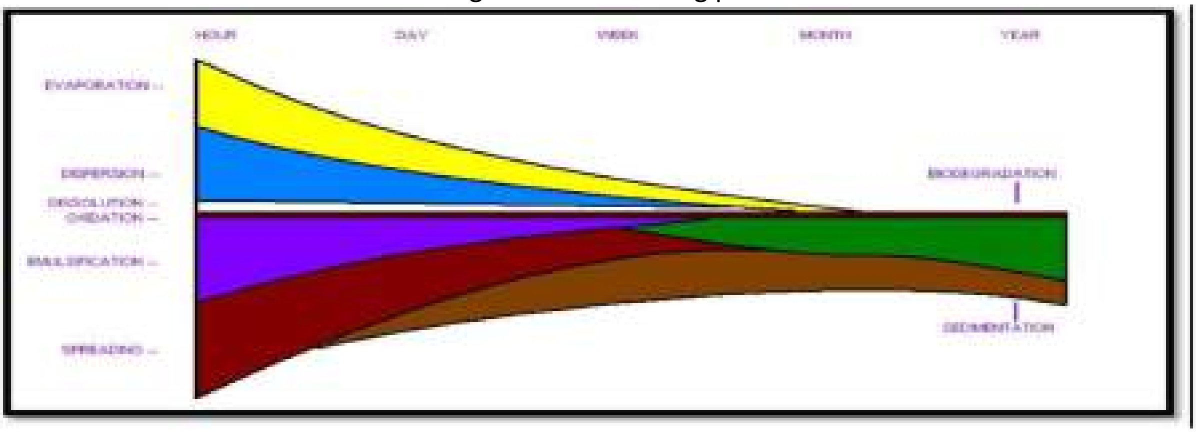
OIL TYPE	DENSITY	Viscosity	Pour point C	Flash point C
	(kg/l) At 15C	mPa at 20C		
Crude oil	0.8- 0.95	1-100	+10 to – 35	Variable
Gasoline	0.70 – 0.78	0.5	Na	Less than 0
Kerosene	0.8	2	Less than – 40	38-60
Jet fuel	0.8	1.5-2	Less than – 40	38-60
Diesel oil	0.85	5	-5 to -30	More than 55
Light FO IFO60	0.9	60 at 50 C	+ 50 to -20	More than 60
Medium FO IFO 180	0.9	180 at 50 C	+ 30 to – 20	More than 60
HeAvgy FO IFO 380	0.99	380 at 50 C	+ 30 to – 20	More than 60

ANNEXURE-10
(Refer Para-2.9,Page-29)

WEATHERING PROCESSES AND TIME SCALES

Process		Importance	Time frame
Evaporation	Conversion of liquid to Gaseous state. Lighter factions are lost first	Major process accounting for loss of oil. At 15 C gasoline will evaporate completely over a 2 day period, 80% of diesel fuel and 40% of light crude , 20% of heavy crude and about 5- 10% Of Bunker C fuel.	< 5 days
Emulsification or mousse formation	Small water droplets get mixed into liquid oil. Water content will reach 50-80%	Will increase the amount of pollutant to be Recovered by a factor of 2-4.	Onset may be delayed but emulsification process will start Rapidly.
Natural dispersion	Breakup of an oil sleek into small droplets	Removes oil from water surface	< 5 days
Dissolution	Mixing of soluble oil components into water	Water soluble components are most toxic	< 5 days
Biodegradation	Breaking of oil by microbes into smaller compounds and finally to water and carbon dioxide	Rate depends on oil type, temperature, nutrients, oxygen and amount of oil	Weeks to months
Formation of tar balls	Breakup of heavy crudes and refined oils into small patches with long persistence	Hard to detect	Days to weeks

Shows schematic diagram of weathering processes with time



The physical and chemical changes, which spilled oil undergo are sometimes collectively known as weathering. However, the main processes are as follows:

2.9.1 Spreading: -Open out (something) so as to extend its surface area, width, or length. Oil spreads out and is pushed across the water by wind and currents.

2.9.2 Evaporation: -The process of turning from liquid into vapour. Oil evaporates very slowly. Oil doesn't mix with water, and most oils are less dense than water.

2.9.3 Photo-oxidation

This process occurring due changes to chemical and physical properties of spilled oil and sets in because of exposure to sunlight and is limited to the surface of oil, resulting in a thin, crusty" skin" on slicks and tar balls. The "skinning" of oil, limits evaporation because the lighter oil components can no longer diffuse through the surface of the slick. Photo-oxidation may increase the ease of emulsification and is considered a long-term weathering process taking weeks to months.

2.9.4 Dispersion: -The action or process of distributing things (oil) over a wide area.

2.9.5 Emulsification: -An emulsion is a mixture of two or more liquids that are normally immiscible

2.9.6 Dissolution: -Water soluble compounds in an oil may dissolve into the surrounding water. ... Most crude oils and all fuel oils contain relatively small proportions of these compounds making dissolution one of the less significant processes.

2.9.7 Oxidation: -Oxidation occurs when oil contacts the water and oxygen combine with the oil to produce water-soluble compounds. This process affects oil slicks mostly around their edges.

2.9.8 Sedimentation: -The process of settling or being deposited as a sediment.

2.9.9 Biodegradation: -Biodegradation is the process by which organic substances are decomposed by micro-organisms into simpler substances such as carbon dioxide, water and ammonia. The processes of spreading, evaporation, dispersion, emulsification and dissolution are most important during the early stages of a spill whilst oxidation, sedimentation and Biodegradation are long-term processes, which determine the ultimate fate of oil.

Emulsification

Mousse begins to form when 19% of the oil has evaporated

Wind and wave conditions

Wind speed – 10 knots from 245 degrees

Wave height – computed from wind speed, unlimited fetch (default)

Water properties

Temperature – 30 degree C Salinity 32ppt
Sediment load – 500g/ m3 (muddy river)
Current – 3.0 knots towards 80 degree

ANNEXURE-11
(Refer Para-2.1.3, Page-23)

CALCULATION OF SPILL QUANTITY AS PER SLICK CHARACTERISTICS

The quantity of oil spilled can be calculated in terms of total rapture and also for pin hole leaks using software taking into account the diameter of hole and flow rate. The formula for total rapture calculation is:

Volume of Spill = 2 Pie X Radius of Pipeline X Length of Pipeline X Flow Volume

SPILL AREA AND OIL VOLUME						
Average Slick Length	2.5	Km	TOTAL SPILL AREA	1,500,000	m^2
Average Slick Width	0.6	Km		1.50	Km^2

OIL TYPE	APPEARANCE	THICKNESS (mm)	LOADING m^3 / Km^2	COVER %	AREA Km^2	VOLUME m^3
Sheen	Silvery	0.0001	0.1	40%	0.60	0.060
Sheen	Rainbow	0.0003	0.3	30%	0.45	0.135
Slick	Yellow/Brown	0.01	10	20%	0.30	3.000
Crude/Fuel Oil	Black/Brown	0.1	100	10%	0.15	15.000
Mousse	Brown Orange	1.0	1000	0%	0.00	0.000
				100%	1.50	

TOTAL OIL VOLUME		
	18,195	L
	18.20	m^3

ANNEXURE-12

(Refer Para 1.1.5, Page-70)

POINT SYMBOLS FOR BIOLOGICAL RESOURCES

ESI HUMAN USE RESOURCE SYMBOLS

Annexure-13
(Refer Para-3.5.1, Page-33)

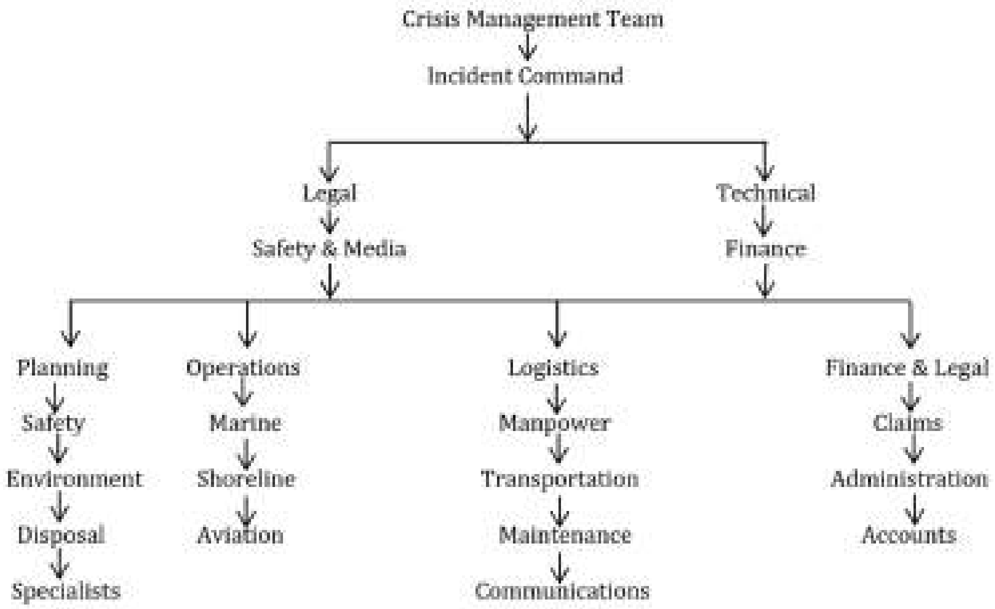
PORT- VESSEL POLLUTION EMERGENCY INTERPHASE

ACTION	RESPONSIBILITY
IMMEDIATE ACTION	
Sounding Emergency Alarm	Person noticing spill
Initiating Vessel Pollution Response Plan	Duty officer
INITIAL RESPONSE	
Suspend cargo ops	Ch. Eng./ Duty officer
Information to Terminal/Port Control / Master	Master / Duty officer/Ch. Engg.
Call crew to Pollution Response Positions	Master/ Duty officer
SECONDARY RESPONSE	
Location of source of spill Assess & consider -	Chief officer
Fire risk & manning of fire positions	Master
Stopping of air intake	Chief Engineer
Transfer of bunker to empty or slack tank, shore /barge	Master/ Ch. Engineer
Prepare detailed report of spill and actions	Master/ Ch. Officer
Inform agent, owners and PI club	Master/ Ch. officer
FURTHER RESPONSE	
Call in external assistance to locate spill (if below waterline)	Master – Port
Consider stability of vessel	Master/ Ch. officer
Follow directions of response authority	Master

Annexure-14

(Refer Para-5.2, Page-38)

ORGANISATIONAL CHART



Annexure-15
(Refer Para-2.5.3 &8.6, page26&57)

NET ENVIRONMENTAL BENEFIT ANALYSIS (NEBA)

Detailed Report of NEBA carried out by National Institute of Oceanography is enclosed

Sensitive areas in an around DPA KANDLA AND OOT VADINAR

PORTS OF NAYARA Energy, IOCL, NAYARA and Reliance

TRANSHIPMENT FACILITIES AT Jetty A & B at OOT Vadinar

SPM

The sensitive areas likely to be threatened in case of oil spill are as follows.

Marine National Park
Mangrove area
Salt pans
Forest area
NAYARA refinery intake
Mangroves Area

MOVEMENT OF OIL:

Spreading and advection are the two major processes that transport oil on water. For small spills (<100 barrels), the spreading process is complete within the first hour of the release, whereas for bigger spills the spreading process could continue for larger durations of time.

Winds, currents, and large-scale turbulence (mixing) are advection mechanisms that transport oil to large distances. For calculation purposes, the oil movement is estimated as the vector sum of the wind drift (using 3% of the wind speed) and 100% of the surface current.

Spreading:

The spreading process occurs quickly and for most spills, mostly within the first hour. In open waters, winds, currents, and turbulence act on and move the oil.

Spreading occurs faster for lighter and for less viscous oils in warm water temperatures and for warm oils. The slick does not spread uniformly but will often have a thick part surrounded by a larger, but thinner sheen. About 90% of the oil is found in 10% of the slick area. A spill is likely to keep spreading until a thickness of about 0.1 mm is reached. At this stage breaking up of slick into windrows is an important source of further spreading.

Vulnerable Areas in case of a spillage

Spill Volume (tones)	SW monsoon	NE monsoon	Post monsoon
700 crudes	-	Marine National Park, NAYARA & IOCL Transshipment Facility at OOT Vadinar Jetty A &B, Mangroves area, Salt Pans, NAYARA Intake.	-
25000 crudes	-	Marine National Park, NAYARA & IOCL Transshipment Facility at OOT Vadinar Jetty A &B, Mangroves area, Salt Pans, NAYARA Intake.	-
700 furnaces	-	NAYARA & IOCL Transshipment Facility at OOT Vadinar Jetty A & B, NAYARA Intake.	-
10000 furnaces	-	NAYARA & IOCL Transshipment Facility at OOT Vadinar Jetty A & B, NAYARA Intake.	-
2200 m^3/h for 15 min	-	NAYARA & IOCL Transshipment Facility at OOT Vadinar Jetty A & B, NAYARA Intake.	-

PAST COMPARATIVE STUDY

SW Monsoon Season (Jun-October)

In the initial period of this season, the surface currents and winds are transition from Northeast to East based on the wind direction. The magnitude of the residual currents is greater than 1 knot. The slick moves transition from Northeast to East direction based on the wind forcing. The effect of wind forcing is significantly higher than surface current drift. The spills at Jetty A& Jetty B would head towards the sea. The behavior of slick movement is more or less similar in various scenarios irrespective of quantities.

NE monsoon (November-February)

In the initial period of this season, the surface currents and winds are towards South west. The magnitude of the residual currents is greater than 1 knot. The slick moves towards South west direction based on the wind and currents forcing. The effect of wind forcing is significantly higher than surface current drift. The spills at landing jetty, Jetty A & B would reach the coast within 10 minutes. The behavior of slick movement is more or less similar in various scenarios irrespective of quantities of oil spilled. The extent of landing of oil differs depending on the source quantities. Nearly 20% of oil volume has been lost due to evaporation and dissolution and remaining will reach the coast.

Post Monsoon Season (November-December)

In the initial period of this season, the surface currents and winds are towards Northeast direction. The magnitude of the residual currents greater than 1 knot. The slick moves towards Northeast direction based on the wind forcing. The effect of wind forcing is significantly higher than surface current drift. The spills at JettyA& Jetty B would reach to shore within 10 minutes. The behavior of slick movement is more or less similar in various scenarios irrespective of quantities of oil spilled.

SHORE LANDING AND SPILL IMPACT AREAS

The quantity of the spill reaching to the coast and affected areas for various seasons for various hydrological and meteorological conditions and predicted BY use of Hyrodyn-OILSOFT software is as follows.

SW monsoon

During this period, no Oil slicks will affect the coast at least for 6-12 hours. No likely areas will be impacted during these seasons for spills of various quantities.

NE monsoon

During this period Oil slicks of approximately 70% spilled at sea reach the coast within an hours after the spill. The likely areas impacted during these seasons for spills of less than 700 Ton are DPA KANDLA AND OOT VADINAR Landing JETTY, NAYARA Intake & adjoin area of jetty. For spills of higher magnitude, the impact zone may extend at NAYARA Intake, Salt Pans& mangrove areas along the coast.

Post monsoon

During this period spilled oil at Jetty A and Jetty B would not reach the coast.

In summary the likely areas affected by the oil spills from oil berths operations at jetties during various seasons are given below:

Spill Analysis: Percentage of oil spill volume reaching the coast

Spill Volume	SW Monsoon	NE Monsoon	Post Monsoon
700 t crude	-	-	70-80
25000 t crude	-	-	75-85
700 t furnace	-	-	85-90
10000 t furnace	-	-	85-90
2200m^3/h for 15 min	-	-	90-95

Extent of oil on the coast (meters)

Spill Volume	SW Monsoon	NE Monsoon	Post Monsoon
700 t crude		-	500
25000 t crude		-	1000
700 t furnace	200	-	1200
10000 t furnace	300	-	1500
2200 m^3/h for 15 min	350	-	2000

SHORE LENGTH AND AREA OF VADINAR

Vadinar Port is covering the **Total area of (12923.9 Sq.Km)** have been notified by the state Govt. to Conserve Biodiversity of the Wetlands.

KPT marine facilities are located at Vadinar near Narara Bet (Lat 22 °26.9', Long69°40.18' E) & in the Pathfinder Inlet, a Natural Creek of the Gulf of Kachchh (Hereinafter referred to as Gulf). The KPT service jetty used for securing the floating crafts, Operational for more than three decades, is located south of the VOTL Terminal. The Pathfinder Inlety is well sheltered from monsoon wags and thereby permits uninterrupted navigation for ships approaching the berths except during cyclones which rarely strike the Gujrat coast.

The Southern Shore of the Gulf in Jamnagar district with abundance of coral reefs and mangroves is demarcated as Marine National Park Sanctuaries. The Inter tidal Zones of Dwarka, Kalyanpur, Khambhalia, Lalpur, Jamnagar and Jodia Talukas along with 42 Islands in the district have been included in the marine protected area. An area of457.92 KM ^{2} stretching from Okha to jodiya comes under Marine National Park and Sanctuary. This area includes 148.92 Km^{2}of small nd big islands and 309 Km^{2}intertidal zone the coast. Area of the MNP is 162.89 Km^2 Whereas the remaining protected areas have the status of Marine Sanctuary.

The MNP&S includes three categories of areas (noticed on 1-1-1983 and 9-11-1983), i.e. (i) 11.82 sq.km Reserve Forests, (ii) 347.90 sq.km unclassified forests notified under sec.4 of IFA 1927, and (iii) 98.20 sq.km territorial waters of india.162.89 sq.km area of MNP is distributed amongst 37 islands and coasts whereas the remaining 295.03. Km area of the sanctuary covers 5 islands and intertidal zone from Navlakhi to Okha. Areas Mentioned under National Park, sanctuary, Reserve Forests and Unclassified Forests are scattered and mostly having no proper specific boundary .398.40 sq.km overlapping area is notified under Port Act before 1980 for maritime activities.

A National Park and four sanctuaries viz. MNP, Jamnagar (162. 9Sq.Km Marine sanctuary (295 sq.km), Khijadia Bird sanctuary (6.1 Sq.km), Wild Ass sanctuary in the Little Rann (4953.7 Sq.km), and Kachchh desert wild life sanctuary (7506.2 Sq.km),

Annexure-16
(Refer Para-9.5
, Page-60)

INCIDENT LOG

INCIDENENT INFORMATION

Incident Title (Name of Vessel) --
Incident Number (Sq number/ dd /mm/ yyyy) ---

1. **DETAILS:**

Time of recording ----------------- (24 hr. format) Day ------------------ Date ----------------

Person / Organization reporting incident

Name ---------------------------------- Designation ------------------- Contact number -----------

2. **INCIDENT:**

Name of VESSEL ----------------------------------- Location --

Position (if not alongside) Latitude ------------------------ Longitude-------------------------
Sounding ---

Incident details

Time ------------------------------------- (Of incident, 24 hrs format) Date ---------------------------------
Cause of spill ---
Type of oil --
Estimated quantity of spill ---
Details of damage to vessel / installation ---

3. COMMENTS:

1. Recorded by:

Name ---
Time --

Note: FOUR COPIES OF INFORMATION ARE TO BE RECORDED. RETAINING ONE FOR OFFICE RECORD, THREE COPIES ARE TO BE CIRCULATED ONE EACH TO -

- **CHIEF INCIDENT CONTROLER**
- **OSC / RESPONDER/ INCIDENT CONTROLER**
- **VESSEL MASTER**

ANNEXURE-17
(Refer Para-9.5, Page-60)

PERSONAL LOG (ALL MEMBSERS OF SPILL RESPONSE ORGANISATION)

Incident Title -----------------------------------Number------------------------ (as per)
____ Date --------------------

Name --Designation (as per C P) ----------------------

Time of Rx / Forwarding Info Activity requested by/ demanded of other Member/s
Observations on day's operations: -

Note – Copy of Personal Log is to be handed over to COC daily or as earliest as possible on completion of a schedule.

ANNEXURE-18

(Refer Para -5, Page-77)

CONTACT DETAILS OF LOCAL ADMINISTRATION – OOT Vadinar

Sr. No.	DESCRIPTION	STD CODE	TELEPHONE NO. OFFICE	Mobile
1	Head DPA OOT VADINAR (COM)	0288	2573001	9819999227
2	Head HSEF, Refinery	02833	662405	9909908685
3	Coast Guard Station, Vadinar	0288	256560	
4	CG PRT (NW), Vadinar	02833	256601	
5	DPA Control Tower, Vadinar	0288	2573009	9825212359
6	Municipal Fire Station, Jamnagar	0288	2672208	9909011502
7	Marine Police, Station, Vadinar.	0288	256541	
8	District Collector, Devbhumi Dwarka, Khambhalia	02833	232805 232102	
9	GPCB, Gandhinagar	079	23237311	
10	Deendayal Port AUTHORITY	0288	2573005	
11	Gujarat Maritime Board (GMB)	0288	2712516	
12	Ministry Of Environment, Gujarat	079	23251062	
13	Principle Chief Conservator Of Forest, Gandhinagar	079	23253903 23254123	
14	Oil Industry Safety Directorate (OISD), New Delhi	011	2593800	

CONTACT DETAILS OF LOCAL ADMINISTRATION – DPA Kandla

Sr. No.	DESCRIPTION	STD CODE	TELEPHONE NO.	
			OFFICE	Mobile
1	Head DPA KANDLA (DC)	02836	233585	9603123449
2	Head HSEF, Refinery	02833	662405	9909908685
3	Coast Guard Station, MUNDRA	02838	271403	
4	CG PRT (NW), KANDLA	02833	256601	
5	DPA Control Tower, KANDLA	02836	270194	9825227246
6	Fire Station, Kandla	02836	270176	9825227041
7	Marine Police, Station, KANDLA.	02836	270527	
8	District Collector, Kutch	02832	2832 250650	
9	GPCB, Gandhinagar	079	23237311	
10	Deendayal Port Authority	02836	233585	
11	Gujarat Maritime Board (GMB)	0288	2712516	
12	Ministry Of Environment, Gujarat	079	23251062	
13	Principle Chief Conservator Of Forest, Gandhinagar	079	23253903 23254123	
14	Oil Industry Safety Directorate (OISD),New Delhi	011	2593800	

ANNEXURE-19
(Refer Para-3, Page -74)

Pollution response equipment specification and details

	**POWER PACK 42 KW** COMPANY- DESMI MAKE-HATZ, TYPE-3M 41L DIMENTIONS-L-73”, W-40”, H-50” WEIGHT-APPROX 750 KG (EMPTY TANK), -APPROX 900KG (WITH FULL TANK) POWER INPUT-AIR COOLED,4 STROKE, DIESEL ENGINE, ENGINE POWER-42 KW,2800 RPM AIR FILTER-DRY TYPE, STARTING –ELECTRIC START BATTERY-12 V 140 AH ALTERNATER-14 V,42A (1500 RPM) AUTOMATIC STOP-IN CASE OF BROKEN V BELT, IN CASE OF TOO LOW LUBE OIL PRESSURE MAX, CONT. PRESSURE-210 BAR (3000 PSI) FLOW RANGE-0-160 L/MIN
	**TERMINATOR / WEIR SKIMMER** MADE-DESMI(DENMARK) DIMENSIONS-L-82.7”, W-91.7”, H-36.6” DRAFT-27.6” WEIGHT DRY-WITH DOP 200DUAL PUMP-160 KG (EXCL. THURSTERS)-183 KG (INCL. THURSTERS) MAX. PRESSURE-WITH DOP200DUAL MOTOR13 BAR (188 PSI) THRUSTERS-OPTIONALS FLOATS, HOPPER, AND FLOATING COLLAR-OIL RESISTANT POLYETHYLENE PLASTIC BELLOWS-OIL RESISTANT NEOPRENE RUBBER, FLOAT POIPES –STAINLESS STEEL OTHER PARTS-SS AND SEAWATER RESISTANT ALUMINIUM COATING (PUMP)-PRIMER /COMPANY PAINT MAX RECOVERY RATE - WITH DOP 200 DUAL **PUMP** **66 M3/H AT 1 BAR**.

POWER PACK 15 KW

POWERPACK FOR – BOOM WITH REEL WINDER
ENGINE TYPE-15 KW,3000 RPM
PRESSURE -210 BAR
GROSS WEIGHT – APPROX 250-500 KG
FUEL TANK – 5 LTR.

POWER PACK 05 KW WITH RO VACMINI TANK

MACHINE NAME-HATZ 1B30 DIESEL ENGINE
ENGINE TYPE-AIR COOLED FOUR STROKE DIESEL ENGINE
START-ELECTRIC AS WELL AS RECOIL START
PUMP DIMENSION-APPROX (L -1050 MM X W-700 MM X H-740 MM)
NO. OF CYLINDERS-SINGLE
VOLUME-APPROX 0.51 M3
WEIGHT-APPROX 123 KG
VACCUM CAPACITY-0.89 BAR @1500 RPM
BATTERY CAP-MIN-12 V-36/60 AH
FUEL TANK CAP-05 LTRS
TANK STORAGE CAPACITY-
RO VACMINI TANK DIMENSION-

	HOPPER	VACUUM HEAD	ASSEMBLED
APPROX (LxWxH mm)	590X780	950X720X550	950X720X109
VOLUME APPROX(M3)	0.21	0.34	0.67
WEIGHT APPROX (KG)	21	22	43

PD75 SPATE PUMP

ENGINE TYPE-YANMAR
CAPACITY-31.8M3/H (7000 GAL/H)
MAX RPM - 1500
MAX. PRESSURE-3 BAR
WEIGHT - 92 KG
TOTAL HEAD-40 M (130FT)
DELIVERY HEAD-30.5M (100 FT)
SELF PRIMING LIFT-8.8M H2O, (29 FT H2O)
SUCTION LIFT-9.1 M (30 FT)
SOLIDS SIZE-6MM (0.25 INCH)

POWER PACK 3.1 KW WITH OSD SYSTEM

ENGINE DESIGN-AIR COOLED, FOUR-STROKE, DIESEL ENGINE
START-ELECTRIC START AS WELL AS RECOIL START
NO. OF CYLINDERS-SINGLE
ENGINE POWER-3.1 KW,3600 RPM
BATTERY CAP-MAX 12 V/60AMP/H
PUMP DIMENSION-APPROX (1120mm X 700mm X 680 mm)
PUMP TYPE-PISTON DIAPHRAGM
WEIGHT APPROX-116 KG
OSD APPLICATION RATIO-**APPROX 1:20 LTR**
ENGINE TYPE-3 KW, HATZ MODEL 1B20 WITH ELECTRIC START
SPRAY ARMS MAT: - ALUMINIUM PIPES IN 2 OR 3 PARTS
NO. OF DISCHARGE HOSES-02 X 1 ½” WITH PVC CAMLOCKS
SEAWATER SUCTION-01 X 1 ½” WITH PVC CAMLOCKS
DISPERSANT SUCTION-01X 1.25” WITH PVC CAMLOCKS

POWER PACK 7.5 KW & DBD SKIMMER

SKIMMER TYPE-DISC/BRUSH
DIMENTION-L-0.93 MTR, W-1.32 MTR, H-0.66 MTR
DRY WEIGHT-95 KG
DRAFT-0.14 MTR
DRIVE UNIT-2XOMM 50 (50CC)
SPEED-0-60 RPM
DISC SIZE-02 SETS OF 15 PCS (295MMX3MM)
BRUSH SIZE-02 SETS OF 300MM
HYDRAULIC FLOW-0-3 L/M
HYRAULIC PRESSURE-140 BAR (MAX)
OUTLET-RECOVERED OIL-3" CAMLOCK

RO BOOM WITH REEL

BOOM TYPE-**2000 SPEED SWEEP**
BOOM WIDTH-2 MTR
CHAMBER SECTION PITCH-4.90 MTR
BUOYANCY CHAMBER LENGTH-4.50 MTR
FREEBOARD-0.59 MTR
DRAUGHT-1.10 MTR
BALLAST CHAIN-13MM
SECTION CONNECTOR MADE-ASTM
VOLUME OF BUOYANCY CHAMBER-923 LTRS
WEIGHT /MTR ENCL.CHAIN-15 KG
EFFICIENT IN WAVES UPTO-4 MTR
STABLE IN CURRENT UPTO-3 KNOT
ACCESSERIES-TOW BAR, SHACKLE, BRIDLE, TOW ROPE, BUOY, VALVE COVER.
BOOM MOUNTED-ON THE SHAFT A REEL WITH END FLANGED.
BOOM REEL ROTATION BY-GEARBOX WITH HYDRAULIC MOTOR.

CURRENT BUSTER BOOM WITH REEL

BOOM TYPE-**1500 SPEED SWEEP**
NETS/SCREENS-SCREENS ARE MADE FROM PU-COATED KEVLAR TAAPES
SCREENS BUOYANCY BY-FOAM FILLED PU GLOBES
BOOM WIDTH-1.50 MTR
CHAMBER SECTION PITCH-3.30 MTR
BUOYANCY CHAMBER LENGTH-03 MTR
FREEBOARD-0.52 MTR
DRAUGHT-0.72 MTR
BALLAST CHAIN-13MM
SECTION CONNECTOR MADE-ASTM
VOLUME OF BUOYANCY CHAMBER-657 LTRS
WEIGHT /MTR ENCL.CHAIN-12 KG
EFFICIENT IN WAVES UPTO-3.5 MTR
STABLE IN CURRENT UPTO-3 KNOT
ACCESSORIES-TOW BAR, SHACKLE, BRIDLE, TOW ROPE, BUOY, VALVE COVER.
BOOM MOUNTED-ON THE SHAFT A REEL WITH END FLANGED.
BOOM REEL ROTATION BY-GEARBOX WITH HYDRAULIC MOTOR.

RO TANK 10 TON

MATERIALS-MADE OF SYNTHETIC, OIL AND WEATHER RESITANT RUBBER AND HAVE FOUR INNER PLIES OF POLYESTER/POLYAMIDE REINFORCEMENT FABRIC EMBEDDED IN NEOPRENE RUBBER.
COLOUR-BLACK
CAPACITY-10 TON
FIELD SIZE-9.4X2.1X0.8MTRS
HOSE CONNECTION-2X3 INCH(BSP)
TANK WEIGHT-230 KG
PILLOW-65 KG
NUMBER OF FLOATS-2 FLOATS (ONE EACH SIDE)

TROIL TANK

MATERIALS-1000 GRAM PU/PVC ALLOY.
RODS-GLASS FIBRE.
PIPES AND CONNECTORS-PLASTIC
STORAGEPACKED-1300X450X250
CAPACITY-2 TON
HEIGHT ERECTED-900 MM

OIL SPILL DISPERSENT

TYPE-II/III
MANUFACTURE- FOAMTECH ANTIFIRE COMPANY
MFG.DT. – 08/2023
EXP.DT. – 08/2033
QTY. – 3000 liters.

ABSORBENTS PADS

NAME – ABSORBENT PADS
SIZE-40X50 MM
QTY-2000 NOS.

	ABSORBENTS BOOM
	**NAME** – ABSORBENT BOOM **SIZE**-20 MM X 3CM **QTY**-500MTR.

	BACKPACK SPRAY
	**NAME** – **BACKPACK SPRAYER** **CAPACITY- 16 LTRS.** **QTY**-5 NOS.

ANNEXURE – 20
(Refer page – 32)

Tel: 011-23074131
E-mail: dte-fe@indiancoastguard.nic.in

TATRAKSHAK MUKHYALAYA
Coast Guard Headquarters
National Stadium Complex
New Delhi – 110 001

EP/0761/OSD

04 Jun 14

M/s Rochem India Pvt Ltd
101, Dheeraj Arma
Bandra (East)
Mumbai 400 051

APPROVAL OF OIL SPILL DISPERSANT FOR USAGE IN INDIAN WATERS: ROCHEM OSD

1. Refer to your letter RI/044/2014-15 dated 23 May 14 requesting issuance of Coast Guard approval/certificate for Rochem (concentrate type 3 & type 2) oil spill dispersant.

2. Taking into consideration National Institute of Oceanography, Goa certificate NIO/TSP-05/2014 dated 27 Mar 14 and OSD Data Sheet submitted by M/S Rochem India Pvt Ltd vide the letter quoted ibid and the Coast Guard Policy and Guidelines for Use of Oil Spill Dispersants in Indian Waters, 2009 the Rochem OSD (concentrate type 3 & type 2) is placed in the list of oil spill dispersant approved for use in Indian waters.

(AA Hebbar)
Deputy Inspector General
Director (FE)
for Director General

R. SINDHAV.

ROCHEM
(INDIA) PVT. LTD.

Final Test Report

Finished Product Name: **OIL SPILL DISPERSANT TYPE II**

Tested on : **28/06/17**

QAD No. : **193/17-18**

Manufactured on: **28/06/17**

Batch No.: **C 193**

SR.NO.	PARAMETERS	SPECIFIED VALUE	OBSERVED VALUE
1.	COLOUR	COLOURLESS	COLOURLESS
2.	CONSISTANCY	LIQUID	LIQUID
3.	SPECIFIC GRAVITY	APPROX 1.0	1.0
4.	p H	6.0 – 8.0	6.63

Note: Master Instruments used during Trials were

*A) Hydrometer **(0.700-1.0)**
*B) Electronic pH Meter

Product Cleared for packing and dispatch.

Signature of QA Representative :

Date : **28/06/17**

28/6/17
P. SINGHAN

Quality OK

Form No.:F/QA /03,Rev-00,01/12/01

ANNEXURE – 21
(Refer Page- 77)

DETAILS OF VESSELS USED FOR OIL SPILL RESPONSE

TUG- Lotus Star

Sl	Particulars	Technical Specification
01	Gross Tonnage	493 T
02	Net Tonnage	147 T
03	Bollard Pull (Steady/Sustained & Maximum)	More than 60 T
04	Year of Built	2016
05	LO.A	30.28 Meters
06	Breadth	2.41 M
07	Depth	5.30 M
08	Draft	4 Meters
09	Main Propulsion Engine	NIIGATA 6L28HX2X1654 Kw
10	Propulsion & Steering	ZP31 B(ZELLER)
11	Flag/Nationality	Indian
12	Auxiliaries	Cummins QSB7,2X164Kw
13	Speed	12 Knots
14	Fuel Capacity	225 M3
15	Fresh water capacity	91 M3
16	Towing Arrangement	1) Towing Winch- Maker-Jebsen & Jebsen, Brake Capacity-150 Tons, Double Drum Type, Pull rate at 10 T x 0-10 Mtrs/Min 2) Towing Hook- Maker-Jebsen & Jebsen, Brake Capacity-60 Tons
17	Communication	MF/HF Trans receiver with DSC & Telex VHF, Hand Held VHF Radio
18	NAvgigation Equipment	Marine Radar, AIS, Echo Sounder, Search Light, GPS, Navigates)
19	Details of External Fire Fighting Equipment with discharge capacity and throw distance of monitors	2400 Cu Mtr/Hart 125 Mtr Head
20	Manning(As per requirement of statutory Authority)	As safe manning regulation issued by MMD, India
21	Fuel Consumption Main Engine (At 100% MCR)	380.67 Lit/Hour/engine
	Main Engine (At 90% MCR)	342.20 Lit/Hour/engine
	Main Engine (At 75% MCR)	287.60 Lit/Hour/engine
	Main Engine (At 40% MCR)	159.53 Lit/Hour/engine
	DG Set (At 100% MCR)	46 Lit/hour

TUG- OCEAN EMPIRE

Sr No.	Particulars	Technical Specification
01	Flag	Indian
02	Port of Registry	Kochi
03	IMO No.	9658862
04	Official No.	41000638
05	MMSI NO	4056
06	CALL SING	AVGWU
07	GT	468
08	NT	140
09	LOA	31.50 M
10	LBP	28.8 M
11	BREADTH MLD	11.0 M
12	DEPTH MLD	6.1 M
13	DWT	287
14	CLASS	ABS/IRS
15	PROPULSION POWER	2 X 1654 KW@724 RPM (DERATED) (NIIGATA 6L28HX)
16	AZIMUTH THRUSTER	NIIGATA ZP-4 SRP
17	SPEED	12.0 KTS
18	BOLLARD PULL	60.25 @100 MCR
19	YEAR BUILT	AUG 2012

DUMB BARGE-ANURADHA

Sr No	Particulars	Technical Specification
01	Flag	Indian
02	Length overall	23.1 m
03	Port of Registry	Kandla
04	Breadth (MLD)	6.0 m
05	Depth (MLD)	2.9 m
06	Draft	1.5 m
07	Frame Spacing	500 mm
08	Generator	02 Nos,25 KVA,415 VAC,3 PH
09	OIL SPILLAGE RESPONSE SYSTEMS	RO-BOOM WITH REEL – 02 NOS.
		CURRENT BUSTER BOOM WITH REEL – 01 NOS.
		DBD SKIMMER-01 SET
		WEIR SKIMMER -01 SET
		POWERPACK 42 KW-01 NOS.
		POWERPACK 7.5 KW-01 NOS.
		POWERPACK 15 KW-02 NOS
		OSD SPRAY PUMP & ACCESSORIES-01 SET

TUG- VIHAAN

Sr No	Particulars	Technical Specification
1	FLAG	INDIA
2	IMO NO.	9691383
3	MMSIO NO.	419001130
4	LOA	31.5 M
5	LBP	26.8 M
6	GT/NT	470/141
7	DEAD WEIGHT	284.606 Mt.
8	LIGHT SHIP	621.4 Mt.
9	DRAFT	SUMMER:5.313 M, FREEBOARD: 1.107 M
		TROPICAL:5.409 M, FREEBOARD: 1.011 M
10	DECK LINE	400 MM BELOW MAIN STEEL DECK
11	HEIGHT KEEL TO TOP OF MAST	24.81 M
12	MAIN ENGINES	NIIGETA 6L26HLX-2X1838KW AT 750 RPM FP (2520MM)PROPELLER 2700MM DIA 4 BLADES-CAST NI-AL-BRONCE
13	BOLLARD PULL	70.72 MT
14	TOWING WIRE AFT	52MMX1000M
15	TOWING WIRE FOR D	52MMX220M
16	TUGGER WINCH	200MX22MM WIRE –SWL 10 MT
17	DECK CRANE	PALFINGER 1200-SWL 600KG AT 12.2M
18	RESCUE BOAT	4500MMX2000MMX850MMX1325KG-6 PERSON
19	D.O CAPACITY	235.3CuM (100%)
20	FW CAPACITY	53.1CuM (100%)
21	BALLAST CAPACITY	61 CuM (100%)
22	ANCHOR	500KG
23	ANCHOR CABLE	5 SHACKLES (PORT),6 SHACKELS(STBD)

ANNEXURE – 22

(Refer Page34, Para3.7)

LIST OF APPROVED RECYCLERS

SL.NO	NAME	ADDRESS
01	M/s ALICID ORGANIC INDUSTRIES LIMITED	OFFICE NO. 35, FIRST FLOOR, GRAIN MERCHANT ASSOCIATION BUILDING, PLOT NO. 297, WARD 12/B, GANDHIDHAM-370201
02	M/s UNITED SHIPPING COMPANY	OIL & GRAIN MERCHANT ASSOCIATION BUILDING, OFFICE: NO.46, FIRST FLOOR, WARD 12-B GHANDHIDHAM, KUTCH 370201
03	M/s ALTAS ORGANICS PVT.LTD.	204/206 ELLISBRIDGE SHOPPING CENTER, OPP.TOWN HALL ASHRAM ROAD, AHMADABAD-380006
04	M/s SHANA OIL PROCESS	NEW GOOD LUCK MARKET, Nr AKSHA MASJID, CHANDOLA LAKE, NAROL ROAD, AHMADABAD-3800028
05	M/s PRIYANSI CORPORATION	H/O. MARURI PETROLEUM, SHOP NO.2, NH-8B, SHAPAR(VERAVGAL)
06	M/s. FINE REFINERS PVT. LTD.	PLOT NO.40, GIDC, CHITRA, VARTEJ, BHAVGNAGAR, BHAVGANAGAR-364060
07	M/s. KUTCH PETROCHEM PVT.LTD.	OFFICE: PLOT NO: 121, SECTOR 9/C, BEHIND ASHOK LEYLAND, POST BOX NO.166, GANDHIDHAM and KUTCH 370201.

ANNEXURE-23
(Refer Page-77)

LIST OF OSR PERSONNEL – DPA OOT VADINAR

Sl	NAME	DESIG.	OSR QUAL.
01	Shri A. Ramasamy	Chief Operations Manager	Level-III
02	Shri Narendra Naik	ME Gr-I	Level-III
03	Shri Palash Jadafva	AE(D/T)	Level-II
04	Shri Devang Kanani	JE Gr-I (M)	Level-I
05	Shri Vaikuntah Rao	Casab	Level-I
06	Comdt. Retd. B. H Kumbhare	Sr. Manager	Level-III
07	Vysakh K K	Manager	Level-II
08	Debi Prasad Dash	Manager	Level-II
09	Debasis Sethi	Manager	Level-II
11	Keelu Vinodkumar	Manager	Level-II
12	Ashrit Mishra	Manager	Level-II
14	Rohit Girase	Responder	Level-I
15	Debendra Mohanta	Responder	Level-I
16	Bhola Singh	Responder	Level-I
17	Rajeev N.R.	Responder	Level-I
18	Jitendra Singh	Responder	Level-I
19	Shankar Singh	Responder	Level-I
20	Pintu Kumar	Responder	Level-I
21	Pawan Baryekar	Responder	Level-I
23	Anil Kumar	Responder	Level-I
28	Sunil Kumar	Responder	Level-I

ANNEXURE-24

LIST OF OSR PERSONNEL – DPA KANDLA

Sl	NAME	DESIG.	OSR QUAL.
1	Capt. Pradeep Mohanty	Deputy Conservator	Level -III
2	Capt. Lalji ram Meena	Harbour Master	Level -III
4	Capt Shishir Pathak	Sr. Pilot	Level -III
3	Nitin Keniya	Flotilla Superdt.	Level-II
4	Vanka Krishna Rao	Serang-C	Level-II
5	Pawan Sontakke	Manager	Level-II
6	Deewansinh Jadeja	Ast. Flotilla Supervisor	Level-I
7	B. Mohan Rao	Serang-c	Level-I
8	Ghanshyam Jatav	Ast. Flotilla Supervisor	Level-I
9	Pawan Bharati	Responder	Level-I
10	Gajendra Behera	Responder	Level-I
11	Saroj Kumar	Responder	Level-I
12	Papun Behera	Responder	Level-I
13	Dilson John	OSR Manager	Level-I
14	Manoj Kumar	Responder	Level-I
15	Ishwar Giri Goswami	Serang-c	Level-I
16	Kishan D. Sodham	Lascar	Level-I
17	Harshad Danicha	Lascar	Level-I
18	Hitesh K. Thacker	Master 1st Class	Level-I
19	Jitendra Ninjar	Ast. Flotilla Supervisor	Level-I

20	Jaydipsinh Gohil	Berthing Supervisor	Level-I
21	Bharat Parmar	AFS	Level-I
22	Kishor Goswami	Master 1st Class	Level-I
23	D.S. Gujar	Station Officer	Level-I
24	K.G. Khalsa	Station Officer	Level-I
25	G. Nethaji	Station Officer	Level-I
26	M. R. Vadavia	POCD	Level-I
27	Sahdev Mondal	Station Officer	Level-I
28	Kartik Raval	Responder	Level-I

ANNEXURE-25

MOU BETWEEN DPA VADINAR, IOCL & VOTL

The MOU between DPA Vadinar, IOCL & VOTL (Placed as an Annexure-25, Page -139). Fulfills the total requirement of OSR Personnel as per NOS-DCP circular no.03/2018. (EP/0720/circular dated 19 Dec 18).

The matter has been discussed with Local Coast Guard Authorities & it is intimated that the matter is been taken up with CGHQ to Lower the risk category of DPA port.

INDIA NON JUDICIAL

Government of Gujarat

Rs. 100

सत्यमेव जयते

Certificate of Stamp Duty

Certificate No.	:	IN-GJ50945344766603R
Certificate Issued Date	:	23-Dec-2019 11:14 AM
Account Reference	:	IMPACC (SH)/ gjshimp17/ JAMNAGAR1/ GJ-JM
Unique Doc. Reference	:	SUBIN-GJGJSHIMP17429583009966683R
Purchased by	:	VADINAR OIL TERMINAL LTD
Description of Document	:	Article 5(h) Agreement (not otherwise provided for)
Description	:	MUTUAL AID SCHEME FOR OIL SPILL RESPONSE AND CONTROL
Consideration Price (Rs.)	:	0 (Zero)
First Party	:	VADINAR OIL TERMINAL LTD
Second Party	:	N A
Stamp Duty Paid By	:	VADINAR OIL TERMINAL LTD
Stamp Duty Amount(Rs.)	:	100 (One Hundred only)

SHCIL JAMNAGAR

MA 0004699178

MUTUAL – AID SCHEME

(FOR OIL SPILL RESPONSE AND CONTROL)

MEMBER ORGANISATIONS

1. **Deendayal Port Trust,** a Major Port having its registered office at Administrative building, Tagore Road, Gandhidham, Gujarat-370201 and Offshore oil Terminal at Vadinar, Gujarat.

2. **M/s Indian Oil Corporation Ltd.**, a company registered under Companies Act, 1956 having its Registered Office at Indian Oil Bhawan, G-9 Ali Yavar Jung Marg, Bandra (East) Mumbai – 400 051 and crude oil tank farm station at Vadinar, Distt: Jamnagar - 361010 (Gujarat)

3. **M/s.Vadinar Oil Terminal Ltd. (Subsidiary of M/s.Nayara Energy Limited)** a company registered under Companies Act, 1956 having its Registered Office at Nayara Refinery Site, 39 KM stone, Okha Highway(SH-25), Khambhalia -361305

Member Organizations shall hereinafter individually referred to as "Member" and collectively as "Members"

The above members are operating in the Gulf of Kutch at Vadinar within Deendayal Port Trust Limit. All the operators have facilities for combating oil spill and are individually having oil spill response equipment. In case of oil spill; one member can take the help of another member. In order to act on the aforesaid arrangement, we the members have formulated the following Mutual Aid Scheme for this purpose.

We the Members of MUTUAL – AID SCHEME hereby agree to abide by the terms and conditions mentioned below:

1. Among the Members, whenever an emergency call is received from any calling Member about the occurrence of oil spill within Vadinar Port Limit, the helping member shall immediately send the oil spill control equipment and the response team as per the request received. The call from the calling member is to be made to the Nodal officer or Control Room of the helping Member. The list of oil spill equipment which can be spared and/or used by the Members during such an emergency is annexed to this Mutual Aid Scheme as Annexure No. 1.

2. Subject to the requirement of the calling Member, any additional assistance will be reviewed by helping Member and efforts, as far as possible, will be made to send such necessary additional assistance viz., oil spill equipment, boats/vessels, medical aid, firefighting equipment etc. at the earliest, along with additional man power subject to their availability.

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3. Helping member shall mobilize the committed resources as per this Mutual Aid Scheme within a period of one hour or less for the mobilization at oil spill site.

4. The entire emergency crew coming from outside for rendering their assistance will work under the On Scene Commander ("OSC"). The OSC will be appointed by the calling Member.

5. Members having Oil Spill Control Equipment will maintain them in working condition for any such emergency. The use of equipment will be provided free of charge except for any damage to the equipments during such emergency which will be paid for and/or replaced by the calling Member unless such damage is caused due to the negligence of the helping Member and/or its representative(s). The consumables used (Details mentioned in Annexure – 2) will be charged to the calling Member.

6. Calling Member representatives shall use appropriate safety equipment and safety gear and shall respond with due diligence for mitigation and containment of incident and safety of personnel and equipments including but not limited to the equipment/property of calling Member during the course of the emergency.
   During emergency any damage caused to calling Member property/personnel from the helping Member actions, shall not be compensated by helping Member, if such actions were taken in good faith and after proper due diligence.

7. In case of any accident in the course of rendering assistance to the calling Member, the calling Member shall handle such situations according to its own policies. In case of any injury to any representative of the helping Member, the first-aid treatment will be given by calling member free of cost if required by helping Member.

8. Detailed log of movement of vessel's mobilization and uses of equipment/consumables and oil spill related information shall be maintained by all the Members. In case of any modification to the list of equipment/consumables the same shall be intimated to the other Members within seven (7) days of such change.

9. Coordination Meeting & Mock drill will be carried out involving all mutual aid agencies, at least once in a year and will be coordinated by Indian Coast Guard.

10. The Members are free to seek assistance from any of the partner/organization as per their requirement in case of any major exigency.

11. The actual charges for repair of equipment rendered unusable to be paid by the calling member.

12. The charges for damage to equipment rendered unusable and consumables are to be submitted within a period of 30 days and to be settled not later than 3 months from the date of such submission.

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13. The Mutual Aid Scheme is valid for a term of five (5) years from the date of its execution.

List of Annexure:

Annexure – 1: List of Oil Spill Response Equipment maintained by each organization.

Annexure – 2: Detail of Charges of oil spill response consumables & equipment.

Annexure – 3: List of officer's contact detail from each organization.

Signed as token of acceptance of above terms & conditions:

Name : R K GURAV
Sign : Gurav
Designation : C.O.M.
Organisation : D.P.T.

मुख्य प्रचालन प्रबंधक
दीनदयाल पोर्ट ट्रस्ट
अपतट तेल टर्मिनल
वाडीनार - 361010

Name : Chinmoy Ghosh
Sign :
Designation : CGM
Organisation : IOCL

चिन्मय घोष
CHINMOY GHOSH
मुख्य महाप्रबंधक
Chief General Manager
इंडियन ऑयल कॉर्पोरेशन लिमिटेड
INDIAN OIL CORPORATION LTD.

Name : Capt Alok Kumar
Sign : Alok Kumar
Designation : VP & Head VOTL
Organisation : VOTL - Nayara Energy Ltd.

Vadinar Oil Terminal Limited NAYARA Energy

Sign in presence of:

Name : Rahul (Dy. Comdt.)
Sign : Rahul Sinha

Designation : Executive officer
Organization : ICGS Vadinar

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ANNEXURE-1
Oil Pollution Inventory Level- as on 23.12.2019 (Consolidated Level and Individual level)

Sr	Description of resources	DPT,Vadinar	Nayara Energy (VOTL)	IOCL,Vadinar	Total of DPT, IOCL & Nayara
1	Inflatable Booms with accessories	2000 mtrs, with 8 power packs	1150 mtrs with 4 power packs	1200 mtrs with 4 power packs	4350 m with 16 power packs
2	Skimmers(20 tph)	4	4	4	12
3	OSD Applicator with Spray arms type along with 02 nozzles systems and 02 hand lancers	6	2	3	11
4	Oil Spill chemical dispersant	10000 liters	10000 liters	11000liters	31000 liters
5	Flex Barge (10 Tons)	4	4	4	12
6	Speed Sweep System	2 nos.	Nil	Nil	2 nos.
7	Sorbent Booms (no)	300	200	100	600
8	Sorbent Pads	2000	7000	1500	10500
9	Mini Vaccum Pumps with capacity of 25m3	5	Nil	1	6
10	Portable Oil Temporary Storage Facility (10m3)	5	Nil	4	9
11	Work Boats (no)	2	2	2	6
12	Tugs (no)	4	1	1	6
13	**Man power**				
	IMO LEVEL -I	10	33	7	50
	IMO LEVEL -II	4	5	5	14
	OTHER / Equipment handlers	15	15	15	45

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ANNEXURE 2

Detail of Charges of oil Spill Response Consumables & Equipment.

A. CONSUMABLE CHARGES :

(Charges will be as per actual rates at the time or to be replenished by the calling organization)

S. No.	Item Description
1.	Oil Spill Dispersant /Bioremediation
2.	Absorbent pads
3.	Absorbent pillows
4.	Absorbent boom
5.	Fuel of Workboats/Tugs consumed during response period

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ANNEXURE - 3

Contact detail of each Member Organization.

1. Deendayal Port Trust , OOT Vadinar

Primary Contact : Mr. R.K.Gurav, Chief Operations Manager
Mobile : +919819999227
Land Line : 02833- 257301
E-mail : com@deendayalport.gov.in

Secondary Contact : Mr. Narendra Nayak, Marine Engineer Gr-I
Mobile : +919979126681
Land Line : 02833-257333
E-mail : megr1.oot@deendayalport.gov.in

Control Room Contact: Signal Station, Vadinar
Mobile : +919825212359

2. Indian Oil Corporation, Vadinar

Primary Contact : Mr. Chinmoy Ghosh, CGM
Mobile : +919437479025
Land Line : 02833-256527
E-mail : ghoshchinmoy@indianoil.in

Secondary Contact : Mr. Anil Meghani, DGM
Mobile : +919212035510
Land Line : 02833-256984
E-mail : anilm@indianoil.in

Control Room Contact: IOCL Control Room

Land Line : 02833-256536
E-mail : controlroomvadinar@indianoil.in

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3. M/s Nayara Energy Limited. (Vadinar Oil Terminal Ltd.)

Primary Contact : Capt. Alok Kumar, Head- VOTL

Mobile : +919909908611
Land Line : 02833-661385
Fax : 02833-661366
E-mail : alok.kumar@nayaraenergy.com

Secondary Contact : Mr. Sachin Shah, JGM & Lead HSEF

Mobile : +919879105470

Land Line : 02833-661376
Fax : 02833-661366
E-mail : sachin.shah@nayaraenergy.com

Control Room Contact: Marine Terminal Control Room (Shift Incharge)

Mobile : +919979868460
Land Line : 02833-661386
Fax : 02833-661366
E-mail : simo@nayaraenergy.com

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Annexure 26

SENSITIVITY MAPPING, RISK ASSESSMENT STUDIES FOR MARINE OIL SPILL FOR JETTIES, CREEKS AND SPMS

The Gulf abounds in marine wealth and is considered as one of the biologically richest marine habitats along the west coast of India. It is endowed with a great diversity of natural ecosystems, of which the major systems are salt pans, intertidal zones, marine algae (seaweeds), sea grass and sand dunes, mangroves, coral reefs, creeks, and Open Ocean. The Risk Assessment Studies for Marine Oil Spill for Jetties and SPMs and sensitive mapping of (Gulf of Kutch) has been carried out by NAYARA Energy Limited, Vadinar through, 60/4, Environ Towers,4th Floor, Hosur Main Road, Electronic City, Bangalore – 560 100. Recently in February 2024 is placed as an **Annexure -26** as the NAYARA Energy Ltd. Operations are within the area of jurisdiction of Kandla and Vadinar port in Gulf of Kutch. sanstivity mapping GOK.pdf (to open "ctrl + click").

SUBMISSION

- **It is of paramount importance to concentrate on preventing spills.**
- **Response to spills should seek to minimize the severity of the environmental damage.**
- **The response should always seek to complement and make use of natural forces to the fullest extent practicable.**
- **Some damage caused by specific response options may be justified if the response has been chosen for the greatest environmental and socioeconomic benefit overall.**
- **Offshore and near shore dispersant spraying can in some cases lead to an outcome of least environmental harm.**

ANNEXURE F
Disaster Management Plan

DEENDAYAL PORT AUTHORITY

DISASTER MANAGEMENT PLAN (DMP)

By

IRCLASS
Indian Register of Shipping

September - 2024

This is to state that at the request of Deendayal Port Authority (DPA), the undersigned surveyors have undertaken visit to Kandla Port to carry out a Risk Assessment and preparation of Disaster Management Plan. The scope of the analysis and the work undertaken are given in the attached report.

ISSUED BY:

Indian Register of Shipping

Prepared by

Somesh Gupta

Sudarshan Daga

Reviewed by

Dipak Sonawane

Approved by

A. Samanta

REPORT REVISION RECORD

Revision No.	Revision Details	Date
00	Draft report issued for review and comment to DPA.	02-07-2024
01	Final report issued to DPA.	02-08-2024
02	Final report issued to DPA.	26-09-2024

Disclaimer

The tasks of preparation of Disaster Management Plan have been executed by IRS as a consulting service at the request of Deendayal Port Authority. Conclusions and recommendations resulting from the consulting services have been formed in good faith and on the basis of the best information available from sources believed by IRS to be reliable.

IRS provides No warranty, express or implied, as for the completeness or correctness of the analysis and report preparation work. While IRS have made every attempt to ensure that the analysis, conclusions or recommendations contained in the report are from reliable sources using reliable methodologies; IRS is not responsible for any errors or omissions, or for the results obtained from the use of the deductions or reports.

The services rendered by IRS are without warranty of any kind, express or implied, including, but not limited to warranties of performance, merchantability and fitness for a particular or intended purpose.

The client(s) understand(s) and agree that IRS and its employees shall bear no liability arising out of or in connection with the results, recommendations or omissions. In no event will IRS, its related partnerships or personnel or agents or employees thereof be liable to or anyone else for any decision made or action taken in reliance on the services provided by IRS including any consequential, special or similar damages, even if advised of the possibility of such damages.

It is concluded that any usage/implementation/interpretation of the recommendation is at the client's risk. In particular, the recommendations should not be construed as certified, legal or otherwise.

INTRODUCTION OF
INDIAN REGISTER OF SHIPPING (IRS)

IRS is a classification society established for the promotion of safety of life and protection of property at sea & promotion of knowledge base. It is therefore engaged in the Management of Safety & Reliability through Development of Rules and Regulations, Surveys, Audits, Certification and Training. It is a member of the 'International Association of Classification Societies' (IACS) which is a consultative body to International Maritime Organisation, a subsidiary body of the 'United Nations Organisation'.

Indian Register of Shipping (IRS) is a public limited company incorporated under section 25 of the Indian companies Act 1956 (Section 8 Indian companies Act 2013), without any shareholders. Therefore, it has no beneficiary owners and no profit distribution. The Company charges fees for the services provided and these fees are its source of income. This is used for self-support, self-perpetuation and growth through continual improvement in its service quality, service coverage, research and development. All these activities are directed towards the enhancement of safety, reliability, quality and protection of the environment.

IRS is a recognized R&D organization by the Department of Scientific and Industrial Research (DSIR), Ministry of Science & Technology, 'Govt. of India' for its research related to the maritime industry.

In NOS-DCP, IRS has been identified as one of the technical specialists (support agency) to provide advice relating to ship safety, structural integrity and stability of marine casualties and to depute representatives to attend to a casualty and salvage at the SMCU when established.

A strong team of highly qualified and experienced experts in various disciplines of engineering and marine sciences/technology is engaged in IRS to offer prompt technical solutions to marine and other industry.

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ABBREVIATIONS

AERB	Atomic Energy Regulatory Board
BARC	Bhabha Atomic Research Centre
CBRN	Chemical, Biological, Radiological and Nuclear
CCA	Central Coordinating Authority
CEC	Chief Emergency Controller
CMO	Chief Medical Officer
CIC	Chief Incident Controller
CISF	Central Industry Security Force
CMG	Crisis Management Group
CWC	Cyclone Warning Centers
DCA	District Coordinating Authority
DCC	District Contingency Committee
DDMA	District Disaster Management Authority
DMP	Disaster Management Plan
DPA	Deendayal Port Authority
EAP	Emergency Action Plan
EOC	Emergency Operation Centre
ERDMP	Emergency Response Disaster Management Plan
GEB	Gujarat Electricity Board
GWSSB	Gujarat Water Supply and Sewerage Board
IDRN	Indian Disaster Resource Network
INCOIS	Indian National Centre for Ocean Information Services
IMD	India Meteorological Department
IMO	International Maritime Organization
IAP	Incident Action Plan
IRT	Incident Response Team
MMD	Mercantile Marine Department
MRCC	Maritime Rescue Coordination Centre
MSDS	Materials Safety Data Sheet
NDMA	National Disaster Management Authority
NIDM	National Institute of Disaster Management
NOSDCP	National Oil Spill Disaster Contingency Plan
OH&S	Occupational Health and Safety
OSRO	Oil Spill Response Organization
PAS	Public Address System
PESO	Petroleum and Explosives Safety Organisation
PNGRB	Petroleum and Natural Gas Regulatory Board
PRO	Public Relation Officer
RMC	Regional Meteorological Centre
SIC	Site Incident Controller
SDMA	State Disaster Management Authority

1. EXECUTIVE SUMMARY

Kandla port situated in Gulf of Kutch is a major port handling multipurpose cargo and serves the northwestern region giving a major fillip to the economy due to its suitably sheltered location and connectivity to the North western India, it is administratively controlled by the Ministry of Ports, shipping and waterways, Government of India.

This plan outlines the process for the management of response to Natural and Operational (man-made) disasters that are the responsibility of the port and stakeholders within port. The plan has been prepared as per the Guidelines and template issued by National Disaster Management Authority (NDMA)-2024 and National Disaster Management Plan (NDMP)-2019.

Sea ports face unique challenges in terms of both security and safety and are vulnerable. It may be emphasized that preventing a crisis to develop into a serious disruption is a key element that would address the roles and the responsibility of port employee and workers in high-risk areas of the port.

Quick and rapid response in a emergency situation helps in risk reduction and averting a crisis. This plan provides guidance for quick response in case of an emergency and helps in realizing sustainable Disaster Risk Reduction for the Port. It serves to seek and address all identified hazards and their risk and vulnerability analysis, elements at risk and the level of impact if any. The plan provides clarity on the roles, delegation of authority and responsibility of the Crisis Management Group (CMG) and Incident Response Team (IRT) members in the organization

2. INTRODUCTION

2.1RATIONALE – KEY LEGISLATION MEASURES INVOLVING DISASTER MANAGEMENT

2.1.1 Disaster Management Act, 2005;

The Disaster Management Act, 2005 (DM Act, 2005) lays down institutional and coordination mechanisms for effective Disaster Management at the national, state, district and local levels.

The Disaster Management Act 2005, Section 36;

This section of the act lays down the primary responsibility of ministries in the GoI and departments with respect to institutional framework for prevention, mitigation, preparedness and capacity building of disasters, allocating sufficient funds and other resources to the National and State government agencies. Enactments and review of its policies, rules and regulations for prevention of disasters, mitigation or preparedness.

The Disaster Management Act 2005, Section 37;

This section of the act lay down the primary responsibility of ministries in the GoI and departments with respect to preparation of Disaster Management Plan, their review, updation and its approvals. Measures for financing the activities within the plan are also required to be spelled out in the plan.

2.1.2 Guidelines for Preparation of DMP for Ministries/Dept. issued by National Disaster Management Authority (NDMA), 2024

The guidelines provide a framework in accordance with National Disaster Management Plan - 2019 and provides direction to the port and its stakeholders for all phases of the disaster management cycle.

2.1.3 Prime Minister of India – Ten-Point Agenda for Disaster Risk Reduction

1. All development sectors must imbibe the principles of disaster risk management
2. Risk coverage must include all, starting from poor households to SMEs to multi-national corporations to nation states
3. Women's leadership and greater involvement should be central to disaster risk management
4. Invest in risk mapping globally to improve global understanding of Nature and disaster risks
5. Leverage technology to enhance the efficiency of disaster risk management efforts
6. Develop a network of universities to work on disaster-related issues
7. Utilize the opportunities provided by social media and mobile technologies for disaster risk reduction
8. Build on local capacity and initiative to enhance disaster risk reduction
9. Make use of every opportunity to learn from disasters and, to achieve that, there must be studies on the lessons after every disaster
10. Bring about greater cohesion in international response to disasters.

2.1.4 Sendai International framework for Disaster Risk Reduction (SFDRR-2015-2030)

The post-2015 goals and agenda are set forth in the three landmark global agreements reached in2015 – the Sendai Framework for Disaster Risk Reduction (Sendai, Japan, March 2015), Sustainable Development Goals (UN General Assembly, New York, September 2015) and Climate Change Agreement (Conference of Parties, COP21, Paris, December 2015). The four priorities for action under the Sendai Framework are:

Figure 2.1: Sendai Framework

2.1.5 Safety initiatives to address Natural Disasters

NDMA guidelines on Disasters like Wind & Cyclone, Tsunami, Earthquake and Floods Management are relevant and these have been prepared to provide the directions to ministries, departments and state authorities for the preparation of their detailed Disaster Management Plans.

2.2 OBJECTIVE AND SCOPE OF THE PLAN

The objectives of the DMP are to:

a. Contain and control the emergency incidents,
b. Proactively safeguard the lives of the port employees, contractors, stakeholders, visitors and neighboring population,
c. Mitigate the effect and minimize the damage to the environment,
d. Limit damages of port assets,
e. Ensure that the port responds according to the priorities set by the Chief Incident Controller (CIC) during response operation,
f. Safely restore operations back to normal as quickly as possible after occurrence of any accident, to enable business to be resumed at the earliest,
g. Initiate off-site emergency plan in case of necessity as and when required.

The scope covers –

a. The existing preventive and mitigation measures;
b. Identification of potential scenarios that are likely to occur considering risk profile of port;
c. The preparedness to develop plans for actions when disaster or emergencies occur;
d. The responses that mobilize the necessary emergency services including responders like fire service, police service, medical service including ambulance, government as well as non-governmental agencies;
e. The initiation of off-site emergency plan, should the situation escalate to call for support of civic administrations (district and/or state) and their resources;
f. The post disaster recovery with aim to restore the affected area to its original condition.

3. PROFILE OF THE PORT

3.1 PROFILE

Deendayal Port, a major port since 1955, is situated on the shores of the Kandla Creek The total length of Deendayal Port approach Channel is around 23 kms and minimum width 250 meters. The port is an all-weather port.

It is well connected by the network of rail and road and provides gate way for export and import of traffic from all North Indian States.

Pilotage is compulsory; and is available round the clock except for tankers (LPG and Ammonia vessels are handled during daylight hours only).

Dedicated anchorage areas for the calling vessels are at outer Tuna Buoy (OTB) and for barges it is located inside the Kandla creek.

Existing Facilities inside the port area are as follows:

1. Dry cargo on berths 1 to 10 and 13 to 16 (Iron Scrap, Steel, Food Grains, Ore, Timber Logs, Salt Extractions, etc.)
2. Container berth 11-12
3. Liquid cargo on oil jetties 1 to 7 (LPG, Ammonia, POL Products, Edible Oils, Other Chemicals, etc.)
4. IFFCO barge jetty
5. Floating Dry Dock Facility

3.2 LOCATION OF THE PORT

The port lies near the city of Gandhidham in Gujarat.

Table 3.1: Location of Port

Latitude	23° 3'47.33"N
Longitude	70°11'50.30"E

3.2.1 Port Layout and Port limit map

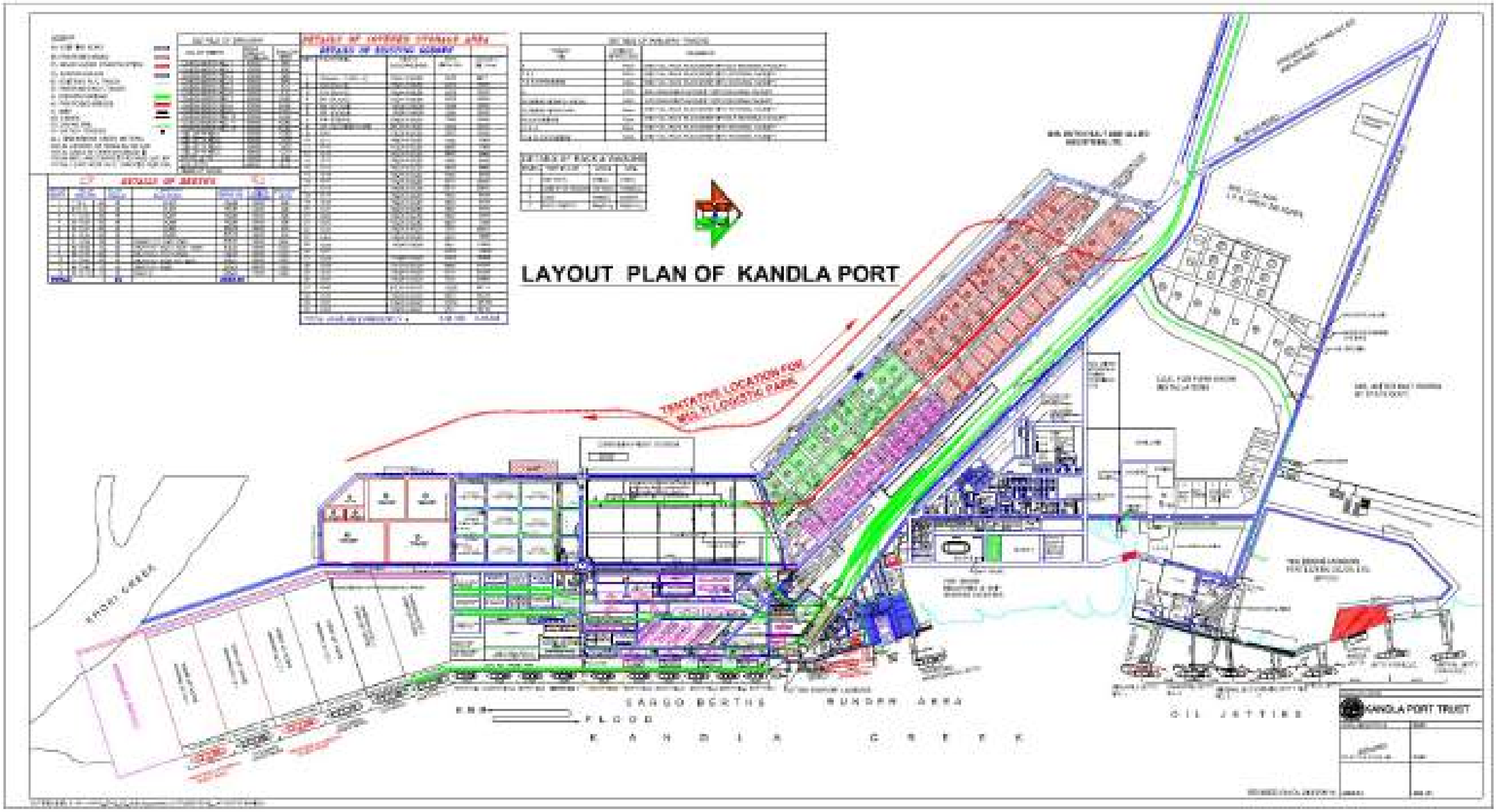

Figure 3.1: DPA Layout

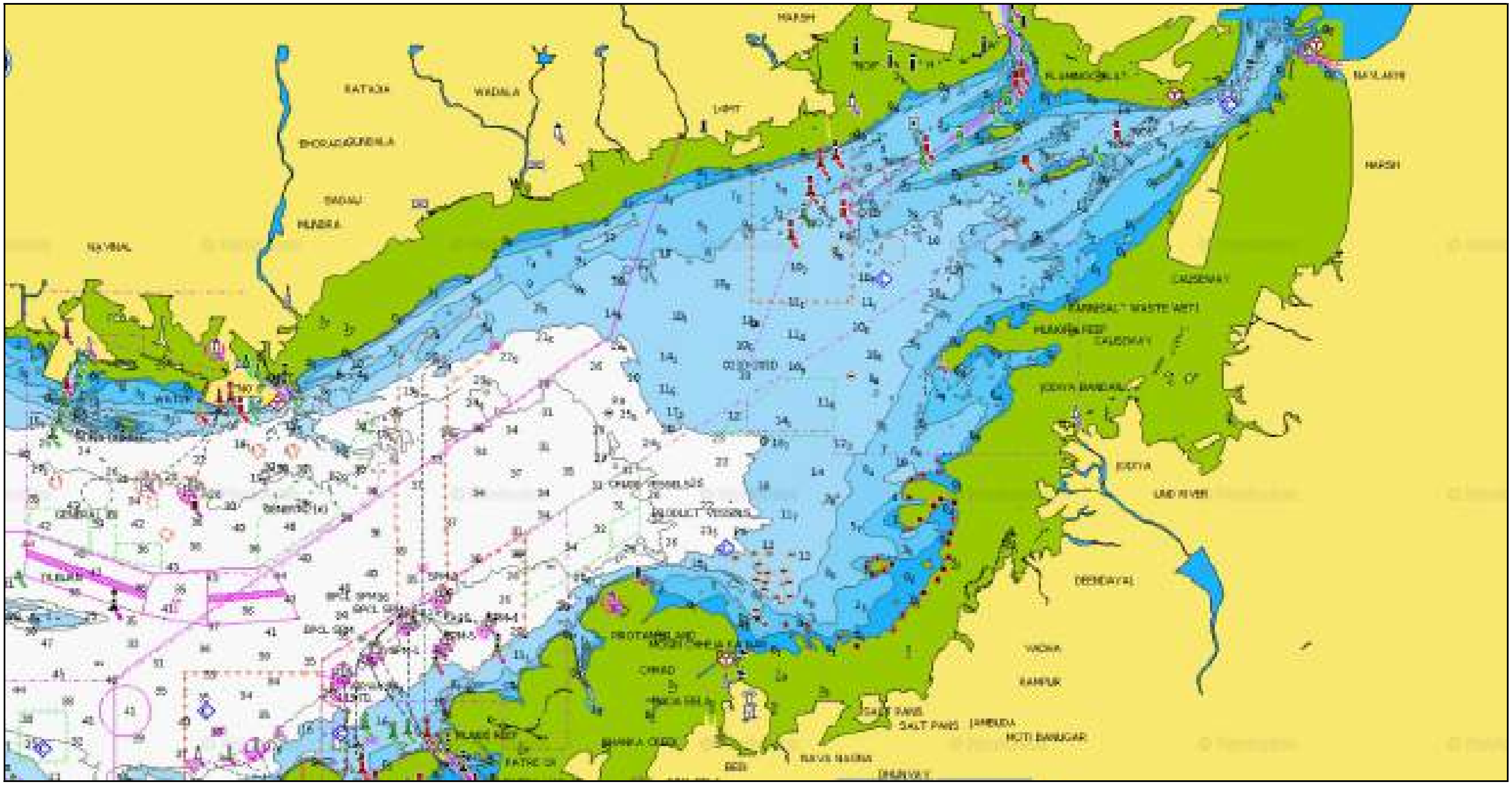

Figure 3.2: Port Limit Map

4. RISK ASSESSMENT

4.1DISASTER RISKS AND VULNERABILITIES

4.1.1 Chemical Disaster (Fire/ Explosion/ Toxic gas/ liquid release)

These can be caused due to loss of containment of hazardous cargo such as LPG, Motor Spirit, Toluene, Butadiene, Naphtha, Acrylonitrile, Ammonia etc.

4.1.2 Fire Disaster- Class A (solid combustible) & E (electrical) - Fire incidents can occur in areas such as the administration building, control rooms, electrical substations, etc.

4.1.3 Navigational Disaster

Potential scenarios such as Collision, Grounding, Oil Spill, Fire on ships. These were identified on the basis of HAZID assessment and discussion with stakeholders.

4.1.4 Natural Disasters

- Wind and Cyclone: In accordance with national and regional hazard map available with BMTPC the Kutch district falls under ***very high damage risk zone (max. wind speed of 50 m/s)***.
- Flood: Due to its geographical situation, the Kutch district is ***not vulnerable to occurrence of Flood***.
- Earthquake: Kutch district fall under ***High to Very High earthquake damage Risk zone (zone category IV & V).***
- Tsunami predictable with technological information.

4.1.5 Terrorism Disaster

These are situations that develop mostly without warning and need specialized handling.

4.2VULNERABILITY & THREAT MATRIX

An assessment of port vulnerable areas vis-a-vis threats due to disasters is prepared depicting low, moderate and high vulnerability categories.

Table 4.1: Vulnerability and Threat Matrix

Threats → / Vulnerable Areas ↓	Vessel Accidents: Collision/ Grounding/ Fire/ Explosion	Fire & Explosion: Manifold/ Pipeline/ Hose/any other fire	Toxic Gas Leakage: Pipeline/ Manifold/ hose	Pollution (Land/ Sea): Oil/ Chemical	Technical Failures: Power/ Transport / Communi -catio/ Infrastruc ture	War & Terrorism: Bomb Threat	Cyclone , Floods	Tsunami/ Earth Quake
VESSEL MOVEMENT								
Navigational Channel	xx	-	-	xx	xx	xx	xx	xx
Anchorage area (OTB and Inner anchorage)	xx	-	-	xx	xx	xx	xx	xx
General Cargo Jetty	x	x	-	x	xx	xx	xx	xxx
Oil Jetties	xx	xx	xx	xx	xx	xx	xx	xxx
Tug Jetties	x	-	-	x	-	x	xx	xx
STORAGE-TRANSFER								
Stack yards (Coal, timber, Sulphur, container etc.)	-	x	-	-	-	x	xx	x
Godowns	-	x	-	-	-	x	xx	xx
CARGO TRANSFER								
Pipelines and loading arms	-	xx	xx	xx	xx	xx	xx	xx
Cranes & Ship Loaders	x	x	-	-	x	x	xx	xx
SERVICES								
Security gates	-	x	x	-	x	xx	x	x
Electric Substations	-	xx	-	-	xx	x	x	xx
Dry Dock	-	x	x	-	x	xx	xx	xx
Port Fire station/ Signal Station	-	x	x	x	xx	x	x	xx
Port tugs, crafts, dredger, launchers	x	x	-	x	x	x	xxx	x
ADMINISTRATION								
Buildings (Admin, hospital)	-	xx	-	-	x	x	xx	xx

Note: x=slightly vulnerable; xx=moderately vulnerable; xxx=highly vulnerable

4.3LEVEL OF DISASTERS

The different levels of disaster in order to facilitate the responses and assistance to ports are as follows

Level 0 – denotes normal times which will be utilized for close monitoring, documentation, prevention and preparatory activities. Training on search and rescue, drills, evaluation and inventory updating for response activities will be carried out during this time

Level 1 – specifies disaster that can be managed at Port level; however, the neighboring industries and district will remain in the state of readiness.

Level 2 – disaster situations are those which require assistance and active participation of the port, the neighboring industries and district/State.

Level 3 – disaster situation is in case of large-scale disaster where the state and district authorities have been overwhelmed and require assistance from the Central Government for rescue, relief, and other response and recovery measures. In most cases, the scale and intensity of the disaster as determined by the concerned technical agency like IMD, INCOIS etc. are sufficient for the declaration of Level 3 disaster.

5. ROLES AND RESPONSIBILITIES

5.1 HUMAN RESOURCE PLANNING

Refer **Figure** 5.1 and 5.2 for Onsite and Offsite Emergency Organization chart respectively.

5.1.1 Crisis Management Group

The Crisis Management Group consists of all HOD`s under the head of the Chairman/Dy. Chairman (CEC) which lays down the policies and decisions.

1. Chairman/Dy. Chairman;
2. Deputy Conservator;
3. Traffic Manager;
4. Chief Engineer (Civil);
5. Chief Mechanical Engineer;
6. Fire Cum Safety Officer;
7. Sr. Commandant-CISF;
8. Chief Medical Officer;
9. Chief Vigilance officer;
10. Secretary (General Administration);
11. Chief Law Officer;
12. Financial Advisor and Chief Account Officer;
13. Sr. Dy. Materials Manager;
14. Environment Cell (External);
15. Public Relation officer;
16. Port Berth Operator/Terminal Managers.

5.1.2 Action Group (Incident Response Team)

The action group carries out the decisions made by CMG. It shall be formed at the time of crisis with Harbour Master (SIC) as the head.

1. Harbour Master;
2. Signal Station Superintendent;
3. Dy. Fire Officer;
4. Dy. Traffic Manager;
5. Pilots;
6. Safety Officer;
7. Dy. Chief Mechanical Engineer;
8. Dy. Chief Engineer (Civil);
9. Sr. Dy. Secretary (General Administration);
10. Flotilla Superintendent;
11. Mooring Team;
12. Dy. CMO (Medical);
13. Dy. Commandant -CISF;
14. Dy. Financial Advisor and Chief Account Officer;
15. Dy. Material Manager;
16. Oil Spill Response Organization (OSRO);
17. Port Berth Operators.

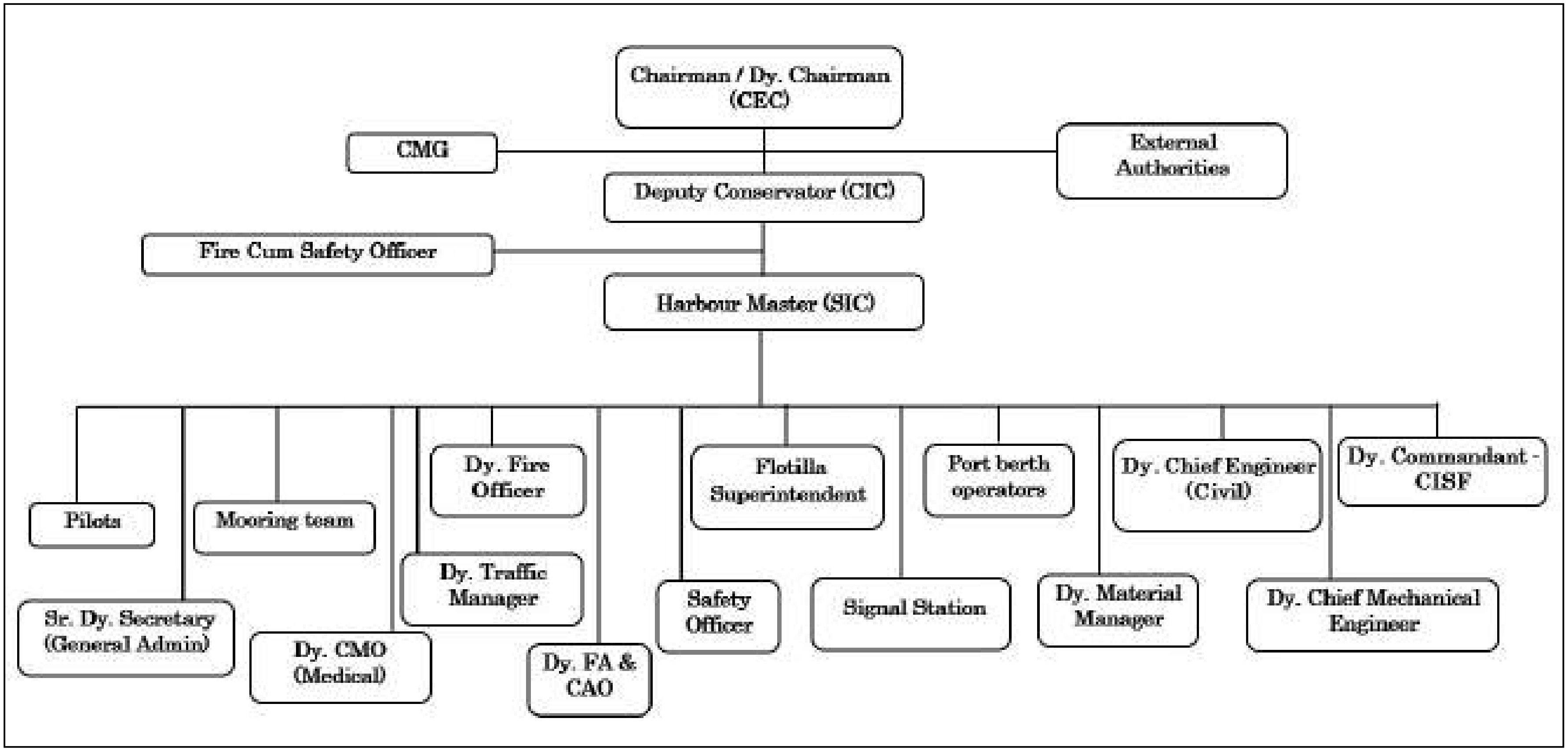

Figure 5.1: On-Site Emergency Organization Chart

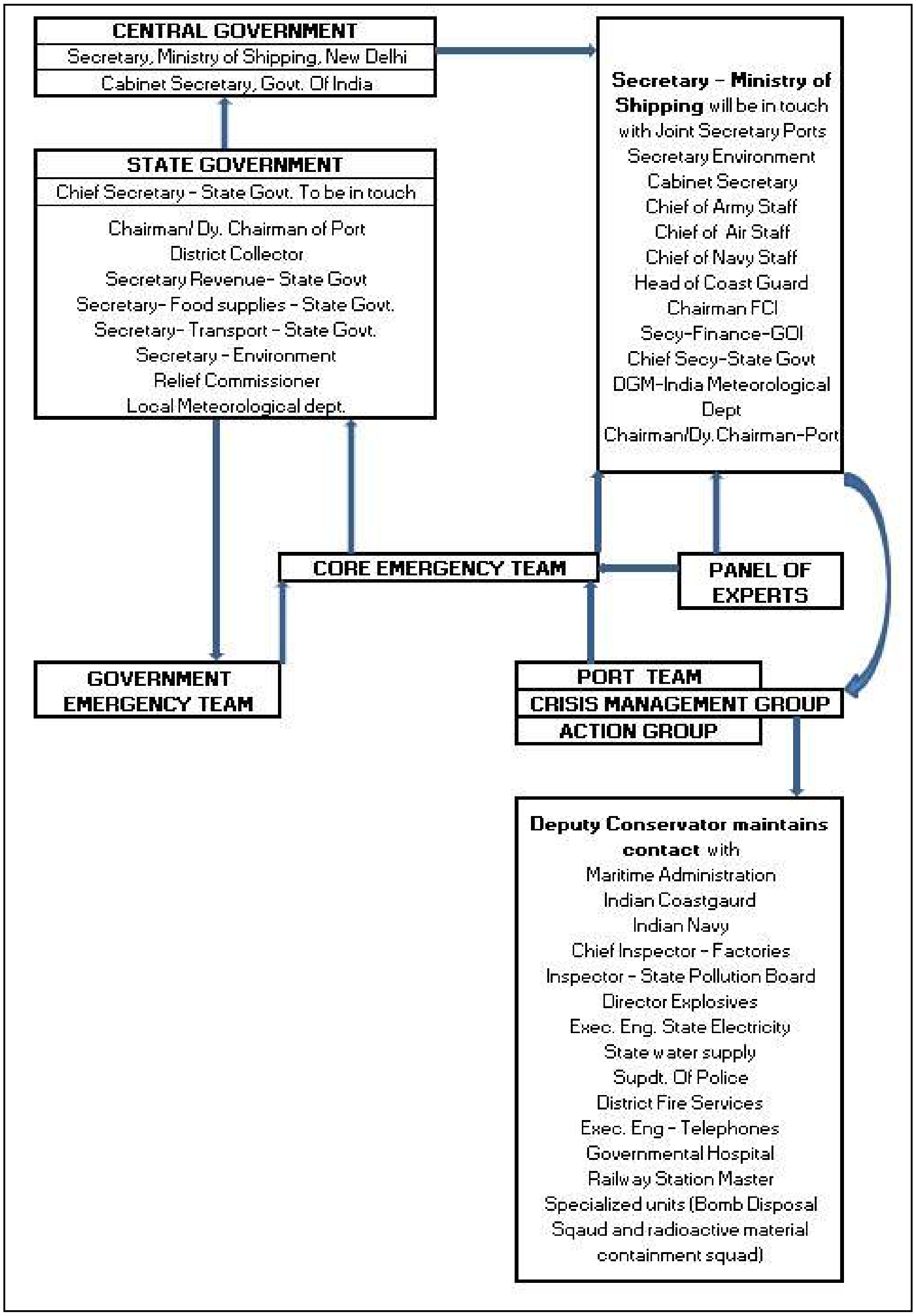

Figure 5.2: Off-Site Emergency Organization Chart – Level 2 and 3

5.1.3 Roles of Terminal/Berth Operators and Port Authority

Role	Terminal/Berth Operators	Port Authority
Prevention	•Prepare, revise, test and exercise own facility EAP/ERDMP, •Train own staff, •Conduct and participate emergency drills and exercises.	• Prepare DMP, •Conduct emergency exercises, •Guideline to encourage all Port Facility Operators to have Emergency Management Plans.
During Response	Undertake following: •First Aid, •Advise staff, •Contain (if possible), •Evacuation (as appropriate), •Partial or Full Shutdown (as appropriate), •Security. When external emergency services arrive: •Provide specialist advise/liaison, •Media Advise as required, •Advise Port, Security, and Harbour Master and neighbouring facilities as required.	•Monitor •Make Strategic decisions regarding: ○ Shipping movements ○ Threats to Port facility operators and effects on their business operations •Advice and assist ~~to~~ affected Port facility Operators on matters where qualified to do so. •Escalate response level by obtaining assistance from Local Crisis Groups.
Recovery and reconstruction	•Establish business continuity of terminal.	•Assist Port facility operators &/or shipping to resume operations. •Establish business continuity of terminal.

Table 5.1: Roles Terminal/Berth Operators and Port Authority

5.1.4 Roles and Responsibility of key personnel

<table>
<tr><th colspan="4">CHIEF EMERGENCY CONTROLLER (CEC)
CHAIRMAN/DEPUTY CHAIRMAN</th></tr>
<tr><th colspan="2">Phase</th><th colspan="2">Action</th></tr>
<tr><td rowspan="6">Mobilization /Activation</td><td>1</td><td colspan="2">Obtain details of incident and of any mitigative actions taken from CIC.</td></tr>
<tr><td rowspan="5">2</td><td colspan="2">Communicate with and coordinate with</td></tr>
<tr><td>a.</td><td>Local, District, State and National Authorities</td></tr>
<tr><td>b.</td><td>Crisis Management Group (CMG)</td></tr>
<tr><td>c.</td><td>Chief Incident Controller (CIC)</td></tr>
<tr><td>d.</td><td>D.G. Shipping</td></tr>
<tr><td rowspan="2">Establishing Control</td><td>3</td><td colspan="2">Nominate alternate person if any functionary is not available.</td></tr>
<tr><td>4</td><td colspan="2">Establish radio or telephone contact with CIC and CMG.</td></tr>
<tr><td rowspan="6">Planning</td><td rowspan="5">5</td><td colspan="2">Advice and provide support to CIC on</td></tr>
<tr><td>a.</td><td>Propriety of response level</td></tr>
<tr><td>b.</td><td>Location of EOC</td></tr>
<tr><td>c.</td><td>Additional Human Resource, materials, equipment and information.</td></tr>
<tr><td>d.</td><td>Authorizes the release of required funds for the necessary arrangements for evacuation, transportation, food & supplies.</td></tr>
<tr><td>6</td><td colspan="2">Advice CIC on activation of DMP.</td></tr>
<tr><td rowspan="2">Ongoing Response</td><td>7</td><td colspan="2">Activate Off Site Plan, if necessary.</td></tr>
<tr><td>8</td><td colspan="2">To issue Media briefings when required.</td></tr>
<tr><td rowspan="3">Response Termination</td><td>9</td><td colspan="2">Terminating response advice given to CIC if conditions are met.</td></tr>
<tr><td>10</td><td colspan="2">Receive incident reports from CIC/ nominated alternate person.</td></tr>
<tr><td>11</td><td colspan="2">Advise on further course of action in consultation with CIC/ nominated alternate person.</td></tr>
</table>

CHIEF INCIDENT CONTROLLER (CIC) DEPUTY CONSERVATOR			
Phase		**Action**	
Mobilization / Activation	1	Obtain details of incident and of any mitigative actions taken.	
	2	Start recording of events in the Personal Log.	
	3	Activate DMP and/or OSCP.	
	4	Communicate and coordinate with	
		a.	Chairman/Dy. Chairman -CEC
		b.	IRT and CMG
		c.	Salvage Association
		d.	CISF-Security and Marine Police
		e.	Local Authorities and Neighboring industries, District, State and National Authorities
		f.	Respective Terminal Managers/Operators
		g.	Relevant external agencies for Natural Disasters.
Establishing Control	5	Assess the level of incident, nature, location, severity, casualties and resource requirement.	
	6	Proceed to the EOC and conduct briefing meeting.	
	7	Authorize any immediate action required by on site staff and contract agencies.	
	8	Establish contact with CIC and CMG.	
Evaluation	9	Determine resources at risk and the level of disaster.	
	10	Evaluate the assessment of the incident, in consultation with the SIC.	
Planning	11	Arrange for monitoring of the event/incident.	
	12	Convene planning meeting.	
	13	Instruct Material Manager to make a list of required needs: Personnel, equipment, transport etc. Authorize acquisition.	
Ongoing Response	14	Implement response actions as per DMP and OSCP.	
	15	Continue to monitor incident.	
	16	Monitor the response by scheduling and undertaking regular briefings/debriefings of IRT.	
	17	Amend the SOP and Action Plan as required.	
	18	Ensure that IRT is supplied with necessary personal needs such as tugs, walkie-talkies, PPE, food etc.	
	19	Monitor casualties and vessel traffic movements.	
	20	Terminate response if conditions are met.	
Response Termination	21	Advise the SIC and inform CEC.	
	22	Ensure that all IRT members, combat and support agencies are informed of termination of response.	
	23	Monitor to ensure safe and complete demobilization.	
	24	Debrief CMG.	
	25	Ensure that all records are collated and stored.	

SITE INCIDENT CONTROLLER (SIC) HARBOUR MASTER			
Phase		**Action**	
Mobilization /Activation	1	Obtain details of incident and of any mitigative actions taken.	
	2	Start recording of events in the Personal Log.	
	3	Initiate	
		a.	DMP, OSCP as required
	4	Communicate and coordinate with	
		a.	CIC
		b.	IRT
		c.	CMG
		d.	Master of the vessel
		e.	Terminal, Berth Managers and Operators
		f.	Functional Heads of the Port
		g.	OSRO
Establishing Control	5	Assess the level of incident, nature, location, severity, casualties and resource requirement.	
	6	Conduct initial briefing.	
	7	Authorize any immediate action required by on site staff and contract agencies.	
	8	Establish radio or telephone contact with CIC and CMG.	
Planning	9	Arrange for	
		a.	Deployment of Pollution and Fire- extinguishing response equipment.
		b.	Multi-Purpose Vessels
		c.	Tugs, etc.
		d.	Ensure evacuation of personnel to assembly areas.
	10	Assist Material Manager to compile a list of needs: Personnel, equipment, transport etc.	
Ongoing Response	11	Implement response actions as per OSCP and DMP.	
	12	Continue to monitor incident.	
	13	Monitor the response as per CIC schedule and undertake regular briefings/debriefings of IRT.	
	14	Coordinate Search and Rescue operations.	
	15	If necessary, call for additional resources.	
	16	Arrange relief for IRT members & Monitor OH&S performance.	
	17	Monitor waste volumes, if any.	
Response Termination	18	Terminate response if conditions are met on permission of CIC.	
	19	Ensure that all IRT members, Contract Agencies and CIC are informed of termination of response.	
	20	Monitor to ensure safe and complete demobilization.	
	21	Ensure that all records are collated and stored.	

SENIOR PILOT				
Phase		**Action**		
Mobilization / Activation	1	Upon callout, report to CIC/SIC.		
	2	Start recording of events in the Personal Log.		
	3	Attend Initial Briefing.		
Assessment	4	Assist and coordinate with SIC, Signal Station Superintendent and Chief hydrographer to obtain and collate available data:		
		a.	Weather.	
		b.	Tides, currents.	
		c.	Latest update on action taken.	
Planning	5	Determine field response equipment/ labor/ transport requirements and provide to CIC.		
Ongoing Response	6	Direct and coordinate marine response activities.		
	7	Prepare all tugs/crafts for mobilization at the earliest. Coordinate with Flotilla Superintendent.		
	8	Coordinate with dredging superintendent.		
	9	Ensure that field response teams receive required		
		a.	Information i.e. Briefings/Inductions/Weather.	
		b.	Personal protective equipment (PPE).	
		c.	Essential supplies (e.g. food, first aid etc.).	
		d.	Weather conditions.	
		e.	Monitoring of response activities.	
	10	Coordinate dispersant operations when permitted.		
	11	Seek for necessary means for aerial observation, containment and recovery actions and vessel dispersant spraying operations.		
	12	Inform in-charge of pollution response cell (OSRO) of anticipated waste quantity and type.		
Response Termination	13	Advise for termination of response operation.		
	14	Ensure safe return of response personnel.		
	15	Ensure that all equipment is cleaned and returned to stores.		
	16	Attend debriefing.		
	17	Ensure that all records are collated and stored.		

SAFETY OFFICER			
Phase		**Action**	
Mobilization / Activation	1	Start recording of events in the Personal Log.	
	2	Communicate and coordinate with	
		a.	CIC
		b.	SIC
		c.	Fire cum Safety Officer
		d.	Ship owners / Agents / C & F agents / stevedores.
		e.	Terminal and Berth/Jetty Managers
		f.	Environmental cell
		g.	Waste/ Sludge disposal agencies
Establishing Control	3	Establish radio or telephone contact with CIC and SIC.	
	4	Furnish information to the SIC with regards to the safety.	
	5	Inform GPCB and other environmental agencies about the incident for getting necessary guidance.	
Initial Action	6	Coordinate and consolidate list of dangerous goods including tanker in port.	
	7	To collect necessary evidence required for detailed investigation of any accidents.	
	8	Coordinate with the salvage association and waste/sludge disposal agencies.	
Ongoing Response	9	Assist in the safe evacuation of the personnel.	
Response Termination	10	Terminate response if conditions are met on permission of CIC/SIC.	
	11	Submit detailed report regarding the accidents to CIC/SIC.	
	12	Ensure that all records are collated and stored.	

CHIEF MECHANICAL ENGINEER (CME)			
Phase		**Action**	
Mobilization / Activation	1	Start recording of events in the Personal Log.	
	2	Communicate and coordinate with	
		a.	CIC
		b.	SIC
		c.	Port Electrical, Workshop divisions
		d.	Maintenance Department
		e.	Engineering Department (Electrical and Civil)
		f.	Fire cum Safety Officer
		g.	Material Management Department
		h.	State Electricity Board
Establishing Control	3	Depute engineers on-site.	
	4	Establish radio or telephone contact with CIC and SIC.	
Initial Action	5	Implements elaborate plans for providing continuity of emergency supplies and services such as, electric power, emergency lighting, communication system, dry docks, vehicles, floating crafts etc.	
	6	Keep alert on duty for any electrical isolation of equipment during an emergency.	
	7	Suggests optimal strategies for conducting emergency isolation operations of damaged equipment, the emergency transfer of materials and all other process related emergency operations	
	8	Maintain sufficient stock of required equipment/materials.	
	9	Coordinate with CIC, SIC and CISF.	
	10	Ensure water supply to the hydrants.	
Ongoing Response	11	Provide necessary advice and supports.	
	12	Arrange for Bulldozers, mobile cranes, forklifts or any other specialized equipment.	
	13	Mobilize cargo handling equipment.	
Response Termination	14	Terminate response if conditions are met on permission of CIC/SIC.	
	15	Ensure that all records are collated and stored.	

CHIEF ENGINEER (CE) – (Civil)			
Phase		**Action**	
Mobilization / Activation	1	Start recording of events in the Personal Log.	
	2	Communicate and coordinate with	
		a.	CIC
		b.	SIC
		c.	Engineering Department (Electrical and Civil)
		d.	Workshop Division
		e.	Material Management Department
		f.	Maintenance department
		g.	Fire cum Safety Officer
Establishing Control	3	Establish radio or telephone contact with CIC and SIC. Depute engineers on-site.	
Initial Action	4	Arrange sandbags, Diesel pumps, sufficient quantities of bleaching powder etc., for the event of Cyclone/flood. Plans/strategy, as contemplated, to be forwarded to higher levels.	
	5	Will look after fenders, sea wall, roofs etc.	
	6	Identify local contractors and keep them as standby to meet emergency requirements such as manpower, equipment etc.	
	7	Render and Monitor assistance for extricating trapped personnel by cutting structures etc.	
	8	To ensure that adequate clean water is available in the reservoirs.	
	9	Instruct the contractors to carry out urgency civil works if required.	
	10	Coordinate with CIC, SIC and CISF.	
Ongoing Response	11	Provide necessary advice and support.	
	12	In case of fire and especially if the fire involves toxic/flammable materials, contain the runoff fire water and other water from the damaged units.	
	13	Cooperate with IRT to conduct the actual cleanup work during and after the emergency including clearing of debris.	
Response Termination	14	Terminate response if conditions are met on permission of CIC/SIC.	
	15	Undertake strengthening of shoreline, buildings and other civil works, in case of damage.	
	16	Ensure that all records are collated and stored.	

TRAFFIC MANAGER			
Phase		**Action**	
Mobilization / Activation	1	Start recording of events in the Personal Log.	
	2	Communicate and coordinate with	
		a.	CIC
		b.	SIC
		c.	Terminal and Berth Managers
		d.	Safety officer
Establishing Control	3	Prepares vessels to vacate from berth.	
	4	Establish radio or telephone contact with CIC and SIC.	
Initial Action	5	Prepare consolidated list of dangerous goods including tankers in port and provide details to SIC.	
	6	Arranges to protect cargo in vicinity from damage.	
	7	Arranges to segregate and shift cargo in sheds.	
	8	Provide necessary advice and supports.	
Response Termination	9	Terminate response if conditions are met on permission of CIC/SIC.	
	10	Ensure that all records are collated and stored.	

FIRE CUM SAFETY OFFICER			
Phase		**Action**	
Mobilization / Activation	1	Obtain details of spill/fire and of any mitigative actions taken.	
	2	Start recording of events in the Personal Log.	
	3	Communicate and coordinate with	
		a.	SIC
		b.	CIC
		c.	Signal Station and Fire Station
		d.	Terminal and Berth Managers
	4	Activate Fire Station.	
Establishing Control	5	Lead Fire Fighting Team	
	6	Establish radio or telephone contact with SIC	
Initial Actions	7	Announce Fire Incident Point on PAS.	
	8	Be updated about wind direction.	
	9	Arrange for	
		a.	• Fire Extinguishers • Maintain sufficient water pressure in fire hydrant system.
		b.	Safety Equipment
		c.	Rescue of injured persons to medical centers
		d.	In consultation with SIC evacuate workers to assembly areas.
	10	Assist SIC to compile a list of needs: personnel, equipment, transport etc.	
Response Actions	11	Implement response actions as per OSCP and DMP as per SIC/CIC instructions.	

	12	If necessary, call for additional resources
Response Termination	13	Terminate response if conditions are met on consultation with SIC.
	14	Ensure safe return of response personnel.
	15	Ensure that all records are collated and stored.

SIGNAL STATION			
Phase		**Action**	
Mobilization / Activation	1	Communicate with	
		a	CIC
		b	SIC
		c	Kandla VTMS, Tuna Tekra and Vadinar
		d	Master of the vessel
		e	Pilots
		f	Meteorological department
		g	Marine Police
Initial Action	2	Gather detailed information about the incident.	
	3	On receipt of instructions from SIC, notify the Master of the Vessel, craft, security boat	
Ongoing Response	4	Coordinate with SIC and provide necessary information.	
Response Termination	5	Terminate response on instructions of CIC/SIC	
	6	Ensure that all records are collated and stored.	

SR. DEPUTY MATERIAL MANAGER			
Phase		**Action**	
Mobilization / Activation	1	Communicate with	
		a	CIC/SIC
		b	Engineering Department
		c	Workshops Division
Initial Action	2	Arrange for material and equipment	
	3	Ensure stock of emergency equipment such as diesel, petrol and such other oils, fire-fighting items such as foam, damage control stores such as cement and other stores required to keep plants, machinery road vehicles and water-craft running.	
	4	One officer to liaise with suppliers of all items mentioned above, so that they can be procured as and when required.	
Response Termination	5	Terminate response if conditions are met on permission of CIC/SIC.	
	6	Ensure that all records are collated and stored.	

Sr. COMMANDANT - CISF (SECURITY)			
Phase		**Action**	
Mobilization / Activation	1	Obtain details of incident and of any mitigative actions taken.	
	2	Start recording of pertinent facts and figures in the Personal Log.	
	3	Communicate and coordinate with	
		a.	CIC
		b.	SIC
		c.	Kutch Police Authorities and other relevant authorities
		d.	State Relief and Rehabilitation department
Establishing Control	4	Authorize any immediate action required by on site staff.	
	5	Establish a special task force for the rescue operation.	
	6	Establish radio and telephone contact with CIC and SIC	
Initial Action	7	Obtain necessary instructions from SIC.	
Ongoing Response	8	Keep extra vigilance on the location or sites which are likely to be affected by cyclone for e.g. electrical substation, store, workshop, cargo berth, dry dock, administration building etc.	
	9	Control entry of unauthorized persons.	
	10	Facilitate entry of authorized persons, agencies.	
	11	Facilitate entry of emergency vehicles such as ambulance etc.	
	12	Assist in Search and Rescue operation.	
	13	Ensures that residents within port area are notified about disaster and instructions to evacuate if necessary.	
Response Termination	14	Carry out a reconnaissance of the evacuated area before declaring the same as evacuated.	
	15	Terminate response if conditions are met on permission of CIC or SIC.	
	16	Ensure that all records are collated and stored.	

CHIEF MEDICAL OFFICER			
Phase		**Action**	
Mobilization / Activation	1	Start recording of events in the Personal Log.	
	2	Communicate and coordinate with	
		a.	CIC
		b.	SIC
		c.	Nearby Hospitals, Medical department of Gov. of Gujarat and Health care professionals.
		d.	Port Signal Station
		e.	CISF
Establishing Control	3	Activate Hospital Emergency Action Plan and depute doctors on-site to give first aid to the injured.	
	4	Establish radio or telephone contact with CIC and SIC and understand the emergency situation.	
	5	Advise CIC/SIC on industrial hygiene and make sure that the frontline personnel are not exposed to unacceptable levels of toxic substances.	
	6	Inform hospitals of the situation in case of a toxic release and apprise them of the antidotes necessary for the treatment	
	7	Coordinate with ICLO. Along with the District Administration and health care professionals, ICLO will facilitate infection control programme in the event of a natural disaster.	
Initial Action	8	Maintain sufficient stock of medicines, antidotes, oxygen, stretchers etc., and arrange for ambulance.	
	9	Suggest and provide an antidote in the event of toxic release	
	10	Coordinate with nearby hospitals, doctors and ambulance.	
Ongoing Response	11	Provide necessary advice and supports for appropriate treatment of the injured persons.	
Response Termination	12	Terminate response if conditions are met on permission of CIC/SIC.	
	13	Ensure that all records are collated and stored.	

TERMINAL/BERTH MANAGER		
Phase		**Action**
Mobilization / Activation	1	Start recording of events in the Personal Log.
	2	Communicate and coordinate with a. CIC b. SIC c. Ship owners / Agents / C & F agents / stevedores. d. Neighboring Terminal Managers
Establishing Control	3	Prepares vessels to vacate from berth.
	4	Establish radio or telephone contact with CIC and SIC.
Initial Action	5	Prepare consolidated list of dangerous goods including tankers in port.
	6	Arranges to protect cargo in vicinity from damage.
	7	Arranges to segregate and shift cargo in sheds.
Ongoing Response	8	Coordinate with ship owners/agents/C&F agents/stevedores.
	9	Provide necessary advice and supports with manpower and equipment including fire-fighting aids.
Response Termination	10	Terminate response if conditions are met on permission of CIC/SIC.
	11	Ensure that all records are collated and stored.

SECRETARY (GENERAL ADMINISTRATION)		
Phase		**Action**
Mobilization / Activation	1	Communicate and coordinate with a. CEC b. CIC c. Administration Department d. FA&CAO e. Legal Department
Initial Action	2	Will remain In-Charge of the Admin. department.
	3	In the event of evacuation, assist Management Group to co-ordinate with State Transport Authority and the Police authority for evacuation. Arrange for food and water and accommodation.
	4	Liaise with Municipal Corporation and the Civil Defence Organisation for arrangements for shelters for the evacuated persons, food for them and later for their rehabilitation.
	5	Keep in close liaison with the evacuating authority and collect all details regarding the evacuated people. This will be necessary to settle claims, if any, at a later date.
	6	Mobilise all vehicles for the transportation needs of the Management Team, the Action Team and support services.
	7	Keep the Legal Advisor of the Port informed of the situation at all times and obtain his advice for legalising all the port’s actions.
	8	Draw lists of Port Personnel affected and involved in an incident, and keep their families informed correctly through Information Centre.

	9	Make proper arrangements for the Port's personnel engaged in combating an emergency for their food and rest.
Response Termination	10	Liaises with media under guidelines provided by the CEC.

CHIEF LAW OFFICER			
Phase		**Action**	
Mobilization / Activation	1	Communicate and coordinate with	
		a.	CEC
		b.	CIC
Initial Action	2	Gather information	
Ongoing Response	3	To assist in issuing notice under Major Port Trust Act, Indian Ports Act, Major Port Prevention and Control of Pollution Rules etc. to the defaulters.	
Response Termination	4	Arrange for settlement of related claims	
	5	Liaises with media under guidelines provided by the CEC.	

FINANCIAL ADVISOR & CHIEF ACCOUNT OFFICER			
Phase		**Action**	
Mobilization / Activation	1	Communicate and coordinate with	
		a.	CEC
		b.	CIC/SIC
Initial Action	2	Gather information	
Ongoing Response	3	Process agreements and/or arrange payments to all departments for their requirements such as leasing/ immediate procuring of equipment.	
	4	Take appropriate action for hiring of specialist services, food, and shelter and transport arrangements, as the situation demands.	
	5	Depute a senior officer to each department involved in combating action, to look after its needs.	
	6	Monitor the expenditure, and services rendered by outside agencies to the Port and vice versa, to avoid disputes later and to facilitate smooth working of mutual aid.	
	7	Depute senior officer of this department assisted by an officer from the General Administration Department, Engineering, Marine Department to document all events, damages and claims.	
Response Termination	8	Liaises with media under guidelines provided by the CEC.	

PUBLIC RELATIONS OFFICER		
Phase		**Action**
Mobilization / Activation	1	Communicate and coordinate with a. CEC b. CIC
Initial Action	2	Set up an Information Centre.
Ongoing Response	3	Liaise between the EOC and outside agencies participating in the emergency.
	4	Provide information to the Police regarding developments as authorised.
Response Termination	5	Liaises with media under guidelines provided by the CEC.

5.2 COORDINATION - HORIZONTAL AND VERTICAL LINKAGES

Coordination with the following external agencies would be required and the Emergency Operation Centre (EOC) will function as the focal point of coordination.

- Gujarat State Disaster Management Authority (GSDMA),
- District Disaster Management Authority (DDMA) – Kutch,
- District Level Committee on Natural Calamity (DLCNC) - Kutch,
- Gujarat Disaster Rapid Action Force (GDRAF),
- State and National Crisis Group,
- Indian Coast Guards, Indian Navy,
- DG Shipping, MMD,
- GPCB, PESO, AERB,
- Gujarat Water Supply and Sewerage Board (GWSSB);
- DD, AIR for media briefing,
- Gujarat Electricity Board (GEB), Gujarat State Electricity Corporation Limited (GSECL),
- Gujarat State Road Transport Corporation (GSRTC),
- IMD, Meteorological Centre – Ahmedabad,
- Co-ordinate with the NGOs and aid agencies,
- P & I Club and their local correspondent,
- Salvage association,
- Public Health Organization.

5.2.1 State and District Level Coordination Mechanism

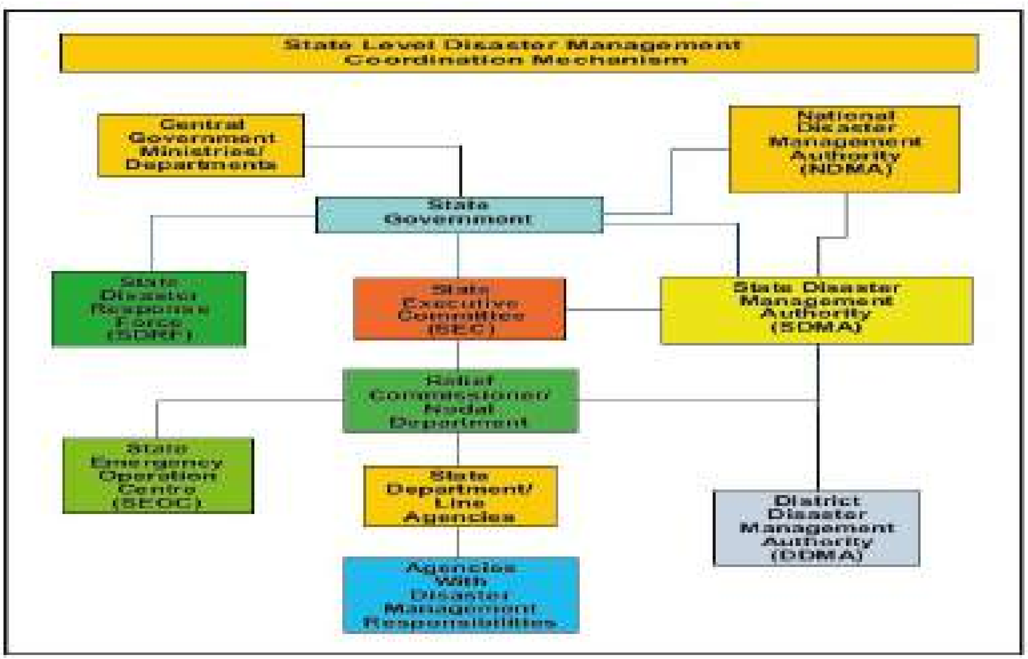

Figure 5.4: State –level disaster management – basic institutional framework

5.2.2 District Level

The DDMA is headed by the District Collector or Deputy Commissioner as the case may be, with the elected representative of the local authority as the Co-Chairperson.

6. PREPAREDNESS MEASURES

6.1 EMERGENCY OPERATION CENTRE

The EOC will be located in the E-Drishti Command and Control Centre or as directed by the CEC/CIC.

6.2 CAPACITY DEVELOPMENT

The capacity development covers all aspects of disaster management. The broad thematic areas for capacity development are summarized in **Table** 6.1.

Table 6.1: Summary of Broad Capacity Development Themes

	Capacity Development Themes
Key Aspect	**Thematic Areas**
Prevention or mitigation for disaster risk reduction	Hazards, Risk, and Vulnerability Assessment • Preparing DM plans, regular updation and mock drills, • Institutional arrangements, policies, legal support, and regulatory framework, • Safety awareness and training, • Mainstreaming of DRR into development plans and programs, • Training and skill development, • Documenting lessons from previous disasters and ensuring their wide dissemination, • Developing appropriate risk transfer instruments by collaborating with insurance companies and financial institutions, • Integrate DRR into business models and practices, • Preparedness and response plans at all levels, • Disaster resilience by maintaining list of nearby hospitals and health care centers, • Business resilience of productive assets by strengthening the supply chains and service providers, ensuring continuity of services.
Effective preparedness and response	Emergency response capabilities – EOCs, infrastructure, equipment upgrades and adoption of best available technologies • Effective coordination with external agencies and relevant stakeholders, • Adoption and adaptation of emerging global good practices, • Early warnings, maps/ satellite data/ effective dissemination of information, • Table-top exercises, simulations, and mock drills to improve operational readiness of the plans, • Strengthening of the Fire and Emergency Service through revamping and modernization, • Transportation systems and network, • Power and fuel supply management,
Recovery and Build Back Better	• Port infrastructure damage assessment mechanism and award of reconstruction projects, contracting including revised specifications for resilient infrastructure, • Studies on past disasters and recovery to draw useful lessons.

6.3 TRAINING

Regular trainings are provided to all personnel who have a role in planning and operational response to an emergency. A well-coordinated programme of training exercises includes activities of varying degrees of interaction and complexity.

6.4 DRILLS & EXERCISES

Emergency drills and integrated exercises have the following objectives:

1. To ensure that the emergency organization personnel are familiar with their duties and responsibilities,
2. Provide hands-on experience with the procedures to be implemented during emergency,
3. To test the adequacy of the effectiveness, timing, and content of the plan and implementing procedures.

The frequency of the drills are depends on the severity of the hazard. However, drills should be conducted at least once a year.

6.5 COMMUNICATION

Communication technology is an integral part of disaster management. It plays an important role in all the four distinct phases of disaster management namely mitigation, preparedness, response and recovery.

The following table provides information on the communication equipment available with the services and authorities.

Table 6.2: Communication Network within the Port

Services & Authorities	Communication Network Element
CMG and IRT	Special fire alarm and normal communication system-VHF-TELEPHONE-WALKIE TALKIE- MOBILE-SATCOM
Fire-fighting craft and Rescue launches, tugs and other harbour craft	UHF/VHF Radio telephones-Mobile
Ships at Berth	Normal UHF/VHF Radio telephone link used in cargo operations. Terminal/Berth Operator representative at tanker berth to also have own radio-SATCOM
District Collector or State Secretary	UHF/VHF Radio telephone, public telephone-hot line for emergency level 2 & 3-SATCOM
Civil authorities Including fire services, Police and medical services	UHF/VHF radio, telephone or public telephone system. SATCOM
Jt. Secretary-Ministry of Ports, Shipping and Waterways, New Delhi	Public telephone-hot line for emergency level 2 & 3 SATCOM

6.6 TEMPORARY SHELTER

In the event of an impending disaster the affected population would have to be transported to intermediate temporary shelter.

Help of the voluntary organizations i.e. NGO may be taken for the rescue and relief operation.

6.7 TRANSPORTATION

All port vehicles (owned or hired) will be used during emergency.

6.8 GENERATOR SETS

Wherever generator sets are required, the engineering department will be contacted, who will immediately hire/procure.

6.9 DECONTAMINATION

Decontamination is employed to remove hazardous materials from people and equipment. The various types are as below:

- ***Clinical decontamination*** - treatment by health professionals of patients affected by or contaminated with hazardous materials;
- ***Personnel decontamination***, meaning the decontamination of uninjured exposed persons;
- ***Equipment decontamination*** is the procedure used to clean the specialist equipment/protective suits which personnel use in dealing with hazardous material incidents.

6.10 MEDICAL FACILITIES

Depending on the nature of the emergency, it may be necessary to alert medical facilities.

6.10.1 FIRST AID CENTER

First Aid treatments provided at the port and the Port ambulance placed at every First Aid center and hired vehicles, can be used for taking the person to the medical center.

6.11 RESOURCE MANAGEMENT

Resources available with the port for the preparedness program can be found in **Chapter 10 and Annex B.**

The various equipment and systems should always be maintained, inspected and tested periodically.

6.12 LOGISTICS/SERVICE DELIVERY MECHANISM

The required/necessary equipment and assistance during various types of emergencies can be requested from the Local Industry crisis groups, District crisis groups, neighboring industries. Additional resources available for disaster relief with the various departments in the Kutch District can be found from IDRN (https://idrn.nidm.gov.in/).

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7. RESPONSE STRATEGIES

7.1 EARLY WARNING/ ALERT SYSTEM

7.1.1 Receiving and managing alerts

Information of the occurrence of incidents in and around the port area may come from a variety of sources. On receipt of information designated personnel must carry out investigation to confirm the incident and gather as many details and as quickly as possible:

- Prepare an incident report.
- Immediately forward the report to and inform the Deputy Conservator/Harbour Master.

7.1.2 Activation of Emergency Operation Centre (EOC) and initial resource coordination (Refer Procedure-A)

7.1.3 Resource mobilization

The CIC/SIC will ensure mobilization of sufficient equipment and personnel resources required to manage the response.

7.1.4 Direction, control and coordination –amongst IRT

The overall responsibility of the Emergency management lies with the CIC.

Table 7.1: Procedure for Establishing EOC

<table>
<tr><th colspan="1">PROCEDURE-A</th><th colspan="4">ESTABLISHING THE
EMERGENCY OPERATION CENTRE (EOC)</th></tr>
<tr><th>Task</th><th colspan="3">Action</th><th>Status</th></tr>
<tr><td>1.0</td><td colspan="3">Obtain and/or assign EOC equipment.</td><td></td></tr>
<tr><td rowspan="4">1.1</td><td colspan="3">Communications</td><td></td></tr>
<tr><td>a</td><td colspan="2">Telephone lines. (1 Hot line linking Dy. Commissioner of the district)</td><td></td></tr>
<tr><td>b</td><td colspan="2">Fax lines.</td><td></td></tr>
<tr><td>c</td><td colspan="2">Radio frequency (as required).</td><td></td></tr>
<tr><td rowspan="7">1.2</td><td colspan="3">Information Display.</td><td></td></tr>
<tr><td>a</td><td colspan="2">Set of forms (minimum of 5 sets).</td><td></td></tr>
<tr><td rowspan="3">b</td><td colspan="2">Regional Maps and Charts:</td><td></td></tr>
<tr><td>i</td><td>Nautical charts.</td><td></td></tr>
<tr><td>ii</td><td>Topographic maps</td><td></td></tr>
<tr><td>c</td><td colspan="2">Overhead projector (in nominated briefing room).</td><td></td></tr>
<tr><td>d</td><td colspan="2">Whiteboards.</td><td></td></tr>
<tr><td>1.3</td><td colspan="3">Copy(s) of the port Risk Assessment, DMP and OSCP.</td><td></td></tr>
<tr><td>1.4</td><td colspan="3">Computer and Printer.</td><td></td></tr>
<tr><td>1.5</td><td colspan="3">Stationary: Markers, Pens, Pencils and A4 white paper.</td><td></td></tr>
<tr><td>1.6</td><td colspan="3">Tables and chairs</td><td></td></tr>
<tr><td>1.7</td><td colspan="3">Order and obtain any items needed (1.1-1.6)</td><td></td></tr>
<tr><td>1.8</td><td colspan="3">Advise reception to direct incoming calls to the EOC.</td><td></td></tr>
</table>

7.1.5 Competent Agencies

The competent agencies are responsible for keeping track of developments in respect of specific hazards assigned to them and inform the designated authorities/agencies at National, State and District levels about the impending disasters.

Table 7.2: Competent agencies for issuing warnings

Disaster	Agencies
Earthquake	IMD/Ministry of Earth Sciences
Flood	Central Water Commission
Cyclone	IMD, Regional Specialized Meteorological Centre (RSMC)
Tsunami and Storm Surge	INCOIS

7.1.6 Communication Flowchart

Communication flowcharts between the key agencies and key personnel of the CMG/IRT for various hazards are as follows

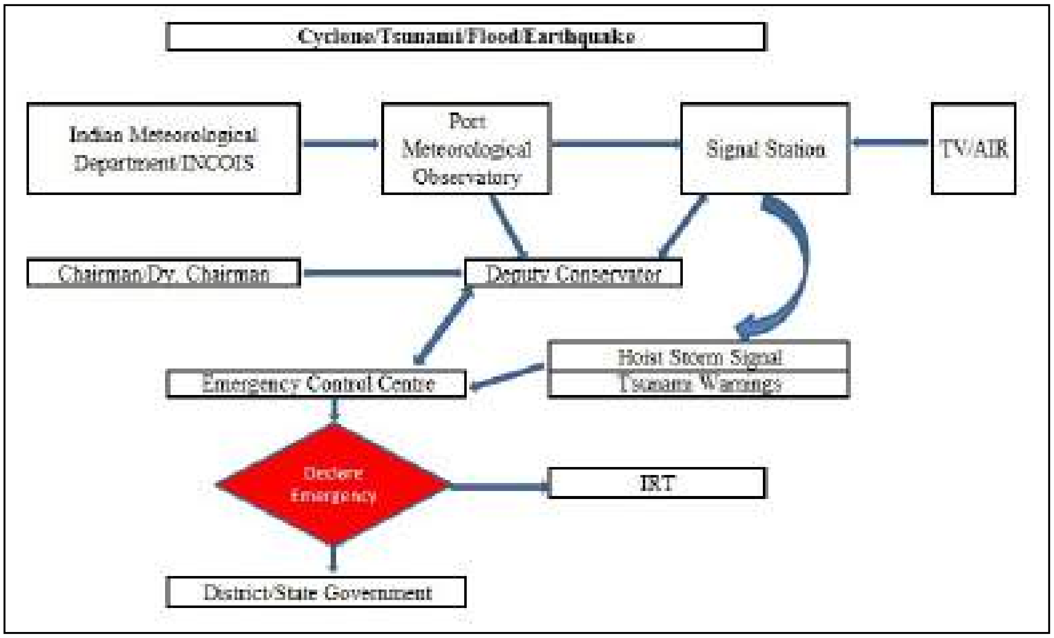

Figure 7.1: Cyclone /Tsunami/Flood/Earthquake

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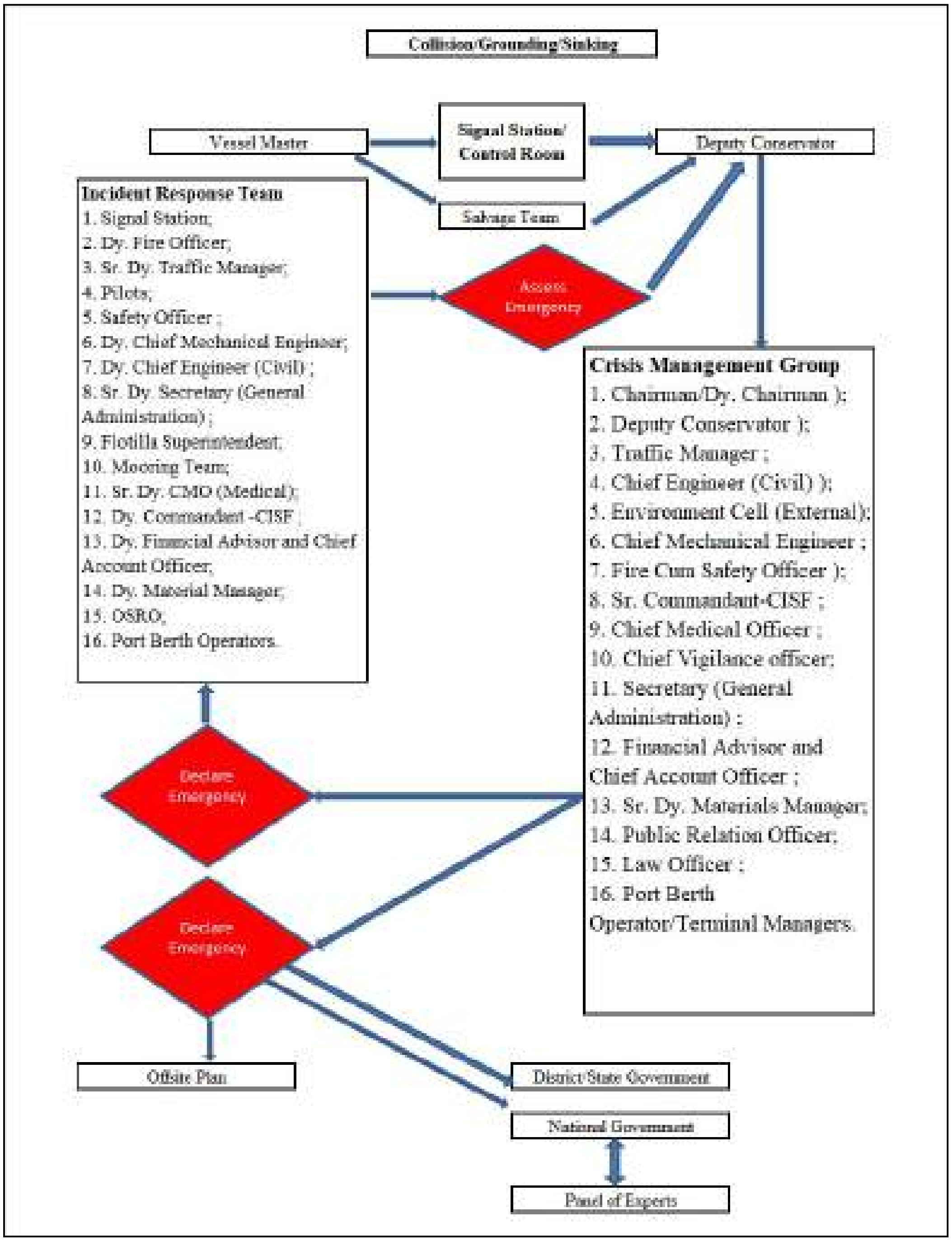

Figure 7.2: Collision/Grounding/Sinking

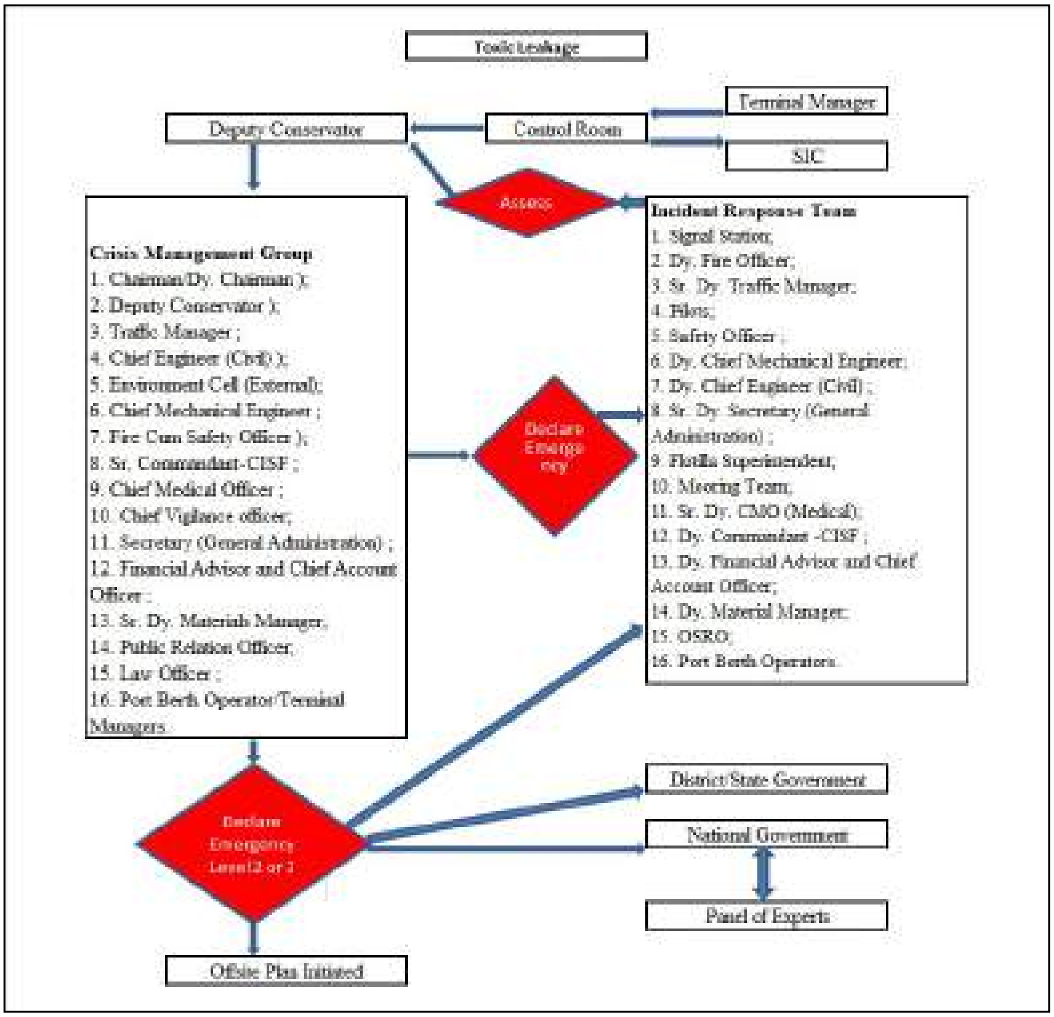

Figure 7.3: Toxic

Note: *For Level of disaster refer paragraph 4.3.*

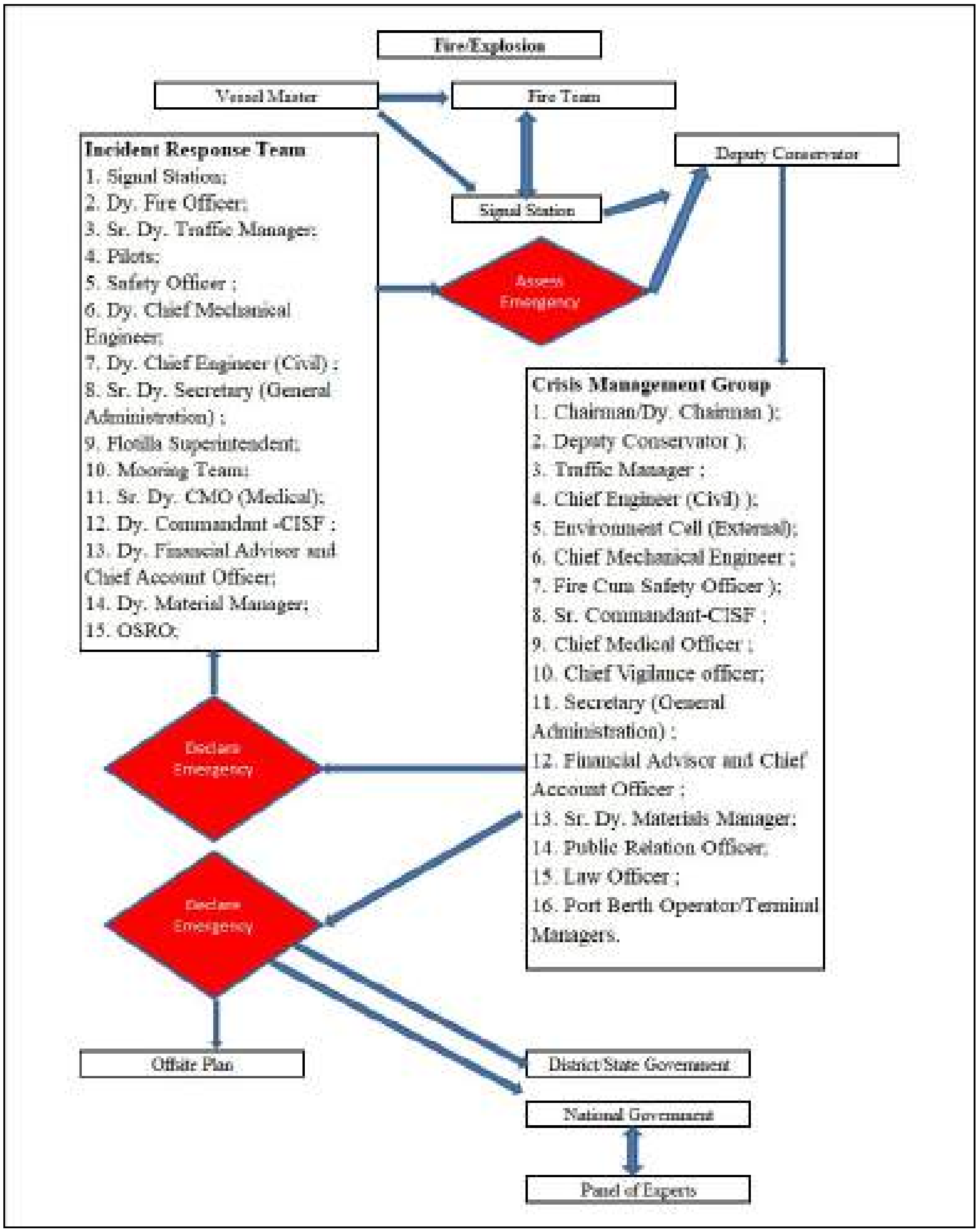

Figure 7.4: Fire/Explosion

***Note:** For level of disaster refer paragraph 4.3.*

7.2 ACTIVATION OF RESPONSE PLAN

7.2.1 Action implementation plan

The observer, noticing an unusual occurrence like a fire / gas release / collapse of structure etc., should immediately notify the Port / Jetty Control Room with available means of communication and contact the concerned officer of the area.

He should:

1. Raise alarm
2. Call Port / Jetty Control room and pass on following information:
    - Introduce himself
    - State briefly the type of emergency
    - Give the location of the incident.
3. Proceed to a safe place. However, he would return to the location of the incident and place himself in a safe area and standby to give assistance if he is part of the action group.
4. After receiving information from the observer, the signal station would notify all the key personnel of the Port.
5. All concerned personnel would move to their respective positions and will begin actions as documented in the action plan.

7.2.2 Site Control Procedure

Table 7.3: Site Control Procedure

<table>
<tr><th colspan="4">SITE CONTROL PROCEDURE</th></tr>
<tr><td colspan="4">Site Control should be established for every site where access is to be controlled. This includes the EOC, sites of shoreline cleanup, waste storage, response vessel mooring areas or any site containing hazards or hazardous materials.</td></tr>
<tr><th>Task</th><th colspan="2">Action</th><th>Status</th></tr>
<tr><td rowspan="4">1</td><td colspan="2">Identify perimeter of the “Hot” (secure or prohibited) zone. This may be:</td><td></td></tr>
<tr><td>i</td><td>Area around the incident (e.g., Fire and Explosion).</td><td></td></tr>
<tr><td>ii</td><td>Jetty/berth area</td><td></td></tr>
<tr><td>iii</td><td>Oiled shoreline. (Note: This zone should contain all hazards and sensitive areas where access should be restricted).</td><td></td></tr>
<tr><td>2</td><td colspan="2">Identify the “Hot” zone perimeter by cordoning.</td><td></td></tr>
<tr><td>3</td><td colspan="2">Identify the “Warm” (exclusion, controlled or support) zone. (Note: This is a non-contaminated/ non-hazardous zone). For e.g.: Shelter, canteen, car parking, etc.</td><td></td></tr>
<tr><td>4</td><td colspan="2">Identify the “Warm” zone perimeter by cordoning.</td><td></td></tr>
<tr><td rowspan="3">5</td><td colspan="2">Establish any required “Hot” zone perimeter facilities. For e.g. (i) and (ii):</td><td></td></tr>
<tr><td>i</td><td>Decontamination facility.</td><td></td></tr>
<tr><td>ii</td><td>Temporary waste storage.</td><td></td></tr>
<tr><td>6</td><td colspan="2">Establish “Warm” zone perimeter facilities.</td><td></td></tr>
<tr><td>7</td><td colspan="2">Establish support facilities within Warm zone as required.</td><td></td></tr>
</table>

Note 1 Entry to a Hot Zone should be restricted to:

- Personnel involved in the on-site work.
- Personnel equipped with appropriate protective gear.
- Personnel who have undergone correct training and induction.

Note 2 The Warm Zone surrounds the Hot Zone and is the zone and is generally:

- The area from which personnel and equipment are deployed.
- The perimeter where site control is exercised i.e. the entry points to the Hot Zone.
- Restricted to those people who operate in the Hot Zone and those who support them.

Note 3 The Cold Zone is all public or otherwise unrestricted areas, i.e. those areas outside of the controlled site.

7.2.3 Mechanism for access control and isolation of the Danger area

1. All gates and berths/jetties should be guarded,
2. Unauthorized person should not be allowed to the restricted area,
3. Authorized person will be entering the zone with all the necessary PPEs,
4. The area should be cordoned off during operation,
5. Proper signage board and warning should be displayed at the place of the operation,
6. Fire-fighting facilities and other required resources should be available till the operation is terminated,
7. The restricted areas should be under surveillance at all times.

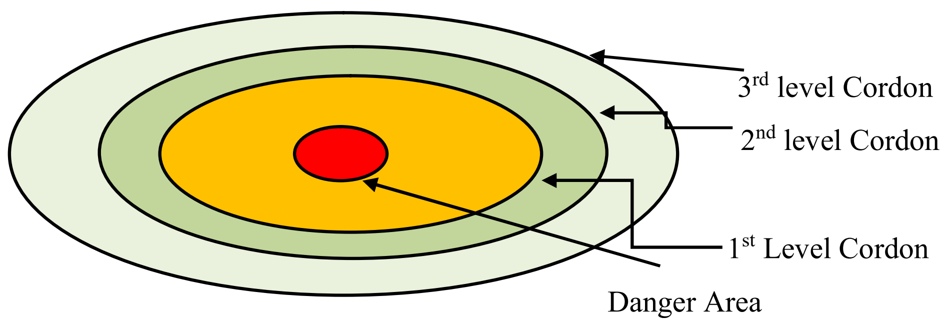

Figure 7.5: Isolation of Danger Area

Danger/Hazardous area
1st Level Cordon off
2nd Level Cordon off

- Site Control point
- Ambulance
- Casualty Clearing point

3rd Level Cordon off

- Traffic Control

Note: *Positions will depend on the wind directions*

7.2.4 Search and rescue operation

Search and Rescue shall start as soon as the public warning signal has been issued and should be carried out as per the instructions of CIC/SIC.

7.2.5 Evacuation

On blast of siren, the workers will assemble at the respective assembly points to be transported to the refuge centers.

7.2.5.1 Evacuation Routes and Assembly Points

In case of a general emergency one of the first duties of the CIC is to alert outside authorities and advise them about the actions that should be taken to protect the public, if any.

The evacuation route could be by two ways

a. Land;
b. Sea/creek

1. The vehicle-carrying casualty should be given priority in traffic movement.
2. While assessing the evacuation route, constant communication link should be maintained with the EOC as well as with the individual assembly point station from where the evacuation is to be undertaken.

The evacuation route is as follows

Table 7.4: Evacuation Routes

Sr. no.	Disaster	Evacuation routes
1.	Natural Calamities	Assemble near assembly points to proceed to the Relief Centers or to other shelters (Coordinated by CISF-Security)
2.	Fire at Oil Jetties	Assemble near assembly points to proceed out from Gate as directed (Coordinated by Port Fire dept. & CISF-Security)
3.	Toxic gas Release	The route decision will be determined depending upon the wind direction at the time of the incident. It will be in the up-wind direction of the outflow source direction. (Coordinated by Port Fire dept. and CISF-Security)
4.	Fire at General Cargo berths, Container terminal	Assemble at the Assembly points near to berth (Coordinated by Port Fire dept. & CISF-Security)
5.	Fire at Office buildings	Assemble at the Assembly points near the buildings (Coordinated by CISF-Security & Port Fire dept.)

7.3 HAZARD SPECIFIC RESPONSE PLAN

Following potential accidental scenarios have been identified in accordance with the risk assessment for the port. The action flowchart and action plan for each scenario has been prepared in accordance with the Incident Response System (IRS-NDMA).

S1: Scenario 1
Part A

1. **Fire due to rupture/leakage of POL/Chemical from pipeline/hose at oil jetty (oil jetties 1-7) – on vessel or ashore**
2. **Precautions:** MSDS, SOP of operator and berthing and un-berthing procedure, Periodic inspection and maintenance of hoses and pipelines.
3. **Impact Zone:** Oil Jetty and surrounding area.
   Consequence analysis indicates that the Naphtha leak from pipeline would cover approx. 345 meters for Jet Fire scenario (Refer Risk assessment report).
4. **Resources required:** Organizational setup enumerated in Figure S1.2 and material and equipment resources as given in Chapter 10.

Figure S1.1: Action Flow Chart

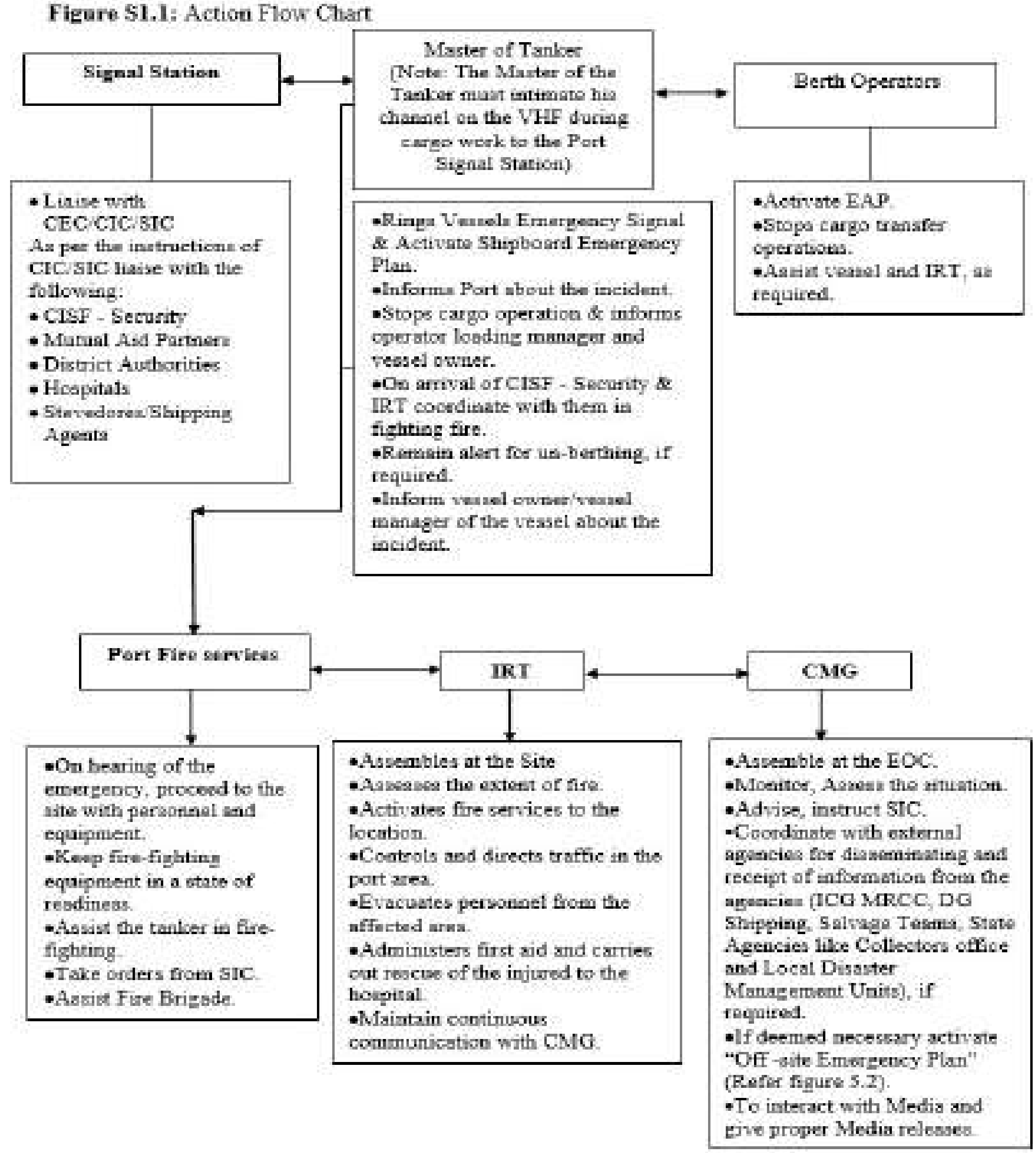

Figure S1.2: Action group

Master of POL/Chemical Tanker (Note: The Master must intimate his working channel on the VHF/any other communication medium during cargo work to the Signal Station).

Harbour Master
8976741054

Crisis Management Group

1. Chairman/Dy. Chairman (233001/234601/234121);
2. Deputy Conservator (9603123449);
3. Traffic Manager (966610773);
4. Chief Engineer (Civil) (9825227038);
5. Environment Cell (External);
6. Chief Mechanical Engineer (9825235196);
7. Fire Cum Safety Officer (270176/270178/9825227041);
8. Sr. Commandant-CISF (271037/9825227282);
9. Chief Medical Officer (225767/220072/9825505796);
10. Chief Vigilance officer;
11. Secretary (General Administration) (7036868889);
12. Financial Advisor and Chief Account Officer (9526062088);
13. Sr. Dy. Materials Manager;
14. Public Relation Officer (9638943800);
15. Law Officer (9712341380);
16. Port Berth Operator/Terminal Managers.

Incident Response Team

1. Signal Station – (270549/9016682249);
2. Dy. Fire Officer (270176/270178/9825221330/9825221352);
3. Sr. Dy. Traffic Manager (9748437052);
4. Pilots;
5. Safety Officer (9909950277);
6. Dy. Chief Mechanical Engineer;
7. Dy. Chief Engineer (Civil) (9427251059);
8. Sr. Dy. Secretary (General Administration) (9825227079);
9. Flotilla Superintendent (9978559903/9825227610);
10. Mooring Team;
11. Sr. Dy. CMO (Medical) (236376/9687607528);
12. Dy. Commandant -CISF (271440/271039/270876);
13. Dy. Financial Advisor and Chief Account Officer (9825227036);
14. Dy. Material Manager;
15. OSRO;
16. Port Berth Operators.

Mutual Aid

- Municipal Fire Station -Gandhidham (02836-226573);
- Neighbouring Industries.

Local, District and State Groups

- DDMA (Gujarat- Kutch) (+9128321077);
- GSDMA (02832-252347);
- MMD Kandla (02836-297015/297127/28);
- GPCB (02836-230828);
- NDRF (6^{th} Battalion) (02688299201/9870006730);
- ICG Mundra (02838-271403);
- Indian Navy -Porbandar (0286-2240954);
- Police Authority (02832-250960/280233);
- Marine Police - Kandla (02836-270527);
- Civil Defence (02832-230603).

Part B: Action Plan

The vessel upon berthing, berth operator will follow standard procedures. However, in a less likely scenario a leak from the pipeline system may occur at the jetty or from the jetty along the route to the terminal (within the port area) leading to self-detection by vessel personnel or by the terminal/operator automatic alarm system. Further in a more unlikely situation due to a possible ignition the leakage might catch fire. The following action will be required:

1. The Master of the Vessel (Alternate: Chief Officer)

	Response Action
a.	Should raise vessels emergency alarm and activate vessel board emergency action plan.
b.	Stop POL/Chemical transfer operation (as per SOP).
c.	Berth operator, Vessel in the vicinity and Port should be informed of any incident on the vessel without delay.
d.	Personnel to remain stand-by to disconnect hoses.
e.	Shall be responsible for fighting the fire with vessels own resources as well as with the available support from IRT.
f.	Also, to remain prepared to un-berth the vessel to the safe area.
g.	The siren should be continued till the vessel is taken to a safe location as per CIC instructions.

2. The berth operator tasked with POL/Chemical cargo operations at the Jetty should

	Response Action
a.	Activate EAP and inform Port.
b.	Shut off isolation valve on POL/Chemical pipeline at the berth (action as per SOP).
c.	Area should be cordoned off.
d.	Pour foam/dry chemical powder on POL/Chemical spillage to reduce rate of vaporization.
e.	Assist IRT and provide all necessary equipment.
f.	He will direct operation staff. Coordinate with the vessel in-charge/C&F agents/stevedores.

3. Deputy Conservator (Alternate: Harbour Master)

	Response Action
a.	Assess the level of disaster and activate the DMP.
b.	Establish EOC and be stationed to review & assess possible developments to determine the most necessary course of action.
c.	Give necessary instructions to SIC and Signal Station & arrange for external aid as necessary.
d.	Review the situation and accordingly inform to the Chairman/ Dy. Chairman.
e.	Decide on clearing of vessels in close proximity to the incident location and evacuating the people.
f.	Assess the condition of site and of potential affected area and take decision on evacuation in consultation with SIC.
g.	Be in constant touch with District and Local Administration for rescue and relief operation.
h.	Terminate the response and debrief before allowing normal operation.

4. The Signal Station

	Response Action
a.	Gather information related to the weather conditions and accordingly convey the message to CIC/SIC and Fire cum Safety Officer.
b.	Liaise with Master of the Vessel/Pilot.
c.	Listening watch to be maintained on VHF channel-08/10/16.
d.	Notify to CIC, SIC and the vessels moving into, through and inside the port. Keep CIC/SIC informed of all the messages received by telephone, VHF sets or by messenger.
e.	Notify the other Authorities (ICG, Navy) and stakeholders within Port as per instructions of CIC/SIC.
f.	Notify the information to the owner of the vessel as per the instruction of CIC/SIC/ Master of the Vessel.

5. The Fire cum Safety Officer should

	Response Action
a.	Ensure raising of Alarm (siren)
b.	Shall take orders from the SIC.
c.	Lead the fire-fighting team and mobilize fire tenders, men & fire-fighting equipment to the scene & extend all necessary support to the Master of the vessel/berth operator for fire-fighting.
d.	Assist CISF in evacuation of workers to the assembly points.
e.	Inform SIC for arrangement of any additional equipment as required.

6. Duties of IRT

Designated Officer	Role	Duties
Harbour Master (Alternate: Pilot)	Site Incident Controller	During Emergency shall proceed to the scene & communicate & collect all information from the Master of the Tanker and berth operator.
		Conduct initial briefing and report the situation to the CIC and assist in assessing the incident.
		Alert vessels within the vicinity.
		Assess the condition of site and of potential affected area and take decision on evacuation in consultation with CIC.
		Extend all necessary help to the Master of the vessel to fight the fire.
		Instruct the fire-fighting team to keep the water tenders in a state of readiness & activate if required.
		Instruct flotilla superintendent/ pilots to keep tugs ready for fire-fighting.
		Coordinate with all functional heads to take actions.
Pilot (Alternate: Pilot)	Signal Station Coordinator and Pilotage	Shall monitor the communication on VHF/any other communication medium & convey and relay messages on the advice from CIC /SIC.
		Responsible for organizing tugs, mooring boats and pilots for combating the fire and rescue.
		Hire additional crafts as necessary.
		Shall be ready for taking the vessel out of berth and be ready for providing any assistance on site.
		Maintain Log of events.
Berth operator (Alternate: Officer)	Cargo Work	Shall be responsible of shutting down of cargo operation & coordinating with Port and rendering necessary assistance to the SIC by providing additional fire-fighting & emergency equipment as required.
Dy. Fire Officer (Alternate: Officer)	Fire, Search and Rescue Coordinator	Shall take orders from Fire cum Safety Officer/SIC.
		Use water sprays and portable nozzles to maintain curtain.
		Ensures availability of the fire tenders and fire-fighting tugs.
		In case of fire onboard assist Master in fighting fire as per Masters Instructions.

		Ensure all the ignition sources in the vicinity are extinguished if fire has not occurred.
		If the fire is under control and extinguished, give all clear signal.
Dy. Commandant-CISF (Alternate: Commandant- CISF)	Security and Evacuation	Shall take orders from the Sr. Commandant – CISF /SIC.
		Cordon off the area.
		Controls & Directs gate security and traffic in the area.
		Shall facilitate evacuation, transport, first aid and rescue of personnel from the scene at the time of emergency.
		Control the entry of unauthorized persons and vehicles.
		Check for entry of emergency vehicles.
		Liaise with the Police authorities.
		Responsible the head count of the personnel.
Dy. Traffic Manager (Alternate: Officer)	Cargo Storage, Shed and Labour Coordinator	Shall take orders from Traffic Manager/SIC.
		Submits consolidated list of dangerous goods in port.
		Coordinates with vessel owners/ agents/C & F agents/stevedores and with labour officer to arrange and ensure evacuation.
Safety Officer (Alternate: Officer)	Safety Coordinator	Shall take orders from SIC/CIC.
		Shall mobilize and dispatch sufficient number of vehicles to the site of emergency.
		Assist in evacuation of the personnel to the assembly point or as directed by SIC.
Executive Engineer (Alternate: Executive Engineer)	Civil Coordinator	Shall be responsible to carry out urgent civil works as required.
Executive Engineer (Alternate: Executive Engineer)	M & E Coordinator	Shall be responsible for uninterrupted electrical supply to vital equipment and utility at the berth.
		Shall remain alert on duty for any electrical isolation of equipment during emergency.
Dy. CMO (Alternate: Medical Officer)	First Aid and Medical Coordinator	In coordination with CMO, shall be responsible to organize and dispatch first aid team with ambulance as required.
		Make arrangements for transportation and treatment of injured persons.
		Check updated list of Blood group of employees is available.

		Shall coordinate with the local hospitals.
Environment Cell and OSRO (Alternate: Officer)	Pollution Control Coordinator	Ensure clean- up work conducted by terminal personnel after spill containment.
		Coordinate with SIC and GPCB and agencies.
Mooring Master (Alternate: Officer)	Mooring Coordinator	Act as per the instruction of SIC/CIC.
		Assess the level of crisis, nature, location, severity, casualties and resource equipment.
		Authorize any immediate action required by on site staff and contract agencies.
Material Manager (Alternate: Officer)	Material procurement Coordinator	Maintain sufficient inventory and provide the same during emergency as per the order of SIC/CIC.

S2: Scenario 2

Part A:

1. **Fire /Explosion due to LPG leakage at Oil Jetty 1 – on vessel or ashore**
2. **Precautions:** MSDS, SOP of LPG terminal and berthing and un-berthing procedures of port.
   Leaks from LPG pump glands, pipes flanges or pipeline ruptures or from vent emissions due to cargo tank over-pressure or relief valve failure will initially produce vapour. This vapour will not ignite immediately but, if the vapour production is large, there is a hazard of the resultant cold and dense vapour cloud of LPG spreading to a source of ignition before it is diluted below the lower explosive limit. Therefore, in case of release of large quantity of flammable vapour cloud, immediate effort should be directed to eliminate such source of ignition. In such an event, eliminate all sources of ignitions i.e. open flames, welding, cutting, operation etc. in the entire port area.
3. **Impact Zone:** Refer Risk Assessment report.
   Consequence analysis indicates that the LPG (Propane/Butane) leak from pipeline would cover approx. 700 meters for Vapor cloud explosion (VCE) scenario.
4. **Resources required:** Organizational setup enumerated in Figure S2.2 and major material and equipment resources as given in Chapter 10.

Figure S2.1: Action Flow Chart

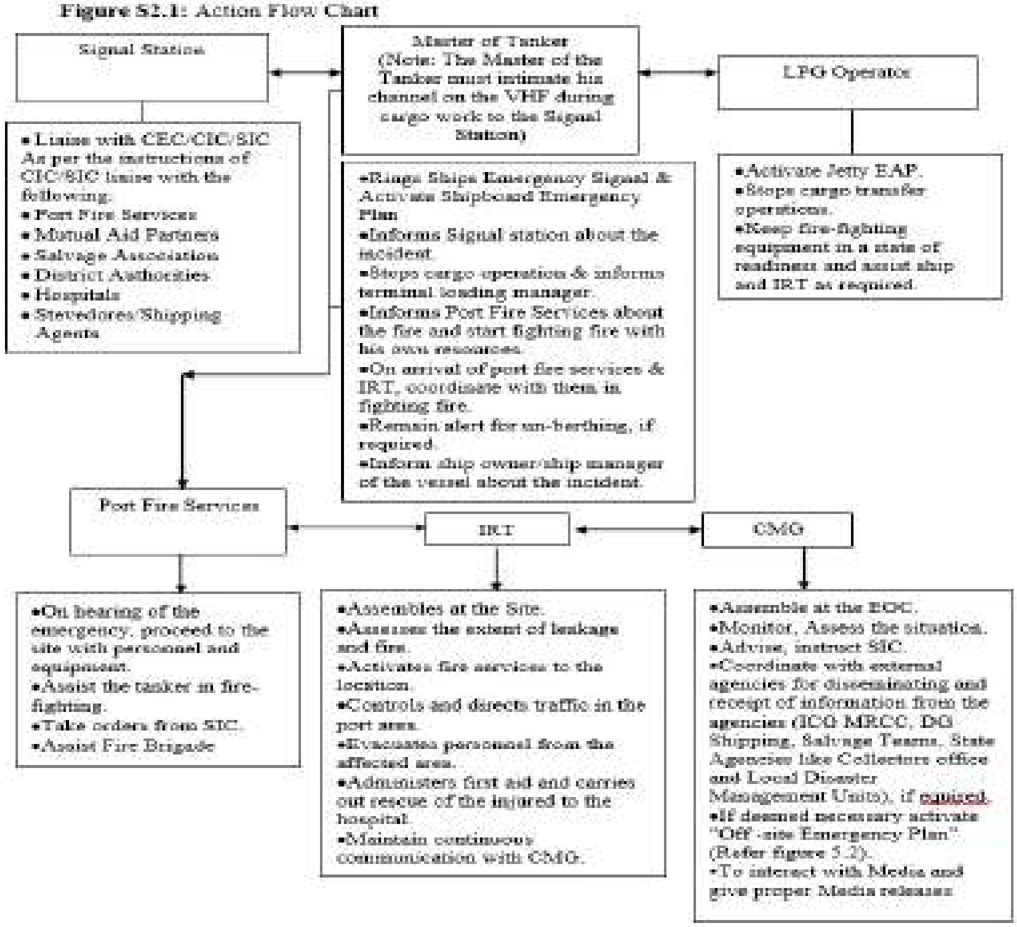

Figure S2.2: Action group

Master of LPG Tanker (Note: The Master must intimate his working channel on the VHF/any other communication medium during cargo work to the Signal Station).

Harbour Master
8976741054

Crisis Management Group

1. Chairman/Dy. Chairman (233001/234601/234121);
2. Deputy Conservator (9603123449);
3. Traffic Manager (966610773);
4. Chief Engineer (Civil) (9825227038);
5. Environment Cell (External);
6. Chief Mechanical Engineer (9825235196);
7. Fire Cum Safety Officer (270176/270178/9825227041);
8. Sr. Commandant-CISF (271037/9825227282);
9. Chief Medical Officer (225767/220072/9825505796);
10. Chief Vigilance officer;
11. Secretary (General Administration) (7036868889);
12. Financial Advisor and Chief Account Officer (9526062088);
13. Sr. Dy. Materials Manager;
14. Public Relation Officer (9638943800);
15. Law Officer (9712341380);
16. Port Berth Operator/Terminal Managers.

Incident Response Team

1. Signal Station – (270549/9016682249);
2. Dy. Fire Officer (270176/270178/9825221330/9825221352);
3. Sr. Dy. Traffic Manager (9748437052);
4. Pilots;
5. Safety Officer (9909950277);
6. Dy. Chief Mechanical Engineer;
7. Dy. Chief Engineer (Civil) (9427251059);
8. Sr. Dy. Secretary (General Administration) (9825227079);
9. Flotilla Superintendent (9978559903/9825227610);
10. Mooring Team;
11. Sr. Dy. CMO (Medical) (236376/9687607528);
12. Dy. Commandant -CISF (271440/271039/270876);
13. Dy. Financial Advisor and Chief Account Officer (9825227036);
14. Dy. Material Manager;
15. OSRO;
16. Port Berth Operators.

Mutual Aid

- Municipal Fire Station -Gandhidham (02836-226573);
- Neighbouring Industries.

Local, District and State Groups

- DDMA (Gujarat- Kutch) (+9128321077);
- GSDMA (02832-252347);
- MMD Kandla (02836-297015/297127/28);
- GPCB (02836-230828);
- NDRF (6th Battalion) (02688299201/9870006730);
- ICG Mundra (02838-271403);
- Indian Navy -Porbandar (0286-2240954);
- Police Authority (02832-250960/280233);
- Marine Police - Kandla (02836-270527);
- Civil Defence (02832-230603).
- Jt. Chief Controller of Explosives - Vadodara (0265-2361035

Part B: Action Plan

The vessel upon berthing at the LPG berth will follow standard procedures. However, in a less likely scenario, a leak from the pipeline system may occur at the jetty leading to self-detection by vessel personnel or by the terminal automatic alarm and detection system. Further in a more unlikely situation, due to a possible ignition the leakage might catch fire and lead to an explosion. The following actions will be required

1. The Master of the Ship (Alternate: Chief Officer)

	Response Action
a.	Should raise ships emergency alarm and activate shipboard emergency action plan.
b.	Stop LPG transfer operation (as per SOP of the ship).
c.	Terminal, Vessel in the vicinity and Port should be informed of any incident on the ship without delay.
d.	Personnel to remain stand by to disconnect metal arms.
e.	Shall be responsible for fighting the fire with ships own resources as well as with the available support from IRT.
f.	Also, to remain prepared to un-berth the ship to the safe area (high sea).
g.	The siren should be continued till the ship is taken to a safe location as per CIC instructions.

2. The berth operator should

	Response Action
a.	Activate Jetty EAP (prepared by the terminal) and inform port.
b.	Shut off isolation valve on LPG pipeline at the berth (action as per SOP of the terminal).
c.	Area should be cordoned off.
d.	Pour Dry Chemical Powder.
e.	Assist IRT and provide all necessary equipment.
f.	He will direct operation staff. Coordinate with the ship in-charge/C&F agents/stevedores.

3. Deputy Conservator (Alternate: Harbour Master) should

	Response Action
a.	Assess the level of disaster and activate the DMP.
b.	Establish EOC and be stationed to review & assess possible developments to determine the most necessary course of action.
c.	Give necessary instructions to SIC and Signal Station & arrange for external aid as necessary.
d.	Review the situation and accordingly inform to the CMG.
e.	Assess the condition of site and of potential affected area and take decision on evacuation in consultation with SIC.
f.	Decide on clearing of vessels in close proximity to the incident location and evacuating the people.
g.	Coordinate with external agencies/authorities within port area such as Indian Navy

	and ICG, if any.
h.	Be in constant touch with District and Local Administration for rescue and relief operation.
i.	Terminate the response and debrief before allowing normal operation.

4. Signal Station

	Response Action
a.	Gather information related to the weather conditions. Monitor the wind directions and accordingly convey the message to CIC/SIC and Fire cum Safety Officer.
b.	Liaise with Master of the Vessel/Pilot.
c.	Listening watch to be maintained on VHF.
d.	Notify to CIC, SIC and the vessels moving into, through and inside the port. Keep CIC/SIC informed of all the messages received by telephone, VHF sets or by messenger.
e.	Notify the other Authorities (ICG, Navy) and stakeholders within Port as per instructions of CIC/SIC.
f.	Notify the information to the owner of the vessel as per the instruction of CIC/SIC/ Master of the Vessel.

5. The Fire cum Safety Officer should

	Response Action
a.	Ensure raising of Alarm (siren)
b.	Shall take orders from the SIC.
c.	Lead the fire-fighting team and mobilize fire tenders, men & fire-fighting equipment to the scene & extend all necessary support to the Master of the vessel/berth operator for fire-fighting.
d.	Assist CISF in evacuation of workers to the assembly points.
e.	Inform SIC for arrangement of any additional equipment as required.

6. Duties of IRT

Designated Officer	Role	Duties
Harbour Master (Alternate: Pilot)	Site Incident Controller	During Emergency shall proceed to the scene & communicate & collect all information from the Master of the Tanker and Terminal Manager.
		Conduct initial Briefing and report the situation to the CIC/CMG and assist CIC in assessing the incident.
		Initiate DMP.
		Alert vessels within the vicinity.
		Assess the condition of site and of potential affected area and take decision on evacuation in consultation with CIC.
		Extend all necessary help to the Master of the vessel to fight the fire.
		Instruct the Fire cum Safety Officer to keep the fixed fire-fighting installation ready and instruct Flotilla superintendent to keep fire-fighting tugs in a state of readiness & activate if required.
		Instruct Flotilla superintendent to keep tugs ready for un-berthing of vessel.
		Coordinate with all functional heads to take actions.
Pilot (Alternate: Pilot)	Signal Station Coordinator and Pilotage	Shall monitor the communication on VHF/any other communication medium & convey and relay messages on the advice from CIC /SIC.
		Responsible for organizing tugs, mooring boats and pilots for combating the fire and rescue.
		Hire additional crafts as necessary.
		Shall be ready for taking the vessel out of berth and be ready for providing any assistance on site.
		Maintain Log of events.
Terminal Manager (Alternate: Assistant Terminal Manager)	Cargo Work	Shut down of cargo operation
		Coordinate with port and render necessary assistance to the SIC by providing additional fire-fighting & emergency response equipment as required.
		Direct operation staff.
		Coordinate with the ship in-charge/C&F agents/stevedores.
Dy. Fire Officer (Alternate: Officer)	Fire, Search and Rescue	Shall take orders from Fire cum Safety Officer/SIC.

	Coordinator	Use water sprays and portable nozzles to maintain curtain. Ensures availability of the fire tenders and fire-fighting tugs. In case of fire onboard assist Master in fighting fire as per Masters Instructions. Ensure all the ignition sources in the vicinity are extinguished if fire has not occurred. If the fire is under control and extinguished, give all clear signal.
Safety Officer (Alternate: Officer)	Safety Coordinator	Shall take orders from SIC/CIC. Shall mobilize and dispatch sufficient number of vehicles to the site of emergency. Assist in evacuation of the personnel to the assembly point or as directed by SIC.
Dy. Commandant-CISF (Alternate: Alternate Commandant- CISF)	Security and Evacuation	Shall take orders from the Sr. Commandant – CISF /SIC. Cordon off the area. Controls & Directs gate security and traffic in the area. Shall facilitate evacuation, transport, first aid and rescue of personnel from the scene at the time of emergency. Control the entry of unauthorized persons and vehicles. Check for entry of emergency vehicles. Liaise with the Police authorities. Responsible the head count of the personnel.
Dy. Traffic Manager (Alternate: Officer)	Cargo Storage, Shed and Labour Coordinator	Shall take orders from Traffic Manager/SIC. Submits consolidated list of dangerous goods in port. Coordinates with vessel owners/ agents/C & F agents/stevedores and with labour officer to arrange and ensure evacuation.
Executive Engineer (Alternate: Executive Engineers)	M & E Coordinator	Shall be responsible for uninterrupted electrical supply to vital equipment and utility at the berth. Shall remain alert on duty for any electrical isolation of equipment during emergency.
Executive Engineer (Alternate: Executive Engineers)	Civil Coordinator	Carry out urgent civil works as required. Liaise with SIC.

Dy. CMO (Alternate: Medical Officer)	First Aid and Medical Coordinator	In coordination with CMO, shall be responsible to organize and dispatch first aid team with ambulance as required.
		Make arrangements for transportation and treatment of injured persons.
		Check updated list of Blood group of employees is available.
		Shall coordinate with the local hospitals.
Mooring Master (Alternate: Officer)	Mooring Coordinator	Act as per the instruction of SIC/CIC.
		Assess the level of crisis, nature, location, severity, casualties and resource equipment.
		Authorize any immediate action required by on site staff and contract agencies.
Material Manager (Alternate: Officer)	Material procurement Coordinator	Maintain sufficient inventory and provide the same during emergency as per the order of SIC/CIC.

RESTRICTED.

S3: Scenario 3
Part A:

1. **Toxic product (e.g. ammonia) leak from pipeline/hose at jetty during operation (oil jetties 2-5) – on Vessel or Ashore**
2. **Precautions:** MSDS**,** SOP, berthing and un-berthing procedures and Periodic inspection and maintenance of hoses and pipelines.
   Stay upwind and wear positive pressure breathing apparatus and full protective clothing, as necessary.
3. **Impact Zone:** Consequence analysis indicates that the Ammonia leak from transfer pipeline would cover 2165 meters for toxic dispersion with IDLH level of 300 ppm. (Refer Risk Assessment report)
4. **Resources required:** Organizational setup enumerated in Figure S3.2 and major material and equipment resources as given in Chapter 10.

Figure S3.1: Action Flow Chart

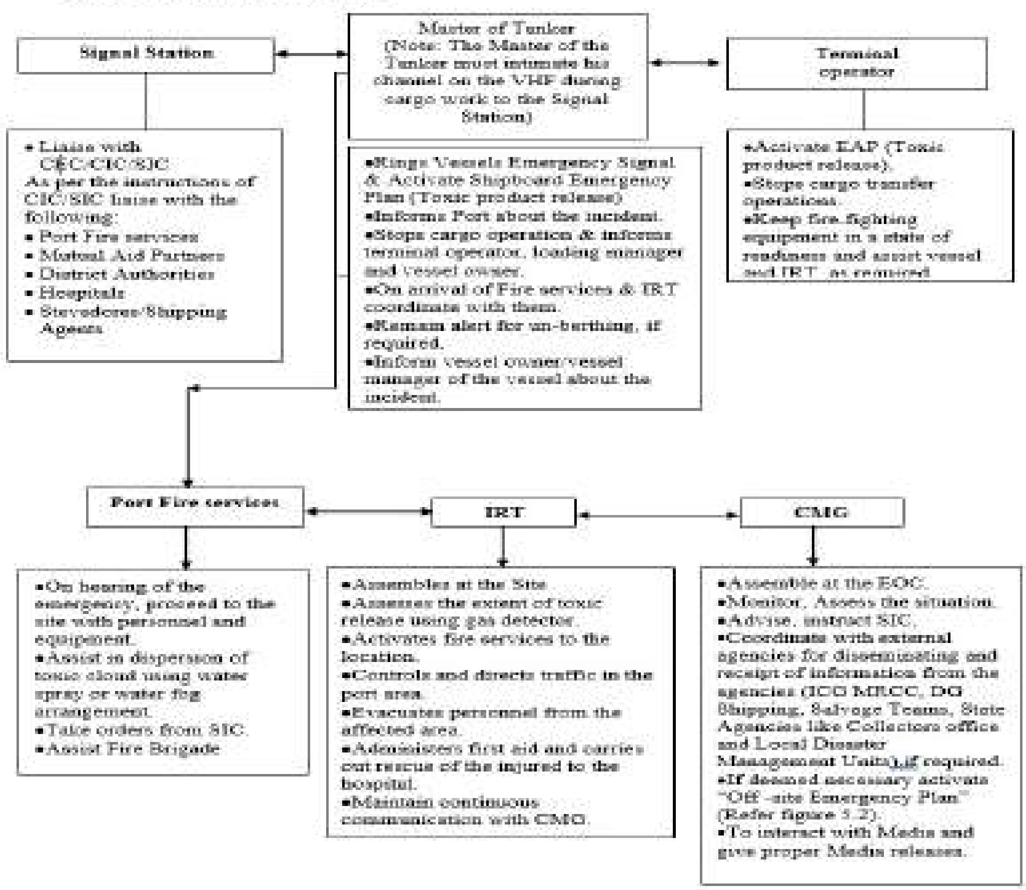

Figure S3.2: Action group

Master of POL/Chemical Tanker (Note: The Master must intimate his working channel on the VHF/any other communication medium during cargo work to the Signal Station).

Harbour Master
8976741054

Crisis Management Group

1. Chairman/Dy. Chairman (233001/234601/234121);
2. Deputy Conservator (9603123449);
3. Traffic Manager (966610773);
4. Chief Engineer (Civil) (9825227038);
5. Environment Cell (External);
6. Chief Mechanical Engineer (9825235196);
7. Fire Cum Safety Officer (270176/270178/9825227041);
8. Sr. Commandant-CISF (271037/9825227282);
9. Chief Medical Officer (225767/220072/9825505796);
10. Chief Vigilance officer;
11. Secretary (General Administration) (7036868889);
12. Financial Advisor and Chief Account Officer (9526062088);
13. Sr. Dy. Materials Manager;
14. Public Relation Officer (9638943800);
15. Law Officer (9712341380);
16. Port Berth Operator/Terminal Managers.

Incident Response Team

1. Signal Station – (270549/9016682249);
2. Dy. Fire Officer (270176/270178/9825221330/9825221352);
3. Sr. Dy. Traffic Manager (9748437052);
4. Pilots;
5. Safety Officer (9909950277);
6. Dy. Chief Mechanical Engineer;
7. Dy. Chief Engineer (Civil) (9427251059);
8. Sr. Dy. Secretary (General Administration) (9825227079);
9. Flotilla Superintendent (9978559903/9825227610);
10. Mooring Team;
11. Sr. Dy. CMO (Medical) (236376/9687607528);
12. Dy. Commandant -CISF (271440/271039/270876);
13. Dy. Financial Advisor and Chief Account Officer (9825227036);
14. Dy. Material Manager;
15. OSRO;
16. Port Berth Operators.

Mutual Aid

- Municipal Fire Station -Gandhidham (02836-226573);
- Neighbouring Industries.

Local, District and State Groups

- DDMA (Gujarat- Kutch) (+9128321077);
- GSDMA (02832-252347);
- MMD Kandla (02836-297015/297127/28);
- GPCB (02836-230828);
- NDRF (6th Battalion) (02688299201/9870006730);
- ICG Mundra (02838-271403);
- Indian Navy -Porbandar (0286-2240954);
- Police Authority (02832-250960/280233);
- Marine Police - Kandla (02836-270527);
- Civil Defence (02832-230603).
- Jt. Chief Controller of Explosives - Vadodara (0265-2361035

Part B: Action Plan

The vessel upon berthing, operator will follow standard procedures. However, in a less likely scenario a leak from the pipeline system may occur at the jetty or from the jetty along the route to the terminal (within port area) leading to self-detection by personnel or by the terminal/operator automatic alarm system. The following action will be required

Spill handling: Evacuate and restrict person's not wearing PPE from area of spill or leak until cleanup is complete. Remove all ignition sources. Stop the flow of gas if it can be done safely. Stay upwind; keep out of low areas. Wear positive pressure breathing apparatus and full protective clothing.

1. The Master of the Vessel (Alternate: Chief Officer)

Response Action
a. Should raise vessels emergency alarm and activate vessel board emergency action plan.
b. Stop cargo transfer operation (as per SOP).
c. Terminal operator, Vessel in the vicinity and Port should be informed of any incident on the vessel without delay.
d. Personnel to remain stand by to disconnect hoses.
e. Shall be responsible to arrest the leak and for fighting the fire with vessels own resources as well as with the available support from IRT.
f. Also, to remain prepared to un-berth the vessel to the safe area.
g. The siren should be continued till the vessel is taken to a safe location as per CIC instructions.

2. The terminal operator tasked with cargo operations at the wharf should

Take personal precautions, protective equipment and follow emergency procedures. Wear respiratory protection. Avoid breathing vapors, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Beware of vapors accumulating to form explosive concentrations. Vapors can accumulate in low areas. Environmental precautions: Prevent further leakage or spillage if safe to do so.

Contain spillage, and then collect with an electrically protected vacuum cleaner (vehicle mounted in some cases) or by wet-brushing and place in container for disposal.

Response Action
a. Activate EAP and inform Port.
b. Shut off isolation valve on pipeline at the jetty (action as per SOP).
c. Area should be cordoned off.
d. Assist IRT and provide all necessary equipment.
e. He will direct operation staff. Coordinate with the vessel in-charge/C&F agents/stevedores.

3. Deputy Conservator (Alternate: Harbour Master)

	Response Action
a.	Assess the level of disaster and activate the DMP.
b.	Establish EOC and be stationed to review & assess possible developments to determine the most necessary course of action.
c.	Give necessary instructions to SIC/ Mooring team and Signal Station & arrange for external aid as necessary.
d.	Review the situation and accordingly inform to the Chairman/ Dy. Chairman.
e.	Consult with Chairman / Dy. Chairman and decide on clearing of vessels in close proximity to the incident location or to sail the tanker to the safe area and evacuating the people from the likely affected zone.
f.	Take decision on evacuation in consultation with SIC.
g.	Be in constant touch with District and Local Administration for rescue and relief operation.
h.	Terminate the response and debrief before allowing normal operation.

4. The Signal Station

	Response Action
a.	Gather information related to the weather conditions. Monitor the wind directions and convey the message to Master of the vessel, CIC/SIC and Fire cum Safety Officer.
b.	Liaise with Master of the Vessel/Pilot.
c.	Listening watch to be maintained on VHF channel-08/10/16.
d.	Notify the CIC, SIC and the vessels moving into, through and inside the port. Keep CIC/SIC informed of all the messages received.
e.	Notify the other Authorities (ICG, Navy) and stakeholders within Port as per instructions of CIC/SIC.
f.	Notify the information to the owner of the vessel as per the instruction of CIC/SIC/ Master of the Vessel.

5. The Fire-fighting Personnel should

	Response Action
a.	Ensure raising of Alarm (siren).
b.	Shall take orders from the SIC.
c.	Lead the fire-fighting team and mobilize fire tenders, men & fire-fighting equipment to the scene & extend all necessary support to the Master of the vessel/berth operator for fire-fighting.
d.	Assist CISF in evacuation of workers to the assembly points.
e.	Inform SIC for arrangement of any additional equipment as required.
f.	In case of leakage/fire onboard assist Master in arresting the leak/diluting the vapour/ fighting fire as per Masters Instructions.
g.	Announce in mobile van with PA system in the effecting zones to evacuate the zone. Ensure complete evacuation and report to the EOC.
h.	If the situation is under control, give all clear signals.

6. Duties of IRT

Designated Officer	Role	Duties
Harbour Master (Alternate: Pilot)	Site Incident Controller	During Emergency shall proceed to the scene & communicate & collect all information from the Master of the Tanker and terminal operator.
		Conduct initial briefing.
		Report the situation to the CIC and assist in assessing the incident.
		Alert vessels within the vicinity.
		Shall assess and decide on the evacuation of the personnel considering the direction of wind and dispersion and will instruct CISF-Security, and Safety Officer to carry out the evacuation in a safe manner.
		He will extend all necessary help to the Master of the vessel to fight the fire, if any.
		Instruct the Fire cum Safety Officer to keep the fire-fighting installation and tenders in a state of readiness & activate if required to fight fire or for disperse the vapour cloud.
		Instruct flotilla superintendent/ pilots to keep tugs ready for fire-fighting.
		Coordinate with all functional heads to take actions.
Pilot (Alternate: Pilot)	Signal Station Coordinator and Pilotage	Shall monitor the communication on VHF/any other communication medium & convey and relay messages on the advice from CIC /SIC.
		Responsible for organizing tugs, mooring boats and pilots for combating the fire and rescue.
		Hire additional crafts as necessary.
		Shall be ready for taking the vessel out of berth and be ready for providing any assistance on site.
		Maintain Log of events.
Terminal Operator (Alternate: Officer)	Cargo Work	Shall be responsible of shutting down of cargo operation & coordinating with Port and rendering necessary assistance to the SIC by providing additional emergency equipment as required.
Dy. Fire Officer (Alternate: Officer)	Fire, Search and Rescue Coordinator	Shall take orders from Fire cum Safety Officer/SIC.
		Start the pumps as per the requirement.

		Use water sprays and portable nozzles to maintain curtain and dilution.
		Open the valves of the monitors and direct the jet on the seat of fire, in case of fire.
		In case of leakage/fire onboard assist Master in arresting the leak/diluting the vapour/ fighting fire as per Masters Instructions.
		Make use of portable DCP, CO2, Foam extinguisher (alcohol-resistant foam) from upwind position.
		Announce in mobile van with PA system in the effecting zones to evacuate the zone.
		Assist CISF-Security in evacuation of workers to the assembly point.
		Inform SIC for arrangement of any additional equipment as required.
Dy. Commandant-CISF (Alternate: Commandant- CISF)	Security and Evacuation	Shall take orders from the Sr. Commandant – CISF /SIC.
		Cordon off the area.
		Controls & directs gate security and traffic in the area.
		Shall facilitate evacuation, transport, first aid and rescue of personnel from the scene at the time of emergency.
		Control the entry of unauthorized persons and vehicles.
		Check for entry of emergency vehicles.
		Liaise with the Police authorities.
		Responsible for the head count of the personnel.
Dy. Traffic Manager (Alternate: Officer)	Cargo Storage, Shed and Labour Coordinator	Shall take orders from Traffic Manager/SIC.
		Coordinates with vessel owners/ agents/C & F agents/stevedores and with labour officer to arrange and ensure evacuation.
		Submits consolidated list of dangerous goods in port.
Safety Officer and (Alternate: Officer)	Safety Coordinator	Inform GPCB and other environmental agencies and take necessary guidance. Coordinate with Environment cell.
		Shall mobilize and dispatch sufficient number of vehicles to the site of emergency.
		Assist in evacuation of the personnel to the assembly point or as directed by SIC.

Executive Engineer (Alternate: Executive Engineer)	Civil Coordinator	Shall be responsible to carry out urgent civil works as required.
Executive Engineer (Alternate: Executive Engineer)	M & E Coordinator	Shall be responsible for uninterrupted electrical supply to vital equipment and utility at the berth.
		Shall remain alert on duty for any electrical isolation of equipment during emergency.
Dy. CMO (Alternate: Medical Officer)	First Aid and Medical Coordinator	In coordination with CMO, shall be responsible to organize and dispatch first aid team with ambulance as required.
		Make arrangements for transportation and treatment of injured persons.
		Check updated list of Blood group of employees is available.
		Shall coordinate with the local hospitals.
Material Manager (Alternate: Officer)	Material procurement Coordinator	Maintain sufficient inventory and provide the same during emergency as per the order of SIC/CIC.
Mooring Master (Alternate: Officer)	Mooring Coordinator	Act as per the instruction of SIC/CIC.
		Assess the level of crisis, nature, location, severity, casualties and resource equipment.
		Authorize any immediate action required by on site staff and contract agencies.

S4: Scenario 4
Part A

1. **Corrosive Acid - Leakage (e.g. Sulphuric acid, phosphoric acid) at oil jetty-5 during operation – on Vessel or Ashore**
2. **Precautions:** MSDS, HAZMAT kit, SOP of terminal/operator and berthing and un-berthing procedures, periodic inspection and maintenance of hoses and pipelines, PPE and Eye wash station.
3. **Impact Zone:** Oil jetty 5.
4. **Resources required:** Organizational setup enumerated in Figure S4.2 and major material and equipment resources as given in Chapter 10.

Figure S4.1: Action Flow Chart

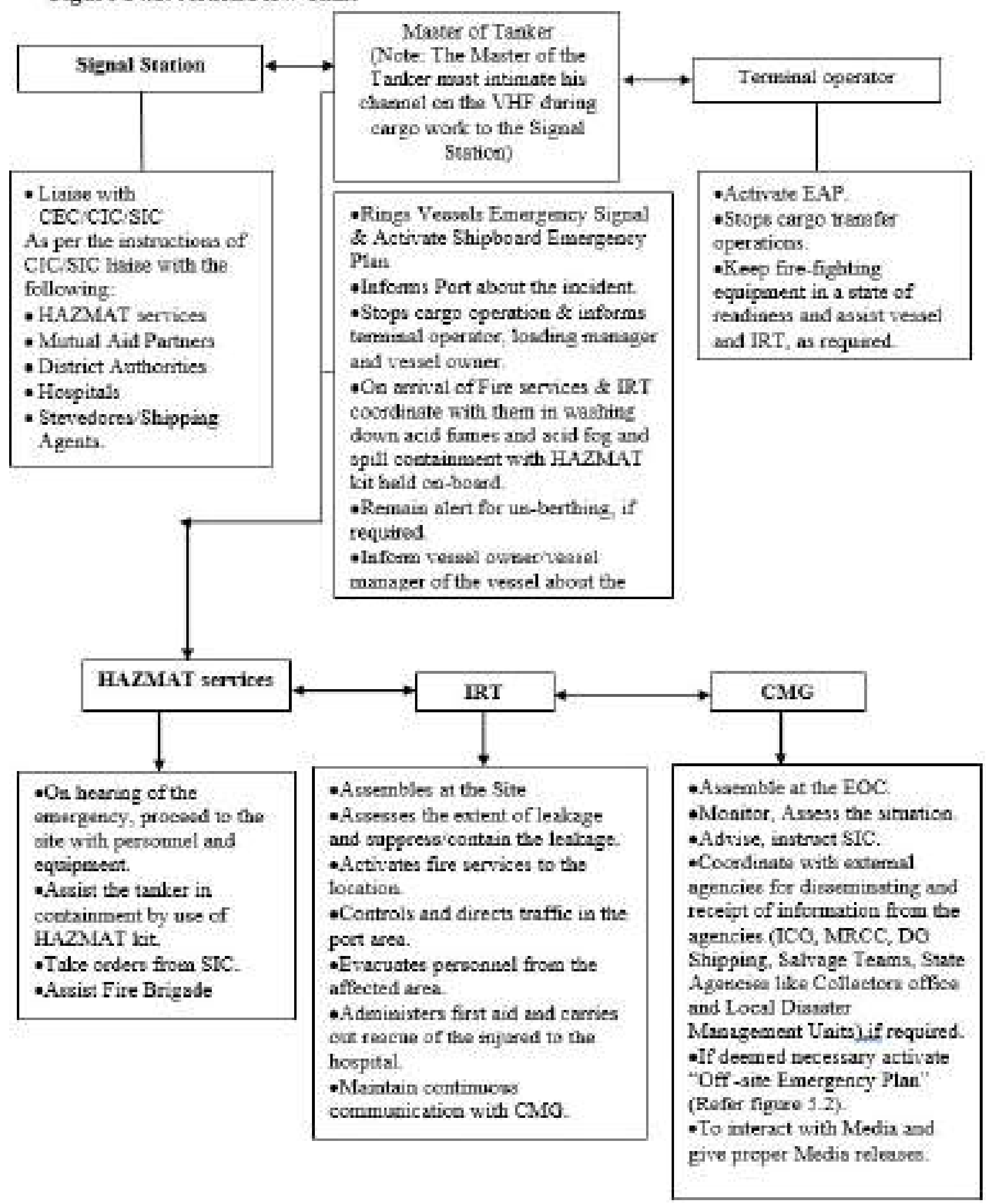

Figure S4.2: Action group

Master of POL/Chemical Tanker (Note: The Master must intimate his working channel on the VHF/any other communication medium during cargo work to the Signal Station).

Harbour Master
8976741054

Crisis Management Group

1. Chairman/Dy. Chairman (233001/234601/234121);
2. Deputy Conservator (9603123449);
3. Traffic Manager (966610773);
4. Chief Engineer (Civil) (9825227038);
5. Environment Cell (External);
6. Chief Mechanical Engineer (9825235196);
7. Fire Cum Safety Officer (270176/270178/9825227041);
8. Sr. Commandant-CISF (271037/9825227282);
9. Chief Medical Officer (225767/220072/9825505796);
10. Chief Vigilance officer;
11. Secretary (General Administration) (7036868889);
12. Financial Advisor and Chief Account Officer (9526062088);
13. Sr. Dy. Materials Manager;
14. Public Relation Officer (9638943800);
15. Law Officer (9712341380);
16. Port Berth Operator/Terminal Managers.

Incident Response Team

1. Signal Station – (270549/9016682249);
2. Dy. Fire Officer (270176/270178/9825221330/9825221352);
3. Sr. Dy. Traffic Manager (9748437052);
4. Pilots;
5. Safety Officer (9909950277);
6. Dy. Chief Mechanical Engineer;
7. Dy. Chief Engineer (Civil) (9427251059);
8. Sr. Dy. Secretary (General Administration) (9825227079);
9. Flotilla Superintendent (9978559903/9825227610);
10. Mooring Team;
11. Sr. Dy. CMO (Medical) (236376/9687607528);
12. Dy. Commandant -CISF (271440/271039/270876);
13. Dy. Financial Advisor and Chief Account Officer (9825227036);
14. Dy. Material Manager;
15. OSRO;
16. Port Berth Operators.

Mutual Aid

- Municipal Fire Station -Gandhidham (02836-226573);
- Neighbouring Industries.

Local, District and State Groups

- DDMA (Gujarat- Kutch) (+9128321077);
- GSDMA (02832-252347);
- MMD Kandla (02836-297015/297127/28);
- GPCB (02836-230828);
- NDRF (6^{th} Battalion) (02688299201/9870006730);
- ICG Mundra (02838-271403);
- Indian Navy -Porbandar (0286-2240954);
- Police Authority (02832-250960/280233);
- Marine Police - Kandla (02836-270527);
- Civil Defence (02832-230603).

Part B: Action Plan

The vessel upon berthing, berth operator will follow standard procedures. However, in a less likely scenario a leak from the pipeline system may occur leading to detection by vessel personnel or by the terminal/operator alarm system. The following action will be required.

1. The Master of the Vessel (Alternate: Chief Officer)

Response Action
a. Should raise vessels emergency alarm and activate vessel board emergency action plan.
b. Stop transfer operation (as per SOP).
c. Terminal operator, Vessel in the vicinity and Port should be informed of any incident on the vessel without delay.
d. Personnel to remain stand by to disconnect hoses;
e. Shall be responsible to arrest the leak with vessels own resources as well as with the available support from IRT.
f. Also, to remain prepared to un-berth the vessel to the safe area (high sea).
g. The siren should be continued till the vessel is taken to a safe location as per CIC instructions.

2. Terminal operator persons tasked with cargo operations at the jetty should

Response Action
a. Activate EAP and inform Port.
b. Shut off isolation valve on pipeline at the berth (action as per SOP of the terminal).
c. Area should be cordoned off.
d. Assist IRT and provide all necessary equipment.
e. Responsible for diluting and neutralizing the acids and disposal of the neutralized liquids.
~~f.~~ He will direct operation staff. Coordinate with the vessel in-charge/C&F agents/stevedores.

3. Deputy Conservator (Alternate: Harbour Master)

Response Action
a. Assess the level of disaster and activate the DMP.
b. Establish EOC and be stationed to review & assess possible developments to determine the most necessary course of action.
c. Give necessary instructions to SIC/ Asst. Mooring Master and Port and arrange for external aid as necessary.
d. Review the situation and accordingly inform the Chairman/ Dy. Chairman.
e. Decide on clearing of vessels in close proximity to the incident location and evacuating the people.
f. Assess the condition of site and take decision on evacuation in consultation with SIC.
g. Be in constant touch with District and Local Administration for rescue and relief

	operation.
h.	Terminate the response and debrief before allowing normal operation.

4. The Signal Station

	Response Action
a.	Gather information related to the vessel type, cargo quantity and position.
b.	Gather information related to the weather conditions and accordingly convey the message to Master of the vessel, SIC and Fire cum Safety Officer.
c.	Liaise with Master of the Vessel/Pilot.
d.	Listening watch to be maintained on VHF channel-08/10/16.
e.	Notify to CIC, SIC and the vessels moving into, through and inside the port. Keep CIC/SIC/ Asst. Mooring Master informed of all the messages received by telephone, VHF sets or by messenger.
f.	Notify the other Authorities (ICG, Navy) and stakeholders within Port as per instructions of CIC/SIC.

5. The Fire cum Safety Officer should

	Response Action
a.	Ensure raising of Alarm (siren)
b.	Shall take orders from the SIC.
c.	Lead the fire-fighting team and mobilize fire tenders, men & fire-fighting equipment to the scene & extend all necessary support to the Master of the vessel/berth operator for firefighting.
d.	Assist CISF in evacuation of workers to the assembly points.
e.	Inform SIC for arrangement of any additional equipment as required.

6. Duties of IRT

Designated Officer	Role	Duties
Harbour Master (Alternate: Pilot)	Site Incident Controller	During Emergency shall proceed to the scene & communicate & collect all information from the Master of the Tanker and terminal operator.
		Conduct initial briefing and report the situation to the CIC and assist in assessing the incident.
		Assess the condition of site and of potential affected area and take decision on evacuation in consultation with CIC.
		Alert vessels within the vicinity.
		Extend all necessary help to the Master of the vessel.
		Instruct the fire-fighting team to keep the water tenders in a state of readiness & activate if required.
		Instruct flotilla superintendent/ pilots to keep tugs ready for fire-fighting.
		Coordinate with all functional heads to take actions.
Pilot (Alternate: Pilot)	Signal Station Coordinator and Pilotage	Shall monitor the communication on VHF/any other communication medium & convey and relay messages on the advice from CIC /SIC.
		Responsible for organizing tugs, mooring boats and pilots for combating the fire and rescue.
		Hire additional crafts as necessary.
		Shall be ready for taking the vessel out of berth and be ready for providing any assistance on site.
		Maintain Log of events.
Terminal Operator (Alternate: Officer)	Cargo Work	Shall be responsible of shutting down of cargo operation & coordinating with Port and rendering necessary assistance to the SIC by providing additional fire-fighting & emergency equipment as required.
Dy. Fire Officer (Alternate: Officer)	Fire, Search and Rescue Coordinator/ HAZMAT Coordinator	Shall take orders from Fire cum Safety Officer/SIC.
		Ensures availability of the fire tenders and fire-fighting tugs.
		Assist CISF-Security in evacuation of workers to the assembly points.
		Inform SIC for arrangement of any additional equipment as required.
Dy. Commandant-CISF (Alternate: Commandant-CISF)	Security and Evacuation	Shall take orders from the Sr. Commandant – CISF /SIC.
		Cordon off the area.
		Controls & Directs gate security and traffic in the area.

		Shall facilitate evacuation, transport, first aid and rescue of personnel from the scene at the time of emergency. Control the entry of unauthorized persons and vehicles. Check for entry of emergency vehicles. Liaise with the Police authorities. Responsible the head count of the personnel.
Dy. Traffic Manager (Alternate: Officer)	Cargo Storage, Shed and Labour Coordinator	Shall take orders from Traffic Manager/SIC. Submits consolidated list of dangerous goods in port. Coordinates with vessel owners/ agents/C & F agents/stevedores and with labour officer to arrange and ensure evacuation.
Safety Officer (Alternate: Officer)	Safety Coordinator	Shall mobilize and dispatch vehicles containing HAZMAT kit to the site of emergency.
Executive Engineer (Alternate: Executive Engineer)	Civil Coordinator	Shall be responsible to carry out urgent civil works as required.
Executive Engineer (Alternate: Executive Engineer)	M & E Coordinator	Shall be responsible for uninterrupted electrical supply to vital equipment and utility at the jetty. Shall remain alert on duty for any electrical isolation of equipment during emergency.
Dy. CMO (Alternate: Medical Officer)	First Aid and Medical Coordinator	Shall be responsible to organize and dispatch first aid team with ambulance as required. Setup casualty receiving center and arrange for first aid. Make arrangements for transportation (ambulance) and treatment of injured persons. Check updated list of Blood group of employees is available. Shall coordinate with the local hospitals.
Mooring Master (Alternate: Officer)	Mooring Coordinator	Act as per the instruction of SIC/CIC. Assess the level of crisis, nature, location, severity, casualties and resource equipment.
Material Manager (Alternate: Officer)	Material procurement Coordinator	Maintain sufficient inventory and provide the same during emergency as per the order of SIC/CIC.
Environment Cell and OSRO (Alternate: Officer)	Pollution Control Coordinator	Ensure clean- up work conducted by terminal personnel after spill containment. Coordinate with SIC and GPCB and agencies.

S5: Scenario 5
Part A

1. **Fire /leakage due to Crane Accidents (Container drop/crane fall) at container berth/yard – secondary event.**
2. **Precautions:** Trained personnel for operation of crane, SOP of the container terminal, HAZMAT training and MSDS.
3. **Impact Zone:** Incident location and **s**urrounding area.
4. **Resources required:** Organizational setup enumerated in Figure S5.2 and major material and equipment resources as given in Chapter 10.

Figure S5.1: Action Flow Chart

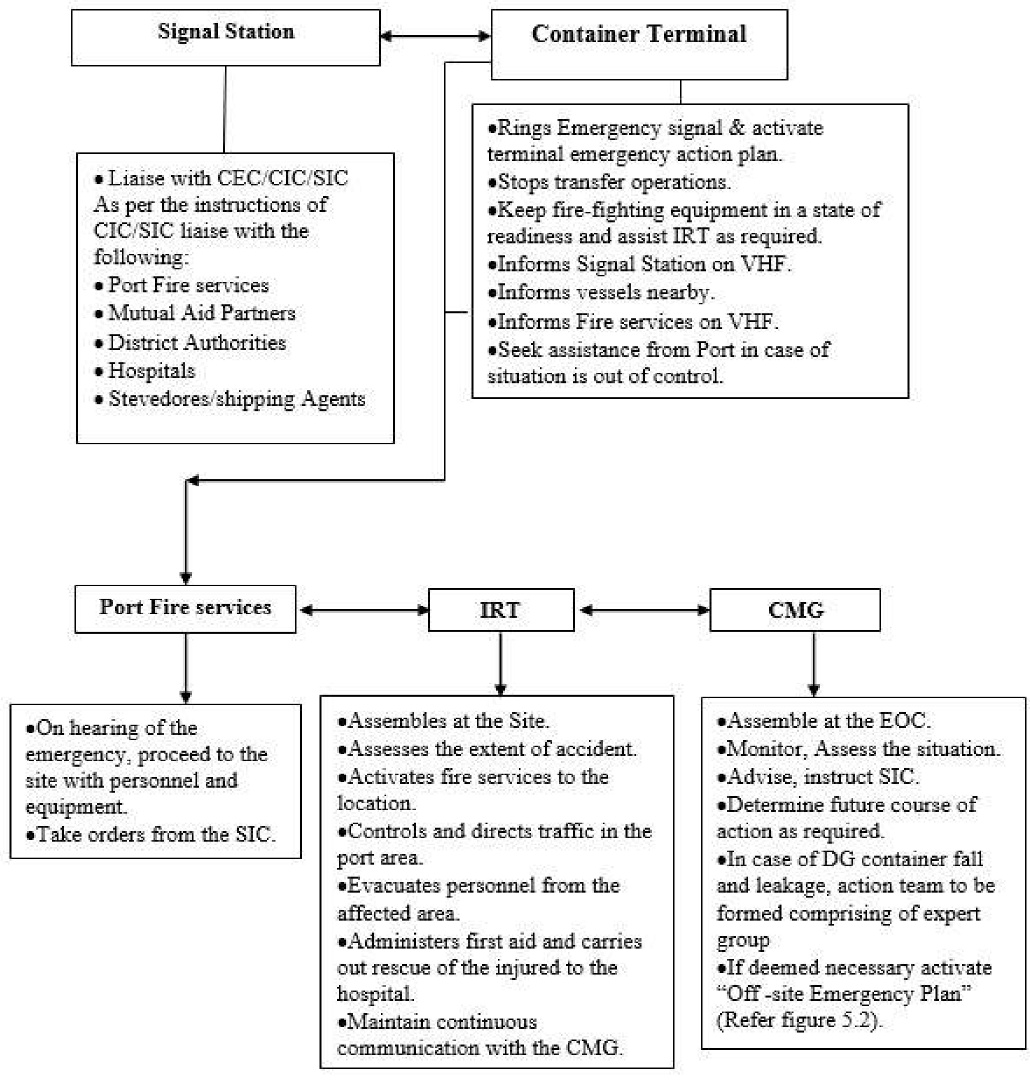

Figure S5.2: Action group

Master of Container vessel
(Note: The Master must intimate his working channel on the VHF/any other communication medium during cargo work to the Signal Station).

Harbour Master
8976741054

Crisis Management Group

1. Chairman/Dy. Chairman (233001/234601/234121);
2. Deputy Conservator (9603123449);
3. Traffic Manager (966610773);
4. Chief Engineer (Civil) (9825227038);
5. Environment Cell (External);
6. Chief Mechanical Engineer (9825235196);
7. Fire Cum Safety Officer (270176/270178/9825227041);
8. Sr. Commandant-CISF (271037/9825227282);
9. Chief Medical Officer (225767/220072/9825505796);
10. Chief Vigilance officer;
11. Secretary (General Administration) (7036868889);
12. Financial Advisor and Chief Account Officer (9526062088);
13. Sr. Dy. Materials Manager;
14. Public Relation Officer (9638943800);
15. Law Officer (9712341380);
16. Port Berth Operator/Terminal Managers.

Incident Response Team

1. Signal Station – (270549/9016682249);
2. Dy. Fire Officer (270176/270178/9825221330/9825221352);
3. Sr. Dy. Traffic Manager (9748437052);
4. Pilots;
5. Safety Officer (9909950277);
6. Dy. Chief Mechanical Engineer;
7. Dy. Chief Engineer (Civil) (9427251059);
8. Sr. Dy. Secretary (General Administration) (9825227079);
9. Flotilla Superintendent (9978559903/9825227610);
10. Mooring Team;
11. Sr. Dy. CMO (Medical) (236376/9687607528);
12. Dy. Commandant -CISF (271440/271039/270876);
13. Dy. Financial Advisor and Chief Account Officer (9825227036);
14. Dy. Material Manager;
15. OSRO;
16. Port Berth Operators.

Mutual Aid

- Municipal Fire Station -Gandhidham (02836-226573);
- Neighbouring Industries.

Local, District and State Groups

- DDMA (Gujarat- Kutch) (+9128321077);
- GSDMA (02832-252347);
- MMD Kandla (02836-297015/297127/28);
- GPCB (02836-230828);
- NDRF (6th Battalion) (02688299201/9870006730);
- ICG Mundra (02838-271403);
- Indian Navy -Porbandar (0286-2240954);
- Police Authority (02832-250960/280233);
- Marine Police - Kandla (02836-270527);
- Civil Defence (02832-230603).

Part B: Action Plan

1. The crane operator

a. Should raise the emergency alarm and inform Terminal operator and Port.

2. The terminal person at the berth should

Response Action	
a.	Activate EAP and inform Port and ask for assistance, if required.
b.	Area should be cordoned off.
c.	Stop transfer operations at the berth.
d.	Manage Truck movements.
e.	Assist IRT and Master of the Vessel and provide all necessary equipment.
f.	He will direct operation staff.
g.	Interview operator and witnesses.
h.	Contact expert agency in case of DG container fire/explosion.

3. Deputy Conservator (Alternate: Harbour Master)

Response Action	
a.	Will be stationed at the EOC to review & assess possible developments to determine the most necessary course of action.
b.	He will give necessary instructions to SIC & arrange for external aid as necessary.
c.	Provide assistance to the Terminal.

4. The Signal Station

Response Action	
a.	Gather information regarding the incident and accordingly convey the message to CIC/SIC and Fire cum Safety Officer.
b.	Liaise with terminal operator and Master of the vessels/pilot.
c.	Listening watch to be maintained on VHF channel-08/10/16.
d.	Keep CIC/SIC informed of all the messages received by telephone, VHF sets or by messenger.
e.	Notify the other Authorities (ICG, Navy) and stakeholders within Port as per instructions of CIC/SIC.

5. The Fire cum Safety Officer should

Response Action	
a.	Shall take orders from the SIC.
b.	Lead the fire-fighting team and mobilize fire tenders, men & fire-fighting equipment to the scene & extend all necessary support.
c.	Assist CISF and terminal in evacuation of workers to the assembly points.
d.	Inform SIC for arrangement of any additional equipment as required.

6. Duties of IRT

Designated Officer	Role	Duties
Harbour Master (Alternate: Pilot)	Site Incident Controller	During Emergency shall proceed to the scene & communicate & collect all information from the crane operator/terminal manager and coordinate actions.
		Assess and report the situation to the CIC/CMG (if required).
		Alert vessels/trucks within the vicinity.
		Instruct the fire-fighting team to keep the fire-fighting installation in a state of readiness & activate if required.
Safety Officer (Alternate: Officer)	Safety Coordinator	Investigate the incident and provide necessary guidance.
		Assist in Rescue.
Pilot (Alternate: Pilot)	Signal Station Coordinator and Pilotage	Shall monitor the communication on VHF/any other communication medium & convey and relay messages on the advice from CIC/SIC.
		Shall prepare vessels to vacate from berth (if required).
		Responsible for organizing tugs for rescue.
		Hire additional crafts as necessary.
		Maintain Log of events.
Dy. Fire Officer (Alternate: Officer)	Fire, Search and Rescue Coordinator	Shall take orders from the Fire cum Safety Officer/SIC.
		Mobilize fire tenders, men & fire- fighting equipment to the scene & extend all necessary support in case of fire.
		Assist the terminal operator and CISF-Security in evacuation.
Dy. Commandant-CISF (Alternate: Commandant-CISF)	Security and Evacuation	Controls & directs traffic in the area.
		Shall supervise evacuation of personnel from the scene at the time of emergency.
Executive Engineer (Alternate: Executive Engineer)	Civil Coordinator	Assist terminal, if required on emergency basis.

Executive Engineer (Alternate: Executive Engineer)	M & E Coordinator	Assist terminal, if required on emergency basis.
Dy. CMO (Alternate: Medical Pilot)	First Aid and Medical Coordinator	Shall be responsible to organize and dispatch first aid team with ambulance as required.
Dy. Traffic Manager (Alternate: Officer)	Cargo Storage, Shed and Labour Coordinator	Shall mobilize and dispatch enough vehicles to the site of emergency.
		Coordinates with SIC and Terminal.

RESTRICTED.

S6: Scenario 6
Part A:

1. **Fire on vessel (non-tankers) at berth**
2. **Precautions:** Vessel fire-fighting system, Port fire station, SOP of the berth operator.
3. **Impact Zone:** Incident location and vicinity of the vessel involved.
4. **Resources required:** Organizational setup enumerated in Figure S6.2 and major material and equipment resources as given in Chapter 10.

Figure S6.1: Action Flow Chart

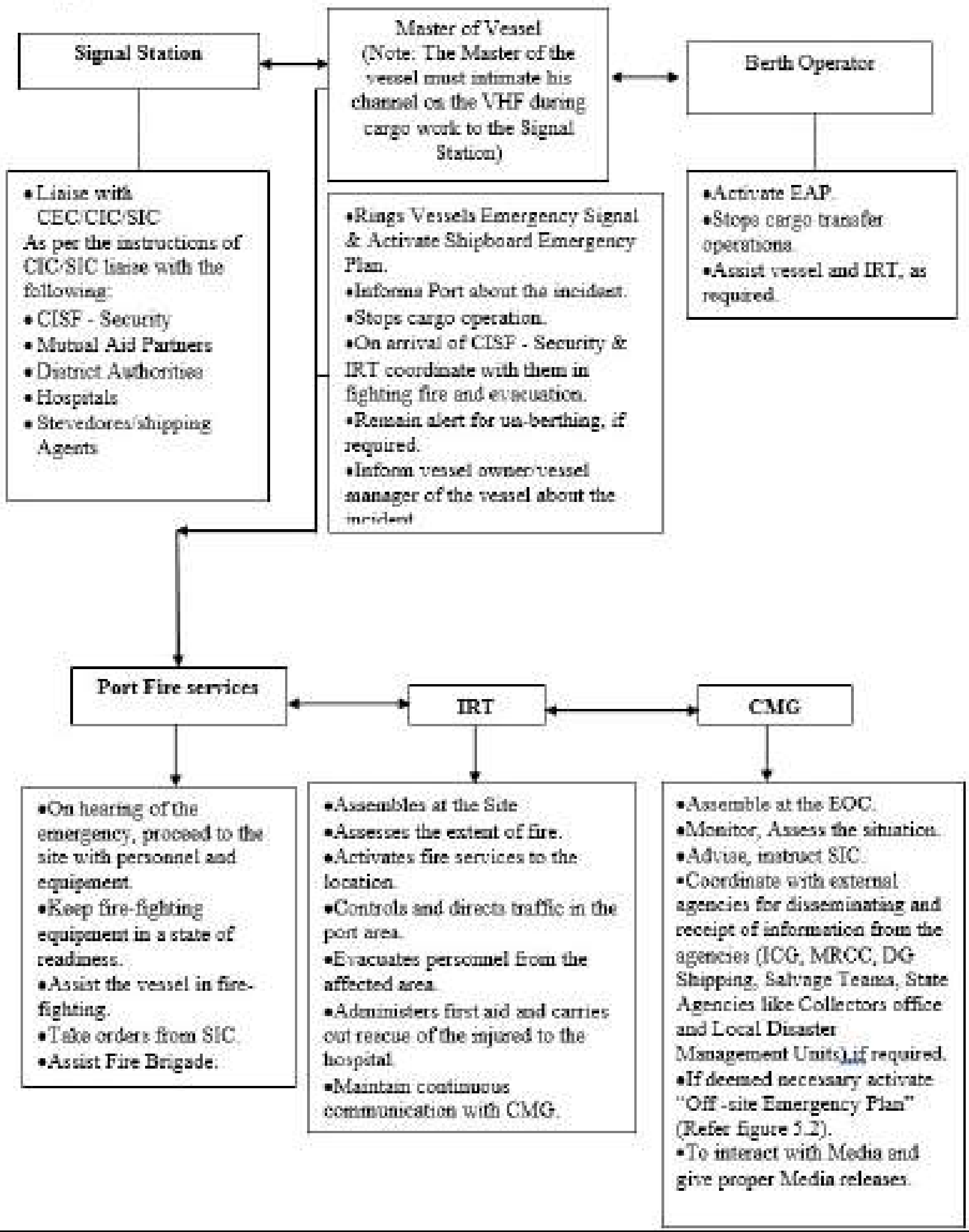

Figure S6.2: Action group

Master of vessel (Note: The Master must intimate his working channel on the VHF/any other communication medium during cargo work to the Signal Station).

Harbour Master
8976741054

Crisis Management Group

1. Chairman/Dy. Chairman (233001/234601/234121);
2. Deputy Conservator (9603123449);
3. Traffic Manager (966610773);
4. Chief Engineer (Civil) (9825227038);
5. Environment Cell (External);
6. Chief Mechanical Engineer (9825235196);
7. Fire Cum Safety Officer (270176/270178/9825227041);
8. Sr. Commandant-CISF (271037/9825227282);
9. Chief Medical Officer (225767/220072/9825505796);
10. Chief Vigilance officer;
11. Secretary (General Administration) (7036868889);
12. Financial Advisor and Chief Account Officer (9526062088);
13. Sr. Dy. Materials Manager;
14. Public Relation Officer (9638943800);
15. Law Officer (9712341380);
16. Port Berth Operator/Terminal Managers.

Incident Response Team

1. Signal Station – (270549/9016682249);
2. Dy. Fire Officer (270176/270178/9825221330/9825221352);
3. Sr. Dy. Traffic Manager (9748437052);
4. Pilots;
5. Safety Officer (9909950277);
6. Dy. Chief Mechanical Engineer;
7. Dy. Chief Engineer (Civil) (9427251059);
8. Sr. Dy. Secretary (General Administration) (9825227079);
9. Flotilla Superintendent (9978559903/9825227610);
10. Mooring Team;
11. Sr. Dy. CMO (Medical) (236376/9687607528);
12. Dy. Commandant -CISF (271440/271039/270876);
13. Dy. Financial Advisor and Chief Account Officer (9825227036);
14. Dy. Material Manager;
15. OSRO;
16. Port Berth Operators.

Mutual Aid

- Municipal Fire Station -Gandhidham (02836-226573);
- Neighbouring Industries.

Local, District and State Groups

- DDMA (Gujarat- Kutch) (+9128321077);
- GSDMA (02832-252347);
- MMD Kandla (02836-297015/297127/28);
- GPCB (02836-230828);
- NDRF (6th Battalion) (02688299201/9870006730);
- ICG Mundra (02838-271403);
- Indian Navy -Porbandar (0286-2240954);
- Police Authority (02832-250960/280233);
- Marine Police - Kandla (02836-270527);
- Civil Defence (02832-230603).

Part B: Action Plan

The vessel upon berthing, terminal/berth operator will follow standard procedures. However, in a less likely scenario a fire may occur on the vessel during transfer operation. The following action will be required:

1. The Master of the Vessel (Alternate: Chief Officer)

	Response Action
a.	Should raise vessels emergency alarm and activate vessel board emergency action plan.
b.	Stop transfer operation (as per SOP).
c.	Terminal/Berth operator, Vessel in the vicinity and Port should be informed of any incident on the vessel without delay.
d.	Shall be responsible for fighting the fire with vessels own resources as well as with the available support from IRT.
e.	Also, to remain prepared to un-berth the vessel to the safe area.
f.	The siren should be continued till the vessel is taken to a safe location as per CIC instructions.

2. The berth operator tasked with cargo operations should

	Response Action
a.	Activate EAP and inform Port.
b.	Area should be cordoned off.
c.	Assist IRT and provide all necessary equipment.
d.	He will direct operation staff. Coordinate with the vessel in-charge/C&F agents/stevedores.

3. Deputy Conservator (Alternate: Harbour Master)

	Response Action
a.	Assess the level of disaster and activate the DMP.
b.	Establish EOC and be stationed to review & assess possible developments to determine the most necessary course of action.
c.	Give necessary instructions to SIC and Port & arrange for external aid as necessary.
d.	Review the situation and accordingly inform to the Chairman/ Dy. Chairman.
e.	Assess the condition of site and of potential affected area and take decision on evacuation in consultation with SIC.
f.	Be in constant touch with District and Local Administration for rescue and relief operation.
g.	Terminate the response and debrief before allowing normal operation.

4. The Signal Station

	Response Action
a.	Gather information related to the weather conditions and accordingly convey the message to CIC/SIC and Fire cum Safety Officer.
b.	Liaise with Master of the Vessel/Pilot.
c.	Listening watch to be maintained on VHF channel-08/10/16.
d.	Notify to CIC, SIC and the vessels moving into, through and inside the dock. Keep CIC/SIC informed of all the messages received by telephone, VHF sets or by messenger.
e.	Notify the other Authorities (ICG, Navy) and stakeholders within Port as per instructions of CIC/SIC.
f.	Notify the information to the owner of the vessel as per the instruction of CIC/SIC/ Master of the Vessel.

5. The Fire cum Safety Officer should

	Response Action
a.	Ensure raising of Alarm (siren)
b.	Shall take orders from the SIC.
c.	Lead the fire-fighting team and mobilize fire tenders, men & fire-fighting equipment to the scene & extend all necessary support to the Master of the vessel/berth operator for firefighting.
d.	Ensures availability of the fire tenders and fire-fighting tugs.
e.	In case of fire onboard assist Master in fighting fire as per Masters Instructions.
f.	If the fire is under control and extinguished, give all clear signal.
g.	Inform SIC for arrangement of any additional equipment as required.

6. Duties of IRT

Designated Officer	Role	Duties
Harbour Master (Alternate: Pilot)	Site Incident Controller	During Emergency shall proceed to the scene & communicate & collect information from the Master of the vessel and berth operator.
		Conduct initial briefing and report the situation to the CIC and assist in assessing the incident.
		Alert vessels within the vicinity.
		Assess the condition of site and of potential affected area and take decision on evacuation in consultation with CIC.
		Extend all necessary help to the Master of the vessel to fight the fire.
		Instruct the fire-fighting team to keep the water tenders in a state of readiness and activate if required.
		Instruct flotilla superintendent/ pilots to keep tugs ready for fire-fighting.
		Coordinate with all functional heads to take actions.
Pilot (Alternate: Pilot)	Signal Station Coordinator	Shall monitor the communication on VHF/any other communication medium & convey and relay messages on the advice from CIC /SIC.
		Responsible for organizing tugs, mooring boats and pilots for combating the fire and rescue.
		Hire additional crafts as necessary.
		Shall be ready for taking the vessel out of berth and be ready for providing any assistance on site.
		Maintain Log of events.
Terminal/ Berth operator (Alternate: Officer)	Cargo Work	Shall be responsible of shutting down of cargo operation & coordinating with Port and rendering necessary assistance to the SIC by providing additional fire-fighting and emergency equipment as required.
Dy. Fire Officer (Alternate: Officer)	Fire, Search and Rescue Coordinator	Shall take orders from Fire cum Safety Officer/SIC.
		Ensures availability of the fire tenders and fire-fighting tugs.
		In case of fire onboard assist Master in fighting fire as per Masters Instructions.
		Assist CISF in evacuation of workers to the assembly points.
		Inform SIC for arrangement of any additional equipment as required.
Dy. Commandant-CISF	Security and Evacuation	Shall take orders from the Sr. Commandant –CISF /SIC.
		Cordon off the area.
		Controls & Directs gate security and traffic in the area.

(Alternate: Commandant-CISF)		Shall facilitate evacuation, transport, first aid and rescue of personnel from the scene at the time of emergency.
		Control the entry of unauthorized persons and vehicles.
		Liaise with the Police authorities.
		Responsible for the head count of the personnel.
Dy. Traffic Manager (Alternate: Officer)	Cargo Storage, Shed and Labour Coordinator	Shall take orders from Traffic Manager/SIC and assist Shift Incharge.
		Submits consolidated list of dangerous goods in port.
		Coordinates with ship owners/ agents/C & F agents/stevedores and with labour officer to arrange and ensure evacuation.
Safety Officer (Alternate: Officer)	Safety Coordinator	Inform GPCB and other environmental agencies and take necessary guidance. Coordinate with Environment cell.
		Shall mobilize and dispatch sufficient number of vehicles to the site of emergency.
		Assist in evacuation of the personnel to the assembly point or as directed by SIC.
Executive Engineer (Alternate: Executive Engineer)	Civil Coordinator	Shall be responsible to carry out urgent civil works as required.
Executive Engineer (Alternate: Executive Engineer)	M & E Coordinator	Shall be responsible for uninterrupted electrical supply to vital equipment and utilities berth.
		Shall remain alert on duty for any electrical isolation of equipment during emergency.
Dy. CMO (Alternate: Medical Officer)	First Aid and Medical Coordinator	Shall be responsible to organize and dispatch first aid team with ambulance as required.
		Make arrangements for transportation and treatment of injured persons.
		Check updated list of Blood group of employees is available.
		Shall coordinate with the local hospitals.
Environment Cell and OSRO (Alternate: Officer)	Pollution Control Coordinator	Ensure clean- up work conducted by terminal personnel after spill containment.
		Coordinate with SIC and GPCB and other agencies.
Mooring Master (Alternate: Officer)	Mooring Coordinator	Act as per the instruction of SIC/CIC.
		Assess the level of crisis, nature, location, severity, casualties and resource equipment.
		Authorize any immediate action required by on site staff and contract agencies.

S7: Scenario 7
Part A:

1. **Fire in Coal Stackyard**
2. **Precautions:** Water tenders, Sprinkler system.
3. **Impact Zone:** Incident Location and vicinity of the area involved.
4. **Resources required:** Organizational setup enumerated in Figure S7.2 and major material and equipment resources as given in Chapter 10.

Figure S7.1: Action Flow Chart

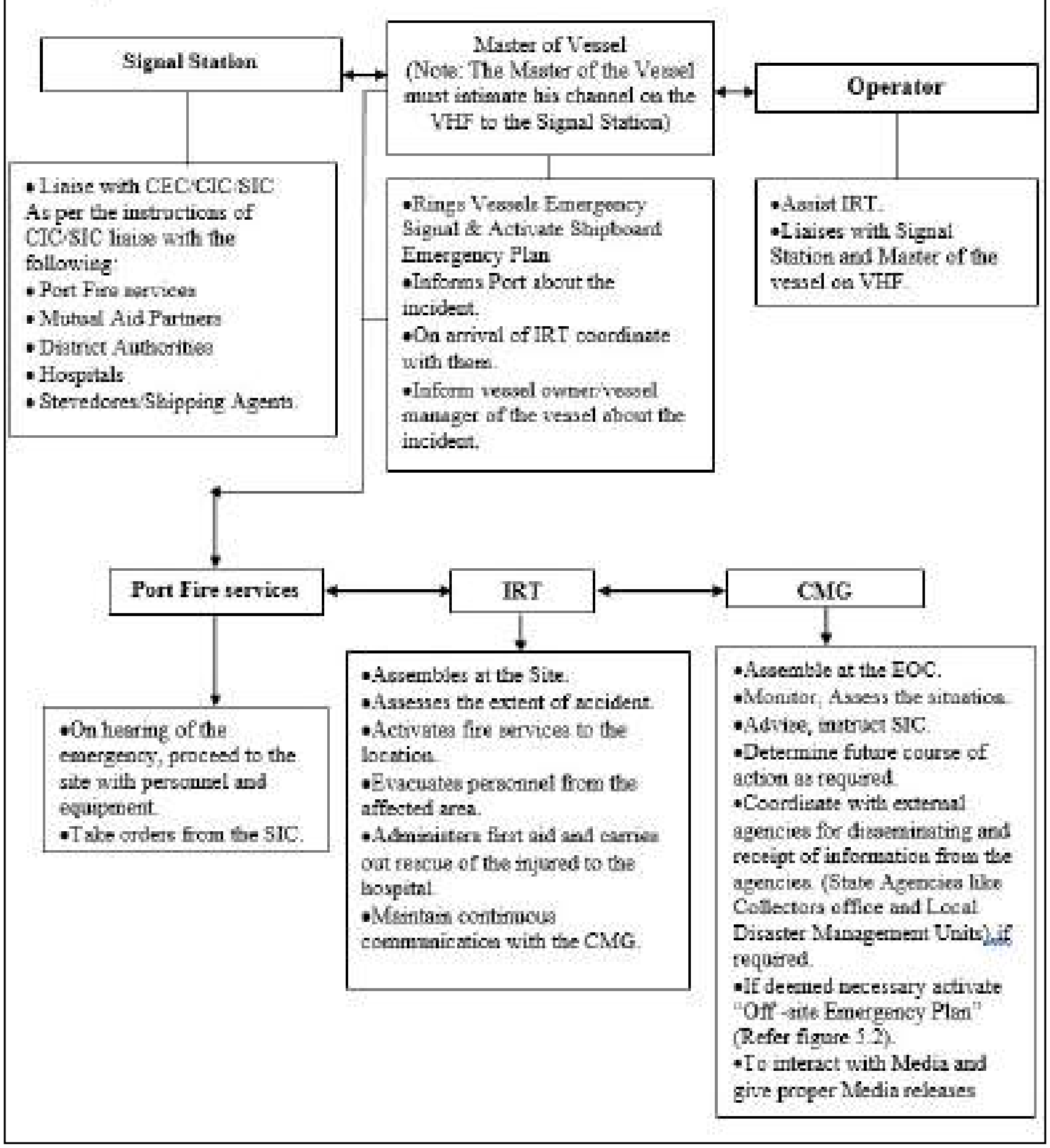

Figure S7.2: Action group

Master of vessel (Note: The Master must intimate his working channel on the VHF/any other communication medium during cargo work to the Signal Station).

Harbour Master
8976741054

Crisis Management Group

1. Chairman/Dy. Chairman (233001/234601/234121);
2. Deputy Conservator (9603123449);
3. Traffic Manager (966610773);
4. Chief Engineer (Civil) (9825227038);
5. Environment Cell (External);
6. Chief Mechanical Engineer (9825235196);
7. Fire Cum Safety Officer (270176/270178/9825227041);
8. Sr. Commandant-CISF (271037/9825227282);
9. Chief Medical Officer (225767/220072/9825505796);
10. Chief Vigilance officer;
11. Secretary (General Administration) (7036868889);
12. Financial Advisor and Chief Account Officer (9526062088);
13. Sr. Dy. Materials Manager;
14. Public Relation Officer (9638943800);
15. Law Officer (9712341380);
16. Port Berth Operator/Terminal Managers.

Incident Response Team

1. Signal Station – (270549/9016682249);
2. Dy. Fire Officer (270176/270178/9825221330/9825221352);
3. Sr. Dy. Traffic Manager (9748437052);
4. Pilots;
5. Safety Officer (9909950277);
6. Dy. Chief Mechanical Engineer;
7. Dy. Chief Engineer (Civil) (9427251059);
8. Sr. Dy. Secretary (General Administration) (9825227079);
9. Flotilla Superintendent (9978559903/9825227610);
10. Mooring Team;
11. Sr. Dy. CMO (Medical) (236376/9687607528);
12. Dy. Commandant -CISF (271440/271039/270876);
13. Dy. Financial Advisor and Chief Account Officer (9825227036);
14. Dy. Material Manager;
15. OSRO;
16. Port Berth Operators.

Mutual Aid

- Municipal Fire Station -Gandhidham (02836-226573);
- Neighbouring Industries.

Local, District and State Groups

- DDMA (Gujarat- Kutch) (+9128321077);
- GSDMA (02832-252347);
- MMD Kandla (02836-297015/297127/28);
- GPCB (02836-230828);
- NDRF (6^{th} Battalion) (02688299201/9870006730);
- Police Authority (02832-250960/280233);

Part B: Action Plan

1. Signal Station should

Response Action
a. Gather information related to the coal stack yard fire and time of incident.
b. Notify to CIC, SIC and the nearby vessels through general alert.
c. Gather information about the wind speed and directions and notify CIC/SIC.

2. Deputy Conservator (Alternate: Harbour Master)

Response Action
a. Assess the level of disaster and activate the DMP.
b. Establish EOC and be stationed to review & assess possible developments to determine the most necessary course of action.
c. Give necessary instructions to SIC and Port & arrange for external aid as necessary.
d. Review the situation and accordingly inform to the Chairman/ Dy. Chairman.
e. Decide on clearing of vessels in close proximity to the incident location.
f. Be in constant touch with District and Local Administration for rescue and relief operation.
g. Terminate the response and debrief before allowing normal operation.

3. Duties of IRT

Designated Officer	**Role**	**Duties**
Harbour Master (Alternate: Pilot)	Site Incident Controller	During Emergency shall proceed to the scene & communicate & collect all information from the coal operator.
		Assess and report the situation to the CIC/CMG (if required).
		Alert vessels within the vicinity.
		Extend all necessary help to the operator.
		Instruct Pilot to keep tugs ready.
		He will coordinate with all functional heads to take actions.
Safety Officer (Alternate: Officer)	Safety Coordinator	Ensure safety of all the personnel.
		Assist SIC and CISF and maintain Log of events.
Dy. Fire Officer (Alternate: Officer)	Fire, Search and Rescue Coordinator	Shall take orders from Fire cum Safety Officer/SIC.
		Mobilize fire tenders, men & firefighting equipment to the scene & extend all necessary support.
		Assist the coal stack yard operator and CISF-Security in evacuation, if required.

Pilot (Alternate: Pilot)	Signal Station Coordinator and Pilotage	Shall monitor the communication on VHF/any other communication medium & convey and relay messages on the advice from CIC/SIC.
		Shall prepare vessels to vacate from berth (if required).
		Responsible for organizing tugs and Pilots.
		Assist SIC and maintain Log of events.
Coal Stack yard Operator (Alternate: Officer)	Fire, Search and Rescue Coordinator	Provide assistance to port and vessel.
Dy. Commandant-CISF (Alternate: Commandant-CISF)	Security and Evacuation	Shall take orders from the Sr. Commandant–CISF /SIC.
		Cordon off the area and take head count of the personnel
		Controls & Directs gate security and traffic in the area.
		Shall facilitate evacuation, transport, first aid and rescue of personnel from the scene at the time of emergency.
		Control the entry of unauthorized persons and vehicles.
		Liaise with the Police authorities.
Executive Engineer (Alternate: Executive Engineer)	Civil Coordinator	Liaise with SIC.
Executive Engineer (Alternate: Executive Engineer)	M & E Coordinator	Arrange for specialized equipment if required as per the instruction of the SIC and requirement of operator.
Dy. CMO (Alternate: Officer)	First Aid and Medical Coordinator	Shall be responsible to organize and dispatch first aid team with ambulance as required.
Dy. Traffic Manager (Alternate: Officer)	Cargo Storage, Shed and Labour Coordinator	Coordinates with Coal Stack yard Operator.
		Shall mobilize and dispatch sufficient number of vehicles to the site of emergency.
Material Manager (Alternate: Officer)	Material procurement Coordinator	Maintain sufficient inventory and provide the same during emergency as per the order of SIC/CIC.
Mooring Master (Alternate: Officer)	Mooring Coordinator	Act as per the instruction of SIC/CIC.
		Assess the level of crisis, nature, location, severity, casualties and resource equipment.

S8: Scenario 8
Part A

1. **Vessel Grounding/Collision within port limit.**
2. **Precautions:** Navigational Aid, Designated Pilots, Continuous monitoring and communication with the Signal Station and Pilot.
3. **Impact Zone:** Navigational and creek channel, Anchorage area.
4. **Resources required:** Organizational setup enumerated in Figure S8.2 and major material and equipment resources as given in Chapter 10.

Figure S8.1: Action Flow Chart

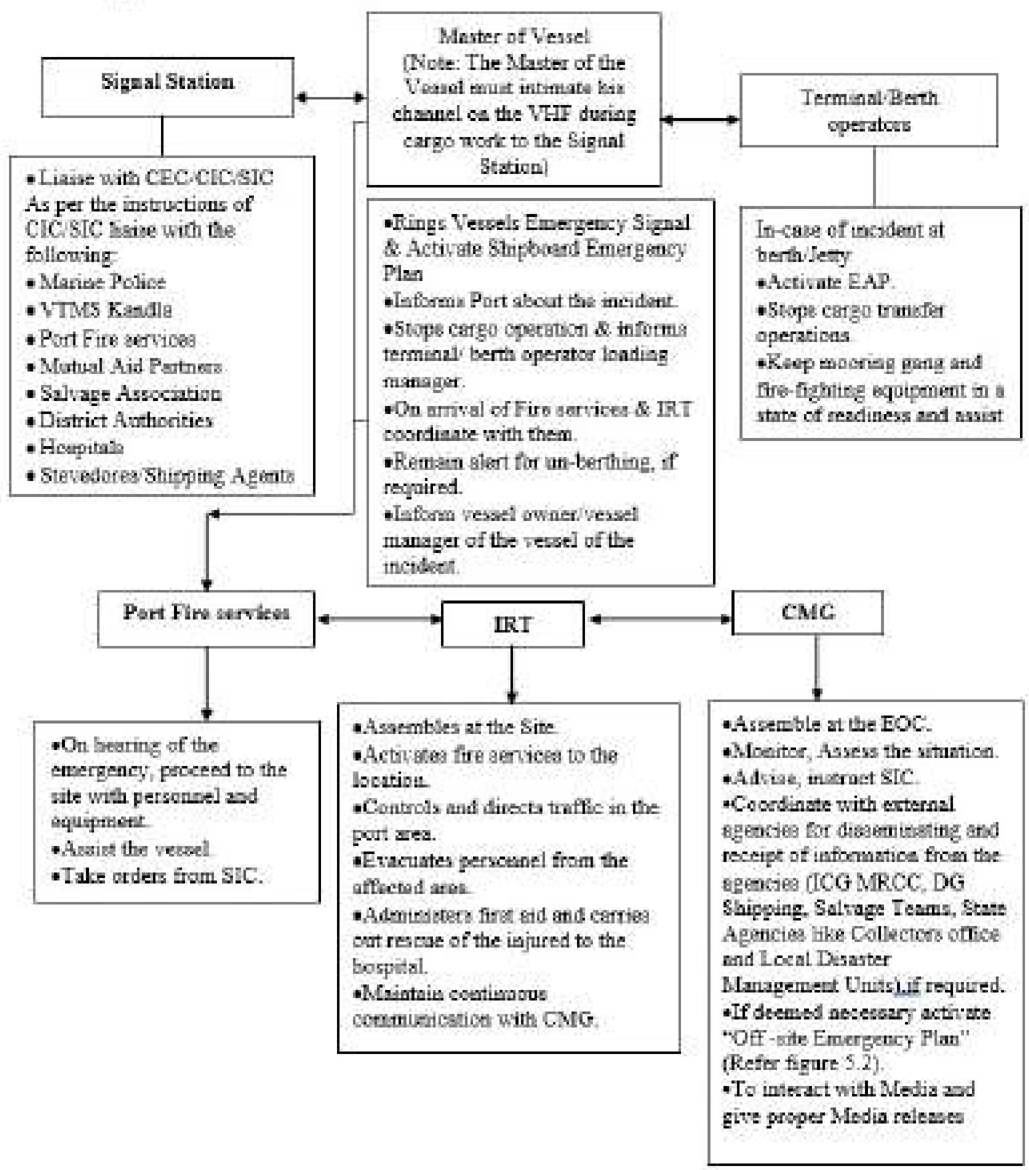

Figure S8.2: Action group

Master of vessel (Note: The Master must intimate his working channel on the VHF/any other communication medium during cargo work to the Signal Station).

Harbour Master
8976741054

Crisis Management Group

1. Chairman/Dy. Chairman (233001/234601/234121);
2. Deputy Conservator (9603123449);
3. Traffic Manager (966610773);
4. Chief Engineer (Civil) (9825227038);
5. Environment Cell (External);
6. Chief Mechanical Engineer (9825235196);
7. Fire Cum Safety Officer (270176/270178/9825227041);
8. Sr. Commandant-CISF (271037/9825227282);
9. Chief Medical Officer (225767/220072/9825505796);
10. Chief Vigilance officer;
11. Secretary (General Administration) (7036868889);
12. Financial Advisor and Chief Account Officer (9526062088);
13. Sr. Dy. Materials Manager;
14. Public Relation Officer (9638943800);
15. Law Officer (9712341380);
16. Port Berth Operator/Terminal Managers.

Incident Response Team

1. Signal Station – (270549/9016682249);
2. Dy. Fire Officer (270176/270178/9825221330/9825221352);
3. Sr. Dy. Traffic Manager (9748437052);
4. Pilots;
5. Safety Officer (9909950277);
6. Dy. Chief Mechanical Engineer;
7. Dy. Chief Engineer (Civil) (9427251059);
8. Sr. Dy. Secretary (General Administration) (9825227079);
9. Flotilla Superintendent (9978559903/9825227610);
10. Mooring Team;
11. Sr. Dy. CMO (Medical) (236376/9687607528);
12. Dy. Commandant -CISF (271440/271039/270876);
13. Dy. Financial Advisor and Chief Account Officer (9825227036);
14. Dy. Material Manager;
15. OSRO;
16. Port Berth Operators.

Mutual Aid

- Municipal Fire Station -Gandhidham (02836-226573);
- Neighbouring Industries.

Local, District and State Groups

- DDMA (Gujarat- Kutch) (+9128321077);
- GSDMA (02832-252347);
- MMD Kandla (02836-297015/297127/28);
- GPCB (02836-230828);
- NDRF (6th Battalion) (02688299201/9870006730);
- ICG Mundra (02838-271403);
- Indian Navy -Porbandar (0286-2240954);
- Police Authority (02832-250960/280233);
- Marine Police - Kandla (02836-270527);
- Civil Defence (02832-230603).

Part B: Action Plan

1. The Master of the Vessels (Alternate: Chief Officers)

Response Action
a. Should raise vessels emergency alarm and activate vessel board emergency action plan including evacuation of the personnel.
b. Vessel in the vicinity, Terminal/berth operator and Port should be informed of any incident without delay.
c. Shut down transfer operation (if at berth).
d. Take appropriate damage control measures in case of flooding including leak stoppage and pumping out, vessel list correction etc.
e. Estimate the extent of under water damage, sounding of tanks and actions for the refloating of the vessel.
f. Shall be responsible for fighting the fire (in case of fire) with vessels own resources as well as with the available support from IRT.

2. The Signal Station

Response Action
a. Liaise with Master of the Vessel/Pilot and gather the information about the type of vessels involved in the incident, cargo and location of the incident and convey the message to CIC/SIC and VTS Kandla.
b. Gather information related to the weather conditions. Monitor the wind directions and accordingly convey the message to CIC/SIC and Fire cum Safety Officer.
c. Listening watch to be maintained on VHF channel-08/10/16.
d. Notify to CIC, SIC, VTS Kandla and the vessels moving into, through and inside the port. Keep CIC/SIC informed of all the messages received by telephone, VHF sets or by messenger.
e. Notify the other Authorities (ICG, Navy) and stakeholders within Port as per instructions of CIC/SIC.
f. Notify the information to the owner of the vessel as per the instruction of CIC/SIC/ Master of the Vessel.

3. Deputy Conservator (Alternate: Harbour Master)

Response Action
a. Assess the level of disaster and activate the DMP and OSCP.
b. Establish EOC and be stationed to review & assess possible developments to determine the most necessary course of action.
c. Give necessary instructions to SIC and Port & arrange for external aid as necessary.
d. Review the situation and accordingly inform to the Chairman/ Dy. Chairman.
e. Decide on clearing of vessels in close proximity to the incident location.
f. Be in constant touch with District and Local Administration for rescue and relief operation.
g. Terminate the response and debrief before allowing normal operation.

4. Duties of IRT

Designated Officer	Role	Duties
Harbour Master (Alternate: Pilot)	Site Incident Controller	During emergency, he shall proceed to the affected location (if vessel is in creek/jetty area) & communicate & collect all necessary information's from the Master of the vessel.
		Report the situation to the CIC/CMG.
		In case of fire on board the vessel after collision or contact, he will extend all necessary help to the Master of the vessel.
		Instruct flotilla superintendent/ pilots to keep tugs ready for firefighting.
		Alert other vessels within the vicinity.
		Ascertain oil pollution- leak source, if any.
		Obtain information regarding stability and hull stress of the vessel.
		If vessels have blocked or a possibility of blocking the channel, in co-ordination with the Master, the vessel shall be taken to berth / anchorage.
		In case of grounding, make arrangements through Harbour Master/Pilots to proceed to the spot and to take soundings, plot them in a chart and to ascertain the location of grounding damage on the hull.
		Depending on the way the vessel is grounded and the available high tide on the day, all advance preparations should be made to commence the towing operation at least two hours before the high water or as advised by CIC/SIC.
		Inform MoEF and GPCB approved parties for safe disposal and providing reception facilities for Oil/Sludge. Also, inform Salvage association.
Pilot (Alternate: Pilot)	Signal Station Coordinator	Shall be ready for taking the instructions from CIC/SIC and evacuate/move/shift the vessel from the area.
		If possible, accompany SIC to inspect the vessel.
		Plot exact location of the incident in coordination with the hydrographic surveyor.
		Responsible for organizing tugs for rescue. Instruct pilots.
		Hire additional crafts as necessary.
Environment cell and OSRO	Marine Pollution	Supervise and direct personnel to follow the instructions given by SIC/CIC.

(Alternate: Officer)	Control Coordinator	OSRO shall use the OSR in case of oil spill in coordination with the environment cell and ICG.
		Coordinate with the party involved in disposal of the Oil/sludge in a safe manner.
		Maintain records of the claims.
Dy. Fire Officer (Alternate: Officer)	Fire, Search and Rescue Coordinator	Shall take orders from the Fire cum Safety Officer/SIC.
		Mobilize fire tenders, men & firefighting equipment to the scene & extend all necessary support to the master of the vessel for firefighting.
Dy. Commandant-CISF (Alternate: Commandant-CISF)	Security and Evacuation	Shall take orders from the Sr. Commandant – CISF /SIC.
		Cordon off the area and take head count of the personnel
		Controls & directs gate security and traffic in the area.
		Shall facilitate evacuation, transport, first aid and rescue of personnel from the scene at the time of emergency.
		Control the entry of unauthorized persons and vehicles.
		Check for entry of emergency vehicles.
		Liaise with the Police authorities.
Dy. CMO (Alternate: Officer)	First Aid and Medical Coordinator	Shall be responsible to organize and dispatch first aid team with ambulance as required.
		Make arrangements for transportation and treatment of injured persons.
		Shall coordinate with the local hospitals.
Executive Engineer (Alternate: Executive Engineer)	Civil Coordinator	Instruct the contractors to carry out urgent civil works as required.
		Hire the barges for collecting the spilled oil and coordinate with the parties involved in the safe disposal of the oil/sludge.
Dy. Traffic Manager (Alternate: Officer)	Cargo Storage, Shed and Labour Coordinator	Coordinates with vessel owners/agents/stevedores.
Mooring Master (Alternate: Officer)	Mooring Coordinator	Act as per the instruction of SIC/CIC.
		Assess the level of crisis, nature, location, severity, casualties and resource equipment.
Material Manager (Alternate: Officer)	Material procurement Coordinator	Maintain sufficient inventory and provide the same during emergency as per the order of SIC/CIC.

S9: Scenario 9
Part A

1. **Fire in Office buildings, Hospital, Electrical substations, Fire stations, Dry docks, Godowns**
2. **Precautions:** Periodic Maintenance and Inspection, Protected/covered Electrical installations, protection from flood (equipment raising from ground level), Fire-fighting systems, trained personnel to combat fire, No-smoking zone, House Keeping.
3. **Impact Zone:** Incident location and immediate surroundings.
4. **Resources required:** Organizational setup enumerated in Figure S9.2 and major material and equipment resources as given in Chapter 10.

Figure S9.1: Action Flow Chart

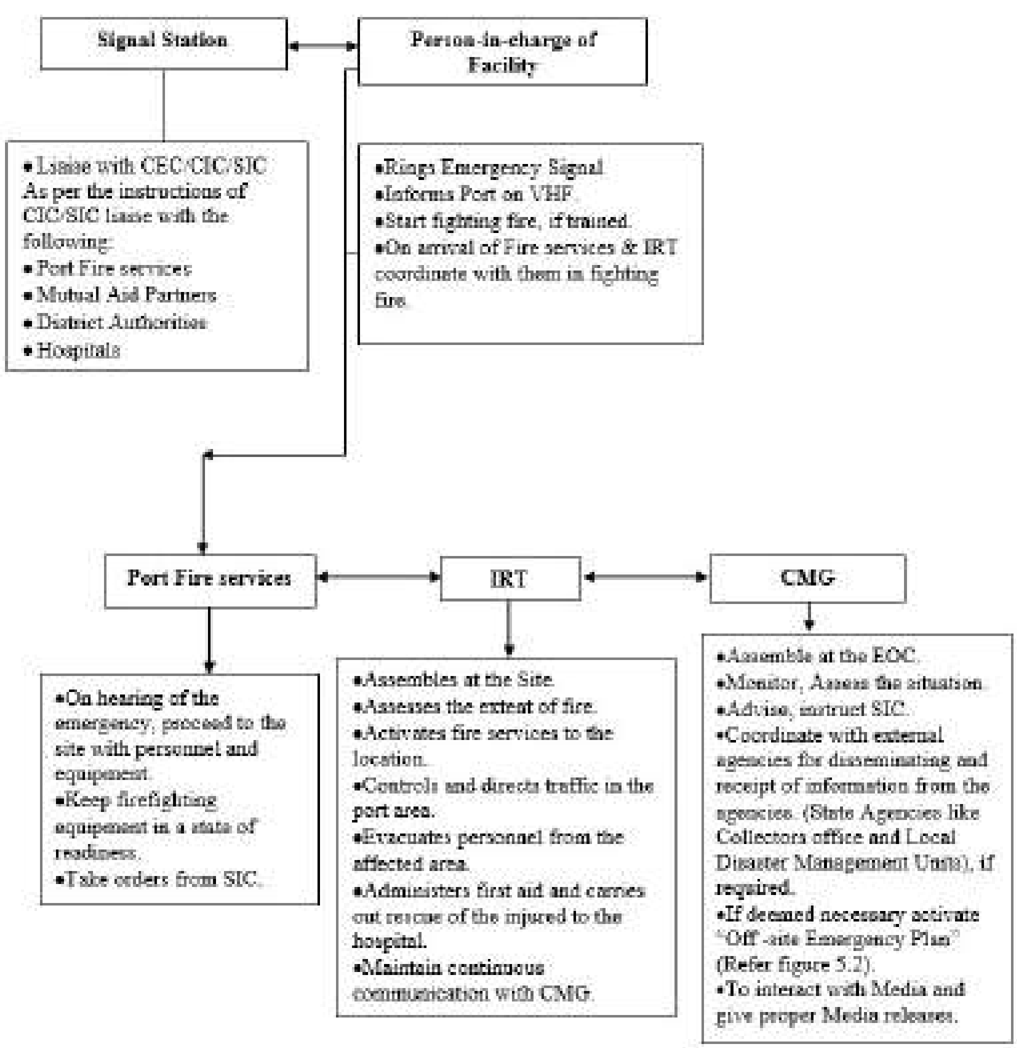

Figure S9.2: Action group

Person-in-charge of Facility

Harbour Master
8976741054

Crisis Management Group

1. Chairman/Dy. Chairman (233001/234601/234121);
2. Deputy Conservator (9603123449);
3. Traffic Manager (966610773);
4. Chief Engineer (Civil) (9825227038);
5. Environment Cell (External);
6. Chief Mechanical Engineer (9825235196);
7. Fire Cum Safety Officer (270176/270178/9825227041);
8. Sr. Commandant-CISF (271037/9825227282);
9. Chief Medical Officer (225767/220072/9825505796);
10. Chief Vigilance officer;
11. Secretary (General Administration) (7036868889);
12. Financial Advisor and Chief Account Officer (9526062088);
13. Sr. Dy. Materials Manager;
14. Public Relation Officer (9638943800);
15. Law Officer (9712341380);
16. Port Berth Operator/Terminal Managers.

Incident Response Team

1. Signal Station – (270549/9016682249);
2. Dy. Fire Officer (270176/270178/9825221330/9825221352);
3. Sr. Dy. Traffic Manager (9748437052);
4. Pilots;
5. Safety Officer (9909950277);
6. Dy. Chief Mechanical Engineer;
7. Dy. Chief Engineer (Civil) (9427251059);
8. Sr. Dy. Secretary (General Administration) (9825227079);
9. Flotilla Superintendent (9978559903/9825227610);
10. Mooring Team;
11. Sr. Dy. CMO (Medical) (236376/9687607528);
12. Dy. Commandant -CISF (271440/271039/270876);
13. Dy. Financial Advisor and Chief Account Officer (9825227036);
14. Dy. Material Manager;
15. OSRO;
16. Port Berth Operators.

Mutual Aid

- Municipal Fire Station -Gandhidham (02836-226573);
- Neighbouring Industries.

Local, District and State Groups

- DDMA (Gujarat- Kutch) (+9128321077);
- GSDMA (02832-252347);
- MMD Kandla (02836-297015/297127/28);
- GPCB (02836-230828);
- NDRF (6^{th} Battalion) (02688299201/9870006730);
- Police Authority (02832-250960/280233);

Part B: Action Plan

1. **The Person-in-charge of Facility**

Response Action	
a.	Should raise emergency alarm.
b.	Fire cum Safety officer/Signal Station should be informed of any incident without delay.
c.	Shall be responsible for fighting the fire with resources available as well as with the available support from IRT.

2. **Signal Station should**

Response Action	
a.	Gather information related to the time of incident.
b.	Notify to CIC, SIC and the Fire cum Safety officer.
c.	Gather information about the wind and notify CIC/SIC and Fire cum Safety officer.

3. **Deputy Conservator (Alternate: Harbour Master)**

Response Action	
a.	Assess the level of disaster and activate the DMP.
b.	Establish EOC and be stationed to review & assess possible developments to determine the most necessary course of action.
c.	Give necessary instructions to SIC, Fire cum Safety officer and Signal Station & arrange for external aid as necessary.
d.	Review the situation and accordingly inform to the Chairman/ Dy. Chairman.
e.	Decide on clearing of vehicles in close proximity to the incident location.
f.	Be in constant touch with District and Local Administration for rescue and relief operation.
g.	Terminate the response and debrief before allowing normal operation.

4. **The Fire cum Safety Officer**

Response Action	
a.	Collect the information from Signal Station/ Person-in-charge of Facility and SIC.
b.	Lead the fire-fighting team and provide assistance person-in-charge of facility in fighting fire as per SIC/CME Instructions.
c.	He will mobilize personnel & fire-fighting equipment to the scene & extend all necessary support in case of fire, if required.
d.	Provide assistance in evacuation of the personnel as directed by SIC.
e.	Inform SIC for arrangement of any additional equipment as required.

5. Duties of IRT

Designated Officer	Role	Duties
Harbour Master (Alternate: Pilot)	Site Incident Controller	During Emergency shall proceed to the scene & communicate & collect all information from the person-in-charge/Fire cum Safety Officer.
		Report the situation to the CIC/CMG and assist in assessing the incident.
		Assess the condition of site and of potential affected area and take decision on evacuation in consultation with CIC.
		Alert vehicles within the vicinity.
		Extend all necessary support to the Fire Team to fight the fire.
		Instruct the Fire Team to keep the fire-fighting installation.
		Instruct flotilla superintendent/ pilots to keep tugs ready for fire-fighting.
		Coordinate with all functional heads to take actions.
Executive Engineer (Alternate: Executive Engineer)	M & E Coordinator	Assist SIC or lead the IRT in coordination with SIC.
		Coordinate with Electricity board.
		Shall be responsible for Electrical connections and disconnections to vital equipment and systems and provide alternate supply if required.
Safety Officer (Alternate: Officer)	Safety Coordinator	Shall take orders for SIC.
		Ensure safely rescue of personnel and labors.
		Ensure cleanup work during and after the emergency as quick as possible.
Pilot (Alternate: Pilot)	Signal Station Coordinator and Pilotage	Shall take orders from the SIC.
		Maintain Log of events.
Dy. Fire Officer (Alternate: Officer)	Fire, Search and Rescue Coordinator	Shall take orders from the Fire cum Safety Officer/SIC.
		Direct the fire-fighting team and mobilize fire tenders, men & fire-fighting equipment to the scene for fire-fighting.
		Assist in safely rescuing of the personnel, if trapped.

		Inform SIC and Fire cum Safety officer for the arrangement of any additional equipment as required.
		If the fire is under control and extinguished, give all clear signal.
Dy. Commandant-CISF (Alternate: Commandant-CISF)	Security and Evacuation	Shall take orders from the Sr. Commandant – CISF /SIC.
		Cordon off the area and take head count of the personnel.
		Controls & Directs gate security and traffic in the area.
		Shall facilitate evacuation, transport, first aid and rescue of personnel from the scene at the time of emergency.
		Control the entry of unauthorized persons and vehicles.
		Check for entry of emergency vehicles.
		Liaise with the Police authorities.
Executive Engineer (Alternate: Executive Engineer)	Civil Coordinator	Liaise with SIC.
Dy. CMO (Alternate: Officer)	First Aid and Medical Coordinator	In coordination with CMO, shall be responsible to organize and dispatch first aid team with ambulance as required.
		Make arrangements for transportation and treatment of injured persons.
		Shall coordinate with the local hospitals.
Dy. Traffic Manager (Alternate: Officer)	Cargo Storage, Shed and Labour Coordinator	Shall prepare vehicles in the vicinity to vacate.
		Shall mobilize and dispatch sufficient number of vehicles to the site of emergency.
		Coordinates with vessel owners/agents/stevedores.
Material Manager (Alternate: Officer)	Material procurement Coordinator	Maintain sufficient inventory and provide the same during emergency as per the order of SIC/CIC.

S10: Scenario 10

Part A:

1. **War and Terrorism.**
2. **Precautions:** Protection of the port facilities receiving seagoing vessels from terrorist attacks is as per the provision of the "The International Vessel and Port Facility Security Code (ISPS Code)".
   Security of the port is being provided by CISF.
   The measures for port security include "installation of signal station, CCTVs, Biometric Access Control System, patrolling of port areas by vehicles, creation of deterrence by creating proper perimeter wall, illuminating port area, cancelling access to ports and vessels, conducting physical verification etc."
3. **Impact Zone:** Entire port.
4. **Resources required:** Intelligence inputs from agencies and organizational setup enumerated in Figure S10.2 and major material and equipment resources as given in Chapter 10.

Part B: Action Plan

When war like situation is developed or during the declaration of war the priority is to be given to all important/critical areas to remain vigilant to prevent sabotage, to remain ready to combat emergency and to keep normal operation going.

B.1 Prior Emergency Situation (after warnings/inputs)

- Set up Crisis management centre and manned continuously.
- CMG to declare plan/guideline to be followed which could be based on CISF Contingency Plan/Government of India/Statutory bodies/Indian Navy/Air Force/Government of Gujarat etc. instructions.
- CMG to ensure utmost vigilance in identified area to ensure the adequate resources in terms of security personnel, experts in handling equipment, trained manpower, and flood lights, earth moving equipment, mobile cranes, and rescue crafts are available to guard all gates, roads etc. In case of any unidentified/unauthorized person is found, the person must be handed over to police.
- CMG to ensure that evacuation plan is prepared and backup systems such as power generator, communication equipment, and safety systems are working. CMG should also ensure that all required manpower such as electricians/technicians/laborer is available all time.
- All terminal/berth operators and sensitive locations should be informed.
- No movement of the vessels in the port vicinity will be allowed.

B.2 During Emergency

- CMG to adopt relevant DMP to combat the emergency.
- In case of an enemy attack inform relevant authorities & internal security to defend installations till the external support arrives.
- When additional security (State ATF/army/BSF) arrives, situation is to be handled jointly.
- CMG to ensure sufficient supply of food and water.
- All vessels inside the port and at the anchorage will observe blackout as per the instruction of CMG.

Figure S10.1: Action Flow Chart

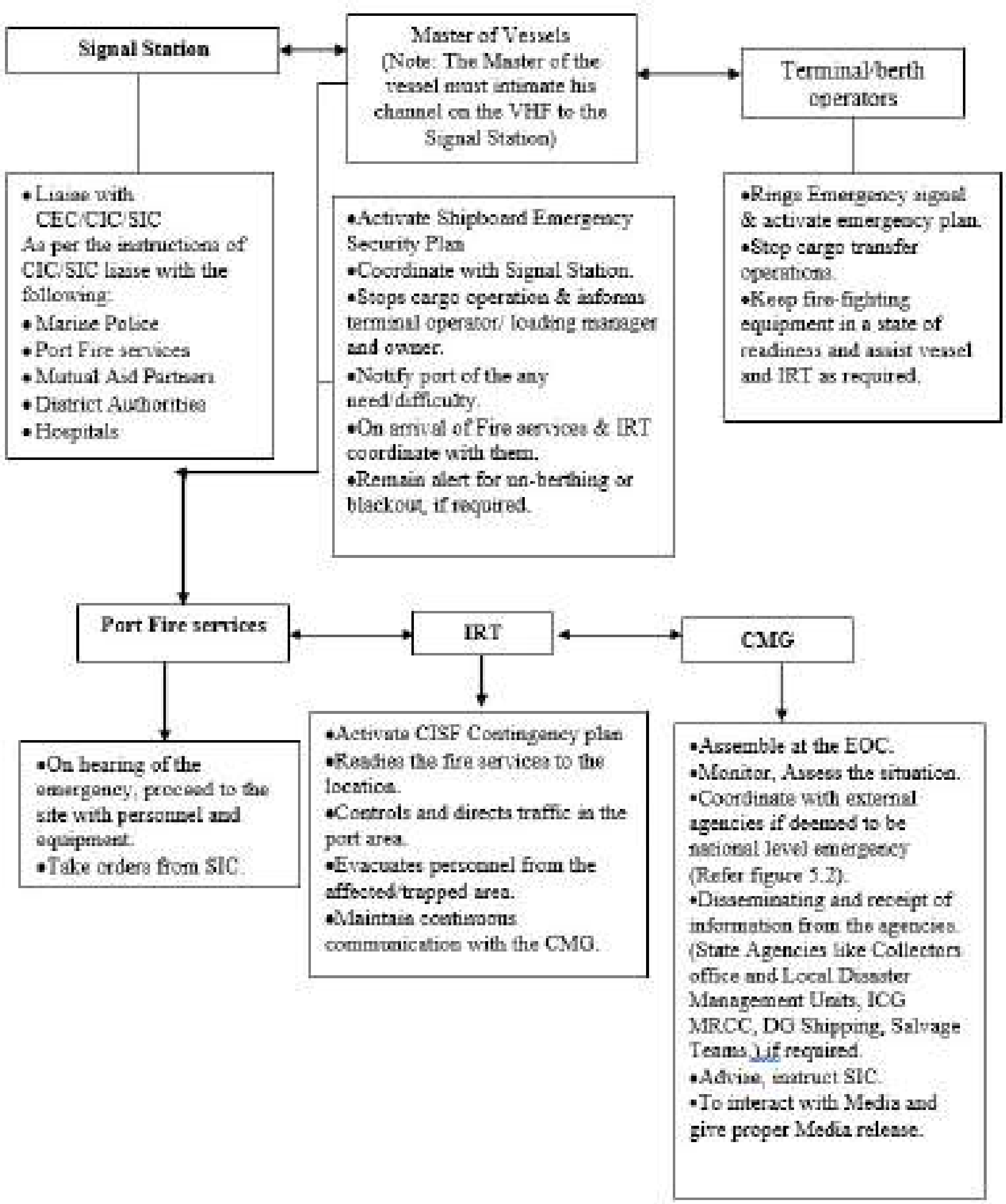

Figure S10.2: Action group

Master of Vessel

Harbour Master
8976741054

Crisis Management Group
1. Chairman/Dy. Chairman (233001/234601/234121);
2. Deputy Conservator (9603123449);
3. Traffic Manager (966610773);
4. Chief Engineer (Civil) (9825227038);
5. Environment Cell (External);
6. Chief Mechanical Engineer (9825235196);
7. Fire Cum Safety Officer (270176/270178/9825227041);
8. Sr. Commandant-CISF (271037/9825227282);
9. Chief Medical Officer (225767/220072/9825505796);
10. Chief Vigilance officer;
11. Secretary (General Administration) (7036868889);
12. Financial Advisor and Chief Account Officer (9526062088);
13. Sr. Dy. Materials Manager;
14. Public Relation Officer (9638943800);
15. Law Officer (9712341380);
16. Port Berth Operator/Terminal Managers.

Incident Response Team
1. Signal Station – (270549/9016682249);
2. Dy. Fire Officer (270176/270178/9825221330/9825221352);
3. Sr. Dy. Traffic Manager (9748437052);
4. Pilots;
5. Safety Officer (9909950277);
6. Dy. Chief Mechanical Engineer;
7. Dy. Chief Engineer (Civil) (9427251059);
8. Sr. Dy. Secretary (General Administration) (9825227079);
9. Flotilla Superintendent (9978559903/9825227610);
10. Mooring Team;
11. Sr. Dy. CMO (Medical) (236376/9687607528);
12. Dy. Commandant -CISF (271440/271039/270876);
13. Dy. Financial Advisor and Chief Account Officer (9825227036);
14. Dy. Material Manager;
15. OSRO;
16. Port Berth Operators.

Mutual Aid
- Municipal Fire Station -Gandhidham (02836-226573);
- Neighbouring Industries.

Local, District and State Groups
- DDMA (Gujarat- Kutch) (+9128321077);
- GSDMA (02832-252347);
- MMD Kandla (02836-297015/297127/28);
- GPCB (02836-230828);
- NDRF (6th Battalion) (02688299201/9870006730);
- Police Authority (02832-250960/280233);

Part B: Action Plan

1. **Sr. Commandant - CISF (Alternate: Dy. Commandant- CISF) should**

	Response Action
a.	Act as per the CISF Contingency plan.
b.	Controls & directs traffic in the area.
c.	Shall supervise evacuation of personnel from the scene at the time of emergency and shift to shelter stations.

2. **Deputy Conservator (Alternate: Harbour Master)**

	Response Action
a.	Assess the situation and activate the DMP and CISF Contingency Plan.
b.	Establish EOC and be stationed to review & assess possible developments to determine the most necessary course of action in coordination with CISF-Security.
c.	Give necessary instructions to SIC and Signal Station & arrange for external aid as necessary.
d.	Review the situation and accordingly inform to the Chairman/ Dy. Chairman.
e.	Be in constant touch with District and Local Administration for rescue and relief operation.
f.	Terminate the response and debrief before allowing normal operation.

3. **Duties of IRT**

Designated Officer	Role	Duties
Harbour Master (Alternate: Pilot)	Site Incident Controller	During Emergency shall communicate & collect all information.
		Report the situation to the CIC/ CMG.
		Extend all necessary help to CISF (Security) as and when required.
		Ensure that there is blackout at the port and the vessels at the anchorage area as per the guidance and instruction of CMG/CIC/CISF.
Pilot (Alternate: Pilot)	Signal Station Coordinator	Shall be ready for taking the instructions from CIC/SIC and evacuate/move/shift the vessel from the area.
Master of the vessel (Alternate: Chief Officer)	In-Charge of operation on board vessel	Be ready to take the vessel out of the port as per the instructions of CIC/SIC.
		Coordinate with IRT leader and will be responsible for shutting down all cargo operation on board in coordination with terminal/operator In-Charge.
Terminal/ Berth Operators (Alternate: Officer)	Cargo Work	Shall be responsible of shutting down of cargo operation & coordinating with Port and render necessary assistance to the SIC by providing additional fire-fighting & emergency equipment

		as required.
		Arrange to protect cargo in vicinity from damage.
Safety Officer (Alternate: Officer)	Safety Coordinator	Ensure all employees (port and contract) within port shifted to safe locations.
Dy. Fire Officer (Alternate: Officer)	Fire, Search and Rescue Coordinator	Shall take orders from the Fire cum Safety Officer/SIC.
		Keep the fire –fighting installation in a state of readiness and be in continuous liaise with SIC/CIC.
		Ensure all employees (port and contract) within port shifted to safe locations.
Executive Engineer (Alternate: Executive Engineer)	Civil Coordinator	Assist SIC.
Executive Engineer (Alternate: Executive Engineer)	M & E Coordinator	Arrange for specialized equipment if required as per the instruction of the SIC.
		Take orders from CIC/SIC with regards to power supply and shutdown.
Dy. CMO (Alternate: Medical Officer)	First Aid and Medical Coordinator	Shall be responsible to organize and dispatch first aid team with ambulance as required. Ensure the hospital is in a state of readiness.
Dy. Traffic Manager (Alternate: Officer)	Cargo Storage, Shed and Labour Coordinator	Submits consolidated list of dangerous goods in port area.
		Coordinates with the truck contractors.
		Ensure sufficient numbers of vehicles are available.

S11: Scenario 11
Part A

1. **Bomb Threat**
2. **Precautions:** Protection of the port facilities receiving seagoing vessels from terrorist attacks is as per the provision of the "The International Vessel and Port Facility Security Code (ISPS Code)".
   Security of the port is being provided by CISF.
   The measures for port security include "installation of signal station, CCTVs, Biometric Access Control System, patrolling of port areas by vehicles, creation of deterrence by creating proper perimeter wall, illuminating port area, cancelling access to ports and vessels, conducting physical verification etc."
3. **Impact Zone:** Entire port.
4. **Resources required:** Organizational setup enumerated in Figure S11.2 and major material and equipment resources as given in Chapter 10.

Figure S11.1: Action Flow Chart

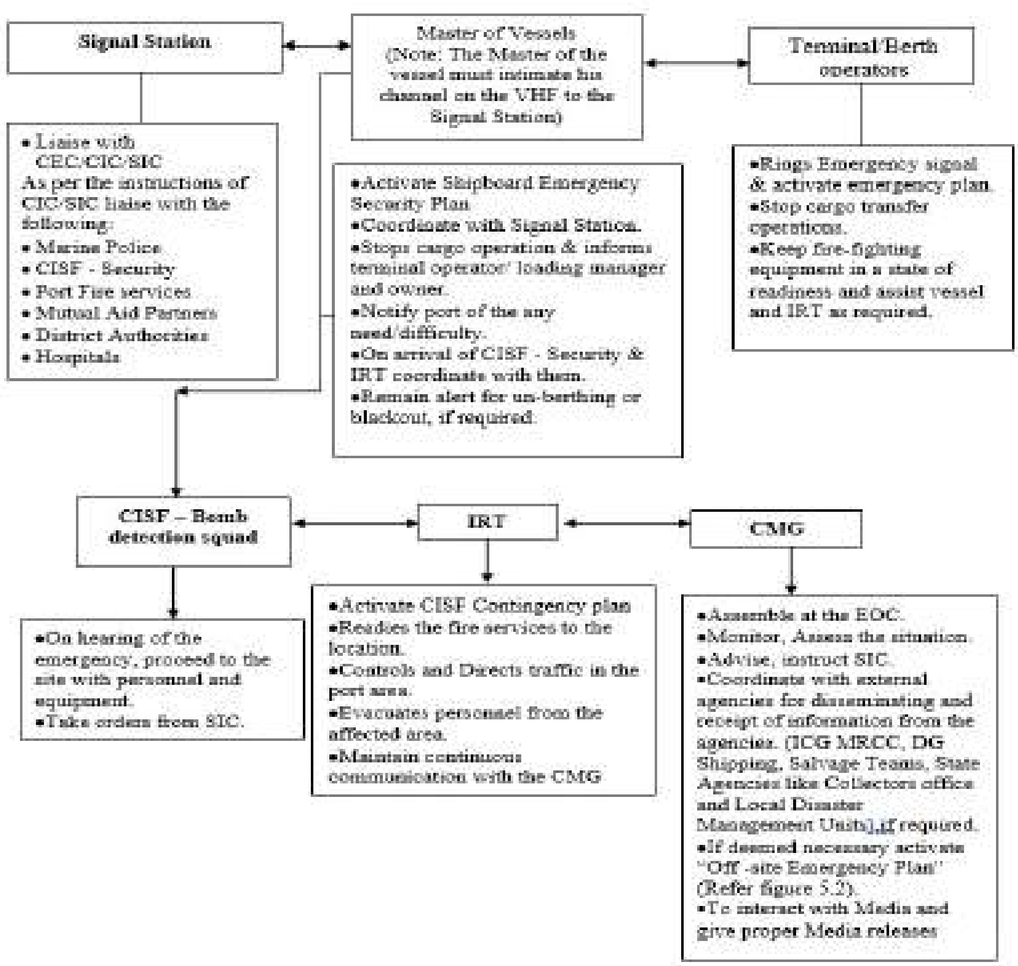

Figure S11.2: Action group

Master of Vessel

Harbour Master
8976741054

Crisis Management Group
1. Chairman/Dy. Chairman (233001/234601/234121);
2. Deputy Conservator (9603123449);
3. Traffic Manager (966610773);
4. Chief Engineer (Civil) (9825227038);
5. Environment Cell (External);
6. Chief Mechanical Engineer (9825235196);
7. Fire Cum Safety Officer (270176/270178/9825227041);
8. Sr. Commandant-CISF (271037/9825227282);
9. Chief Medical Officer (225767/220072/9825505796);
10. Chief Vigilance officer;
11. Secretary (General Administration) (7036868889);
12. Financial Advisor and Chief Account Officer (9526062088);
13. Sr. Dy. Materials Manager;
14. Public Relation Officer (9638943800);
15. Law Officer (9712341380);
16. Port Berth Operator/Terminal Managers.

Incident Response Team
1. Signal Station – (270549/9016682249);
2. Dy. Fire Officer (270176/270178/9825221330/9825221352);
3. Sr. Dy. Traffic Manager (9748437052);
4. Pilots;
5. Safety Officer (9909950277);
6. Dy. Chief Mechanical Engineer;
7. Dy. Chief Engineer (Civil) (9427251059);
8. Sr. Dy. Secretary (General Administration) (9825227079);
9. Flotilla Superintendent (9978559903/9825227610);
10. Mooring Team;
11. Sr. Dy. CMO (Medical) (236376/9687607528);
12. Dy. Commandant -CISF (271440/271039/270876);
13. Dy. Financial Advisor and Chief Account Officer (9825227036);
14. Dy. Material Manager;
15. OSRO;
16. Port Berth Operators.

Mutual Aid
- Municipal Fire Station -Gandhidham (02836-226573);
- Neighbouring Industries.

Local, District and State Groups
- DDMA (Gujarat- Kutch) (+9128321077);
- GSDMA (02832-252347);
- MMD Kandla (02836-297015/297127/28);
- GPCB (02836-230828);
- NDRF (6^{th} Battalion) (02688299201/9870006730);
- Police Authority (02832-250960/280233);

Part B: Action Plan

1. The Observer

Response Action	
a.	Signal Station/CISF should be informed without delay.

2. Sr. Commandant - CISF (Alternate: Dy. Commandant- CISF) should

Response Action	
a.	Gather the information as per CISF bomb threat checklist based on Intelligence inputs.
b.	Should Implement/activate CISF Contingency Plan and search operation as per the message received of the location.
c.	Identify the location and cordon off the area.
d.	Assist District Police and Bomb Squad as required.
e.	All terminal/operators should be informed.
f.	Relevant port area should be shut down and people inside the port should be taken to a safe location.

3. Deputy Conservator (Alternate: Harbour Master)

Response Action	
a.	Assess the situation and activate the DMP.
b.	Establish EOC and be stationed to review & assess possible developments to determine the most necessary course of action.
c.	Give necessary instructions to SIC, CISF and Signal Station & arrange for external aid as necessary.
d.	Review the situation and accordingly inform to the Chairman/ Dy. Chairman.
e.	Be in constant touch with District and Local Administration for rescue and relief operation.
f.	Terminate the response and debrief before allowing normal operation.

4. Duties of IRT

Designated Officer	Role	Duties
Harbour Master (Alternate: Pilot)	Site Incident Controller	During Emergency shall communicate & collect all information.
		Ensure that the identified location is cordoned off and the people are evacuated.
		Report the situation to the CIC/ CMG.
		Extend all necessary help to CISF as and when required.
Pilot (Alternate: Pilot)	Signal Station Coordinator and Pilotage	Shall be ready for taking the instructions from CIC/SIC and evacuate/move/shift the vessel from the area.
Safety Officer (Alternate: Officer)	Safety Coordinator	Ensure all employees (port and contract) within port shifted to safe locations.
Master of the vessel (Alternate: Chief Officer)	In-Charge of operation on board vessel	Be ready to take the vessel out of the port as per the instructions of CIC/SIC.
		Coordinate with IRT leader and will be responsible for shutting down all cargo operation on board in coordination with terminal/operator In-Charge.
Terminal/ Berth Operator (Alternate: Officer)	Cargo Work	Shall be responsible of shutting down of cargo operation & coordinating with Port and rendering necessary assistance to the SIC by providing additional equipment as required.
		Coordinate with the agencies for screening of their cargoes.
		Arrange to protect cargo in vicinity from damage.
Dy. Fire Officer (Alternate: Officer)	Fire, Search and Rescue Coordinator	Shall take orders from the SIC/Fire cum Safety Officer.
		Keep the fire –fighting installation in a state of readiness and be in continuous liaise with SIC/CIC.
		Ensure all employees (port and contract) within port shifted to safe locations.
Executive Engineer (Alternate: Executive Engineer)	Civil Coordinator	Assist SIC.
Executive Engineer (Alternate: Executive Engineer)	M & E Coordinator	Arrange for specialized equipment if required as per the instruction of the SIC.
		Take orders from CIC/SIC with regards to power supply and shutdown.

Dy. CMO (Alternate: Officer)	First Aid and Medical Coordinator	Shall be responsible to organize and dispatch first aid team with ambulance as required. Ensure hospital is in a state of readiness.
Dy. Traffic Manager (Alternate: Officer)	Cargo Storage, Shed and Labour Coordinator	Submits consolidated list of dangerous goods in port area.
		Coordinates with the truck contractors.
		Ensure sufficient number of vehicles is available.
		Controls traffic in the Port area.

S12: Scenario 12
Part A:

1. **Natural Disaster (Cyclone)**
   Note: *The action plan will come into force as soon as the storm warning signal no.5 or higher is hoisted.*
2. **Precautions:** SOP for Cyclone, Continuous weather monitoring, Early warning system, Cyclone Shelters.
3. **Impact Zone:** Entire port**.**
   Note: *The Gujarat - Kutch districts fall under very high damage risk zone (max. wind speed of 50 m/s) as per the vulnerability hazard map of the region.*
4. **Resources required:** Refer Figure S12.2 and Chapter 10 for resources.

Figure S12.1: Action Flow Chart

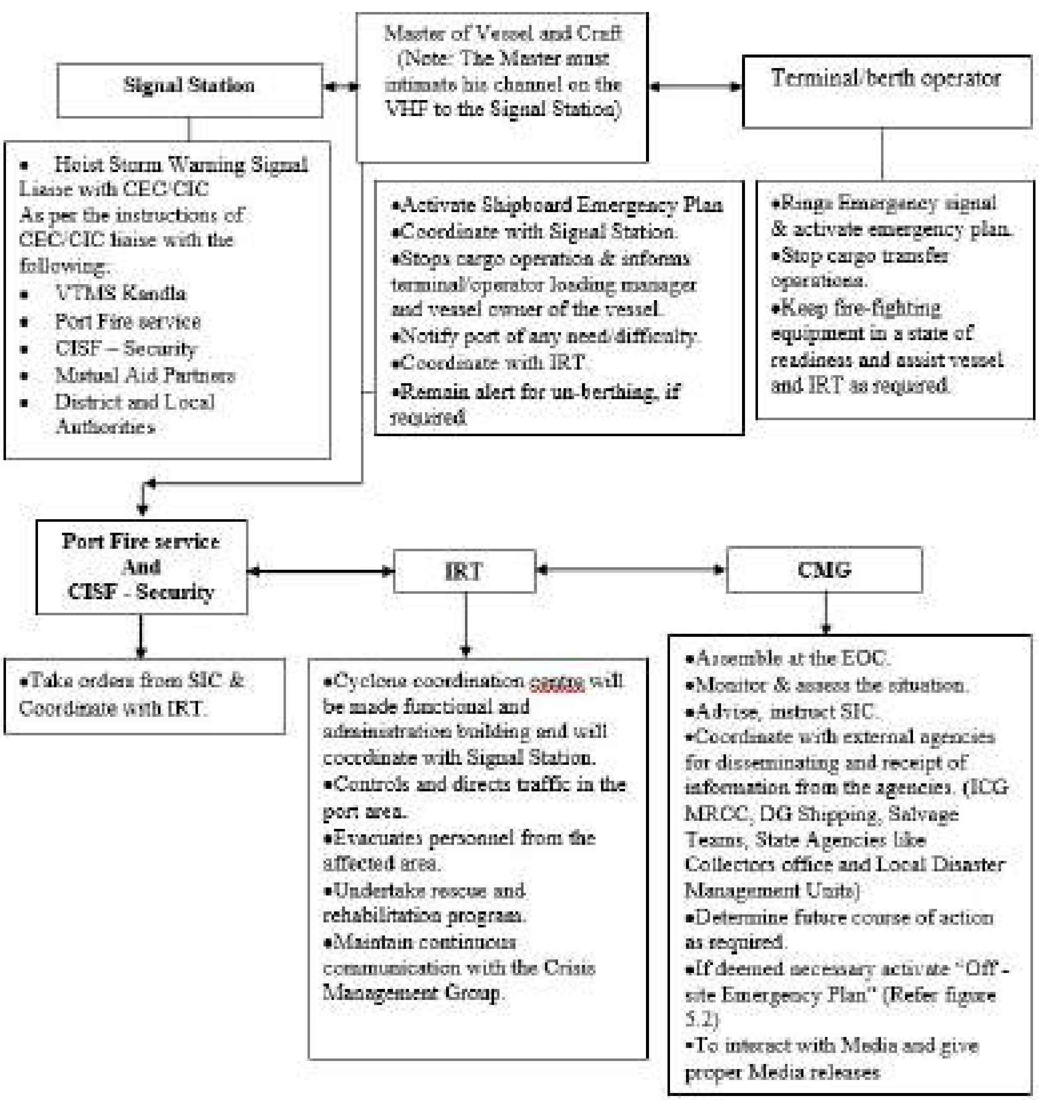

Figure S12.2: Action group

Master of Vessel

Harbour Master
8976741054

Crisis Management Group
1. Chairman/Dy. Chairman (233001/234601/234121);
2. Deputy Conservator (9603123449);
3. Traffic Manager (966610773);
4. Chief Engineer (Civil) (9825227038);
5. Environment Cell (External);
6. Chief Mechanical Engineer (9825235196);
7. Fire Cum Safety Officer (270176/270178/9825227041);
8. Sr. Commandant-CISF (271037/9825227282);
9. Chief Medical Officer (225767/220072/9825505796);
10. Chief Vigilance officer;
11. Secretary (General Administration) (7036868889);
12. Financial Advisor and Chief Account Officer (9526062088);
13. Sr. Dy. Materials Manager;
14. Public Relation Officer (9638943800);
15. Law Officer (9712341380);
16. Port Berth Operator/Terminal Managers.

Incident Response Team
1. Signal Station – (270549/9016682249);
2. Dy. Fire Officer (270176/270178/9825221330/9825221352);
3. Sr. Dy. Traffic Manager (9748437052);
4. Pilots;
5. Safety Officer (9909950277);
6. Dy. Chief Mechanical Engineer;
7. Dy. Chief Engineer (Civil) (9427251059);
8. Sr. Dy. Secretary (General Administration) (9825227079);
9. Flotilla Superintendent (9978559903/9825227610);
10. Mooring Team;
11. Sr. Dy. CMO (Medical) (236376/9687607528);
12. Dy. Commandant -CISF (271440/271039/270876);
13. Dy. Financial Advisor and Chief Account Officer (9825227036);
14. Dy. Material Manager;
15. OSRO;
16. Port Berth Operators.

Mutual Aid
- Municipal Fire Station -Gandhidham (02836-226573);
- Neighbouring Industries.

Local, District and State Groups
- DDMA (Gujarat- Kutch) (+9128321077);
- GSDMA (02832-252347);
- MMD Kandla (02836-297015/297127/28);
- GPCB (02836-230828);
- NDRF (6th Battalion) (02688299201/9870006730);
- Police Authority (02832-250960/280233);

Part B: Action Plan

1. Signal Station

	Response Action
a.	Gather information related to the vessel type and position in the port limit.
b.	Gather information related to the weather conditions by liaising with competent agencies for issuing warnings and other media. Monitor the weather map either through Internet or Television and record approximate position of the weather and information about its movement as given in the news.
c.	As per the instructions of SIC, sufficient number of staff will be detailed. The staff of Signal Station will remain on duty until they are relieved by next shift staff or till alternative arrangements are made or till the storm has passed and the Harbour Master releases them.
d.	Every two hourly barometer reading will be recorded after cyclone warning signal No. 3 is hoisted but the same will be made hourly if further upward signal is placed.
e.	Liaise with Master of the Vessel/Pilot.
f.	Ensure that telephones, one VHF and one walkie-talkie all are operational. Listening watch to be maintained on VHF channel-08/10/16.
g.	Notify CIC/SIC, HOD and the vessels moving into, through and inside the port. Keep CIC/SIC informed of all the messages received by telephone, VHF sets or by messenger.
h.	Notify the other Authorities (ICG, Navy) and stakeholders within Port as per instructions of CEC/CIC.
i.	Inform the Harbour Master/Flotilla Superintendent of any buoys or crafts or any Port installation is seen adrift.
j.	Hoist signals or raise alarms, as per the warnings received by the competent agencies for issuing warnings.

2. Tidal observatory

	Response Action
a.	The Gauge Clerk will record the range of tide, time and heights of high and low water and will report to Chief hydrographer who in turn will apprise the CIC and the SIC of the actual and predicted tides.

3. The Master of the Vessel (Alternate: Chief Officer)

	Response Action
a.	Should raise vessels emergency alarm and activate shipboard emergency action plan.
b.	Having raised the alarm, the Master will be responsible for taking all immediate steps to safeguard his vessel.
c.	The Master will provide the Port Authority with details of the vessel.
d.	Should follow the instruction of the CIC/SIC and be in continuous liaison with the CIC/SIC/Signal Station.
e.	Should be in a state of readiness to take the vessel out of the port.

4. The terminal/berth operator personnel should

	Response Action
a.	Activate EAP and inform Port.
b.	Shall be responsible of shutting down of cargo operation (as per SOP and/ contingency plan) & coordinate with Port and Master of the Vessel and rendering necessary assistance to the SIC and vessel by providing emergency equipment as required.
c.	Submit consolidated list of dangerous goods in port and Vessels in port. Make arrangements to protect cargo.
d.	Assist IRT and provide all necessary equipment.
e.	He will direct operation staff. Coordinate with the vessel in-charge/C&F agents/stevedores.

5. Deputy Conservator (Alternate: Harbour Master)

	Response Action
a.	He will keep himself apprised of the weather developments. If the storm is observed on the radar screen, the Deputed officer will inform Chairman/ Dy. Chairman and cyclone station.
b.	He will be stationed in EOC to review & assess possible developments to determine the necessary course of action.
c.	Give instructions to SIC and Signal Station & arrange for external aid as necessary.
d.	Review the situation periodically and accordingly inform to the Chairman/ Dy. Chairman.
e.	Consult with Chairman / Dy. Chairman and decide on berthing of vessels as soon as the cyclone is confirmed to pass in close proximity to the Port.
f.	Plan movements of vessels such that the vessels are cleared in shortest possible time.
g.	Coordinate with external agencies/authorities such as Indian Navy and ICG.
h.	Be in constant touch with District and Local Administration for rescue and relief operation.
i.	Terminate the response and debrief before allowing normal operation.

6. Duties of IRT

Designated Officer	Role	Duties
Harbour Master (Alternate: Pilot)	Site Incident Controller	During Emergency shall proceed to the Signal Station & communicate & collect all information.
		Take over the charge and ensure the action plan is promulgated as per the instructions of CIC.
		Inform vessels, Mooring team and Flotilla superintendent alongside berths to double up their moorings, provide shore gang assistance and ask Masters to keep their vessels ready to proceed to the sea at short notice as per the instruction of CIC.
		He will keep close liaison will IMD, Radar Station, Police Wireless Station, ICG and Vessels in Port in regard to the likely weather conditions in the near further.
		Ensure Signal Station, hoists appropriate storm signal as per the situation.
		Report the situation to the CIC & the CMG.
		Keep rescue team ready with rubber boats, Life jackets etc.
		Ensure that the hazardous cargoes are shifted out of the port or secured/stored in a safe manner.
		Ensure that the operations are brought back to normal after the termination of the emergency procedure.
Pilot (Alternate: Pilot)	Signal Station Coordinator	Shall monitor the communication on VHF/any other communication medium & convey and relay messages on the advice from CIC/SIC.
		Instruct Flotilla superintendent to secure tugs, crafts and workboats.
		Ensure securing of dock cranes and loose equipment/items.
		He will maintain log of events.
Safety Officer (Alternate: Officer)	Safety Coordinator	Ensure workers within perimeter of safety dangerous / chemical tank farms shifted to sheltered location.
		All non-essential workers to move out of port area.
Dy. Fire Officer (Alternate: Officer)	Fire, Search and Rescue Coordinator	Shall take orders from the Fire cum Safety Officer/SIC.
		Keep fire tenders and fire-fighting equipment in a state of readiness.
		Ensure the FIFI tugs is properly manned and secured with double ropes and engines running in idling condition.

		Responsible for mobilizing fire tenders, men & fire-fighting equipment to the scene & extend all necessary support.
		Liaise with State Fire brigade for any assistance.
Dy. Commandant-CISF (Alternate: Commandant-CISF)	Security and Evacuation	Shall take orders from Sr. Commandant- CISF/SIC.
		Shall be responsible for forming a cyclone task force and will lead the same.
		Controls & directs traffic in the area.
		Shall supervise evacuation of personnel from the scene at the time of emergency and Responsible for rescue operation.
		Till normality is restored, arrangements will be made for thorough checks on all out-going vehicles to guard against pilferage.
Dy. Traffic Manager (Alternate: Officer)	Cargo Storage, Shed and Labour Coordinator	Submits consolidated list of dangerous goods in port area.
		Coordinate with the truck contractors.
		Ensure availability of vehicles and mobilize and dispatch sufficient number of vehicles to the site during emergency.
Executive Engineer (Alternate: Executive Engineer)	Civil Coordinator	Shall ensure the standard procedure before the monsoon has been followed and complied with by all the divisions.
		All types of cranes, forklifts, heavy earth moving equipment to be secured in a safe manner.
		Keep enough number of cement bags ready as per SIC instructions.
		Pumphouse equipment and all generator sets shall be tried out and kept ready.
		Ensure all the drains and obstructions in the creeks/ culverts are cleaned for easy discharge of sludge water.
Executive Engineer (Alternate: Executive Engineer)	M & E Coordinator	Shall ensure the standard procedure before the monsoon has been followed and complied with by all the divisions.
		Shall form and head Cyclone mitigation Team comprising of Electrical, Mechanical and Maintenance Engineers.
		Shall ensure that all the installations and equipment are secure. All division and workshops shall follow their standard procedures for securing the equipment and installations.
		Shall be responsible for alternate electrical supply to vital equipment and systems at the berth.

		All electrical sub stations will be manned round the clock or person should be readily available incase of any emergency requirement.
Dy. CMO (Alternate: Medical Officer)	First Aid and Medical Coordinator	Shall be responsible to organize and dispatch first aid team with ambulance as required.
Executive Engineer (Alternate: Executive Engineer)	Hydrographic Survey	Assist SIC.
Duty Pilot (Alternate: Pilot)	In-Charge of Pilotage	Shall be ready on site for taking the vessel out of berth or will not bring the vessel to berth as per the instruction given by CIC/SIC.
		Inform the Masters of all vessels at the berths to double the moorings and to keep engine ready to proceed out to sea if situation warrants.
		Decision regarding moving vessels to the anchorage will be taken depending on the strength of the wind likely to be encountered and number of vessels in the Port.
		Maintain a close liaison and co-ordination with the Operations In-charge.
		Take all necessary steps for the safety of the Port crafts.
		Fender and extra lengths of ropes/wires will be kept ready so as to attend to any craft whose moorings may part.
		Inform the Signal Station/ Flotilla superintendent immediately in the event any craft is seen adrift or any other Port installation is seen in danger. Arrange an Emergency Maintenance team.
		Responsible for directing tugs for combating the fire and rescue.
Mooring Master (Alternate: Officer)	Mooring Coordinator	Act as per the instruction of SIC/CIC.
		Assess the level of crisis, nature, location, severity, casualties and resource equipment.
		Authorize any immediate action required by on site staff and contract agencies.
Material Manager (Alternate: Officer)	Material Management	During cyclonic season sufficient stock of stores like corrugated iron sheets, J.Hooks, screw hinges, gunny bags, tarpaulins, ropes and wires for Port Crafts, diesel oil, kerosene oil, hurricane lantern, kerosene lamps, torch lights with batteries and bulbs, electrical items etc. is kept.

POST-CYCLONE DUTIES	
Sr. no.	**Duty**
1.	All the Heads of the Departments are required to assess the damage and submit a detailed report indicating the estimate to the Chairman/Dy. Chairman. For this, a team may be formed comprising Officers of Executive Engineer and above in rank at departmental level and may associate one Officer from Finance Department. The preliminary report is to be submitted within 3 hours and detailed report within three days.
2.	Hydrographic survey to be conducted to assess the channel condition and Shipping to resume as early as possible.
3.	In case of any small craft sunk or grounded, the same to be removed to make the channel/ berth safe for navigation. SIC/CIC will detail a salvage party.
4.	A team of Officers to be nominated by Secretary to supervise the rescue and relief operation and disposal of carcasses in co-ordination with the local and District Administration.
5.	Mobile medical service, if required, to be provided by CMO. Preventive measures for epidemics to be taken.
6.	All the operating systems need to be attended urgently and made operational as early as possible on war footing basis to resume operation.
7.	Spot tendering procedure can be followed if required in emergency.
8.	Water supply and electricity to be given priority. The Chief Engineer (Mechanical/Electrical/Civil) shall be authorized to extend all assistance for manpower, conveyance, equipment and materials etc. to electrical board, if required, for resuming power supply. The electrical cabling network to be checked area wise.
9.	All the damaged temporary roofed warehouses are to be repaired.
10.	The Material Manager will nominate a team of officers and staff for procurement and supply of essential materials for repair of various structures and equipment as reported.
11.	To assess the progress of repair works, HOD meeting will be held daily till normalcy is restored.
12.	Damage to furniture, building fixtures may be prepared.

S13: Scenario 13
Part A:

1. **Natural Disaster (Flood due to high tide and/or heavy rains)**
   Note: *Instances of flooding increase due to storm/cyclonic conditions coupled with infrastructural challenges such as drainage systems, bulk handling and storage yards, internal roads and natural topography of the area. Instances of flooding can also occur as a result of heavy rainfall coupled with high tide. Similar organizational setup for managing this emergency on the lines of cyclone situation will be required.*
2. **Precautions:** Pre-monsoon preparation, Continuous weather monitoring, Early warning system.
3. **Impact Zone:** Entire port**.**
4. **Resources required:** Refer Figure S13.2 and Chapter 10 for resources.

Figure S13.1: Action Flow Chart

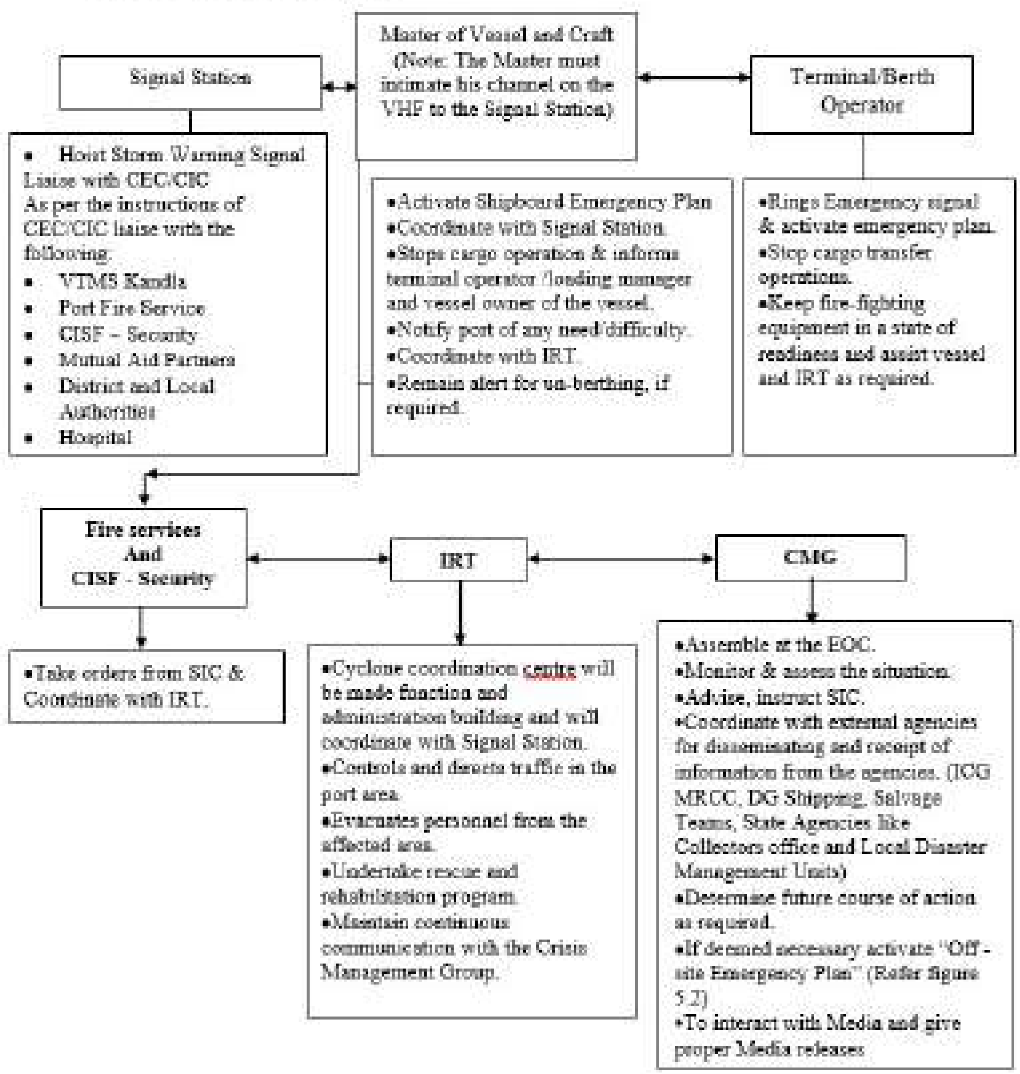

Figure S13.2: Action group

Master of Vessel

Harbour Master
8976741054

Crisis Management Group
1. Chairman/Dy. Chairman (233001/234601/234121);
2. Deputy Conservator (9603123449);
3. Traffic Manager (966610773);
4. Chief Engineer (Civil) (9825227038);
5. Environment Cell (External);
6. Chief Mechanical Engineer (9825235196);
7. Fire Cum Safety Officer (270176/270178/9825227041);
8. Sr. Commandant-CISF (271037/9825227282);
9. Chief Medical Officer (225767/220072/9825505796);
10. Chief Vigilance officer;
11. Secretary (General Administration) (7036868889);
12. Financial Advisor and Chief Account Officer (9526062088);
13. Sr. Dy. Materials Manager;
14. Public Relation Officer (9638943800);
15. Law Officer (9712341380);
16. Port Berth Operator/Terminal Managers.

Incident Response Team
1. Signal Station – (270549/9016682249);
2. Dy. Fire Officer (270176/270178/9825221330/9825221352);
3. Sr. Dy. Traffic Manager (9748437052);
4. Pilots;
5. Safety Officer (9909950277);
6. Dy. Chief Mechanical Engineer;
7. Dy. Chief Engineer (Civil) (9427251059);
8. Sr. Dy. Secretary (General Administration) (9825227079);
9. Flotilla Superintendent (9978559903/9825227610);
10. Mooring Team;
11. Sr. Dy. CMO (Medical) (236376/9687607528);
12. Dy. Commandant -CISF (271440/271039/270876);
13. Dy. Financial Advisor and Chief Account Officer (9825227036);
14. Dy. Material Manager;
15. OSRO;
16. Port Berth Operators.

Mutual Aid
- Municipal Fire Station -Gandhidham (02836-226573);
- Neighbouring Industries.

Local, District and State Groups
- DDMA (Gujarat- Kutch) (+9128321077);
- GSDMA (02832-252347);
- MMD Kandla (02836-297015/297127/28);
- GPCB (02836-230828);
- NDRF (6^{th} Battalion) (02688299201/9870006730);
- Police Authority (02832-250960/280233);

Part B: Action Plan

1. Signal Station

	Response Action
a.	Gather information related to the vessel type and position in the port limit.
b.	Gather information related to the weather conditions by liaising with competent agencies for issuing warnings and other media. Monitor the weather map either through Internet or Television and record approximate position of the weather and information about its movement as given in the news.
c.	Liaise with Master of the Vessel/Pilot.
d.	Ensure that telephones, one VHF and one walkie-talkie all are operational in the Port Signal Station. Listening watch to be maintained on VHF channel-08/10/16.
e.	Notify to CEC, CIC, HOD and the vessels moving into, through and inside the port. Keep CIC informed of all the messages received by telephone, VHF sets or by messenger.
f.	Notify the other Authorities (ICG, Navy) and stakeholders within Port as per instructions of CEC/CIC.
g.	Inform the Harbour Master/Flotilla Superintendent of any buoys or crafts or any Port installation is seen adrift.
h.	As per the instructions of SIC, sufficient number of staff will be detailed. The staff of Signal Station will remain on duty until they are relieved by the next shift staff or till alternative arrangements are made or till the storm has passed and the Harbour Master release them.

2. Tidal observatory

	Response Action
a.	The Gauge Clerk will record the range of tide, time and heights of high and low water and will report to Chief Hydrographer who in turn will apprise the CIC and SIC of the actual and predicted tides.

3. The Master of the Vessel (Alternate: Chief Officer)

	Response Action
a.	Should raise vessels emergency alarm and activate vessel board emergency action plan.
b.	Having raised the alarm, the Master will be responsible for taking all immediate steps to safeguard his vessel.
c.	The Master will provide the Port Authority with details of the vessel.
d.	Should follow the instruction of the CIC/SIC and be in continuous liaise with the CIC/SIC/Signal Station.
e.	Should be in a state of readiness to take the vessel out of the port.

4. The terminal/berth operator should

	Response Action
a.	Activate EAP and inform Port.
b.	Shall be responsible of shutting down of cargo operation (as per SOP and/ contingency plan) & coordinate with Port and Master of the Vessel and rendering necessary assistance to the SIC and vessel by providing emergency equipment as required.
c.	Submit consolidated list of dangerous goods in port and Vessels in port. Make arrangements to protect cargo.
d.	Assist IRT and provide all necessary equipment.
e.	He will direct operation staff. Coordinate with the vessel in-charge/C&F agents/stevedores.

5. Deputy Conservator (Alternate: Harbour Master)

	Response Action
a.	He will apprise himself of weather the developments.
b.	He will be stationed at EOC to review & assess possible developments to determine the most necessary course of action.
c.	Give necessary instructions to SIC and Signal Station & arrange for external aid as necessary.
d.	Review the situation and accordingly inform to the Chairman/ Dy. Chairman.
e.	Consult with Chairman / Dy. Chairman and decide on clearing of vessels as soon as the cyclone is confirmed to pass in close proximity to the Port.
f.	Plan movements of vessels such that the vessels are cleared in shortest possible time.
g.	Coordinate with external agencies/authorities such as Indian Navy and ICG.
h.	Be in constant touch with District and Local Administration for rescue and relief operation.
i.	Terminate the response and debrief before allowing normal operation.

6. Duties of IRT

Designated Officer	Role	Duties
Harbour Master (Alternate: Pilot)	Site Incident Controller	During Emergency shall proceed to the Signal Station and communicate & collect all information.
		Take over the charge and ensure the action plan is promulgated as per the instructions of CIC.
		Inform vessels alongside berths to double up their moorings, provide shore gang assistance and ask Masters of vessels to keep their vessels ready to proceed to the safe area at short notice as per the instruction of CIC.
		He will keep close liaison with IMD, CWC, Radar Station, Police Wireless Station, ICG, and Vessels in Port in regard to the likely weather conditions in the near further.
		Report the situation to the CIC & the CMG.
		Keep rescue team ready with rubber boats, Life jackets etc.
		Ensure that the hazardous cargoes are shifted out in a safe manner.
		Ensure that the operations are brought back to normal after the termination of the emergency procedure.
Pilot (Alternate: Pilot)	Signal Station Coordinator	Shall monitor the communication on VHF/any other communication medium & convey and relay messages on the advice from CIC/SIC.
		Instruct Flotilla Superintendent to secure tugs, crafts and workboats.
		He will maintain log of events.
Safety Officer (Alternate: Officer)	Safety Coordinator	Shall take orders from the SIC. Assist in evacuation of the personnel to the assembly point or as directed by SIC.
Dy. Fire Officer (Alternate: Officer)	Fire, Search and Rescue Coordinator	Shall take orders from the SIC.
		Keep fire tenders and fire-fighting equipment in a state of readiness.
		Responsible for mobilizing fire tenders, men & fire-fighting equipment to the scene & extend all necessary support, if required.
		Liaise with State Fire brigade for any assistance.
Dy. Commandant-CISF (Alternate:	Security and Evacuation	Shall take orders from Sr. Commandant- CISF/SIC.
		Shall be responsible for forming a cyclone/flood task force and will lead the same.

Commandant-CISF)		Controls & directs traffic in the area.
		Shall supervise evacuation of personnel from the scene at the time of emergency.
		Till normality is restored, arrangement will be made for thorough checks on all out-going vehicles to guard against pilferage.
		Shall be responsible for rescue of the personnel.
Dy. Traffic Manager (Alternate: Officer)	Cargo Storage, Shed and Labour Coordinator	Submits consolidated list of dangerous goods in port area.
		Coordinate with the truck contractors.
		Ensure availability of vehicles and mobilize and dispatch sufficient number of vehicles to the site during emergency.
Executive Engineer (Alternate: Executive Engineer)	Civil Coordinator	Shall ensure the standard procedure before the monsoon has been followed and complied with by all the divisions.
		Keep enough number of cement bags ready as per SIC instructions.
		Pump house equipment and all generator sets shall be tried out and kept ready.
		Ensure all the drains and obstructions in the creeks/ culverts are cleaned for easy discharge of sludge water. Also, make arrangements for additional dewatering pumps as required.
		As soon as the contingency plan is made operational all the water tanks should be filled up and standby arrangement for supply of water to be made.
Executive Engineer (Alternate: Executive Engineer)	M & E Coordinator	Shall ensure the standard procedure before the monsoon has been followed and complied with by all the divisions.
		Shall form and head Cyclone/Flood mitigation Team comprising of Senior Electrical, Mechanical and Maintenance Engineers.
		Ensure that all division and workshops standard procedures has been followed and equipment and installations are secured in a safe manner.
		Shall be responsible for alternate electrical supply to vital equipment and systems.
		All electrical sub stations will be manned round the clock or person should be readily available in case of any emergency requirement.
Dy. CMO (Alternate:	First Aid and Medical	Shall be responsible to organize and dispatch first aid team with ambulance as required.

Medical Officer)	Coordinator	
Executive Engineer (Alternate: Executive Engineer)	Hydrographic Survey	Assist SIC.
Duty Pilot (Alternate: Pilot)	In-Charge of Pilotage	Shall be ready on site for taking the vessel out of berth or will not bring the vessel to berth as per the instruction given by CIC/SIC.
		Inform the Masters of all vessels at the berths to double the moorings and to keep engine ready to proceed out to sea if situation warrants.
		Decision regarding moving vessels to the anchorage will be taken depending on the strength of the wind likely to be encountered and number of vessels in the Port.
		Take all necessary steps for the safety of the Port crafts.
		Ensure all other crafts are placed at safe place and properly secured excepting one pilot launch and one stand by launch used for inspection and emergency duties.
		Fender and extra lengths of ropes/wires will be kept ready so as to attend to any craft whose moorings may part.
		Inform the Signal Station immediately in the event any craft is seen adrift or any other Port installation is seen in danger. Arrange an Emergency Maintenance team.
		Responsible for directing tugs for combating the fire and rescue.
Material Manager (Alternate: Officer)	Material Management	During cyclonic season sufficient stock of stores like Corrugated iron sheets, J.Hooks, screw hinges, gunny bags, tarpaulins, ropes and wires for Port Crafts, diesel oil, kerosene oil, hurricane lantern, kerosene lamps, torch lights with batteries and bulbs, electrical items etc. is kept.
		All the materials which are likely to get damaged in rain and flood are covered with tarpaulin.

POST FLOOD DUTIES	
Sr. no.	**Duty**
1.	All the HODs are required to assess the damage and submit a detailed report indicating the estimate to the Chairman. For this, a team may be formed comprising Officers of Executive Engineer and above in rank at departmental level and may associate one Officer from Finance Department. The preliminary report is to be submitted.
2.	Hydrographic survey to be conducted to assess the channel condition and Shipping to resume as early as possible.
3.	A team of Officers to be nominated by Secretary to supervise the rescue and relief operation and disposal of carcasses in co-ordination with the local and District Administration.
4.	Mobile medical service, if required, to be provided by CMO. Preventive measures for epidemics to be taken.
5.	All the operating systems to be attended urgently and made operational as early as possible on war footing basis to resume operation.
6.	Spot tendering procedure can be followed for repairs.
7.	Water supply and electricity to be given priority. The Chief Engineer (Mechanical/Electrical/Civil) shall be authorized to extend all assistance for manpower, conveyance, equipment and materials etc. to electrical board, if required, for resuming power supply. The electrical cabling network to be checked area wise.
8.	The Material Manager will nominate a team of Officers and staff for procurement and supply of essential materials for repair of various structures and equipment as reported.
9.	To assess the progress of repair works, HOD meeting will be held daily till normalcy is restored.
10.	Damage to furniture, building fixtures may be prepared.

S14: Scenario 14
Part A:

1. **Natural Disaster (Tsunami)**
2. **Precautions:** Continuous weather monitoring, Early warning system, Tsunami Shelters.
   Note: *INCOIS and its monitoring centres will provide early warning by way of messages to the port about the occurrence of tsunami.*
3. **Impact Zone:** Entire port**.**
   Note: *While in the past the Indonesian tsunami (2004) generated a small wave the damages in the event of a higher wave would be in proportion to the proximity to the earthquake zone and the resultant height of wave generation. Thus, the wave energy would impact the port and its constituents including marine and fixed assets in proportion to its severity. Actions at the National and State level for evacuation measures will be taken if the impact assessment is of a high magnitude. Thus, necessary coordination with District and State agencies will be required in case of "Red" and "Orange" alerts.*
4. **Resources required:** Refer Figure S14.2 and Chapter 10 for resources.

Figure S14.1: Action Flow Chart

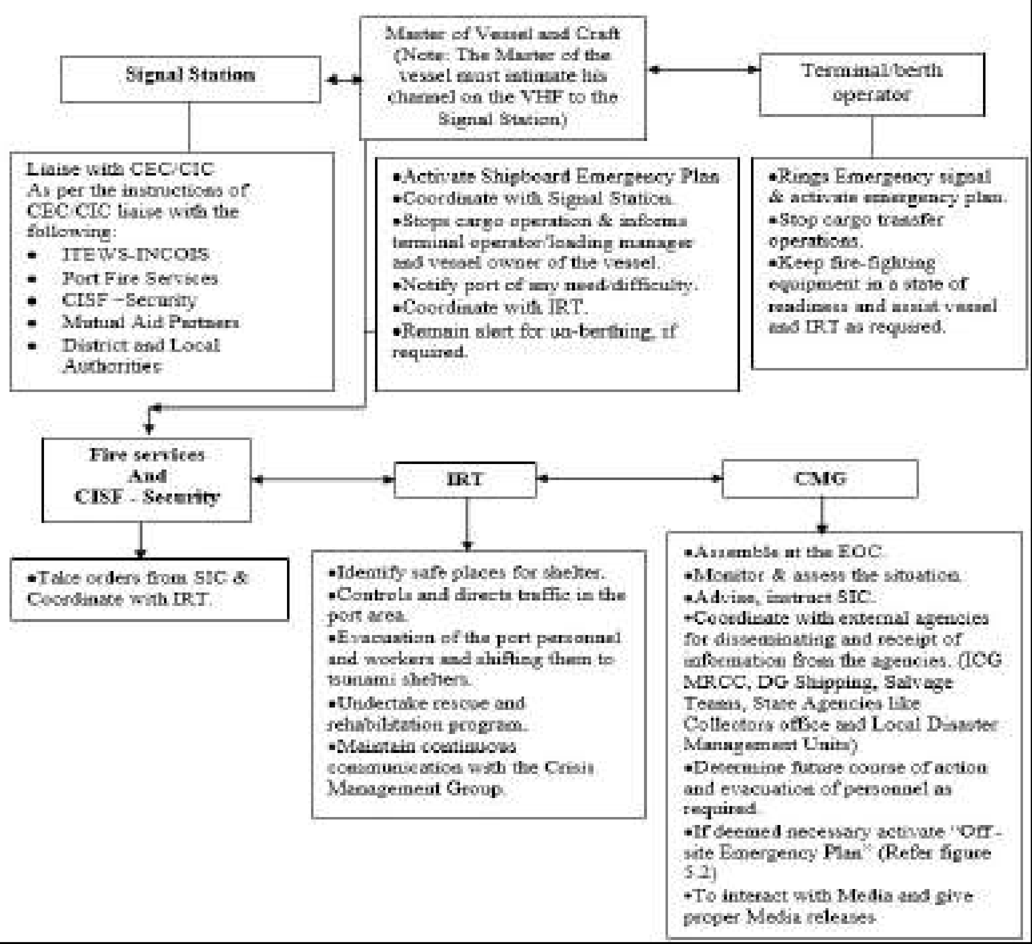

Figure S14.2: Action group

Master of Vessel

Harbour Master
8976741054

Crisis Management Group
1. Chairman/Dy. Chairman (233001/234601/234121);
2. Deputy Conservator (9603123449);
3. Traffic Manager (966610773);
4. Chief Engineer (Civil) (9825227038);
5. Environment Cell (External);
6. Chief Mechanical Engineer (9825235196);
7. Fire Cum Safety Officer (270176/270178/9825227041);
8. Sr. Commandant-CISF (271037/9825227282);
9. Chief Medical Officer (225767/220072/9825505796);
10. Chief Vigilance officer;
11. Secretary (General Administration) (7036868889);
12. Financial Advisor and Chief Account Officer (9526062088);
13. Sr. Dy. Materials Manager;
14. Public Relation Officer (9638943800);
15. Law Officer (9712341380);
16. Port Berth Operator/Terminal Managers.

Incident Response Team
1. Signal Station – (270549/9016682249);
2. Dy. Fire Officer (270176/270178/9825221330/9825221352);
3. Sr. Dy. Traffic Manager (9748437052);
4. Pilots;
5. Safety Officer (9909950277);
6. Dy. Chief Mechanical Engineer;
7. Dy. Chief Engineer (Civil) (9427251059);
8. Sr. Dy. Secretary (General Administration) (9825227079);
9. Flotilla Superintendent (9978559903/9825227610);
10. Mooring Team;
11. Sr. Dy. CMO (Medical) (236376/9687607528);
12. Dy. Commandant -CISF (271440/271039/270876);
13. Dy. Financial Advisor and Chief Account Officer (9825227036);
14. Dy. Material Manager;
15. OSRO;
16. Port Berth Operators.

Mutual Aid
- Municipal Fire Station -Gandhidham (02836-226573);
- Neighbouring Industries.

Local, District and State Groups
- INCOIS;
- DDMA (Gujarat- Kutch) (+9128321077);
- GSDMA (02832-252347);
- MMD Kandla (02836-297015/297127/28);
- NDRF (6th Battalion) (02688299201/9870006730);
- Police Authority (02832-250960/280233);

Part B: Action Plan

1. Signal Station

	Response Action
a.	Gather information related to the vessel type and position in the port limit.
b.	Gather information related to the tsunami conditions by liaising with competent agencies for issuing warnings and other media. Monitor the conditions through Internet or Television and record approximate position of the tsunami and information about its movement as given in the news.
c.	Liaise with Master of the Vessel/Pilot.
d.	Ensure that telephones, one VHF and one walkie-talkie all are operational in the Port Signal Station. Listening watch to be maintained on VHF channel-08/10/16.
e.	Notify to CEC, CIC, HOD and the vessels moving into, through and inside the port. Keep CIC informed of all the messages received by telephone, VHF sets or by messenger.
f.	Notify the other Authorities and stakeholders within Port as per instructions of CEC/CIC.
g.	Inform the Harbour Master/Flotilla Superintendent of any buoys or crafts or any Port installation is seen adrift.
h.	Hoist signals or raise alarms, as per the warnings received by the competent agencies for issuing warnings.

2. Tidal observatory

	Response Action
a.	The Gauge Clerk will record the range of tide, time and heights of high and low water and will report to Chief Hydrographer who in turn will apprise the CIC and SIC of the actual and predicted tides.

3. The Master of the Vessel (Alternate: Chief Officer)

	Response Action
a.	Should raise vessels emergency alarm and activate shipboard emergency action plan.
b.	Having raised the alarm, the Master will be responsible for taking all immediate steps to safeguard the vessel.
c.	The Master will provide the Port Authority with details of the vessel.
d.	Should follow the instruction of the CIC/SIC and be in continuous liaison with the CIC/SIC/Signal Station.
e.	Should be in a state of readiness to take the vessel out of the port.

4. The terminal/berth operator should

	Response Action
a.	Activate EAP and inform Port and be in a state of readiness to move out all types of cargo, equipment and vehicles (mobile cranes) outside the port area.
b.	Shall be responsible of shutting down of cargo operation (as per SOP and/ contingency plan) & coordinate with Port and Master of the Vessel and rendering necessary assistance to the SIC and vessel by providing emergency equipment as required.
c.	Submit consolidated list of dangerous goods in port and Vessels in port. Make arrangements to protect cargo.
d.	Assist IRT and provide all necessary equipment.
e.	He will direct operation staff. Coordinate with the vessel in-charge/C&F agents/stevedores.

Note: *It is important to understand that movable objects and structures which may float as a result of high-water levels will tend to generate flotsam and move with the current during the flooding and ebb situation of tsunami. This normally results in floating debris in large swaths causing structural, environmental and living beings damages.*

As a lifesaving measure multi-storey building higher than 45ft are considered as safe zones in coastal areas.

5. Deputy Conservator (Alternate: Harbour Master)

	Response Action
a.	Activate the DMP.
b.	He will be stationed at EOC to review & assess possible developments to determine the most necessary course of action.
c.	Give necessary instructions to SIC and Signal Station & arrange for external aid as necessary.
d.	Review the situation and accordingly inform to the Chairman/ Dy. Chairman.
e.	Consult with Chairman / Dy. Chairman and decide on clearing of vessels as soon as the tsunami is confirmed.
f.	Plan movements of vessels such that the vessels are cleared in shortest possible time.
g.	Coordinate with external agencies/authorities such as Indian Navy and ICG.
h.	Be in constant touch with District and Local Administration for rescue and relief operation.
i.	Terminate the response and debrief before allowing normal operation.

6. Duties of IRT

Designated Officer	Role	Duties
Harbour Master (Alternate: Pilot)	Site Incident Controller	During Emergency shall proceed to the Signal Station and communicate & collect all information.
		Take over the charge and ensure the action plan is promulgated as per the instructions of CIC.
		Inform vessels alongside berths to double up their moorings, provide shore gang assistance and ask master's to keep their vessels ready to proceed to the sea at short notice as per the instruction of CIC.
		Keep close liaison with INCOIS, Radar Station, Police Wireless Station, ICG, and Vessels in Port.
		Ensure Signal Station, hoists appropriate signal.
		Report the situation to the CIC & the CMG.
		Keep rescue team ready with necessary equipment.
		Ensure that the hazardous cargoes are shifted out or secured/stored in a safe manner.
		Ensure that the operations are brought back to normal after the termination of the emergency procedure.
Pilot (Alternate: Pilot)	Signal Station Coordinator	Shall monitor the communication on VHF/any other communication medium & convey and relay messages on the advice from CIC/SIC.
		Instruct Flotilla Superintendent to secure tugs, crafts and workboats.
		He will maintain log of events.
Safety Officer (Alternate: Officer)	Safety Coordinator	Shall take orders from the SIC. Assist in evacuation of the personnel to the assembly point or as directed by SIC.
Dy. Fire Officer (Alternate: Officer)	Fire, Search and Rescue Coordinator	Shall take orders from the SIC.
		Liaise with State Fire brigade for any assistance.
Dy. Commandant-CISF (Alternate: Commandant-CISF)	Security and Evacuation	Shall take orders from Sr. Commandant- CISF/SIC.
		Shall be responsible for forming a task force and will lead the same.
		Controls & directs traffic in the area.
		Shall supervise evacuation of personnel from the port at the time of emergency and moving them to identified tsunami shelters.
		Responsible for rescue operation.
Dy. Traffic Manager (Alternate:	Cargo Storage, Shed and Labour	Submits consolidated list of dangerous goods in port area.
		Coordinate with the truck contractors.

Officer)	Coordinator	Ensure availability of vehicles and mobilize and dispatch sufficient number of vehicles to the site during emergency.
		Ensure all the drains and obstructions in the creeks/ culverts are cleaned for easy discharge of sludge water.
Executive Engineer (Alternate: Executive Engineer)	M & E Coordinator	Shall ensure the standard procedure has been followed and complied with by all the divisions.
		Shall form and head mitigation Team comprising of Electrical, Mechanical and Maintenance Engineers.
		All types of cranes, forklifts, heavy earth moving equipment to be secured in a safe manner.
		Shall be responsible for alternate electrical supply to vital equipment and systems at the berth.
		All electrical sub stations will be manned round the clock or person should be readily available in case of any emergency requirement.
Dy. CMO (Alternate: Medical Officer)	First Aid and Medical Coordinator	Shall be responsible to organize and dispatch first aid team with ambulance as required.
Hydrographer (Alternate: Officer)	Hydrographic Survey	Assist SIC.
Duty Pilot (Alternate: Pilot)	In-Charge of Pilotage	Shall be ready on site for taking the vessel out of berth or will not bring the vessel to berth as per the instruction given by CIC/SIC.
		Inform the Masters of all vessels at the berths to double the moorings and to keep engine ready to proceed out to sea if situation warrants.
		Decision regarding moving vessels to the anchorage will be taken depending on the strength of the tsunami likely to be encountered and number of vessels in the Port.
		Take all necessary steps for the safety of the Port crafts.
		Ensure all other crafts are placed at safe place and properly secured excepting one pilot launch and one stand by launch used for inspection and emergency duties.
		Fender and extra lengths of ropes/wires to be kept ready so as to attend to any craft whose moorings may part.

		Ensure shifting of crafts at suitable places as directed by the SIC and will secure them suitably with additional moorings.
		Extra fenders will be kept ready on board the Tug for use as required.
Material Manager (Alternate: Officer)	Material Management	Ensure availability of sufficient stock of stores like Corrugated Iron sheets, J.Hooks, screw hinges, gunny bags, tarpaulins, ropes and wires for Port Crafts, diesel oil, kerosene oil, hurricane lantern, kerosene lamps, torch lights with batteries and bulbs, electrical items etc. is kept.

POST TSUNAMI DUTIES

Sr. no.	Duty
1.	All the HODs are required to assess the damage and submit a detailed report indicating the estimate to the Chairman/Dy. Chairman. For this, a team may be formed comprising Officers of Executive Engineer and above in rank at departmental level and may associate one Officer from Finance Department. The preliminary report is to be submitted. The level of restoration and efforts required to clear the area of debris, carcasses and damaged equipment will depend on the level of disaster.
2.	Hydrographic survey to be conducted to assess the channel condition and Shipping to resume as early as possible.
3.	In case of any small craft sunk or grounded, the same to be removed to make the channel/ berth safe for navigation. SIC will detail a salvage party.
4.	A team of Officers to be nominated by the Secretary to supervise the rescue and relief operation and disposal of carcasses in co-ordination with the local and District Administration.
5.	Mobile medical service, if required, to be provided by CMO. Preventive measures for epidemics to be taken.
6.	All the operating systems need to be attended urgently and made operational as early as possible on war footing basis to resume operation.
7.	Spot tendering procedure can be followed for repairs.
8.	Water supply and electricity to be given priority. The Chief Engineer (Mechanical/Electrical/Civil) shall be authorized to extend all assistance for manpower, conveyance, equipment and materials etc. to electrical board, if required, for resuming power supply. The electrical cabling network to be checked area wise.
9.	All the damaged temporary roofed warehouses are to be repaired.
10.	Material Manager will nominate a team of Officers and staff for procurement and supply of essential materials for repair of various structures and equipment as reported.
11.	To assess the progress of repair works, HOD meeting will be held daily till normalcy is restored.
12.	Damage to furniture, building fixtures may be prepared.

S15: Scenario 15

Part A:

1. **Natural Disaster (Earthquake)**
   Note: *As there are no warning signals for major earthquake the action plan will be for the aftermath of the emergency.*
2. **Precautions:** Earthquake resilient buildings, equipment (cranes), pipeline infrastructure (as per relevant standards), Periodic inspection of old structures, pipelines and their support structures etc.
3. **Impact Zone:** Entire port**.**
   Note: *The Gujarat - Kutch district falls under Seismic zone category IV/V as per the vulnerability hazard map of the region.*
4. **Resources required:** Refer Figure S15.2 and Chapter 10 for resources.

Figure S15.1: Action Flow Chart

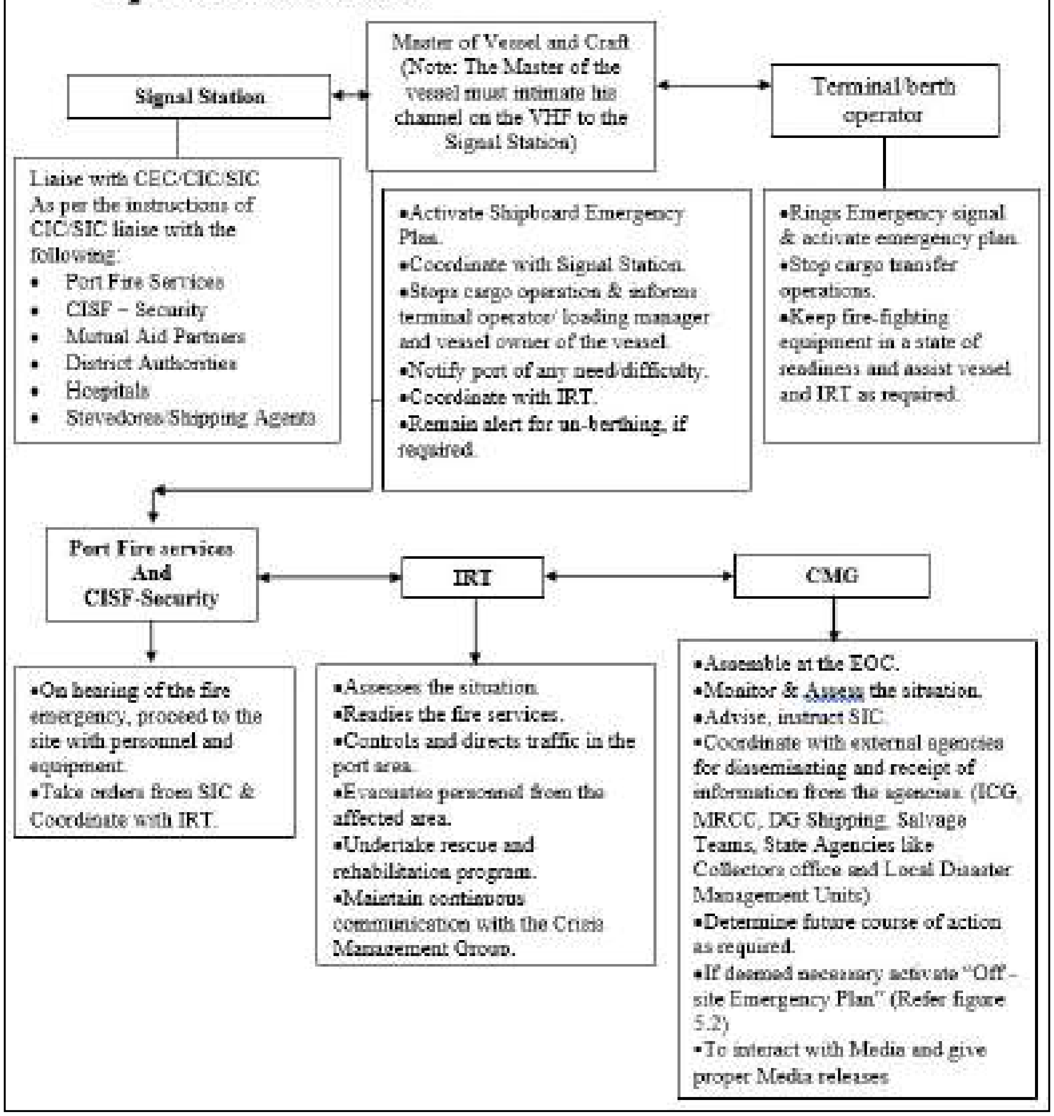

Figure S15.2: Action group

Master of Vessel

Harbour Master
8976741054

Crisis Management Group
1. Chairman/Dy. Chairman (233001/234601/234121);
2. Deputy Conservator (9603123449);
3. Traffic Manager (966610773);
4. Chief Engineer (Civil) (9825227038);
5. Environment Cell (External);
6. Chief Mechanical Engineer (9825235196);
7. Fire Cum Safety Officer (270176/270178/9825227041);
8. Sr. Commandant-CISF (271037/9825227282);
9. Chief Medical Officer (225767/220072/9825505796);
10. Chief Vigilance officer;
11. Secretary (General Administration) (7036868889);
12. Financial Advisor and Chief Account Officer (9526062088);
13. Sr. Dy. Materials Manager;
14. Public Relation Officer (9638943800);
15. Law Officer (9712341380);
16. Port Berth Operator/Terminal Managers.

Incident Response Team
1. Signal Station – (270549/9016682249);
2. Dy. Fire Officer (270176/270178/9825221330/9825221352);
3. Sr. Dy. Traffic Manager (9748437052);
4. Pilots;
5. Safety Officer (9909950277);
6. Dy. Chief Mechanical Engineer;
7. Dy. Chief Engineer (Civil) (9427251059);
8. Sr. Dy. Secretary (General Administration) (9825227079);
9. Flotilla Superintendent (9978559903/9825227610);
10. Mooring Team;
11. Sr. Dy. CMO (Medical) (236376/9687607528);
12. Dy. Commandant -CISF (271440/271039/270876);
13. Dy. Financial Advisor and Chief Account Officer (9825227036);
14. Dy. Material Manager;
15. OSRO;
16. Port Berth Operators.

Mutual Aid
- Municipal Fire Station -Gandhidham (02836-226573);
- Neighbouring Industries.

Local, District and State Groups
- DDMA (Gujarat- Kutch) (+9128321077);
- GSDMA (02832-252347);
- MMD Kandla (02836-297015/297127/28);
- GPCB (02836-230828);
- NDRF (6^{th} Battalion) (02688299201/9870006730);
- Police Authority (02832-250960/280233);

Part B: Action Plan

1. The Signal Station

Response Action	
a.	Gather information related to the vessel type and position in the port limit.
b.	Liaise with Master of the Vessel/Pilot.
c.	Ensure that telephones, one VHF and one walkie-talkie all are operational in the Port Signal Station. Listening watch to be maintained on VHF channel-08/10/16.
d.	Notify to CIC, SIC and the vessels moving into, through and inside the port. Keep CIC/SIC informed of all the messages received by telephone, VHF sets or by messenger.
e.	Notify the other Authorities and stakeholders within Port as per instructions of CIC/SIC.
f.	Notify the information to the owner of the vessel as per the instruction of CIC/SIC/ Master of the Vessel. Pass the information to various Port departments and other Port related organizations through telephones and VHF.

2. The Master of the Vessel (Alternate: Chief Officer)

Response Action	
a.	Should raise vessels emergency alarm and activate ship board emergency action plan.
b.	Having raised the alarm, the Master will be responsible for taking all immediate steps to safeguard his vessel.
c.	The Master will provide the Signal Station with details of the vessel.
d.	Should follow the instruction of the CIC/SIC and be in continuous liaise with the CIC/SIC/Signal Station.
e.	Should be in a state of readiness to take the vessel out of the port, if required.

3. The terminal/berth operator should

Response Action	
a.	Activate EAP and inform Port.
b.	Shall be responsible of shutting down of cargo operation (as per SOP and/ contingency plan) & coordinate with Port and Master of the Vessel and rendering necessary assistance to the SIC and vessel by providing emergency equipment as required.
c.	Submit consolidated list of dangerous goods in port and Vessels in port. Make arrangements to protect cargo.
d.	Assist IRT and provide all necessary equipment.
e.	He will direct operation staff. Coordinate with the vessel in-charge/C&F agents/stevedores.

4. Deputy Conservator (Alternate: Harbour Master)

Response Action	
a.	Activate the DMP and OSCP (if any pollution).
b.	He will be stationed in EOC to review & assess the damage and determine the most necessary course of action.
c.	Give necessary instructions to SIC and Signal Station & arrange for external aid as necessary.
d.	Review the situation and accordingly inform to the Chairman/ Dy. Chairman.
e.	Consult with Chairman / Dy. Chairman and decide on clearing of vessels.
f.	Be in constant touch with District and Local Administration for rescue and relief operation.

5. Duties of IRT

Designated Officer	Role	Duties
Harbour Master (Alternate: Pilot)	Site Incident Controller	Communicate & collect all information.
		Take charge of Signal Station and ensure the action plan is promulgated as per the instructions of CIC.
		Ensure that the operations are brought back to normal after the termination of the emergency procedure.
Pilot (Alternate: Pilot)	Signal Station Coordinator	Shall monitor the communication on VHF/any other communication medium & convey and relay messages on the advice from CIC/SIC.
		He will maintain log of events.
Safety Officer (Alternate: Officer)	Safety Coordinator	All other workers to move out to safe (open) area. Assist in evacuation of the personnel to the assembly point or as directed by SIC.
Dy. Fire Officer (Alternate: Officer)	Fire, Search and Rescue Coordinator	Shall take orders from Fire cum Safety Officer/SIC.
		Responsible for mobilizing fire tenders, men & fire-fighting equipment to the scene & extend all necessary support after the earthquake.
		Liaise with State Fire brigade for any assistance.
Dy. Commandant-CISF (Alternate: Commandant-CISF)	Security and Evacuation	Controls & directs traffic in the area.
		Shall search and rescue operations of the personnel trapped under the debris. A special task force can be formed for the same. Shifting of the injured and causalities to hospital.
		Till normality is restored, arrangements will be made for thorough checks on all out-going vehicles to guard against pilferage.
		Coordinate with the truck contractors.

		Ensure availability of vehicles and mobilize and dispatch sufficient number of vehicles to the site during emergency.
Executive Engineer (Alternate: Executive Engineer)	Civil Coordinator	Assist SIC/CIC and CISF after an earthquake emergency.
		Deploy engineers to direct or guide earth moving equipment and cranes to remove debris.
Executive Engineer (Alternate: Executive Engineer)	M & E Coordinator	Shall be responsible for Electrical supply to vital equipment and systems.
		Ensure that all Sub Stations, Power Control rooms will be inspected and made operation.
Dy. CMO (Alternate: Officer)	First Aid and Medical Coordinator	Shall be responsible to organize and dispatch first aid team with ambulance as required.
		Mobile medical service, if required, to be provided.
Material Manager (Alternate: Officer)	Material Management	Ensure availability of sufficient stock of stores like Corrugated iron sheets, J.Hooks, screw hinges, gunny bags, tarpaulins, ropes and wires for Port Crafts, diesel oil, kerosene oil, hurricane lantern, kerosene lamps, torch lights with batteries and bulbs, electrical items etc. is kept.
		Will nominate a team of officers and staff for procurement and supply of essential materials for repair of various structures and equipment as reported.

ADDITIONAL POST-EARTHQUAKE DUTIES	
Sr. no.	**Duty**
1.	All the HODs are required to assess the damage and submit a detailed report indicating the estimate to the Chairman/Dy. Chairman. For this, a team may be formed comprising Officers of Executive Engineer and above in rank at departmental level and may associate one Officer from Finance Department. The preliminary report is to be submitted.
2.	A team of Officers to be nominated by Secretary to supervise the rescue and relief operation and disposal of carcasses in co-ordination with the local and District Administration.
3.	All the operating systems to be attended urgently and made operational as early as possible on war footing basis to resume operation.
4.	Spot tendering procedure can be followed for repairs.
5.	Water supply and electricity to be given priority. The Chief Engineer (Mechanical/Electrical/Civil) shall be authorized to extend all assistance for manpower, conveyance, equipment and materials etc. to electrical board, if required, for resuming power supply. The electrical cabling network to be checked area wise.
6.	To assess the progress of repair works, HOD meeting will be held daily till normalcy is restored.

8. DISASTER RISK REDUCTION AND MITIGATION

DMP incorporates the framework for Disaster Risk Reduction (DRR) under the **six thematic areas** for action as follows

1. Understanding Risk
2. Inter-Agency Coordination
3. Investing in DRR – Structural Measures
4. Investing in DRR – Non-Structural Measures
5. Capacity Development
6. Climate change risk management.

The Disaster Risk Reduction (DRR) requires responsibilities to be shared by different divisions/departments of port and stakeholders. The effectiveness of DRR will depend on coordination mechanisms with all stakeholders.

In accordance with the Sendai framework, the measures illustrated in para 8.1 provides a brief description of actions by the port and their relevant time frames for each thematic areas in the form of responsibility matrix.
The timeframes considered for these measures are as below:

Short Term	Two years
Medium Term	Two to five years
Long Term	Ending up to 2030

8.1 HAZARD-WISE RESPONSIBILITY MATRICES FOR DISASTER RISK MITIGATION

For the successful implementation of DM plans, it is necessary to identify various stakeholders within the port and clearly specify their roles and responsibilities. For each hazard/disaster, in the subsections that follow, themes for action are presented in a separate responsibility matrix for each of the five thematic areas for action. The port will play a pro-active role in disaster situations. In the domains of DM planning, preparedness, and capacity building, the port will constantly work to upgrade DM systems and practices. This section covers the matrices for the identified hazards relevant to port as listed below:

Hazard	Chemical Disaster (Oil Jetties 1 -7, Container Terminal, Navigational Channel)						
1. Thematic area	Understanding Risk						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
1	Information Systems and Research	Support and coordination	• DPA, • Terminal/ Berth Operators.	• Coordination with vessel for port entry Ship to Shore checklist, • Berthing and Unberthing schedule • Allotment of tugs, • Deployment of Competent and experienced pilot, • Provision and maintenance of safe navigational channel, • Navigation support through Port Control Room, • Inventory of oils/chemicals/IMDG cargo handled.			
		Information on (operation and during emergency) dealing with HAZCHEM	• DPA, • Terminal/ Berth Operators.	• MSDS copy maintained, • Hazardous Waste Management Plan.			
		Chemical Accident Information Reporting System	• DPA, • Terminal/ Berth Operators.	• Incidents records maintained with Signal Station, Fire Cum Safety officer and terminals	• Centralized mechanism for data collection /incident database with DPA		

Hazard	Chemical Disaster (Oil Jetties 1 -7, Container Terminal, Navigational Channel)						
1. Thematic area	Understanding Risk						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
2	Zoning/ Mapping	Industrial zones on basis of hazard potential and effective disaster management for worst case scenarios	• DPA, • Terminal/ Berth Operators.	• Navigational charts and passage plan, • Hazardous area classification for oil jetties, • Dedicated area for pipeline connections at the jetty and Y- junction.	• PESO approval for oil jetties (in process), • Safety instructions to be displayed and ensured for oil cargo handling, • Updation of zoning carried out regularly after any addition or up-gradation of the facility.		
		Carry out the mapping and related studies in collaboration with central agencies/ technical organizations	• DPA, • Terminal / Berth Operators.	• Port limit and Port layout maps, • Hydrographic survey, • Pipeline layout map, • Firefighting system layout map, • Mapped DG cargo storage and Hazardous bund area	• Updation of maps	Adhere to CRZ mapping	Land Use Plan
3	Monitoring	Monitoring compliance with safety norms for HAZCHEM	• DPA, • Terminal / Berth Operators.	• Compliance of Statutory norms, • Standard Operating Procedure,	• Installation of fire fighting system as per OISD 156		

Hazard	Chemical Disaster (Oil Jetties 1 -7, Container Terminal, Navigational Channel)						
1. Thematic area	Understanding Risk						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
				• CCTV surveillance • Record keeping of MSDS	standard at oil jetties.		
		Disposal of hazardous waste	• DPA, • Terminal / Berth Operators.	• Recording and Monitoring of generation of hazardous waste, • Disposal of waste through GPCB approved waste management parties.			
4	Hazard Risk Vulnerability and Capacity Assessment (HRVCA)	Undertake and provide technical support to HRVCA as part of preparing and periodic revision of plans and risk assessment	• DPA, • Terminal / Berth Operators.	• Port DMP as per Disaster Management Act -2005, NDMA Guidelines 2018 and NDMP 2019, • Risk Assessment, • Port OSCP, • Port CMP, • Navigational Risk Assessment, • Emergency Action Plan (EAP), • Emergency Response Disaster Management Plan (ERDMP).	• Periodic update plans and related documents		
		Constitute/ strengthen the mechanism for consultation with experts and stakeholders	• DPA, • Terminal / Berth Operators.	• SOPs, • Revamping of oil jetty product pipeline, • Audits (Structural, Fire,	• Execute plans for removal of abandoned pipelines at Oil		• Land Use Plan, • Business Development

Hazard	Chemical Disaster (Oil Jetties 1 -7, Container Terminal, Navigational Channel)						
1. Thematic area	Understanding Risk						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
				Safety and Navigational, Electrical), • Safety Committee Meetings, • Mock Drills, • Training and Awareness, • Land use planning.	Jetties. • Implementation/ execution of the decision taken during the safety committee meetings in a time bound manner.		Plan, • Environment Management Plan.

Hazard	Chemical Disaster (Oil Jetties 1 -7, Container Terminal, Navigational Channel)						
2. Thematic area	Inter- agency coordination						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
1	Overall disaster governance	Providing coordination, technical inputs, and support, Periodical inspection from competent agencies.	• DPA, • Terminal / Berth Operators.	• EOC - E-Drishti Command and Control Centre, • Coordination with DRR Cell (at Ministry level), • Coordination with SDMA and DDMA, • PNGRB, PESO, GPCB, OISD, MoEF, ICG, Navy, NDRF, Dock Safety, Electrical inspector.	• Compliance to recommendation s.		
		Address/ identify gaps in equipment/ infrastructure and human resources with DM tasks	• DPA, • Terminal / Berth Operators.	• Developmental project reports, • Safety Committee Meetings, • Audits.	• Gap analysis / Periodic reviews in equipment/ infrastructure and human resources.		
2	Warnings, Information, data	Effective coordination and seamless communication among various stakeholders	• DPA, • Vessel Master, • CISF, • Terminal Operators.	• Signal Station, • VHF/UHF, • Satellite Phone, • Mobile/Landline, • PA system, • Emergency Siren, • Email.			
		Dissemination of warnings and information	• DPA, • Vessel Master, • CISF,	Dissemination of information to/from • Vessel Master,			

Hazard	Chemical Disaster (Oil Jetties 1 -7, Container Terminal, Navigational Channel)					
2. Thematic area	Inter- agency coordination					

Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
			• Terminal / Berth Operators, • Local and District Authority.	• CMG, • MoPSW, DG shipping, DDMA/SDMA, IMD, ICG, MMD, PESO, GPCB, Navy, Marine Police, Local Authorities,			
3	Response	Organizing and coordinating with Government agencies and stakeholders of the port	• DPA, • Vessel Master, • CISF, • Terminal / Berth Operators.	• Coordinating with CMG, • Coordinating with Vessel Master, • Coordinating with DG Shipping, NDMA, SDRF, DDMA, Local admin., ICG, IMD, MMD, PESO, GPCB, Navy, etc., • Vessel restriction guideline.	• Mutual aid agreement with relevant stakeholders.		

Hazard	Chemical Disaster (Oil Jetties 1 -7, Container Terminal, Navigational Channel)						
3. Thematic area	Investing in DRR – Structural measures						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
1	Evacuation and support facilities. Multiple routes for reliable access and escape. Decontamination facilities	• Identification of hospitals and first aid	• DPA, • CISF, • Terminal / Berth Operators, • Local Authorities.	• Port Hospital, • Tie up with nearby hospitals, • First Aid centers, • Ambulances.		• Expansion of Hospital facilities	
		• Ensuring freshwater storage facilities for drinking purpose	• DPA	• Municipal water supply, • Water tankers.			
		• Providing wide roads and multiple routes to allow quick access by first responders and to ensure escape pathways	• DPA	**Evacuation by Land facilities** • Entry-exit Gate available, • Internal roads, • Port and hired vehicles, • Individual terminal vehicles, • Coordination with Local administration, • Land Use Planning **Evacuation by sea route facilities** • Port owned/hired crafts	• Vehicle Traffic management should be made available. • Repair of access roads, • Providing alternate evacuation/emergency gates		
		• Establish decontamination facilities	• DPA	Personnel decontamination • Port Hospital, • Tie up with nearby hospitals, • First Aid Facilities, • Eyewash and Safety			

Hazard	Chemical Disaster (Oil Jetties 1 -7, Container Terminal, Navigational Channel)						
3. Thematic area	Investing in DRR – Structural measures						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
				Showers.			
2	Disaster Response equipment	Ensuring and maintaining fire-fighting equipment (as per OISD and other relevant requirements)	• DPA, • Terminal / Berth Operators.	• Fire-fighting systems as per relevant standards, • Port Fire Station, • Fire Water storage facilities, • FIFI Tugs.	• Provision of Fire-fighting as per OISD-156 at Oil Jetties.		
		Ensuring and maintaining oil pollution response equipment (as per ICG requirements)	• DPA, • Terminal / Berth Operators.	• Pollution response equipment of Port maintained by OSRO – Sadhav Shipping Ltd.	• Provision of OSR equipment as per ICG requirement for Tier I facility.		

Hazard	Chemical Disaster (Oil Jetties 1 -7, Container Terminal)						
4. Thematic area	Investing in DRR – Non- Structural measures						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
1	Laws Regulations, Techno Legal regimes Enforcement, compliance and Monitoring Institutional arrangements	Formulate/ strengthen the SOP for the compliance w.r.t. the statutory requirements ensuring greater safety in hazardous industries and reduce the likelihood of disasters	• DPA, • Terminal / Berth Operators.	• Periodical inspection and testing of Oil/chemical Pipelines, • Periodical inspection and testing of Hoses and fire-fighting systems, • Audits - Fire, Safety, • Navigational Safety Audit, • Risk Assessment, • Safety committee meetings.	• Compliance of recommendations.		
2	Risk Transfer	Insurance	• DPA, • Terminal / Berth Operators.	• Workmen Compensation Policy, • Public Liability Insurance, • Port Package Policy for entire set of risk to the port.	• Periodic Renewals of Policies.		

Hazard	Chemical Disaster (Oil Jetties 1 -7, Container Terminal)						
5. Thematic area	Capacity Development						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
1	Training	• Training and orientation programs on management (handling, storage and transfer) and disposal of HAZCHEM • Incorporating disaster response, search and rescue in the training programs	• DPA, • Terminal / Berth Operators, • CISF.	• IMO level training (OSR) for the identified personnel, • ISO and OHSAS training, • Fire-fighting training, • Safety Training, • First Aid training, • CBRN training, • Hazard identification and management training, • Annual training schedule.			
2	Mock drills/ Exercises	• Planning and execution of emergency drills by all the stakeholders	• DPA, • Terminal / Berth Operators, • CISF, • Other stakeholders.	• Mock drills, • Annual drill schedule.	• Mock Drill should be conducted regularly with all the stakeholders		
		• Joint planning and execution of emergency drills	• DPA • Terminal / Berth Operators, • CISF, • Other stakeholders.	• Organize and participation (involving all the stakeholders) mock-drills through various government agencies like ICG, CISF, NDRF, NSG, SDMA, Local authorities, etc.			

Hazard	Chemical Disaster (Oil Jetties 1 -7, Container Terminal)						
5. Thematic area	Capacity Development						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
3	Documentation	Ensure accurate documentation of all aspects of disaster events for creating good historical records for future research and Risk Management planning	• DPA, • Terminal / Berth Operators, • CISF.	• Maintenance of the incident and near miss record. • Accident/incident reporting, analysis, investigation and implementation of recommendations.	• Centralized mechanism for documentation		
4	Awareness	Promote culture of disaster risk prevention, mitigation, and better risk management	• DPA, • Terminal / Berth Operators, • CISF, • Other stakeholders.	• Quarterly Dock Safety committee meeting • Safety Campaigns, Dock Safety week, • Notification for Dangerous Goods as per relevant Regulation of Dock workers (Safety, Health and Welfare). • Safety Inspection of port, • Training center for safety and productivity re-engineering & container-based training center, • Preparation and updation of Safety manual, • Preparation of Ship bunkering guideline,			

Hazard	Chemical Disaster (Oil Jetties 1 -7, Container Terminal)						
5. Thematic area	Capacity Development						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
				• Circular for restriction of usage of mobile phones in oil jetty and promote safety culture, • Safety Advisories to port users for preventing dangerous occurrence of incidents, • Pocket booklet of traffic safety management.			

Hazard	Fire (Coal stackyard/ Office Buildings / Fire station / Electrical Substation / Signal Station / Godown/ Hospital / Command and Control Center)						
1. Thematic area	Understanding Risk						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
1	Information Systems and Research	Support and coordination	• DPA	• Port Fire Stations, • Support from terminals and neighboring industries, • Nearby - fire station.			
2	Zoning/ Mapping	Mapping of sites that pose fire risks	• DPA, • Terminal / Berth Operators.	• Fire system layout, • Electrical system layout, • Coal and sulphur stack yard identified as a fire risk zone.	• Update layout plans.		
3	Monitoring	Monitoring compliance with safety norms	• DPA, • Terminal / Berth Operators.	• Firefighting and extinguishing system as per the requirements, • CCTV surveillance, • Manning/Patrolling of the areas.	• Periodic reviews about the efficacy.		
4	Hazard Risk Vulnerability and Capacity Assessment (HRVCA)	Undertake HRVCA as part of preparing and periodic revision of DM plans	• DPA, • Terminal / Berth Operators.	• Port DMP as per Disaster Management Act -2005, NDMA Guidelines and NDMP, • Port CMP, • Emergency Action Plan (EAP)	• Periodic updation of plans.		
		Constitute/ strengthen the mechanism for consultation	• DPA, • Terminal / Berth Operators.	Mechanism for strengthening of the port disaster management through • Periodical inspection and testing of response equipment,	• Compliance of recommendations		

Hazard	Fire (Coal stackyard/ Office Buildings / Fire station / Electrical Substation / Signal Station / Godown/ Hospital / Command and Control Center)						
1. Thematic area	Understanding Risk						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
		with experts and stakeholders		• Fire Audit, • Capacity analysis, • Drills, • Training and Awareness, • Safety Committee meetings.			

Hazard	Fire (Coal stackyard/ Office Buildings / Fire station / Electrical Substation / Signal Station / Godown/ Hospital / Command and Control Center)						
2. Thematic area	Inter- agency coordination						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
1	Overall disaster governance	Identify and address the gaps in existing capabilities, equipment, infrastructure, and human resources	• DPA, • CISF, • Terminal / Berth Operators, • Hospital.	• EOC - E-Drishti Command and Control Centre, • Periodic reviews and upgradation of the fire systems/equipment and manpower as per the relevant standards and best practices.	• Mutual aid agreement for sharing of resources.	• Install and upgrade systems as per periodic reviews	
		Establish fire stations	• DPA.	• Port Fire stations, • Identified list of nearby Fire Stations.			
		Implementation of DM plans	• DPA, • CISF, • Terminal / Berth Operators, • Hospital.	• Conducting fire and evacuation drills, • Training and Awareness.	• Implementation of the updated DMP.		
2	Warnings, Information, data	Effective coordination and seamless communication	• DPA, • CISF, • Terminal / Berth Operators, • Hospital.	Coordination and effective dissemination of warnings, information and data via • VHF, • Landline, • PA system, • Mobile Phones, • Emergency Siren, • Email.			

Hazard	Fire (Coal stackyard/ Office Buildings / Fire station / Electrical Substation / Signal Station / Godown/ Hospital / Command and Control Center)						
2. Thematic area	Inter- agency coordination						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
3	Response	Organizing and coordinating the immediate response Coordinate with Government agencies and stakeholders of the port	• DPA, • CISF, • Terminal / Berth Operators, • Hospital.	• Activation of DM Plan, • Coordinating with Fire stations (Port & External), • Coordination with SDMA and DDMA.			

Hazard	Fire (Coal stackyard/ Office Buildings / Fire station / Electrical Substation / Signal Station /Godown/ Hospital / Command and Control Center)						
3. Thematic area	Investing in DRR – Structural measures						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
1	Smoke, Heat, Fire detection and fire-fighting systems	Procurement and maintenance of fire Fighting systems as per relevant Standard and Rules	• DPA, • Terminal / Berth Operators.	• Periodical testing and maintenance of the Portable and fixed fire-fighting facility.	• Installation/ up-gradation of the fire-fighting system.		
2	Evacuation and support facilities. Multiple routes for reliable access and escape.	Identification of Assembly points	• DPA, • CISF, • Terminal / Berth Operators, • Hospital.	• Identified assembly points.	• Updation of assembly points and sign boards. • Display of evacuation maps at suitable locations for buildings.		
		Providing vehicles for safe transportation	• DPA, • CISF, • Terminal / Berth Operators, • Hospital.	List of • Passenger vehicles of DPA (hired or tie up). • Passenger vehicles of operators, • Passenger vehicles of CISF.	• Periodical repair of Internal roads.		

Hazard	Fire (Coal stackyard/ Office Buildings / Fire station / Electrical Substation / Signal Station /Godown/ Hospital / Command and Control Center)						
3. Thematic area	Investing in DRR – Structural measures						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
3	First aid and Decontamination facilities	• Establish First aid and decontamination facilities • Identification of hospital	• DPA, • CISF, • Terminal / Berth Operators, • Hospital.	Personnel first aid and decontamination • First Aid Centre • Port Hospital, • Other identified hospitals as per **Annex B**.			

Hazard	Fire (Coal stackyard/ Office Buildings / Fire station / Electrical Substation / Signal Station /Godown/ Hospital / Command and Control Center)						
4. Thematic area	Investing in DRR – Non- Structural measures						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
1	Rules, laws, guidelines	Strict implementation and strengthening of fire safety rules	• DPA, • CISF, • Terminal / Berth Operators, • Hospital.	• Safety Committee Meeting, • Environment, Health and Safety Policy, • Safety budget, • Work Permit System.	• Fire-fighting and evacuation plan.		
2	Fire safety audit of structures and buildings	Carry out fire safety audit of buildings and critical infrastructure	• DPA, • Terminal / Berth Operators.	• Periodical Fire audit, • Periodical Electrical audit. • External Safety Audit by OISD and NSC, • Compliance of Statutory requirements in coordination with Inspectorate of Dock Safety	• Compliance of recommendations.		
3	Risk Transfer	Insurance	• DPA, • CISF, • Terminal / Berth Operators, • Hospital.	• Workmen Compensation Policy, • Public Liability Insurance, • Port Package Policy for entire set of risk to the port.	• Periodical renewal of policies.		

Hazard	Fire (Coal stackyard/ Office Buildings / Fire station / Electrical Substation / Signal Station /Godown/ Hospital / Command and Control Center)						
5. Thematic area	Capacity Development						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
1	Training	Incorporating disaster response in the training programs	• DPA, • CISF, • Terminal / Berth Operators, • Hospital.	• Induction/Refresher Training, • Fire-fighting training, • First Aid training.			
2	Mock drills/ Exercises	Planning and execution of emergency drills by all the stakeholders Joint planning and execution of emergency drills	• DPA, • CISF, • Terminal / Berth Operators, • Hospital.	• Fire and evacuation Mock drills.	• Annual Drill schedule.		

Hazard	Fire (Coal stackyard/ Office Buildings / Fire station / Electrical Substation / Signal Station /Godown/ Hospital / Command and Control Center)						
5. Thematic area	Capacity Development						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
3	Documentation	Ensure accurate documentation of all aspects of disaster events for creating good historical records for future research and Risk Management planning	• DPA, • CISF, • Terminal / Berth Operators, • Hospital.	• Maintenance of the incident and near miss record, • Accident/incident reporting, analysis, investigation and implementation of recommendations.	• Centralized mechanism for the accident / incident and near miss record.		
4	Awareness	Promote culture of disaster risk prevention, mitigation, and better risk management	• DPA, • CISF, • Terminal / Berth Operators, • Hospital.	• Quarterly Dock Safety committee meeting • Safety Campaigns, Dock Safety week, • Notification for Dangerous Goods as per relevant Regulation of Dock workers (Safety, Health and Welfare). • Safety Inspection of port, • Training center for safety and productivity re-engineering &	• Promote awareness by posting details of activities on social media platforms regarding important events.		

Hazard	Fire (Coal stackyard/ Office Buildings / Fire station / Electrical Substation / Signal Station /Godown/ Hospital / Command and Control Center)						
5. Thematic area	Capacity Development						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
				container-based training center, • Preparation and updation of Safety manual, • Preparation of Ship bunkering guideline, • Circular for restriction of usage of mobile phones in oil jetty and promote safety culture, • Safety Advisories to port users for preventing dangerous occurrence of incidents, • Pocket booklet of traffic safety management.			

Hazard	Natural Disaster (Wind and Cyclone, Flood, Earthquake, Tsunami)						
1. Thematic area	Understanding Risk						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring /Regular measures**	**Short term**	**Medium term**	**Long term**
1	Observation networks, Information systems, Research, Forecasting, Early warning	Enhancement of Observational Network Stations (ONS)	• DPA	Wind and cyclone: • Internet sources, • IMD Bulletins, • NAVAREA warnings. Flood: • Tide/Bore tide gauging, • Sea and creek water level monitoring, • IMD bulletins, • CWPRS/PWD bulletins, • Hydrographic study.			
		Establishment of at least one High Wind Speed Recorder and one surge recorder		• Wind speed recorder at Signal Station.	• Surge Recorder.		
2	Zoning / Mapping	Identification of the vulnerable areas	Not applicable to port for zoning and mapping.	• Cyclone hazard map (Very High damage risk zone – maximum wind speed of 50 m/s). • Flood: Due to its geographical situation, the Kutch district is not vulnerable to occurrence of Flood. • Earthquake: Kutch district fall	Maintenance and new construction of drainage system		

Hazard		Natural Disaster (Wind and Cyclone, Flood, Earthquake, Tsunami)					
1.	**Thematic area**	Understanding Risk					
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring /Regular measures**	**Short term**	**Medium term**	**Long term**
				under High to Very High earthquake damage Risk zone (zone category IV & V).			
				• Earthquake hazard map as given in BMTPC.	The requirements of BIS standard 1893-2016 are to be complied with for seismic zone V as per BMTPC chart.		
				Tsunami hazard map as per Gujarat State Disaster Management Authority.			
3	Monitoring	System to monitor natural disaster	• DPA	Wind and Cyclone, Flood monitoring via • TV /Radio, • IMD bulletins. Tsunami monitoring via • Forecasting agencies, • INCOIS.			
4	Hazard Risk Vulnerability and Capacity	Undertake HRVCA as part of	• DPA, • Terminal / Berth Operators	• Port DMP as per Disaster Management Act -2005, NDMA Guidelines and NDMP,	Periodic update Plans		

Hazard		Natural Disaster (Wind and Cyclone, Flood, Earthquake, Tsunami)					
1. Thematic area		Understanding Risk					
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring /Regular measures**	**Short term**	**Medium term**	**Long term**
	Assessment (HRVCA)	preparing and periodic revision of DM plans		• Emergency Action Plan (EAP), • Port CMP, • Emergency Response Disaster Management Plan.			
		Constitute/ strengthen the mechanism for consultation with experts and stakeholders	• DPA, • Terminal / Berth Operators	Mechanism for strengthening through • Project development reports incorporating effective draining and anti-flooding measures, • Hydrographic Survey.			Land use planning

Hazard	Natural Disaster (Wind and Cyclone, Flood, Earthquake, Tsunami)						
2. Thematic area	Inter- agency coordination						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
1	Overall disaster governance	Providing coordination, technical inputs, and support.	• DPA, • Terminal / Berth Operators.	• EOC - E-Drishti Command and Control Centre, • Coordination with IMD, CWPRS, PWD, INCOIS • Coordination with DRR Cell (at Ministry level), DG Shipping, SDMA and DDMA, • As per NDMA Guidelines for Cyclone, Flood and Earthquakes			
2	Warnings, Information, data collection	Effective communication to ensure quick, clear, effective dissemination of warnings, information and data.	• DPA, • Terminal / Berth Operators, • Vessel Master, • CISF.	Effective communication via: • Signal Station, • VHF/UHF, • Landline/Mobile, • Satellite phones, • Email, • PA System. • Tide tables.			
3	Response	Coordinating with port stakeholders and Government agencies	• DPA, • Terminal / Berth Operators, • Vessel Master, • CISF.	• CMG group, • Vessel Master, • NDRF, SDRF, GPCB, Civil Defense, Local authorities, • ICG and Navy.			

Hazard	Natural Disaster (Wind and Cyclone, Flood, Earthquake, Tsunami)						
3. Thematic area	Investing in DRR – Structural measures						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
1	Multi-Purpose Shelters	Identification of safe buildings and sites with basic facilities like drinking water, food, sanitation and first aid to serve as temporary shelters for people evacuated from localities at risk.	• DPA, • Terminal / Berth Operators.	• Identified nearby shelters such as schools, community halls, etc. • Identified shelters for tugs and crafts (Refer Chapter 10)			
2	Hospitals and First Aid Centres	• Identification hospitals and first aid	• DPA, • Terminal / Berth Operators, • Hospital.	• Port Hospital, • Tie up with nearby hospitals, • First Aid centers.			
3	Civil works	• Upgrade and maintenance of the existing systems/ facilities	• DPA, • Terminal Operators/ Berth.	• Periodic maintenance of drainage system, • Availability of dewatering pump system. • Refurbishment of old dry cargo berths, open plots, roads, drainages and warehouses. • Seismically safe design and construction of jetties, trestles,	• CSR activity like improving/ providing the drainage system • Strengthening and seismic retrofitting as per recommendatio		

Hazard	Natural Disaster (Wind and Cyclone, Flood, Earthquake, Tsunami)						
3. Thematic area	Investing in DRR – Structural measures						
Sr. no.	**Sub-thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
				pipeline trestles, office buildings and utilities.	ns of structural audits		
4	Strengthening and retrofitting of prioritized vulnerable and critical structures	• Ensure compliance with relevant building codes or hazard resistant construction	• DPA, • Terminal /Berth Operators.	• Implementation in compliance with relevant building codes/ standards/ technical guidance. e.g. NDMA guidelines for Tsunami and Earthquake			
		Identification and repair/ retrofitting of houses and buildings as per the recommendations of structural audit Detailed assessment of hazard to the structure and foundation and the benefits of strengthening	• DPA, • Terminal /Berth Operators.	• Periodic inspection of vulnerable/critical structures (electrical sub stations, warehouse, fire station, office buildings, marine structures, etc.). • Repairs/ retrofitting done as and when required for tsunami resistance, • Refurbishment of old dry cargo berths, open plots, roads, drainages and warehouses.			

Hazard	Natural Disaster (Wind and Cyclone, Flood, Earthquake, Tsunami)						
4. Thematic area	Investing in DRR – Non- Structural measures						
Sr. no.	**Sub- thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
1	Regulation and enforcement of relevant laws	Ensure compliance with coastal environment protection laws and regulations such as the CRZ	• DPA, • Terminal / Berth Operators.	• EIA / EMP recommendations regarding environment sustainability measures viz air quality, sewage and effluent. • Implementing land-use regulation as per flood control norms. • Implementation of GSCZR			• Land-use planning
2	Operation and Maintenance of Drainage Systems	Budgetary Provision	• DPA	• Adequate budget to be provided to take care of the men, material, equipment and machinery for O&M of drainage systems.			
3	Non-structural shore stabilization measures and bio-shields	Establishment of bio-shields like mangroves, as natural defense	• DPA	• Plantation of mangroves			
3	Risk Transfer	Insurance	• DPA, • Terminal / Berth Operators.	• Workmen Compensation Policy, • Public Liability Insurance, • Port Package Policy for entire set of risk to the port.	• Periodic Renewals of Policies		

Hazard	Natural Disaster (Wind and Cyclone, Flood, Earthquake, Tsunami)						
5. Thematic area	Capacity Development						
Sr. no.	**Sub- thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
1	Training	Training and awareness regarding cyclone related emergencies and do's and don'ts	• DPA, • Terminal / Berth Operators, • Hospital.	• Training and awareness as per NDMA guidelines • Training by Civil Defense and other agencies			
2	Mock drills/ Exercises	Joint planning and execution of emergency drills	• DPA, • Terminal / Berth Operators, • Hospital.	• Participation in drills/exercises with the District and State Disaster Authorities.			

Hazard	Natural Disaster (Wind and Cyclone, Flood, Earthquake, Tsunami)						
6. Thematic area	Climate change risk management						
Sr. No	**Sub- thematic area**	**Plan components**	**Responsible section**	**Recurring / Regular measures**	**Short term**	**Medium term**	**Long term**
1	Climate change adaptation (CCA)	Sensitization and awareness creation	• DPA, • Terminal / Berth Operators.	Port has taken an initiative related to environmental protection as part of Green Port Initiative from GoI. This includes • Monitoring of the level of air, water and soil pollution regularly, • Provision of curtain barrier for coal dust pollution, • Installation of Dry fogging and sprinkler system (Dust suppression system). • Prohibition of disposal of all kind of garbage in creek. • Capital and Maintenance Dredging.	• Use of renewable energy • Use of Ship-shore power supply	• Use of battery power tugs	• Setting of Hydrogen Hub

8.2 MAINSTREAMING DISASTER RISK REDUCTION

The objective of mainstreaming is ensuring the ongoing and new development projects of the port leading to integration measures. The sub-thematic areas where such measures can lead to DRR are as follows:

1. Awareness and understanding of disaster risk;
2. Disaster governance;
3. Disaster risk transfer;
4. Institutional arrangements and capacity development;
5. Budget allocations for integrating DRR into development programs;
6. Project appraisals, scrutiny of development plans, effective and detailed land-use plans, from the point of view of expected hazards;
7. Setting targets and monitoring mechanisms.

In the context of above sub-thematic areas, the following measures may lead to mainstreaming DRR:

8.2.1 INVESTING IN DRR – STRUCTURAL MEASURES

The port is constructing marine and critical infrastructure (e.g., Jetty, Transfer pipeline and support structure, Drainage system, buildings, godowns etc.) as per relevant standards.

8.2.2 INVESTING IN DRR – NON-STRUCTURAL MEASURES

Port land area is being used for activities such as harbour area, industrial area, road network, water supply network, storm water drainage system and greenbelt/green cover.

Measures instituted includes Preparation and Implementation of the following:

- Port Policy, Rules and Regulations,
- Circulars,
- Notices,
- SOPs,
- Operational Manuals and Guidelines.

8.2.3 CAPACITY BUILDING

Port takes initiative by deputing various personnel to attend and undergo various trainings such as Disaster and Safety Management, Oil Spill Management, Fire & Safety, Dock Safety, First Aid etc.

Port undertakes consultative measures with expert agencies such as IITs, Govt. Departments, technical Universities and private institutions for advice in Land use planning, port development, projects implementation, environmental management and training of personnel. It will also conduct and participate in awareness programme through agencies such ICG, Civil Defence, NDRF, SDRF, GSDMA, DGFASLI, Security services etc.

8.3 DISASTER RISK GOVERNANCE PROGRAMMES AND PRACTICES

8.3.1 Environmental macro level-Coastal zone monitoring

The macro level monitoring includes following aspects.

1. Master planning of the port facilities with respect to the traffic forecast and identification of projects.
2. Environmental impact analysis, land use planning and finalisation of the location of the projects.
3. Finalisation of the Port's conceptual plan for future development.
4. The port's plans for Integrated Management System (IMS), including ISO-14001 Environment Management System.
5. Obtaining statutory permissions like Environmental Clearance, Consent to Establish/Operate from the MoEF & CC, PESO approval and State Pollution Control Board.

8.3.2 Micro Level Monitoring

The port undertakes various initiatives at the micro level which are as follows:

- Plantation of trees for a green belt.
- The level of air, water pollution to be monitored regularly and required steps to retain the pollution level within the permissible limit taken.
- Maintenance of Drainage system.
- Obtaining environmental clearances for projects and monitoring of the pollutants during the execution of the project as per the approved Environmental Management Plan (EMP).

In addition, the port maintains the CSR program and issues are highlighted periodically for implementation.

8.4 CLIMATE CHANGE RISK MANAGEMENT AND DRR

The SDG Goal 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development) has set targets for significant reduction of marine pollution and aims to minimize.

In respect of aspects relating to climate change the following plan/procedures by port have been identified having bearing on disaster risk reduction and resilience:

- Plantation of trees for green belt and utilisation of non-conventional energy sources.
- The level of air, water and soil pollution to be monitored regularly and required steps to retain the pollution level within the permissible limit taken.
- Sea level rise – Minimum height of landside construction above Mean Sea Level (MSL) will be adequately planned for developmental activities.
- Heavy rainfall (cloudburst) and flooding – Land use planning and the detailed development thereafter will factor-in the requirements of natural slope, land topography, storm water drainage, height and width of culverts, natural drainage for ponds.
- High wind and cyclone – Implementation of SOPs for preventing damage during an event.

8.5 BUDGETING AND FINANCIAL ARRANGEMENTS

8.5.1 DM Budget

The port will assign sufficient funds towards disaster management under following broad categories as follows:

i. **DRR measures (Structural and Non-structural):**
   - Firefighting and Oil Spill Response Equipment;
   - Tugs;
   - Navigational aids;
   - Training of Personnel;
   - Risk Transfer – Insurance;
   - Civil works –Jetty-fenders-Repair and maintenance.

ii. **Restoration Measures:**
   - Administrative building damage;
   - Power Supply;
   - Damage to tugs;
   - Damaged buoys- loss of buoys;
   - Repair of damaged roads;
   - Injury & infection-medical treatment;
   - Flooding & stagnant water - clean drains;
   - Electrical & Mechanical works;
   - Civil works –Jetty-fenders-Damage Repair.

8.5.2 Insurance of Port Assets

The Insurance cover for the port assets/properties should be as follows

1. Building, workshop and other structure inside port;
2. Navigational aids structures and equipment;
3. Fire-fighting aids;
4. Jetty;
5. Port Equipment;
6. Floating craft;
7. Electrical Installations.

9. RECOVERY AND BUSINESS CONTINUITY

9.1 RESPONSIBILITY FOR TERMINATING THE RESPONSE

The decision to terminate a response is taken by the CIC in consultation with the CEC.

9.2 CONDITIONS FOR TERMINATION

9.2.1 **In the case of Natural Disasters** Response action can also be terminated as per the information received from the "Competent early warnings agencies e.g., IMD" (Refer 7.1.5)**.**

9.2.2 **Fire Extinguishing operation** should be terminated when:

- Fire has been completely extinguished,
- Area has been declared as "Risk or Hazardous or Smoke' free area.

9.2.3 **Marine Response Operations in case of oil spill** should be terminated when:

- Oil has been recovered to the extent practicable; or
- The surface oil slick has broken up; or
- The oil slick has gone out to sea and is beyond the range of response options, and is unlikely to return; or
- Oil has impacted shorelines and is no longer on the water.

In the last case marine response resources must remain on standby and equipment maintained at the ready until shoreline response operations have been completed.

9.2.4 **Shoreline Response Operations** should be terminated when:

- All accessible shorelines are clean to the extent practicable.
- Cleanup is having no further net beneficial effect or having a deleterious effect on the shoreline or associated plants or animals.

Shoreline cleanup operations may be terminated only upon the instruction of the **GPCB/ICG.**

9.2.5 **Land Spill Response Operations** should be terminated when:

- Area has been declared "Risk or Hazardous" free.
- Source of leakage is stopped and the condition of the area is safe for operation.

9.2.6 **Human Induced Disasters** response may be terminated when

a. War and terrorism threats are evaluated by the security agencies and as such the response will be terminated gradually in stages as per the input received from them.
b. Bomb threat related response will be terminated on case to case to basis as per instructions from district and state authorities.

9.3 STAND-DOWN PROCEDURES

9.3.1 Return of Equipment

Upon completion of the response, the SIC (or delegate) will:

- Arrange recovery of all equipment and unused materials.
- Ensure that all equipment is cleaned and returned to the owner.

9.3.2 Debrief

The SIC may hold a post-incident debriefing. Debriefing should address:

- Spill causes (if known) and future prevention methods.
- Speed of response activation.
- Effectiveness or suitability of strategies, tactics and equipment.
- Health and Safety issues (if any).
- Any other issues required to be communicated.
- Damage in terms of life, injury and loss of property should be assessed.

9.3.3 Incident Report

The CEC may request the preparation of an Incident Report.

9.3.4 Cost recovery

1. All records of costs must be collated for submission to the relevant insurer.
2. For expenses incurred assisting third parties, costs should be kept and submitted to relevant authority.

9.4 DAMAGE, LOSS AND NEED ASSESSMENT

9.4.1 Initial Damage Assessments

Following any major disaster, rapid assessment of damage is important for restoring the facilities, resuming Port operations and cost recovery. In certain cases e.g. terrorism and security related, thorough site or damage assessment is not possible immediately after an event. Access to, and assessment of Port facilities and its contents may be delayed for a period of time. The delays may be due to possible loss of structural integrity, necessary forensic investigation, or the existence or potential existence of hazardous materials.

Immediately following a disaster and as soon as it is safe to do so, the designated team shall conduct a preliminary damage assessment.

9.4.2 Secondary Damage Assessments/Temporary Repairs

Once the affected site is approved for entry, a Damage Assessment Team will conduct a thorough assessment. This assessment will focus on those assets needed to facilitate a rapid recovery such as electric power, communications and transportation. The assessment should also identify any potential environmental issues that require immediate attention. Damage should be noted in enough detail to allow it to be communicated to begin developing action plans for recovery. Local utility companies need to be contacted at this time for anticipated schedules for restoration of critical utility services.

9.4.3 Assessment of Damage to Navigational Channel

Assessment of damage to the berthing and navigation portion area of the channel and Aids to Navigation is under the jurisdiction of the port. The Harbour Master will provide a status report of the condition of the channel to the Deputy Conservator.

9.4.4 Potential loss estimates analyzed include

- Physical damage to buildings, critical facilities and infrastructure.
- Economic loss, business interruptions, repair and reconstruction costs.
- The decision to rehabilitate or abandon port structures depends on the extent of damage, importance of the structure, and limits on its use. Aspects of an inspection may include:
  - An underwater inspection by divers to check for possible demolition damage or deterioration of footings.
  - An inspection of the piling at low water from a boat to check for decay or damage. The stringers and deck are examined from below to determine the need for repair.
  - Jetty will be inspected for damage.
  - Assessment of buildings to ensure that damaged or repaired buildings are safe for occupancy.

9.5 RECOVERY PLANNING

9.5.1 Short-term recovery planning

Short-term recovery planning runs parallel to short term response and begins during and immediately after an incident.

9.5.2 Medium-term recovery planning

In the medium-term recovery planning, port will engage in contracting and setting up for large scale reconstruction and reconstitution operations. This may include financial planning, contracting, and the formation of joint venture agreements to assist in long-term business continuity.

The reconstruction activities may require an Environmental Impact Assessment. The lessons learned about the disaster impact and failures will be incorporated based on reviews of latest standards and global best practices to ensure a **"Build Back Better"** approach.
These steps will involve the following;

a. Debris Removal,
b. Emergency Protective Measures,
c. Repair to Pre-Disaster Condition including improved resilience.

9.5.3 Long-term recovery planning

In the event that a part or the entire port becomes unusable or requires rebuilding, the long-term reconstruction considerations will be taken by stakeholders considering the financial planning, budgetary support and other resources.

9.6 RE-OPENING OF BERTHS TO VESSELS

In the event of damage to the port infrastructure during the disaster and subsequent recovery, steps will be taken by the management in consultation with MoPSW to open the port and navigational channel to resumption.

9.7 ENSURING BUSINESS CONTINUITY (General Guidelines)

9.7.1 OBJECTIVES

- Port resuming business operations as quickly and efficiently as possible.
- Preservation of cargo transport and supply chains.
- Developing partnerships between the public and private sector with a view to improve resiliency.
- Assessing and determining resources required to mitigate economic impacts of an incident on the port and its businesses.
- Determining how to create redundant and resilient power, water, sanitation, and data storage systems.

9.7.2 BUSINESS IMPACT ASSESSMENT

In the case of Level 2 and Level 3 disasters where serious disruptions in port business is possible due to collapse and damage to infrastructure and services in addition to human casualties, the process of recovery is conducted by undertaking a Business Impact Assessment (BIA). The following table lists the involvement of various authorities in case of major disasters.

Table 9.1: Involvement of Authorities for Level 2 and 3 type disasters

SCENARIOS	LEVEL 2 & 3 – ACTION BY
Vessel- Collision/Grounding-Evacuation	IRT + CMG + Salvage efforts + Navy + ICG
Casualties	Port + District + State
Fire & Explosion on Vessel or Terminal	IRT + CMG + Terminal + District (Fire wing)
Fire in Office buildings, Hospital, Electrical substations, Pump houses and control rooms, Dry docks, Godowns, Coal stack yard	IRT + CMG + Port Fire team + District (Fire wing)
Oil or Chemical Spill	IRT +CMG + Master of vessel + OSRO + ICG + District/state assistance
Toxic Gas Leakage	IRT + CMG + Master of vessel + District/state assistance + outside agencies
Cyclone, Tsunami, Flood, Earthquake	IRT + CMG + Master of vessel + Terminal +National Disaster Management Group + CMG + District + State
Human related – Bomb threat, War and terrorism	CISF (Security) + CMG+ Terminal + National Disaster Management Group + District + State

9.7.2.1 TOLERABLE RECOVERY TIME

The Port EOC will provide the initial response to a major disaster and stakeholders will have assigned unique functions on their respective parts for recovery and restoration efforts. Each stakeholder is expected to maintain their respective business recovery plan for use and activation. It has to be kept in mind that the business impact of the identified disasters will be in accordance the vulnerability profile of the port. Thus, a concept of "tolerable recovery time" for resuming business operations after an emergency is an important part of business continuity plan. The maximum tolerable recovery duration for some of the emergencies will be as follows:

1. 2 days for transport accident scenarios (rail and road);
2. 2 days hours for utility functional failures;
3. 4 days for collision, grounding and fire related disasters;
4. 2-4 days for disasters in service and administration facilities;
5. 21 days for Natural disasters;
6. 30 days for disasters during cargo storage or transfer.

The following table list the tolerable recovery times for the port for various identified scenarios as per HRVCA (Refer Risk assessment report).

Table 9.2: Time to Restore for identified scenarios

EVENT/SCENARIO SPECTRUM	TIME TO RESTORE FACILITIES
DISASTER DURING CARGO STORAGE/TRANSFER	
Fire due to rupture/leakage of POL/Chemical from pipeline/hose at oil jetty (oil jetties 1-7) – on vessel or ashore	2-30 days
Fire /Explosion due to LPG leakage at Oil Jetty 1 – on vessel or ashore	2-30 days
Toxic product (e.g. ammonia) leak from pipeline/hose at jetty during operation (oil jetties 2-5) – on Vessel or Ashore	2-7 days
Corrosive Acid - Leakage (e.g. Sulphuric acid, phosphoric acid) at oil jetty-5 during operation – on Vessel or Ashore	2-4 days
Fire /leakage due to Crane Accidents (Container drop/crane fall) at container berth – secondary event.	2-7 days
Fire on vessel (non-tankers) at berth	2-4 days
Fire in Coal Stackyard	2 days
NAVIGATIONAL DISASTERS	
Collision of small craft with Tanker/Container/BC/Dredger/Barge	4-96 hours
Collision between two vessels	4-96 hours
Collision of Vessel with dredger	4-96 hours
Dragging anchor at Anchorage area	4-96 hours
Grounding- Tanker/Container/BC- Pilot onboard	4-96 hours
Grounding- Tanker/Container/BC- Pilot not onboard	4-96 hours
Tanker /Container/BC vessel tug assisted berthing - Contact with Berth/Jetty/Shore installations	12-96 hours

Contact with channel marking buoys	12-96 hours
Fire on vessel in the navigational channel	12-96 hours
Fire on vessel at the anchorage	
Fire on vessel at the Berth/Jetty	
DISASTER IN SERVICE AND ADMINISTRATION FACILITIES	
Fire in Office buildings, Hospital, Electrical substations, Fire stations, Dry docks, Godowns, Coal stack yard	12 hours – 96 hours
NATURAL DISASTER	
Cyclone/ Floods/ Tsunami/ Earthquake	7-21days
UTILITY FUNCTION FAILURE	
Electrical sub station	12-96 hours
Pump house	12-48 hours

9.7.3 PLANNING CONSIDERATIONS FOR BUSINESS CONTINUITY

In actual practice, deviations may occur due to reasons beyond control and same can be recorded so as to gain from experiences and work towards a "Build Back Better" approach. The recovery planning outlined for short, medium- and long-term measures will therefore need to be objective enough to meet these timelines. The lessons learned from earthquake damage to Kandla Port during Bhuj earthquake 2001 reveals damage to jetties, piles and RCC structures such as godowns, the signal control tower and office building. In such an eventuality occurring at port steps to restore the functioning of the affected cargo berths and control stations will need extensive repair and rehabilitation measures.

In case of major incident or following a natural disaster resulting in stoppage of port operations, a BIA will be undertaken. Priority areas will be identified for short term recovery amounting to approx. 30 % capacity of cargo handling, medium term recovery amounting to approx. 70 % capacity of cargo handling and long-term recovery for 100 % capacity cargo handling.

Port will consider short-, medium-, and long-term priorities to better organize and improve recovery

- Local priorities would be taken into account when determining where to focus recovery efforts.
- Assess the port functions, both internally and externally, to determine which manpower, materials, procedures and equipment are necessary to keep the port operating.
- Create a contact list for existing critical business contractors and others that the port can use in an emergency.

9.7.4 SHORT-TERM RECOVERY PLANNING

9.7.4.1 Damage Assessment and Prioritization of Restoration Work

Tasks during initial damage assessment will include the following.

- Assessment of Engineering Assets
- Assessment of Current Condition of Facilities
- Assessment of Utility Infrastructure

9.7.4.2 Actions that assist in damage assessment will include the following.

- Documentation of Replacement Costs
- As-Built Building Plans, Specifications and Other Facility Records
- Determining, positioning, and planning for assistance to obtain Critical Recovery Resources

9.7.4.3 Scope of inspection may include the following:

- Assessment of facilities by civil engineers to ensure compliance with local building and architectural codes and to ensure that damaged or repaired buildings are safe for occupancy.
- An underwater inspection by divers to check for possible demolition damage or deterioration of footings.
- An inspection of the piling at low water from a boat to check for damage. The stringers and deck are examined from below to determine the need for repair.
- Berths/jetties, or seawalls are inspected for damage.

9.7.5 MEDIUM-TERM RECOVERY PLANNING

In medium-term recovery planning, the port will engage in contracting and setting up for reconstruction and resumption of operations at the affected site. This may include financial planning, contracting and the formation of mutual aid agreements to assist in business continuity.

9.7.5.1 Mutual Assistance

The port may include the recovery operations plans, provisions for the pooling of recovery and business resources (heavy lift equipment, for example), and pre-positioning where needed.
Port may require to develop an alternate operational logistics support plan for cargo diversion in an incident at the port. It may also explore the agreements with Railways regarding goods movement in the event of an incident.
In case of damage to road infrastructure, port may also consider examining alternative transportation routes to and from the port and also within the port itself.

9.7.5.2 Medium-term reconstruction projects include:

- Expedient repair of existing structures.
- Repair of unloading facilities e.g. quay cranes, pipelines etc.

9.7.5.3 Marketing and Communications

Post-incident, port may consider publishing press releases and advertisements to demonstrate to the public that the port is open for business and still functional.

9.7.6 LONG-TERM RECOVERY PLANNING

This may include assessment and short- and medium-term measures as discussed earlier to provide temporary relief and alternate sites for cargo handling. For full recovery steps including as listed below will be required.

- Determining the financial impact of the emergency on the port and the budget needed for recovery, including insurance reimbursement and non-reimbursement issues, and central govt. assistance;
- Building relationships with emergency management and first responders based on unmet coordination needs;

- Initiating public relations activities to rebuild confidence in the transition period on the part of customer and the community in its entirety;
- Administering a comprehensive cargo movement recovery policy;
- Provide support for Construction & Maintenance, repair, alteration and reconstruction of port facilities and infrastructure;
- Laying out of plans and specifications and other contract documents necessary for the construction of new facilities and for any modifications to existing port facilities by engineering department;
- Repair of extensive damage to port buildings and properties and its maintenance;
- Assessment of environmental impacts of reconstruction projects and determining mitigation measures as appropriate by Environment department.

10. RESOURCE INVENTORY

10.1 Fire - fighting equipment details of OJ-1:

There are three nos. sea water fire pumps as follows.

1. Diesel driven fire pump – Capacity 500 m^3/hr., Head 156 m.
2. Electrical driven fire pump – Capacity 500 m^3/hr., Head 156 m
3. Electrical driven flushing pump – Capacity 500 m^3/hr., Head 156 m.
4. There are 2 nos. foam tanks of capacity 250 liters each provided with fixed firefighting monitor.

10.2 Fire - fighting equipment details of OJ-2:

This jetty is provided with the following firefighting infrastructure.

1. Diesel driven fire pumps 2 nos. – capacity 820 m^3/hr., Head 105 m;
2. Electrical driven jockey pump 2 nos. – Capacity 30 m^3/hr., Head 105 m;
3. Two Foam pump (One Electrical & One Diesel driven) Capacity 22 m^3/hr., Head 150m (both);
4. One Foam storage tank inside pump house – Capacity 14 m^3;
5. Six No water curtains of capacity 180 m^3/hr;
6. There are two water cum foam tower monitors of capacity, 3000 LPM at 7 kg/cm^2.

10.3 Fire - fighting equipment details of OJ-3:

This jetty has the following facilities.

1. Two Foam pump (One Electrical & One diesel driven) capacity 250 LPM, Head 150 m (Both);
2. One foam storage tank of capacity 15 KL;
3. There are two Nos. Water curtain of capacity 3000 LPM each;
4. There are two water cum foam tower monitors of capacity, 3,000 LPM at 7 kg/cm^2.

10.4 Fire - fighting equipment details of OJ-4:

1. There are three nos. Sea Water Fire pumps as follows:
    a. Diesel driven Fire Pump – capacity 500 m^3/hr., Head 156 m;
    b. Electrical driven fire pump – capacity 500 m^3/hr., head 156 m;
    c. Electrical driven Flushing pump – capacity 500 m^3/hr., Head 156 m;
2. Two Foam pump (One Electrical & One Diesel driven) Capacity 250 LPM, Head 150M(Both);
3. One Foam storage tank inside the pump house 15 KL capacity;
4. There are Two No water curtains, capacity 3000 LPM;
5. There are two water cum foam tower monitors of capacity 3000 LPM at 7 kg/cm^2.

10.5 Manpower resource – Fire Brigade section

Sr. no.	Name	Designation	Training details
1.	Aseem C	FcSO	Divisional officer course – NFSC, Nagpur
2.	DS Gurjar	Dy. FO	Divisional officer course – NFSC, Nagpur
3.	Edward Brady	STO	Sub officer course – NFSC, Nagpur
4.	G Nethaji	STO	Station officer & instruction course - NFSC, Nagpur
5.	GR Vaghela	STO	Sub officer course - NFSC, Nagpur
6.	HV Patel	STO	Sub officer course - NFSC, Nagpur
7.	KG Khalsa	STO	Sub officer course - NFSC, Nagpur
8.	MB Makwana	STO	Sub officer course - NFSC, Nagpur
9.	MR Vadaviya	STO	Sub officer course - NFSC, Nagpur
10.	NK Maheshwari	STO	Sub officer course - NFSC, Nagpur
11.	NM Jogi	STO	Sub officer course - NFSC, Nagpur
12.	NP Rajput	STO	Sub officer course - NFSC, Nagpur
13.	RS Maheshwari	STO	Sub officer course - NFSC, Nagpur
14.	S Mandal	STO	Station officer & instruction course - NFSC, Nagpur
15.	SK Saha	STO	Sub officer course - NFSC, Nagpur
16.	TR Pariyani	STO	Sub officer course - NFSC, Nagpur

10.6 Major Fire equipment and Appliances – Fire Brigade section

Sr. No.	Name of the Appliances	Quantity
1.	Safety Jeep (Bolero)	1 No.
2.	Water Tender Fire engine	04
3.	Foam Tender Fire engine	02
4.	Multipurpose Tender	01
5.	Dry Chemical Powder Tender	01
6.	Portable Fire Pump (Single Delivery)	06
7.	Trailer Fire Pump	04
8.	DCP Fire Extinguisher 50 kg	05
9.	Two wheeled Trolley Trailer	01
10.	Sea water Fire pump Electrically Operated (Oil jetty)	04
11.	Sea water Fire pump Diesel Operated (Oil jetty)	04
12.	Sea water Fire pump Electrically Operated (Cargo jetty)	01
13.	Sea water Fire pump Diesel Operated (Cargo jetty)	03

14.	Ground monitor	01
15.	Compressed Air B.A. Set	16
16.	RRL Delivery hose	500
17.	Gasometer	03
18.	Explosive meter	01
19.	Motorola VHF Base station set	03
20.	Walkie Talkie set	12
21.	Deep lift pump	01
22.	Sea water fire hydrants double headed – oil jetty	157
23.	Sea water fire hydrants – cargo jetty	750
24.	Air compressor for BA set cylinder	01
25.	Fire entry suit	04
26.	Ejector pump	01
27.	Multipurpose fireman axe	05
28.	Hose washing machine	01
29.	Foam compound AFFF	30000 ltrs
30.	Alcohol resistance (ARFFF)compound	10000 ltrs
31.	Air compressor (for vehicle)	01
32.	Car washer	01
33.	Multi gallobage hand held nozzle	10
34.	Multipurpose hand held nozzle	10
35.	Water mist & CAF fire extinguisher	07
36.	Life gear full body safety harness	12
37.	Life gear safety stretcher	01
38.	Chemical Protective suit	15
39.	Chemical & Gas protective suit	01
40.	Combustible gas alarm (pocket type)	10
41.	Gastight suit for LPG & Ammonia	10
42.	Fire proximity suit	08

10.7 Fire Engines – Fire Brigade section

Sr. No.	Fire engines	Nos.	Capacity
1.	Water Tender Fire engine	04	6000 ltrs. Water for each fire engine
2.	Foam tender fire engine	02	5000 ltrs. Water, 1000 ltrs. Foam compound & 2 nos. vessel * 75 kgs DCP for each fire engine
3.	Multipurpose tender	01	5000 ltrs. Water, 1000 ltrs. Foam compound, 2 nos. vessel * vessel 75 kgs DCP & 4 nos. CO2 cylinder – 22.5 kg. capacity each
4.	Dry chemical powder tender	01	2 nos. vessel * 1000 kg DCP each vessel

10.8 Protective Equipment

Sr. No.	Type of Equipment	ERC	OJ-1	OJ-2	OJ-3	OJ-4
1	Breathing apparatus (SCBA)	05	01	01	01	01
2	First Aid Box	02	01	01	01	01
3	Gas Tight Suit for LPG & Ammonia	--	03	01	01	01
4	Proximity Suit	04	--	--	--	--
5	Chemical Suit	07	01	01	01	01
6	Fire Entry Suit	02	01	--	--	--
7	Stretcher	02	--	--	--	--
8	Full body safety harness	01	--	--	--	--
9	Respirator	02	01	01	01	01

10.9 FIRE PROTECTION FACILITIES AT IFFCO JETTY, i.e. Jetty No.5

1. Two Fire pumps - one electrical driven and one diesel engine driven having capacity of 273 m^3/hr installed.
2. Diesel Tank of 1000 ltr. provided for requirement of Diesel Driven Fire pump
3. One jockey pump of 15 m^3/hr capacity installed to keep fire line pressurised
4. There are two foam monitors with 1000 ltr. foam tank and 2250 lpm capacity installed on the both ends of wharf area of the jetty.
5. Total 4 Nos. of double headed hydrants on main berth.
6. Jetty fire water network is connected with Plant fire water network which is pressurised all the time and four 273 m^3/hr pumps are installed in the plant so they can be used in extreme emergency.
7. Fire Hydrant network is connected to Deendayal Port Authority's Jetty No. 4 Fire Pump House.
8. Two ammonia gas detectors are installed on Jetty having indication on local and in Ammonia Control Room.
9. DCP, CO_2 Fire Extinguishers and Fire Hoses are available at Jetty.

10. Safety Shower provided at Jetty.
11. Self-Contained Breathing Apparatus available during ammonia ship unloading.
12. Explosion proof lighting fixture provided.
13. Hand Gloves, Chemical Protective suit, Safety Goggles, Face Shield, life bouy, & life jacket are provided at Jetty.

10.10 Floating Crafts

Sr. No.	Type of Floating Crafts	Number	Name
1.	Tugs (Shipping)	02	Jyeshte
			Kritika
2.	Pilot Launches	03	Magh
			Rohini
			Swati
3.	Survey Launches	01	Nirikshak
4.	Mooring launches	04	Alok
			Atri
			Hasta
			Vishakha
5.	OSR Dumb barge	01	Karishma

****Note:*** *During cyclone all the port crafts will be sheltered inside the Bunder area.*

10.11 Pollution Response equipment

Sr. no.	Equipment	Make, Type, Model	Qty.	Ops	Non-Ops	Total
1.	Pressure Inflatable Boom. H-630mm, F-250mm, D-360mm Containment Boom	ECO-AB630N	1200 mtr	1100 mtr	100 mtr	1100 mtr
2.	Boom Reel	ECO-BR2	06 nos	06 nos	0	06 nos
3.	Hydraulic Diesel Power unit 8 KW for Boom Reel.	ECO-PD10W/PUMP	06 nos	06 nos	0	06 nos
4.	Temporary storage/Tow Tank Capacity-10 Ton	ECO-MT10	05 nos	05 nos	0	05 nos
5.	Fast flow Belt skimmer 49m3/hr capacity with suitable pump & Power pack	ECO – OBWS	02 set	02	0	02

6.	Dispersant Spray System Capacity-100 LPM,	ECO-DSS8-01 & DESMI-02	03 nos	03 nos	0	03 nos
7.	Permanent Boom. H-500mm, F-230mm, D-270mm, Containment Boom	ECO-CB500U	1000 mtr	940 mtr	60 mtr	940 mtr
8.	DBD Skimmer 20 m3/hr capacity with Suitable pump & Power pack 7.5 KW	DESMI	01 set	01 set	0	01 set
9.	Air Blower for Inflating Boom	STITHL BR550	03 nos	03 nos	0	03 nos
10.	Mini Vaccume Pump set	DESMI	01 set	01 set	0	01 set
11.	Sorbent Pads	40 x 50 cm	1900 nos	1900 nos	0	1900 nos
12.	Oil Spill Dispersant (Nova 4G OSD NIO/CG Approved	Type III &II	5000 lits	-	-	5000 lits

10.12 IMO Level Trained Personnel

Sr. no.	IMO Level – I	IMO Level - II
1.	Gajendra Behera (Site In-charge)	Pawan Sontakke (Manager)
2.	Saroj Kumar Swain (Responder)	Tohid Shaikh (Manager)
3.	Pawan Bharti (Responder)	
4.	Kartik Kumar N R (Responder)	
5.	Manoj Kumar (Responder)	
6.	Abhishek Kumar (Responder)	

10.13 Port maintains following schedule for the contingency mock drills

TRAINING CALENDAR				
JANUARY	Bunker Oil Spill	Tsunami	Tanker Fire At the Oil Jetty	Harbour Craft's LSA & FFA Training
FEBRUARY	PPE Training	Port Worker's Equipment Training	Administration Building Fire	Harbour Craft's LSA & FFA Training
MARCH	Ammonia Gas Leak	Collision	Fire/Explosion Off Berth	Harbour Craft's LSA & FFA Training
APRIL		Flood	Fire at General Cargo Berths	Harbour Craft's LSA & FFA Training
MAY	Oil or Chemical Pollution	PPE Training	Fire At Cargo Shed	Harbour Craft's LSA & FFA Training
JUNE	Harbour Craft PMS Training	Sinking Of The Vessel	Fire at Cargo Shed	Harbour Craft's LSA & FFA Training
JULY	Bunker Oil Spill	Cyclone	Tanker Fire at the Oil Jetty	Harbour Craft's LSA & FFA Training
AUGUST	PPE Training	Port Worker's Equipment Training	Fire/Explosion Off Berth	Harbour Craft's LSA & FFA Training
SEPTEMBER	Ammonia Gas Leak	Vessel Grounding In Port	Administration Building Fire	Harbour Craft's LSA & FFA Training
OCTOBER	Earthquake		Fire at General Cargo Berths	Harbour Craft's LSA & FFA Training
NOVEMBER	Oil or Chemical Pollution	PPE Training	Tanker Fire at The Oil Jetty	Harbour Craft's LSA & FFA Training
DECEMBER	Harbour Craft PMS Training	Pilot's Port Specific Simulator Traning	Fire at Cargo Shed	Harbour Craft's LSA & FFA Training

10.14 Navigational Buoys and Leading lights

22 lighted navigational buoys with solar light, as per IALA system, are provided in the Kandla navigational channel.

Sathsaida Leading Lights lead through Sogal Channel; a second pair, leads across the inner bar to Kandla Creek

Outer Tuna Lighted Buoy (22°51'N., 70°07'E.), painted red, marks the entrance of the channel to Kandla.

10.15 Available Emergency Control Room equipment

Sr. no.	Equipment
1.	BSNL satellite phone
2.	VHF sets
3.	Telephones
4.	Walkie-talkie sets & mobile
5.	Charts
6.	Emergency lights and torches
7.	Portable PA/loud hailer set

10.16 Mutual Aid Agreement

All Port operators/agencies/institutions, where possible, will supply resources to support emergency response operations when requested by CEC/CIC/SIC or whole of Port Emergency Operation Centre as per the Mutual Aid Agreement.

10.17 Resource Inventory (IDRN)

India Disaster Resource Network is an online inventory designed as a decision-making tool for the Government administration and crisis managers to coordinate effective emergency response operations in the shortest possible time.

The Ministry of Home Affairs, Government of India has developed a web-based database of resource named India Disaster Resource Network (IDRN). This database contains information about equipment (such as boats, bulldozers, etc.), manpower (divers, swimmers, etc.) and critical supplies (oxygen cylinder, firefighting foams, etc.) required during the response.

Resources which are available with the various departments in the Gujarat - Kachchh are uploaded in IDRN.

Gujarat-Kachchh: https://idrn.nidm.gov.in/

11. PLAN MAINTENANCE

11.1 DEVELOPMENT, APPROVAL, IMPLEMENTATION, REVIEW AND REVISION

- This plan is developed in accordance with the guidelines issued by NDMA (2024), NDMP (2019) and NDMA guidelines and structured to suit the port organization. The implementation will be undertaken by the Deputy Conservator in association with stakeholders. It is understood that lessons learned from previous near disaster/disaster situations have been studied and cognizance of the after effect of these disasters have been considered. Understanding of risk and preventive measures has thus been analyzed and mitigation plan prepared. Prioritization of risks has been done as per risk assessment.
- Plan would be circulated to stakeholders.
- Regular Drills/exercises would be conducted to test the efficacy of the plan and check the level of preparedness.
- NDRF, SDRF and other agencies e.g., civil defense, local govt. departments suggestions would be integrated into the plan.
- Review and updating of the plan would be carried out annually as per Disaster Management Act, 2005.
- Consequent to any modification/expansion in the infrastructure, the Deputy Conservator is responsible for updating and maintaining the DMP.

ANNEX A
CHECKLIST

A.1 Checklist for POL's & Chemicals

A.1.1 Vessel and Berthing details

1.	Name of the Tanker	
2.	Name of the Berth	
3.	Berthing Date & Time	
4.	Checking Date & Time	

A.1.2 Shift In-charge should check the following before berthing of the Tanker.

Sr. No	Check Points	Yes	No
1.	Fire Fighting System in Remote Mode		
2.	Functioning of Siren		
3.	No Hot Job is permitted within 100m radius		
4.	Compliance to "NO SMOKING" regulations		
5.	Concerned Staff wear PPE		
6.	MSDS is displayed for the product being handled		

Note: If any laps are found, immediately the same is to be brought to the notice of Fire Officer for necessary action.

A.1.3 Signature

Shift-in-charge	**Loading / unloading Master**	**Fire cum Safety Officer**

A.2 Checklist for LPG

A.2.1 Vessel and Berthing details

1.	Name of the Tanker	
2.	Name of the Berth	
3.	Berthing Date & Time	
4.	Checking Date & Time	

A.2.2 Shift In-charge should check the following before berthing of the LPG Tanker.

Sr. No	Check Points	Yes	No
1.	Monitor line should be pressurized with Jockey pumps		
2.	Monitor Motor driven pump in auto mode		
3.	Monitor Engine driven pump in auto mode		
4.	Hydrants, water curtains and ground monitor motor driven pump in remote mode		
5.	Hydrants, water curtains and ground monitor motor engine driven pump in remote mode		
6.	Gas detection system is in 'ON' position		
7.	Siren and Manual call points system is in 'ON' position		
8.	PA System is in 'ON' position		
9.	Keep adequate number of extinguishers at the unloading platform		
10.	MSDS should be displayed by Terminal		
11.	Wind Sock is erected		
12.	BA Sets and canisters are available		
13.	All the concerned staff including unloading master and hose fitters of concerned handing company should wear PPE		
14.	No Hot Job is permitted near the operational area		
15.	Compliance to 'NO SMOKING' regulations		
16.	Area must be continuously manned		
17.	Remote control room must be continuously manned		
18.	Generator should be in auto mode and electrical staff to be available at sub-station round the clock		
19.	Pump house to be manned round the clock by Mechanical staff		

Note: If any laps are found, immediately the same is to be brought to the notice of Fire Officer for necessary action.

A.2.3 Signature

Shift-in-charge	**Loading / Unloading Master**	**On-duty Officer (LPG Berth)**	**Fire cum Safety Officer**

A.3 Checklist for Toxic Cargo

A.3.1 Vessel and Berthing details

1.	Name of the Tanker	
2.	Name of the Berth	
3.	Berthing Date & Time	
4.	Checking Date & Time	

A.3.2 Shift In-charge should check the following before berthing of the Tanker.

Sr. No	Check Points	Yes	No
1.	Standby of Water tender and Trailor pump at manifold area is in readiness		
2.	Functioning of freshwater shower on the berth		
3.	Functioning of eye wash		
4.	Chemical suit is made available at the manifold area by the receiver of cargo		
5.	Functioning of Siren		
6.	Wind sack is erected		
7.	BA Sets are made available by Fire team		
8.	Concerned Staff wear PPE		
9.	MSDS for product displayed		

Note: If any laps are found, immediately the same is to be brought to the notice of Fire Officer for necessary action.

A.3.3 Signature

Shift-in-charge	**Loading / unloading Master**	**Fire cum Safety Officer**

A.4 Checklist for Sulphuric Acid / Phosphoric Acid

A.4.1 Vessel and Berthing details

1.	Name of the Tanker	
2.	Name of the Berth	
3.	Berthing Date & Time	
4.	Checking Date & Time	

A.4.2 Shift In-charge should check the following before berthing of the Cargo Tanker.

Sr. No	Check Points	Yes	No
1.	Fresh water Shower functioning on Berth		
2.	Eyewash Functioning		
3.	Neutralizing agent is readily available nearer to the manifold area		
4.	Unloading Staff wear PPE while handling above Chemicals		
5.	Chemical Suit is made available at the manifold area by the receiver of the cargo		
6.	30Mtrs area around the manifold barricaded		
7.	MSDS is displayed for the Chemical, that is being handled		

Note: If any laps are found, immediately the same is to be brought to the notice of Fire Officer for necessary action.

A.4.3 Signature

Shift-in-charge	**Loading / unloading Master**	**Fire cum Safety Officer**

A5. Grounding of a Vessel within Port Limit

A.5.1 Vessel and Incident details

1.	Name and Type of the Vessel	
2.	Master of the Vessel	
3.	Name of the Agent	
4.	Incident Date & Time	
5.	Vessel Length and Draft	
6.	Pilot on Board, if any	
7.	Location of the incident	
8.	Current location of the vessel	
9.	Port Launches Order (time)	

A.5.2 Other details

1.	Time of Grounding	
2.	Cause of Grounding	
3.	Extent of Grounding	
4.	Weather Conditions	
5.	Direction of Vessels head	
6.	Movement of other vessels stopped	
7.	Pollution type (oil/chemical)	
8.	Location and Extent (impact on environment) of Pollution	
9.	Fire/Explosion	
10.	Evacuation of Passengers (if any)	
11.	Plans to refloat vessel	
12.	Additional actions taken by port	
13.	Divers required	
14.	Salvage company informed	
15.	Remarks	

A6. Sinking/Capsize of a Vessel within Port Limit

A.6.1 Vessel and Incident details

1.	Name and Type of the Vessel	
2.	Master of the Vessel	
3.	Name of the Agent	
4.	Incident Date & Time	
5.	Vessel Length and Draft	
6.	Pilot on Board, if any	
7.	Location of the incident	
8.	Current location of the vessel	
9.	Port Launches Order (time)	

A.6.2 Other details

1.	Time of Sinking/Capsize	
2.	Cause of Sinking/Capsize	
3.	Extent of Sinking/Capsize	
4.	Weather Conditions	
5.	Direction of Vessels head	
6.	Movement of other vessels stopped	
7.	Pollution type (oil/chemical)	
8.	Location and Extent (impact on environment) of Pollution	
9.	Fire/Explosion	
10.	Evacuation of Passengers (if any)	
11.	Plans to refloat vessel	
12.	Additional actions taken by port	
13.	Divers required	
14.	Salvage company informed	
15.	Remarks	

A7. Collision between two Vessels within Port Limit

A.7.1 Vessels and Incident details

1.	Name and Type of the Vessels	Vessel 1: Vessel 2:
2.	Master of the Vessel	
3.	Name of the Agent	
4.	Incident Date & Time	
5.	Vessel Length and Draft	
6.	Pilot Onboard, if any	
7.	Location of the incident	
8.	Current location of the vessel	
9.	Port Launches Order (time)	

A.7.2 Other details

1.	Time of Collision	
2.	Cause of Collision	
3.	Extent of Collision (condition of vessels)	
4.	Weather Conditions	
5.	Direction of Vessels head	
6.	Movement of other vessels stopped	
7.	Pollution type (oil/chemical)	
8.	Location and Extent (impact on environment) of Pollution	
9.	Fire/Explosion	
10.	Evacuation of Passengers (if any)	
11.	Plans to move the vessel	
12.	Additional actions taken by port	
13.	Remarks	

A8. Fire Onboard a vessel within Port Limit

A.8.1 Vessels and Incident details

1.	Name and Type of the Vessels	
2.	Master of the Vessel	
3.	Name of the Agent	
4.	Incident Date & Time	
5.	Vessel Length and Draft	
6.	Pilot Onboard, if any	
7.	Location of the incident	
8.	Current location of the vessel	
9.	Number of Passengers Onboard	
10.	Fire Fighting facilities on vessel	
11.	Location of Fire	
12.	Substance burning	
13.	Details of dangerous goods on board, if any	
14.	Port Launches Order (time)	

A.8.2 Other details

1.	Cause of Fire	
2.	Extent of Fire (condition of vessel)	
3.	Weather Conditions	
4.	Direction of Vessels head	
5.	Movement of other vessels stopped	
6.	Actions taken, by Master of vessel	
7.	Master consulted with the Port/Fire Officer	
8.	Evacuation of Passengers (if any)	
9.	Plans to move the vessel	
10.	Additional actions taken, by port	• Protection of Port property • Precautions against re-ignition • Security
11.	Remarks	

A9. Fire onboard a tanker within Port Limit

A.9.1 Vessels and Incident details

1.	Name and Type of the Vessels	
2.	Master of the Vessel	
3.	Name of the Agent	
4.	Incident Date & Time	
5.	Vessel Length and Draft	
6.	Pilot Onboard, if any	
7.	Location of the incident	
8.	Current location of the vessel	
9.	Number of Passengers Onboard	
10.	Fire Fighting facilities on vessel	
11.	Location of Fire	
12.	Substance burning	
13.	Details of cargo on board	Type Quantity
14.	Port Launches Order (time)	

A.9.2 Other details

1.	Cause of Fire	
2.	Extent of Fire/Explosion (condition of vessel) or Likelihood of Explosion	
3.	Weather Conditions	
4.	Cargo Operations ceased	
5.	Hoses/Metals arms disconnected	
6.	Movement of other vessels stopped or area cleared	
7.	Actions taken, by Master of vessel	
8.	Master consulted with the Port/Fire Officer	
9.	Evacuation of Passengers (if any)	
10.	Plans to move the vessel or other vessels	
11.	Additional actions taken, by port	• Protection of Port property • Precautions against re-ignition • Security
12.	Remarks	

ANNEX B
EMERGENCY CONTACT NUMBERS

PORT KEY PERSONNEL		
Sr. no.	**Designation**	**Telephone Nos.**
1.	Chairman	02836- 233001/234601
2.	Dy. Chairman	02836- 234121/236323
3.	Deputy Conservator	9603123449
4.	Harbour Master	8976741054
5.	FA&CAO	9526062088
6.	Traffic Manager	9666107773
7.	Chief Engineer (Civil)	9825227038
8.	Chief Mechanical Engineer	9825235196
9.	Chief Medical Officer	9825505796
10.	Deputy FA&CAO	9825227036
11.	Dy. Chief Engineer (Civil)	9427251059
12.	Sr. Dy Traffic Manager	9748437052
13.	Sr. Dy. Chief Medical Officer	9687607528
14.	Signal Station	270549/ 9016682249

GENERAL ADMINISTRATION DEPARTMENT		
Sr. no.	**Designation**	**Telephone nos.**
1.	Secretary	7036868889
2.	Sr. Deputy Secretary	9825227079
3.	TP & PRO	9638943800
4.	Law Officer	9712341380

CISF			
Sr. no.	**Designation/Location**	**Telephone nos.**	
		Office	**Mobile**
1.	Commandant	271037	9825227282
2.	PA to Sr. Comdnt.	271037	9951492174
3.	Control Room	270140	
4.	North Gate	271440	-
5.	West Gate – I	271039	-
6.	West Gate II	270876	-

FIRE STATION		
Sr. no.	**Designation**	**Telephone nos.**
1.	Main Station (Emergency Response Centre)	270176 / 270178
2.	Cargo Jetty West Gate No. 1 (Tilak Fire Station)	9825221330
3.	Cargo Jetty (Azad Fire) Nr. Berth No. 8	9825221352
4.	Fire cum Safety Officer	270176 (O) / 227512/ 9825227041

FLOTILLA SECTION		
Sr. no.	**Section**	**Telephone nos.**
1.	Flotilla Section	9825227630
2.	Flotilla Supdt.	9978559903/9825227610

VADINAR CONTROL ROOM		
Sr. no.	**Designation**	**Telephone nos.**
1.	Signal Station	02833-2573026/9825212359

POLICE DEPERTMENT		
DESIGNATION	**Telephone nos.**	**Address and Email**
SP Kutch (East)	02832-280233	SP Office, Near Court, DC-5, Gandhidham sp-east-kut@gujarat.gov.in
SP Kutch (West)	02832-250960	SP Office, Near District court, Bhuj-370001 sp-kut@gujarat.gov.in

GUJARAT STATE DISASTER MANAGEMENT AUTHORITY (GSDMA)		
Address	**Email id**	**Telephone nos.**
Block No.11, 5thFloor, Udyog Bhavan, Sector-11, Gandhinagar, Gujarat.	info@gsdma.org	079-23259283 State Control Room: 1070
Kutch Office	mehul.nitb04@gmail.com	02832-252347

Name Of Office	Telephone nos./Email
IMD, Ahmedabad	079-29705010, 9428909340 m.mohanty@imd.gov.in met_mm@yahoo.co.in
INCOIS, Hyderabad	040-23886000 webmaster@incois.gov.in, director@incois.gov.in
District Collector, Collector Office, Jilla Seva Sadan, Bhuj-370001	02832-250020 collector-kut@gujarat.gov.in
District Emergency operation Centre	02832-250923/252347 dismgmt-kut@gujarat.gov.in
Kandla Airport	02836 269 401
Indian Navy -Porbandar	0286-2240954
Indian Railways	139/182
GSRTC Inquiry	02836 – 220198/1800 233 666666
Water Supply	1916/ 079-23220859
Ambulance	102/108

MUNICIPAL FIRE STATIONS	
Station name	**Telephone nos.**
Fire Station Gandhidham Municipality	02836-226573
Fire Station IFFCO Kandla	02836-270352

NDRF – 6TH BATTALION		
Designation	**Address**	**Telephone nos. & email id**
Commandant	6th Bn NDRF, Jarod Camp, Teh-Wagodia, Vadodara, Pin - 391510	02688-29920/09870006730/ 09429199493 guj06-ndrf@nic.co.in

EXPERTS	
Name of Body	**Telephone nos.**
Nautical Advisor cum addl. DG (Nautical), DG Shipping	022-25752009/ 25752005 / 25752010
MMD, Kandla	02836-297015/127/28 kandla-mmd@gov.in
Indian Register of Shipping, Mumbai	022-30519400 / 25703611 ho@irclass.org
Ministry of Environment, Forest and Climate Change (MoEF &CC), Admin, New Delhi	011-24695328
The National Environmental Engineering & Research Institute (NEERI), Nagpur	0712-2249885-88 / 2249970-72

Ministry of Petroleum & Natural Gas	011-23382426 / 23383100
National Institute of Ocean Technology (NIOT), Chennai	044-66783300 / 22460275 / 22460645
Jt. Chief Controller of Explosives, Vadodara (Gujarat)	0265-2225159/2361035 dyccebaroda@explosives.gov.in
GPCB – Regional office; Room No. 215-217 Administrative Office Building, Kandla Port Trust, Sector 8, Gandhidham, Kutch	02836- 230828 ro-gpcb-kute@gujarat.gov.in
Inspectorate Dock Safety, Kandla	02836 – 270249 idskandla@dgfasli.nic.in sp@dgfasli.nic.in
Office of Industrial Safety and Health, Kutch	02836-260020/262 dd1-dish-adi@gujarat.gov.in dydish-kutch@gujarat.gov.in
Civil Defence	02832-230603 dg-homegrd-ahd@gujarat.gov.in

STATE/DISTRICT EMERGENCY OPERATION CENTRE		
Sr. No.	**EOCs / Control rooms**	**Telephone nos.**
1.	State Emergency Operation Centre	079 - 23251900 / 23251902 / 23251914 /1070
2.	District Emergency operation Centre	02832-250923/252347 dismgmt-kut@gujarat.gov.in

MARINE POLICE NUMBERS				
Sr. No.	**Marine Police Station**	**Designation of In-charge**	**Telephone nos.**	**Mobile**
1.	Okha	Police sub-inspector	02892-262396	9376200200
2.	Vadinar	Police sub-inspector	02833-256541	9979899110
3.	Bedi	Police sub-inspector	0288-2755293	9913653885
4.	Mundra	Police sub-inspector	02838-224077	8000648100
5.	Kutch	DSP	02836-250444	
6.	Kandla	Police sub-inspector	0283-6270527	9879252427 9979904919
7.	Salaya	Police sub-inspector	0283-3285338	9426979493 9979904919

INDIAN COASTGUARD		
Sr. no.	**Station**	**Telephone nos.**
1	Mundra	02838-271403
2	Vadinar	02833-256560
3	Okha	02892-263450

HOSPITALS		
Sr. no.	**Name**	**Telephone nos.**
1	Rambaugh Hospital, Gandhidham	02836-261626
2	Railway Hospital, Gandhidham	02836-231874
3	General Hospital, Bhuj Civil Surgeon, Bhuj	02832- 246417/18 02832-258071/ 258080
4	Referal Hospital, Anjar	02836-232455

VEHICLE SUPLIERS		
Sr. no.	**Name of travels**	**Telephone nos.**
1.	M/s. Rohit Enterprise / Rishabh Enterprise	228550/237538 237547 (O); 234140 (R) 9825225121
2.	M/s. Jai Somnath Travels (GIM)	9825386739

SALVAGE ASSOCIATIONS	Telephone nos.
Vishwakarma Marine Pvt. Ltd., Porbandar - 360575	0286-2242836
Sealord Diving & Salvage Pvt. Ltd., Navi Mumbai - 400706	022-27682825
http://www.marine-salvage.com/membership/#tabs-1-4	

NON-GOVERNMENTAL ORGANISATION https://kachchh.nic.in/public-utility-category/ngos/		
NGO	**Contact**	**Email**
Arid Communities & Technologies	02832-645152	mail@act-india.org
Arya Samaj Gandhidham Charitable Trust	02836-231223	aryagan@aryagan.org
Kandla Seafarers Welfare Association	02836-224013	pwckandla@gmail.com
SANKALP	02836-296109	sankalp.gandhidham@gmail.com

STEVEDORES AT THE PORT			
Sr. No.	**Name**	**Address**	**Telephone Nos.**
1.	M/s. A.V.Joshi & Co.	Plot No. 18, Sector-8, Maitry Bhavan, Nr. Post Office, Gandhidham –Kutch	231070/232227/231588
2.	M/s. Agarwal Handling Agencies	DBZ-N-47, Gandhidham – Kutch	220282/233187
3.	M/s. ACT Shipping P. Ltd.	Seva Sadan-II, Room No. 206/207, New Kandla	270111/270112/270015/229967/231734
4.	M/s. J.M. Baxi & Co.	Seva Sadan – II, Room No. 301 / 306, New Kandla	270630/270550/270448
5.	Rishi Shipping	Plot 50, Sector 1/A GIM	229830/229831
6.	Parekh Marine Agency	C-8, Shaktinagar GIM	229297/221158/ 230587
7.	Krishna Shipping and Allied Services	Transport Nagar, NH GIM	230501/223814/ 229085
8.	Velji P & Sons(P) Ltd	2nd Floor, Deepak Compex, 315, 12/B GIM	231545/231546/ 225466
9.	Rishikiran Roadlines	Kiran House, Plot 8 Sector 8, GIM	231894/234108
10.	Seaways Shipping (P) Ltd	2nd Floor, Plot 351 Ward 12/B, GIM	226183/237147
11.	Liladhar Pasoo Forwarders P.Ltd	Plot 4, Sector –1 KASEZ, GIM	252286/252297/252612
12.	Patel Shipping Agency	Patel Avenue, Floor 2, Plot 170, Sector 1/A GIM	224024

VTS GOK OFFICERS OF MASTER CONTROL CENTER (MCC) KANDLA		
Sr. No.	**Designation**	**Mobile number**
1.	Deputy Director	7383576832
2.	Deputy Director	9428863924
3.	Asst. Executive Engineer	9016106566
4.	Asst. Executive Engineer	9408553192

TANK FARM TERMINAL					
Sr. No.	**Name of Terminal**	**Storage**	**Name of Person**	**Contact**	**Email ID.**
1	M/S N P Patel (l) Pvt Ltd.	Chemical/Edible	Kumaresan	9099075877	kumaresan@thekirangroup.com
2	M/S Kesar Terminal and Infrastructure Ltd -	Chemical/Edible	Shekhar Pradhan	9974248587	shekharpradhan@kesarindia.com
3	M/S Kesar Terminal and Infrastructure Ltd	Chemical	Nitin Bhoyar	9375349181	nitinbhoya@kesarindia.com
4	M/S Chemical Resins Ltd. - I	Chemical	Ashish Kachoriya	9998954375	ashish.kachoriya@aegisvopak.com
5	M/S Chemical Resins Ltd. - Il	Edible	Ashish Kachoriya	9998954375	ashish.kachoriya@aegisvopak.com
6	M/S Chemical Resins Ltd. - Ill	Chemical	Paresh Choxi	7359074019	paresh.choxi@aegisvopak.com
7	M/S Rishi Kiran Logistic Pvt Ltd	Chemical	Kumaresan	9099075877	kumaresan@thekirangroup.com
8	M/.s Aegis Vopak Terminal Ltd- I	Chemical	Suresh Joshi	9974812277	suresh.joshi@aegisvopak.com
9	M/.s Aegis Vopak Terminal Ltd-	Chemical	Paresh Choxi	7359074019	paresh.choxi@aegisvopak.com
10	M/.s Aegis Vopak Terminal Ltd- Ill	Edible	Paresh Choxi	7359074019	paresh.choxi@aegisvopak.com
11	M/.s Aegis Vopak Terminal Ltd- IV	Edible	Devender Musterya	7710954748	devender.musterya@aegisvopak.com
12	M/S JRE Tank Terminal	Chemical	Mahesh N Shah	9898500289	maheshshah@imc.net.in
13	M/S Indo Nipoon Chemical Company	Chemical	Amit Pathak	9879546836	kandla@indo-nippon.com
14	M/S Ahir Salt & Allied Products Ltd.	Chemical/Edible	Dharamsi B Agariya	9925247904	agriyadb@neelkanth.co.in
15	M/S Shreeji Liquid Storage Terminal	Chemical/Edible	Murali Krishna	9940666336	muralikrishna@shreeji-group.com

16	M/S Kutch Oil & Soap Industries	Edible	Asgarali Khoja	9825237214	kutchppl@rediffmail.com
17	M/S Sunshine Liquid Storage Terminal	Edible	Ramesh Chaturani	9825226026	sunshineliquidl@gmail.com
18	M/S Ambaji Import Ltd.	Edible	Sushil Rao	9081244117	gm@ambajimports.com
19	M/S Seabridge Terminals Pvt. Ltd.	Edible	Ambati K Rao	9909008876	arao@seabridge.co.in
20	M/S Gokul Agro Resources Ltd.	Edible	Mahendra G T	9825229260	mahendra.terminal@gokulagro.com
21	M/S Emperious Infra Logistics Pvt Ltd.	Edible	Hemant Rangwani	9426965566	hemant.rangwani@emperiusindia.com
22	M/S Deepak Estate Agency	Edible	Narendrabhai Thakkar	9879611243	dipakterminall@gmail.com
23	M/S Parker Agrochem Exports	Edible	Vidhanbhai Acharya	9638138833	parkeragrochem@gmail.com
24	M/S Tejumalbhai & Co.	Edible	Ashok Chandan	9825225101	tejmalbhaico@yahoo.com
25	M/S Liberty Investments	Edible	Thomas C D	9099011340	thomas@libertyoilmills.com
26	M/S Agency and Cargo Care	Edible	Vaibhav Aggarwal	9699667152	operation@acclkandla.com
27	M/S Avean International	Edible	Bharat Rathod	9375310260	aipkdl@gmail.com
28	M/S IMC Dry Cargo Jetty - New Kandla	Petroleum	Mahesh N Shah	9898500289	maheshshah@imc.net.in
29	M/S IMC Ltd Gas Terminal	Petroleum	Mahesh N Shah	9898500289	maheshshah@imc.net.in
30	M/S IMC Ltd Near Shirva	Chemical	Mahesh N Shah	9898500289	maheshshah@imc.net.in
31	M/S IFFCO	Gas/Acid	A K Sharma	9099982004	aksharma@iffco.in
32	M/S Indian Oil Corporation Ltd Foreshore Terminal	Petroleum	R K Mishra	9913716108	mishrark@indianoil.in

33	M/S Indian Oil Corporation Ltd Viramgam Kandla Pipeline	Petroleum	Rajesh kumar C	9047535311	rajeshkumar3@indianoil.in
34	M/S Indian Oil Corporation Ltd - LPG Import Plant	Gas	Bhaveshkumar Chauhan	7657888122	bkchauhan@indianoil.in
35	M/S Indian Oil Corporation Ltd - Main Terminal	Petroleum	S K Bandhe	7440937432	sbandhe@indianoil.in
36	M/S Hindustan Petroleum Corporation Ltd	Petroleum	Yasvendra Singh	9996620338	yasvendarsingh@hpcl.in
37	M/S Bharat Petroleum Corporation Ltd.	Petroleum	S Mandal	9874444332	mandals@bharatpetroleum.in
38	M/S J K Synthetics	Chemical	Kumaresan	9099075877	kumaresan@thekirangroup.com
39	M/S Bharat Food Company Ltd.	Edible	Nitin Patel	9315338532	nitin.pate1789@gmail.com

LICENSE HOLDERS TO KEEP CRAFTS INSIDE THE PORT AREA		
Sr. no.	**Name of Party**	**Name of Craft**
1.	POLESTAR MARITIME LTD	JASMINE STAR
		SUNFLOWER STAR
		COSMOS STAR
		MT BAHUDA
2.	EMERALD MARINE SYSTEMS	BURAQ V
		DEFENDER
		MT QASWA
3.	SHREE KRISHNA QUARRY PVT.LTD.	SONAL
		VIDHYALAXMI-1
4.	Adani Bunkerings Pvt. Limited	AEL II
5.	OCEAN SPARKLE LIMITED	MT OCEAN LANCER
		OCEAN PROGRESS
		MT OCEAN CHALLENGER
		DOLPHIN NO 30
6.	GAUTAM FREIGHT PVT.LTD	MV GAUTAM SHIVANK
		MT GAUTAM SHLOK
		MT GAUTAM JAYANI
		MT GAUTAM HANUMAN
		MT LUV KUSH
		MT GAUTAM VARUN
		MV GAUTAM REHANSH
		MV GAUTAM ATHARV
		MV GAUTAM ANANYA
		MV GAUTAM ADITI
		MV GAUTAM KRISHAV

		MV GAUTAM BHIMJI
		MV GAUTAM AARAY
		MV GAUTAM KAVYA
		PONTOON GAUTAM -I
		MV GAUTAM AROHI
7.	BAPU'S SHIPPING JAMNAGAR PVT.LTD	MT ADINATH-8
		MT VAILANKANNI
		MT SAGAR URMIKA
		DWARKESH
		MV SOMNATH
8.	INTEROCEAN NAVIGATION LIMITED	MT KCS-I
9.	WATERWAYS MARITIME GANDHIDHAM	MT KB-IV
		MT MUC LAXMI
10.	RISHI SHIPPING INDIA PVT.LTD	RISHI-XXI
		DUMB BARGE RISHI-XVII
		MAHARUDRA HANUMAN
		MV RISHI-IV
		MV RISHI-XXIX
		MV RISHI-II
		MV RISHI-XXIV
		MV RISHI-XXIII
		MV SRIJOY-1
		MT SAI VISTARA 2
		MT SHANIYA
		MV BARGE JAYRAM-III
		MT MARIGOLD
		MV BARGE JAYRAM-IV

		MV SAI GAURESH
		MV JAY ASHWINI
		MV AJIT
		MILIKA
11.	GENESIS SHIPPING SERVICE	MT GENESIS-III
12.	Rishi Mansukhani Port & Infrastructure P.Ltd.	MT RISHI-XXX
		MT RISHI-XIV
		MT KARMA-VIII
		MT RISHI -XXV
		MT BDS-SP-2
		MV RISHI-XII
13.	SILVER PORT SERVICES PVT.LTD.	MT SPS PHALGUNI
		MT SPS ROHINI
		SPS ASHWINI
		CHITRA
		SPS REVATI
14.	APEX OFFSHORE LLP	DULDUL
		MV SUCCESS GLORY
		MV MANALI -III
		MV MANALI -II
		MV MANALI -V
		MV RAMA
15.	OMEGA OFFSHORE	MV ZEENNE
		MT MARS
16.	MALARA SEA LOGISTICS	MV MALARA PRIDE

MAJOR HEAVY LIFT OPERATORS		
Name Of Party	**Contact Person**	**Phone Number**
Swastik Heavy Lifters	Mr. Jigneshbhai Mr. Aslambhai	9825758151 9825228421
Kutch Carrier Transport Co	Mr. C. R. Thackar	9825225591
Agarwal Handling Agency	Mr. Rakesh Thackar	9426928728
Active Cargo Movers	Mr. Narendra	9825220411
Raghuvirsingh & Sons	Mr. Harcharan	9879104853
Thacker Brothers	Mr. Kamleshbhai	9825296107
Kiran Roadlines	Mr. Pankaj Gadvi	9879104552
Regal Shipping	Mr. Ashok Dudi	9825326328
Rathore Freight Carriers		220759/ 220380

ANNEXURE G
Detail of CSR Work

YEAR WISE ACTUAL WORK COSTING OF CSR WORKS APPROVED BY BOARD

1) **CSR Works executed during the year 2011 – 2012 and year 2012 – 2014. (Upto Dec'21)**

Sr. no	Name of work	Actual cost (Rs in Lakhs)
1.	(a).Road from Dr. Baba Saheb Ambedkar Circle to N.H. 8-A (Via Ganesh Nagar).	Rs.482.65 Lakhs
	(b)Road from S.T. Bus Stand (N.H. 8 – A) to Sunderpuri Cross Road Via Collector Road.	
	(C)Road from N.H. 8 –A Railway Crossing to Maninagar (Along Rly Track).	
	(d)Road from Khanna Market Road (Collector Road) to Green Palace Hotel.	
2.	Construction of Internal Roads at "Shri Ram" Harijan Co-op. Housing Society Ltd. (Nr. Kidana).	
3.	(a)Construction of Cremation Ground and kabrastan with other facilities at Vadinar.	Rs 19.44 (Lakhs)
4.	(b)Providing Cement Concrete internal roads in village Vadinar Stage –I.	Rs 16.16 (Lakhs)
	(a)Approach Road provided for developing the Tourism at village Veera near Harsidhi Mata Temple where lot of tourists & Pilgrims visit.	Rs. 4.65 (Lakhs)
	(b)Water Tank along with R.O. provided near by developing Tourism area.	Rs. 30,000 (Thousand)
	(c)Creating facility of flooring and steps surrounding the lake to stop the soil erosion and attract the tourists, at Village Veera.	Rs. 4.80 (Lakhs)
	Total Rs	**528 Lakhs**

2) **CSR Works for the year 2014-2015.**

Sr. no	Name of work	Actual cost (Rs in Lakhs)
1.	Construction of Community Hall-cum school at Maheshwari Nagar, G'dham	Rs 51.90 Lacs
2.	Renovation of "Muktidham" at Kandla	Rs 10.65 Lacs
3.	Sunderpuri-1 valmiki community hall	Rs 5.00 Lacs
	Sunderpuri-2 valmiki community hall	Rs 5.00 Lacs
	Ganeshnagar Community Hall	Rs 10.00 Lacs
	JagjivanMaheshwari community hall	Rs 10.00 Lacs
	Various works of Road of Sapanagar	Rs 99.19 Lac
4.	Construction of compound wall in the Dam of Jogninar village	Rs 14.48 lacs
5.	In addition above 30 Lakhs as committed in Public Hearing meeting held on 18/12/2013 an amount Rs 30 Lakhs shall also be contributed for the CSR works to be carry out at villages Tuna, Vandi , Rampar, Veera etc.	Rs 30.00 Lacs
	Total Rs.	**Rs 236.22 Lacs**

3) **CSR Works for the year 2015-2016.**

Sr. no	Name of work	Actual cost (Rs in Lakhs)
1.	Construction of toilets for Girls / Ladies at Khari Rohar village	**Rs. 3.00 Lakhs**
2.	Construction of Toilets for Girls manatMathak Primary School, Mathak Village	**Rs. 3.00 Lakhs**
	Total	**Rs.6.00 Lakhs**

4) **CSR Works for the year 2016-2017.**

Sr. no	Name of work	Actual cost (Rs in Lakhs)
1.	RCC Community Hall at Harshidhi Mata Temple, Veera village, AnjarTaluka	Rs.19.00 Lakhs
2.	Fabricated Community Hall at Sanghad village, AnjarTaluka	Rs.21.00 Lakhs
3.	CSR Works for Shri MaheshwariMeghvadSamaj, Gandhidham at Grave Yard , Behind Redison Hotel.	Rs.8.00 Lakhs
4.	CSR works for ShirDhanrajMatiyadevMuktiDham, Sector-14 , Rotary Nagar, Gandhidham	Rs. 30.50 Lakhs
5.	CSR works for NirvasitHarijan Co-operative Housing Society, Gandhidham.(Health Cum Education Centre)	Rs. 41.00 Lakhs
6.	CSR works for Shri Rotary Nagar Primary school, Gandhidham.	Rs. 2.80 Lakhs
7.	CSR works at NU -4 , NU-10(B) Sapnanagar& Saktinagar, Golden Jublee Park, at Gandhidham	Rs. 18.00 Lakhs
	Total	**Rs 140.30 Lakhs**

5) **CSR Works for the year 2017-2018.**

Sr. no	Name of work	Actual cost (Rs in Lakhs)
1.	CSR works at Shri Ganesh Nagar Govt High School, Gandhidham	38.30
2.	Grant Financial contribution for facility of Army cantonment for 50 air coolers at Kutch Border Area.	15.00
3.	CSR works at Tuna & Vandi villages (providing drainage lines under Swachh Bharat Abhiyan)	39.80
4.	CSR works for S.H.N Academy English School (Managed by Indian Institute of Sindhology –Bharati Sindhu Vidyapeeth), Adipur	40.00
5.	Construction of Internal Road at Bhaktinagar Society, Kidana	
	Total	**148.10**

6) CSR Works for the year 2018-19

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

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

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

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

Sr. no	**Name of work**	**Actual cost (Rs in Lakhs)**
1.	CSR Proposal for earmarking of 15% Funds for National Marintime Heritage Complex, Lothal, Gujarat (NMHC) from allocated CSR Fund of Rs 3.46 Cr	51.90
	Total	**51.90**

9) CSR Works for the year 2021-22

Sr. no	**Name of work**	**Actual cost (Rs in Lakhs)**
1.	CSR Activities for providing Water supply pipe line for drinking water facilities for poor people & Fishermen at VANDI Village.	20
2.	CSR activities for providing facilities in Girls Hostel of Kasturba Gandhi Balika Vidhyalay, Gandhidham. Cost for Construction of compound wall, entrance gate, girls toilets)	30
3.	CSR works for Construction of Auditorium Hall at RSETI (Rural Self Employment Training Institute) at Bhujodi-Bhuj.	16
4.	CSR works for the providing of SOLAR POWER SYSTEM and other facilities for 0the JEEV SEVA SAMITI at Gandhidham.	9.3
5.	CSR Activities for providing HD projector for KANYA MAHA VIDYALAYA, Adipur	1.5
6.	CSR works for Construction of New Building for Setting up of skill development centre at Rajkot (Sewa Gujarat).	250
7.	CSR Works for Ladies Environment Action Foundation (LEAF) Trust for providing infrastructure to the primary school at Gandhinagar District	46.5
8.	CSR works lor Providing of Furniture for the School "Shri Galpadar Panchayat Prathmic Kumar group Sala" at Galpadar village,Taluka:Gim	5
	Total Cost	**378.3**

10) CSR Works for the year 2022-23

Sr. no	**Name of work**	**Actual cost (Rs in Lakhs)**
1.	CSR work for providing One Bore hole with construction one room along with Motor pump at Village MOTI NAGALPAR, Anjar.	18
2.	CSR work for Construction of Shamashan bhoomi (Crematorium) at Gandhidham.	49.5
3.	CSR work for providing metallic sheet DOME in Community Hall at Old Sunderpuri for Shri Juni Sundarpuri Maheshwari Samaj at Gandhidham.	15
4.	CSR Activities for construction of Samajwadi at village: Rampar,Taluka:Anjar.	15
5.	Financial assistance under CSR for providing basic facilities at Gandhidham GSRTC bus station.	25
6.	CSR Activities for construction of School Building for physically disabled, deaf & mute children, Shri & Shrimati Chhaganlal Shyamjibhai Virani Behera Munga Shala Trust, Virani Deaf School at Rajkot.	5
7.	CSR work for construction of new Administrative staff block for the Maitri Maha Vidhyalaya, Adipur.	64.65
8.	Financial support under CSR for providing 60 seater school bus for "Aadhaar Sankul", Manav Seva Trust,Gandhidham.	25
9.	CSR work for extension of Night shelter cum old age home for “DADA BHAGWANDAS ADVANI TRUST” Adipur.	78
10.	Financial assistance under CSR for Rooftop Solar System & Afforestation under clean energy & sustainable development in 10 villages around DPA	63.72
	Total Cost	**358.87**

11) **CSR Works for the year 2023-24 till September**

Sr. no	**Name of work**	**Actual cost (Rs in Lakhs)**
1.	CSR works for Shree Kachchh Mahila Kalyan Kendra, Bhuj-Kutch	55
2.	CSR Activities for Installation of 125 no. Sanitary Pad Vending Machines at Women Hostels,NGOs etc, in Kutch District	15
3.	CSR Fund for Vadinar Village & surrounding	128.54
4.	CSR Activities for Girls Hostel at Kasturba Gandhi Balika Vidhyalaya At Shinay, Taluka:Gim.	33.25
5.	CSR request for Allotment of fund for construction of Community hall at Adipur for Maheshwari Meghval Samaj.	25
6.	CSR Request for requirement of funds for renovation work in Sector-7, Gandhidham (Aryasamaj Gandhidham)	30
7.	CSR Request for providing"Antim Yatra Bus" & Mortuary Cabinet Morgue" for Adipur-Gandhidham from CSR Funds,	25
8.	CSR Request for creation of a Children park at Gandhidham Military Station, Gandhidham	15
9.	CSR Request for construction of Toilet block units for Girls & Boys NAV JIVAN VIKLANG SEVA SHREY Bhachau	3.04
10.	CSR Request for laying Synthetic Athletic track in Galpadar and to Provide One E-Kart facility for Conveyance of youths at BSF Campus, Gandhidham	75
11.	CSR request for submitted by AAS, Indore for solid waste Management at Gandhidham & Kandla.	49.93
12.	CSR request from Trikamsaheb Manav Seva Trust at Madhapar Near Bhuj for grant for Construction of Community Hall, Compound Wall etc.	40
13.	CSR Request for construction of Dome shaped shed at Rampar Village Prathmik Shala,Rampar	24
14.	CSR Fund for development of School premises of Shri Guru Nanak Education	4.5
15.	CSR Request for conducting Awareness campaigns on T.B. Prevention & treatment, Mumbai	60
16.	CSR Request for fund under CSR for Railway Institute, Gandhidham, Western	5
17.	CSR Proposal project for Sanitary Pad Making Machine for School Girls, Anjar	12.39
18	CSR Funds for Building Construction of girl's hostel (Kanya Chhatralay) @Luni,Akhil Kutch Ganesh Sevak Sarvajanik Trust-Luni	₹ 50.00
19	CSR request for amenities for Devlopment of sports facilities Through CSR Funds, Navy Head Quarter Porbandar,NAVYat Navy Head Quarter, Porbandar	₹ 47.18
20	CSR request for financial support under CSR for '' Organizing Programs on Skill Development'',Gandhidham Collegiate Board, Adipur	₹ 98.76
21	CSR fund for construction work for Community hall(samajvadi for cause of human services).Kidana,Kutch Andhra Seva Trust, Gandhidham	₹ 20.00
22	CSR funds for Karam Educational Complex@mirapar,Bhuj,Akhil Kutch MAheshwari Vikas Seva Sangh, Bhuj(Karam Sankul EDU)	₹ 50.00
23	CSR fund for vadinar village & surrounging for prathmik shala,Vadinar prathmik shala managed by dist. Panchayat	₹ 28.47
24	CSR fund for repairing of construction for school,Shree vadinar vadi school vadinar	₹ 16.04
25	CSR Project proposal for Outdoor flooring and laundry Construction for mentally Disturbed women, St. Joseph's Hospital Trust-Gandhidham ,St, Joseph's Hospital trust-Gandhidham	₹ 29.16
26	CSR request for creation of Bio Diversity Miyawaki Forest at Gandhidham Military Station, Gandhidham	₹ 57.64

27	CSR Funds request for the Construction of Hall/Dome for Indoor games at Gandhidham,Shri kutch Deshiya Saraswat Brahmin mahasthan trust-Gandhidham.	₹ 20.00
28	CSR Request for repairing of School shed, R.O. Plant, School Colour Work at Ganeshnagar Panchayat Prathmik kumar shala At Gandhidham-Kutch.,Shri Ganeshnagar Panchayat Prathmik Kumar Shala Gandhidham	₹ 8.00
29	CSR request for livelihoods Development of rural women at Kutch Area, ,BAIF Institute for Sustainble Livelihoods and development, pune	₹ 8.71
30	Improvement of village pond at Kidana, Taluka: Gandhidham.,Deputy collector & sub divisional magistrate office , anjar	₹ 72.90
31	CSR request for construction of Gym and Indoor Badminton Court as well as Synthetic Tennis Court,Anjar	₹ 77.90
32	Sanik Kaleyan Board bhuj and Jamnagar	₹ 44.00
33	NMHC Projects	₹ 605.80
	Total Cost	**Rs.1835.21 Lakh**