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/4660 (EC)/ Part V / 351 Dated: 14/08/2023

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

Sub: "Construction of 13th to 16th Cargo Berths at Kandla" by M/s Deendayal Port Authority (Erstwhile Deendayal Port Trust) – **Point wise Compliance to the stipulations in CRZ Recommendations reg.**

Ref.: 1) Director (Env)'s letter no.ENV-10-2006-138- P dated 14/2/2008
2) KPT letter no. EG/WK/4660 (EC)/Part III/1088 dated 9/12/2013
3) KPT letter no. EG/WK/4660 (EC)/Part III/252 dated 19/5/2014
4) KPT letter no. EG/WK/4660 (EC)/Part III/199 dated 14/11/2014
5) KPT letter no. EG/WK/4660 (EC)/Part III/255 dated 11/05/2015
6) KPT letter no. EG/WK/4660 (EC)/Part III/163 dated 15/10/2015
7) KPT letter no. EG/WK/4660 (EC)/Part III/132 dated 09/05/2016
8) KPT letter no. EG/WK/4660(EC)/Part IV/168 dated 26/12/2016
9) DPT letter no. EG/WK/4660(EC)/Part V/324 dated 26/06/2018
10) DPT letter no. EG/WK/4660(EC)/Part V/54 dated 14(16)/02/2019
11) DPT letter no. EG/WK/4660(EC)/Part V/206 dated 30(6)/11(12)/2019
12) DPT letter no. EG/WK/4660(EC)/Part V/108 dated 15/01/2021
13) DPT letter no. EG/WK/4660(EC)/Part V/91 dated 07/10/2021
14) DPA letter no. EG/WK/4660 (EC)/Part V dated 28/03/2022
15) DPA letter no. EG/WK/4660 (EC)/Part V/150 dated 19/07/2022
16) DPA letter no. EG/WK/4660 (EC)/Part V/231 dated 02/02/2023

Sir,

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

In this connection, it is to state, that Director (Environment), Forest & Environment Department, GoG vide above referred letter dated 14/2/2008 had granted CRZ Recommendations for the subject proposal. Accordingly, Deendayal Port Authority (Erstwhile Deendayal Port Trust) had regularly submitted point wise compliance report to the stipulated conditions in CRZ Recommendations.

In this regard, as requested under General condition no. 21 in the above referred letter dated 14/2/2008 i.e. A six-monthly report on compliance of the

...Cont...

conditions mentioned in this letter shall have to be furnished by the DPA on a regular basis to this Department and MoEF&CC, GoI, please find enclosed herewith compliance report of Deendayal Port Authority along with necessary annexure (**Annexure 1**) for the period upto May, 2023 for kind information and record please.

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

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

Thanking you.

Yours faithfully,

Manager (Env.)
Deendayal Port Authority

Copy to:
Shri Amardeep Raju,
Scientist E, Ministry of Environment Forests & Climate change,
&Member Secretary (EAC-Infra 1),
Indira Paryavaran Bhavan,
3rd Floor, Vayu Wing, Jor Bagh Road, Aliganj,
New Delhi – 110 003.
Email Id: ad.raju@nic.in

Annexure -1

Annexure 1

Compliance Report for the Period upto May, 2023.

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

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

STATUS OF Berths:

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

CONSENT TO OPERATE:

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

Sr. No.	Conditions in CRZ Recommendation Letter	Compliance
Specific Conditions		
1	The provisions of the CRZ notification of 1991 and subsequent amendments issued from time to time shall be strictly adhered to by the KPT. No activity in contradiction to the Provisions of the CRZ Notification shall be carried out by the KPT.	All the 4 berths are under operation. The provisions of the CRZ notification of 1991 and subsequent amendments issued from time to time are being strictly followed by Deendayal Port Authority (Erstwhile Deendayal Port Trust).
2	The KPT shall participate financially for installing and operating the Vessel Traffic Management System in the Gulf of Kachchh and shall also take lead in preparing and operationalizing and updating regularly after getting it vetted by the Indian Coast Guard.	As informed earlier also, DPA had already contributed an amount of Rs. 41.25 Crores for installing and operating the VTMS in Gulf of Kachchh. VTMS has been handed over to Directorate General of Lighthouse and Lightships, Ministry of Shipping, GoI for operating and updating regularly to statutory authorities.
3	The KPT shall strictly ensure that no creeks or rivers are blocked due to any activity at Kandla.	All the four berths are under operation
4	Mangrove plantation in an area of 1000 ha. Shall be carried out by the KPT within 5 years in time bound manner on Gujarat coastline either within or outside the Kandla port Trust area at an appropriate place in consultation with the Forest and Environment Department. A six-monthly compliance report along with the satellite images shall be submitted to the Ministry of Environment and Forest as well as to this Department without fail.	As per the directions of the GCZMA and MoEF&CC, GoI, till date, DPA has undertaken Mangrove Plantaion in an area of 1500 Hectares since the year 2005. In addition to it, DPA has carried out additional mangrove plantation of 100 ha. in consultation with Gujarat Ecology Commission vide Work Order No. DD/WK/3050/Pt-I/GIM/PC-44 dated 02/06/2022. The copy of the details has already been communicated with the earlier compliance reports submitted. It is also relevant to submit here that, as per the direction of the Gujarat Coastal Zone Management Authority, DPA had already prepared & submitted a report on mangrove conservation and management plan formulated by Gujarat Institute of Desert Ecology during the study period of Jan-April, 2015 (Report already submitted along with earlier compliance reports submitted). For regular monitoring, DPA vide work order dated 3/5/2021 has assigned work to M/s GUIDE, Bhuj for Monitoring of mangrove plantation carried out by DPA (Period from 24/5/2021 to 23/5/2022). The final report submitted by GUIDE, Bhuj has already been communicated with the last compliance report submitted.
5	No activities other than those permitted by the competent authority under the CRZ	All the four berths are under operation.

	Notification shall be carried out in the CRZ area.	
6	No ground water shall be tapped for any purpose during the proposed expansion modernization activities.	Groundwater requirement is met through GWSSB or private tankers.
7	All necessary permissions from different Government Departments / agencies shall be obtained by the KPT before commencing the expansion activities.	DPA obtained Consolidated Consent & Authorization (CC&A) from the GPCB vide Consent Order no-AWH-110594 dated of issue-8/12/2020, with a validity period upto 21/7/2025– Detailed Order issued by the GPCB vide outward no. 581914 dated 22/1/2021 & subsequently, issued Correction in CC&A order vide letter no. PC/CCA-KUTCH-812(5)/GPCB ID 28494/588116 dated 9/4/2021 (The copy of the Order has already been communicated with the last compliance report submitted).
8	No effluent or sewage shall be discharged into the sea/creek or in the CRZ area and It shall be treated to conform to the Norms prescribed by Gujarat Pollution Control Board and would be reused/recycled within the plant premises to the extent possible.	Generated sewage is treated in the existing STP (1.5 MLD capacity) of DPA. In addition to that, it also has septic tanks at places where STP is inaccessible. The treated sewage is being used for gardening and plantation purposes. For monitoring of environmental parameters including the STP, DPA has been appointing NABL Accredited laboratory and reports are being submitted from time to time to the Regional Office as well as to the MoEF&CC, GoI, New Delhi. Recently, DPA appointed GEMI, Gandhinagar for regular monitoring of environmental parameters vide Work Order dated 15/02/2023. The Environmental Monitoring Plan submitted by GEMI is attached herewith as **Annexure A**.
9	All the recommendations and suggestion given by the NIOT in their Comprehensive Environment Impact Assessment report for conservation / protection and betterment of environment shall be implemented strictly by the KPT.	Currently, all the four berths are under operation. As per the directions of the GCZMA and MoEF&CC, GoI, till date, DPA has undertaken Mangrove Plantaion in an area of 1500 Hectares since the year 2005. In addition to it, DPA has carried out additional mangrove plantation of 100 ha. in consultation with Gujarat Ecology Commission vide Work Order No. DD/WK/3050/Pt-I/GIM/PC-44 dated 02/06/2022. The copy of the details has already been communicated with the earlier compliance reports submitted. For regular monitoring, DPA vide work order dated 3/5/2021 has assigned work

		to M/s GUIDE, Bhuj for "Monitoring of mangrove plantation" carried out by DPA (Period from 24/5/2021 to 23/5/2022). The final report submitted by GUIDE, Bhuj has already been communicated with the last compliance report submitted. Further, DPA vide work order dated 03/05/2021 has assigned work to M/s GUIDE 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 second year post-monsoon report for the year 2022-2023 submitted by GUIDE, Bhuj is attached herewith as **Annexure B.** To control fugitive emissions, DPA has installed Mist Canon at the Port area. Further, to control dust pollution in other area, regular sprinkling through tankers on roads and other staking yards is being done. it is relevant to mention that Pollution under Control (PUC) Certificates has been made mandatory for vehicles in the port area. For waste generated from ships, DPA issued Grant of License/Permission to carry out the work of collection and disposal of "Hazardous Waste/Sludge/ Waste Oil" and for removal of "Dry Solid Waste (Non-Hazardous)" from Vessels calling at Deendayal Port through DPA contractors. Further, it is to state that, all ships are required to follow DG Shipping circulars regarding the reception facilities at Swachch Sagar portal. Further, DPA vide work order dated 24/01/2023 has appointed GEMI, Gandhinagar for "Preparation of Plan for Management of Plastic Wastes, Solid Waste including C&D waste, Hazardous wastes including Biomedical and Non-Hazardous Waste in the Deendayal Port Authority area". The work is in progress. For monitoring of environmental parameters including the STP, DPA has been appointing NABL Accredited laboratory and reports are being submitted from time to time to the Regional Office as

		well as to the MoEF&CC, GoI, New Delhi. Recently, DPA appointed GEMI, Gandhinagar for regular monitoring of environmental parameters vide Work Order dated 15/02/2023. The Environmental Monitoring Plan submitted by GEMI is attached herewith as **Annexure A**.
10	The construction activities and dredging shall be carried out only under the constant supervision and guidelines of the NIOT.	All the four berths are currently under operation.
11	The KPT shall contribute financially for any common study or project that may be proposed by this Department for environmental management / conservation / improvement for the Gulf of Kachchh.	Point noted
12	The construction debris and / or any other of waste shall not be disposed of into the sea, creek or the CRZ areas. The debris shall be removed from the construction site immediately after the construction is over.	All the 4 berths are currently under operation.
	General Conditions	
13	The construction camps shall be located outside the CRZ area and the construction labour shall be provided with the necessary amenities, including sanitation, water supply and fuel and it shall be ensured that the environmental conditions are not deteriorated by the construction labours.	All the 4 berths are currently under operation.
14	The KPT shall bear the cost of the external agency that may be appointed by this Department for supervision / monitoring of proposed activities and the environmental impacts of the proposed activities.	Point noted
15	The KPT shall take up massive greenbelt development activities in and around Kandla and also within the KPT limits.	Deendayal Port Authority had taken up massive greenbelt development activities in and around Kandla, Residential colony, administrative building etc. DPA had entrusted the work to Forest Department, Gujarat during August, 2019 for developing green belt in and around Port area at a cost of Rs. 352 lakhs in an area of about 32 hectares and the work is completed. Further, 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 has been completed and the final report submitted by GUIDE, Bhuj is attached as **Annexure C**.
16	The KPT shall have to contribute financially for talking up the socio-economic upliftment activities in this region in construction with the Forest and Environment Department and the District Collector / District Development Officer.	CSR activities are being attended by DPA. Copy of the activities undertaken by DPA as a part of CSR is enclosed as **Annexure D.**
17	A separate budget shall be earmarked for environmental management and socioeconomic activities and details there of shall be furnished to this Department as well as the MoEF, GOI. The details with respect to the expenditure from this budget head shall also be furnished.	The allocation made under the scheme of "Environmental Services & Clearance thereof other related Expenditure" during BE 2023-24 is Rs. 274 Lakhs. The expenditure made under the scheme of "Environmental Services & Clearance thereof other related Expenditure" is Rs. 73.99 Lakhs from Dec, 2022 to May 2023.
18	A separate environmental management cell with qualified personnel shall be created for environmental monitoring and management during construction and operational phases of the project.	DPA is already having Environment Management cell. Further, DPA has also appointed expert agency for providing Environmental Experts from time to time. Recently, DPA appointed M/s Precitech Laboratories, Vapi for providing Environmental Experts vide work order dated 5/2/2021. In addition, it is relevant to submit here that, DPA has appointed Manager (Environment) on contractual basis for the period of 3 years and further extendable to 2 years (Copy of the details has already been communicated with the last compliance report submitted).
19	An Environmental report indicating the changes, if any, with respect to the baseline environmental quality in the coastal and marine environment shall be submitted every year by the KPT to this Department as well as to the MoEF, GOI.	For monitoring of environmental parameters, DPA has been appointing NABL Accredited laboratory and reports are being submitted from time to time to the GPCB, IRO, MoEF&CC, GoI, Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar for regular monitoring of environmental parameters vide Work Order dated 15/02/2023. The Environmental Monitoring Plan submitted by GEMI is attached herewith as **Annexure A**.
20	The KPT shall have to contribute financially to support the National Green Corps Scheme being implemented in Gujarat by the GEER Foundation, Gandhinagar, in	Point noted

	construction with Forests and Environment Department	
21	Six monthly reports on compliance of the conditions mentioned in this letter shall have to be furnished by the KPT on regular basis to this department/ MoEF, GOI.	DPA has regularly submitted the compliance reports to GCZMA, Gandhinagar and MoEF&CC, GOI. The last compliance report of the conditions stipulated in CRZ recommendations issued by GCZMA was submitted on 02/02/2023.
22	Any other condition that may be stipulated by this department from time to time for environmental protection/management purpose shall also have to be complied with by the KPT.	Point noted

Annexure -A

Environmental Monitoring Plan (EMP) for "Preparing and monitoring of environmental monitoring and management plan for Deendayal Port Authority at Kandla and Vadinar for a period of 3 years"

Document Ref No.: GEMI/DPA/782(2)/2022-23/36

Submitted to:

Deendayal Port Authority (DPA), Kandla

Gujarat Environment Management Institute (GEMI)

(An Autonomous Institute of Government of Gujarat)

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

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

About this Document

Gujarat Environment Management Institute (GEMI) has been assigned with the project "***Preparing and Monitoring of Environmental Monitoring and Management Plan for Deendayal Port Authority at Kandla and Vadinar for a period of 3 years*** by Deendayal Port Authority, Kandla. Under the said project the Environmental Monitoring Plan is prepared.

Name of the Report:	Environmental Monitoring Plan for Deendayal Port Authority (DPA)
Date of Issue:	21/03/2023
Version:	2.0
Document Ref.:	GEMI/DPA/782(2)/2022-23/36
Prepared by:	Ms. Surbhi Yadav, Assistant Environmental Engineer Ms. Madhavi Pimparkar, Deputy Environmental Engineer
Reviewed by:	Dr. Nitasha Khatri, Senior Scientific Officer & Lab Head
Approved by:	Dr. Jaipal Singh, IFS, APCCF & Director

Table of Contents

Chapter: 1 4

Introduction 4

1.1 Introduction 4

1.2 Green Ports Initiative 4

1.3 Importance of EMP 5

1.4 Objectives and scope of the Study 7

1.5 Study Area: 8

Chapter: 2 10

Methodology adopted for the study 10

2.1 Introduction: 10

2.2 Preliminary site survey: 11

2.3 Sample collection, preservation, storage and transportation to GEMI's Laboratory 12

2.4 Testing and Analysis at GEMI's Laboratory 14

Chapter: 3 15

Environmental Monitoring at Kandla and Vadinar 15

3.1 Introduction 15

3.1.1 Ambient Air: 15

3.1.2 Drinking Water: 18

3.1.3 Noise Level Monitoring: 21

3.1.4 Soil Quality Monitoring: 23

3.1.5 Sewage Treatment Plant (STP) Monitoring: 26

3.1.6 Marine Water: 28

3.1.7 Marine Sediment Monitoring: 32

3.1.8 Monitoring of Meteorological Parameters 35

3.1.9 Monitoring of DG Sets 35

3.1.10 Marine Ecological Monitoring 36

Chapter 4 39

Deliverables of the study 39

Chapter 5 40

Detailed Monitoring Plan 40

List of Tables

Table 1: Details of the sampling collection by GEMI 12
Table 2: Details of monitoring locations of Ambient Air for Kandla and Vadinar 16
Table 3: List of parameters along with the instrument used for monitoring of Ambient Air 17
Table 4: Details of Sampling Locations for Drinking Water 18
Table 5: List of parameters to be monitored for the Drinking Water at Kandla and Vadinar 20
Table 6: Details of locations for Noise Monitoring at Kandla and Vadinar 22
Table 7: Details of the Noise Monitoring to be carried out at Kandla and Vadinar 23
Table 8: Details of the Soil quality monitoring locations 24
Table 9: List of parameters to be monitored for Soil Quality at Kandla and Vadinar 25
Table 10: Details of the monitoring locations of Sewage Water Treatment PlantTable:. 26
Table 11: List of parameters to be monitored for Inlet and Outlet of STP's at Kandla and Vadinar.. 28
Table 12: Details of the sampling locations for Marine water 29
Table 13: List of parameters to be monitored for Surface Water at Kandla and Vadinar 30
Table 14: Details of the sampling locations for Marine water 32
Table 15: List of parameters to be monitored for Sediments at Kandla and Vadinar 34
Table 16: Details of Meteorological Parameters to be monitorred at Kandla and Vadinar 35
Table 17: List of parameters to be monitored for DG Emissions at Kandla and Vadinar 35
Table 14: Details of the sampling locations for Marine water 36
Table 18: List of parameters to be monitored for Marine Ecological Monitoring at Kandla and Vadinar 38
Table 19: Detailed monitoring plan 40

List of Figures

Figure 1: Methodology adopted for the study 10
Figure 2: Photographs of the Preliminary Site Visit 11
Figure 3: GEMI's state of the art laboratory equipped with modern analystical Instrument 14
Figure 4: Detailed Monitoring plan for Kandla for the month of April 2023 43
Figure 5: Detailed Monitoring Plan for Vadinar for the month of April 2023 44
Figure 6: Detailed monitoring plan for Kandla for the month of May 2023 45
Figure 7: Detailed monitoring plan for Vadinar for the month of May 2023 46

List of Maps

Map 1: Map of Kandla and Vadinar Ports 9
Map 2: Monitoring locations for Ambient Air at Kandla 16
Map 3: Monitoring locations for Ambient Air at Vadinar 17
Map 4: Sampling and Monitoring locations for Drinking Water at Kandla 19
Map 5: Sampling and Monitoring locations for Drinking Water at Vadinar 19
Map 6: Locations for Noise Monitoring at Kandla 22
Map 7: Locations for Noise Monitoring at Vadinar 23
Map 8: Sampling location for Soil Quality Monitoring at Kandla 24
Map 9: Sampling location for Soil Quality Monitoring at Vadinar 25
Map 10: Sampling location for Sewage Water Treatment Plant Monitoring: Kandla 27
Map 11: Sampling location for Sewage Water Treatment Plant Monitoring: Vadinar 27
Map 12: Sampling location for Marine Water at Kandla 29
Map 13: Sampling loaction for Marine Water at Vadinar 30
Map 14: Locations for Marine Sediment Sampling at Kandla 33
Map 15: Locations of Marine Sediment sampling at Vadinar 33
Map 16: Locations for Marine Ecological Monitoring at Kandla 37
Map 17: Locations of Marine Ecolgical Monitoring at Vadinar 37

Chapter: 1 Introduction

1.1 Introduction

Deendayal Port's journey began in 1931 with the construction of RCC Jetty by Maharao Khengarji. After, the independence of India in 1947, Deendayal Port's success story continued and it emerged to be India's No. 1 Port in the year 2007-08 and has retained the top position for the 14th consecutive year since then. On 31st March 2016, Deendayal Port created history by handling 100 MMT cargo in a year – the first Major Port to achieve this milestone.

Kandla Port, also known as the Deendayal Port is a seaport in Kutch District of Gujarat state in the western India, near the city of Gandhidham. Located on the Gulf of Kutch, it is one of major ports on the western coast. Kandla was constructed in the 1950s as the chief seaport serving western India, after the independence of India. The Port of Deendayal is located on the Gulf of Kutch on the northwestern coast of India, some 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 Authority, India's busiest major port in recent years, is gearing up to add substantial cargo handling capacity with private sector participation.

The Deendayal Port Authority 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, having a capacity of 54 MMTPA, which was first of its kind in India. Further, significant Quantum of infrastructural upgradation has been carried out & excellent maritime infrastructure has been created at Vadinar for the 32MMTPA Essar Oil Refinery in Jamnagar District.

Deendayal Port Authority (DPA), Kandla crossed the landmark 100 MMT in cargo throughput for FY 2022-23 on December 28, 2022, thereby becoming the first Major Port to reach three figures in cargo handling, that too in only 3 quarters of a fiscal year.

1.2 Green Ports Initiative

Deendayal Port Authority 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 equipments 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.

Deendayal Port Authority has also appointed Gujarat Environment Management Institute (GEMI) as an Advisor for "Making Deendayal Port a Green Port - Intended Sustainable Development under the Green Port Initiatives.

Deendayal Port Authority 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 Deendayal Port Authority. 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. Coastal habitats may be destroyed and navigational channels silted due to causeway construction and land reclamation.
2. Unregulated mariculture activities in the port and harbour areas may threaten navigation safety.
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. Air pollutant emissions due to ship emissions, loading and unloading activities, construction emission and emissions due to vehicular movement.

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 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 all construction and 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 both during the construction and operational phases of the new port but only for operation of existing ports to ensure the effectiveness of the mitigation measures and to give guidance as to the most appropriate way of dealing with any unforeseen effects.

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. It is extremely essential that port and harbour projects should have an environmental management plan (EMP), which incorporates monitoring of air, marine water, soil, sediment quality along with the collection of online meteorological data throughout the life of the project. This documents presents the environmental monitoring plan for Kandla and Vadinar. An EMP is a essentially a site-specific plan developed to ensure that all necessary measures are identified and implemented in order to protect the environment and comply with environmental legislation

1.4 Objectives and scope of the Study

In line with the work order, the key objective of the study is "Preparing and Monitoring of Environmental Monitoring and Management Plan at Kandla and Vadinar"

The scope of work includes:

1. To review the locations of Ambient Air, Ambient Noise, Drinking water, and Marine Water, Soil and Sediments monitoring stations 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 Kandala and two 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 stations 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. Every week a sample (Treated wastewater) of the Sewage Treatment Plant (STP) shall be analyzed to see the water quality being discharged by DPA.
9. Noise monitoring will be carried out 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 and precise and continuous data collection is of utmost importance. The data collected is analyzed as per the standards. Meteorological data on wind speed, wind direction, temperature, relative humidity, solar radiation and rainfall will be collected from one permanent station at DPA and one permanent station at Vadinar.
11. To suggest incorporates, 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 managment plans on Monitoring programme based on findings of study.

1.5 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 two ports of DPA, i.e. Kandla and Vadinar have been dicussed hereunder:

a. Kandla:

Kandla is a village where Deendayal Port Authority is an Organization, a seaport in Kutch District of Gujarat state in western India, near the city of Gandhidham located at 23.03°N and 70.22°E. Located on the Gulf of Kutch, it is one of major ports on west coast. Kandla was constructed in the 1950s as the chief seaport serving western India. Deendayal Port Authority is situated in the Kandla Creek and the creek system consists of 3 main creeks the Nakti, the Kandla and the Hansthal, and the Little Gulf of Kutch interconnecting through many other big and small creeks, all along the coast. Very few rivers drain into the Gulf and they carry only a small quantity of freshwater, except during the brief monsoon. It is a protected natural harbour. Today, the Port of Kandla is India's hub for exporting grains and importing oil and one of the highest-earning ports in the country. Major imports entering the Port of Kandla are petroleum, chemicals, and iron and steel and iron machinery, but it also handles salt, textiles, and grain.

The Marine water of Gulf of Kutch and its creeks like Kandla creek, Nakti creek and Khori creek are providing the suitable habitat for marine vegetation. The Gulf abounds in marine wealth and is considered as one of the biologically rich marine habitat along the west coast of India.

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

b. Vadinar:

Vadinar is located at West Coast India in India at coordinates N 22° 27' 16.20" - E 069° 40' 30.01". The Deendayal Port Authority 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, having a capacity of 54 MMTPA. The locations of Kandla Port and Vadinar port have been depicted in the **Map 1** as follows:

Map 1: Map of Kandla and Vadinar Ports

Chapter: 2
Methodology adopted for the study

2.1 Introduction:

The aim of the project management methodology is to allow the control of the whole process of management through effective decision-making and problem solving. The methodology adopted for the present study is as follows in figure 1:

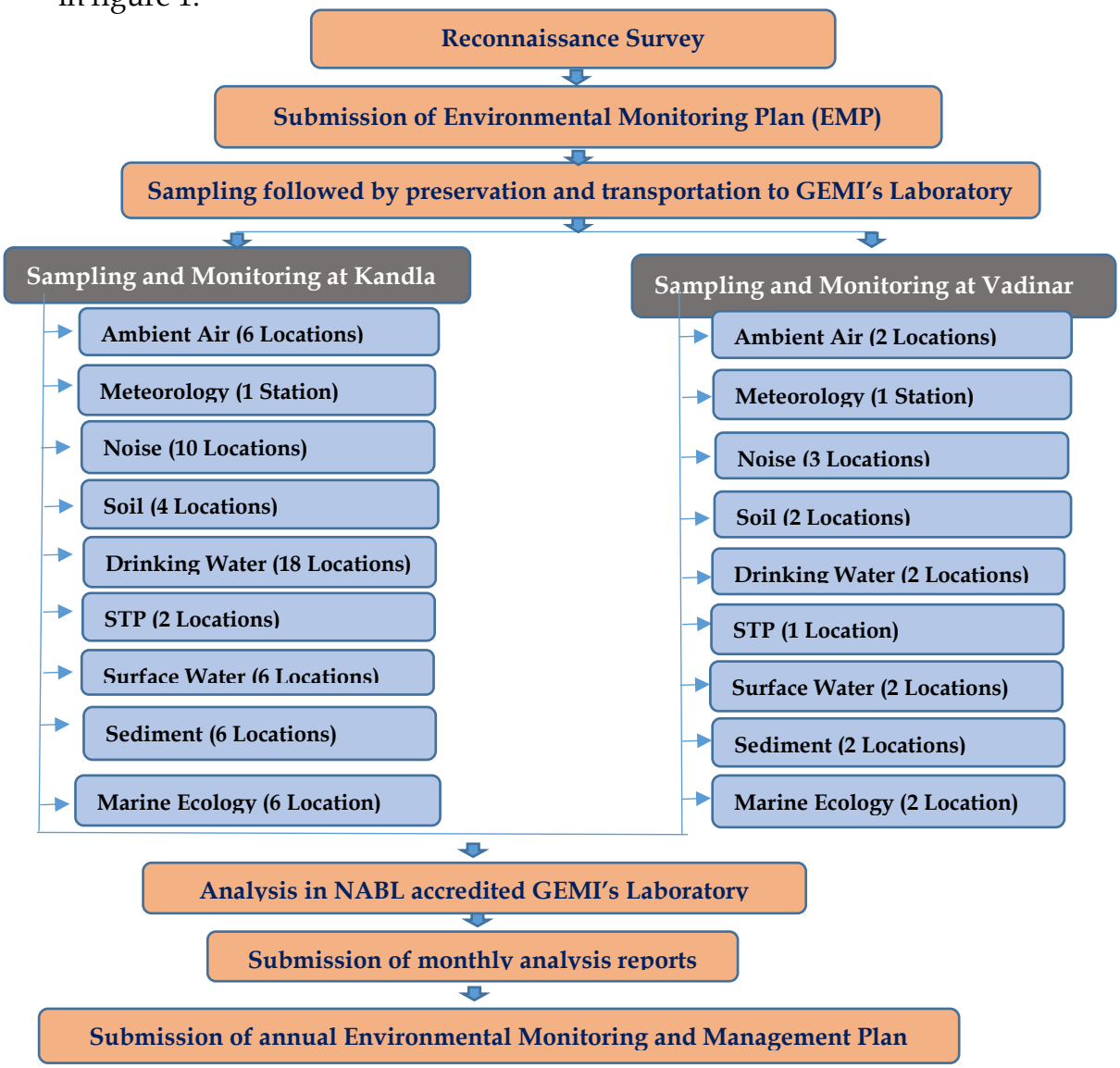


Figure 1: Methodology adopted for the study

2.2 Preliminary site survey:

With an aim of finalizing the monitoring locations at Kandla, the preliminary site visit was conducted on 24th January 2023 by the officials of GEMI accompanied by the monitoring team. Based on the said site visit, the monitoring locations as well as the frequency of the parameters was finalized. The few photographs of the monitoring locations visited and finalized during the preliminary site survey are depicted as **Figure 2:**

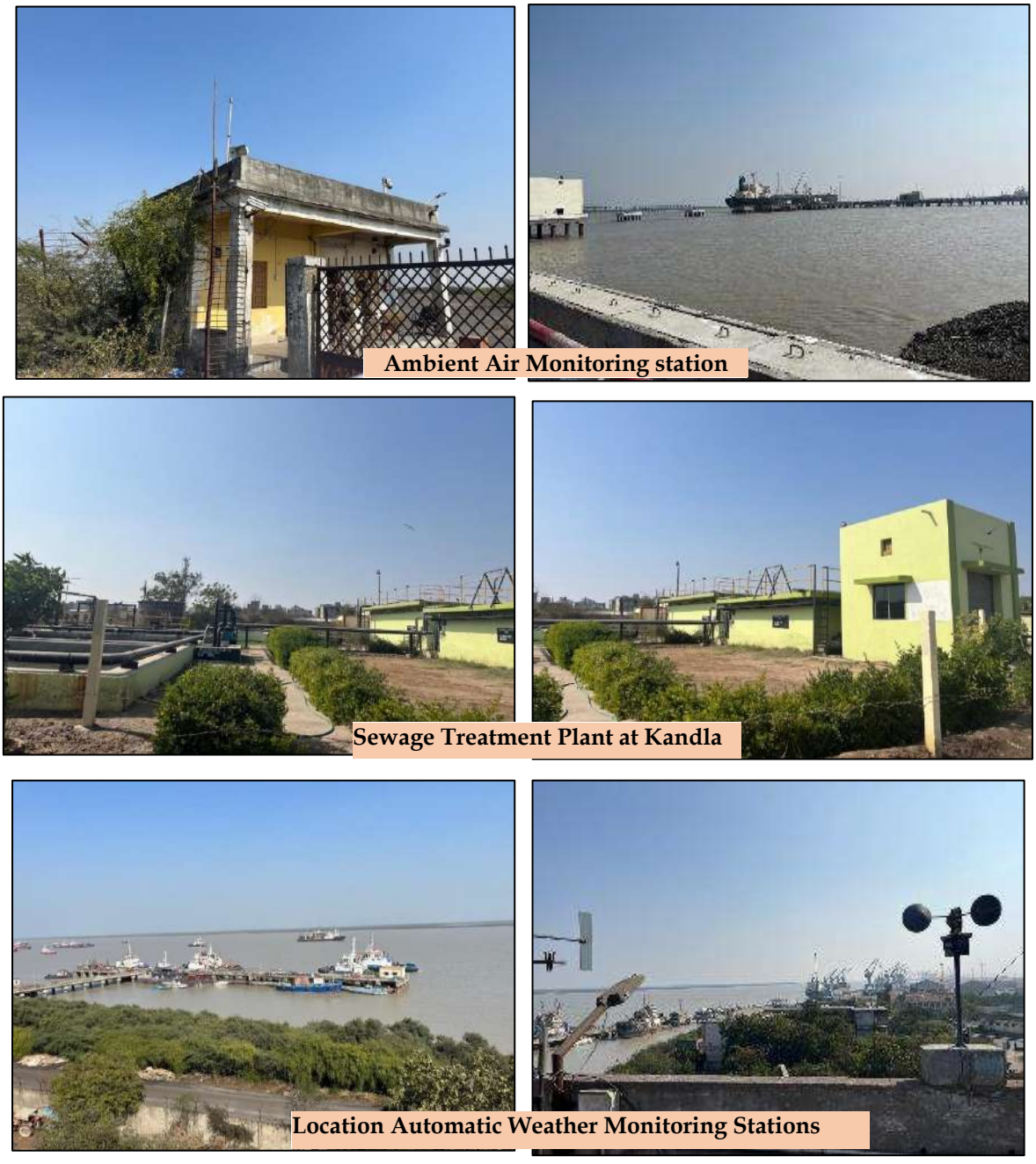


Figure 2: Environmental Monitoring locations at Kandla

2.3 Sample collection, preservation, storage and transportation to GEMI's Laboratory

GEMI has framed its own protocols for sampling of water, wastewater and soil. Whereas, for the other components of environment such as Ambient Air, Noise, Marine Ecology, Marine Water and Sediments the other sampling and monitoring guidelines/manuals brought out by CPCB shall be followed. The sampling is carried out by GEMI's trained manpower and timely calibrated instruments. The details of the environmental samples and its respective standards are summarized in **Table 1:**

Table 1: Details of the sampling collection by GEMI

Sr. No.	Type of sample		Manual/ Standards and Protocols
1.	**Ambient Air**	PM_{10}	IS 5182 (Part 23): 2006-
		$PM_{2.5}$	IS:5182 (Part:24):2019
		SO_x	IS:5182 (Part-2):2001
		NO_x	IS:5182 (Part-6):2006
		Carbon Monoxide	GEMI/SOP/AAQM/11; Issue no 01, Issue date 17.01.2019: 2019
		Benzene	IS 5182 (Part 11): 2006
		VOC	IS 5182(Part 17): 2004
		PAH	IS 5182 (Part 12): 2004
		Non-Methane VOC	IS 5182 (Part 11): 2001
2.	**DG Stack**		IS: 11255 and USEPA Method
3.	**Meteorological data**		Installation of Automatic Weather Stations so as to get the periodic Meteorological data as per the requirement
4.	**Water** **(Drinking Water, Surface Water and Sewage Effluent)**		• Guidelines on Water Quality Monitoring, 2017 by Central Pollution Control Boards

		• Sampling Protocol for Water & Wastewater 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.
5.	**Soil and Marine Sediments**	Soil Sampling Manual by GEMI published in November 2016
6.	**Noise**	IS 9989:2014
7.	**Marine Ecology**	Technical guidance book – An introduction to aquatic Bio-monitoring using Macro-invertebrates, 2021 by CPCB

2.4 Testing and Analysis at GEMI's Laboratory

GEMI's Laboratory is National Accreditation Board for Testing & Calibration Laboratories (NABL) accredited for Physical, Chemical, and Microbiological and Air parameters. It has been recognized as 'State Water Lab', 'State Air Lab' and "Environmental Laboratory" under the provisions of Water Act 1974, Air Act 1981 and Environment Protection Act 1986 respectively.

The samples are collected, appropriately preserved & transported to GEMI's Laboratory for further analysis. The analysis is carried out by proficient and trained laboratory scientists using modern analytical instruments as shown in **Figure-3**.

Figure 3: GEMI's state of the art laboratory equipped with modern analystical Instrument

All the test procedures adopted to analyze the physico-chemical and biological parameters are as per the Standard Methods along with various Standard methods adopted from Indian Standards (IS), EPA, ICAR, etc.

Chapter: 3
Environmental Monitoring at Kandla and Vadinar

3.1 Introduction

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 any deterioration in environmental conditions due to operation of the project, to enable taking up 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 monitoring.

Environmental Monitoring Plan (EMP) comprises of monitoring of the various aspects of the environment such as Ambient Air, Noise, Meteorology, Surface Water, Marine water and sediments as well as Marine Ecology. The environmental monitoring is carried out taking into consideration the following objectives:

1. Verify effectiveness of planning decisions;
2. Measure effectiveness of operational procedures;
3. Confirm statutory and corporate compliance; and
4. Identify unexpected changes.

The environmental impacts of various activities in port and harbour principally concern coastal and estuarine water quality, contamination of soil, degradation in sediment quality, air quality, noise generation beyond the permissible limits and generation of various types of wastes. There is always apprehension that the contaminants in both water and air affect marine and coastal life, crops, trees, wild animals and their habitats. Human health is also affected directly or indirectly. Samples of different environment, i.e. Water, Sediment, Air and Noise have been collected to study the status of pollution arising due to various increased activities at the Kandla and Vadinar Port.
Under the present study, the various sectors of Environment are proposed to be monitored, which are as follows:

3.1.1 Ambient Air:

Ports require air quality monitoring to have information about the current air quality of their port and surrounding area. To improve air quality, ports need to know the cause of pollution. Once the source is identified, ports can then develop a strategy to reduce pollution.

As defined in the scope by Deendayal Port Authority (DPA), the Air monitoring shall be carried out at eight locations, six at Kandla and two at Vadinar. The monitoring cycle at all eight monitoring stations is twice in a week for a period of 24 hours. Sampling for PAH and Non-methane VOC monitoring will be done for once in a month. The details of the locations to be monitored is as mentioned in **Table 2:**

Table 2: Details of monitoring locations of Ambient Air for Kandla and Vadinar

Sr. No.	Location Name		Location Code	Latitude	Longitude
1.	Kandla	Oil Jetty No. 1	A-1	23.027580N	70.219992E
2.		Oil Jetty No. 7	A-2	23.043538N	70.218617E
3.		Kandla Port Colony	A-3	23.019797N	70.213536E
4.		Marine Bhavan	A-4	23.007653N	70.222197E
5.		Coal Storage Area	A-5	23.000190N	70.219757E
6.		Gopalpuri Hospital	A-6	23.081506N	70.135258E
7.	Vadinar	Admin Building	A-7	22.441806N	69.677056E
8.		Vadinar Colony	A-8	22.401939N	69.716306E

The map depicting the locations of Ambient Air to be monitored in Kandla and Vadinar have been mentioned in **Map 2 and 3** as follows:

Map 2: Monitoring locations for Ambient Air at Kandla

Map 3: Monitoring locations for Ambient Air at Vadinar

The list of parameters to be monitored under the projects for the Ambient Air been mentioned in **Table 3** as follows:

Table 3: List of parameters along with the instrument used for monitoring of Ambient Air

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

3.1.2 Drinking Water:

In India, for checking drinking water quality, IS has specified standards (IS 10500:2012) to provide safe drinking water to the people. It is necessary that drinking water sources should be tested regularly to know whether water is meeting the prescribed standards for drinking. Monitoring the drinking water quality is essential to protect human health and the environment.

As defined in the scope by Deendayal Port Authority (DPA), the Drinking Water sampling and analysis shall be carried out once a month at twenty locations i.e, eighteen at Kandla and two at Vadinar. The details of the locations to be monitored are mentioned in **Table 4** as follows:

Table 4: Details of Sampling Locations for Drinking Water

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

The map depicting the locations of Drinking Water to be sampled and analysed in Kandla and Vadinar have been mentioned in **Map 4 and 5** as follows:

Map 5: Sampling and Monitoring locations for Drinking Water at Kandla

Map 4: Sampling and Monitoring locations for Drinking Water at Vadinar

The list of parameters to be monitored under the projects for the Drinking Water has been mentioned in **Table 5** as follows:

Table 5: List of parameters to be monitored for the Drinking Water at Kandla and Vadinar

Sr. No.	Parameters	Reference method	Instrument
1.	pH	APHA, 23rd Edition (Section-4500-H+B):2017	pH Meter
2.	EC	APHA, 23rd Edition (Section-2510 B):2017	Conductivity Meter
3.	TDS	APHA, 23rd Edition (Section-2540 C):2017	Vaccum Pump with filtration assembly and Oven
4.	Chloride	APHA, 23rd Edition (Section-4500-Cl-B):2017	Titration Apparatus
5.	Total Hardness	APHA, 23rd Edition (Section-2340 C):2017	Titration Apparatus
6.	Ca Hardness	APHA, 23rd Edition (Section-3500-Ca B):2017	Titration Apparatus
7.	Mg Hardness	APHA, 23rd Edition (Section-3500-Mg B):2017	Titration Apparatus
8.	Turbidity	APHA, 23rd Edition (Section -2130 B):2017	Nephlo Turbidity Meter
9.	Fluoride	APHA, 23rd Edition (Section-4500-F-D):2017	UV- Visible Spectrophotometer
10.	Sulphate	APHA, 23rd Edition (Section 4500-SO4-2-E):2017	UV- Visible Spectrophotometer
11.	Sodium	APHA, 23rd Edition (Section-3500-Na-B):2017	Flame Photometer
12.	Potassium	APHA,23rd Edition, 3500 K-B: 2017	Flame Photometer
13.	Nitrate	APHA, 23rd Edition, 4500 NO3- B: 2017	UV- Visible Spectrophotometer
14.	Nitrite	APHA, 23rd Edition, 4500 NO2-B: 2017	UV- Visible Spectrophotometer
15.	Manganese	APHA,23rd Edition, ICP Method 3120 B: 2017	ICP-OES
16.	Mercury	EPA 200.7	ICP-OES
17.	Salinity	APHA, 23rd Edition (section 2520 B, E.C. Method)	Salinity /TDS Meter
18.	Free Residual Chlorine	APHA 23rd Edition, 4500	Titration Apparatus
19.	Lead	APHA ICP 23rd Edition (Section-3120 B):2017	ICP-OES
20.	Cadmium	APHA ICP 23rd Edition (Section-3120 B):2017	ICP-OES

Sr. No.	Parameters	Reference method	Instrument
21.	Iron	APHA ICP 23rd Edition (Section-3120 B):2017	ICP-OES
22.	Total Chromium	APHA ICP 23rd Edition (Section-3120 B):2017	ICP-OES
23.	Hexavalent Chromium	APHA, 23rd Edition, 3500 Cr B: 2017	UV- Visible Spectrophotometer
24.	Copper	APHA,23rd Edition, ICP Method 3120 B: 2017	ICP-OES
25.	Zinc	APHA ICP 23rd Edition (Section-3120 B):2017	ICP-OES
26.	Arsenic	APHA ICP 23rd Edition (Section-3120 B):2017	ICP-OES
27.	Colour	APHA, 23rd Edition, 2120 B:2017	Color Comparator
28.	TSS	APHA, 23rd Edition, 2540 D: 2017	Vaccum Pump with filtration assembly and Oven
29.	Micro (MPN)	IS 15185: 2016	LAF/ Incubator

3.1.3 Noise Level Monitoring:

The noise monitoring at Port is aimed to understand the source and intensity of port-related noises and respond to community concerns regarding noise. An effective noise monitoring is helpful to identify noise limits exceedings of the port areas and will assist to formulate a plan incorporating the mitigation measures if needed. The sources of noise at the port may vary according to daily activities. The sources may be domestic, natural (shores, birds/animal shouts, wind movement, sea tide movement, waterfalls etc.), commercial (automobiles, aeroplanes, machinery etc.), industrial (generator sets, boilers, plant operations, trolley movement, transport vehicles, pumps, motors etc.).

As defined in the scope by Deendayal Port Authority (DPA), the Noise Monitoring shall be carried out at total thirteen locations, i.e., 10 at Kandla and 3 at Vadinar. The Noise will be monitored once in a month at all the locations for a period of 24 hours. Data will be recorded using automated Sound Level Meter conforming to **IEC 61672-1(Latest)/ IS:15575/(Pt1 & Pt2) with category Class-I.** The intensity of sound will be measured in sound pressure level (SPL) and common unit of measurement is decibel (Db). The details of the Noise Monitoring are as mentioned in **Table 6**:

Table 6: Details of locations for Noise Monitoring at Kandla and Vadinar

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

The map depicting the locations of Noise Level Monitoring at Kandla and Vadinar have been depicted in **Map 6 and 7** as follows:

Map 6: Locations for Noise Monitoring at Kandla

Map 7: Locations for Noise Monitoring at Vadinar

The details of Noise Monitoring to be carried out under the study has been mentioned in **Table 7** as follows:

Table 7: Details of the Noise Monitoring to be carried out at Kandla and Vadinar

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

3.1.4 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. Sampling will be done once in a month at all stations in Kandla and Vadinar. The details of the locations to be monitored is mentioned in **Table 8:**

Table 8: Details of the Soil quality monitoring locations

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

The map depicting the locations of Soil Quality Monitoring to be monitored in Kandla and Vadinar have been mentioned in **Map 8 and 9** as follows:

Map 8: Sampling location for Soil Quality Monitoring at Kandla

Map 9: Sampling location for Soil Quality Monitoring at Vadinar

The list of parameters to be monitored under the projects for the Soil Quality Monitoring heen mentioned in **Table 9** as follows:

Table 9: List of parameters to be monitored for Soil Quality at Kandla and Vadinar

Sr. No.	Parameters	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		Titration Apparatus
3.	Inorganic Phosphate	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	IS 14767: 2000	Conductivity Meter
7.	Particle size distribution & Silt content	Methods Manual Soil Testing in India January 2011	Sieves Apparatus

8.	SAR	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	EPA Method 3051A	ICP-OES
11.	Chromium	EPA Method 3051A	ICP-OES
12.	Nickel	EPA Method 3051A	ICP-OES
13.	Copper	Methods Manual Soil Testing in India January, 2011, 17a	ICP-OES
14.	Zinc	Methods Manual Soil Testing in India January, 2011, 17a	ICP-OES
15.	Cadmium	EPA Method 3051A	ICP-OES
16.	Lead	EPA Method 3051A	ICP-OES
17.	Arsenic	EPA Method 3051A	ICP-OES
18.	Mercury	EPA Method 3051A	ICP-OES

3.1.5 Sewage Treatment Plant (STP) Monitoring:

The principal objective of wastewater treatment is generally to allow human and industrial effluents to be disposed off without danger to human health or unacceptable damage to the natural environment. As defined in the scope by Deendayal Port Authority (DPA), Kandla, the Sewage Water Treatment Plant Monitoring as to be carried out at three locations, one at Kandla, one at Gopalpuri and one STP at Vadinar. The samples each from the treated wastewater of the STP have to be collected weekly. The details of the locations of Sewage Treatment Plants to be monitoried for Kandla and Vadinar are as mentioned in **Table 10** as follows:

Table 10: Details of the monitoring locations of Sewage Water Treatment PlantTable:.

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

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

Map 10: Sampling location for Sewage Water Treatment Plant Monitoring: Kandla

Map 11: Sampling location for Sewage Water Treatment Plant Monitoring: Vadinar

The list of parameters to be monitored under the projects for the Sewager Water Treatment Plants have been mentioned in **Table 11** as follows:

Table 11: List of parameters to be monitored for Treated Wastewater of STP's at Kandla and Vadinar

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

3.1.6 Marine Water:

Major water quality concerns at ports include wastewater and leaking of toxic substances from ships, stormwater runoff. This oily wastewater, combined with other ship wastes, including 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 Deendayal Port Authority (DPA), the Marine Water sampling and analysis as to be carried out at total eight locations, six at Kandla and two at Vadinar. The marine water samping will be carried out with the help of Niskin Sampler. It is a device used to take water samples at a desired depth without the danger of mixing with water from other depths. The details of the locations to be monitored is as mentioned in **Table 12:**

Table 12: Details of the sampling locations for Marine water

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

The map depicting the locations of Marine Water to be sampled and analysed in Kandla and Vadinar have been mentioned in **Map 12 and 13** as follows:

Map 12: Sampling location for Marine Water at Kandla

Map 13: Sampling loaction for Marine Water at Vadinar

The list of parameters to be monitored under the projects for the Marine water Sampling and monitoring been mentioned in **Table 13** as follows:

Table 13: List of parameters to be monitored for Marine Water at Kandla and Vadinar

Sr. No.	Parameters	Reference method	Instrument
1.	Electrical Conductivity	APHA, 23rd Edition (Section-2510 B):2017	Conductivity Meter
2.	DO	APHA, 23rd Edition, 4500 O C, 2017	Titration Apparatus
3.	pH	APHA, 23rd Edition (Section-4500-H^+B):2017	Ph meter
4.	Color	APHA, 23rd Edition, 2120 B: 2017	Color comparator
5.	odour	IS 3025 Part 5: 2018	Heating mantle & odour bottle
6.	Turbidity	IS 3025 Part 10: 1984	Nephlo Turbidity Meter
7.	Total Dissolved Solids	APHA, 23rd Edition (Section-2540 C):2017	Vaccum Pump with Filtration Assembly and Oven
8.	Total Suspended Solids	APHA, 23rd Edition, 2540 D: 2017	Vaccum Pump with filtration assembly and Oven
9.	Particulate Organic Carbon	APHA, 23rd Edition, 2540 D and E	TOC analyser
10.	COD	IS-3025, Part- 58: 2006	Titration Apparatus plus Digester

11.	BOD	IS-3025,Part 44,1993,	BOD Incubator plus Titration apparatus
12.	Silica	APHA, 23rd Edition, 4500 C, 2017	UV- Visible Spectrophotometer
13.	Phosphate	APHA,23rd Edition, 4500 P-D: 2017	UV- Visible Spectrophotometer
14.	Sulphate	APHA, 23rd Edition, 4500 SO4-2 E : 2017	UV- Visible Spectrophotometer
15.	Nitrate	APHA, 23rd Edition, 4500 NO3-B : 2017	UV- Visible Spectrophotometer
16.	Nitrite	APHA, 23rd Edition, 4500 NO2- B: 2017	UV- Visible Spectrophotometer
17.	Sodium	APHA,23rd Edition, 3500 Na- B : 2017	Flame photometer
18.	Potassium	APHA,23rd Edition, 3500 K-B: 2017	Flame photometer
19.	Manganese	APHA,23rd Edition, ICP Method 3120 B: 2017	ICP-OES
20.	Iron	APHA,23rd Edition, ICP Method 3120 B: 2017	ICP-OES
21.	Total Chromium	APHA, 23rd Edition, 3500 Cr B: 2017	ICP-OES
22.	Hexavalent Chromium	APHA, 23rd Edition, 3500 Cr B: 2017	UV- Visible Spectrophotometer
23.	Copper	APHA, 23rd Edition, ICP Method 3120 B: 2017	ICP-OES
24.	Cadmium	APHA, 23rd Edition, ICP Method 3120 B: 2017	ICP-OES
25.	Arsenic	APHA, 23rd Edition, ICP Method 3120 B: 2017	ICP-OES
26.	Lead	APHA, 23rd Edition, ICP Method 3120 B: 2017	ICP-OES
27.	Zinc	APHA,23rd Edition, ICP Method 3120 B: 2017	ICP-OES
28.	Mercury	EPA 200.7	ICP-OES
29.	Floating Material (Oil grease scum, petroleum products)	APHA, 23rd Edition, 5520 C: 2017	Soxhlet Assembly
30.	Total Coliforms (MPN)	IS 1622: 2019	LAF/ Incubator

3.1.7 Marine Sediment Monitoring:

The unconsolidated materials derived from pre-existing rocks or similar other sources by the process of denudation are deposited in water medium is 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 harbor water along with sediment and thus collected as harbour sediment sample. These loose 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.

As defined in the scope by Deendayal Port Authority (DPA), the Marine Sediment sampling carried out once in a month at total eight locations, six at Kandla and two at Vadinar. The samping at the locations of the Marine Sediment will be carried out with the help of Van Veen Grab Sampler. A Van Veen grab is an instrument to sample (disturbed) sediment up to a depth of 15 cm in the seafloor. While letting the instrument down on the seafloor, sediment can be extracted. The details of the locations to be monitored is as mentioned in **Table 14** as follows:

Table 14: Details of the sampling locations for Marine water

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

The map depicting the locations of Marine Sediment samplingp in Kandla and Vadinar have been mentioned in **Map 14 and 15** as follows:

Map 14: Locations for Marine Sediment Sampling at Kandla

Map 15: Locations of Marine Sediment sampling at Vadinar

The list of parameters to be monitored under the projects for the Marine Sediment sampling been mentioned in **Table 15** as follows:

Table 15: List of parameters to be monitored for Sediments at Kandla and Vadinar

Sr. No.	Parameters	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	Practical Manual Chemical Analysis of Soil and Plant Samples, ICAR-Indian Institute of Pulses Research 2017	UV- Visible Spectrophotometer
4.	Silica	EPA METHOD 6010 C & IS : 3025 (Part 35) – 1888, part B	UV- Visible Spectrophotometer
5.	Phosphate	EPA Method 365.1	UV- Visible Spectrophotometer
6.	Sulphate as SO4- (Available Sulphur)	IS : 2720 (Part 27) - 1977	UV- Visible Spectrophotometer
7.	Nitrite	ISO 14256:2005	UV- Visible Spectrophotometer
8.	Nitrate	Methods Manual Soil Testing in India January, 2011, 12	UV- Visible Spectrophotometer
9.	Calcium as Ca (Exchangeable)	Methods Manual Soil Testing in India January 2011, 16.	Titration Apparatus
10.	Magnesium as Mg (Exchangeable)	Method Manual Soil Testing in India January 2011,	Titration Apparatus
11.	Sodium	EPA Method 3051A	Flame Photometer
12.	Potassium	Methods Manual Soil Testing in India January, 2011	Flame Photometer
13.	Aluminium	EPA Method 3051A	ICP-OES
14.	Chromium	EPA Method 3051A	ICP-OES
15.	Nickel	EPA Method 3051A	ICP-OES
16.	Zinc	EPA Method 3051A	ICP-OES
17.	Cadmium	EPA Method 3051A	ICP-OES
18.	Lead	EPA Method 3051A	ICP-OES
19.	Arsenic	EPA Method 3051A	ICP-OES
20.	Mercury	EPA Method 3051A	ICP-OES

3.1.8 Monitoring of Meteorological Parameters

Meteorological parameters are very important from air pollution point of view and precise and continuous data collection is of utmost importance. The data collected is analyzed as per the standards. The data shall be collected by Installation of Automatic Weather Stations so as to get the periodic Meteorological data as per the requirement. Meteorological data such as wind speed, wind direction, temperature, relative humidity, solar radiation and rainfall will be collected from one permanent station at Kandla and one at Vadinar installed by GEMI.

The details of the Meteorological data to be monitored at Kandla and Vadinar have been mentioned in **Table 16**: as follows:

Table 16: Details of Meteorological Parameters to be monitorred at Kandla and Vadinar

Sr. No.	Details of Meteorological Data	Unit of Measurement
1.	Wind Direction	degree
2.	Wind Speed	m/sec
3.	Rainfall	mm/hr
4.	Relative Humidity	% RH
5.	Temperature	^{o}C
6.	Solar Radiation	W/m^2

3.1.9 Monitoring of DG Sets

DG sets at the Deendayal Port Authority (DPA) are generally utilized as a secondary power source. The sampling and monitoring of the DG sets are proposed to be monitored as and when required, specifically once a month. The monitoring of the DG Set will be carried out with the help of Handy Sampler for the following parameters mentioned in **Table 17** as follows:

Table 17: List of parameters to be monitored for DG Emissions at Kandla and Vadinar

Sr. No.	Parameters	Reference method
1.	Particulate matter	IS: 11255 Part I
2.	Sulphur Dioxide	USEPA Method 6C: 2017
3.	Oxides of Nitrogen	USEPA Method 7E: 2019
4.	Carbon Monoxide	USEPA Method 10: 2017
5.	Carbon Dioxide	USEPA Method 3A: 2019

3.1.10 Marine Ecological Monitoring

The monitoring of the biological and ecological parameters is important to assess the marine environment. Marine environmental monitoring is undertaken to provide evidence that environmental management targets are being met. Deendayal Port and its surroundings have mangroves, mudflats and creek systems as major ecological entities.

As defined in the scope by Deendayal Port Authority (DPA), the Marine Ecological Monitoring shall be carried out once in a month specifically at eight locations, six at at Kandla and two at Vadinar. The sampling of the Benthic Invertebrates will be carried out with the help of D-frame nets, whereas the sampling of zooplankton and phytoplankton shall be carried out with the help of Plankton Nets (60 micron and 20 micron). The details of the locations to be monitored is as mentioned in **Table 18** as follows:

Table 18: Details of the sampling locations for Marine Ecological Monitoring

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

The map depicting the locations of Marine Ecological monitoring in Kandla and Vadinar have been mentioned in **Map 16 and 17** as follows:

Map 16: Locations for Marine Ecological Monitoring at Kandla

Map 17: Locations of Marine Ecolgical Monitoring at Vadinar

The various parameters to be monitored under the study for Marine Ecological Monitoring are mentioned in **Table 19** as follows:

Table 19: List of parameters to be monitored for Marine Ecological Monitoring at Kandla and Vadinar

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

Chapter 4
Deliverables of the study

The deliverables of the study are as follows:

1. Submission of the monthly sampling and analysis report to Deendayal Port Authority.
2. Preparation and submission of Annual Environmental Management Plan (EMP) with an aim of identification and prediction of impacts and suggestive mitigation measures for prevention of environmental aspects.

   The Environmental Management plan (EMP) is a site specific plan developed to ensure that the project is implemented in an environmentally sustainable manner and understand the potential environmental risks arising from the allied activities. The EMP also comprises of implementing the appropriate mitigation actions to minimize the identified risks to reduce adverse environmental impacts. The annual EMP formulated under the study shall comprise of the following:

a. Various statutary and legal compliance regarding the port
b. Current Environment Management Policy of DPA and its implemetations
c. Study on the environmental conditions of the Kandla and Vadinar Ports and its compliance in line with the regulatory requirnment. Findings based on the styding the primary as well as secondary data and their significant Impact on the Environmental Conditions due to port and its allied activities.
d. Data collected shall be reviewed for identification of the data gaps, which shall be subsequently filled up during the field study.
e. The collected data shall be analysed and the same shall be interpreted by the means of Statistical, graphical, numerical modelling, etc to arrive at a meaningful information/interpretation.
f. The collected Environmental data (Air, Water, Soil, noise, etc.) shall be compared with the relevant/latest National/International norms/standards.
g. Review of status and trend of environmental factors against which the impacts shall be identified.
h. Gaps with respect to the relevant norms/standards and further analysing the significance of such gaps by suitable statistical tools.
i. Environment Management Plan consists of below components and its current status and mitigation measures conforming to applicable environmental norms/standards.

   Ambient Air Quality ,Drinking Water Monitoring, Sewage Treatment Plant Monitoring Meteorological Parameters, Marine Sediment Quality, Ecological Monitoring,Noise Monitoring, DG Emissions (if any)
j. Recommendations of Best Management practices/policy interventions.

Chapter 5
Detailed Monitoring Plan

As per scope specified by DPA, the detailed monitoring plan to be implemented for the study is mentioned in **Table 19** as follows:

Table 20: Detailed monitoring plan

Sr. No.	Parameter	No. of locations	Frequency	Parameters to be monitored	Submission of Reports
1.	Ambient Air Quality Monitoring (8 Locations)	6 at Kandla and 2 at Vadinar	Twice a week	PM_{10}, $PM_{2.5}$, Sulphur Dioxide, Oxides of Nitrogen, Carbon Monoxide, Benzene, Volatile Organic Compound	Monthly (15th of every month for the preceding month)
			Once in a month	PAH	
				Non-methane VOC	
2.	Drinking Water Monitoring (20 Locations)	18 at Kandla and 2 at Vadinar	Once in a month	Odour, Color, pH, Turbidity, TDS, TSS, Conductivity, Chloride, Calcium as Ca, Magnesium, Total Hardness, Sulphate as SO4-, Nitrate as NO3, Nitrite as No2, Fluoride as F, Sodium as Na, Iron as Fe, Potassium as K, Manganese, Total Chromium, Hexavalent Chromium, Copper Cadmium, Arsenic, Lead, Zinc, Mercury, Salinity, Free Residual Chlorine, Micro (MPN)	Monthly (15th of every month for the preceding month)
3.	Noise level Monitoring (13 Locations)	10 at Kandla & 3 at Vadinar	24 hrs period once in a month	Leq(Day) & Night	Monthly (15th of every month for the preceding month)

4.	Soil Quality Monitoring (6 Locations)	4 at Kandla and 2 at Vadinar	Once in a month	Total Organic Matter, Organic Carbon, Inorganic Phosphate (Ortho), Texture, pH, Conductivity, Particle size distribution & Silt content, SAR, Water Holding Capacity, Aluminium, Chromium, Nickel, Copper, Zinc, Cadmium, Lead, Arsenic, Mercury	Monthly (15th of every month for the preceding month)
5.	Sewage Treatment Plant Monitoring (3 Locations)	2 at Kandla and 1 location in Vadinar	Once in a week for inlet and outlet	pH, TDS, TSS, DO, COD, BOD, SAR, Microbiological (MPN) (TC)	Monthly (15th of every month for the preceding month)
6.	Meteorological Data Monitoring (2 Locations)	1 at Kandla and 1 location in Vadinar	Daily	Wind Speed , Wind Direction, Rainfall, Relative Humidity, Temperature, Solar Radiation	Monthly (15th of every month for the preceding month)
7.	Marine Water Quality (8 Locations)	6 Stations in Kandla and 2 stations at Vadinar	Once in a month	Odour, Color, pH, Turbidity, TDS, TSS, Conductivity, DO, Particulate Organic Carbon, COD, BOD, Silica, Phosphate, Sulphate as SO4-, Nitrate as NO3, Nitrite as No2, Sodium as Na, Potassium as K, Manganese, Iron as Fe, Total Chromium, Hexavalent Chromium, Copper, Cadmium, Arsenic, Lead, Zinc, Mercury, Floating Material (Oil grease scum, petroleum products), Microbiological (MPN), Density	Monthly (15th of every month for the preceding month)
8.	Marine Water Quality for Biological Monitoring	6 Station in Kandla and 2 station at Vadinar	Once in a month	Productivity (Net and Gross), Chrlorophyll-a, Pheophytin, Biomass, Relative Abundance, species composition and diversity of phytoplankton, Relative	Monthly (15th of every month for the preceding month)

	(8 Locations)			Abundance, species composition and diversity of zooplankton, Relative Abundance, species composition and diversity of benthic invertebrates (Meio, Micro and macro benthos), Particulate oxidisable organic carbon Secchi Depth	
9.	Sediments Quality (8 Locations)	6 Stations in Kandla and 2 stations at Vadinar	Once in a month	Texture, Organic Matter, Inorganic Phosphates, Silica Phosphate, Sulphate as SO4-, Nitrite, Nitrate, Calcium as Ca, Magnesium as Mg, Sodium, Potassium, Aluminium, Copper, Chromium, Nickel, Zinc, Cadmium, Lead, Arsenic, Mercury	Monthly (15th of every month for the preceding month)

The detailed monthly monitoring plan under the study has been prepared for the months of April and May for the locations of Kandla and Vadinar have been mentioned in figures 4 to 7 as follows:

Figure 4: Detailed Monitoring plan for Kandla for the month of April 2023

Environmental Monitoring Plan for Kandla for April 2023

Project Start Date	4-10-23
Sampling and Monitoring Team	Mr. Pratap Vaja Mr. Jignesh Parmar Mr. Sunil Parmar Mr. Raj Patel Mr. Nikunj Choksi Mr. Deep Bakori Mr. Bhrugu Pandya Mr. Jaydeep Tadvi

Legends
Ambient Air Monitoring
Noise Monitoring
Drinking Water Monitoring
Soil Monitoring
Marine water and Sediment Monitoring
Marine Ecology Monitoring
STP Monitoirng

				Apr 10, 2023							Apr 17, 2023							Apr 24, 2023						
				10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
TASK	Activity Start Date	Activity End Date	Days required	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
Environmental Monitoring scope																								
Drinking Water (18 Locations)	10 April 2023	10 April 2023																						
Noise Monitoring (1 Location)	10 April 2023	11 April 2023	2																					
Noise Monitoring (1 Location)	12 April 2023	13 April 2023	2																					
Noise Monitoring (1 Location)	14 April 2023	15 April 2023	2																					
Ambient Air (6 Locations)	17 April 2023	18 April 2023	2																					
Noise Monitoring (1 Location)	17 April 2023	18 April 2023	2																					
Noise Monitoring (1 Location)	18 April 2023	19 April 2023	2																					
Marine Water and Marine Sediments (6 Locations)	19 April 2023	19 April 2023	1																					
Noise Monitoring (1 Location)	19 April 2023	20 April 2023	2																					
Ambient Air (6 Locations)	20 April 2023	21 April 2023	2																					
Noise Monitoring (1 Location)	20 April 2023	21 April 2023	2																					
Sewage Treatment Plant (2 Locations)	21 April 2023	21 April 2023	1																					
Soil Monitoring (4 Locations)	21 April 2023	21 April 2023	1																					
Noise Monitoring (1 Location)	21 April 2023	22 April 2023	2																					
Ambient Air (6 Locations)	24 April 2023	25 April 2023	2																					
Noise Monitoring (1 Location)	25 April 2023	26 April 2023	2																					
Ambient Air (6 Locations)	27 April 2023	28 April 2023	2																					
Sewage Treatment Plant (2 Locations)	28 April 2023	28 April 2023	1																					
Noise Monitoring (1 Location)	28 April 2023	29 April 2023	2																					
Marine Ecology Monitoring (1 Location)	29 April 2023	29 April 2023	1																					

Figure 5: Detailed Monitoring Plan for Vadinar for the month of April 2023

Environmental Monitoring Plan for Vadinar for April 2023

Project Start Date	10-Apr-23
Sampling and Monitoring Team	Mr. Pratap Vaja
	Mr. Jignesh Parmar
	Mr. Sunil Parmar
	Mr. Raj Patel
	Mr. Nikunj Choksi
	Mr. Deep Bakori
	Mr. Bhrugu Pandya
	Mr. Jaydeep Tadvi

Legends	
Ambient Air Monitoring	
Noise Monitoring	
Drinking Water Monitoring	
Soil Monitoring	
Marine water and Sediment Monitoring	
Marine Ecology Monitoring	
STP Monitoirng	

				Apr 10, 2023							Apr 17, 2023							Apr 24, 2023						
				10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
TASK	Sctivity Start Date	Activity End Date	Days required	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
Environmental Monitoring scope																								
Drinking Water (2 Locations)	10 April 2023	10 April 2023	1																					
Noise Monitoring (1 Location)	11 April 2023	12 April 2023	2																					
Ambient Air (2 Locations)	11 April 2023	12 April 2023	2																					
Noise Monitoring (1 Location)	13 April 2023	14 April 2023	2																					
Ambient Air (2 Locations)	13 April 2023	14 April 2023	2																					
Sewage Treatment Plant (1 Locations) (Inlet & Outlet)	14 April 2023	14 April 2023	1																					
Ambient Air (2 Locations)	17 April 2023	18 April 2023	2																					
Sewage Treatment Plant (1 Locations) (Inlet & Outlet)	18 April 2023	18 April 2023	1																					
Marine Water and Marine Sediments (2 Locations)	19 April 2023	19 April 2023	1																					
Ambient Air (2 Locations)	20 April 2023	21 April 2023	2																					
Noise Monitoring (1 Location)	20 April 2023	21 April 2023	2																					
Ambient Air (2 Locations)	24 April 2023	25 April 2023	2																					
Sewage Treatment Plant (1 Locations) (Inlet & Outlet)	25 April 2023	25 April 2023	1																					
Marine Ecology Monitoring (1 Location)	26 April 2023	26 April 2023	1																					
Ambient Air (2 Locations)	27 April 2023	28 April 2023	2																					
Soil Monitoring (2 Locations)	28 April 2023	28 April 2023	1																					

Figure 6: Detailed monitoring plan for Kandla for the month of May 2023

Environmental Monitoring Plan for Kandla for May 2023

Project Start Date	1-May-23
Sampling and Monitoring Team	Mr. Pratap Vaja
	Mr. Jignesh Parmar
	Mr. Sunil Parmar
	Mr. Raj Patel
	Mr. Nikunj Choksi
	Mr. Deep Bakori
	Mr. Bhrugu Pandya
	Mr. Jaydeep Tadvi

Legends
Ambient Air Monitoring
Noise Monitoring
Drinking Water Monitoring
Soil Monitoring
Marine water and Sediment Monitoring
Marine Ecology Monitoring
STP Monitoirng
Submission of Monthly analysis reports

TASK	Sctivity Start Date	Activity End Date	Days required
Environmental Monitoring scope			
Monthly submission of analysis report for May 2023	15 May 2023	15 May 2023	1
Ambient Air (6 Locations)	01 May 2023	02 May 2023	2
Noise Monitoring (1 Location)	01 May 2023	02 May 2023	2
Soil Monitoring (4 Locations)	03 May 2023	03 May 2023	1
Sewage Treatment Plant (2 Locations) (Inlet & Outlet)	03 May 2023	03 May 2023	1
Ambient Air (6 Locations)	04 May 2023	05 May 2023	2
Noise Monitoring (1 Location)	04 May 2023	05 May 2023	2
Ambient Air (6 Locations)	08 May 2023	09 May 2023	2
Noise Monitoring (1 Location)	08 May 2023	09 May 2023	2
Sewage Treatment Plant (2 Locations) (Inlet & Outlet)	09 May 2023	09 May 2023	1
Marine Water and Marine Sediments (6 Locations)	10 May 2023	10 May 2023	1
Marine Ecology Monitoring (6 Location)	10 May 2023	10 May 2023	1
Ambient Air (6 Locations)	11 May 2023	12 May 2023	2
Noise Monitoring (1 Location)	11 May 2023	12 May 2023	2
Drinking Water (18 Locations)	15 May 2023	15 May 2023	1
Ambient Air (6 Locations)	16 May 2023	17 May 2023	2
Noise Monitoring (1 Location)	16 May 2023	17 May 2023	2
Noise Monitoring (1 Location)	18 May 2023	19 May 2023	2
Ambient Air (6 Locations)	18 May 2023	19 May 2023	2
Sewage Treatment Plant (2 Locations) (Inlet & Outlet)	19 May 2023	19 May 2023	1
Ambient Air (6 Locations)	21 May 2023	22 May 2023	2
Noise Monitoring (1 Location)	21 May 2023	22 May 2023	2
Sewage Treatment Plant (2 Locations) (Inlet & Outlet)	23 May 2023	23 May 2023	1
Noise Monitoring (1 Location)	23 May 2023	24 May 2023	2
Ambient Air (6 Locations)	24 May 2023	25 May 2023	2
Noise Monitoring (1 Location)	24 May 2023	25 May 2023	2
Ambient Air (6 Locations)	28 May 2023	29 May 2023	2
Noise Monitoring (1 Location)	28 May 2023	29 May 2023	2
Sewage Treatment Plant (2 Locations) (Inlet & Outlet)	30 May 2023	30 May 2023	1

Figure 7: Detailed monitoring plan for Vadinar for the month of May 2023

Environmental Monitoring Plan for Vadinar for May 2023

Project Start Date	1-May-23
Sampling and Monitoring Team	Mr. Pratap Vaja
	Mr. Jignesh Parmar
	Mr. Sunil Parmar
	Mr. Raj Patel
	Mr. Nikunj Choksi
	Mr. Deep Bakori
	Mr. Bhrugu Pandya
	Mr. Jaydeep Tadvi

Legends
Ambient Air Monitoring
Noise Monitoring
Drinking Water Monitoring
Soil Monitoring
Marine water and Sediment Monitoring
Marine Ecology Monitoring
STP Monitoirng

Task	Activity Start Date	Activity End Date	Days required
Environmental Monitoring scope			
Ambient Air (2 Locations)	01 May 2023	02 May 2023	2
Noise Monitoring (1 Location)	01 May 2023	02 May 2023	2
Drinking Water (2 Locations)	02 May 2023	02 May 2023	1
Soil Monitoring (2 Locations)	03 May 2023	03 May 2023	1
Sewage Treatment Plant (1 Locations) (Inlet & Outlet)	03 May 2023	03 May 2023	1
Ambient Air (2 Locations)	04 May 2023	05 May 2023	2
Noise Monitoring (1 Location)	04 May 2023	05 May 2023	2
Marine Ecology Monitoring (1 Location)	05 May 2023	05 May 2023	1
Ambient Air (2 Locations)	08 May 2023	09 May 2023	2
Noise Monitoring (1 Location)	08 May 2023	09 May 2023	2
Sewage Treatment Plant (1 Locations) (Inlet & Outlet)	10 May 2023	10 May 2023	1
Ambient Air (2 Locations)	11 May 2023	12 May 2023	2
Ambient Air (2 Locations)	15 May 2023	16 May 2023	2
Marine Water and Marine Sediments (2 Locations)	17 May 2023	17 May 2023	1
Ambient Air (2 Locations)	18 May 2023	19 May 2023	2
Sewage Treatment Plant (1 Locations) (Inlet & Outlet)	19 May 2023	19 May 2023	1
Ambient Air (2 Locations)	21 May 2023	22 May 2023	2
Sewage Treatment Plant (1 Locations) (Inlet & Outlet)	23 May 2023	23 May 2023	1
Ambient Air (2 Locations)	24 May 2023	25 May 2023	2
Ambient Air (2 Locations)	28 May 2023	29 May 2023	2
Sewage Treatment Plant (1 Locations) (Inlet & Outlet)	29 May 2023	29 May 2023	1

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

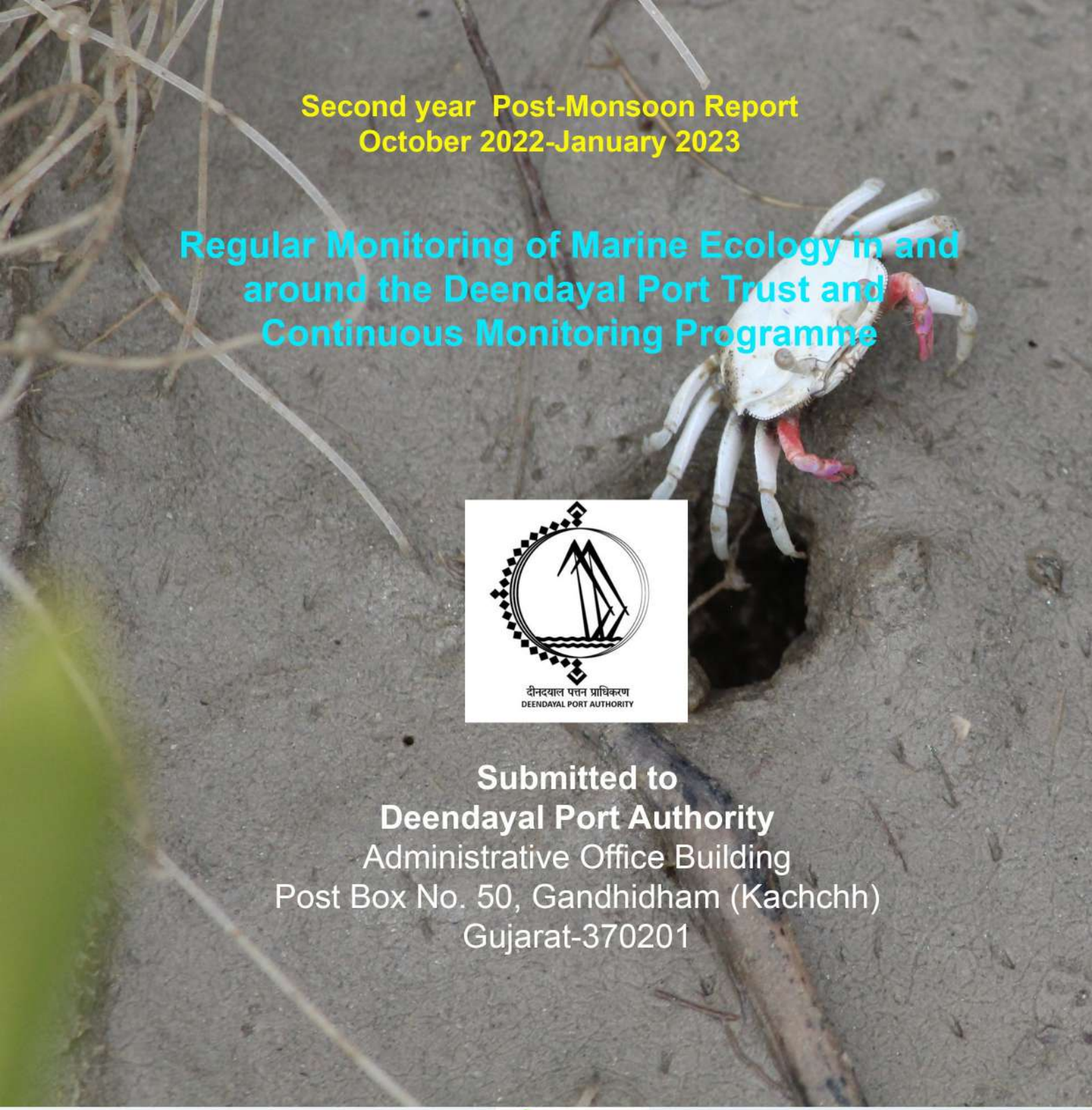
Plot No. B-64, Electronic Estate GIDC, Sector-25

Gandhinagar - 382024 (Gujarat)

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

Annexure -B

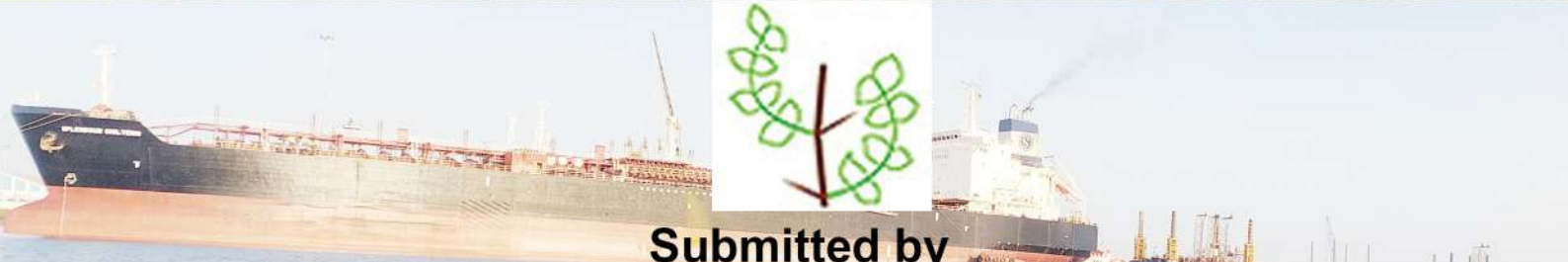


Second year Post-Monsoon Report
October 2022-January 2023

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

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY

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



Submitted by
GUJARAT INSTITUTE OF DESERT ECOLOGY
P.B. No. 83, Mundra Road, Opp. Changleshwar Temple
Bhuj-Kachchh, Gujarat-370001

March 2023

Second year Post-Monsoon Report
October 2022-January 2023

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

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

Submitted by
GUJARAT INSTITUTE OF DESERT ECOLOGY
P.B. No. 83, Mundra Road, Opp. Changleshwar Temple
Bhuj-Kachchh, Gujarat-370001

March 2023

Project Coordinator

Dr. V. Vijay Kumar, Director

Principal Investigator

Dr. Durga Prasad Behera	Project Scientist	Phytoplankton & Zooplankton, Physico-chemical parameters, Marine Fisheries, Intertidal and Subtidal benthos

Core Team

Dr. Jaikumar, M.	Senior Scientist	Mangrove & Mudflat
Dr. L. Prabha Devi	Advisor	Management Plan
Dr. Nikunj B. Gajera,	Scientist	Avifauna
Dr. Kapilkumar Ingle	Project Scientist	Mangrove Ecology
Dr. Dhara Dixit	Project Scientist	Halophytes, Sediment

Team members

Mr. Dayesh Parmar	Project officer	GIS & Remote sensing
Ms. Pallavi V. Joshi	Junior Research Fellow	Phytoplankton and Zooplankton, Water & Sediment

Snapshot

Post-monsoon (October2022 to January 2023)

S. No	Components of the Study	Remarks
1	MoEF & CC sanction letter and details	(i). EC & CRZ clearance granted by the MoEF &CC, GoI dated 19/12/16 Dev. Of 7 integrated facilities – specific condition no. xviii. (ii). EC & CRZ clearance granted by the MoEF &CC, GoI dated 18/2/2020 Dev. Remaining 3 integrated facilities – specific condition no. xxiii. (iii). EC & CRZ clearance granted by the MoEF &CC, GoI dated 19/2/2020 Dev. integrated facilities (Stage II-5 -specific condition no. xv. (iv). EC & CRZ clearance granted by the MoEF &CC, GoI dated 20/11/20 – Creation of waterfront facilities (OJ 8 to 11- Para VIII Marine Ecology, specific condition iv.
2	Deendayal Port letter sanctioning the project	DPA work Order: WK/4751/Part/ (Marine Ecology Monitoring)/11 date 03.05.2021
3	Duration of the project	Three years-from 24.05.2021 to 23.05.2024
4	Period of the survey carried	Second Year Post-Monsoon season (October 2022 to January 2023)
5	Survey area within the port limit	All major and minor creek systems from Tuna to Surajbari and Vira coastal area.
6	Number of sampling locations	Fifteen sampling locations in and around the DPA port jurisdiction
7	**Components of the report**	
7a	Mangroves	The overall average density was 3011 trees/ha of *A. marina* during Post-monsoon 2022-2023. Among the 12 sampling sites, the mean plant density was maximum at Tuna creek (4371/ ha), followed by Jangi creek (3210/ Ha). Considering the sampling sites individually the highest tree density was reported at S12 in the Tuna creek area (6515/Ha). The lowest average tree density of individual sites was reported in S-5 (1491 trees/ Ha) sampling site located at Phang creek. In terms of creeks, the lowest average density was recorded at Kharo creek in which only one sampling site is located S-7 (2291/ha.
7b	Mudflats	The highest TOC value (0.87%) was recorded at station S-6 followed by S-10 site. The lowest TOC value was reported at S-1. It is observed that TOC values varied significantly among the sampling stations, which means that organic carbon depends on the living life forms and the type of life forms in the mudflats.

7c	Zooplankton	The zooplankton identified from the 15 stations falls under 10 phyla and 45 genera which are described 15 groups. The phylum Arthropoda was the predominant represented with 30 genera, including copepods, crabs, shrimps and their larvae. The highest percentage was due to the calanoid copepods (40.4%) followed by Decapoda (16.4%) and Gastropoda (6.4%).
7d	Phytoplankton	The generic number recorded during the monsoon period ranged from 22 to 26 at the sampling stations with remarkable variations concerning the composition. The maximum number (26 genera) was observed at S-3 &S-9, and the minimum from S-8 represented 22 genera. The percentage composition of the various groups varied from 1 % to 61 %, of which the centrales and pennales are the dominant, constituting 61% and 38%, respectively.
7e	Intertidal Fauna	The intertidal fauna and the species diversity of the invertebrates showed the maximum for phylum Mollusca (8 species) followed by Arthropoda (6 species). The phylum Chordata was represented by one species. The overall percentage composition of the four groups of intertidal fauna at the 15 sites revealed the Arthropoda (31.6%), Mollusca (42.1%), Nematoda, Nemertea and Chordata (each 5.3%).
7f	Sub-tidal Macrobenthos	The DPA port environment revealed that Mollusca (13 species) and Annelida (6 species) were the major constituents, followed by Arthropoda (2 species) and Cnidaria (1 species). The phylum Mollusca constituted the maximum (59%) share of the subtidal Fauna, followed by Annelida (27%), least number of percentage was contributed by Cnidaria (5%).
7g	Seaweeds	No seaweed is reported in the DPA area.
7h	Seagrass	No seagrass is reported in the DPA area.
7i	Marine reptiles	One species of reptile was recorded from the DPA area.
7j	Marine mammals	Two species of marine mammal was recorded from the DPA area.
7k	Halophytes	Four halophytes were recorded along the selected Deendayal Port Authority sites during the Monsoon sampling; among the halophyte species recorded, *Salicornia brachiata* alone was found in the 3 sampling locations. The percentage of *Salicornia brachiata* was found to be the highest at stations S-11 (100%) and the lowest at S-3.
7l	Avifauna	A total of 79 species belonging to 9 orders, 32families and 59 genera were recorded from the coastal area of Deendayal Port Authority during the Monsoon season study.

Contents

S. No	Title	Page No
1	**Introduction**	1
1.1	**Rationale of the present study**	**2**
1.2	**Scope of work**	**3**
1.3	**Study Area**	**4**
2	**Sampling of Water and sediment samples**	**5**
2.1	**Methodology**	**6**
	Physico-chemical parameters	6
	pH and Temperature	6
	Water sample collection	6
	Salinity	6
	Total Suspended Solids (TSS)	6
	Total Dissolved Solids (TDS)	6
	Turbidity	7
	Dissolved Oxygen (DO)	7
	Phosphate	7
	Total phosphorus	7
	Nitrite	7
	Nitrate	7
	Petroleum Hydrocarbons (PHC)	8
2.2	**Sediment characteristics**	**8**
	Sediment Texture	8
	Total Organic Carbon	8
	Petroleum Hydrocarbons (PHC)	8
2.3	**Biological Characteristics of water and sediment**	8
	Primary productivity	8
	Phytoplankton	9
	Zooplankton	9
	Intertidal Fauna	**10**
	Subtidal macro benthic Fauna	**10**

2.4	**Mudflats**	**13**
	Sampling locations	13
	Total Organic Carbon	14
	Estimation of Bulk Density (BD)	15
2.5	**Mangrove assessment**	**15**
2.6	**Halophytes**	**17**
2.7	**Marine Fishery**	**18**
2.8	**Avifauna**	**19**
	Boat Surveys	19
2.9	**Data Analysis**	**19**
3	**Results**	**19**
3.1	**Water quality assessment**	**20**
	Temperature (°C) and pH	20
	Salinity (ppt)	20
	Dissolved oxygen (DO)	20
	Suspended Solids (TSS)	20
	Total Dissolved solids (TDS)	21
	Turbidity	21
	Water nutrients (Nitrate, Nitrite and Total Phosphorus)	21
	Petroleum Hydrocarbon (PHs)	21
3.2	**Sediment**	**24**
	Sediment texture	24
	Total Organic Carbon (TOC)	25
3.3	**Biological characteristics of water and sediment**	**26**
	Primary productivity	26
	Phytoplankton	27
3.4	**Generic status**	**27**
	Percentage composition of phytoplankton	27
	Percentage of occurrence	29
	Phytoplankton density and diversity	29
3.5	**Zooplankton**	**34**
	Phylum, group and generic status	34
	Percentage composition	34
	Percentage occurrence of zooplankton	36

	Density of zooplankton	37
3.6	**Intertidal Fauna**	**41**
	Composition of Intertidal Fauna	41
	Intertidal genera and Population density	43
	Percentage composition Intertidal species	43
	Diversity indices	44
3.7	**Subtidal Fauna (Macrobenthos)**	**46**
	Phylum composition of Subtidal fauna	46
	Total genera and population density (No/m^2)	48
	Percentage composition of Species	48
3.8	**Seaweeds**	**51**
3.9	**Seagrass**	**51**
3.10	**Halophytes**	**52**
3.11	**Mangroves**	**54**
	Tree Density	54
	Height	55
	Canopy Crown Cover	56
	Basal area	56
	Regeneration and recruitment class	57
3.12	**Marine Reptiles**	**61**
3.13	**Marine Fishery**	**62**
3.14	**Marine Mammals**	**63**
4	**Mudflat**	**64**
	Bulk density of the sediment samples	64
	Total Organic Carbon (TOC)	64
5	**Avifauna**	**66**
	Status, distribution and diversity of avifauna in different stations	66
	References	**71-74**

List of Figures

Fig No	Figure details	Page No
1	Map showing the proposed sampling locations 2021-2024	4
2	Petroleum Hydrocarbons in water (µg/L) during Post-monsoon 2022-2023	22
3	Textural Characteristics of sediment at DPA in Post-monsoon 2022-2023	23
4	Total Organic Carbon content (%) in DPA during Post-monsoon 2022-2023	25
5	Chlorophyll 'a' concentration at the study stations in Post-monsoon 2022-2023	26
6	Number of Phytoplankton genera in Post-monsoon 2022-2023	28
7	Percentage composition of phytoplankton groups in Post-monsoon 2022-2023	28
8	Percentage occurrence of phytoplankton genera in Post-monsoon 2022-2023	29
9	Phytoplankton density in Post-monsoon 2022-2023	30
10	Different diversity indices of Phytoplankton	31
11	Phylum and generic status of Zooplankton during Post-monsoon 2022-2023	35
12	Percentage composition of zooplankton groups during Post-monsoon 2022-2023	35
13	Percentage occurrence of Zooplankton groups during Post-monsoon 2022-2023	36
14	Zooplankton Density in the different stations during Post-monsoon 2022- 2023	37
15	Different diversity indices of Zooplankton	40
16	Percentage of Intertidal faunal composition in Post-monsoon 2022-2023	42
17	Intertidal genera and population density in Post-monsoon 2022-2023	42
18	Percentage composition of intertidal species during Post-monsoon 2022- 2023	43
19	Diversity indices of Intertidal fauna during Post-monsoon 2022-2023	44
20	Phylum composition of subtidal macrobenthos during Post-monsoon 2022-2023	47
21	Total genera and Population density of macrobenthos in Post-monsoon 2022-2023	48
22	Percentage composition of Subtidal Macrobenthic species in Post-monsoon 2022-2023	48
23	Diversity indices of Subtidal fauna during Post-monsoon 2022-2023	49

List of Figures

Fig No	Figure details	Page No
24	Mangrove Plant density during Post-monsoon 2022-2023	55
25	Plant height during Post-monsoon 2022-2023	55
26	Mangrove canopy cover during Post-Monsoon 2022-2023	56
27	Mangrove basal area during Post-monsoon 2022-2023	57
28	Bulk density of mudflat sediment during Post-monsoon 2022-2023	65
29	Percentage of Total Organic Carbon in the mudflat in Post-monsoon 2022-2023	65
30	Number of Avian species recorded from the DPA in Post-monsoon2022-2023	67
31	Behavioral status of Avian species from the DPA in Post-monsoon 2022-2023	67
32	Habitat wise distribution of Bird species in Post-monsoon 2022-2023 from DPA	68

List of Tables

S. No	Table details	Page No
1	Physico-chemical and biological parameters analysed	5
2	Physico-chemical characteristics of coastal waters during Monsoon 2022	23
3	Phytoplankton density, percentage composition and occurrence during Post-monsoon 2022-2023	32-33
4	Zooplankton generic status during Monsoon 2022 in Deeendayal Port Authority area	38-39
5	Intertidal faunal distribution along Deendayal Port Authority area during Post-monsoon 2022	45
6	Macro-benthic faunal distribution during Post-monsoon 2022-2023 in Deendayal Port Area	50
7	Percentage of Halophytes cover in the DPA during Post-monsoon 2022-2023	52
8	Density of mangroves in the DPT vicinity during Post- monsoon 2022-2023	59
9	Regeneration and Recruitment class plants during Post-monsoon 2022-2023	60
10	Stationwise Diversity Indices recorded from the Deendayal port Area Post-monsoon 2022-2023	69

List of Photo plates

Plate No	Plate details	Page No
1	Estimation of intertidal fauna by the quadrate method	11
2	Collection of Plankton and macrobenthos in subtidal habitat	12
3	Sediment sample collection at mangrove and mudflat areas	14
4	Assessment of mangrove density, height, canopy cover & girth	16
5	Assessment and percentage cover of halophytes	17
6	Collection of fisheries information from DPA environment	18
7	Halophyte species on the intertidal zone of Deendayal Port Authority area	53
8	Mangrove species recorded along the Deendayal Port Authority area	58
9	Marine reptiles recorded along the Deendayal Port Authority area	61
10	Fishery catch along the Deendayal Port Authority in Post-monsoon 2022-2023	62
11	Indian Ocean humpback dolphin *Sousa plumbea* common dolphin	63

1. Introduction

Deendayal Port is located at the inner end of Gulf of Kachchh on the Kandla creek (22°59'4.93N and longitude 70°13'22.59 E) in the Kachchh district of Gujarat state, operated by Deendayal Port Authority (DPA). Being the India's busiest major port in recent years, is gearing to add substantial cargo handling capacity with private participation. Since its formation in the 1950s, the Deendayal Port provides the maritime trade requirements of states such as Rajasthan, Madhya Pradesh, Uttar Pradesh, Haryana and Gujarat. Because of its proximity to the Gulf countries, large quantities of crude petroleum are imported through this port. About 35% of the country's total export takes place through the ports of Gujarat in which the Deendayal port has a considerable contribution. Assortments of liquid and dry cargo are being handled at DPA Port. The dry cargo includes fertilizers, iron and steel, food grains, metal products, ores, cement, coal, machinery, sugar, wooden logs, etc. The liquid cargo includes edible oil, crude oil and other petroleum products. Cargo handling has increased from 117.5 MMT to127 MMT during 2021-2022. Presently, the Port has total 1-16 dry cargo berths for handling dry cargo, 6 oil jetties, and one barge jetty at Bunder basin, dry bulk terminal at Tuna Tekra, barge jetty at Tuna and two SPMs at Vadinar for handling oil. Regular expansion or developmental activities such as the addition of jetties, allied SIPC and ship bunkering facilities are underway in order to cope with the increasing demand for cargo handling during the recent times.

A developmental initiative of this magnitude is going on since past 7 decades, which will have its own environmental repercussions. Being located at the inner end of Gulf of Kachchh, Deendayal Port Authority encompasses a number of fragile marine ecosystems that includes a vast expanse of mangroves, mudflats, creek systems and associated biota. Deendayal Port is a natural harbour located on the eastern bank of North-South trending Kandla creek at an aerial distance of 90 km from the mouth of Gulf of Kachchh. The Port's location is marked by a network of major and minor mangrove lined creek systems with a vast extent of mudflats. Coastal belt in and around the port has an irregular and dissected configuration. Due to its location at the inner end of the Gulf, the tidal amplitude is elevated, experiencing 6.66 m during mean high-water spring (MHWS) and 0.78 m during mean low water spring (MLWS) with MSL of 3.88 m. Commensurate with the increasing tidal amplitude, vast intertidal expanse is present in and around the port environment. Thus, the occurrence of mudflats on the intertidal zone enables mangrove formation to an extensive area. Contrary to the southern coast of Gulf of Kachchh, the coral formations, seaweed and

seagrass beds are absent in the northern coast due to high turbulence induced suspended sediment load in the water column, a factor again induced due to the conical Gulf geomorphology and surging tides towards its inner end.

1.1. Rationale of the present study

The ongoing developmental activities at Deendayal Port Authority has been intended for the following.

i. The development of 3 remaining integrated facilities (Stage 1) within the existing Port at Kandla which includes development of a container terminal at Tuna off Tekra on BOT base T shaped jetty, construction of port craft jetty and shifting of SNA section of Deendayal port and railway line from NH-8A to Tuna port.

ii. EC & CRZ clearance granted by the MoEF &CC, GoI dated 18/2/2020 Dev. Remaining 3 integrated facilities – specific condition no. xxiii.

iii. EC & CRZ clearance granted by the MoEF &CC, GoI dated 19/2/2020 Dev. integrated facilities (Stage II-5 -specific condition no. xv.

iv. EC & CRZ clearance granted by the MoEF &CC, GoI dated 20/11/20 – Creation of water front facilities (OJ 8 to 11- Para VIII Marine Ecology,specific condition iv).

As per the environmental clearance requirements to these developmental initiatives, by MoEF & CC, among other conditions, has specified to conduct the continuous monitoring of the coastal environment on various aspects covering the three the seasons. The regular monitoring shall include physico-chemical parameters coupled with biological indices such as mangroves, seagrasses, macrophytes and plankton on a periodic basis during the construction and operation phase of the project. Besides, the monitoring study also includes assessment of Mudflats, Fisheries, and Intertidal fauna including the macrobenthos as components of the management plan. The regular marine ecology monitoring includes Micro, Macro and Mega floral and fauna components of marine biodiversity of the major intertidal ecosystems, the water and sediment characteristics. In accord with MoEF&CC directive, DPA has consigned the project on 'Regular Monitoring of Marine Ecology in and around the Deendayal Port Authority and Continuous Monitoring Programme" to Gujarat Institute of Desert Ecology (GUIDE), Bhuj during May, 2021. Further, Deendayal Port authorities has entrusted Gujarat Institute of Desert Ecology (GUIDE) to continue the study for another three years, i.e., 2021 – 2024. The study covers all the seasons as specified by the specific condition of the Ministry of Environment, Forest and Climate Change

(MoEF&CC). The present study is designed considering the scope of the work given in the EC conditions.

1.2. Scope of work

The scope of the present investigation includes physico-chemical and marine biological components as mentioned in the specific conditions of MoEF&CC, EC & CRZ clearance dated 19.12.2016,18.2.2020,19.2.2022 and 20.11.2020 with specific conditions xviii, xxiii, xv & iv respectively. A detailed holistic approach to different components of the study such as marine physico-chemical parameters of water and sediment and marine biodiversity within the Deendayal Port area will be carried out. Based on the results obtained during the project period, a detailed management plan will be drawn at the end of the project period. The biological and physico-chemical variables will be investigated during the present study on a seasonal basis i.e., monsoon, post monsoon and pre-monsoon as follows.

- ✓ Physico-chemical characteristics of water and sediment
- ✓ Detailed assessment of mangrove vegetation structure including density,
- ✓ diversity, height, canopy, and other vegetation characteristics.
- ✓ GIS and RS studies to assess different ecological sensitive land use and land cover categories within the Port area such as the extent of dense and sparse mangroves, mudflats, creek systems, and other land cover categories within the port limits.
- ✓ Quantitative and qualitative assessment of the intertidal fauna, composition, distribution, diversity, density, and other characteristics.
- ✓ Data collection on the species composition, distribution, diversity and density of sub-tidal benthic fauna.
- ✓ Estimation of primary productivity at the selected sampling sites located in around the DPA area.
- ✓ Investigation of the species composition, distribution, density, and diversity of phytoplankton and zooplankton.
- ✓ Recording the occurrence, diversity and distribution of halophytes, seagrasses, seaweeds and other coastal flora. Investigations on the Avifaunal density, diversity, composition, habitat, threatened and endangered species and characters. Fishery Resources – Species composition, diversity, Catch Per Unit Effort (CPUE) and other socio-economic information.

1.2.1. Study Area

The coastal belt in and around Deendayal Port Authority jurisdiction is characterized by a network of creek systems and mudflats which are covered by sparse halophytic vegetation like scrubby to dense mangroves, creeks and salt-encrusted landmass which form the major land components. The surrounding environment in 10 km radius from the port includes built-up areas, salt pans, human habitations and port related structures on the west and north creek system, mangrove formations and mudflats in the east and south. The nearest major habitation is Gandhidham town located about 12 km away on the western part with population of 2,48,705 (as per 2011 census).

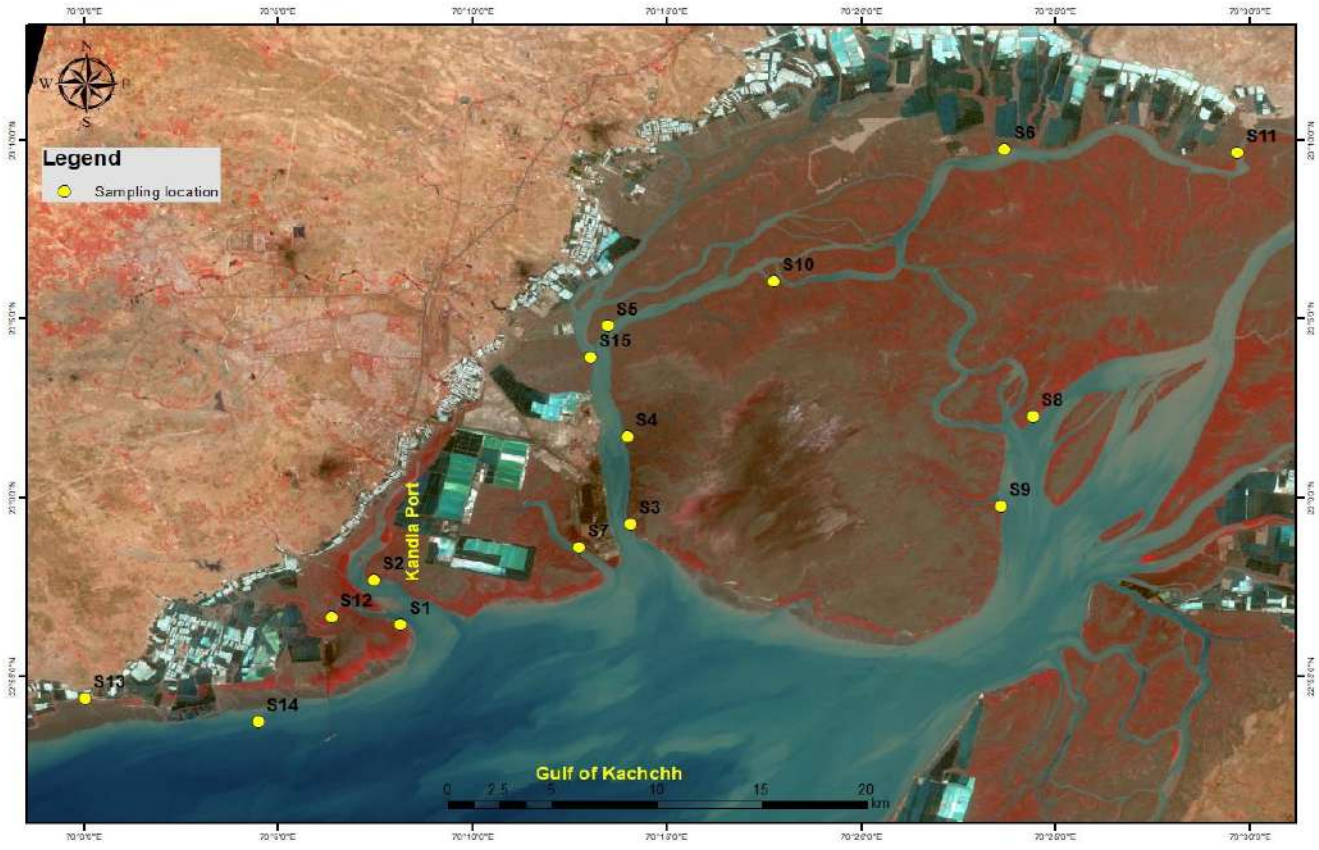


Figure 1: Map showing the sampling locations 2021-2024

2. Sampling of water and sediment samples

Sampling was carried out for the coastal water (surface) and sediment to determine physical and chemical characteristics from the prefixed sampling sites. The biological parameters (benthic and pelagic fauna, flora and productivity) were also estimated (Table.1).

Table 1: Physico-chemical and biological parameters analysed

Parameters	
Water	**Mangrove & Other Flora**
• pH	**Mangrove**
• Temperature	• Vegetation structure, density
• Salinity (ppt)	• Diversity
• Petroleum Hydrocarbons-PHC	• Height
• Dissolved oxygen	• Canopy and other vegetation characteristics
• Total Suspended Solids (TSS)	
• Total Dissolved solids (TDS)	**Halophytes:**
Nutrients	• Percentage of distribution
Nitrate (NO_3)	• Diversity
• Nitrite (NO_2)	
• Total Nitrogen	**Seagrass and Seaweed**
• **Sediment**	• Occurrence, distribution, and diversity.
• Texture	**Intertidal fauna**
• Total organic carbon (TOC)	• Composition, distribution, diversity, density and other characteristics.
• **Biological Parameters**	**Avifauna**
Phytoplankton- Genera, abundance, diversity and biomass	• Density, diversity, composition, habitat,
• Productivity-Chlorophyll a	• Threatened and endangered species and characters
• Zooplankton – Species, abundance, diversity	
• Macrobenthos - genera, abundance, diversity	
• Fishery Resources	
• Common fishes available	
• composition, diversity	
• Catch Per Unit Effort (CPUE)	

The water samples were collected from each pre-designated site in pre-cleaned polyethylene bottles. Prior to sampling, the bottles were rinsed with sample water to be collected and stored in an ice box for transportation to laboratory and refrigerated at 4°C till further analysis. The analysis of the water quality parameters was carried out by following standard methods (APHA, 2017). All extracting reagents were prepared using metal-free, AnalaR grade chemicals (Qualigens Fine Chemicals Division of Glaxo SmithKline Pharmaceuticals Limited, Mumbai) and double distilled water prepared from quartz double distillation assembly.

2.1. Methodology

Physico-chemical Parameters

pH and Temperature

A Thermo fisher pH / EC / Temperature meter was used for pH and temperature measurements. The instrument was calibrated with standard buffers just before use.

Salinity

A suitable volume of the sample was titrated against Silver nitrate (20 g/l) with Potassium chromate as an indicator. The chlorinity was estimated, and from that, salinity values were derived using a formula (Strickland and Parsons,1972).

Total Suspended Solids (TSS)

About 100 ml of the water sample was filtered through pre-weighed filter paper and placed in the Hot air oven at a specified temperature as per the protocol for 1 hour. The filter paper was allowed to cool in a desiccator to obtain a constant weight by repeating the drying and desiccation steps.

Total Dissolved Solids (TDS)

The water samples were subjected for gravimetric procedure for confirmation of the readings obtained from the hand -held meter. About 100 ml of the water sample was taken in a beaker and filtered which was then dried totally in a Hot Air Oven (105°C). The TDS values were calculated using the difference in the initial and final weight of the container.

Turbidity

The sample tube (Nephelometric cuvette) was filled with distilled water and placed in the sample holder. The lid of the sample compartment was closed. By adjusting the'SET ZERO' knob, the meter reading was adjusted to read zero. The sample tube with distilled water was removed, the 40 NTU standard solutions were filled in the tube, and the meter reading was set to read 100. Other standards were also run. The turbidity of the marine water sample was then found by filling the sample tube with the sample, and the reading was noted.

Dissolved Oxygen (DO)

DO was determined by Winkler's method (Strickland and Parsons,1972).

Phosphate

Acidified Molybdate reagent was added to the sample to yield a phosphomolybdate complex that is reduced with Ascorbic acid to a highly coloured blue compound, which is measured at the wavelength of 690 nm in a Spectrophotometer (Shimadzu UV 5040).

Total phosphorus

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

Nitrite

Nitrite in the water sample was allowed to react with Sulphanilamide in acid solution. The resulting diazo compound was reacted with N-1-Naphthyl ethylenediamine dihydrochloride to form a highly coloured azo-dye. The light absorbance was measured at the wavelength of 543 nm in Spectrophotometer (Shimadzu UV 5040).

Nitrate

The Nitrate content was determined as nitrite (as mentioned above) after its reduction by passing the sample through a column packed with amalgamated Cadmium.

Petroleum Hydrocarbon (PHs)

The water sample (1liter) was extracted with hexane and the organic layer was separated, dried over anhydrous sulphate and reduced to 10 ml at 30°C under low pressure. Fluorescence of the extract was measured at 360 nm (excitation at 310 nm) with Saudi Arabian crude residue as a standard. The residue was obtained by evaporating lighter fractions of the crude oil at 120°C.

Sediment characteristics

Sediment samples were collected from the prefixed stations by using a Van Veen grab having a mouth area of 0.04m^2 or by a non-metallic plastic spatula. Sediment analysis was carried out using standard methodologies. In each location (grid), sediment samples were collected from three different spots and pooled together to make a composite sample, representative of a particular site. The collected samples were air dried and used for further analysis.

Sediment Texture

For texture analysis, specified unit of sediment sample was sieved through sieves of different mesh size as per Unified Soil Classification System (USCS). Cumulative weight retained in each sieve was calculated starting from the largest sieve size and adding subsequent sediment weights from the smaller size sieves (USDA,1951). The percentage of the various fractions was calculated from the weight retained and the total weight of the sample. The cumulative percentage was calculated by sequentially subtracting percent retained from the 100%.

Total Organic carbon

Percentage of organic carbon in the dry sediment was determined by oxidizing the organic matter in the sample by Chromic acid and estimating the excess Chromic acid by titrating against Ferrous ammonium sulphate with Ferroin as an indicator (Walkley and Black, 1934).

2.3. Biological Characteristics of water and Sediment

Primary productivity

Phytoplankton possess the plant pigment chlorophyll ‘a’ which is responsible for synthesizing the energy for metabolic activities of phytoplankton through the process of photosynthesis in which CO_2 is used and O_2 is released. It is an essential component to understand the consequences of pollutants on the photosynthetic efficiency of phytoplankton in the system. To estimate this, a

known volume of water (500 ml) was filtered through a 0.45 µm Millipore Glass filter paper and the pigments retained on the filter paper were extracted in 90% Acetone. For the estimation of chlorophyll 'a' and pheophytin pigments the fluorescence of the Acetone extract was measured using Fluorometer before and after treatment with dilute acid (0.1N HCL) (Strickland and Parsons,1972).

Phytoplankton

Phytoplankton samples were collected from prefixed 15 sampling sites from the coastal water in and around DPA location using standard plankton net with a mesh size of 25µm and a mouth area of 0.1256 m^2 (20 cm radius). The net fitted with a flow meter (Hydrobios) was towed from a motorized boat moving at a speed of 2 nautical miles/hr. Plankton adhering to the net was concentrated in the net bucket by splashing seawater transferred to a pre-cleaned and rinsed container and preserved with 5% neutralized formaldehyde and appropriately labelled indicating the details of the collection, and stored for further analysis. The Quantitative analysis of phytoplankton (cell count) was carried out using a Sedgewick-Rafter counting chamber. The density (No/l) was calculated using the formula: $N=n \times v/V$ (Where, N is the total No/liter, n is the average number of cells in 1 ml, v is the volume of concentrate; V is the total volume of water filtered. The identification was done by following the standard literature of Desikachary, (1987), Santhanam et.al. (2019) and Kamboj et.al. (2018).

Zooplankton

Zooplankton samples were collected using a standard zooplankton net made of bolting silk having 50µm with mouth area of 0.25 m^2 fitted with a flow meter. The net was towed from a boat for 5 minutes with a constant boat speed of 2 nautical miles/hr. The initial and final reading in the flow meter was noted down and the plankton concentrate collected in the bucket was transferred to appropriately labeled container and preserved with 5% neutralized formaldehyde. One ml of the zooplankton concentrate was added to a Sedgwick counting chamber and observed under a compound microscope and identified by following standard literature. The group/taxa were identified using standard identification keys and their number was recorded. Random cells in the counting chamber were taken for consideration and the number of zooplankton was noted down along with their binomial name. This process was repeated for five times with 1 ml sample and the average value was considered for the final calculation. For greater accuracy, the final density values were counter-checked and compared with the data collected by the settlement method.

Univariate measures such as Shannon-Wiener diversity index (H'), Margalef's species richness (d), and Pielou's evenness (J'), Simpson's dominance (D) was determined using PAST software.

Intertidal Fauna

Intertidal faunal assemblages were studied for their density, abundance and frequency of occurrence during Post-monsoon 2022 at the pre-fixed 15 sampling locations within the DPA jurisdiction. Sample collection and assessment of intertidal communities were done in the intertidal zone during the low tide period. At each site, 1 x1 m^2 quadrates were placed randomly and all visible macrofaunal organisms encountered inside the quadrate were identified, counted and recorded. At each site, along the transects which run perpendicular to the waterfront, three to six replicate quadrate samples were assessed for the variability in macro-faunal population structure and the density was averaged for the entire intertidal belt. Organisms, which could not be identified in the field, were preserved in 5% formaldehyde, brought to the laboratory and identified using standard identification keys (Abott, 1954; Vine, 1986; Oliver, 1992; Rao, 2003; 2017; Psomadakis *et al.,* 2015; Apte, 2012; 2014; Naderloo 2017; Ravinesh *et al.* 2021; Edward *et al.,* 2022). Average data at each site were used to calculate the mean density (No/m^2).

Subtidal macro benthic Fauna

The sampling methods and procedures were designed in such a way to obtain specimens in the best possible condition as to maximize the usefulness of the data obtained. For studying the benthic organisms, triplicate samples were collected at each station using Van Veen grab, which covered an area of 0.04m^2. The wet sediment was passed through a sieve of mesh size 0.5 mm for segregating the organisms. The organisms retained in the sieve were fixed in 5-7% formalin and stained further with Rose Bengal dye for ease of spotting at the time of sorting. The number of organisms in each grab sample was expressed as No. /m^2. All the species were sorted, enumerated and identified by following the available literature. The works of Day (1967), Hartman (1968, 1969), Rouse and Pleijel (2001), Robin et al., (2003), Amr (2021), were referred for polychaetes; Crane (1975), Holthuis (1993), Naderloo (2017). Xavier et al., (2020) for crustaceans; Subba Rao (1989, 2003. 2017), Apte (2012, 2014), Ramakrishna and Dey (2007), Ravinesh *et al*. (2021) and Edward *et al*, (2022) for molluscs. Statistical analyses such as diversity indices and quadrat richness were calculated using Paleontological Statistics Software Package for Education and Data (PAST) version 3.2.1 (Hammer et al., 2001).

Plate 1: Estimation of intertidal fauna by the quadrate method

Plate 2: Collection of Plankton and macrobenthos in subtidal habitat

2.4. Mudflats

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

Sampling locations

The Sediment samples were collected from 15 sampling locations by using sediment corer. From each site triplicate samples were collected from up to 100 cm depth with four intervals (0-25cm, 25-50cm, 50-75cm & 75-100cm) and made into composite sample for analysis. The samples were packed in zip lock bags, stored in icebox and shifted to the laboratory for subsequent analysis.

Plate 3: Sediment sample collection at mangrove and mudflat areas

Total Organic Carbon

The organic carbon content of the mudflats was estimated to assess the biological productivity of the sediment. Soil Organic Carbon (SOC) was estimated following the method of Walkley and Black (1934). In this method, organic matter (humus) in the soil gets oxidized by Chromic acid (Potassium dichromate plus concentrated H2SO4) by utilizing the heat evolved with the addition of H_2SO4. The unreacted dichromate is determined by back titration with Ferrous ammonium sulphate (redox titration). Organic carbon was determined by following the below given formula:

$$\text{Oxidizable organic carbon (\%)} = \frac{10\ (B\ -\ T)}{B} \times\ 0.003\ \times\ \frac{100}{\text{wt. of soil}}$$

Where B = volume (mL) of Ferrous ammonium sulfate required for blank titration.T = volume of Ferrous ammonium sulfate needed for soil sample. Wt. =weight of soil (g).

Estimation of Bulk Density (BD)

The soil under field condition exists as a three-phase system viz. solid (soil particles), liquid (water) and gas (mostly air). The soil organic matter contained in a unit volume of the soil sample is called its bulk density. The amount of bulk density depends on the texture, structure and organic matter status of the soil. High organic matter content lowers the bulk density, whereas compaction increases the bulk density. To determine the bulk density of the sediment samples collected during the present study, the oven-dry weight of a known sediment volume was considered, and mass per unit volume was calculated (Maiti, 2012).

2.5. Mangrove assessment

Mangroves are widely distributed on the Deendayal Port Authority jurisdiction along the Kandla coast. The 15 mangrove sites selected at the different creeks belong to Deendayal Port Authority jurisdiction and all these stations are supposed to be sufficient to represent the mangroves status in Kandla. The mangrove stations in this study were named Tuna, Jangi, Kandla, Phan and Navlakhi based on the nearest location to the respective creek system. The Point Centered Quadrate Method (PCQM) was used for the collection of data of mangrove vegetation structure. The data included measurements of density of plants, height variations, canopy and basal area of mangrove trees as per the method of Cintron and Novelli (1984). For this method, a transect of a maximum of 200 m was applied mostly perpendicular or occasionally parallel to the creek. The sampling points considered at an interval of every 10 m and the vegetation structure of the that area were recorded. As the orientation of the transect line was already fixed, it was easy for movements within the station area for data recording. The distance between trees from the center of the sampling point for nearest 4 trees of four different directions, height of trees from the ground level, canopy length and canopy width were measured to determine the canopy cover in this study. The equipments utilized in the field were handy, and easy to use such as ranging rods, pipes and for measurement of girth at root collar above the ground (GRC), a measuring tape was used. The plants with a height <50 cm was considered as regeneration class and >50 cm but <100 cm was

considered as recruitment class. Along the transects, sub-plots of 1×1 m^2 for regeneration and 2×2 m^2 were laid randomly for recruitment class of the mangrove sites.

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

2.6. Halophytes

To quantify and document the halophytes at Deendayal Port Authority region, quadrate method was followed. At each sampling location quadrates of various sizes have been laid during every seasonal sampling. For recording the plant density at each transect, a quadrate 1 x 1m^2 has been laid within the site each tree quadrates were used randomly (Misra,1968; Bonham, 1989). Four quadrates each for shrubs and herbs were laid in side each tree quadrate to assess the halophytes and the percentage cover in the study area. To enrich the species inventory, areas falling outside the quadrates were also explored and the observed species were recorded and photographed and identified using standard keys. Specimens of the various species were collected to know more information on habitat and for the preparation of herbarium.

Plate 5: Assessment and percentage cover of halophytes

2.7. Marine Fishery

Fishery resources and the diversity were assessed from the selected sampling sites. Finfish and shellfish samples were collected using a gill net with a 10 mm mesh size. The net was operated onto the water from a canoe or by a person standing in waist deep water during the high tide using a cast net. For effective sampling, points were fixed at distances within the 15 offshore sites for deploying fishing nets to calculate the Catch per Unit effort estimated per hour. The collected specimens were segregated into groups, weighed and preserved in 10% neutralized formalin solution. Finfishes were identified following Fischer and Bianchi (1984), Masuda *et al*. (1984), de Bruin et al. (1995) and Mohsin and Ambiak (1996). Relevant secondary information pertaining to fishery resources of Deendayal Port creek systems were gathered through technical reports, the District Fisheries department, Government gazette and other research publications.

Plate 6: Collection of fisheries information from DPA environment

2.8. Avifauna

The Avifauna population was determined along DPA mangrove strands for which the area was demarcated into fifteen major stations. In each station, creeks of varying lengths from 2 to 5 km are available. These creeks were surveyed by using boat and adopting "line transect" method. A total of fifteen boat transect (one in each site) survey was conducted in the Post-monsoon October 2022 to January 2023). Survey was done in both terrestrial habitats like Mangrove plantations adjoining the mudflats, waste land, and aquatic habitats, like creek area, rivers and wetland.

Boat Surveys

Mangrove bird diversity was calculated by using Boat Survey method. Birds were observed from an observation post on board the boat which has given the greatest angle of clear view. Birds within a 100 meter transect on one side of the boat were counted in 10-minute blocks of time (Briggs *et al.* 1985; van Franeker, 1994). Detection of birds was done with a binocular (10 x 40) and counts were made: (1) continuously of all stationary birds (swimming, sitting on mangrove, or actively feeding) within the transect limits and (2) in a snap-shot fashion for all flying birds within the transect limits. The speed of the boat determines the forward limit of the snapshot area within a range of 100 meters. Longer or shorter forward distances were avoided by adapting the frequency of the snapshot counts. Birds that following and circling the boat were omitted from both snapshot and continuous counts. If birds arrive and then follow the boat, they were included in the count only if their first sighting falls within a normal snapshot or continuous count of the transect area. For each bird observation species, number of individuals and activity at the time of sighting, were recorded. Species richness and diversity index were calculated for different mangrove patches (i.e. fifteen station) of the study station in the Deendayal port Authority.

2.9. Data analysis

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

3. Results

3.1. Water quality assessment

The data on the mean water quality parameters measured at the time of sampling of the biological components from the 15 study sites during post-monsoon are presented in Table1.

Temperature (°C) and pH

The water temperature at the sampling sites ranged from 9°C to 28°C with average of 19°C .The maximum temperature of seawater was reported at S-6 and the minimum at S-9 in Kandla (Navlaki) creek. The pH of creek water ranged from 7.1 to 8.1 with average of 7.9. The highest pH was reported at sites S-2 and S-5 and the lowest pH 7.1 was noticed at S-11 in Janghi creek. The overall observation along the port environment revealed that the temperature fluctuation might be due to the low atmospheric temperature(winter) in the month of December and the pH range showed minor fluctuations among the sampling locations.

Salinity (ppt)

The salinity of Deendayal Port authority ranged from 12 ppt to 43 ppt with the average value of 39 ppt. The minimum salinity was observed at S-10 and maximum at S-9. The hypersaline condition of creek system during post-monsoon season might be due release of brine water from salt pan in to this creek system.

Dissolved oxygen (DO)

The dissolved oxygen in the coastal waters of Deendayal port authority area ranged from 3.9 mg/L to 7.7 mg/L with the average of 6.8 mg/L. The highest dissolved oxygen concentration was observed at S-6 and the lowest was observed at S-5. The concentration of dissolved oxygen varies mainly due to the rate of photosynthesis and respiration by plants and animals in water. Generally, the coastal waters are having high level of dissolved oxygen due to the dissolution from the atmosphere through diffusion process on the surface layer (CCME,1999).

Suspended Solids (TSS)

The total suspended solids (TSS) concentration at the 15 sampling sites ranged from 140 mg/L to 640 mg/L with the average of 209 mg/L. The highest TSS values was reported at S-8 in the Navlaki creek . The minimum TSS value was recorded at S-12 which was 140 mg/L.

Total Dissolved solids (TDS)

The total dissolved solids (TDS) in the water consist of inorganic salts and dissolved materials which mostly comprises of anions and cations in creek water system . The TDS of the samples varied from 32,200mg/L to 45,700 mg/L with an average of 39,500 mg/L. The maximum value was reported at S-2 which may be due to replenishment dissolved solids due to the gulf current system and movement s of cargo in the navigation channel of Kandla creek system.

Turbidity

The turbidity of the water samples from the study sites ranged between 46 NTU and 342 NTU with the average of 190 NTU. The lowest value was reported at S-15 and the highest value at S-6 followed by S-9.

Water nutrients (Nitrate, Nitrite and Total Phosphorus)

The nutrients influence growth, metabolic actions and reproduction of biotic components in the aquatic environment. The distribution of nutrients mainly depends upon tidal conditions, types of season and fresh water influx from land. The nitrate concentration ranged from 0.003 mg/L to 0.140 mg/L with an average of 0.060 mg/L. The highest nitrate concentration was observed at station S-9 and the lowest at station S-1. Very miniature variation was noticed concentration of nitrate among the study station. Likewise, nitrite values varied between 0.007 mg/L to 0.021 mg/L. The highest concentration was observed at station S-1 and lowest concentration was observed at station S-9. The Total phosphorus values among the study station ranged from 0.67 mg/L to 2.02 mg/L with in average of 1.26 mg/L. The highest phosphorus concentration was observed at station S-3 near oil jetty of Kandla creek and the lowest concentration was observed at S-12 inTuna creek . Highest concentration might be due to leaching of phosphatic fertilizers while handling of cargo port area**.**

Petroleum Hydrocarbons (PHs)

Petroleum Hydrocarbons (PHs) represent the most commercially utilized fossil fuels (Adelaja, 2015). Reports have indicated that their consumption is projected to rise exponentially from 85 million barrels in 2016 to 106.6 million barrels by 2030 (Igunnu et. al, 2014). They are used as raw materials in many industries and primary energy sources. However, they also represent one of the prioritized and widespread contaminants posing serious threats to the ecology owing to their stability and robustness (Cozzarelli et. al, 2014; Pablo et. al, 2020; Uddin et. al, 2021).

PHs comprise the polycyclic aromatic hydrocarbons (PAHs), alkanes, paraffin, cycloalkanes, organic pollutants, and non-hydrocarbon components like phenol, sulfur compounds, thiol, metalloporphyrin, heterocyclic nitrogen, naphthenic acid, and asphaltene. The introduction of the PHs immediately alters the composition of that particular ecological niche/ecosystem, subsequently reducing the overall functionality and inducing weathering. This weathering of the PHs triggers a series of influences which may be either chemical (auto-oxidation/photo-oxidation), physical (dispersion), physiochemical (sorption, dissolution, evaporation), or biological (microbial and plant catabolism of hydrocarbons) (Truskewycz et. al, 2019). Marine organisms get affected by the presence of the PHs. The bioaccumulation of lethal PHs in the aquatic food chain persists for many years and in turn influences the primary producers, primary consumers, and secondary consumers. About 90% of the PHs discharge can be associated with anthropogenic activities (oil spills) in both, the terrestrial as well as marine environments. It has been reported that around 8.8 million metric tonnes of oil are annually discharged into the aquatic environment (Dadrasnia and Agamuthu, 2013).In the current study, the presence of PHs in water samples collected along all the 15 sampling sites were detected and estimated. The PHs ranged from 1.45 µg/L to 8.75 µg/L. The PHs detected from the individual sites have been represented in (Fig…..). The highest concentration of the PHs was detected at S-1 site (Tuna creek) while the lowest was noted for S-11 (Janghi creek). A moderate level of the PH content was noted down at site S-2 (7.65 µg/L) and S-6 (7.25 µg/L) followed by S-9 (6.8 µg/L) and the rest of the sites.

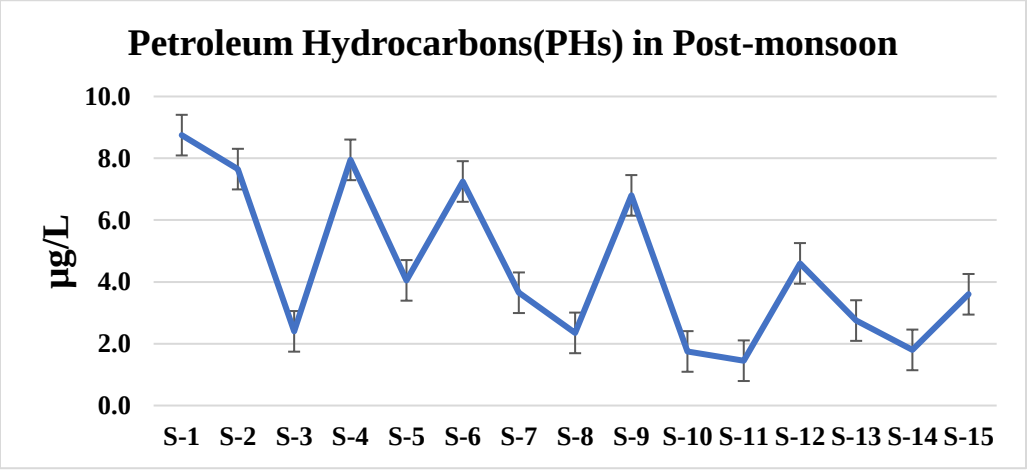


Figure 2: Petroleum hydrocarbons in water (µg/L) during Post-monsoon 2022-2023

Table 2: Physico-chemical characteristics of coastal waters during Post-monsoon 2022-2023

Parameters	**S-1**	**S-2**	**S-3**	**S-4**	**S-5**	**S-6**	**S-7**	**S-8**	**S-9**	**S-10**	**S-11**	**S-12**	**S-13**	**S-14**	**S-15**
Temp (°C) (Air)	24	24	21	21	32	30	20	14	12	29	23	23	19	18	26
Temp (°C) (Water)	20	20	21	20	24	28	17	10	9	20	16	17	16	19	24
pH	7.8	8.1	8	7.9	8.1	7.9	7.9	8	7.8	7.8	7.1	8	8	7.9	8
Salinity (ppt)	39	38	39	41	41	41	42	41	43	12	39	40	43	41	40
Dissolved oxygen (mg/L)	7	7	7	7	4	8	8	6	7	7	6	7	7	7	7
Total Suspended Solids (TSS) (mg/L)	207	163	199	181	160	219	165	640	232	148	175	140	192	158	154
Total Dissolved solids (TDS) (mg/L)	40000	41200	39300	39200	39700	40000	39600	45700	35100	39300	41500	40600	38100	32200	41000
Turbidity (NTU)	265	235	218	139	73	132	209	249	342	273	228	227	167	49	46
Nitrate (NO_3) (mg/L)	0.003	0.034	0.136	0.059	0.015	0.026	0.066	0.111	0.140	0.034	0.074	0.029	0.131	0.029	0.018
Nitrite (NO_2) (mg/L)	0.012	0.017	0.008	0.014	0.021	0.015	0.015	0.011	0.007	0.015	0.014	0.017	0.016	0.007	0.007
Total Phosphorus (mg/L)	1.83	0.87	2.02	1.54	1.06	1.83	0.96	0.87	1.35	0.77	1.25	0.67	0.87	1.35	1.73
PHs (µg/L)	8.75	7.65	2.4	7.95	4.05	7.25	3.65	2.35	6.8	1.75	1.45	4.6	2.75	1.8	3.6
Chlorophyll a (mg/L)	0.58	0.49	0.14	0.25	0.32	0.80	1.00	0.64	0.22	1.14	0.34	0.65	0.16	0.28	0.83

3.2. Sediment

Sediment texture

The percentage composition of the soil particles in the sediment analyzed from the 15 sampling sites are presented in Fig.3.There were noticeable variations in the soil fractions,(Texture) sand, silt and clay, among the stations. In the present study the highest percentage of clay was reported at S-7 followed by S-2. The highest percentage of sand was observed at S-11 followed by S-15 station. As per the observations, the percentage of silt content was less compared to clay and sand in many sampling sites except S-15. The nature of soil texture was characterized by the proportion of clay, sand and silt fractions. The Soil texture (Percetnage) revealed the dominance of sandy-clay type in all the stations with less variations among them. This consistently high clay-loam value may be attributed to the sifting activity of sediment transport system. The absence of perennial flow of freshwater into the coast along with lack of wave induced sand transport from open sea are the possible reasons for this uniform pattern of soil texture.

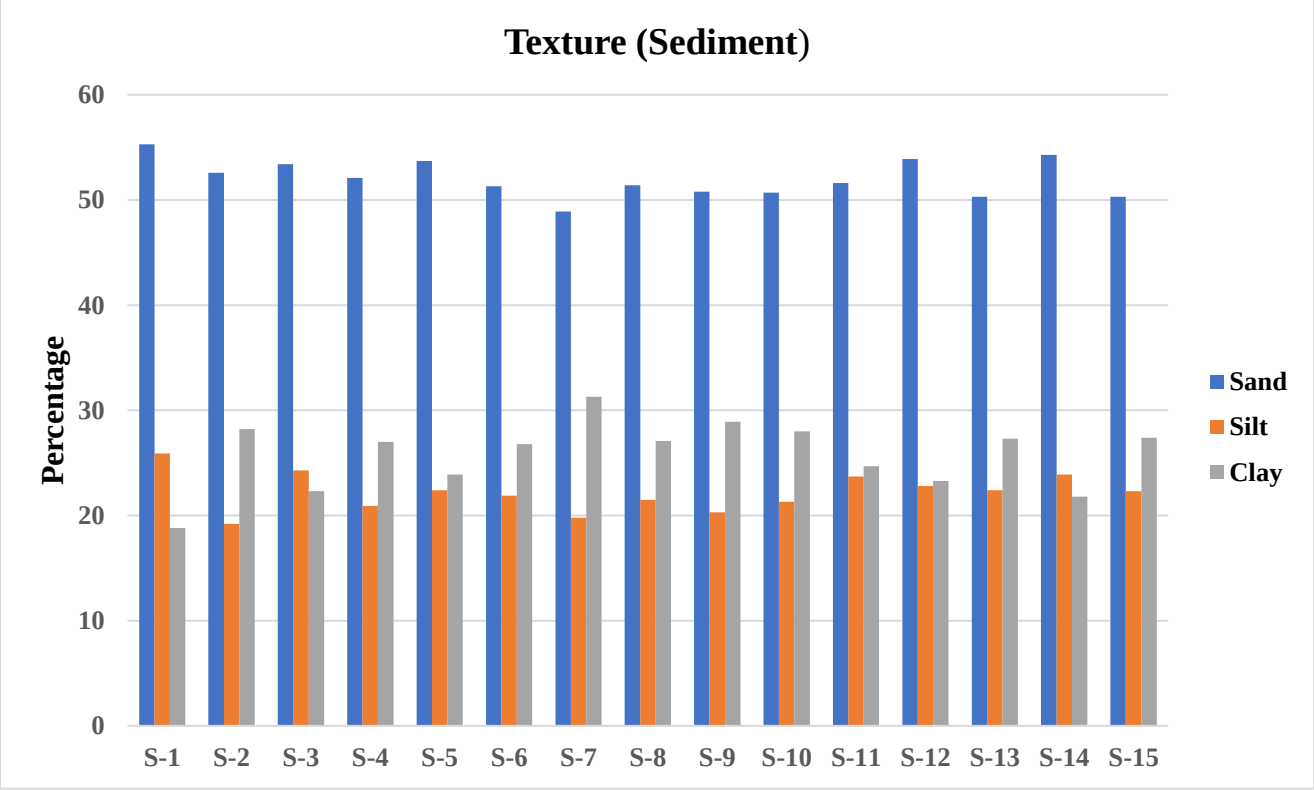


Figure 3: Textural characteristic of sediment at DPA in Post-monsoon 2022-2023

Total Organic Carbon (TOC)

In the present study, the total organic carbon content in the sediment varied from 0.60% to 1.06% (Fig.4). The highest value-of TOC were reported at S-6 followed by S-9. The lowest TOC value was recorded at S-15. The distribution of total organic carbon closely followed the distribution of sediment type i.e., sediment low in clay content contained relatively low organic carbon.

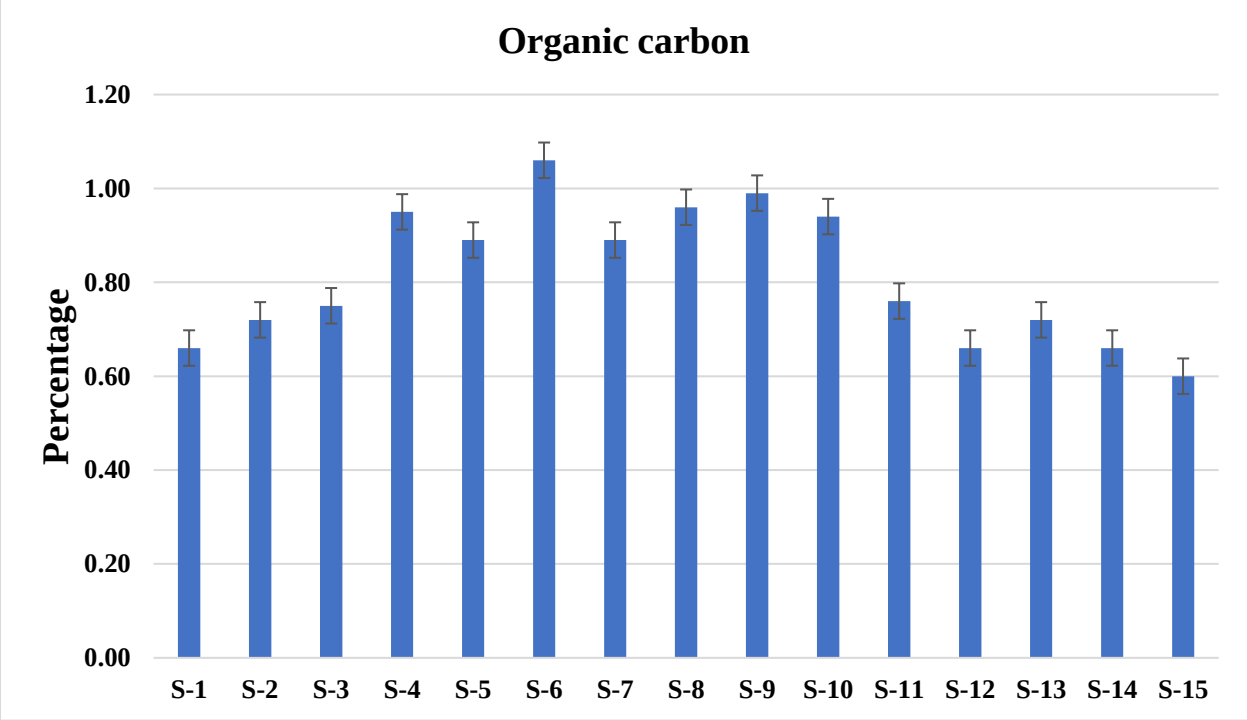


Figure 4: Total Organic Carbon content (%) in DPA during Post-monsoon 2022-2023

3.3. Biological characteristics of water and sediment

Primary productivity

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

In the present study, Chlorophyll ‘a’ concentration fluctuated from 0.14 mg/L to 1.14 mg/L with average of 0.52 mg/L. The highest concentration 1.14 mg/L was reported at S-10 (Fig.5) followed by S-7 (1.00) . The photosynthetic pigment chlorophyll a which is a measure of the population density of phytoplankton during the Post-monsoon period showed wide range of variations among the sites. The Chlorophyll ‘a’ content was very low at S-3.

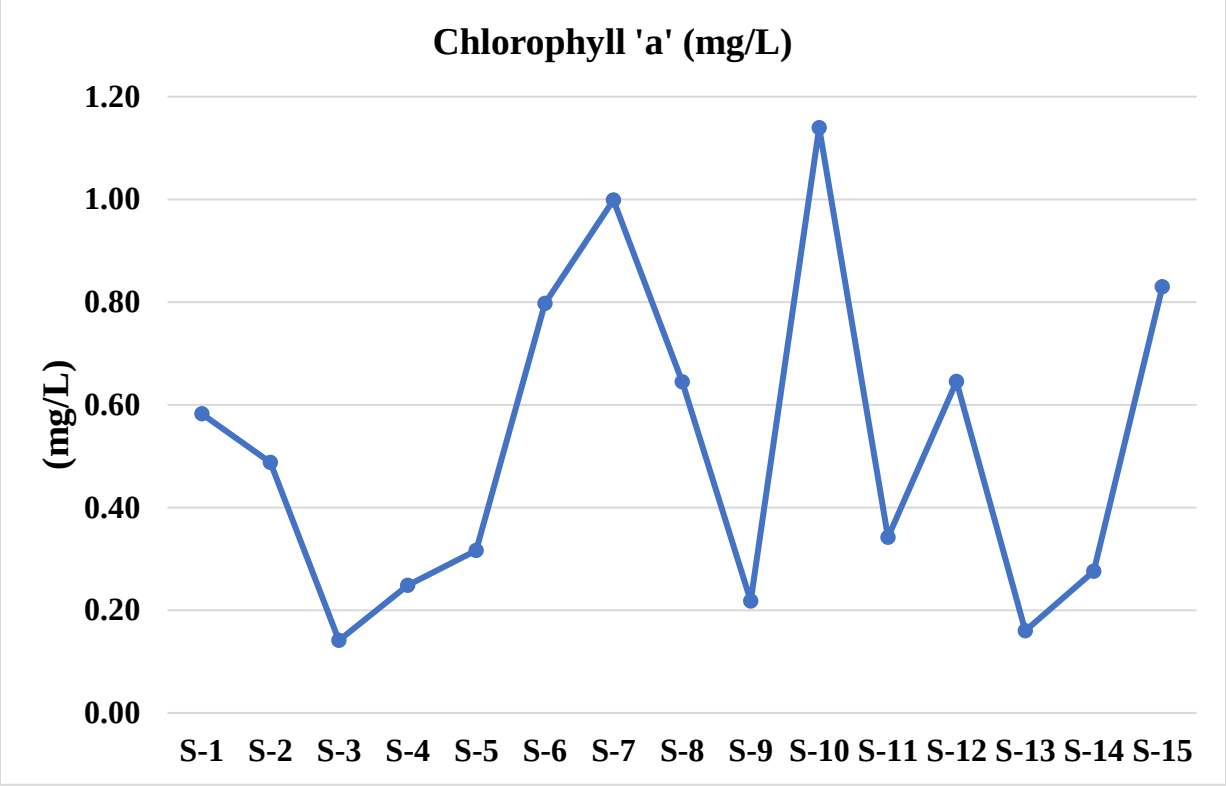


Figure 5: Chlorophyll ‘a’ concentration at the study stations in Post-monsoon 2022-2023

3.4. Phytoplankton

Phytoplankton are free-floating, photosynthetic, aquatic microorganisms, which are distributed either actively by their locomotory organs (flagella) or passively by water currents. Most of the phytoplankton survive on the open surface waters of lakes, rivers and oceans. The phytoplankton community is mainly represented by algal representatives including both prokaryotes and eukaryotic genera. Plankton populations are mostly represented by members of Cyanobacteria, Chlorophyta, Dinophyta, Euglenophyta, Haptophyta, Chrysophyta, Cryptophyta, and Bacillariophyta. Planktonic representative taxa are absent in other algal divisions like Phaeophyta and Rhodophyta.

Generic Status

There were four groups of phytoplankton occurred during Post-monsoon along the DPA, Kandla coast and its peripheral creek system which include Diatom (Pennales, Centrales), Dinophyceae and Cyanophyceae. The number of genera recorded during the Post-monsoon period varied between was 22 to 26 at the 15 sampling stations. The maximum number genera (26) was observed at S-3,S-9 and S-12 and the minimum from S-8 representing 22 genera. As far as generic status is concerned the centrales diatom contributed a greater number of genera (16) followed by Pennales (9) (Fig.6 & Table 3). Among the diatoms of phytoplankton, the genera Coscinodiscus ,and Thalassionema were primarily dominated at all the study stations. The genera representing of the groups Dinophyceae and Cyanophyceae encountered in minimum numbers.

Percentage composition of phytoplankton

The cumulative percentage composition of the five groups of phytoplankton from all the study sites is presented in Fig.7. The percentage composition varied from 1 % to 61 % of which the pennales and centrales are the dominant constituting 38% and 61% respectively. The diatoms pennales and centrales together formed 99% of the phytoplankton population by number of genera as well as number of individuals while the rest 1% is constituted by Dinophyceae during the Post-monsoon 2022-2023.

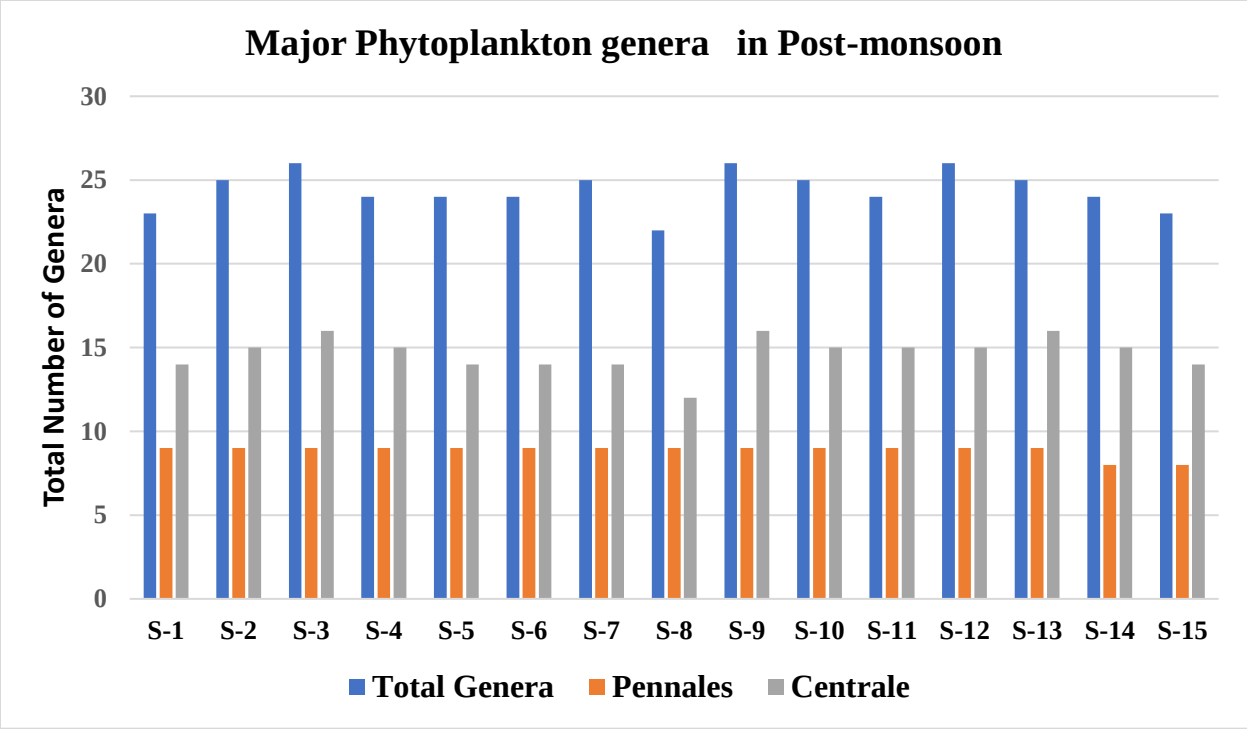


Figure 6: Number of Phytoplankton genera in Post-monsoon 2022-2023

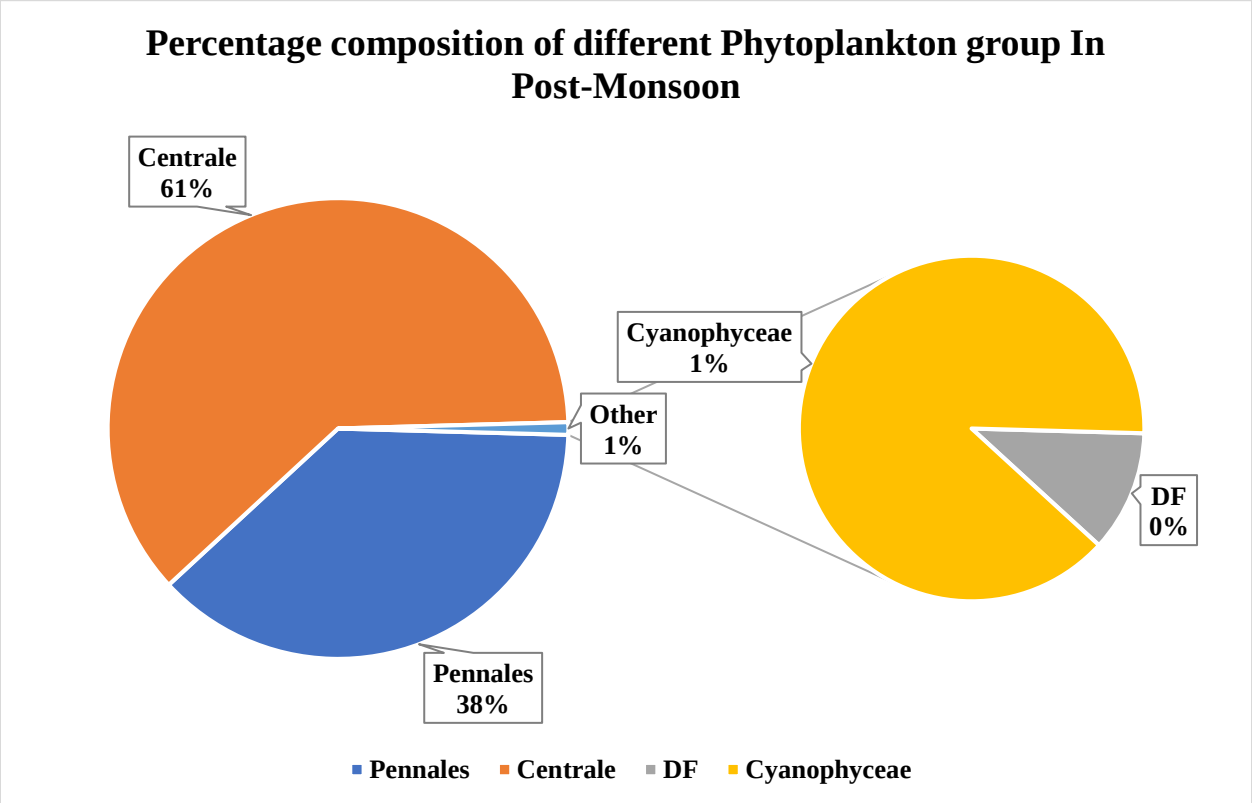


Figure 7: Percentage composition of phytoplankton groups in Post-monsoon 2022-2023

Percentage of occurrence

The percentage occurrence denotes the number of representations by a genus among the sites sampled. The percentage occurrence of different phytoplankton genera varied from 13% to 100% with an average of 87%. Nineteen phytoplankton genera have the highest percentage of occurrence (100%) (fig 8) followed by Planktoniella (80%) occurrence during the Post-monsoon season 2022-2023.

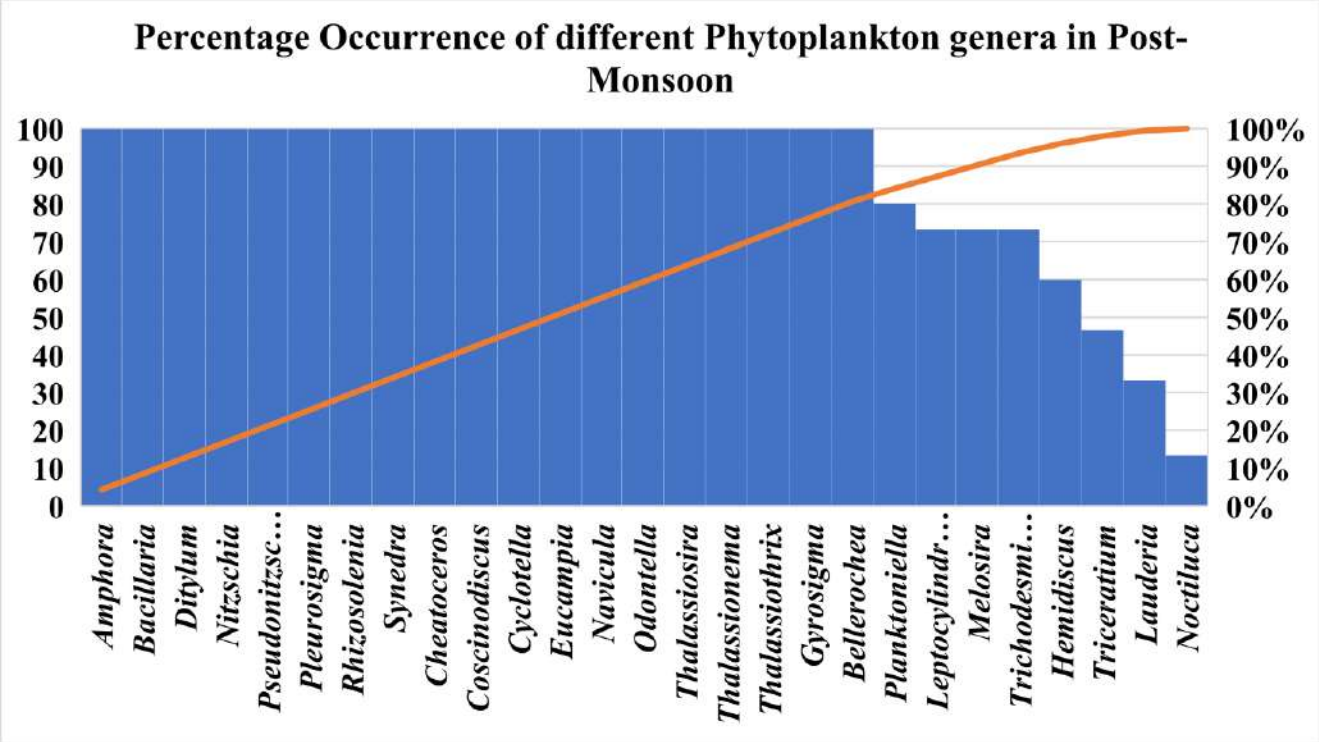


Figure 8: Percentage occurrence of phytoplankton genera in Post-monsoon 2022-2023

Phytoplankton density and diversity

The density signifies the abundance of plankton which is measured as cell/ individual/L. The phytoplankton density varied from 16,320No/L to 35,040 No/L with the average 21,887 No/L. The highest phytoplankton density was observed at station S-13 (35,040 No/L) followed by S-14 (30,080 No/L), whereas the lowest 16,320 No/L at S-6(fig.9). Diversity indices have become part of standard methodology in the ecological studies particularly, impact analysis and biodiversity monitoring of the environments (PEET,1974). Biodiversity indices reflects the biological variability which can be used for comparison with space and time. Various species diversity

indices respond differently to different environmental factors and behavioral patterns of biotic communities. Among the different stations, the number of phytoplankton taxa varied from 22 to 26 (Table-4). During Post-monsoon the Margalef and Menhinik richness indices were maximum at stations S-12 &S-6 (2.50 & 0.19 respectively). The Shannon diversity index was maximum 3.04 (S-9) and minimum 2.81 at S-7. The Simpson index clearly reflects the species dominance (genera) at S-9 (0.95) and the low value (0.92) was noticed at S-17.

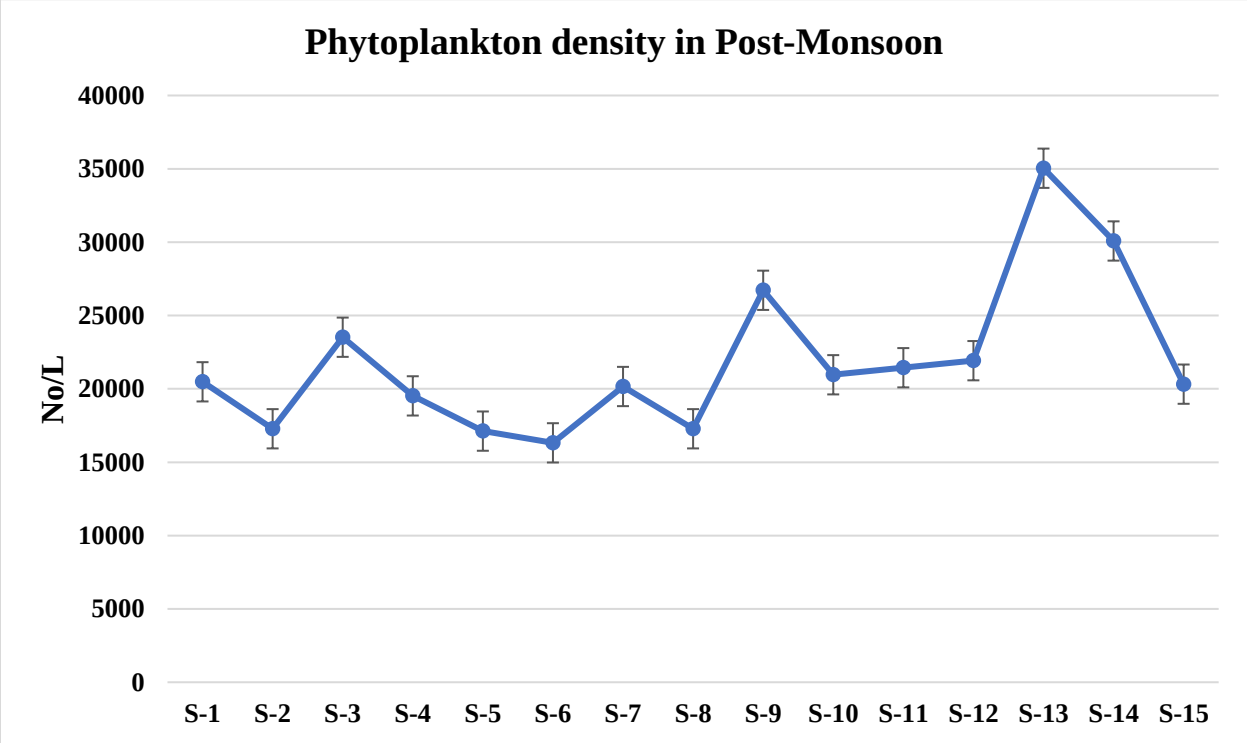


Figure 9: Phytoplankton density in Post-monsoon 2022-2023

As per Shannon Wiener's rules for the aquatic environment i.e., both soil and water are classified as very good when H' value is greater than four (>4), whereas the good quality represents the H' value with a range of 4-3, similarly moderate-quality (H' value 3-2), poor quality (H' value 2-1) and very poor-quality H' value significantly less than one (<1). Presently Deendayal Port Authority and its periphery environment has been influenced by contaminants deposited from industries and the cargo movements. Accordingly, species diversity decreases at sites with poor water quality. As deduced from the Shannon diversity index values between 2.81 to 3.04 representing the poor quality of environmental status dominated by the few genera such as *Coscinodiscus* and *Thalassionema*. A community dominated by relatively few species indicates

environmental stress (Plafkin *et al.*, 1989). According to Staub *et. al* (1970) species diversity index value between 3.0 to 4.5 represents slightly polluted and the lightly polluted environment, the index value characterizes 2.0-3.0, similarly, moderately polluted environment shows index value of 1.0-2.0 and finally, the heavily polluted environment index value is 0.0-1.0. While considering the overall index values it is inferred that the study sites can be included under the category of lightly polluted (Fig.10).

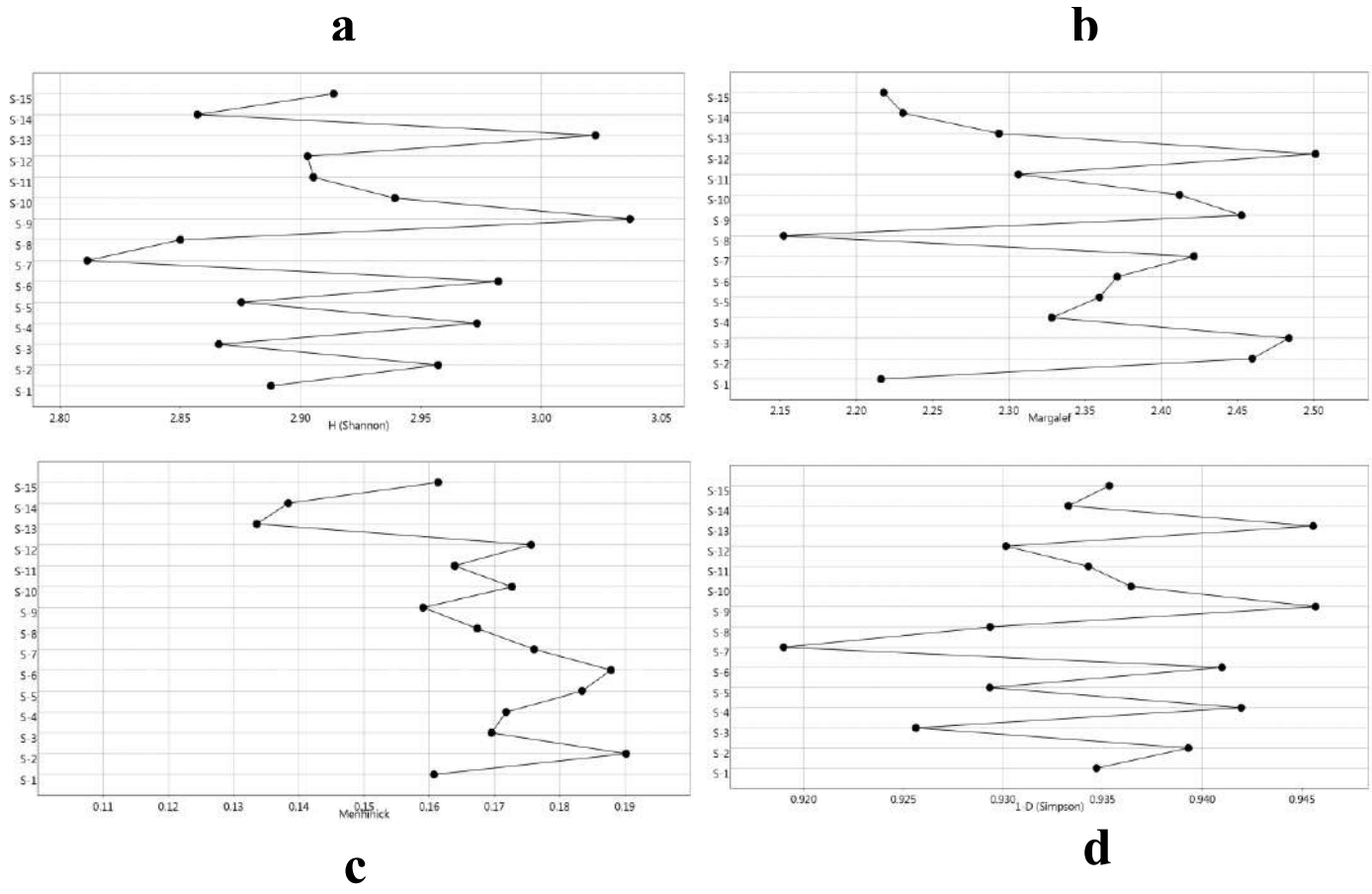


Figure 10: Different diversity indices of Phytoplankton

a. Shannon Index b. Menhinick Index c. Margalef Index d. Simpson Index

Table 3: Phytoplankton density, percentage composition and occurrence during Post-monsoon 2022-2023 in DPA

Grpou	Genera	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	PC	PO
Pennales	*Amphora*	320	160	320	320	640	800	160	480	1120	800	320	1280	320	160	1440	2.6	100
	Bacillaria	960	960	640	320	160	480	640	960	1120	800	480	640	1440	800	1280	3.6	100
	Ditylum	960	1280	1760	1440	800	320	640	960	2240	960	2080	1760	2240	1760	640	6.0	100
	Nitzschia	1760	1440	800	320	640	960	2240	960	2080	1760	1440	1280	2240	1600	1120	6.3	100
	Pseudonitzschia	480	640	320	800	640	480	1120	800	320	160	640	160	160	160	320	2.2	100
	Pleurosigma	320	320	640	160	160	320	160	480	1120	640	160	320	960	1280	640	2.3	100
	Rhizosolenia	640	960	960	1280	800	480	640	160	800	640	640	800	1440	1600	480	3.8	100
	Synedra	1760	1440	1120	1280	2240	1280	1120	1920	1600	1440	960	1760	2720	2400	1760	7.6	100
	Navicula	1120	640	640	1280	800	640	320	480	1440	160	1120	480	1760	0	0	3.3	87
Centrales	*Cheatoceros*	1600	1440	2720	2080	1760	1600	3360	960	1280	2720	2560	1760	3200	3040	1600	9.7	100
	Coscinodiscus	1760	1600	3360	960	1280	1600	1440	2720	2080	1760	1600	3360	2400	3040	2720	9.7	100
	Cyclotella	160	160	160	480	320	160	320	160	480	480	640	320	800	1440	960	2.1	100
	Eucampia	480	320	320	320	160	160	640	320	800	480	160	320	320	160	800	1.8	100
	Lauderia	160	160	0	0	0	0	0	0	160	0	160	0	0	0	0	0.2	33
	Leptocylindricus	480	160	160	160	320	320	0	0	160	160	0	320	1280	640	320	1.4	73
	Melosira	160	320	320	160	160	320	0	0	160	320	160	0	320	0	160	0.8	73
	Odontella	1120	1440	1760	1440	800	480	640	960	2400	960	2400	1760	2400	3040	800	6.8	100
	Planktoniella	0	0	160	640	320	480	640	800	0	320	640	480	800	160	320	1.8	80
	Triceratium	0	0	160	320	0	0	160	0	320	0	0	160	480	160	0	0.5	47
	Thalassiosira	160	320	800	1120	160	1280	800	960	1120	320	640	160	1120	960	320	3.1	100
	Hemidiscus	0	160	160	0	0	0	160	0	160	160	160	320	320	160	0	0.5	60
	Thalassionema	2560	640	2880	800	2240	480	2720	640	1120	1600	960	1600	2400	2720	1760	7.7	100
	Thalassiothrix	960	1120	800	1120	480	1280	640	1120	960	1440	640	800	1440	1120	800	4.5	100
	Gyrosigma	640	480	1120	960	640	320	160	640	800	1280	1120	960	1440	1120	640	3.8	100
	Bellerochea	800	320	640	480	640	1120	800	160	1120	960	640	320	1280	1120	800	3.4	100
DF	Noctiluca	0	0	0	0	0	0	160	0	0	0	0	160	0	0	0	0.1	13
Cyanophyceae	Trichodesmium	0	160	160	0	160	320	160	160	320	480	0	160	0	160	320	0.8	73

Total Density	**20480**	**17280**	**23520**	**19520**	**17120**	**16320**	**20160**	**17280**	**26720**	**20960**	**21440**	**21920**	**35040**	**30080**	**20320**	
Total Genera	**23**	**25**	**26**	**24**	**24**	**24**	**25**	**22**	**26**	**25**	**24**	**26**	**25**	**24**	**23**	

PC: Percentage of composition

PO: Percentage of Occurrence

3.5. Zooplankton

Zooplankton are highly sensitive to changes caused by physical and chemical factors in aquatic ecosystems and their distribution deliver information regarding the productivity and pollution of the particular area (Gajbhiye and Desai, 1981). Zooplankton are distributed in a wide range of habitats extending from the neuston to benthos and play vital roles influencing fisheries, oceanography and climate (Terdalkar and Pai, 2001). It has various significant roles in the estuarine ecosystem and connecting link between nutrient cycling and phytoplankton, primary production and many commercial fisheries in estuaries and coastal waters and form a chief food for a variety of pelagic consumers including coelenterates, ctenophores, fish larva forage fish and some benthic organisms such as sponges and molluscs (Day *et al*., 1989).

Phylum, group and generic status

The zooplankton identified from the 15 stations falls under 10 phyla and 45 genera belonging to the 15 groups (Table 5). The phylum Arthropoda was the predominant, represented with 30 genera including copepods, crabs, shrimps and their larva. The phylum Arthropoda dominated in the samples with major groups Calanoida, Harpacticoida, Cyclopoida, (Copepoda) Decapoda, Branchiopoda,Thecostraca, Onychopoda ,and the larval forms of crustaceans. There were 19 genera of copepods of Phylum Arthropoda occurred in the samples. Among the copepods 12 gernera, of the Calanoida ranked first in terms of generic representation ,*Acartia Acrocalanus*, *Aetideus Nannocalanus* .*Temora a*nd *Calanus* while the other 2 groups, Harpacticoida ,Cyclopoida were poor in generic status.(figure-11). Besides this 11 genera belonging to Foraminifera(*Tintinnopsis, Codonellopsis*,),Chaetognatha, Nematoda, Polychaeta, Branchiopoda, Thecostraca, Cnidaria and fish were also present in the samples.

Percentage composition

The overall percentage of the various groups of zooplankton varied from 5.4% to 40.4%. The highest percentage was due to the calanoid copepods (40.4%) followed by Decapoda (16.4%) and Gastropoda (6.4%). The group which contributed the least was *Appendicularia* (5.4%) (Fig.12). The minor group of 11 genera constituted 25.8% of population in which contributed by fish larvae, Globigerina and Branchiopoda (Table 4). Among the zooplankton groups calanoid group was the predominant zooplankton at all sites

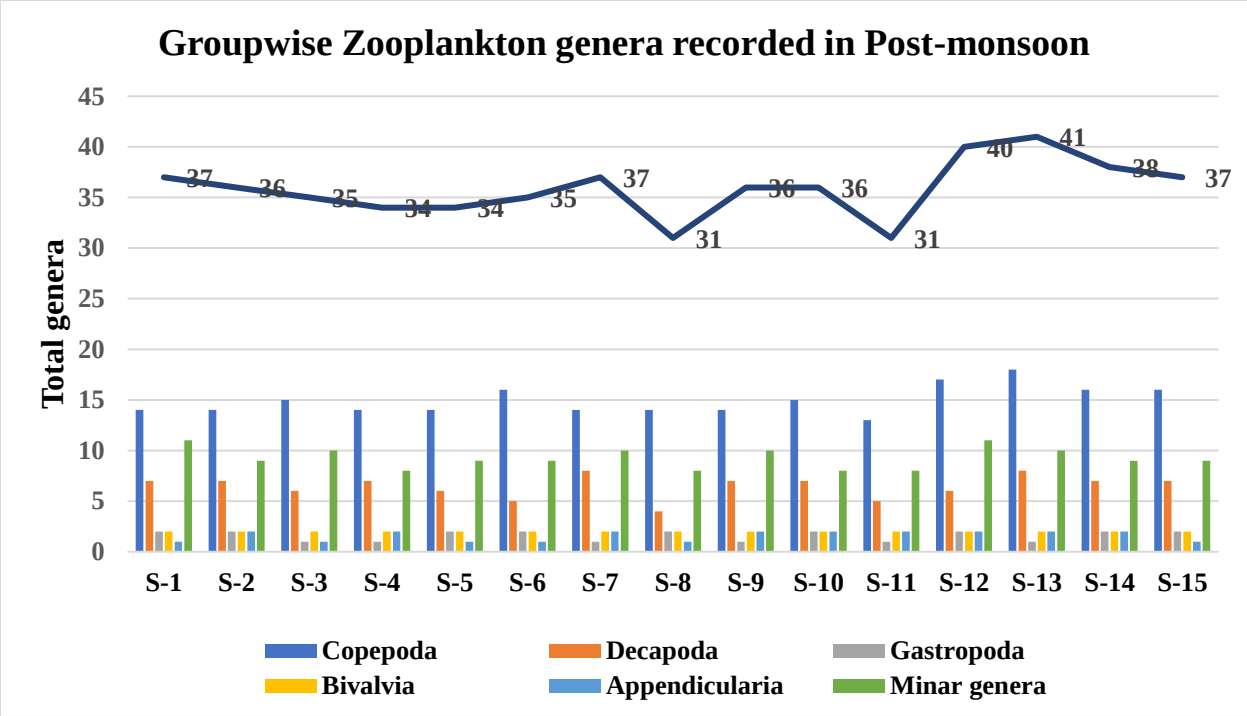


Figure 11: Phylum and generic status of zooplankton during Post-monsoon 2022-2023

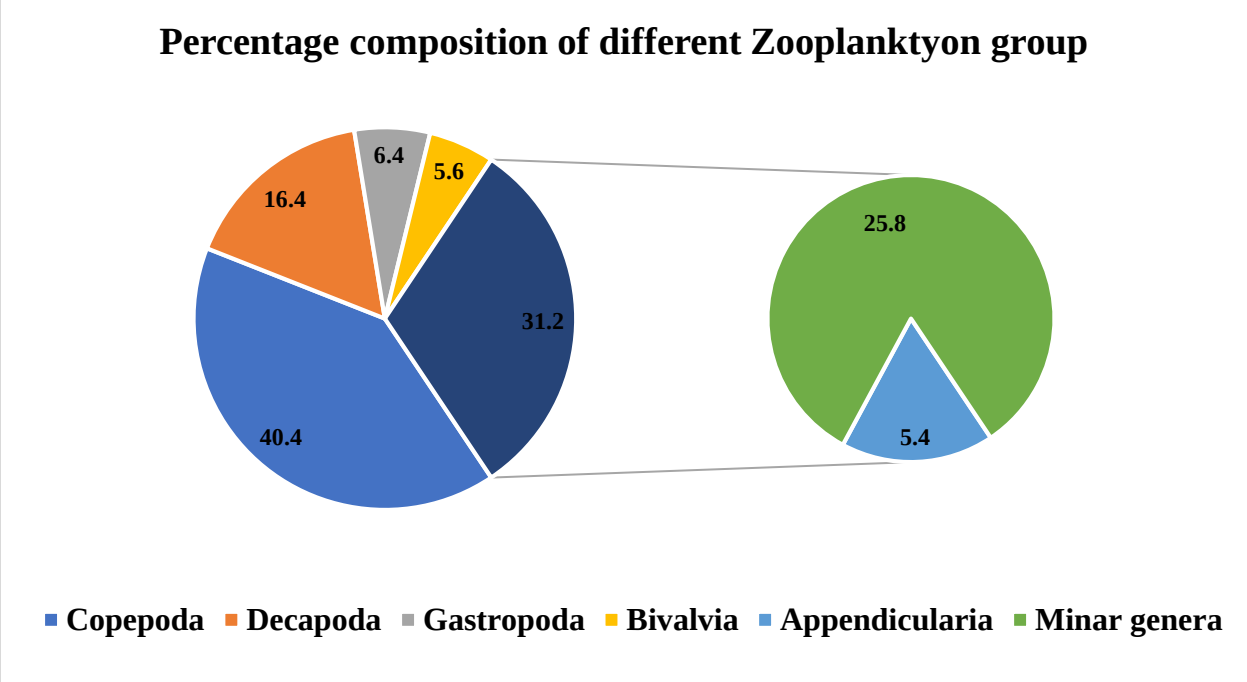


Figure 12: Percentage composition of zooplankton groups during Post-monsoon 2022-2023

Percentage occurrence of zooplankton

The percentage occurrence of zooplankton communities varied from 37% to 100 % (.Figure 13). There were 7 zooplankton genera that exhibited 100% of occurrence (Fig.12) followed by *Branchiopoda Thecostraca* (90%) occurrence. from the study sites (Table4).

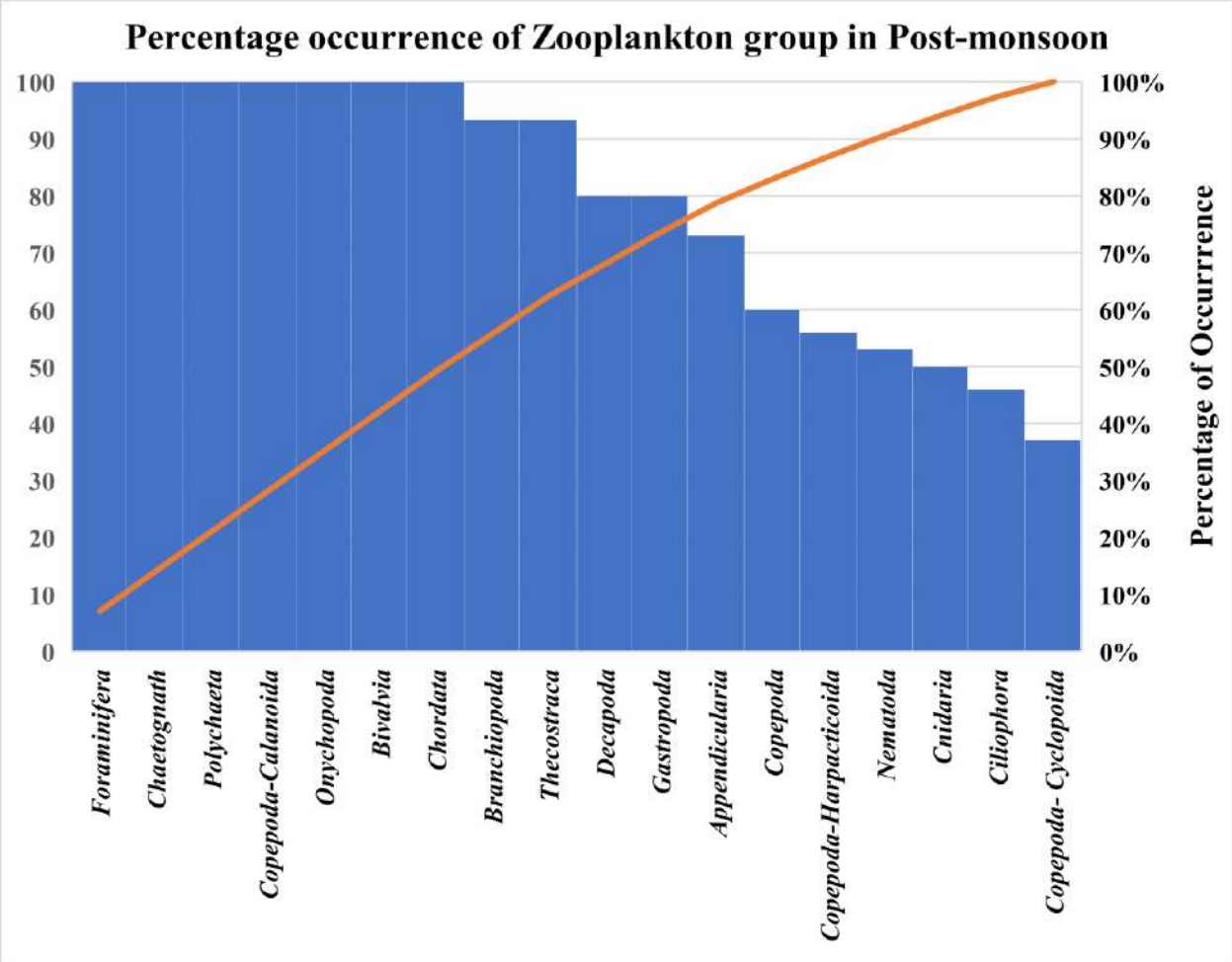


Figure 13: Percentage occurrence of Zooplankton groups during Post-monsoon 2022-2023

Density of zooplankton

Zooplankton population density values during the Post-monsoon 2022 at the 15 sampling sites ranged from 16,840 No/L to37,280 No/L with an overall average of 24,523 No/ L (Table 5). Station-wise, the highest density of 37,280 No/ L was recorded in S-14 and lowest density was reported at S-1 (16,480 No/ L) (Figure 14).

Diversity Index

The Shannon diversity index of the zooplankton ranged between 3.05 to 3.34. Similarly, Margalef and Menhinick species richness index also varied from 2.98 to 3.77, and 0.19 to 0.26 respectively representing the suspended load environment (Figure 15).

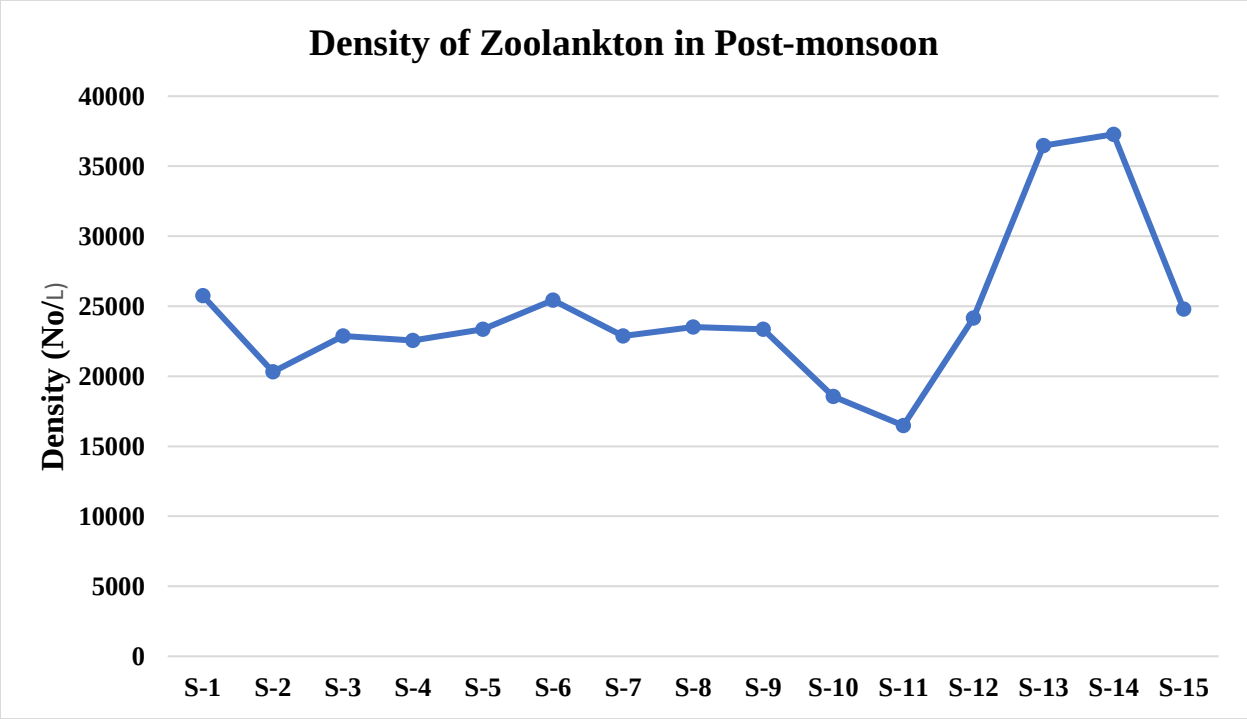


Figure 14: Zooplankton Density in the different stations during Post-monsoon 2022-2023

Table 4: Zooplankton generic status during Post-monsoon 2022-2023 in Deendayal Port Authority area

Phylum	Groups	Genera/ name	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	PC	PO
Protozoa	**Foraminifera**	*Globigerina*	2400	320	1120	2880	160	3680	1920	800	480	640	960	160	1440	480	1760	5.2	100
Colenterate	**Cnidaria**	*Obelia*	160	0	320	0	160	0	0	160	160	0	0	0	160	0	0	0.3	47
		Physalia	0	0	160	0	0	160	160	0	160	0	0	320	160	0	160	0.3	53
Ciliophora		*Tintinnopsis*	160	0	0	0	0	0	160	0	0	0	0	160	0	0	0	0.1	20
		Codonellopsis	320	160	320	0	160	320	160	0	0	160	160	320	320	160	0	0.7	73
	Chaetognath	*Sagitta*	480	320	640	160	160	800	1760	1120	1440	640	800	480	1120	480	320	2.9	100
Annelida	**Nematoda**	*Nematode worm*	480	160	0	160	0	0	160	0	320	0	0	160	0	160	160	0.5	53
	Polychaeta	*Polychaete larvae*	480	2880	640	480	1120	160	320	640	160	640	320	800	480	1120	1760	3.3	100
Arthropoda	**Copepoda Calanoida**	*Acartia*	1440	960	800	800	320	1120	800	1600	1760	1280	480	0	800	2720	480	4.2	
		Acrocalanus	1760	1280	2560	480	2720	960	960	1440	1600	1440	960	800	2720	2080	1760	6.4	100
		Aetideus	640	320	480	1280	800	960	1120	1600	320	480	640	1760	1440	800	480	3.6	
		Calanopia	640	320	160	160	1120	480	800	1120	160	320	480	1120	800	480	640	2.4	
		Calanus	800	800	320	1120	800	1600	1760	1280	480	0	800	2720	480	1440	1120	4.2	
		Centropages	320	160	320	320	160	160	480	800	160	160	320	640	1600	2080	1120	2.4	
		Eucalanus	640	320	160	160	1120	480	800	1120	160	320	480	1120	800	480	640	2.4	
		Labidocera	320	320	160	160	320	480	160	800	640	320	320	160	160	640	160	1.4	
		Nannocalanus	320	1120	800	1600	1760	1280	480	0	800	2720	480	640	800	960	1120	4.0	
		Paracalanus	480	320	160	160	160	320	160	320	320	640	480	480	320	160	320	1.3	
		Pseudodiaptomus	480	480	160	320	320	160	480	480	160	320	320	160	320	160	160	1.2	
		Temora	640	320	480	1280	800	960	1120	1600	320	480	640	1760	2880	1440	480	4.1	
		Tomopteris	0	0	0	0	0	0	0	0	0	0	0	0	160	0	0	0.0	
	Copepoda Harpacticoida	*Corycaeus*	0	0	160	0	0	160	0	320	0	160	0	160	0	0	160	0.3	40
		Clytemnestra	320	160	320	0	160	160	0	0	0	160	0	160	320	160	0	0.5	60
		Euterpina	160	0	160	320	0	320	0	320	480	160	0	160	640	320	160	0.9	73
		Microsetella	0	0	0	160	0	320	0	160	0	160	0	160	160	320	160	0.4	53
	Copepoda-Cyclopoida	*Oithona*	0	160	0	0	0	0	160	0	160	0	320	0	160	0	0	0.3	33
		Oncaea	0	0	0	0	160	0	160	0	0	0	0	160	160	320	160	0.3	40

	Decapoda	*Caridean larvae*	640	320	160	480	640	800	160	320	1120	320	640	160	640	320	800	2.0	100
		Euphausia	1600	320	1440	320	640	1920	640	320	3360	2400	1920	1760	1280	5600	2240	7.0	100
		Lucifer	160	640	0	640	320	0	160	0	160	320	160	0	160	160	1600	1.2	73
		Megalopa larva	160	0	160	0	0	160	160	0	160	0	0	160	320	160	0	0.4	53
		Mysis	480	320	1440	320	160	160	160	0	160	320	0	160	160	160	160	1.1	87
		Nauplius larvae	960	320	640	480	160	0	800	320	160	160	640	160	1440	640	320	2.0	93
		Phyllosoma larva	0	160	0	320	0	0	160	0	0	160	0	0	160	0	160	0.3	40
		Zoea larvae	1120	800	320	640	160	480	160	320	1120	800	160	800	960	320	640	2.4	100
	Branchiopoda	*Cladocera*	480	1280	1600	480	2400	160	0	640	1120	320	160	960	1440	800	1120	3.5	93
	Thecostraca	*Cirriped nauplius*	640	320	160	160	0	320	640	800	320	160	480	160	1120	800	160	1.7	93
	Onychopoda	*Evadne*	800	640	320	640	160	480	160	160	320	160	320	160	640	800	160	1.6	100
Mollusca	**Gastropoda**	*Creseis*	160	160	0	0	160	320	0	160	0	320	0	160	0	320	480	0.6	60
		Gastropod larvae	1920	640	320	3360	2400	1920	1600	320	1440	320	640	1280	2080	1760	1280	5.8	100
	Bivalvia	*Bivalve larvae*	1280	480	1440	960	320	320	1120	640	800	320	160	640	640	1760	160	3.0	100
		Veliger Larva	320	960	640	160	640	160	320	320	1120	320	160	960	1760	1440	160	2.6	100
Chordata		*fish larvae*	160	1280	1760	640	800	2080	1440	1120	800	320	1120	1280	3360	2880	1760	5.7	1000
Appendicularia		*Oikopleura*	1440	640	2080	800	1920	1120	960	2400	640	160	800	640	1920	2400	320	5.0	100
		Copelata	0	160	0	160	0	0	160	0	320	480	160	160	0	0	0	0.4	47
Total Density			25760	20320	22880	22560	23360	25440	22880	23520	23360	18560	16480	24160	36480	37280	24800		
Total genera			37	36	35	34	33	35	37	31	36	36	31	39	40	37	37		

PC: Percentage of composition

PO: Percentage of Occurrence

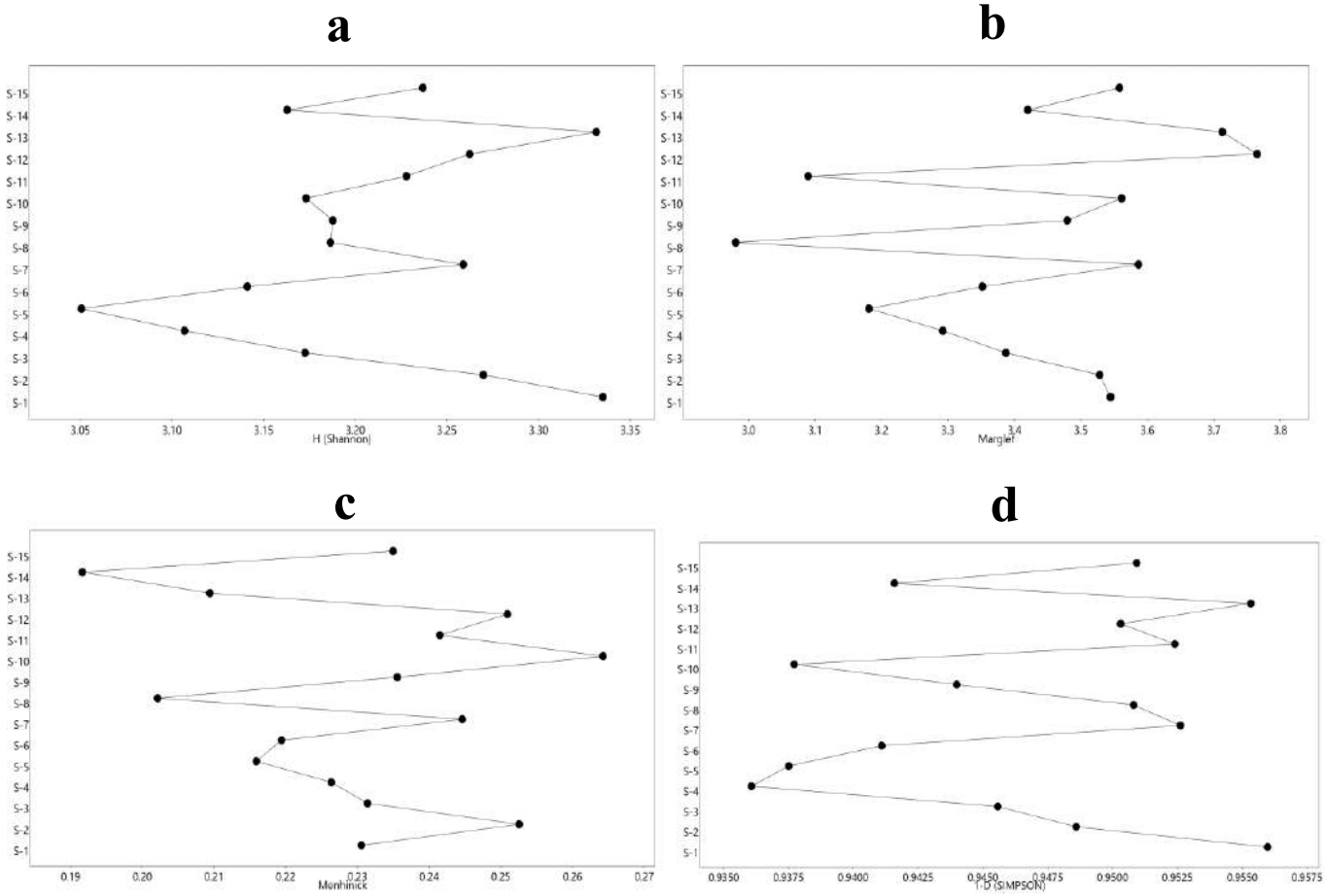


Figure 15: Diversity indices of Zooplankton

a. Shannon Index b. Menhinick Index c. Margalef Index d.Simpson Index

3.6. Intertidal Fauna

The intertidal zone is the area above the water level at low tide and submerged at high tide. Intertidal habitats are found along the margins of the sea and include rocky shores, mudflats, salt marshes, and estuaries. The intertidal diversity was documented during Post-monsoon at the prefixed 15 sampling locations within the DPA jurisdiction. All the macroinvertebrates and vertebrate samples were collected from the sampling stations during the low tide. At each site, 1x 1 m^2 quadrate was placed randomly, and all visible macro-faunal organisms encountered inside the quadrate were identified, counted and recorded. At each site along the transects that run perpendicular to the waterfront, three to six replicate quadrate samples were assessed for the variability in macro-faunal population structure (Davidson *et al*., 2004; Ravinesh and Biju Kumar, 2013). The density of the different faunal groups was averaged for the entire intertidal belt. Organisms, which could not be identified in the field, were preserved in 5% formaldehyde, brought to the laboratory and identified using standard identification keys (Abott, 1954; Vine, 1986; Oliver, 1992; Rao, 2003; 2017; Psomadakis *et al*., 2015; Apte, 2012; 2014; Naderloo 2017; Ravinesh *et al*., 2021; Edward *et al.*, 2022). The invertebrates' taxonomic composition, relative abundance, species richness and diversity were determined (Zar, 1984) to describe the mangrove environment's overall biodiversity at DPA premises. Statistical analyses such as diversity indices and richness were calculated using Paleontological Statistics Software Package for Education and Data (PAST) version 3.2.1 (Hammer *et al*., 2001).

Intertidal Fauna

Composition of intertidal Fauna

The intertidal ecological survey has been conducted at the prefixed 15 locations within the vicinity of the Deendayal Port Authority. The species diversity of the invertebrate phyla showed the maximum for phylum Mollusca (8 species) which is followed by Arthropoda (6 species), Annelida (1species), Nematoda (1 species) and Nemertea (1 species). The phylum Chordata (1) was represented by a single species. The percentage composition of the phyla represented in the samples varied from 5.3% to 42.1%. Among the fauna the highest percentage was contributed by Mollusca (42.1%) followed by Arthropoda (31.6%) and least percentage was due to Nematoda, Nemertea and Chordata (each 5.3%) in the study area during post monsoon (Table 5 & Fig.16).

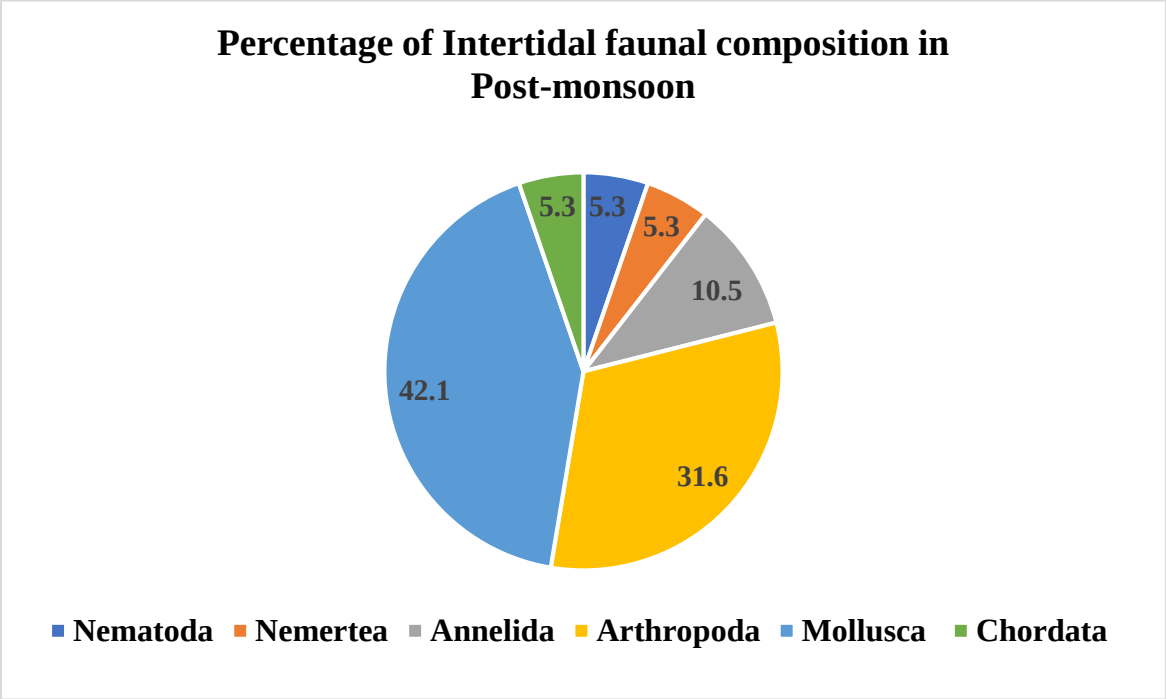


Figure 16: Intertidal Faunal composition (percentage) during post-monsoon 2022-2023

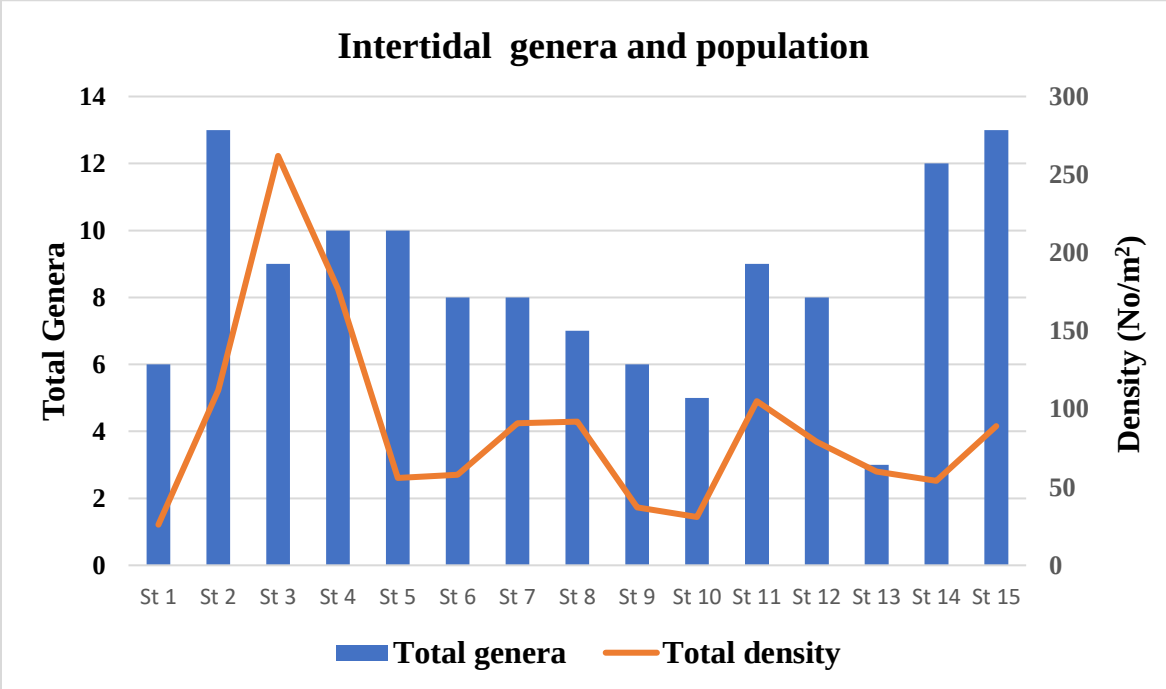


Figure 17 Intertidal genera and population density in Post-monsoon 2022-2023

Intertidal genera and total Population density in (No/m^2)

The population density of intertidal fauna recorded during the post monsoon survey are presented in Fig17. The total genera of intertidal fauna varied from 3 to 13 at the different sampling sites and the average being 8 genera. Highest number of genera was recorded in station S-15 & S-2 followed by S-14,S4 and S-5 (10 each). Least number of genera (3) was recorded at the station S-13. Similarly the density of intertidal fauna varied from 26 No/m2 to 262 No/m2 with average variation of 89 No/m2. The highest population density was recorded at S-3 and lowest population density was recorded at S-1

Percentage composition of species

The percentage composition of intertidal species presented in Fig 18. The overall percentage composition of the four groups of intertidal Fauna at the 15 stations varied from 0.1% to 33.6%. The highest percentage was contributed by the species Pirenella cingulata (33.6%) followed by Optediceros breviculum (13.5%) and Amphibalanus amphitrite (10.9% and the lowest percentage was represented by Metaplax indica (0.1%).

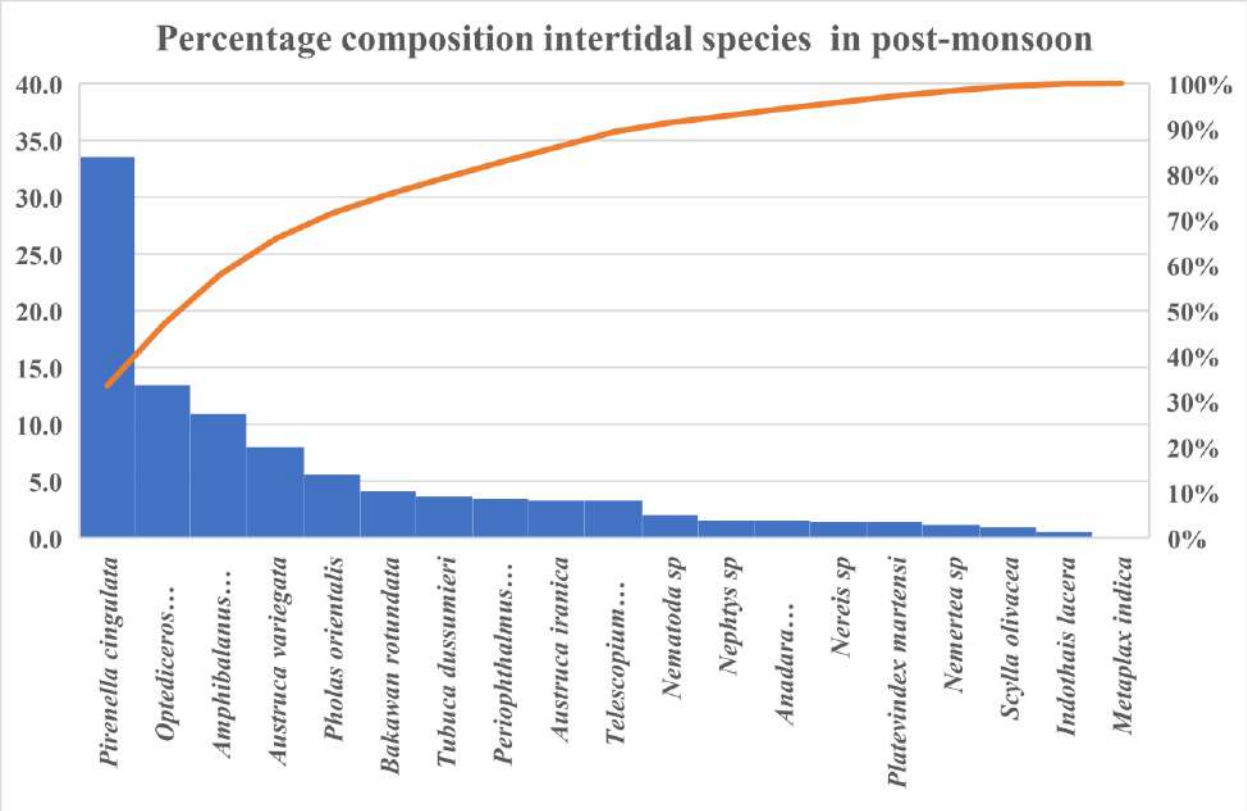


Figure 18: Percentage composition of Intertidal species during post-monsoon 2022-2023

Diversity indices

Figure .19 represents the various intertidal diversity indices calculated for the different fauna recorded from the 15 sites adjoining the DPA port area, Kandla. Diversity indices were calculated for the subtidal fauna in which the Shannon diversity (H') values varied from 0.67 (S-3) to 2.32 (S-14). The Simpson_1-D varied from 0.28 (S -3) to 0.89 (S-14). The menhinick index varied from 0.39 to 1.63, with the maximum in S-14 and the minimum at S-13. The Margalef index ranged from 0.49 to 2.76, the maximum at S-15 and the minimum at S-13.

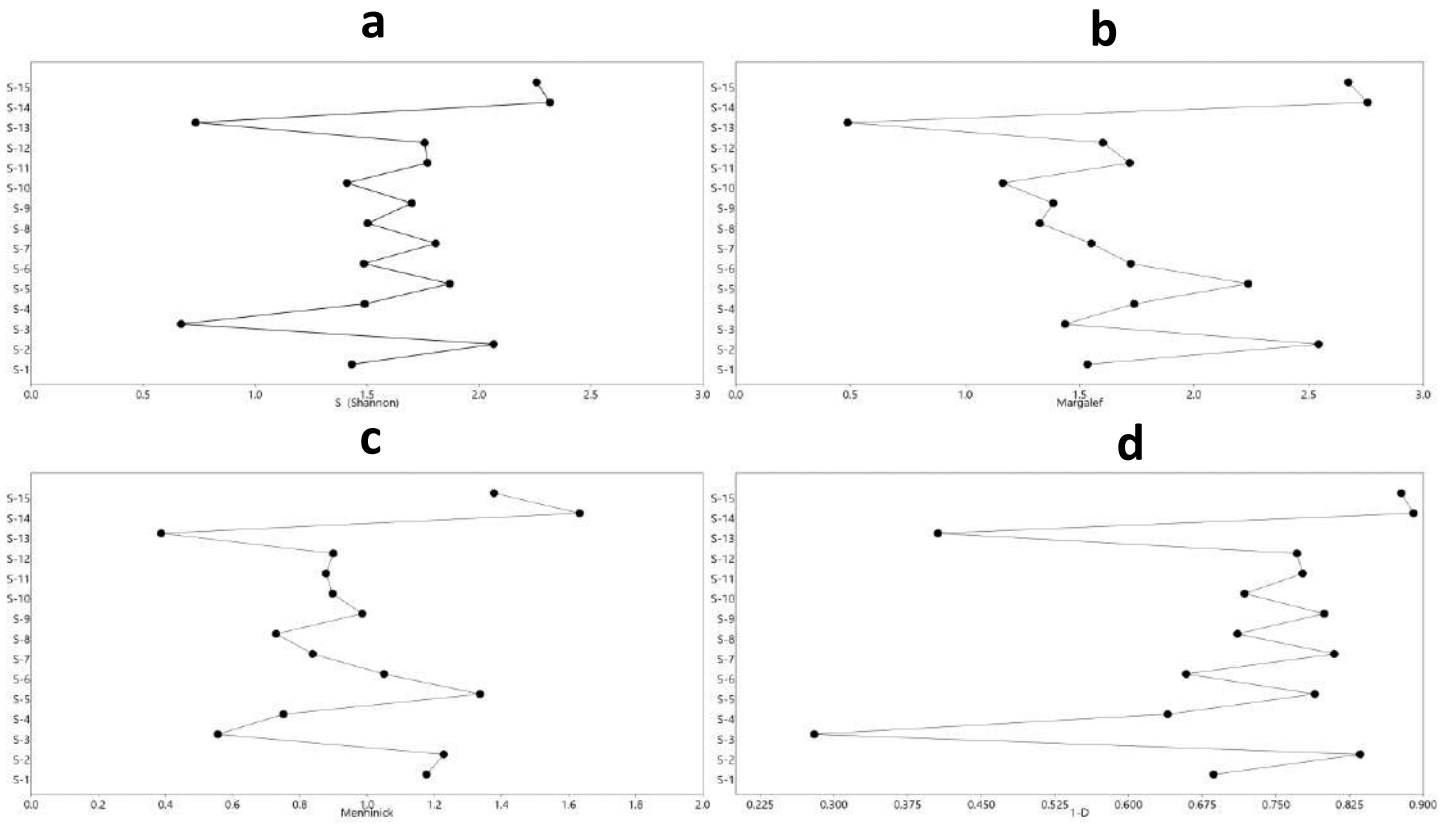


Figure 19: Diversity indices of Intertidal fauna during post-monsoon 2022-2023

a. Shannon Index b. Menhinick Index c. Margalef Index d.Simpson Index

Table 5: Intertidal faunal distribution along Deendayal Port Authority area during Post-monsoon 2022-2023

Phylum	Species	S-1	S-2	S-3	St 4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	St 12	S- 13	S-14	S- 15	PC	PO
Nemertea	*Nemertea* sp	0	0	1	2	0	1	0	0	0	2	0	3	0	3	3	1.1	47
Nematoda	*Nematoda sp*	0	13	0	0	3	1	0	2	0	5	0	0	0	1	2	2.0	47
Annelida	*Nereis* sp	3	0	0	3	2	0	0	6	0	0	0	4	0	0	1	1.4	40
	Nephtys sp	0	4	3	0	0	4	0	0	3	0	3	0	0	3	0	1.5	40
Arthropoda	*Scylla olivacea*	0	1	0	0	4	0	2	0	0	0	3	0	0	3	0	1.0	33
	Austruca variegata	0	10	4	7	1	0	11	21	5	8	11	9	0	3	16	8.0	80
	Austruca iranica	0	32	0	0	0	0	0	0	0	3	0	7	0	1	1	3.3	33
	Metaplax indica	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	7
	Amphibalanus amphitrite	0	23	0	31	21	0	0	42	0	0	0	14	0	0	14	10.9	40
	Tubuca dussumieri	0	1	2	7	11	0	0	13	0	0	0	6	0	0	9	3.7	47
Mollusca	*Pirenella cingulata*	0	0	221	100	0	6	26	3	5	0	34	0	45	6	0	33.6	60
	Telescopium telescopium	2	0	3	5	0	0	11	0	6	0	7	0	7	0	3	3.3	53
	Indothais lacera	1	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0.5	13
	Bakawan rotundata	2	3	2	0	3	3	22	0	0	0	8	0	0	9	3	4.1	60
	Platevindex martensi	0	0	3	0	3	0	2	0	0	0	4	0	0	4	3	1.4	40
	Optediceros breviculum	13	11	23	11	1	32	0	0	12	0	32	32	0	0	12	13.5	67
	Anadara inaequivalvis	0	2	0	4	0	5	0	5	0	0	0	4	0	0	0	1.5	33
	Pholas orientalis	5	9	0	0	7	0	12	0	0	13	0	0	8	7	13	5.6	47
Chordata	*Periophthalmus waltoni*	0	2	0	7	0	6	5	0	6	0	3	0	0	8	9	3.5	53
Density /m2		**26**	**112**	**262**	**177**	**56**	**58**	**91**	**92**	**37**	**31**	**105**	**79**	**60**	**54**	**89**		
Total genera		**6**	**13**	**9**	**10**	**10**	**8**	**8**	**7**	**6**	**5**	**9**	**8**	**3**	**12**	**13**		

3.7. Subtidal Fauna (Macrobenthos)

Subtidal ecosystems are permanently submerged due to tidal influence, whereas intertidal ecosystems are found between the high tide and low tide, experiencing fluctuating influences of land and sea. Macrobenthos are an important component of estuarine and marine ecosystems. At large scales, food may be the prime limiting factor for benthic biomass. Depending on the system's characteristics, grazing by benthic suspension feeders may be the most important factor determining system dynamics. The sampling methods and procedures were designed in such a way as to obtain specimens in the best possible condition to maximize the usefulness of the data obtained. For studying the benthic organisms, triplicate samples were collected at each station using Van Veen grab, which covered an area of $0.04m^2$. The wet sediment was passed through a sieve of mesh size 0.5 mm for segregating the organisms. The organisms retained in the sieve were fixed in 5-7% formalin and stained further with Rose Bengal dye for the ease of spotting at the time of sorting (Ravinesh and Biju Kumar, 2022). The number of organisms in each grab sample was expressed as No $/m^2$. All the species were sorted, enumerated and identified by following available literature. The works of Day (1967), Hartman (1968, 1969), Rouse and Pleijel (2001), Robin et al., (2003), Amr (2021), were referred for polychaetes; Crane (1975), Holthuis (1993), Naderloo (2017). Xavier *et a*l., (2020) for crustaceans; Subba Rao (1989, 2003. 2017), Apte (2012,2014), Ramakrishna and Dey (2007), Ravinesh *et al.* (2021) and Edward *et al*., (2022). for molluscs. Statistical analyses such as diversity indices and quadrat richness were calculated using Paleontological Statistics Software Package for Education and Data (PAST) version 3.2.1 (Hammer *et al*., 2001).

Subtidal macrobenthos

Phylum composition of subtidal Fauna

The subtidal macrofauna survey was conducted at 15 locations within the vicinity of the Deendayal Port Authority. The species diversity calculated was maximum for phylum Mollusca (13 species) which is followed by Annelida (6species) and Arthropoda (2 species),The Cnidaria was represented by a single species (Table.6). The fanatic composition varied from 5% to 59%. Among the fauna the highest percentage of contribution was contributed by Mollusca (59%) followed by Annelida (27%) and least number of percentage was contributed by Cnidaria (5%) (Fig 20.)

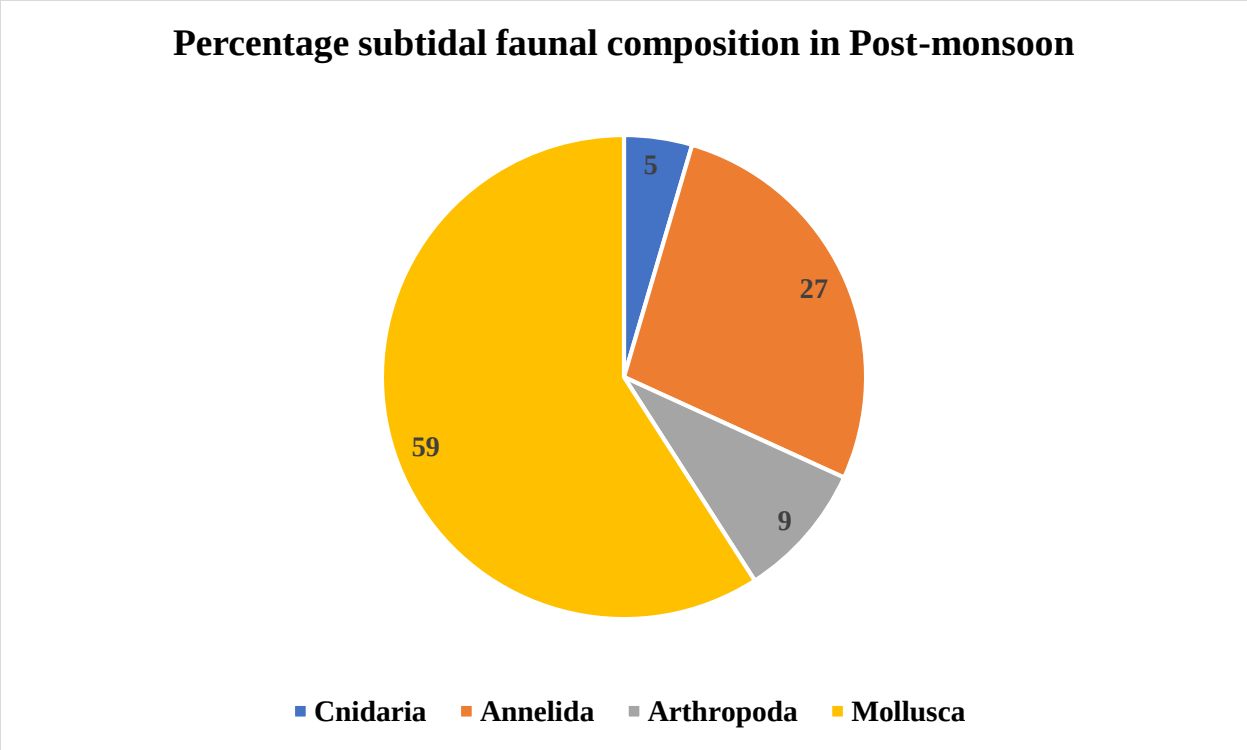


Figure 20. Phylum composition of subtidal macrobenthos during Post-monsoon 2022-2023

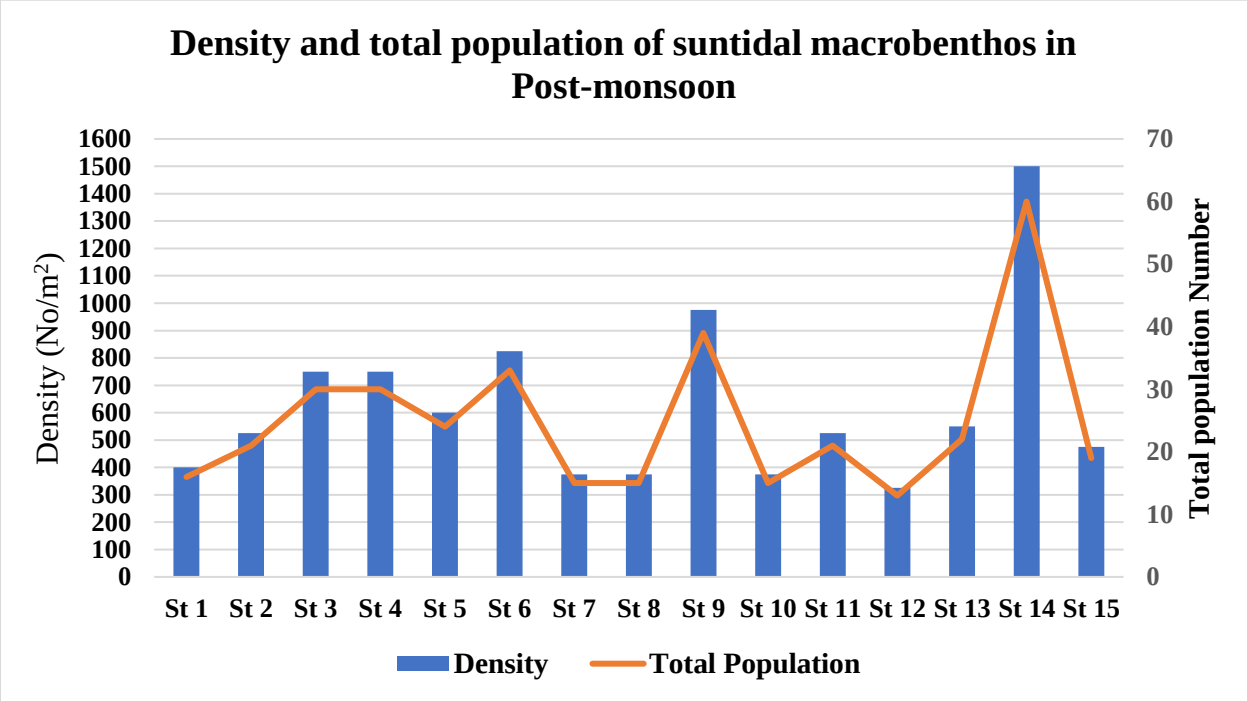


Figure 21: Total genera and population density macrobenthos during Post-monsoon 2022-2023

Total genera &populationa density(No/m^2)

The number of intertidal fauna population collected from the intertidal zone and its density are presented in Fig 21. The total genera of subtidal fauna varied from 6 to 116 with average of 9 number. Highest number of genera was recorded in station S-14 (16) and lowest number of genera was recorded along the station S-7 (3 No). Similarly the total population of subtidal fauna varied from 13-60 number with average variation of 25 number. Highest number of population was recorded at S-14 (60 no) and lowest was recorded at S-12 (13 no). Likewise the subtidal macrobenthos population density varied from 325 No/m^2 to 1500 No/m2 with average 622 No/m^2. The highest population density was recorded at S-14 (1500 No/ m^2) followed by S-9 (975 No/ m^2) and the lowest density was recorded at S-12 throughout the study period.

Percentage composition of species

The overall percentage composition of the four groups of subtidal genera/species at the 15 stations varied between 0.5% to 14% with an average of 4.5% (Fig.22). The highest percentage of species composition was contributed *Glauconome angulata* (13.7%) followed by *Pirenella cingulata* (12.9%) and *Clypeomorus bifasciata*(6.4%) and *Nereis sp.* (6.4%) while the least was (0.5%). represented by *Turritella sp.*

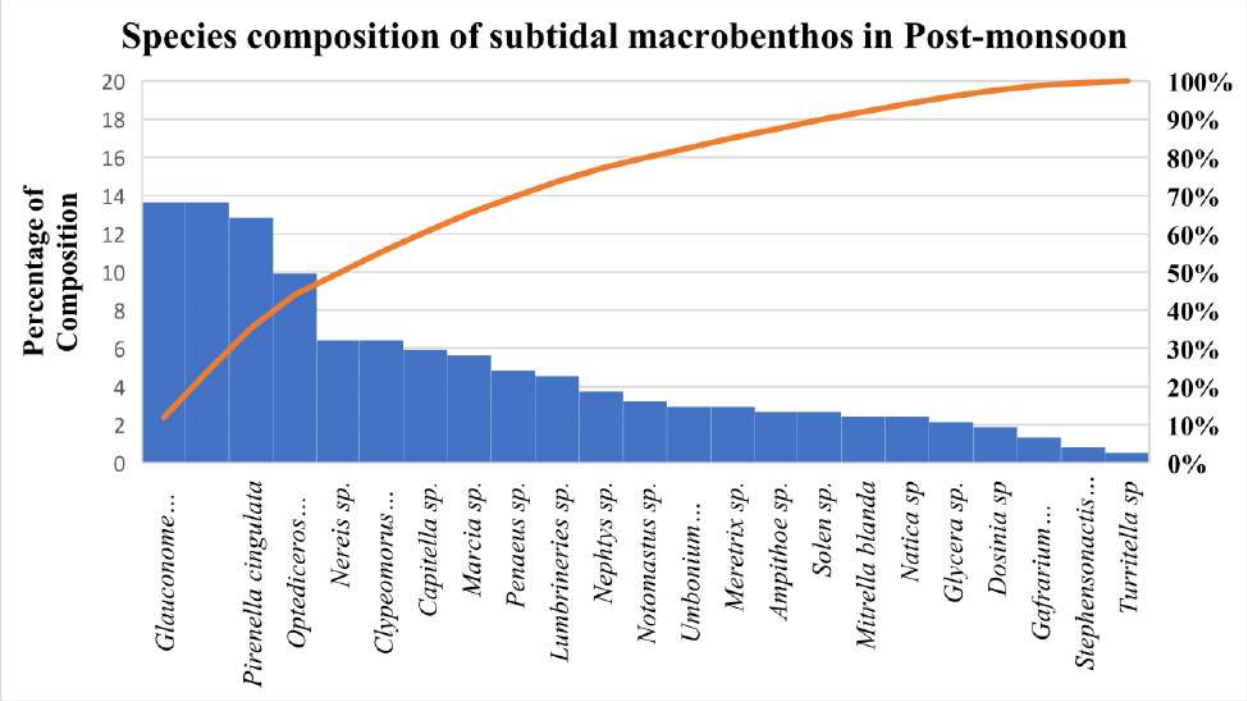


Figure 22. Percentage composition of Subtidal Macrobenthic species in Post-monsoon 2022-2023

Diversity indices

Figure 23 represents the various intertidal diversity indices calculated for the different fauna recorded from the 15 sites adjoining the DPA port area, Kandla. Diversity indices were calculated for the subtidal fauna in which the Shannon diversity (H') values varied from 1.53 (S-10) to 2.60 (S-14). The Simpson_1-D varied from 0.74 (S -5) to 0.92 (S-14). The menhinick index varied from 1.23 to 2.07, with the maximum in S-14& S-15 and the minimum at S-5. The Margalef index ranged from 1.57 to 3.66, the maximum at S-14and the minimum at S-5.

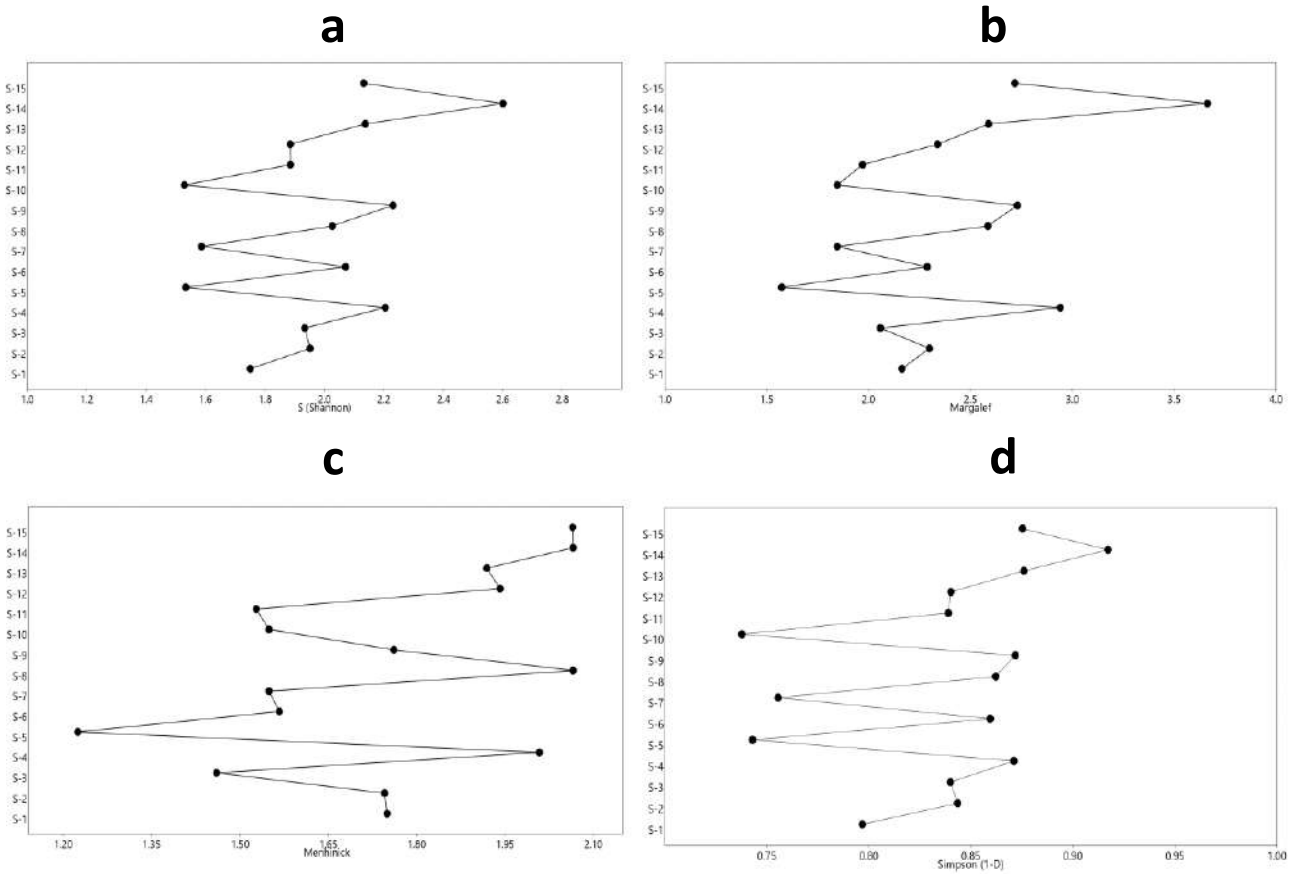


Figure 23: Diversity indices of Subtidal fauna during Post-monsoon 2022-2023

a. Shannon Index b. Menhinick Index c. Margalef Index d. Simpson Index

Table 6: Macro-benthic faunal distribution during Post-monsoon 2022 -2023in Deendayal Port Area

Phylum	Genera/Species	St 1	St 2	St 3	St 4	St 5	St 6	St 7	St 8	St 9	St 10	St 11	St 12	St 13	St 14	St 15	PC
Cnidaria	*Stephensonactis* sp.	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0.8
Annelida	*Capitella* sp.	0	3	0	0	3	0	0	0	5	4	3	1	0	3	0	5.9
	Glycera sp.	0	1	0	0	0	0	2	0	2	0	0	0	3	0	0	2.1
	Lumbrineries sp.	1	0	4	3	0	0	1	0	0	2	0	2	2	0	2	4.6
	Nephtys sp.	2	0	2	1	0	3	0	2	3	0	0	0	0	1	0	3.8
	Nereis sp.	0	3	1	1	0	4	0	0	3	1	4	0	4	0	3	6.4
	Notomastus sp.	2	0	0	2	0	3	0	0	2	0	0	0	3	0	0	3.2
Arthropoda	Ampithoe sp.	0	0	0	0	2	0	0	1	3	0	0	2	0	2	0	2.7
	Penaeus sp.	0	2	0	0	1	4	0	0	3	0	2	0	2	1	3	4.8
Mollusca	*Umbonium vestiarium*	1	0	0	2	0	3	0	1	0	1	0	0	0	3	0	2.9
	Mitrella blanda	0	0	0	0	0	0	0	0	0	0	2	0	0	7	0	2.4
	Clypeomorus bifasciata	0	0	0	0	0	0	0	2	10	0	2	3	0	6	1	6.4
	Natica sp	0	0	0	1	0	0	0	0	0	0	0	0	1	7	0	2.4
	Optediceros breviculum	4	5	6	4	2	2	3	2	1	0	0	0	0	5	3	9.9
	Pirenella cingulata	5	0	5	6	7	5	1	2	3	1	5	2	3	1	2	12.9
	Turritella sp	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0.5
	Marcia sp.	0	0	3	2	0	1	2	3	0	0	0	1	2	5	2	5.6
	Glauconome angulata	0	2	7	6	9	8	6	2	0	6	3	2	0	0	0	13.7
	Dosinia sp	0	0	2	2	0	0	0	0	0	0	0	0	0	3	0	1.9
	Gafrarium divaricatum	0	1	0	0	0	0	0	0	0	0	0	0	0	2	2	1.3
	Meretrix sp.	0	4	0	0	0	0	0	0	0	0	0	0	0	6	1	2.9
	Solen sp.	0	0	0	0	0	0	0	0	4	0	0	0	0	6	0	2.7
Density No/m^2		**400**	**525**	**750**	**750**	**600**	**825**	**375**	**375**	**975**	**375**	**525**	**325**	**550**	**1500**	**475**	
Total Population		**16**	**21**	**30**	**30**	**24**	**33**	**15**	**15**	**39**	**15**	**21**	**13**	**22**	**60**	**19**	
Total genera		**7**	**8**	**8**	**11**	**6**	**9**	**6**	**8**	**11**	**6**	**7**	**7**	**9**	**16**	**9**	

3.8. Seaweeds

Along the Gujarat coast which is represented by 1600 km coastline, harbors 198 species of which 109 species from 62 genera belonging to Rhodophyta, 54 species of 23 genera to Chlorophyta, and 35 species from 16 genera to Ochrophyta (Jha *et.al*.,2009). According to Mantri *et.al*. (2020) there are 13 potential sites for the occurrence of seaweed density and diversity. The survey conducted by CSIR-CSMCRI (Jha *et.al*., 2009) confirmed the presence of industrially important taxa, namely, *Gelidiella acerosa, Gelidium micropterum, G. pusillum, Ahnfeltia plicata, Gracilaria dura, G. debilis, Gracilariopsis longissima* (formerly *G. verrucosa*), *Hypnea musciformis, Meristotheca papulosa, Porphyra sp, Asparagopsis taxiformis* (Rhodophyta), *Sargassum tenerrimum, S. plagiophyllum, S. swartzii, Turbinaria ornata* (Ochrophyta), *Ulva prolifera* (formerly *Enteromorpha prolifera*), *Ulva compressa* (formerly *Enteromorpha compressa*), and *Ulva flexuosa* (formerly *Enteromorpha tubulosa*) (Chlorophyta) from the coastal waters of Gujarat. In the present study, an attempt was made to describe the occurrence, diversity and other ecological features of seaweeds within Deendayal Port jurisdiction. It was found that except for some drifted species *Enteromorpha and Chaetomprpha* at S-13 and S-14 of Vira coast (Plate-6) no natural seaweed beds are seen in the different locations within DPA environment.

Seaweeds grow in the rocky intertidal and sub tidal habitats that offer a hard substratum for attachment. Low turbidity level in the water column with high nutrient content is a major habitat requirement that enables photosynthesis. Total dissolved solids (TDS) load in the Deendayal Port area creek waters ranged from 32200 to 45700 mg/L and suspended solids value between 140-640 mg/L restricts the photosynthetic activity of seaweeds which are highly sensitive to light. Hence, seaweed formations are absent in the creek systems of the Deendayal Port coastal environment.

3.9. Seagrass

Similar to seaweeds, sea grasses were also absent in the creek systems of Deendayal Port area and in the adjacent coastal stretches of Kachchh due to inherent habitat conditions. Sea grasses generally thrive in shallow coastal waters and are adapted to live in submerged conditions from mid intertidal to depth as much as 50 m when light penetration is sufficient; conditions contrary to the one prevailing in Deendayal Port and the nearby creek systems explain the total absence of sea grasses.

3.10. Halophytes

The holophytes are the plants that are adopted in coastal estuaries and salt marshes. It is common in arid and desert milieu which often have substantial salt accumulation. Technically it is the plant which has tolerance to moderate to high salt concentration in its growth substrate. Halophytes, that survive to reproduce in environments where the salt concentrations around 200 mM NaCl or more, constitute about 1% of the world's flora. (Timothy *et al*., 2008). Halophytes are classified based on their growth conditions as obligate halophytes, facultative halophytes, and habitat-indifferent halophytes. In the present study, four major halophytes recorded along the selected Deendayal Port Authority sites during the Post-monsoon sampling, were *Salicornia brachiata, Aeluropus lagopoides, Salvadora persica* and *Sesuvium portulacastrum*. Among the halophyte species recorded, *Salicornia brachiata* alone was found in the 8 sampling locations. (Table-7 and Plate-12). The percentage of *Salicornia brachiata* was found to be the highest at station S-9 and the lowest in S-11(100%), followed by *Salvadora persica* 20% (S-10) and *Sesuvium portulacastrum* (15%) at S-12. The halophytes grass *Aeluropus lagopoides* reported at S-11 as 33% from Deedayal Port Authority periphery environment.

Table 7: Percentage of Halophytes cover in the DPA during Post-monsoon 2022-2-23

Halophytes	**S-1**	**S-2**	**S-3**	**S-4**	**S-5**	**S-6**	**S-7**	**S-8**	**S-9**	**S-10**	**S-11**	**S-12**	**S-13**	**S-14**	**S-15**
Aeluropus lagopoides		0	0	0	0	0	0	0	0	0	33	0	0	0	0
Salicornia brachiata		0	10%	52%	81%	0	0	64%	100%	35	100%	0	0	0	66%
Salvadora persica		0	0	0	0	0	0	0	0	20%	0	0	0	0	0
Sesuvium portulacastrum		0	60%	0	0	0	0	0	0	0	0	15%	0	0	0

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

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

3.11. Mangroves

In India, mangroves are distributed over nine states and three union territories; among those, the state of Gujarat has a longest coastline. With this, two (Gulf of Kachchh and Gulf of Khambhat) out of the three major gulfs of India are located in Gujarat. This makes Gujarat coastal area as one of the most important area in terms of ecology and environment for providing the suitable habitats for various plants and animal species living in coastal environment. Mangroves are found in intertidal areas which protect the coastal areas against various problems such as erosion caused by wind and water currents. With this, mangroves are capable to protect the coast from various natural disasters such as cyclones and tsunamis. They are also play important role as carbon sinks in coastal and intertidal zones. Gujarat shows the second largest mangrove cover of India after the state of West Bengal. This is the success of conservation and development activities had been priorities in the Gujarat for mangroves. Mangrove cover in Gujarat is distributed over a few parts such as Kachchh and Gulf of Kachchh, Saurashtra, and South Gujarat particularly Gulf of Khambhat. Gulf of Kachchh hosts one of the major mangrove formations of India spreading to an area of 980 km2. The vegetation characteristics of mangroves of Gulf of Kachchh have been thoroughly studied and documented by GUIDE.

Tree Density

During the post-monsoon 2022-23, total 12 mangrove sites were surveyed for the recoding the plant growth parameters such as height, girth, canopy cover etc and the density of plants. Among the 12 sampling sites, the mean plant density was maximum at Tuna creek (4371/ ha), followed by Jangi creek (3210/ Ha). Considering the sampling sites individually the highest tree density was reported at S12 in the Tuna creek area (6515/Ha). The lowest average tree density of individual sites was reported in S-5 (1491 trees/ Ha) sampling site located at Phang creek. In terms of creeks, the lowest average density was recorded at Kharo creek in which only one sampling site is located S-7 (2291/ha). All these results show that inconsistency in mangroves was with respect to local geomorphology and various ecological and environmental characteristics. (Fig.24 & Table 8).

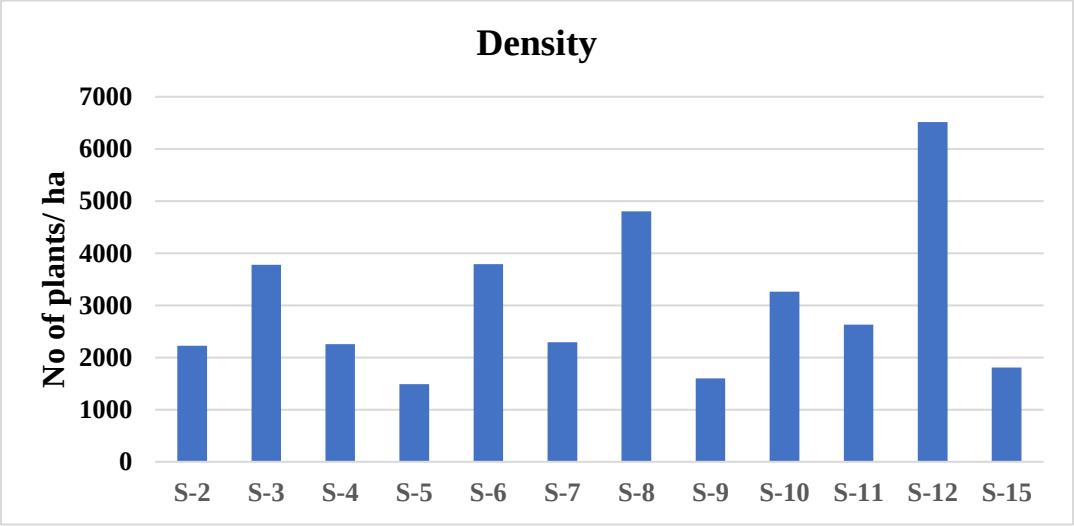


Figure 24. Mangrove Plant density during Post-monsoon 2022-2023

Height

The overall mean height of the mangroves from study sites along the DPT port environment was 1.8 m during post-monsoon season of 2022 (Fig.25). The highest average tree height was recorded at Phang creek area (2.1 m), followed by at Tuna creek (1.9 m). In terms of individual sites, the average highest tree height was recorded at the site S-2 located at Tuna creek, followed by site S-10 located at Phang creek. The average tree heights of the various sites varied between 1.2 m and 2.6 m during the post-monsoon period.

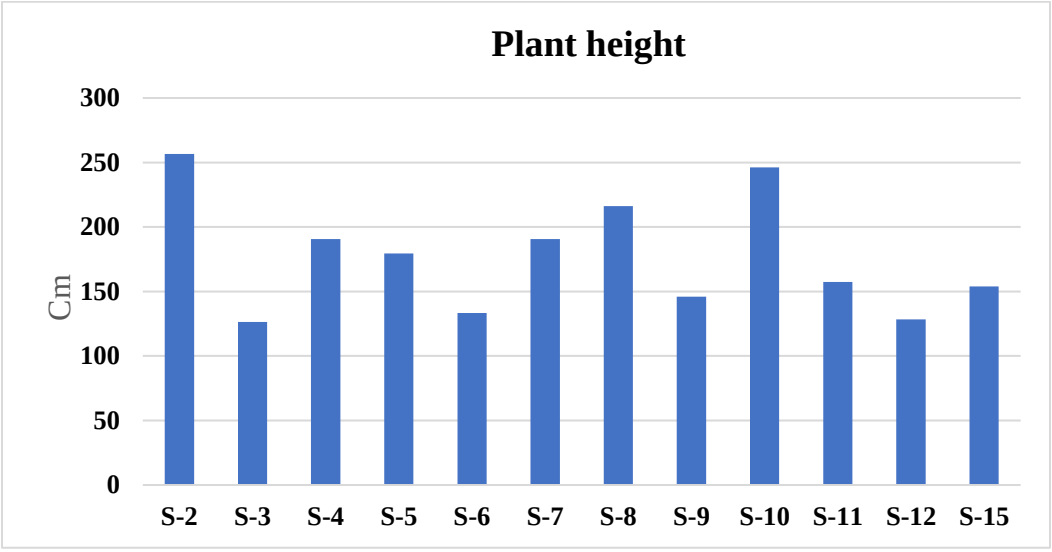


Figure 25. Plant height during Post-monsoon 2022-2023

Canopy Crown Cover

In DPA Kandla sampling area, the canopy cover of mangroves show variations in wide extends. The overall average canopy cover was reported 4.8 m2 during the post-monsoon 2022. The sites S-12 at Tuna creek, S-3 at Kandla creek and S-6 at Jangi creek showed relatively lower average canopy cover compared to others. The highest average canopy cover was reported at S-2 (Tuna creek) which was ranging from 0.48 m to 22.5 m. The second largest average canopy cover was reported at S-15 site of Kandla creek which was ranging from 4 m to 8.4 m (Fig.26).

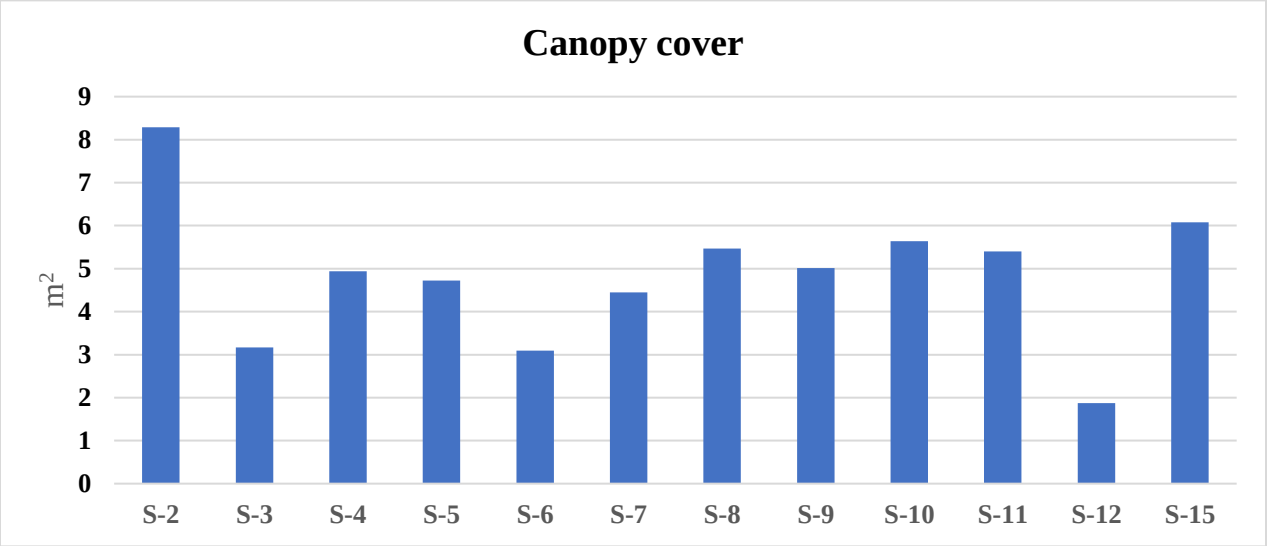


Figure 26. Mangrove canopy cover during Post-monsoon 2022-2023

Basal area

The overall average basal girth of the mangroves of the DPA sampling sites was reported 21.7 cm. In case of individual sampling sites, the highest average basal area (40 cm) was at site S-5 followed by site S-10 (39.7 cm), located in the Phang creek. The lowest average basal girth was reported in the site S-12 (8.7 cm) of Tuna creek. The mangrove plants have multiple stems pattern which is general characteristics of a few mangrove species particularly *Avicennia marina* which is generally found in the DPA Kandla area (Fig.27).

.

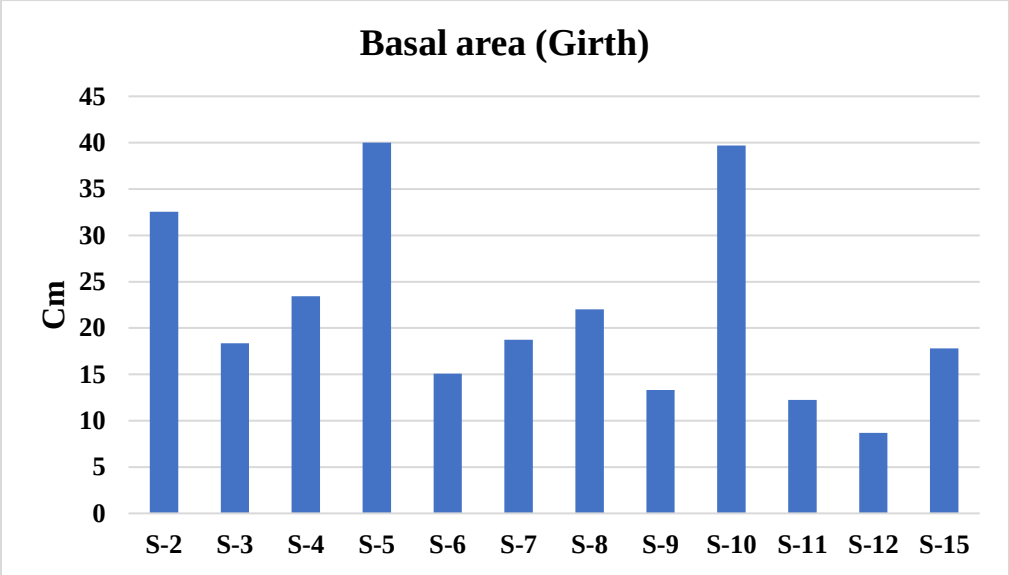


Figure 27. Mangrove basal area during Post-monsoon 2022-2023

Regeneration and Recruitment class

The overall average regeneration class density was 67829 plants/ha and that of recruitment class 13483 plants/ha. The highest average regeneration class plants were recorded (141000 plants/ha) at S-8 site located in Navlakhi creek and for recruitment class, the highest average plants were recorded at site S-3 (28625 plants/ha) located in the Kandla creek during this post-monsoon season. The highest ratio for tree density to recruitment class was observed at S-3 site while the lowest ratio was observed at S-11 site. The complex hydro-edaphic conditions in the DPA Kandla premises can influence the mangrove stature and are substantiated with infrequent tidal coverage and high evapotranspiration. The availability of regeneration and recruitment class plants in the sampling sites can assure that there are plants to take position of trees in case of any harm to mature plants (Table 9).

Plate 8: Mangrove species recorded along the Deendayal Port area

a. ***Avicenna marina*** **b.** ***Aegiceras corniculatum*** **c.** ***Ceriops tagal*** **d.** ***Rhizophora mucronata***

Table 8: Density of mangroves in the DPA vicinity during Post-monsoon 2022-2023

Sampling stations	Density (Tree/Ha)	Tree height (m)			Canopy cover (m^2)			Basal Area (cm)		
		Min	Max	Avg.	Min	Max	Avg.	Min	Max	Avg.
Tuna creek										
S2	2226.55	130.00	450.00	256.67	0.48	22.50	8.29	7.00	120.00	32.56
S12	6515.31	110.00	180.00	128.33	0.12	5.46	1.87	7.00	12.00	8.67
Mean	4370.93	120.00	315.00	192.50	0.30	13.98	5.08	7.00	66.00	20.62
Phang creek										
S5	1490.74	110.00	310.00	179.50	1.54	10.54	4.72	12.00	110.00	40.00
S10	3265.31	100.00	420.00	246.25	0.56	16.40	5.64	7.00	120.00	39.69
Mean	2378.03	105.00	365.00	212.88	1.05	13.47	5.18	9.50	115.00	39.85
Kandla creek										
S3	3780.86	105.00	210.00	126.32	0.42	15.58	3.17	7.00	80.00	18.37
S4	2256.25	110.00	380.00	190.53	0.40	12.24	4.94	7.00	80.00	23.42
S15	1810.77	110.00	230.00	154.00	3.99	8.40	6.08	10.00	40.00	17.80
Mean	2615.96	108.33	273.33	156.95	1.60	12.07	4.73	8.00	66.67	19.86
Kharo creek										
S7	2290.89	110.00	400.00	190.71	0.54	20.00	4.45	7.00	100.00	18.75
Jangi creek										
S6	3790.74	110.00	290.00	133.39	0.12	9.30	3.09	7.00	45.00	15.09
S11	2629.85	100.00	200.00	157.50	2.04	8.70	5.40	9.00	17.00	12.25
Mean	3210.30	105.00	245.00	145.45	1.08	9.00	4.25	8.00	31.00	13.67
Navlakhi creek										
S8	4805.21	110.00	400.00	216.29	0.72	21.60	5.47	7.00	80.00	22.00
S9	1600.00	105.00	200.00	146.00	2.21	9.60	5.01	9.00	18.00	13.30
Mean	3202.61	107.50	300.00	181.15	1.47	15.60	5.24	8.00	49.00	17.65
Overall average	3011.45	109.31	316.39	179.94	1.01	14.02	4.82	7.92	71.28	21.73

Table 9: Regeneration and Recruitment class plants during Post-monsoon 2022-2023

Station	Tree density- No/ha (1)	Regeneration density- No/ha (2)	Recruitment density- No/ha (3)	Ratio of 1:3	Ratio of 2:3
Tuna creek					
S-2	2226.55	140000	11775	1 : 5.29	11.89 : 1
S-12	6515.31	70000	11750	1 : 1.80	5.96 : 1
Mean	4370.93	105000	11763	1 : 2.69	8.93 : 1
Phang creek					
S-5	1490.74	80000	6562	1 : 4.40	12.19 : 1
S-10	3265.31	43000	11250	1 : 3.45	3.82 : 1
Mean	2378.03	61500	8906	1 : 3.75	6.91 : 1
Kandla creek					
S-3	3780.86	46500	28625	1 : 7.57	1.62 : 1
S-4	2256.25	84000	7000	1 : 3.10	12.00 : 1
S-15	1810.77	48000	8750	1 : 4.83	5.49 : 1
Mean	2615.96	59500	14792	1 : 5.65	4.02 : 1
Kharo creek					
S-7	2290.89	45000	22250	1 : 9.71	2.02 : 1
Jangi creek					
S-6	3790.74	54444	12500	1 : 3.30	4.36 : 1
S-11	2629.85	34500	4375	1 : 1.66	7.89 : 1
Mean	3210.30	44472	8438	1 : 2.63	5.27 : 1
Navlakhi creek					
S-8	4805.21	141000	16000	1 : 3.33	8.81 : 1
S-9	1600.00	42000	13500	1 : 8.44	3.11 : 1
Mean	3202.61	91500	14750	1 : 4.61	6.20 : 1
Overall average	3011.45	67828.67	13482.94	1 : 4.48	5.03 : 1

3.12. Marine Reptiles

During the field surveys, one reptilian species, the saw-scaled *viper Echis carinatus sochureki* was recorded at site S-10 located in the western part of Sat Saida bet opposite to Phang creek during Post-monsoon season. This species was spotted on the ground among the mangrove trees. The literature describes the species as aggressive and strikes at a lightning speed, the observed specimen was active.

Plate 9: Marine reptiles recorded along the Deendayal Port Authority area

3.13. Marine Fishery

Marine fish production of India during the financial year 2019-2020 was 37.27 lakhs tons (Fisheries statistics 2021). The production varied from 0.2 to 7.01 lakh tons and Gujarat state contributed the highest production (Fisheries statistics 2021). The Ichthyofauna diversity of the Gulf of Kachchh includes a total of 20 orders, 47 families and 96 species (Katira & Kardani 2017). Along the Sikka coast of Jamnagar where 112 ichthyofauna species belonging to 50 families, 12 orders, and 84 genera has been reported. Similarly, the locality of Jamnagar Marine National Park, Gulf of Kachchh reported 109 ichthyofauna species belonging to 58 families, 19 orders, and 93 genera (Brahmane et al. 2014). Apart from this, a recent study conducted by Sidat *et al.*, (2021) reported 96 species which include 20 order and 47 families. During the field observation, in the gill net catches *Mugil cephalus*, *Planiliza klunzinger*i, *Planiliza planiceps*, *Planiliza macrolepis* (Plate 9) were observed of which *Mugil cephalus* catch was the maximum during Post-monsoon season of (100 kg) followed by Lobester(30 kg) and shrimp 30 kg.from the Deendayal port periphery environment by local fishermen (Personal communication)

Plate 10: Fishery catch along the Deendayal Port Authority in Post-monsoon 2022-2023

3.14. Marine Mammals

Sousa plumbea (Cuvier, 1829) is commonly referred to as the Indian Ocean humpback dolphin. During the field surveys, the Indian Ocean humpback dolphin (*Sousa plumbea*) was recorded at the site between the S-15 and S-5 in phang creek during Post-monsoon season of total 3 number . The length of the humpback dolphin is approximately 1.7 to 2m. Humpback dolphins feed mostly on small fishes, sometimes shrimps; occur mostly in small groups (mostly 12 or less); have limited nearshore movements and in most parts of their range, exhibit a fission/fusion type of social organization. The evaluation of the conservation status of a species and its subsequent listing as a Threatened species is a function of its risk of extinction, which is influenced primarily by population dynamics (population size and trends, population structure) and the key biological and environmental factors influencing those dynamics (distribution, behaviour, life history, habitat use and the effects of human activities). Besides this common dolphin also sighed in our observation.

Plate 11. Indian Ocean humpback dolphin *Sousa plumbea*

4. Mud flat

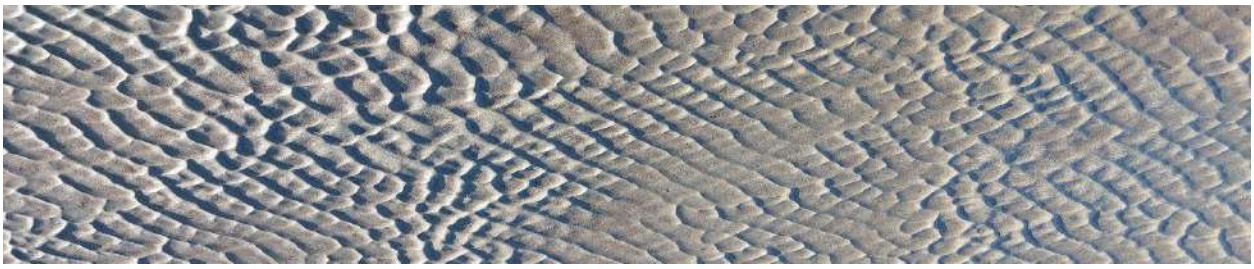
Mudflats and mangroves establish a major ecosystem of the DPA coastal region and the significance of ecosystem services rendered by mudflat is endorsed in Coastal Regulation Zone (CRZ, 2011) as it accords special status to highly productive zone. Mudflat has an assemblage of plant-animal-geomorphological entities. DPA has been surrounded by two major ecosystems such as mangroves and mudflats which support a number of ecosystem services like nursery grounds for fish and shellfishes and breeding/feeding grounds for the birds (Spencer and Harvey, 2012). The TOC concentration is direct indicator of mudflat productivity and blue carbon sequestration.

Bulk density of the sediment samples

The data on the bulk density of the sediment samples are presented in (Fig.28). The bulk density of mangrove soil at Deendayal Port Authority coastal region in post-monsoon ranged from 1.23g/cm^3 to 1.52 g/cm^3. The highest bulk density was recorded at S-13 and the lowest bulk density was recorded at site S-1 located at Tuna creeek.

Total Organic Carbon (TOC)

The highest TOC value (0.87%) was recorded at station S-6 followed by S-10 . Lowest TOC value was reported at site S-1 (Fig.29). It is observed that TOC values varied significantly among the sampling stations which means that organic carbon is dependent on the living life forms and variations in the life forms in the mudflats. The TOC concentration is a direct indicator of mudflat productivity and blue carbon sequestration. The data on Post-monsoon samplings revealed that the different sampling sites of Deendayal Port Authority jurisdiction have considerable variations with respect to organic carbon.



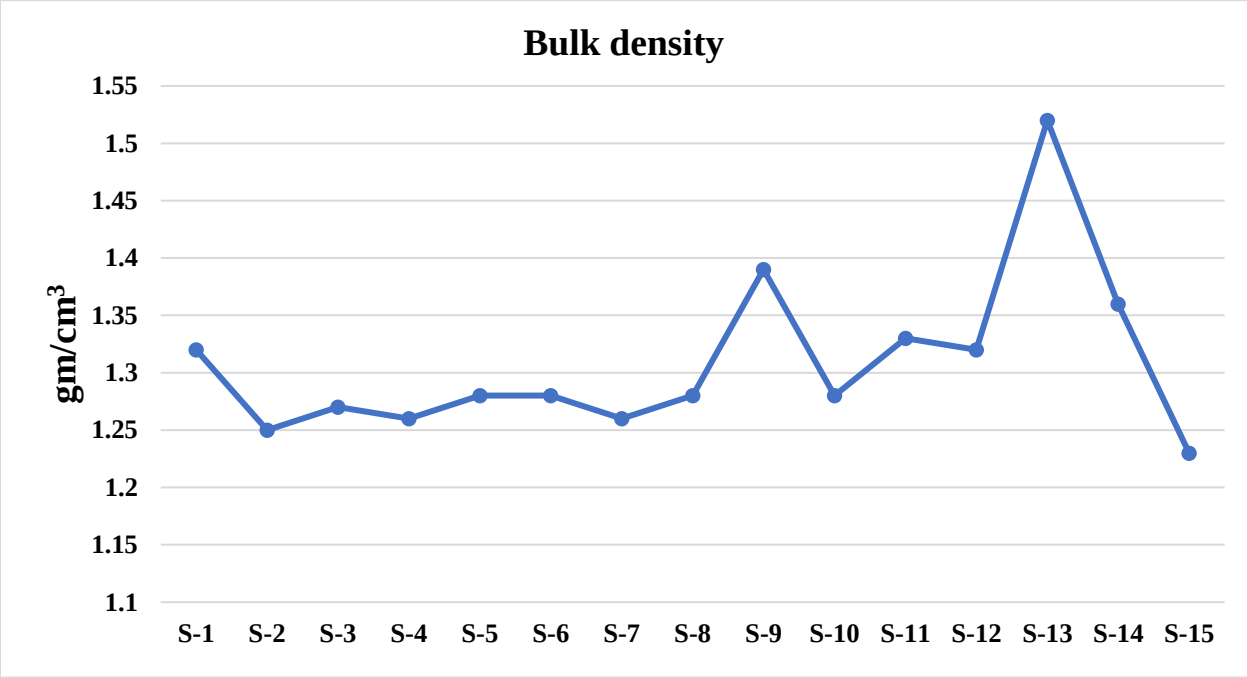


Figure 28: Bulk density of mudflat sediment during Post-monsoon 2022-2023

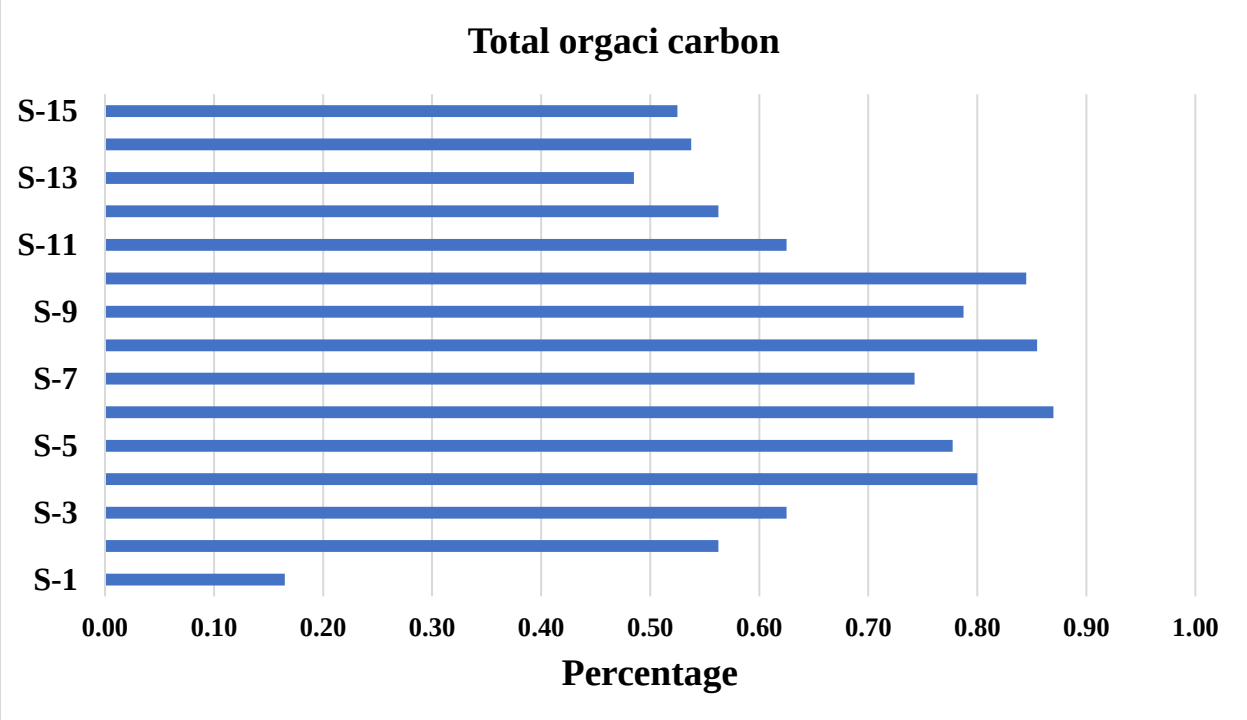


Figure 29: Percentage of Total Organic Carbon in the mudflat in Post-monsoon 2022

5. Avifauna

A total of 79 species belonging to 9 orders, 32 families and 59 genera were recorded from the coastal area of Deendayal Port during this study (Annexure 1). Among these, 49 species were aquatic and 30 species were terrestrial, which included 6 species listed as Near Threatened in the IUCN 2023, Red List. Order Charadriiformes i.e. aquatic birds (including raptors and most water birds) constituted the predominant groups representing 35% of all species recorded from the study area followed by order Passeriformes (24%), Pelecaniformes (19%) and other six orders formed 22% of the recorded species. The families with a greater number of species were Scolopacidae (12 spp.), Ardeidae (8 spp.), Laridae (6 spp.), Charadriidae (5 spp.), Alcedinidae, Hirundinidae, Threskiornithidae each family having (three spp.), six families each having 2 species and eight families each having one species. From the recorded species, 26 species were migrants, 13 species were local migrants or resident migrants, 40 species were breeding resident.

Thirteen (13) kinds of feeding guilds, viz., aquatic invertebrate-feeder, piscivore, insectivore, granivore, frugivore, reptile-feeder, amphibian feeder, nectarivore, weedivore, plankton-feeder, herbivore, carrion-feeder and predatory were identified; among the bird species observed (Ali & Ripley 1987). Here, the aquatic invertebrate guild is the most frequent one with thirty six percent incidence and 31 species occurring under this shared category. Whereas, omnivore, frugivore, granivore, and plankton-feeder guilds are the least frequent with only one species observed in each.Overall mean bird species is 79 calculated from the study area. The overall Shannon diversity (H') is 4.04 with overall species richness index for study area is 9.80. The overall species evenness index value for study area is 0.72 with overall Equitability is 0.92. (Table 10).

Status, distribution and diversity of avifauna in different stations:

Total fifteen sites were surveyed and the results shows that the maximum number of species found from the Site Site 1 (57 spp.) followed by Site 2 (55 spp.), Site 9 (46 spp.), 7 (45 spp.), and. Sites 5 have found lowest avifaunal species (31 spp.) (Fig. 30).

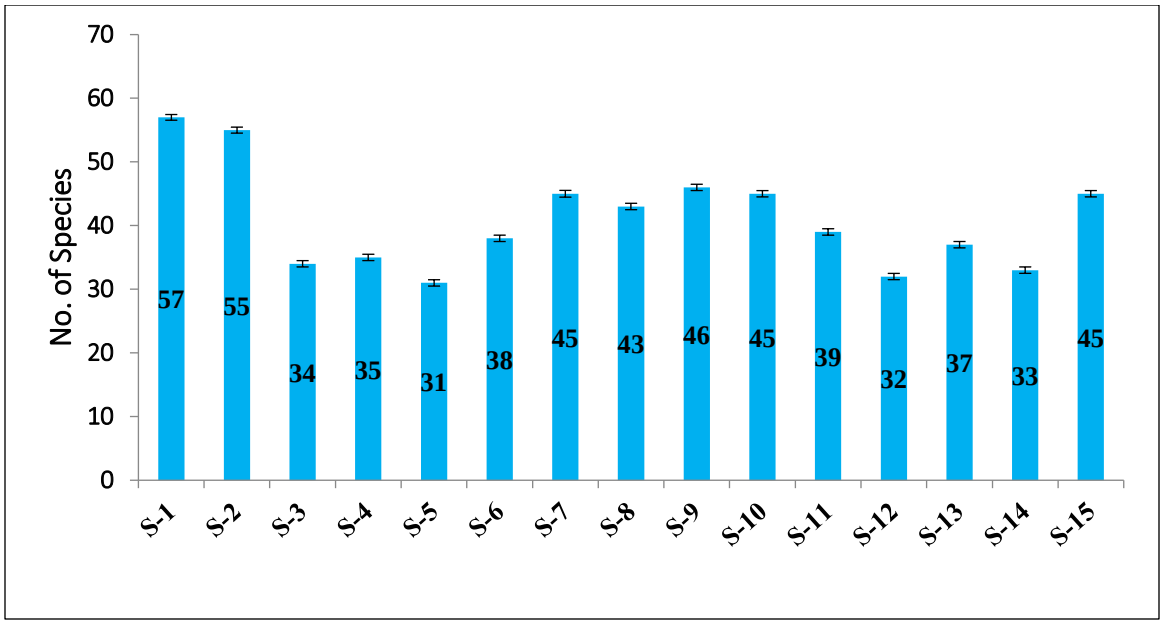


Figure 30. Number of Avian species recorded from the DPA in Post-monsoon2022-2023

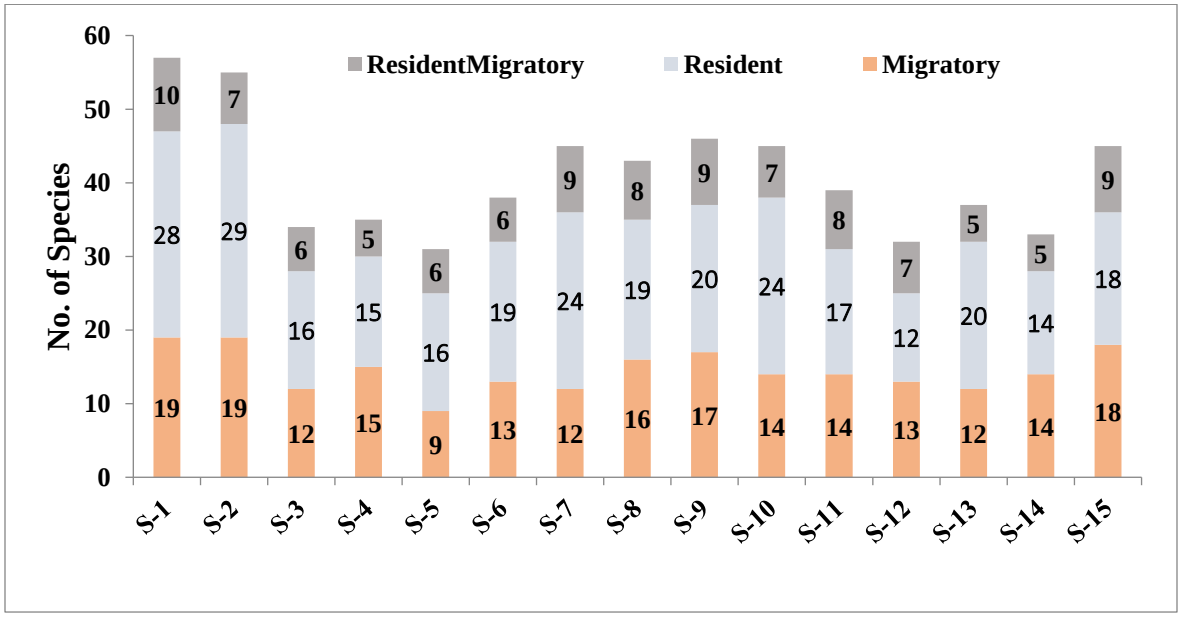


Figure 31. Behavioral status of Avian species from the DPA in Post-monsoon 2022-2023

Each site's wise migratory status was also calculated and the results shows that the maximum migratory species found from the site Site 1&2 (19 spp.) followed by Site 15 (18 spp.), Site 9 (17 spp.) and site 5 (9 spp.) (Fig. 31)..

During the survey we have surveyed both terrestrial habitat like Mangrove plantation adjoining to the Mudflats and waste land, and aquatic habitats like creek area, rivers and wetland. From the study site wise all the species categorised into two habitats i.e. terrestrial and aquatic and the results shows that the maximum terrestrial avifaunal species recorded from the site 1 (23 spp.) and site 2 (21 spp.) followed by site 7,9,15 (17 spp.) and site 6,8,10 (16 spp.). Whereas aquatic avifaunal species recorded more from Site 1 & 2 (34 spp.) followed by site 9,10 (29 spp.), site 7,15 (28 spp.) and site 8 (27 spp.)(Fig. 32)

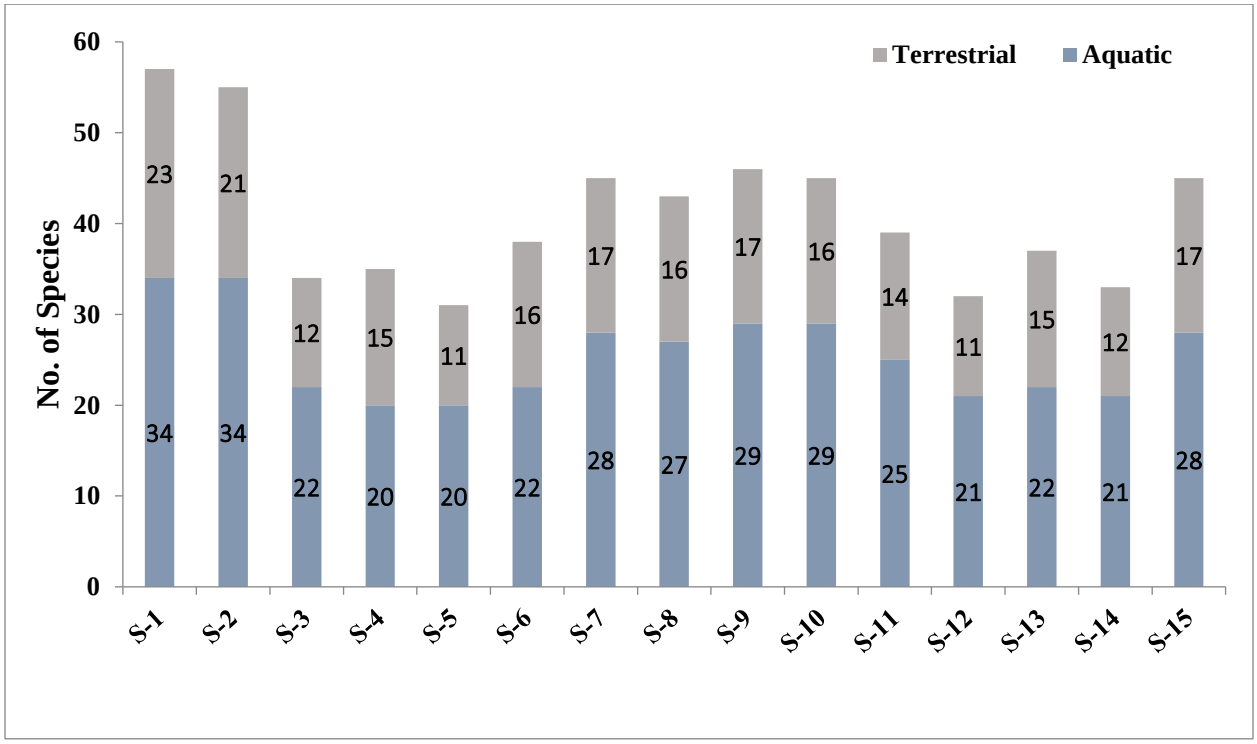


Figure 32. Habitat wise distribution of Bird species in Post-monsoon 2022-2023 from DPA

During the present investigation birds with diverse food habits were observed, viz., Aquatic, Insectivores, Granivores, Piscivores, Frugivores, Omnivores and Nectarivores. All the sites have found more number of species of aquatic plant/insect feeder birds species (maximum 35 species recorded from Site 1&2) followed by Insectivores (Maximum 8 species recorded from Site 1&2), granivore (maximum 8 species recorded from Site 2) and piscivores (maximum 4 species recoded from Site 3,6,8&11) and least species found of frugivores, omnivores and nectorivores.

Data collected from point counts allows us to calculate species diversity, richness and species composition. The results shows that the maximum diversity found from the Site 1 (H' 3.8) followed by Site 2 (H' 3.7) and the minimum diversity recorded from site 7 (H' 2.7) and Site 5 (H' 2.9). The results of species richness shows that maximum species richness recorded from Site 1 (10.38 spp.) and minimum species richness recorded from Site 5 (6.11 spp.). Other diversity indices details were given in the table 10.

Table 10. Stationwise Diversity Indices recorded from the Deendayal port Area

Diversity Indices	No. of Species	Individuals	Dominance_D	Shannon_H	Evenness_e^H/S	Margalef	Equitability_J
S-1	57	220	0.03	3.83	0.81	10.38	0.95
S-2	55	269	0.03	3.72	0.75	9.65	0.93
S-3	34	157	0.06	3.18	0.70	6.53	0.90
S-4	35	116	0.04	3.40	0.86	7.15	0.96
S-5	31	135	0.08	2.91	0.59	6.12	0.85
S-6	38	161	0.03	3.49	0.86	7.28	0.96
S-7	45	305	0.17	2.78	0.36	7.69	0.73
S-8	43	204	0.04	3.48	0.75	7.90	0.93
S-9	46	261	0.06	3.28	0.58	8.09	0.86
S-10	45	193	0.04	3.56	0.78	8.36	0.93
S-11	39	174	0.05	3.40	0.77	7.37	0.93
S-12	32	155	0.07	3.09	0.68	6.15	0.89
S-13	37	137	0.03	3.47	0.87	7.32	0.96
S-14	33	155	0.05	3.22	0.76	6.35	0.92
S-15	45	212	0.04	3.53	0.76	8.21	0.93
Total	**79**	**2854**	**0.02**	**4.05**	**0.73**	**9.80**	**0.93**

References

1. Abott, R.T. (1954). *American Sea shells*. Dvan Nostrand Company Inc, Newyork, pp 541.
2. Amr, Z.S. (2021) *The state of biodiversity in Kuwait. Gland*, Switzerland: IUCN; The State of Kuwait, Kuwait: Environmental Public Authority.
3. APHA (2017). *Standard Methods for the Examination of Water and Wastewater*, 23nd edition. American Public Health Association,1546.
4. Apte DA (2012) Field Guide to the Marine Life of India - 1st Edition. Stusa Mudra Private Limited Mumbai, 502.
5. Apte, D.A. (2014) *Sea Shells of India. An Illustrated Guide to Common Gastropods*. Bombay Natural History Society & Oxford University Press, Mumbai, 197
6. Barnes RD (1980). *Invertebrate Zoology*, Saunders College, Philadelphia 108pp.
7. Brahmane, V.T., Temkar, G.S., Metar, S.Y., Sikotaria, K.M. & Desai, A.Y. (2014). Ichthyofaunal diversity in the vicinity of marine protected areas, Jamnagar, Gulf of Kachchh, India. *Asian Journal of Advanced Basic Science,* 3: 78–88.
8. Briggs, K.T., Tyler, W.B. & Lewis, D.B. (1985). Comparison of ship and aerial surveys of birds at sea. *Journal of Wildlife Management*, 49:405-411.
9. Chapgar, B.F. (1957). *Marine crabs of Bombay state,* Taraporevala Marine Biological Station, Bombay pp 88.
10. Crane, J. 1975. *Fiddler crabs of the world*. Ocypodidae: Genus Uca. Princeton University Press, Princeton, New Jersey.
11. Davidson, I.C., Crook, A.C., & Barnes, D.K.A. (2004). Quantifying Spatial Patterns of Intertidal Biodiversity: Is Movement Important?. *Marine Ecology*, 25 (1), 15–34.
12. Day, J.H. (1967). *A Monograph on the Polychaeta of Southern Africa part I Errantia*. Trustees of the British Museum (Natural History) London, 458pp.
13. Day, J.H. (1967). *A monograph on the Polychaeta of Southern Africa*. British Museum (Natural History). London. vol 1 & vol 2, 878pp.
14. Day, J.W., Hall. C.A.S., Kemp W.M. and Araneibia Y.A.C. (1989) *Estuarine Ecology*. John Wiley Sons, Inc.
15. De Bruin, G.H.P., Russell, B.C. & Bogush, A. (1995). *FAO species identification field guide for fishery purposes The Marine Fishery Resources of Sri Lanka*, Food and Agricul-

tural Organization of the United Nations, Rome 110pp.

16. Desikachary, T.V. (1987). *Atlas of diatoms*, 3 and 25. Madras Science Foundation Madras: plates, 22-4000
17. Dyer, K.R., Christie, M.C. & Wright, E.W. (2000). The classification of intertidal mudflats. *Continental Shelf Research*, 20(10-11): 1039-1060.
18. Edward, J.K.P., Ravinesh, R. & Biju Kumar, A. 2022. *Molluscs of the Gulf of Mannar, India and Adjacent Waters: A Fully Illustrated Guide*, (Dekker, H. & Oliver, P.G. Eds.). Suganthi Devadason Marine Research Institute, Tuticorin & Department of Aquatic Biology & Fisheries, University of Kerala, India, 524pp.
19. Fauvel, P. (1953). *The Fauna of India including Pakistan, Ceylon, Burma and Malaya. Annelida: Polychaeta*, Allahabad. 507pp.
20. Fischer, W. & Bianchi, G. (1984). *FAO species identification sheets for fishery purposes Western Indian Ocean,* Fishing area 51 Prepared and prints with the support of the Danish International Development Agency DANIDA Rome, Food and Agricultural Organization of the United Nations, I-IV 20-55
21. Gajbhiye, S. N. & Desai. B.N. (1981). Zooplankton variability in polluted and unpolluted waters off Bombay. *Mahasagar*., 14(3): 173-182.
22. Hammer, Ø., Harper, D.A.T. & Ryan, P.D. (2001). PAST: Paleontological statistics software package foreducation and data analysis. version 3.2.1.
23. Hartman, O. (1969). *Atlas of the sedentariate polychaetous annelids from California*. Allan Hancock Foundation, University of Southern California. Los Angeles, 812.
24. Hartman, O. (1968). *Atlas of the errantiate polychaetous annelids from California*. Allan Hancock Foundation, University of Southern California. Los Angeles, 828.
25. Holthuis, L.B. (1993). *The Recent genera of the caridean and stenopodidean shrimps (Crustacea, Decapoda): With an appendix on the order Amphionidacea*. Nationaal Natuurhistorisch Museum Leiden. 328.
26. Jha, B., C.R.K. Reddy, M.C. Thakur and M.U. Rao. (2009). *Seaweeds of India: the diversity and distribution of seaweeds of the Gujarat coast*. Springer, Dordrecht. 198
27. Joshi, A., Parmar, E.A.R., Temkar, G.S., Desai, A.Y. & Bhatt, A.J. (2018). Ichthyofaunal biodiversity of Kharakuva Fish Market, Veraval, Gujarat, India. *International Journal of Bio-resource and Stress Management* 9: 596-605.

28. Kamboj, R.D., Salvi, H., Patel, R. & Bhagat, R. (2018) *Monograph on Phytolankton of Gulf of Kachchh*. Gujarat Ecological aeduction and Research (GEER) Foundation . 182
29. Klein, G.D. (1985). *Intertidal Flats and Intertidal Sand Bodies*, pp187-224. In: Davis, R.A. (eds) *Coastal Sedimentary Environments*. Springer, New York, NY.
30. Lyla, P.S., Velvizhi, S. & Khan, A.S. (1999). A Monograph on the amphipods of Parangipettai coast, Annamalai University, India pp78.
31. Mantri, V.A., Kavale, M.G & Mudassar A.K (2020) Seaweed Biodiversity of India: Reviewing Current Knowledge to Identify Gaps, Challenges, and Opportunities. Diversity. 1-22.
32. Masuda, H., Amaoka, K., Araka, C., Vyeno, T. & Yoshino T (1984). *The Fishes of Japanese Archipelago*. Tokai University Press, Japan 437.
33. McCann, S.B. (1980). *Classification of tidal environments*, In, McCann, SB Ed, Sedimentary Processes and Animal Sediment Relationships in Tidal Environments, Short Course Notes, Geological Association Canada, St Johns, Newfoundland, 1: 1-24.
34. Mohsin, A.K.M. & Ambiak, M.A. (1996). *Marine Fishes and Fisheries of Malaysia and Neighboring Countries*, University Pertanian Malaysia Press, Serdang 743.
35. Mohsin, A.K.M. & Ambiak, M.A. (1996). *Marine Fishes and Fisheries of Malaysia and Neighboring Countries.* University Pertanian Malaysia Press, Serdang 743.
36. Naderloo, R. (2017). Atlas of Crabs of the Persian Gulf. Springer International Publishing AG, Switzerland, 445pp.
37. Oliver, P.G. (1992) Bivalved Seashells of the Red Sea. National Museum of Wales, Cardiff, 330.
38. Oza, R.M., Krishnakumar, G.R., Mairh, O.P. & Zaidi, S.H. (2001) Cultivation of *Ulva fasciata* Delili on the coast of Diu, west coast of India. Seaweed Resarch utilisation, 23, 5–12
39. Psomadakis, P.N., Osmany, H.B. & Moazzam, M. (2015). *Field identification guide to the living marine resources of Pakistan*. FAO Species Identification Guide for Fishery Purposes, Rome, FAO. 386.
40. Ramakrishna and Dey (2007) *Hand book on Indian Freshwater Molluscs*. Published by the Director, Zoological Survey of India, Kolkata, 399pp.
41. Rao N.V.S. (1989) *Handbook of freshwater molluscs of India*. Zoological Survey of India,

Calcutta

42. Rao, N.V.S. (2003). *Indian Sea Shells (Part I). Polyplacophora and Gastropoda*. Zoological Survey of India, Kolkata, 416.
43. Rao, N.V.S. (2017) *Indian Seashells, Part B Bivalvia*. Zoological Survey of India, Kolkata, 676.
44. Ravinesh, R. and Biju Kumar, A. (2022) *Collection, preservation, and documentation of estuarine and marine benthic invertebrates*.pp 33-82. In: Prince S.G., Salom, G.T.V. and Krishnakumar, S. (Eds) *Ecology and Biodiversity of Benthos*, Elsevier Radarweg 29, PO Box 211, 1000 AE Amsterdam, Netherlands.
45. Ravinesh, R., and Biju Kumar A. (2013) Comparison of intertidal biodiversity associated with natural rocky shore and sea wall: A case study from the Kerala coast, India. *Indian Journal of Geo-Marine Sciences*, 42(2): 223-235.
46. Ravinesh, R., Biju Kumar, A. and Anjana, V.L (2021) Diversity and distribution of molluscan fauna of Asthamudi estuary, Kerala, India, *Wetlands Ecology and Management*. 29 (5), 745-765.
47. Robin S.W., Pat, H.A. & Glasby, C.J. (2003). *Polychaetes: An Interactive Identification Guide*. CSIRO Publishing, Melbourne.
48. Rouse, G.W. & Pleijel, F. (2001). *Polychaetes*. Oxford University Press: Oxford, UK, 354 pp.
49. Santhanam, P., Pachiappan, P., and Begum, A. (2019). *Methods of Collection, Preservation and Taxonomic Identification of Marine Phytoplankton*. pp25-61. In: Santhanam, P., Begum, A., Pachiappan, P. (eds) *Basic and Applied Phytoplankton Biology*. Springer, Singapore.
50. Sidat Azaz., Mukherji P., Trivedi T. & Mankodi P.C. (2021) Ichthyofauna species diversity of Gulf of Kachchh, Gujarat, India Case study: Jakhau and Mandvi coast.Iranian *Journal of Ichthyology*. 8(2): 134-150
51. Subba Rao N.V., Surya Rao, K.V. & Maitra, S. (1991). *Marine molluscs*. State Fauna Series 1, *Fauna of Orissa (Part 3).* Zoological Survey of India, Calcutta, 1-175.
52. Terdalkar, S. & Pai. I.K. (2001) Statistical approaches for computing diversity of zooplankton in the Andaman Sea. *Tropical Ecology*, 42, 243-250.

53. van Franeker, J.A. (1994). A comparison of methods for counting seabirds at sea in the Southern Ocean. *Journal of Field Ornithology*, 65:96-108

54. Vine, P. (1986). *Red Sea Invertebrates*. Immel Publishing, London. 224 pp.

55. Walkley, A, & Black, I.A. (1934). An examination of the Degljareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*, 37: 29-38.

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

57. Zar, J.H. (1984) *Biostatistical Analysis*. 2nd Edition, Prentice-Hall, Inc., Englewood Cliffs, 718.

Annexure -C

Final Report

On

Greenbelt Development for the Deendayal Port Authority at Kandla Port

Submitted to

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

Prepared by

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

Final Report

on

Greenbelt Development for the Deendayal Port Authority at Kandla Port, Kandla

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

Technical Support
Mr. Prakash Patel, Executive Enginier
Mr. Ajay K. Gohel, Project Fellow

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

Content

Sr. No	Title	Page No
1	Introduction	1
2	Rationale	3
3	Project Site	5
4	Scope of Work	5
5	Approach and Methodology for Greenbelt Development	5
6	Plantation techniques	7
7	Selection of plant species for plantation	8
8	Number of sapling	8
9	Management and Monitoring of Greenbelt	8

List of Table

Sr. No	Title	Page No
1	Time Schedule for Watering	9
2	List of Plants for Plantation at Site for Greenbelt Development	9

List of Figure

Sr. No	Title	Page No
1	Before Plantation	10
2	Map of Plantation Area	11
3	Digging Out Trench for Plantation	11
4	Transportation of Plants to Site	12
5	Fertile Soil for Better Survival of Plants	12

6	Plantation Pits of Soil Filling	12
7	Organic Manure for Better Growth and Survival	13
8	Regular Watering of the plants by tanker	13
9	Plantation in October 2022	14
10	Plantation in December 2022	15
11	Plantation in February 2023	16
12	Plantation in May 2023	17

Introduction

Green vegetation cover surrounding human environment is a vital entity for supply of oxygen, food, fodder and medicine for the survival of all living being, and also it has played an important role in maintaining ecological balance, climate regulation, biodiversity conservation, retention of soil moisture, control of soil erosion, increasing soil fertility, maintaining pleasant micro climate of the region, etc. In addition, vegetation cover also 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 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 power of resistance of each organism helps themselves to overcome the hazards caused by such pollutants.

Therefore, development of green belts alongside of industries, mines, thermal power station, roadsides, and other development unit is an effective mechanism to rejuvenate vital vegetation cover for safeguarding health of human and other living being. Green belts in and around urban and industrial areas are important to the ecological health of any given region. Greenbelt is the raw of trees planted 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 developed considering 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 has helps in improving the ecology, maintenance of biodiversity, mitigation of dust pollution and fugitive emission, control of noise pollution, provide fresh air, mitigates soil erosion, 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 tonnes 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 fragile marine ecosystem with a vast expanse of mangroves, mudflats, creek systems and allied biota. The Port location is marked by a network of major and minor mangrove-lined creek systems with a vast extent of mudflats. The coastal belt in and around 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 mudflats 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 and mudflats on the east and south. The Deendayal Port and its surroundings have mangroves, mudflats 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. It was finalised to raise 5000 plants at a suitable site during the first phase.

Project Site

Based on observation made by the GUIDE Team and Officials from Deendayal Port Authority, a site at adjacent to Berth 11-12 (Wood log site) have been selected on the peripheral boundary of two sides.

The area proposed for green development of Deendayal Port is barren land without any vegetation. The soil of the area is black muddy highly saline soil and with saline ground water. The area is very dry and hot during the summer. The highest temperature used to be recorded in this area.

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 native species of plants for the greenbelt plantation.
4. Adopting plantation technique of plant saplings.
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 have been cleared by removing

unwanted weeds and material such as stones, plastics etc.by JCB and also with labours.

- Landscaping of the area and land preparation Trench line of 2.5x 2.5 ft. have been dig out through JCB along the boundary adjacent to birth 11 & 12 wood log area up to approximately 5000 ft.
- Soil and moisture conservation work since the port area is highly saline, SMC work was very much essential for better survival of the plants. Eight dumper of fertile soil from the field have been added.

- 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*.
- 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 irrigation facilities was not feasible therefore activity was planned preferably through tankers. The watering of the plantation have been schedule 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 of 12,500 kg 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 site is wood log site hence, the wood log used to roll down on a path for water tanker while uploading and downloading the wood log. The regular visit to the site has been made for monitoring and clearing the road for water tanker for irrigation. Gap filling were 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 in 'nalas', construction of bunds or check dams, 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 6 dumper have been added for better survival of plants
- Organic manure around 12,500 kg. Have been given for better growth and survival.
- The pit have 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 out in two phase since the some areas were blocked by wood logs.
- Around 4100 saplings have been planted during the month of September 2022 at available plantation area.
- The remaining and gap filling of 1500 saplings have been planted after the clearance of the area during the month of Feb.2023. A total number of 5000 plantations, were completed in the area.

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:

- Peripheral plantation adjacent to birth 11-12 (along the boundary of the wood log area both sides): 5000 saplings

Management and Monitoring of Greenbelt:

The plantation within the identified site have been managed and monitored for a period of one year from June 2022 to June 2023 The management of plantation includes appropriate irrigation of the plantation in regular intervals, during summer and winter periods and if required even during monsoon with dry spells.

Watering have been made through tanker service at given schedule during the different seasons. (Table 1)

The all plants are growing very well and reached more 4-6 ft. height. The survival of plants have been noted very high as 98% during June 2023.

Table: 1 Time Schedule for Watering

Sr. No.	Month & Year	Number of Time
1	September 2022	4 times/month
2	October 2022	5 times/ month
3	November 2022	8 times/ month
4	December 2022	8 times/ month
5	January 2023	8 times/ month
6	February 2023	8 times/ month
7	March 2023	12 times/ month
8	April 2023	12 times/ month
9	May 2023	12 times/ month
10	June 2023	2 times/ month (end of the project 4th June 2023

Table: 2 List of Plants for Plantation at Site for Greenbelt Development

SI. No.	Scientific Name	Local Name	No. of Plant
1	*Conocarpus lancifolius*	Conocarpus	3500
2	*Ficus religiosa*	Piplo	100
3	*Azadirachta indica*	Limblo	200
4	*Peltophorum pterocarpum*	Pletoforam	300
5	*Millettia pinnata*	Karanj	300
6	*Cassia fistula*	Garmalo	100
7	*Delonix regia*	Gulmahor	300
8	*Mimusops elengi*	Borssalii	200

Fig. 1 Before Plantation

Fig. 2 Map of Plantation Area

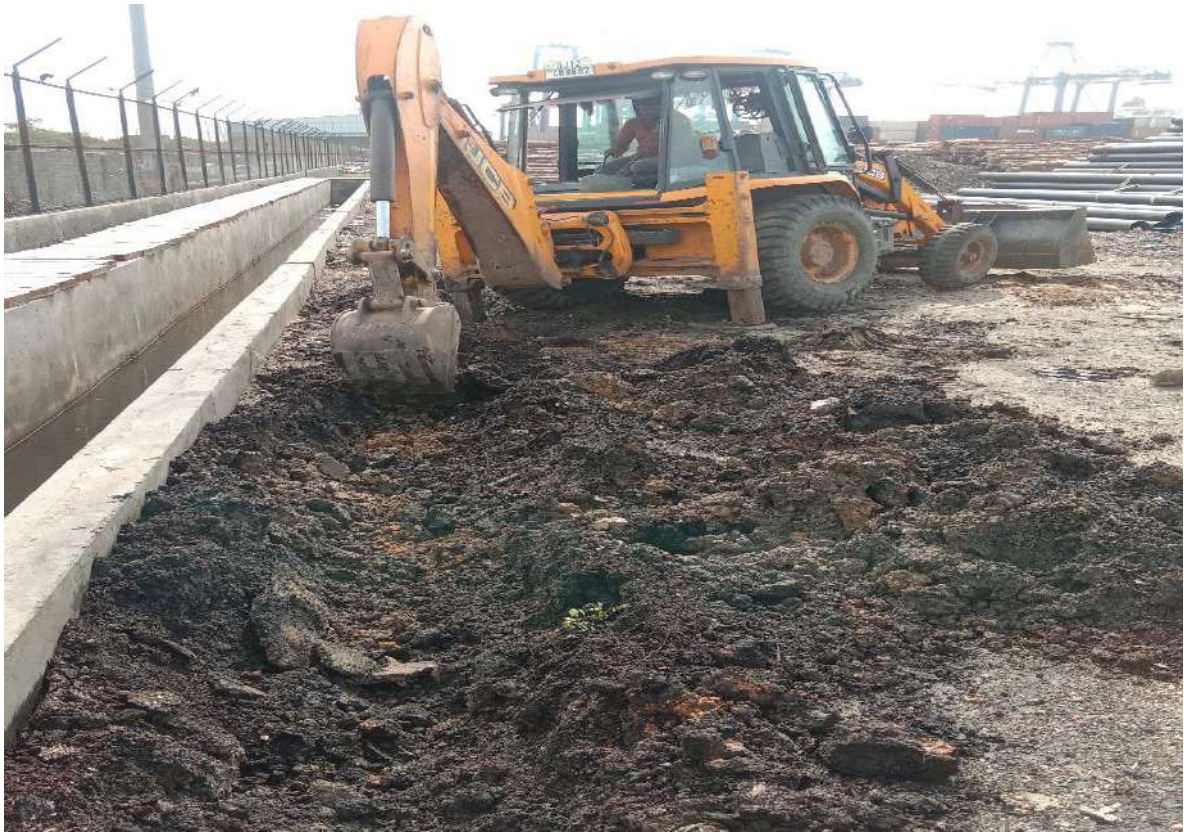


Fig. 3 Digging Out Trench for Plantation

Fig. 4 Transportation of Plants to Site

Fig. 5 Fertile Soil for Better Survival of Plants

Fig. 6 Plantation Pits of Soil Filling

Fig. 7 Organic Manure for Better Growth and Survival

Fig. 8 Regular Watering of the plants by tanker

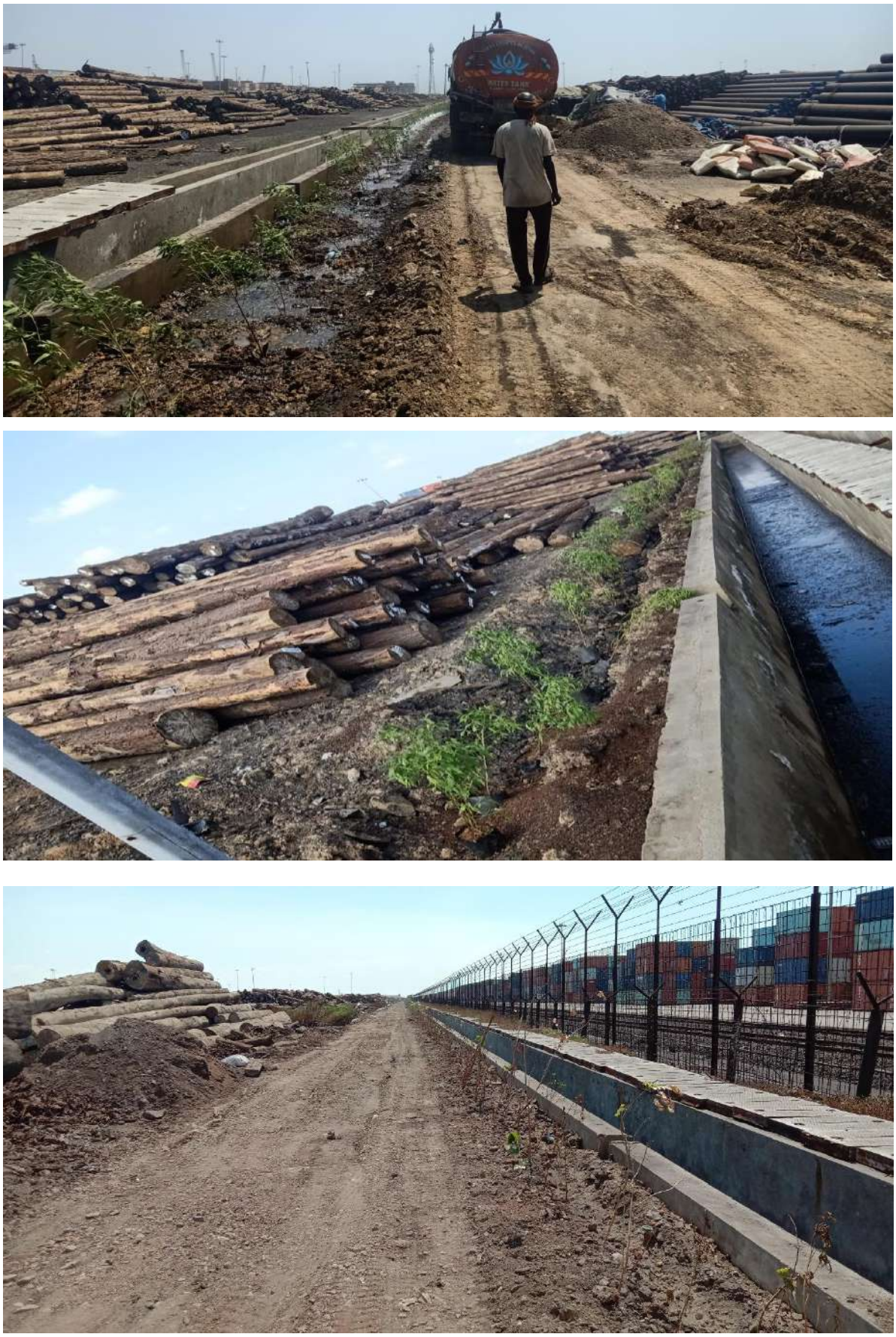


Fig. 9 Plantation in October 2022

Fig. 10 Plantation in December 2022

Fig. 11 Plantation in February 2023

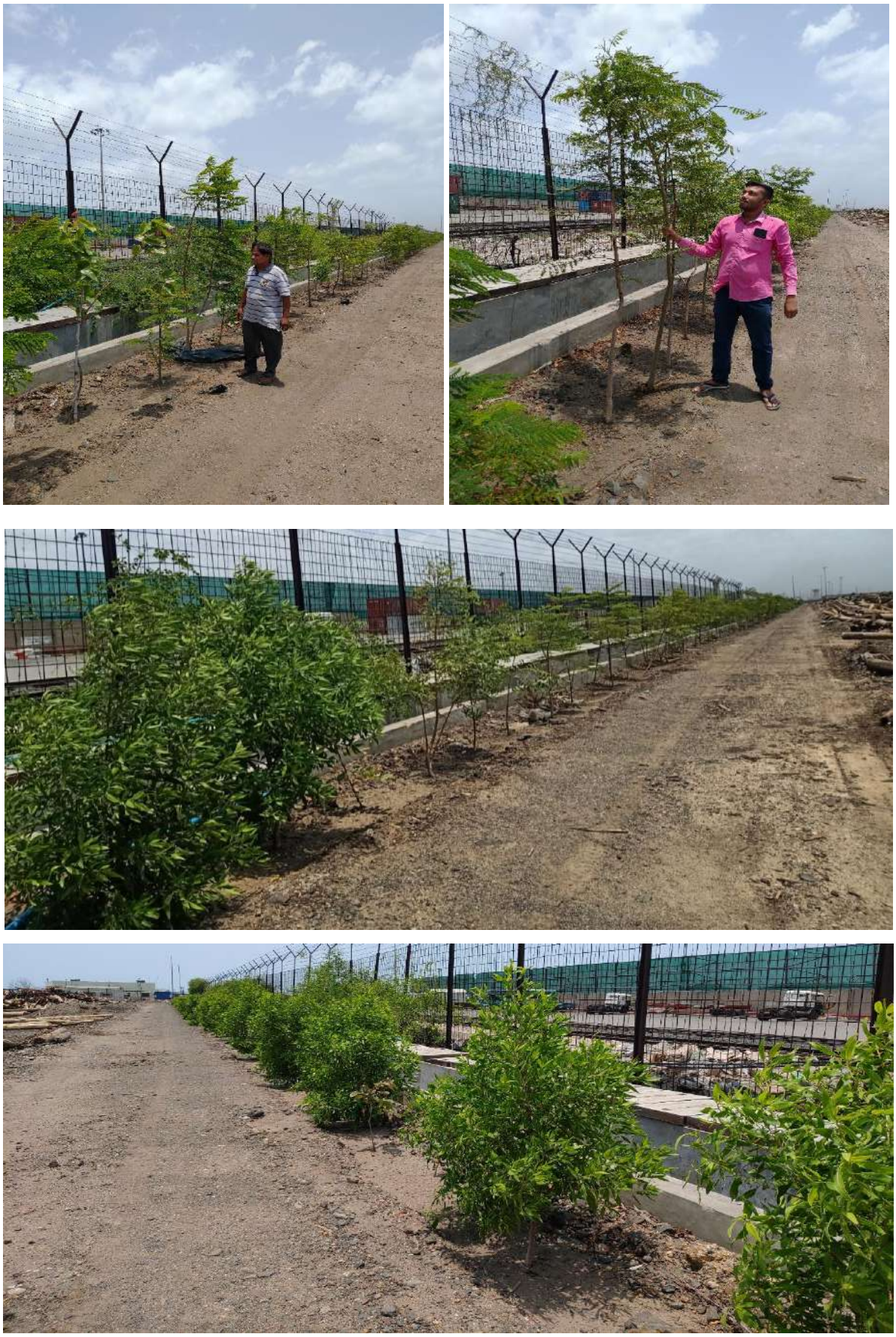


Fig. 12 Plantation in May 2023

Annexure -D

Annexure C

CSR Activities at Deendayal Port Trust

Details of CSR

Sr. No	Year	Board Resolution For Budget Provision	Board Approved Budget Provision	Board Resolution for approval of the CSR activities	Board Approved Amount For CSR Activities	Actual Exp. Upto Nov'20 (Rs. In Lakhs)	Net balance (Rs. In Lakhs)	Remarks
1	2	3	4	5	6	7	6-7	
1	2011-2012	369 of 28.03.2012	3.00 Cr					
2	2012-2013	17 of 31.05.2012	4.00 Cr					
				61 of 30.08.2012	564.00 Lakh	564.00	Nil	Works completed
3	2013 -2014	99 of 30.09.2013	6.43 Cr					
4	2014-2015	322 of 21.11.2014	1.07 Cr	20 of 16.04.2015	236.22 Lakh	188.18	8.04	Works in progress
5	2015-2016	151 of 12.02.2016	1.50 Cr	48 of 12.08.2016	28.00 Lakh	5.00	23.00	Works in progress
6	2016-2017	138 of 06.01.2017	2.60 Cr	52 of 2.8.2017	140.30 Lakh	146.00	-5.70	Works completed
7	2017-2018	41 of 2.08.2017	7.02 Cr	15 of 04.05.2018	155.10 Lakh	115.37	39.73	Works in progress
8	2018-19	51 of 07.08.2019	6.70 Cr	111 of 4.12.2018	154.90 Lakh	50.50	104.40	Works in progress
					1278.52 Lakh	**1069.05**	**209.47**	
9	2019-20	58 of 10.10.2019	5.49 Cr	92 of 06.12.2019	1838.57 Lakh	Nil		MoS approval is awaited
		Total	**37.81 Cr**		**3117.09 Lakh**			
						Spent in PM Fund for COVID-19=800 Lakhs		

Year-wise details of CSR works undertaken by DPT during 2012 – 13 to 2019 – 20 are given in **Tables 7.3a, 7.3b, 7.3c, 7.3d, 7.3e, 7.3f** and **7.3g**.

Table 7.3a: CSR Works Undertaken by DPT during 2011-12 and 2012 – 13

Sl. No.	Name of Work	Cost (Rs. In lakhs)
1	Repair of road from Dr. Baba Saheb Ambedkar Circle to NH 8A (via Ganesh Nagar)	518
2	Repair of road from S.T. Bus Stand to Sunderpuri Cross Road via Collector Road	
3	Repair of road from NH 8A Railway Crossing to Maninagar (along railway track)	
4	Repair of road from Khanna Market Road (Collector Road) to Green Palace Hotel	
5	Construction of internal roads at "Shri Ram" Harijan Co-operative Housing Society (near Kidana)	
6	Construction of cremation ground and graveyard with other facilities at Vadinar	19.44
7	Providing cement concrete internal roads in Village Vadinar Stage - I	16.16
8	Approach road provided for developing tourism at Village Veera near Harsidhi Mata Temple	4.65
9	Water tank along with R.O. provided near developing tourism area	0.30
10	Creating facilities of flooring and steps surrounding lake to stop soil erosion and attract tourists at Village Veera.	4.80
	TOTAL	563.35

Table 7.3b: CSR Works Undertaken by DPT during 2014-15

Sl. No.	Name of Work	Cost (Rs. In lakhs)
1	Construction of community hall – cum – school at Maheshwari Nagar, Gandhidham	51.90
2	Renovation of "Muktidham" (cremation ground) at Kandla	10.65
3	Sunderpuri – 1 Valmiki Community Hall	5.00
4	Sunderpuri – 2 Valmiki Community Hall	5.00
5	Ganeshnagar Community Hall	10.00
6	Jagjivan Maheshwari Community Hall	10.00
7	Various works of road at Sapnanagar	99.19
8	Construction of compound wall in the dam of Jogninar Village	14.48
	TOTAL	206.22

Table 7.3c: CSR Works Undertaken by DPT during 2015-16

Sl. No.	Name of Work	Cost (Rs. In lakhs)
1	Construction of Bus Stand at Vadinar Village	10.00
2	Providing drainage system at Vadinar Village	6.00
3	Providing and laying of water supply lines in Vadinar Village	6.00
4	Road from Gandhidham Post Office to Merchantile Marine Department Office along with toilet facilities	60.00
5	Construction of toilets for girls / women at Khari Rohar, Village	3.00
6	Construction of toilets for girls at Mathak Primary School, Mathak, Village	3.00
	TOTAL	**88.00**

Table 7.3d: CSR Works Approved by DPT Board for 2016-17

Sl. No.	Name of Work	Cost (Rs. In lakhs)
1	RCC community hall at Harsidhi Mata Temple, Village Veera, Anjar Taluka	19.00
2	Fabricated Community Hall at Sanghad Village, Anjar Taluka	21.00
3	CSR Works for Shri Maheshwari Meghvad Samaj, Gandhidham at graveyard behind Redison Hotel	8.00
4	CSR Works for Shri Dhanraj Matiyadev Mukti Dham, Sector 14, Rotary Nagar, Gandhidham	30.50
5	CSR Works for Nirvasit Harijan Co-operative Housing Society, Gandhidham Health Cum Education Centre	41.00
6	CSR Works for Shri Rotary Nagar Primary School, Gandhidham	2.80
7	CSR Works at NU-4, NU-10(B) Sapnanagar & Saktinagar, Golden Jubilee Park at Gandhidham	18.00
	TOTAL	**140.30**

Table 7.3e: CSR Works Approved for 2017-18

Sl. No.	Name of Work	Proposal Received from / / Name of Organization / N.G.O	Cost (Rs. In lakhs)
1	CSR Works at Shri Ganesh Nagar High School, Gandhidham	Principal, Shri Ganesh Nagar Govt High School, Gandhidham	38.30 Lakhs
2	CSR Works for MOLANA AZAD Primary School, Kandla	Shri M L Bellani, Trustee, DPT, Shri Kandla Port Education Society, New Kandla	7.00 Lakhs
3	Grant financial contribution for facility of Army Cantonment for 50 nos. air coolers at Kutch Border Area	Shri Vinod L Chavda, MP	15 Lakhs
4	40% of the estimated cost of providing drainage lines at Tuna and Vandi villages under Swachh Bharat Abhiyan.	Shri Sarpanch, Tuna Village & Vandi village & Shri M L Bellani, Trustee, DPT	**Rs. 39.80 Lakhs** *Approx. estimated Cost Rs.99.50 Lakhs, of which 40% to be contributed by DPT.*
5	CSR works for S.H.N. Academy English School (managed by Indian Inst. Of Sindhology – Bharati Sindhu Vidyapeeth), Adipur	Director, S.H.N Academy English School	**40 Lakhs**
6	Construction of internal roads at Bhaktinagar Society, Kidana	Smt Maltiben Maheshwari, MLA	**15 Lakh**
		TOTAL	**155.10**

Table 7.3f: CSR Works Approved for 2018-19

Sl. No.	Name of Work	Proposal Received from / / Name of Organization / N.G.O	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	Chairman, Atharva Foundation, Mumbai	**24.00**
2	CSR work to Donate ONE (40 Seater) School Bus for Deaf Children Students for the Institute of Mata Lachmi Rotary Society, Adipur	Mata Lachmi Rotary Society, Adipur	**18.00**
3	CSR work to Providing One R.O Plant with Cooler at PanchyatPrathmikSala, Gadpadar Village for the ANARDE Foundation, Kandla&Gandhidham Center.	Dist. Rural Development Officer, Annarde Foundation-Kandla & Gandhidham	**1.50**
4	CSR work for Providing Drainage Line at MeghparBorichi village, AnjarTaluka	Shri Vasanbhai Ahir, MLA, Gujarat Govt	**25.00**
5	CSR work for Construction of Health Centre at Kidana Village	Shri Vinod L Chavda, MP	**13.00**
6	CSR work to provide 4 Nos. of Big Dust Bin for MithiRoharJuth Gram Panchayat.	Shri Sarapanch, Mithi RoharJuth Gram Panchayat	**3.40**

Sl. No.	Name of Work	Proposal Received from / / Name of Organization / N.G.O	Cost (Rs. In lakhs)
7	CSR work for Renovation & construction of shed at CharanSamaj, Gandhidham –Adipur.	Shri Vinod L Chavda, MP	**10.00**
8	CSR Work for Renovation/Repairing of Ceiling of School Building at A. P Vidhyalay, Kandla.	Smt Maltiben K. Maheshwary, MP, Gandhidham.	**10.00**
9	CSR work for Construction of Over Head Tank & Providing 10 Nos of Computers (for students) of NavjivanViklangSevashray, Bhachau, Kutch	Shri Jitendra Joshi, Founder Secretary, Shri Navjivan Viklang Sevashray, Bhachau, Kutch	**9.50**
10	CSR work to Provide Books & Tuition fees for Educational facilities to weaker section children of ValmikiSamaj, Kutch.	Shri Manohar Jala, Chairman of "National Commission of Safai Karamcharis"	**2.00**
11	CSR work to provide Water Purifier & Cooler for the ST. Joseph's Hospital, Gandhidham	Smt. Maltiben K Mahewari, MLA ,Gandhidham	**1.50**
12	CSR work for Construction of Second Floor (Phase – I) for Training Centre of "GarbhSanskran Kendra" "Samarth Bharat Abhiyan" of Kutch Kalyan Sangh, Gandhidham	Shri Vinod L Chavda, MP, Kutch	**37.00**
		TOTAL	**154.90**

Table 7.3g: CSR works approved for the year 2019-20 (approval from Ministry of Shipping still awaited)

Sl. No.	Name of Work	Proposal Received from / / Name of Organization / N.G.O	Cost (Rs. In lakhs)
1	CSR activities for Providing Drainage line at Nani Nagalpar village.	Sarpanch of Village:-Nani Nagalpar, Taluk: Anjar.	**3.00**
2	CSR activities for Development of ANGANWADI Building at School no- 12 at Ward no 3 & 6 at Anjar.	Shri Vasanbhai Ahir, MLA	**7.00**
3	CSR activities for Improving the facilities of Garden at Sapna Nagar(NU-4)& (NU-10 B),Gandhidham.	Shri K P Maheshwari, Resident Sapnanagar, Gandhidham	**18.00**
4	CSR activities for Providing of Plastic Shredding Machine to Mirror Charitable Trust, Gandhidham.	Mirror Charitable Trust ,Gandhidham	**4.75**
5	CSR activities for development of School premises of Shri Guru Nanak Edu. Society, Gim.	Shri Guru Nanak Education Society, Gandhidham.	**30.00**
6	CSR activities for the improvement of the facilities at St. Joseph Hospital & Shantisadan at Gandhidham	St. Joseph Hospital Trust, Gandhidham	**20.00**
7	CSR activities for the improvement of the facilities at SVP (SardarValabhbhai Patel) Multipurpose Hall at Gandhidham	Request from MarwadiYuva Munch & UNION Gandhidham	**500.00**
8	Consideration of Expenditure for running of St Ann's High School at Vadinar of last 5 years 2014 to 2019 under CSR.	Proposal from COM, OOT Vadinar, DPT	**825.00**
9	CSR activities for development of school premises of Shri Adipur Group Kanya Sala no-1 at Adipur	Principal, Shri Adipur Group KanyaSala, Adipur	**6.50**
10	CSR activities for development of school premises of Shri Jagjivan Nagar Panchyat Prathmiksala, Gandhidham.	Principal, Shri Jagjivan Nagar Panchyat Prathmiksala, Gandhidham.	**16.50**
11	CSR activities for development of school premises of Ganeshnagar Government high school, Gandhidham.	Shri Vinod L Chavda, MP, Kutch	**9.00**
12	CSR activities for improving greenery, increase carbon sequestration and beat Pollution at Kandla, DPT reg.	Work awarded to Forest Department , Bhuj	**352.32**
13	CSR activities for providing infrastructures facilities at "Bhiratna Sarmas Kanya Chhatralaya" under the Trust of Samaj Nav- Nirman at Mirjapur highway, Ta Bhuj.	SamajNav- Nirman at Mirjapur highway, Ta Bhuj.	**46.50**
		TOTAL	**1838.57**

List of CSR applications received from various NGOs , Organizations , Village Sharpanchs etc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
1	CSR activities for the development of gardening at Sector -5 , Gim	Shri Sarvodaya Co-Operative Housing Society Ltd	**Appx Cost – Rs 25.00 Lakhs** **Cost for** – Comp wall, Benches, Plantation, walkway, other facilities (Land is reserved for Garden development only since from 50 years)
2	CSR activities for providing various facilities in SHRI GANESHNAGAR GOVT HIGHSCHOOL, GANDHIDHAM	Principal of School	**Appx cost –Rs 20.00 Lakhs** (Two times CSR works carried out at school by DPT)
3	CSR activities for the VadhiyarVankarSamajvaadi, NaviSunderpuriGim	SmtMaltiben K Maheswari, MLA	**Appx Cost Rs 6.00 Lakhs** Cost for Const. of Comp Wall
4	CSR activities for Construction work of Cabin at Oslo Area- Gim	SmtMaltiben& Shri VinadChavda	Cost not mentioned.
5	CSR activities & Land requirement forAkhil Kutch SamastaMeghvanshiGurjarmeghwal Charitable Trust ,Gim.	Shri Akhil Kutch SamastaMeghvanshiGurjarmeghwal Charitable Trust. Shri Dharmendra R Gohil	Cost Not mentioned. (demand of Land for development of SAMAJ VADI in Gandhidham)
6	CSR Activities for providing Water supply pipe line, Play ground and sports equipment, electric facilities, drinking water facilities for poor people & Fishermen at VANDI Village.	Shri R RKhambhra, PRO , Collector Office, Bhuj.	**Appx Cost Rs 51.00 Lakhs** (Last year also applied by village Sarpanch) & Recommended by Shri VASANBHAI AHIR, MLA, Shri V L Chavda, MP)
7	CSR activities for the Tuna village,	Sarpanch, Tuna village	**Appx Cost Rs. 25 Lakhs** **Cost for :-**

List of CSR applications received from various NGOs , Organizations , Village Sharpanchs etc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
	Ta -Gim		2 No Fab shed 20'x20'x1250= 10 Lakh 2 Nos of Agnawadi =10 Lakh Fab shed for school=5 Lakh
8	CSR activities for the Global Vision India Foundation, Gim	Global vision India Foundation, G'dham	Requirement of Land –OR- Old building at Gandhidham for foundation of welfare activities.
9	CSR activities for the UNITED ORPHANAGE FOR THE DISABLED, TAMIL NADU	UNITED ORPHANAGE FOR THE DISABLED, TAMIL NADU	**Cost Rs 25,000.00** (Winter sweaters for children)
10	CSR activities for the Garden Development on already bounded area with Compound wall near Plot no 448 Sector-1/A, Gandhidham.	Residents, near Plot no 448, Sector-1/A, Gim.	**AppxCost Rs 20.00 Lakhs** (Requirement to provide benches, drinking water facility, plantation, lightings & walkways in side bounded area)
11	CSR activities for donation of Land for the Shri SUNDARPUI Govt Primary School, Gim	SmtMalti ben Maheshwari, MLA	(request for Land Requirement)
12	CSR activities for Extension of Adarsh Primary School building, Adipur	GandhidhamMatri Mandal, English Medium School, Adipur	**Appx Cost Rs. 40.00 Lakhs** (Construction for 4 Rooms extension) (Trust registered under Societies Registration Act XXI -1860, Reg No F-42 dtd 23.9.1965. Land belong to Trust)
13	CSR Activities for providing HD projector for KANYA MAHA VIDYALAYA, Adipur	Principal, KANYA MAHA VIDYALAYA, Adipur	**Cost Rs 1.50 Lakhs** (School Managed by G'dhamMaitry Mandal, Adipur)

List of CSR applications received from various NGOs , Organizations , Village Sharpanchs etc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
14	CSR activities for DONATION various Medical Equipment for the Hospital of Gandhidham Jain SevaSamiti, Adipur	Gandhidham Jain SevaSamiti, Adipur	**Cost for** :- 1) Fresenius Haemodialysis Machine Rs 38.00 Lakh 2) Maltislice Helical CT Scanner- Rs 52.00 Lakhs 3) Others Rs 54.00 Lakhs (**Total Appx Cost Rs 144 Lakhs**)
15	CSR activities for SHRI VIDI JUTH GRAM PANCHAYAT, Vidi, Anjar	Sarpanch, Vidi Gram	**Appx Cost Rs 30.00 Lakhs** Cost for- Drainage , Garbage vehicle, and Cattle shed (Already applied earlier at Sr-5/12)
16	CSR activities for SOS CHILDRESN'S VILLAGES INDIA, Madhapar, Bhuj	Director, SOS Children's Village of India-Bhuj	**Appx Cost Rs 31.00 Lakhs** (request for Financial support towards parentless and abandoned Children Education support located at Bhuj) & support to women working in SOS.
17	Gujarat Biodiversity Board, Gandhinagar invites to involved National & Global endeavour of conservation of biodiversity by creating financial partnership with GBB under CSR programme of expenditure to be incurred 187 Lakh.	GUJARAT BIODIVERSITY BOAD, GANDHINAGAR	**Requirement-** Financial Support from DPT for **AppxRs 1.88 Cr.** (Cost for various meetings, collection of primary data from villagers , processing of documentation, printing , TA DA of Technical support &Miscexp for 150 Peoples Biodiversity Register (PBR).

List of CSR applications received from various NGOs , Organizations , Village Sharpanchs etc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
18	CSR activities for providing furniture & Home appliances for ROJAVANAM TRUST at Madurai.	Shri Arul Kannan, Director	**Appx Cost Rs 30 Lakhs** (seeking help to provide facilities to Aged & Homeless people living in Trust and Purchasing of New Ambulance)
19	CSR activities for providing Dialysis Machine for treatment of Kidney patients at "ST JOSEPH'S HOSPITAL TRUST" at Gandhidham.	Sr. Franciline, Administrator of Hospital.	**Appx Cost Rs 31.36 Lakhs** (Cost of 5 Nos of Dialysis Machines for treatment of kidney patients)
20	CSR activities for providing facilities in Girls Hostel of Gasturba Gandhi BalikaVidhyalay, Gandhidham.	Shri Vinod L Chavda, MP	**Appx cost Rs 30 Lakhs.** (Cost of Comp Wall, Entrance gate, Girls toilets etc)
21	CSR works for providing Oxygen Generator Plant and 45 KV Silent Generator for COVID HOSPITAL at Swami LilashahKutia, Adipur.	Secretary, BHARAT VIKAS PARISHAD, Gandhidham	**Appx Cost Rs 80.00 Lakhs** (Facilities for 100 Beds of COVID patient which it to be extend upto 240 Beds)
22	CSR works for providing Two Numbers of Oxygen Concentrator and others medical equipment for the Trust ,Antarjal, Gim.	President SHRI SARV JEEV KALYAN TRUST, ANTARJAL, Gandhidham	**Appx Cost Rs21.50 Lakhs** (Facilities to be provided for the treatment of CORONA PATIENTS at their trust.)
23	CSR works for providing Fabricated Shed , Construction of Compound Wall and Land levelling for the Cattle of **GauSevaSamiti-Tappar** at Gram-Tappar, Ta Anjar.	Shri Vinod Chavda, MP &Presedent , GauSevaSamiti, village Tappar, Ta-Anjar	**Appx Cost Rs84 Lakhs** (Facilities to be provided for Cattle shelters at Village.) (Land belongs to Gram-panchayat)
24	CSR works for Construction of Auditorium Hall at RSETI (Rural Self Employment Training Institute) at	Shri Vinod Chavda, MP & Director of RSETI, Bhuj	**Cost not mentioned.** (Facilities to be provided

List of CSR applications received from various NGOs , Organizations , Village Sharpanchs etc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
	Bhujodi-Bhuj.		for the people needs Self-employment activities.)
25	CSR works for Providing of Furniture for the School "SHRI GALPADAR PANCHAYAT PRATHMIC KUMAR GROUP SALA " atGalpadar Village Ta Gim.	Principal, SHRI GALPADAR PANCHAYAT PRATHMIC KUMAR GROUP SALA " atGalpadar Village Ta Gim.	**Cost not mentioned.** (Facilities to be provided for the Students of Workers & poor village people who study in the school.)
26	Construction of Shed, hall and Gate for the DADA Bhagwandas Charitable Trust, Adipur. (Sr no -4)	Shri Vinod Chavda, MP & DADA BHAGWANDAS CharitableTrust, Gandhidham	As per CSR Guideline- ➢ Promoting gender equality and empowering women ➢ Eradicating extreme hunger and poverty (Considered shed and hall) Fab Shelter Shed - 30'x100' x 1250=37.00 Lakh & RCC Hall – 20'x100'x1500=30.00 Lakh (**Appx Cost Rs67.00 Lakhs**) Land authority belongs to Trust given by GDA and NOC given by SRC.Doc submitted.
27	CSR work for reconstruction of the Internal Roads of the Sector-9B-C and Sector-10 area in Gandhidham.	President, Shri TejaKangad, The Gandhidham Chamber of Commerce and Industry, Gandhidham.	Cost not mentioned.

List of CSR applications received from various NGOs , Organizations , Village Sharpanchsetc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
	CSR Applications kept pending in last year Agenda:-		
27	CSR Activities for providing Water supply pipe line, Play ground and sports equipment, electric facilities, drinking water facilities for poor people & Fishermen at VANDI Village. (Sr no-3)	Sarpanch ,Village-VANDI , Ta- Anjar (Recommd. By Shri VASANBHAI AHIR, MLA, Shri V L Chavda, MP)	As per CSR Guideline- ➢ Env Sustainability ➢ Eradicating extreme hunger and poverty (to be Consider for health Center ,Drainage line, Water sump etc activities) **(Appx Cost - 51.00 Lakhs)** (Land authorization of Gram Panchayat)
28	Construction of Shed, hall and Gate for the DADA Bhagwandas Charitable Trust, Adipur. (Sr no -4)	DADA BHAGWANDAS CharitableTrust, Gandhidham (Recommd. By Shri V L Chavda, MP)	As per CSR Guideline- ➢ Promoting gender equality and empowering women ➢ Eradicating extreme hunger and poverty (Considered shed and hall) Fab Shed - 30'x100' x 1250=37.00 Lakh & RCC Hall – 20'x100'x1500=30.00 Lakh (**Appx Cost Rs 67.00 Lakhs**) Land authority belongs to Trust given by GDA and NOC given by SRC. Doc submitted.
29	10 Nos of Computers required for ShirMaheswarinagar Panchayat Girls Primary School, Gandhidham& Boys Group School, Gandhidham. (Sr no-8)	Maheswarinagar Panchayat Primary Kanya Sala, Gandhidham (Contact no 9913903686)	**AppxRs 5.00 Lakhs** As per CSR Guideline- ➢ Promotion of Education (to be consider for 20 Computers)

List of CSR applications received from various NGOs , Organizations , Village Sharpanchsetc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
			Visited the site. Land belongs to MahewariMeghwadSamaj given by SRC for school purpose, doc are awaited.
30	Construction of Shed and Roof at JeparMatiyadev, shamsanbhumi at Kidana village &Maheswari Community Hall at JuniSundarpuri ,Gandhidham. (Sr no-10)	Shri VINOD CHAVDA, MP	**AppxRs 15.00 Lakhs** (Land authorization not mentioned)
31	Drainage, road, Dust bins, & shed for Cattle shelters at VIDI Village, Ta –Anjar. (Sr no- 12)	Village- VIDI, Ta: Anjar	**AppxRs 30.00 Lakhs** As per CSR Guideline- ➢ Env Sustainability ➢ Eradicating extreme hunger and poverty (Consider for Garbage vehicle & Drainage Cost)
32	Education, Women empowerment and Primary health care services at Kutch area. (Sr no-13)	Light of Life Trust, **Mumbai.**	Cost not mentioned.
33	Request for Help Divyang persons to employment by providing machineries. (Sr no-14)	Kutch DivyangSangthan, Gandhidham.	Cost not mentioned
34	Construction of 2nd Floor of Shri MaheswariMeghwadSamaj, Gandhidham. (Sr no-20)	Shri MaheswariMeghwadSamaj, Gandhidham	**AppxRs. 15.00 Lakhs** (Visited the site and Land ownership documents awaited) (Name plate of DPT fixed at the Asset)

List of CSR applications received from various NGOs , Organizations , Village Sharpanchsetc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
35	Installation of Mini Science Center at Anjar and Gandhidham. (Sr no-21)	STEM Learning Pvt Ltd, Mumbai.	Cost not mentioned.
36	CSR work for Shri Rampar Gram Panchayat. ➢ Wall Plastering for Cattles -7 Lakhs ➢ Shed for Cattel's-15 Lakhs (Sr no-25)	Shri Sarpanch, Rampar Village.	**AppxRs 22.00 Lakhs** (Land authorization of Gram Panchayat and under taking submitted by applicant)
37	CSR activities for the 45,000 Patients over the period of 3 years by "SMILE FOUNDATION", Mumbai. 1. Concept for Nutrition covering 3 years 2. Concept for Mobile Health Unit reaching beneficiaries for 3 years 3. Concept for Vocational Training with NGO (Sr no-29)	Proposal from "SMILE FOUNDATION " Mumbai.	Appx Cost- **Rs 539 Lakhs** for 3 years
38	Development of Park in Public utility plot in between Block "C" & "D" of Sapna Nagar (NU-4) , Gandhidham (Sr no -31)	Shri RAVI MAHESHWARI, DPT	Land belongs to DPT earmarked for recreational purpose. (Total Cost –Rs**88.75 Lakhs**)
39	CSR works for NariJanshsktiVikas Foundation at Gandhidham near Shakti Nagar. (Sr no-33)	NariJanshsktiVikas Foundation, Ahmedabad	➢ Promoting gender equality and empowering women ➢ Env Sustainability ➢ Under promotion of education (Consider for Computers with printers, Sewing machine & RO plant**Cost Rs 48 Lakhs**)