DEENDAYAL PORT AUTHORITY
(Erstwhile: DEENDAYAL PORT TRUST)

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY

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

www.deendayalport.gov.in
EG/WK/4660(EC) Part -V/ 230

Date: /01/2023
02/02/2023

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

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

Ref.: 1) EC & CRZ Clearance granted vide MoEF F.No. 11-70/2006-IA-III dated 1/10/2008.
2) KPT letter no.EG/WK/4660 (EC)/654 dated 6/10/2010.
3) KPT letter no.EG/WK/4660 (EC)/ 112 dated 4/2/2012.
4) KPT letter no. EG/WK/4660(EC)/223 dated 4/9/2012.
5) KPT letter no. EG/WK/4660(EC)/144 dated 16 (17) /5/2013.
6) KPT letter no. EG/WK/4660 (EC)/Part 111/1087 dated 9/12/2013.
7) KPT letter no. EG/WK/4660 (EC)/Part 111/250 dated 17/05/2014.
8) KPT letter no. EG/WK/4660 (EC)/Part 111/198 dated 14/11/2014.
9) KPT letter no. EG/WK/4660 (EC)/Part 111/256 dated 11/05/2015.
10) KPT letter no. EG/WK/4660 (EC)/Part 111/162 dated 15/10/2015.
11) KPT letter no. EG/WK/4660 (EC)/Part 111/133 dated 09/05/2016.
12) KPT letter no. EG/WK/4660 (EC)/Part IV/167 dated 26/12/2016.
13) DPT letter no. EG/WK/4660 (EC)/Part IV/325 dated 26/06/2018.
14) DPT letter no. EG/WK/4660 (EC)/Part V/53 dated 14(16)/2/2019.
15) DPT letter no. EG/WK/4660(EC)/PartV/205 dated 30(6)/11 (12)/2019.
16) DPT letter no. EG/WK/4660 (EC)/Part V dated 15/01/2021.
17) DPT letter no. EG/WK/4660 (EC)/Part V/92 dated 30(07)/9(10)/2021.
18) DPT letter no. EG/WK/4660 (EC)/Part V dated 28/03/2022
19) DPA letter no. EG/WK/4660 (EC)/Part V/149 dated 19/07/2022

Sir,

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

In this connection, it is to state that, as directed under above referred letter dated 5/8/2009 of MoEF, Regional Office, Gandhinagar, Deendayal Port Authority (Erstwhile Deendayal Port Trust) vide above referred letters had regularly submitted Six Monthly compliance report of stipulated conditions and Monitoring report in Data Sheet, in connection with subject project.

.....cont.....

Now, as directed in above referred letter dated 5/8/2009 of MoEF, GoI, please find enclosed herewith point wise compliance to various stipulation in Environmental & CRZ Clearance granted by MoEF, GoI vide letter 11-70/2006-IA.III dated Sept, 2008 (**Annexure 1**) & Monitoring Report in Data Sheet (**Annexure 2**), for the period from June, 2022 to November, 2022 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 rowz.bpl-mef@nic.in & eccompliance-guj@gov.in.

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

Thanking You.

Yours faithfully,

Manager (Env.)
Deendayal Port Authority

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

1) Shri Amardeep Raju, MoEF&CC,GoI
and Member Secretary (EAC-Infra.1),
Indira Paryavaran Bhavan,
Ministry of Environment, Forest and Climate Change
Jor Bagh Road, Aliganj,
New Delhi-110003.
Email: ad.raju@nic.in

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

3) Smt. Urvashi Upadhyay,
Environment Engineer,
Unit Head, Kachchh,
Gujarat Pollution Control Board,
Paryavaran Bhavan,
Sector 10A, Gandhinagar- 382 010.
Email-kut-uh-gpcb@gujarat.gov.in

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

Annexure -1

Annexure 1

Compliance Report for the period upto November, 2022

Subject: - Compliance of conditions stipulated in Environmental & CRZ Clearance granted by the MoEF&CC, GoI for "Construction of 13th to 16th Cargo Berths at Deendayal Port Authority (Erstwhile: Deendayal Port Trust)".

- The MoEF, GoI granted Environmental & CRZ Clearance for the subject project vide no. F.No. 11-70/2006-IA-III dated Sep 2008.

- 7/2/2014 – The MoEF&CC, GoI extended the validity period of Environmental & CRZ Clearance for a further period of 5 years i.e. up to 30/9/2018.

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	Remarks
A	**Specific Condition**	
1	All measures indicated in the letter dated 4/8/2008 shall be strictly complied with.	Compliance Report of conditions stipulated in the CRZ recommendation granted by Forest & Environment Department, GoG vide letter dated 14/02/2008 is placed at **Annexure A.**
2	Necessary clearances from the Gujarat State Pollution Control Board shall be obtained before initiating the project.	GPCB vide order no. PCC/CCA-BHUJ-179(3)/575 dated 9/1/2009 granted No Objection Certificate to the said project. Currently, all the 4 berths are under operation. Further, GPCB vide order dated 22/1/2021 has issued Consolidated Consent & Authorization. Subsequently, GPCB 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 same is enclosed herewith as **Annexure B.**
3	The project proponent shall not undertake any destruction of mangroves during construction and operation of project.	All the 4 berths are under operation. As a part of mangrove conservation, DPA has undertaken Mangrove Plantaion in an area of 1500 Hectares at various locations **(Annexure C)** till date under the directions of the GCZMA and MoEF&CC,GoI. In addition to it, DPA is carrying out additional mangrove plantation of 100 ha. in consultation with Gujarat Ecology Comission vide Work Order No. DD/WK/3050/Pt-I/GIM/PC-44 dated 02/06/2022 (**Annexure D**). It is also relavent to mention here that, as per the direction of the Gujarat Coastal Zone Management Authority, DPA has 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 M/s GUIDE is attached

		herewith as **Annexure E.**
4	Sewage arising in the Port area shall be treated to conform to the standards stipulated by Gujarat State Pollution Control Board and shall be utilized/ recycled or gardening, plantation and irrigation.	The sewage generated in the port area is treated in the existing STP of 1.5 MLD capacity at Kandla. The treated wastewater is utilized for gardening and plantation purposes. In addition to that, it also has septic tanks at places where STP is inaccessible. For monitoring of environmental parameters including the STP, DPA appointed M/s Detox Corporation (NABL Accredited laboratory), Surat and reports are being submitted from time to time to the Regional Office as well as to the MoEF&CC, GoI, New Delhi. The monitoring report is attached herewith as **Annexure F.**
5	Project proponent shall prepare Disaster Management Plan covering emergency evacuation mechanisms etc.deal with natural disaster events and regularly update from time to time.	DPA is already having a Disaster Management Plan. The copy of the same has been communicated with earlier compliance reports submitted.
6	There shall be no withdrawal of ground water in COASTAL REGULATION ZONE area, for this project. The proponent shall ensure that as a result of the proposed constructions, ingress of saline water into ground water does not take place. Piezometers shall be installed for regular monitoring for this purpose at appropriate locations on the project site.	All the 4 berths are currently under operation.
7	The facilities to be constructed in the COASTAL REGULATION ZONE area as part of this project shall be strictly in conformity with the provisions of the COASTAL REGULATION ZONE Notification, 1991 as amended subsequently.	All the 4 berths are currently under operation.
8	Green belt area shall be developed along the project and budget earmarked.	DPA had entrusted the work to Forest Department, Gujarat 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 already 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 31stMay, 2022 **(Annexure G)**.
9	No product other than those permissible in the COASTAL REGULATION ZONE Notification, 1991 shall be stored in the COASTAL REGULATION ZONE area.	Point Noted. Cargo is being stored at back-up area of berths viz. 13th to 16th CB, as per the EC & CRZ Clearance accorded by the MoEF&CC, GoI.
B	**General Conditions**	
I	Construction of the proposed structures shall be undertaken meticulously conforming to the existing Central/Local rules and regulations including COASTAL REGULATION ZONE Notification, 1991 & its amendments. All the construction design/drawings relating to the proposed construction activities must have approvals of the concerned State Government Department/Agencies.	Currently, all the 4 berths are under operation.
II	Adequate provisions for infrastructure facilities such as water supply, fuel, sanitation etc. shall be ensured for construction workers during the construction phase of the project so as to avoid feeling of trees / mangroves and pollution of water and surroundings.	All the 4 berths are currently under operation.
iii	The project authorities must make necessary arrangement for disposal of solid wastes and for the treatment of Effluents by providing a proper wastewater treatment plant outside the COASTAL REGULATION ZONE area. The quality of treated effluents, solid wastes and noise level etc. must conform to the standards laid down by the competent authorities including the Central/State Pollution Control Board and the Union Ministry of Environment and Forests	Companies authorized by Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) have been awarded the work of collection, transporting and disposal of solid waste by the Deendayal Port Authority. 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. DPA appointed M/s Detox Corporation (NABL Accredited laboratory), Surat for monitoring of Environmental parameters viz. Air, Water, Noise etc. and reports are being submitted

	under the Environment (Protection) Act, 1986, whichever are more stringent.	from time to time to the Regional Office as well as to the MoEF&CC, GoI, New Delhi. The monitoring report is attached herewith as **Annexure F**.
Iv	The proponents shall provide for a regular monitoring mechanism as to ensure that the treated effluents conform to the prescribed standards. The records of analysis reports must be properly maintained and made available for inspection to the concerned State/Central officials during their visits.	For monitoring of treated sewage, DPA appointed M/s Detox Corporation (NABL Accredited laboratory), Surat and reports are being submitted from time to time to the Regional Office as well as to the MoEF&CC, GoI, New Delhi. The monitoring report is attached herewith as **Annexure F**.
V	In order to carry out the environmental monitoring during the operational phase of the project, the project authorities shall provide an environmental laboratory well equipped with standard equipment and facilities and qualified manpower to carry out the testing of various environmental parameters.	DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of environmental parameters. For the purpose, well equipped laboratory has already been established by M/s Detox Corporation at DPA. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted (**Annexure F).**
vi	The sand dunes if any on the site shall not be disturbed in any way.	No sand dunes at project site prevail.
Vii	A copy of the clearance letter will be marked to the concerned Panchayat/local NGO, if any from whom any suggestion/ representation has been received while processing the proposal.	No suggestion/ representation has been received while processing the proposal.
Viii	The Gujarat Pollution Control Board shall display a copy of the clearance letter at the Regional Office, District Industries Centre and Controller's Office/Tehsildar's Office for 30 days.	-------
ix	The funds earmarked for environment protection measures shall be maintained, in a separate account and there shall be no diversion of these funds for any other purpose. A year-wise expenditure on environmental safeguards shall be reported to this Ministry's Regional Office at Bhopal and the State Pollution Control Board.	Point noted. The allocation made under the scheme of "Environmental Services & Clearance thereof other related Expenditure" during BE 2021-22 is Rs. 266 Lakhs & BE 2022-23 is Rs. 345 Lakhs. The expenditure made under the scheme of "Environmental Services & Clearance thereof other related Expenditure" is Rs. 275.36 lakhs for period up to November, 2022.

		The year wise expenditure on environmental safeguards is regularly submitted in the monitoring datasheet to Ministry's Regional Office at Bhopal (Now Gandhinagar).
X	Full support shall be extended to the officers of this Ministry's Regional Office at Bhopal and the officers of the central and State Pollution Control Board by the project proponents during their inspection for monitoring purpose, by furnishing full details and action plans including the action taken reports in respect of mitigate measures and other environment protection activities.	Point Noted.
xi	In case of deviation of alteration in the project including the implementing agency, a fresh reference shall be made to this Ministry for modification in the clearance conditions or imposition of new ones for ensuring environment protection.	Point Noted.
Xii	This ministry reserves the right to revoke this clearance, if any of the conditions stipulated are not complied with to satisfaction of this ministry.	Point Noted.
Xiii	This Ministry or any other competent authority may stipulate any other additional conditions subsequently, if deemed necessary, for environment protection, which shall be complied with.	Point Noted.
Xiv	The project proponent shall advertise in at least two local newspapers widely circulated in the region around the project, one of which shall be in the vernacular language of the locality Concerned, informing that the project has been accrued environment clearance and copies of clearance letters are available with the State Pollution Control Board and may also be seen at website of the Ministry of Environment & Forests at http;//www.envfornic.in. The advertisement shall be made	Advertisement had already been made in Kutch Mitra on 21/10/2008 and Kutch Uday on 22/10/2008. Further, Newspaper cuttings had already been sent to Regional office, MoEF, Bhopal vide DPA letter No.: EG/WK/4660(EC)/01 dated 31/10/2008.

	within 7 days from the date of issue of the clearance letter and a copy of the sameshall be forwarded to the Regional office of this Ministry at Bangalore.	
xv	The project proponent shall inform the Regional office at Bhopal as well as the Ministry the date of financial closer and final approval of the Project by the concerned authorities and the date of Start of Land Development work.	The necessary details have already been provided by the DPA from time to time along with the earlier compliance reports submitted. Now, all the 4 berths are under operation.
10	The above-mentioned stipulations will be enforced among others under the water (Prevention and Control of Pollution) Act, 1974, the Air (Prevention and Control of Pollution) Act, 1981, the Environment (Protection) Act 1986, the Hazardous Chemicals (Manufactures, storage and Import) Rules, 1989, the Coastal Regulation Zone Notification, 1991 and its subsequent amendments and the Public Liability Insurance Act, 1991 and the Rules made there under from time to time. The project proponents shall also ensure that the proposal complies with the provisions of the approved Coastal Zone Management Plan of Gujarat State.	DPA has obtained consolidated consent and authorization vide 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. The copy of the same is enclosed herewith as **Annexure B.** Moreover, DPA retained M/s Detox Corporation for regular environmental monitoring and the report is enclosed at **Annexure F**. Public Liability Insurance is renewed time to time as required. The Public Liability Insurance has been renewed and is valid till 23/07/2023. The same is attached herewith as **Annexure H.** Deendayal Port Authority had already obtained Coastal Regulation Zone Recommendations dated 14/02/2008 from State Forest &Environment Department, Government of Gujarat for the project. All the 4 berths are under operation.

ANNEXURE A

DEENDAYAL PORT AUTHORITY
(Erstwhile: DEENDAYAL PORT TRUST)

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY

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

www.deendayalport.gov.in

EG/WK/4660 (EC)/ Part V/231 Dated: /01/2023
02/02/2023

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 Berth at Deendayal Port – **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

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 Trust along with necessary annexure (Annexure 1) for the period upto November, 2022.**

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 November, 2022.

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 i.e. 25% of the total project cost of 165 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 Plantation in an area of 1500 Hectares since the year 2005. A statement showing details of mangrove plantation with cost incurred is placed at **Annexure A**. Further, DPA is carrying out additional mangrove plantation of 100 Ha. With consultation of Gujarat Ecology Commission vide Work Order No. DD/WK/3050/Pt-I/GIM/PC-44 dated 02/06/2022 (**Annexure B**). It is also relevant to submit here that, as per the direction of the Gujarat Coastal Zone Management Authority, DPA had already prepared & submitted a report on mangrove 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) (**Report attached as Annexure C**).
5	No activities other than those permitted by the competent authority under the CRZ Notification shall be carried out in the CRZ area.	All the four berths are under operation.
6	No ground water shall be tapped for any purpose during the proposed expansion modernization activities.	All the four berths are under operation.
7	All necessary permissions from different Government Departments / agencies shall be obtained by the KPT before commencing the expansion activities.	DPA obtained Consolidated Consent & Authorization (CC&A) from the GPCB vide Consent Order no-AWH-110594 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**(Annexure D)**.
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 appointed M/s Detox Corporation (NABL Accredited laboratory), Surat and reports are being submitted from time to time to the Regional Office as well as to the MoEF&CC, GoI, New Delhi. The monitoring report is attached herewith as **Annexure E**.
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. In this regard, it is to state that, DPA has already undertaken Mangrove Plantation in an area of 1500 Ha. till date since the year 2005. A statement showing details of mangrove plantation with cost incurred is placed at **Annexure A**. Further, DPA is carrying out additional mangrove plantation of 100 ha. With consultation of Gujarat Ecology Comission vide Work Order No. DD/WK/3050/Pt-I/GIM/PC-44 dated 02/06/2022 (**Annexure B**). 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 for the year 2021 to 2022 is attached herewith as **Annexure C**. 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 first season report for the year 2022-2023 submitted is attached herewith as **Annexure F.** To control fugitive emissions, DPA has installed Mist Canon at the Port area and has already installed continuous sprinkling system in coal stack yard in DPA (40 ha. area) to prevent dust pollution. Further, to control dust pollution in other area, regular sprinkling through tankers on roads and other staking yards is being done. 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. DPA appointed M/s Detox Corporation, Surat for monitoring of Environmental parameters viz. Air, Water, Noise etc. and reports are being submitted from time to time to the Regional Office as well as to the MoEF&CC, GoI, New Delhi. The monitoring report is attached herewith as **Annexure E**.
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 (**Annexure H**).
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 I.**
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 2021-22 is Rs. 266 Lakhs & BE 2022-23 is Rs. 345 Lakhs. The expenditure made under the scheme of "Environmental Services & Clearance thereof other related Expenditure" is Rs. 275.36 lakhs for period up to November, 2022.
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 **(Copy of work order & scope of work attached as Annexure K).** 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. A copy of office order is attached herewith as **Annexure L.**
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	DPA appointed M/s DETOX Corporation, Surat for regular monitoring of Environmental parameters **(Copy of monitoring report – Annexure E).**

	MoEF, GOI.	
20	The KPT shall have to contribute financially to support the National Green Corps Scheme being implemented in Gujarat by the GEER Foundation, Gandhinagar, in construction with Forests and Environment Department	Point noted
21	Six monthly reports on compliance of the conditions mentioned in this letter shall have to be furnished by the KPT on regular basis to this department/ MoEF, GOI.	DPA has regularly submitted the compliance reports to GCZMA, Gandhinagar and MoEF&CC, GOI. The last compliance report of the conditions stipulated in CRZ recommendations issued by GCZMA was submitted on 19/07/2022.
22	Any other condition that may be stipulated by this department from time to time for environmental protection/management purpose shall also have to be complied with by the KPT.	Point noted

ANNEXURE B

GPCB

GUJARAT POLLUTION CONTROL BOARD
PARYAVARAN BHAVAN
Sector-10-A, **Gandhinagar**-382 010
Phone : (079) 23226295
Fax : (079) 23232156
Website : www.gpcb.gov.in

By R.P.A.D

In exercise of the power conferred under section-25 of the Water (Prevention and Control of Pollution) Act-1974, under section-21 of the Air (Prevention and Control of Pollution)-1981 and Authorization under rule 6(2) of the Hazardous and Other Waste (Management and Trans boundary) Rules, 2016 framed under the Environmental (Protection) Act-1986.

And whereas Board has received consolidated consent application **inward No.176457** dated 22/09/2020 for the **Renewal of Consolidated Consent and Authorization (CC&A)** of this Board under the provisions / rules of the aforesaid Acts. Consents & Authorization are hereby granted as under:

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

To,
M/s. Deendayal Port Trust, (New name) (ID-28494)
M/s. Kandla Port Trust, (Old name),
Kandla, A.O Building Gandhidham,
Tal: Gandhidham, Dist: Kutch - 370201

1. **Consent Order No. AWH-110594 Date of issue: 08/12/2020.**
2. The consents shall be **valid upto 21/07/2025** for the use of outlet for the discharge of trade effluent and emission due to operation of industrial plant for manufacturing of the following items/ products:

Sr. No	Product/Services	Quantity
1	Dry Cargo Handling	26,54,00,000 MT/Month
2.	Liquid Cargo Handling	54,64,00,000 MT/Month
3.	Loading and unloading operation at 13th Berth	2 MMTPA
4.	Loading and unloading operation at 15th Berth	2 MMTPA

Subject to specific condition:

1. Unit shall strictly adhere to compliance ministry in its Clearance letter file no. 11-82/2011-IA-III, dated 19/12/2016.
2. Unit shall also strictly adhere to all conditions of Environment and CRZ Clearance issued by MoEF vide letter no. F. no. 11-70/2006-IA-III dated 01/10/2008.
3. Applicant shall comply with Manufacture, Storage and Import of Hazardous Chemicals Rules-1989 (MSIHC) as amended time to time.
4. Applicant shall ensure that all storage terminal located within DPT area shall strictly comply with MSIHC Rules including site notification & submit details periodically to board with relevant details.
5. Applicant shall renew Public Liability Insurance time to time & submit a copy to this Board.

6. Unit shall notify site under MSIHC Rule-1989 from competent authority as mentioned in schedule-5 of MSIHC Notifications.
7. Industry shall not withdraw groundwater without prior NOC from CGWA as per Hon. National Green Tribunal order.
8. Industry shall manage Solid Wastes generated from industrial activities as per Solid Waste Management Rules-2016 (solid waste as defined in Rule-3(46)).
9. Industry shall comply with Plastic Waste Management Rules– 2016 and amendments made therein.
10. Industry shall strictly comply with coal handling guideline of this board.
11. Industry shall provide dedicated storage facility for dry cargos & ensure to take adequate measures to prevent dusting.
12. Applicant shall ensure that there shall be no damage to the existing mangrove patches near site and also ensure the free flow of water to avoid damage to the mangroves.
13. Applicant shall ensure as per EC condition that no creeks or rivers are blocked due to any activities at the site and free flow of water is maintained.
14. Applicant shall provide proper system for collection, storage & treatment & disposal of waste water generated by vessel as per MARPOL & maintain records.
15. Applicant shall install storm drainage catch basin to avoid directly discharge into surface water.
16. Waste effluent accumulated with port activities including storm water & sewage from port operation including sewage ballast water, bilge water & clean waste water from ships shall be as per MARPOL norms.
17. Applicant shall make separate records regarding generation, collection, transportation & disposal of waste generation from ship & maintain its records.
18. Applicant shall made necessary arrangement for the plastic Waste. Solid Waste or other waste generation due to port activities & for facilitation of reception facilities under MARPOL & Environment (Protection) Act-1986 rules etc.
19. Ports shall obtain approval of their oil spill contingency plan (OSCP) as required under national oil spill disaster contingency plan (NOS-DCP) of coast guard, ministry of defence, govt. of India.
20. Best environmental practices by ports maybe uploaded on "Indian ports Association" as well as the same maybe linked to websites of CPCB and respective SPCBs.
21. Manually handling of cargo should be converted into mechanized system, in time bound manner.

3. Conditions under the Water act-1974:

3.1 Source of Water: - GWIL.

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

3.3 The quantity of the fresh water consumption for domestic purpose shall not exceed 1300 KLD.

3.4 The quantity of domestic waste water shall not exceed 800 KLD.

GPCB

GUJARAT POLLUTION CONTROL BOARD

PARYAVARAN BHAVAN
Sector-10-A, **Gandhinagar**-382 010
Phone : (079) 23226295
Fax : (079) 23232156
Website : www.gpcb.gov.in

3.5 Domestic effluent shall be treated in existing STP & treated effluent conforming to following norms shall be discharged on land within premises strickly for gardening and plantation purpose & no sewage shall be disposed outside premises in any manner.

PARAMETERS	PRESCRIBED LIMITS
pH	6.5 to 8.5
BOD (3 days at 27° C)	30 mg/L
Suspended Solid	100 mg/L
Fecal Coli form	< 1000 MPN/ 100 ml

3.6 Treated domestic effluent confirming to above norms shall be discharge on land only for gardening & plantation within premises.

3.7 Unit shall provide flow meter at inlet & outlet of STP & maintain its record.

3.8 Disposal system for storm water shall be provided separately. In no case storm water & sewage from port facility shall not be discharge into surface water.

4. Conditions under the Air Act-1981:

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

Sr. No.	Utility	Fuel	Quantity
1	D.G. Sets	HSD	500 Ltr/Hr

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

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

Sr. No.	Stack attached to	Stack height in Meter	APCM	Parameter	Permissible Limit
1 & 2	DG sets (2 nos.) (1010 KVA)	15 each	--	PM SO_2 NO_x	150 mg/NM^3 100 ppm 50 ppm

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

4.5. The concentration of the following parameters in the ambient air within the premises of the industry and a distance of 10meters from the source) other than the stack/vent) shall not exceed the following levels.

Sr. No.	Pollutant	Time Weighted Average	Concentration in Ambient air in µg/M^3
1.	Sulphur Dioxide (SO_2)	Annual 24 Hours	50 80
2.	Nitrogen Dioxide (NO_2)	Annual 24 Hours	40 80
3.	Particulate Matter (Size less than 10 µm) or PM_{10}	Annual 24 Hours	60 100
4.	Particulate Matter (Size less than 2.5 µm) or $PM_{2.5}$	Annual 24 Hours	40 60

4.6. The applicant shall provide portholes, ladder, platform etc at chimney(s) for monitoring the air emissions and the same shall be open for inspection to/and for use of Board's staff. The chimney(s) vents attached to various sources of emission shall be designed by numbers such as S-1, S-2, etc. and these shall be painted/displayed to facilitate identification.

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

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

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

5.1 Authorization order no:-**AWH-110594**Date of issue: 08/12/2020.

5.2 **M/s. Kandla Port Trust** is hereby granted an authorization to operate facility for following hazardous wastes on the premises situated at Kandla, A.O Building Gandhidham, Tal: Gandhidham, Dist : Kutch.

Sr. No.	Waste	Quantity/ Year	Schedule &Category	Facility
1	Used Spent Oil	1125 MT	I- 5.1	Collection, Storage, Transportation and disposal by selling to authorized recycler.
2	Waste Residue Containing Oil	3344.43 MT	I-5.2	Collection, Storage, Transportation and disposal by selling to authorized recycler.

5.3 The authorization shall be valid up to **21/07/2025.**

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

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

5.6 **<u>TERMS AND CONDITIONS OF AUTHORISATION</u>**

1. The applicant shall comply with the provisions of the Environment (Protection) Act-1986 and the rules made there under.
2. The authorization or its renewal shall be produced for inspection at the request of an officer authorized by the Gujarat Pollution Control Board.
3. The persons authorized shall not rent, lend, sell, and transfer or otherwise transport the hazardous wastes without obtaining prior permission of the Gujarat Pollution Control Board.

GPCB

GUJARAT POLLUTION CONTROL BOARD

PARYAVARAN BHAVAN
Sector-10-A, **Gandhinagar**-382 010
Phone : (079) 23226295
Fax : (079) 23232156
Website : www.gpcb.gov.in

4. Any unauthorized change in personnel, equipment or working conditions as mentioned in the authorization order by the persons authorized shall constitute a beach of this authorization.
5. The person authorized shall implement Emergency Response Procedure (ERP) for which this authorization is being granted considering all site specific possible scenarios such as spillages, leakages, fire etc. and their possible impacts and also carry out mock drill in this regard at regular interval of time;
6. The person authorized shall comply with the provisions outlined in the Central Pollution Control Board guidelines on "Implementing Liabilities for Environmental Damages due to Handling and Disposal of Hazardous Wastes and Penalty"
7. It is the duty of the authorized person to take prior permission of the Gujarat Pollution Control Board to close down the facility.
8. An application for the renewal of an authorization shall be made as laid down in rules 6(2) under Hazardous and Other Waste Rules, 2016.
9. The imported hazardous and other wastes shall be fully insured for transit as well as for any accidental occurrence and its clean-up operation.
10. The record of consumption and fate of the imported hazardous and other wastes shall be maintained.
11. The hazardous and other wastes which gets generated during recycling or reuse or recovery or pre-processing or utilization of imported hazardous or other wastes shall be treated and disposed of as per specific conditions of authorization.
12. The importer or exporter shall bear the cost of import or export and mitigation of damages if any.
13. Any other conditions for compliance as per the Guidelines issued by the Ministry of Environment, Forest and Climate Change or Central Pollution Control Board from time to time.
14. The waste generator shall be totally responsible for (i.e. collection, storage, transportation and ultimate disposal) the wastes generated.
15. Records of waste generation, its management and annual return shall be submitted to Gujarat Pollution Control Board in Form-4 by 30th day of June of every year for the preceding period April to March.
16. In case of any accident, details of the same shall be submitted on Form-11 to Gujarat Pollution Control Board.
17. As per "Public Liability Insurance Act-91" company shall get Insurance Policy, if applicable.
18. Empty drums and containers of toxic and hazard material shall be treated as per guideline published for "Management & Handling of discarded containers". Records of the same shall be maintained and forwarded to Gujarat Pollution Control Board regularly.
19. In case of transport of hazardous wastes to a facility for (i.e. treatment, storage and disposal) existing in a State other than the State where hazardous wastes are generated, the occupier shall obtain 'No Objection Certificate' from the State Pollution Control Board or Committee of the concerned State of Union Territory Administration where the facility exists.
20. Unit shall take all concrete measures to show tangible results in waste generation, reduction, avoidance, reuse and recycle. Actions taken in this regard shall be submitted within three months and also along with Form-4.

21. Industry shall have to display the relevant information with regards to hazardous waste as indicated in the Hon. Supreme Court's Order in W.P. No.657 of 1995 dated 14th October, 2003.
22. Industry shall have to display on-line data outside the main factory gate with regard to quantity and nature of hazardous chemicals being handled in the plant, including wastewater and air emissions and solid hazardous wastes generated within the factory premises.

6. **SPECIFIC CONDITIONS:-**
   6.1 The authorized actual user of hazardous and other wastes shall maintain records of hazardous and other wastes purchased in a passbook issued by the State Pollution Control Board along with the authorization.
   6.2 Handling over of the hazardous and other wastes to the authorized actual user shall be only after making the entry in the passbook of the actual user.
   6.3 In case of renewal of authorization, a self-certified compliance report in respect of effluent, emission standards and the conditions specified in the authorization for hazardous and other wastes shall be submitted to SPCB.
   6.4 The occupier of the facility shall comply Standard operating procedure/guidelines published by MOEF&CC or CPCB or GPCB from time to time.
   6.5 Unit shall comply provisions of E-Waste Management Rules-2016.
   6.6 The disposal of Hazardous Waste shall be carried out as per the waste Management hierarchy.
   6.7 The occupiers of facilities shall not store the hazardous and other wastes for a period not exceeding **ninety days**. Prior permission of the Board shall be obtained for extension of the storage period.
   6.8 The occupier shall maintain the records of generation, sale, storage, transport, recycling, co processing and disposal of hazardous waste and make available during the inspection.
   6.9 The transportation of the hazardous waste shall be carried out in GPS mounted dedicated vehicles.

7. **GENERAL CONDITIONS: -**
   7.1 Any change in personnel, equipment or working conditions as mentioned in the consents form/order should immediately be intimated to this Board.
   7.2 Applicant shall also comply with the general conditions given in annexure I.
   7.3 Whenever due to accident or other unforeseen act or ever, such emissions occur or is apprehended to occur in excess of standards laid down such information shall be forthwith reported to Board, concerned Police Station Office of Directorate of Health Service, Department of Explosives, Inspectorate of Factories and local body.
   7.4 In case of failure of pollution control equipments, the production process connected to it shall be stopped. Remedial actions/measures shall be implemented immediately to bring entire situation normal.

GPCB

GUJARAT POLLUTION CONTROL BOARD

PARYAVARAN BHAVAN
Sector-10-A, **Gandhinagar**-382 010
Phone : (079) 23226295
Fax : (079) 23232156
Website : www.gpcb.gov.in

7.5 The Environmental Management Unit/Cell shall be setup to ensure implementation on and monitoring of environmental safeguards and other conditions stipulated by statutory authorities. The Environmental Management Cell/Unit shall directly report to the Chief Executive of the organization and shall work as a focal point for internalizing environmental issues. These cells/units also coordinate the exerciseof environmental audit and preparation of environmental statements.

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

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

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

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

For and on behalf of
GUJARAT POLLUTION CONTROL BOARD

(Smt. U.K. Upadhyay)
Environment Engineer

NO: GPCB/CCA-Kutch-812(5)/ID-28494/ **Date:-**
Issued to:
M/s. Deendayal Port Trust, (New name),
M/s. Kandla Port Trust, (Old name),
Kandla, A.O Building Gandhidham,
Tal: Gandhidham, Dist: Kutch - 370 201

GPCB

GUJARAT POLLUTION CONTROL BOARD
PARYAVARAN BHAVAN
Sector-10-A, **Gandhinagar**-382 010
Phone : (079) 23226295
Fax : (079) 23232156
Website : www.gpcb.gov.in

By R.P.A.D.

NO: PC/ CCA- KUTCH-812(5)/ GPCB ID: 28494/ **Date: -**

Correction in Consolidated Consent & Authorization order no AWH-110594 date of issue 22/01/2021 (Under the provisions/rules of Environmental acts)

To,
M/s. Deendayal Port Trust, (New name)
M/s. Kandla Port Trust, (old name),
Kandla, A.O Building Gandhidham,
Tal:-Gandhidham,
Dist: Kutch – 370 201.

Subject : Correction of Consolidated Consent and Authorization (CC& A) of this Board
Reference : 1) CCA issued vide order no. PC/ CCA- KUTCH-812(5)/ GPCB ID: 28494/ 581914 dated 22/01/2021.
2) Your letter dated 25/01/2021.

In exercise of the power conferred under section-27 of the Water (Prevention and Control of Pollution) Act-1974, under section-21 of the Air (Prevention and Control of Pollution)-1981 and Authorization under rule 6(2) of the Hazardous & Other Waste (Management &Transboundary Movement) Rules-2016 & as amended framed under the Environmental (Protection) Act-1986 and without reducing your responsibility under the said Acts/Rules in anyway. The Board had granted CCA vide order no. AWH-110594 dated 22/01/2021.

ANDWHEREAS the Board is empowered to amend CCA conditions. Accordingly, considering your request for corrected & after care full consideration, the CCA order no. AWH-110594 is hereby corrected/ amended as below;

1. The condition no. 2 of the said CCA order shall be corrected as below;
   2. The consent shall be **valid upto 21/07/2025** for the use of outlet for the discharge of trade effluent and emission due to operation of industrial plant for manufacturing of the following items/ products:

Sr No.	Product	Quantity
1.	Dry Cargo Handling	26,54,00,000 MT/Month
2.	Liquid Cargo Handling	54,64,00,000 MT/Month
3.	Loading and unloading operation of 13th and 15th berth	2 MMTPA(Each)
4.	Loading and unloading operation of 14th and 16th berth	4.5 MMTPA (Each)

2. All other terms and condition mentioned in AWH – 110594 issued vide CCA letter PC/ CCA- KUTCH-812(5)/ GPCB ID: 28494/581914 dated 22/01/2021 shall remain unchanged.

For and on behalf of
Gujarat Pollution Control Board

(Smt. U. K. Upadhyay)
Environment Engineer

Annexure -C

DEENDAYAL PORT TRUST

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

Sr. No.	Name of the Organization	Total Mangrove Plantation carried out in Hectares till date and place of plantation and agency	Cost incurred
	(A) MANGROVE PLANTATION ALREDY CARRIED OUT		
1	DEENDAYAL PORT TRUST (CRZ Recommendation 13th to 16th CB issued by the GCZMA) (Total 1000 ha.)	20 Hectares – 2005-06 Satsida Bet,Kandla, by GUIDE,Bhuj 50 Hectares – 2008-09 Nakti Creek,Kandla by Patel Construction 100 Hectares – 2010-11 Nakti Creek ,Kandla by GEC. (Board 29/1/2010) 200 Hectares – 2011-12 by Forest Department, GoG at Satsaida Bet 300 Hectares – 2012-13 by Forest Department, GoG at Satsaida Bet 330 Hectares – 2013-14 by Forest Department, GoG at Satsaida Bet **TOTAL 1000 HA.**	Rs. 8.8 lakhs Rs. 27.4 lakhs Rs.24.5 lakhs Rs. 66.5 lakhs Rs. 157.5 lakhs (total 630 hectares)
2	Creation of Berthing & allied Facilities off- tekra near Tuna (Outside Kandla Creek) – EC & CRZ Clearance. (Total 500 ha. – 250Ha. by DPT & 250 ha by Adani (concessionaire) MOU signed with GEC during Vibrant Gujarat Summit 2015 for 300 Ha.	300 Hectares – 2015-17 by GEC at Kantiyajal, Bharuch District	Rs. 90.0 lakhs
3.	EC & CRZ Clearance dated 19/12/2016 for Developing 7 integrated facilities (Condition 100 Ha)	100 Ha. –2018- 20 by GEC	Rs. 45 lakhs
TOTAL MANGROVE Plantation till date by DPT 1400 Ha. – Total 419.7 lakhs			

	(B) Proposed Mangrove Plantation		
1.	Development of Integrated facilities (Stage-II) within the existing Deendayal Port Trust (Erstwhile Kandla Port Trust) at District Kutch, Gujarat. (1. Setting up of Oil Jetty No.7 ; 2. Setting up of Barge jetty at Jafarwadi ; 3. Setting up of Barge port at Veera; 4. Administrative office building at Tuna Tekra; 5. Road connecting from Veera barge jetty to Tuna gate by M/s Deendayal Port Trust (Erstwhile : Kandla Port Trust) - Environmental & CRZ Clearance accorded by the MoEF&CC,GoI dated 19/12/2020.	**50 Ha. as per CRZ Recommendation issued by the GCZMA dated 29/6/2016.**	Rs. 45 lakhs
2.	Development of 3 Remaining Integrated Facilities (stage I) within the existing Deendayal Port Trust (Erstwhile : Kandla Port Trust) at Gandhidham, Kutch, Gujarat - Environmental & CRZ Clearance accorded by the MoEF&CC,GoI dated 18/2/2020.	**50 Ha. as per CRZ Recommendation issued by the GCZMA dated 29/6/2016. .**	

Annexure -D

DEENDAYAL PORT AUTHORITY

(Erstwhile Deendayal Port Trust)

Ministry of Ports, Shipping & Waterways, Govt. of India

Mech. Engg. Deptt.

SAGARMALA

Tel: (02836)220636 / 270184
FAX: (02836) 270184 / 270475
Email :- cmedpt @gmail.com
cme@deendayalport.gov.in

Office of the Chief Mechanical Engineer,
Port & Customs Building,
New Kandla (Kutch), Gujarat-370210

No. DD/WK/3050/Pt-I/ Gnm/Pt-44 Date: 02.06.2022

Sir,

To,
Gujarat Ecology Commission
Forest & Environment Department
Block No. 18, First Floor, Udhyog Bhavan,
Gandhinagar, Gujarat

Sub: Work Order to carry out Mangrove Plantation-reg.

The Competent Authority, Deendayal Port Authority has been pleased to approve:

1. To carry out mangrove plantation in 100 Ha. area with consultation of concern Gujarat Ecology Commission and at tentative estimated cost amounting to Rs. 50,00,000/- (excluding GST) for the said mangrove Plantation to be carried out in an area of 100 Ha. as per the stages mentioned by them in the MoU as follows:

Sr. No.	Terms and Condition	Rs. (in lakhs)
1	50% of the project cost of 100 Ha. Mangrove Plantation after singing the MoU.	**Rs. 25.00**
2	40% of the project cost of 100 Ha Mangrove Plantation after nursery preparation.	**Rs. 20.00**
3	10% of the project cost of 100 Ha Mangrove Plantation after plantation and submission of First year progress report.	**Rs. 5.00**
	Total	**50.00**

2. To sign MoU with the Gujarat Ecology Commission, Government of Gujarat during the ensuing Vibrant Gujarat Summit 2022, regarding proposed Mangrove Plantation to be carried out in an area of 100 Hectares through the Gujarat Ecology Commission.
3. To authorize Dy. CME & CME (I/c) to sign MoU with the Gujarat Ecology Commission, Government of Gujarat during upcoming Vibrant Gujarat Summit 2022 for proposed Mangrove Plantation in an area of 100 Hectares through GEC.

The Expenditure shall be chargeable under Code 841/587/9744 WC-13001

Authority: Approved by Board vide Resolution No. 30 in the board meeting held on 27.05.2022

Chief Mechanical Engineer(I/c)
Deendayal Port Authority

Copy to:
1) SE(M)
2) A.O. (Works Audit)

Annexure -E

Regular Monitoring of Mangrove Plantation (1400 ha) carried out by Deendayal Port Authority, Kandla

DPA Work Order No: WK/EG/4751/Part/ (Marine Ecology Monitoring)/10

Dt.03/05/2021

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

MAY 2022

Gujarat Institute
of Desert Ecology

Certificate

This is to state that this Final report of the work entitled, **"Regular Monitoring of Mangrove Plantation (1400 Ha) carried out by Deendayal Port Authority (Statutory Requirement)"** has been prepared in the line with the work order issued by DPA vide No. EG/WK/4751/Part (Marine Ecology Monitoring))/10. Dt. 03.05.2021.

This report covers the study conducted during the period between May'2021 and May'2022.

Authorized Signatory

Institute of Desert Ecology Bhuj Gujarat

Institute Seal

P. O. Box No. # 83, Opp. Changleshwar Temple, Mundra Road, Bhuj (Kachchh) - 370 001, Gujarat (India)
Tel : 02832 - 235025 Tele / Fax : 235027
www.gujaratdesertecology.com, E-mail : desert_ecology@yahoo.com

PROJECT TEAM

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

Name of the Staff	Designation	Role
Dr. M. Jaikumar	Senior Scientist	Principal Investigator
Dr. Durga Prasad Behera	Project Scientist	Team Member
Dr. R. Ravinesh	Project Scientist	Team Member
Dr. Dhara Dixit	Project Scientist	Team Member
Dr. Kapilkumar. N. Ingle	Project Scientist	Team Member
Dr. L. Prabhadevi	Advisor	Team Member
Mr. Dayesh Parmar	Project Officer (RS&GIS)	Team Member
Mr. Sai Vineeth Perla	Senior Research Fellow	Team Member
Ms. Bhagavati Kannad	Junior Research Fellow	Team Member
Ms. Pallavi Joshi	Junior Research Fellow	Team Member

Snapshot of the Project, "Regular Monitoring of Mangrove Plantation (1400 Ha) carried out by Deendayal Port Authority (Statutory requirement)"

S. No	Components of the Study	Remarks
1	Deendayal Port's letter sanctioning the project	EG/ WK/4751/Part/ (Marine Ecology Monitoring)/10 dated 3/5/2021
2	Duration of the project	One year from 24.05.2021 to 23.05.2022
3	Period of the survey carried out for various components	July-2021 – April 2022
4	Survey area within the port limit	Sat Saida Bet, Nakti creek and Kantiyajal mangrove plantation sites
5	No of locations sampled within the port limits	05 blocks in Sat Saida Bet, 02 blocks in Nakti creek and 3 block at Kantiyajal
6	Components of the report	
6a	Mangrove density	*Sat Saida Bet:* Density of *A. marina* varied from 1300 to 3500 and individuals/ha and tree height ranging from 70 - 260cm *Nakti creek:* Density of *A. marina* varied from 900 – 3400 individuals/ha and tree height ranges from 72 - 280 cm. *Kantiyajal:* Density of *A. marina* varied from 1200 - 5200 individuals/ha tree height ranges from 13-220 cm. The density of *R. mucronata* at Kantiyajal was 1800 to 3500 individuals/ha and height ranges from 13 to 210 cm.
6b	Mangrove survival	The highest survival rate for *A. marina* plantation in 150 ha area at Kantiyajal was 75%, followed by 50ha area at Sat Saida bet (62.7%) and Nakti (54%).
6c	Assessment of below ground Carbon stock	The below ground Total Biomass Carbon of *A. marina* plantation varied from 42.36t/ha to 79.5t/ha. The highest below ground carbon stock potential was at Sat Saida Island.
6d	Assessment of above ground carbon	The above ground biomass was maximum 210.0 gm at Sat Saida Bet while at Nakti it was 161.0gm and at Kantiyajal 164.60gm.
7d	Management	The restoration efforts to be done to improve the sparse mangrove patches with multi-species plantation initiatives along with promotion of natural regeneration through long term efforts.
8	Status of 2017-2018 plantation	Sat Saida Bet

		Average density of *A. marina* plants 2031 - 5387 individuals/ha with average height ranging from 39 - 113 cm. Nakti creek Plant density (*A. marina)* varied from 2340 – 2370 individuals/ha with average height from 53 - 84 cm. Very few *R. mucronata* and *C. tagal* plants survived. Kantiyajal *A. marina* average density between 1460 and 2220 individuals/ha with an average height between 32 -37 cm. Average density of *R. mucronata* was 1280 individuals/ha with an average height of 30 cm and *R. mucronata* as frontline vegetation along the fringes of the block. Highest survival rate (88.8%) for *A. marina* plantation in 150 ha at Kantiyajal followed by *A. marina* plantation in 20 ha at Sat Saida bet (81.6%) during 2017-2018. The Total Biomass Carbon of A. marina plantation varied from 0.041 to 0.202 Mg/ha. The highest Carbon sequestration potential was of Nakti creek during 2017-2018.

Table of Contents

List of Figures

List of Tables

List of Plates

1 Introduction

Mangrove forests make up one of the most productive and biologically diverse ecosystems on the planet. They grow in a variety of depths of salt water with breathing roots or Pneumatophores providing habitat for different macro and micro faunal species. The ability of mangroves to absorb up to four times more carbon dioxide by area than other terrestrial forests recognize their importance in global warming (Donato *et. al.,* 2011). The mangroves are economically important by supporting fisheries, ecotourism and carbon sequestration (Baig *et. al*., 2015). Over the years, the global scientific community has widely realized the ecological role of mangroves and the services they provide. Despite the benefits it provides, mangroves are being overexploited and deteriorated for various reasons and area under mangrove cover decreased at an alarming rate and poorly restored (UNEP, 2014). Thus, researchers eventually tried to restore mangrove through plantation/conservation to retain the ecological and economic values, and as a result the rate of loss has been decreased and stabilized during the period of 1980 to 2000 compared to the terrestrial forest loss (Duraiappah *et. al.*, 2005). India has a total of 7516.6 km coastline distributed among nine maritime states and four Union Territories (Anon, 2001), of which Gujarat possesses the longest coastline extending to 1650 km. A total of 46 true mangrove species belonging to 14 families and 22 genera are found in Indian mangrove habitats (Ragavan *et. al.,* 2016). Around 3 % of the earth's total mangrove vegetation is found in India (FSI, 2021). Gujarat has the country's second-largest mangrove cover (1175Km^2).

Mangrove being the woody habitats forms the vital carbon sinks in the coastal regions. Deendayal Port Authority (hereafter DPA) has been involved in the mangrove plantation activity as per the specifications by the Ministry of Environment Forests and Climate Change, Govt. of India, (hereafter MoEFCC) in the port premises and the adjoining creek environments in order to mitigate the environmental impacts due to the Port's regular activities in the coastal waters and the land. The coastal water itself can absorb the atmospheric carbon dioxide, and the microscopic phytoplankton tends to remove a huge amount of it through photosynthesis and diffusing oxygen into the water. The monitoring of the mangrove plantation carried out by the DPA has been undertaken by Gujarat Institute of Desert Ecology (hereafter GUIDE) regularly as per the specification in the work order (EG/WK/4751/part Marine Ecology Monitoring)/10 dated 03.05.21. This report describes the monitoring results of the mangrove plantation managed by the DPA at Nakti creek, Kantiyajal and Sat Saida Bet during the period of 2021 to 2022.

2 Objectives of the study

This study aims to assess the growth and survival rate of mangrove plantations, factors affecting the health of the mangrove and suggest appropriate remedial measures and techniques for conserving them.

The specific objectives are:

i. To evaluate 1400 Ha of mangrove plantation at Sat Saida Bet, Nakti creek in Kachchh coast, and Kantiyajal in Bharuch district carried out by the Gujarat Ecology Commission (GEC), and the Department of Forest, Govt. of Gujarat.

ii. To assess the extent of the plantation, health status, survival of the sapling, mortality rate and growth of the planted mangroves.

iii. To provide a comprehensive overview of both the composition and distribution of the planted mangroves.

iv. To assess the potential below ground carbon stock of the mangrove plantation in view of climate change.

3 Mangroves as blue-carbon stock

Mangrove ecosystems are large and dynamic carbon reservoirs, involved in the global carbon cycle and a potential sink of atmospheric carbon dioxide (Clark, 2001; Matsui *et. al*., 2010). Currently, the world's mangroves store carbon equivalent to over 21 gigatons of CO_2. Destruction of mangrove ecosystems releases this carbon into the atmosphere, accelerating the rate of climate change. (Lovelock *et. al*., 2022). It has been estimated that mangroves prevent more than $65 billion in property damages and reduce flood risk to some 15 million people every year (Spalding *et. al*.,.2021). In the face of accelerating climate change, mangroves are significant contributors to ecosystem-based adaptation, with a robust capacity to support lives and livelihoods, even in the expected future changes predicted by most of the general circulation models (IPCC 2013). A salient feature of mangrove forests is converting carbon dioxide to organic carbon at higher rates than almost any other existing habitat on earth (Ezcurra *et al.,* 2016). This 'blue carbon' is stored both in the living plants and their thick muddy soils, where it can remain fixed for centuries.

Although the area covered by mangrove forests represents only a tiny fraction of the tropical forests, their position at the terrestrial-ocean interface and possible exchange with coastal ocean

waters make a unique contribution to the total carbon cycle in the coastal ocean (Twilley, 1992). The contribution of coastal and marine ecosystems to mitigate climate change through carbon sequestration and storage is much more compared to their terrestrial counterparts (Steven *et. al*., 2008; Yee. 2010). Blue carbon sinks include open oceans, kelp forests, salt marshes, sea grass beds, coral reefs and mangroves. Management of these blue carbon sinks is currently not being accounted for in most of the climate change policies and is excluded from national carbon inventories and international carbon payment schemes (Lasco, 2004). There are two different mangrove biomass estimation methods well established viz. field measurement and remote sensing & GIS-based approach. Amongst them, the field measurement has been considered to be precise and accurate (Petrokofsky *et al.*, 2012). Further, field-based data is also required for validation in remote sensing and GIS-based approach. Hence, in recent years, field measurements have been conducted to support and collate satellite data for meaningful estimations. Approximation of the global carbon cycle done through, scaling- up of successful protection and restoration measures (Lovelock *et. al*., 2022). And additionally, these coastal ecosystems provide numerous benefits and services that are essential for climate change adaptation, including coastal protection and food security for many communities globally (IUCN 2017). On an implementation global level, carbon stores in different level *viz*., mangroves, salt marshes and seagrasses can be included in national accounting**,** according to the Intergovernmental Panel on Climate Change (IPCC 2013). Although there was no record of sea grass in the DPA area (GUIDE 2018).

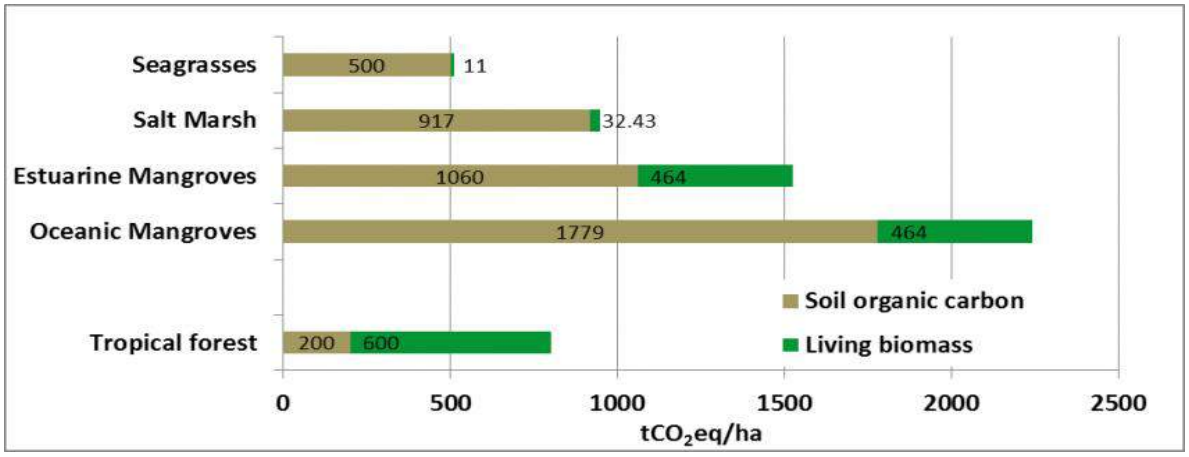


Figure 1. Different level of Carbon Storage
(Source-**IPCC, 2013 Supplement to the 2006 Guidelines for National Greenhouse Gas Inventories: Wetlands).**

4 Rationale

DPA is one of the largest ports in India, having one of the largest coastal habitats, with mangroves (24328.7ha) and mudflats (31089.06 ha) around its jurisdiction. The Port Authority has been very keen and dedicated in restoring the environmental quality of both the shore line and the coastal zone by implementing reliable modern technologies with the participation of the state and central government departments and the local people. Besides the legal mandates, the port authority itself has been implementing projects, time to time towards the conservation of the mangrove and other plants and protecting their coastal habitats and measures been taken to conserve and preserve mangroves within the DPA area, to retain the ecosystem services of mangroves. Accordingly, DPA has carried out mangrove plantation in 1400 ha between 2005 and 2019 through various implementing agencies at Sat Saida Bet and Nakti creek in Kandla and Kantiyajal in Bharuch district. The DPA has entrusted the task of evaluating the status of 1400 ha of mangrove plantation in these locations to the GUIDE, Bhuj. The detailed report on the mangrove plantation evaluation is submitted to the DPA time to time.

5 Study Area

5.1 Deendayal Port Environment

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 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. Due to its location, the tidal amplitude varies, experiencing 6.66 m during Mean High-Water Spring (MHWS) and 0.78 m during Mean Low Water Spring (MLWS) with an MSL of 3.88 m. Commensurate with the increasing tidal amplitude, vast intertidal expanses are present in and around the Port environment. This, along with the occurrence of mudflats, enables mangrove formations at the intertidal belts. Annual rainfall during 2021 was 466 mm, which is often irregular (GWRDC, 2021). There are no perennial or seasonal rivers in Gandhidham taluka. 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 November-December. The average wind speed is 4.65 m/s, with a maximum wind speed of 10.61 m/s during June. The drought phenomenon is common with two drought years in a cycle of 5 years. The annual mean maximum and minimum temperatures are 42.8°C and 21.3°C, respectively (Table 1).

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. Various ecosystem services provided by the mangrove ecosystem is depicted in Fig-2 (IUCN-2017).

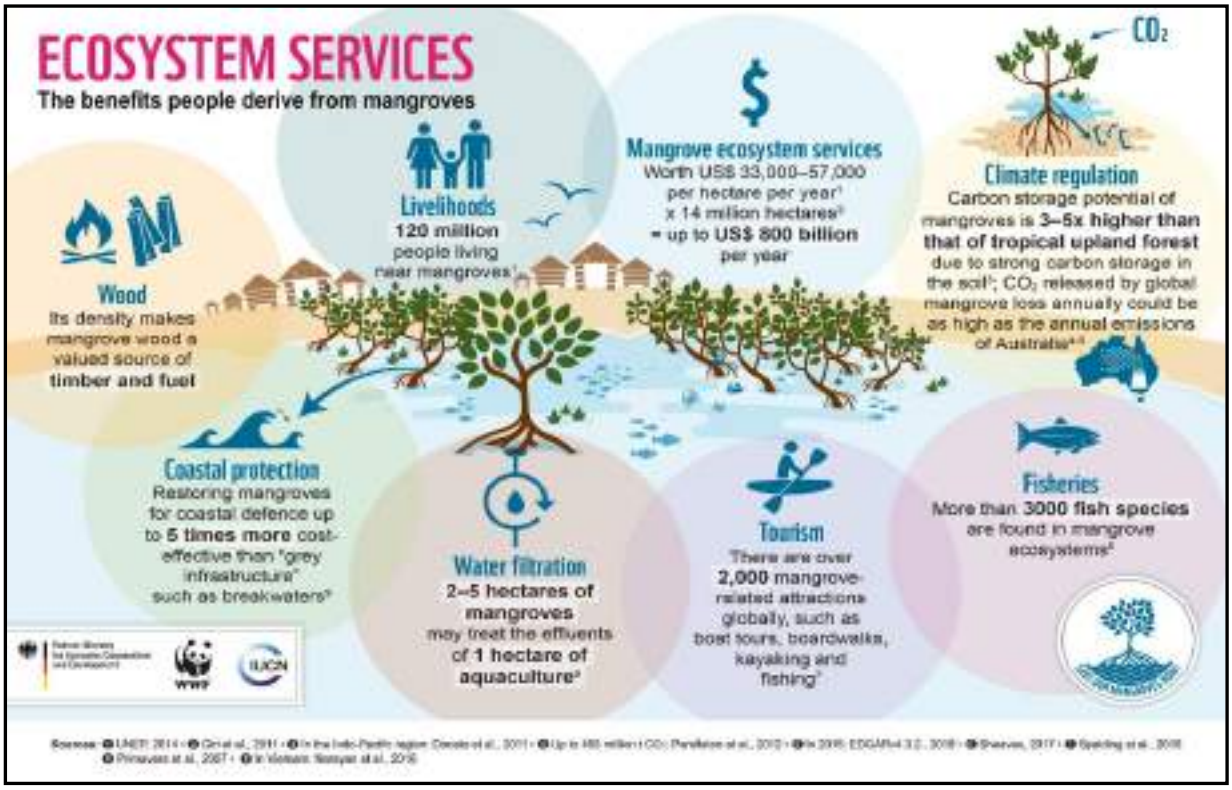


Figure 2. Schematic diagram of Ecosystem services of Mangroves (IUCN, 2017)

Table 1. Environmental setting of the Deendayal Port region

Sl. No.	Particulars	Details
1	Deendayal Port Co-ordinates	22° 59'39.77' N, 70°13'20.14'' E
2	Elevation above Mean Sea level	~20 ft
3	Climatic Conditions	As per Meteorological Station, Deendayal Port Annual Mean Max Temp: 42.8°C Annual Mean Min Temp: 21.3°C Rainfall: 466 mm (Annual mean 2021)
4	Land Use of nearby areas	Comparatively flat marshy land with stunted and dense mangrove formation, mudflats, creek systems, coastal halophytes, saltpans and salt swamps
5	Nearest Highway	National Highway 8A
6	Nearest Railway Station	Gandhidham RS
7	Nearest major airport	Bhuj (~60 km, NW)
8	Nearest Village habitation	Tuna (~12 km, North)
9	Nearest Major Town	Gandhidham (12 km, Northwest)
10	Reserved Forest	Nil
11	Historically Important Places	Nil
12	Rivers/streams around the project environs	Nil
13	Major Dams and barrages	Nil
14	Survey of India Topo sheet covering the proposed site and surroundings	41J1and 41I4
15	Seismic Zone	Zone –V

5.2 Details of plantation sites

The present study focused on the assessment of the present status of the mangrove at Sat Saida bet and Nakti creek in the Kandla (Kachchh) and Kantiyajal in the Bharuch district vicinity covering eight blocks occupying an area of 1300 ha, where plantation activities have been conducted during the period between 2005 and 2017. However, the present study (2021-2022) will also cover the additional 100 ha plantations carried out at Sat Saida bet (50 ha), and Kantiyajal (50 ha) during 2018 and 2019 with a total coverage area of 1400ha. The primary goal of this study is to assess the survival rate of mangrove plantations and the carbon sequestration potential of planted mangroves and suggest achievable conservation measures. The details of the mangrove plantation work carried out in a phased manner by the DPA is presented in Fig -3 & 4 and Table 2, 3 & 4.

Table 2. Details of the implemented mangrove plantation activities by DPA

Location	**Year of Plantation**	**Area (ha)**	**Species planted**	**Implementing Agency**
Sat Saida Bet, Kachchh district	2005-2006	20	*A. marina*	Gujarat Institute of Desert Ecology, Bhuj
	2011-2012	200	*A. marina*	Forest Department, GoG
	2012-2013	300	*A. marina*	Forest Department, GoG
	2013-2014	330	*A. marina*	Forest Department, GoG
	2018-2019	50	*A. marina*	Gujarat Ecology Commission
Nakti Creek, Kachchh district	2008-2009	50	*A. marina*	M/s. Patel Construction Co, Gandhidham
	2010-2011	100	*A. marina* *R. mucronata* *C. tagal*	Gujarat Ecology Commission
Kantiyajal, Bharuch District	2015-2016	150	*A. marina*	Gujarat Ecology Commission
	2016-2017	150	*A. marina* *R. mucronata*	Gujarat Ecology Commission
	2018-2019	50	*A. marina*	Gujarat Ecology Commission
Total		**1400**		

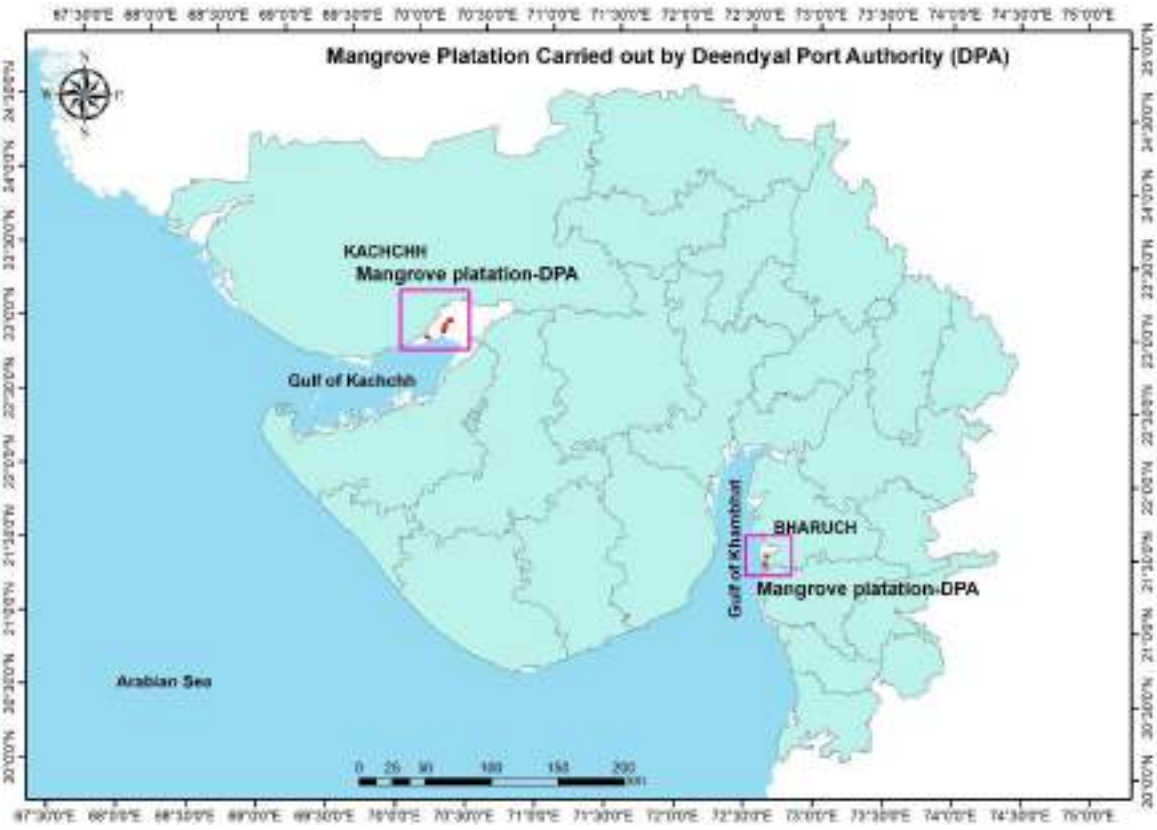


Figure 3. Mangrove plantation carried out by DPA at Kantiyajal and in the Gulf of Kachchh

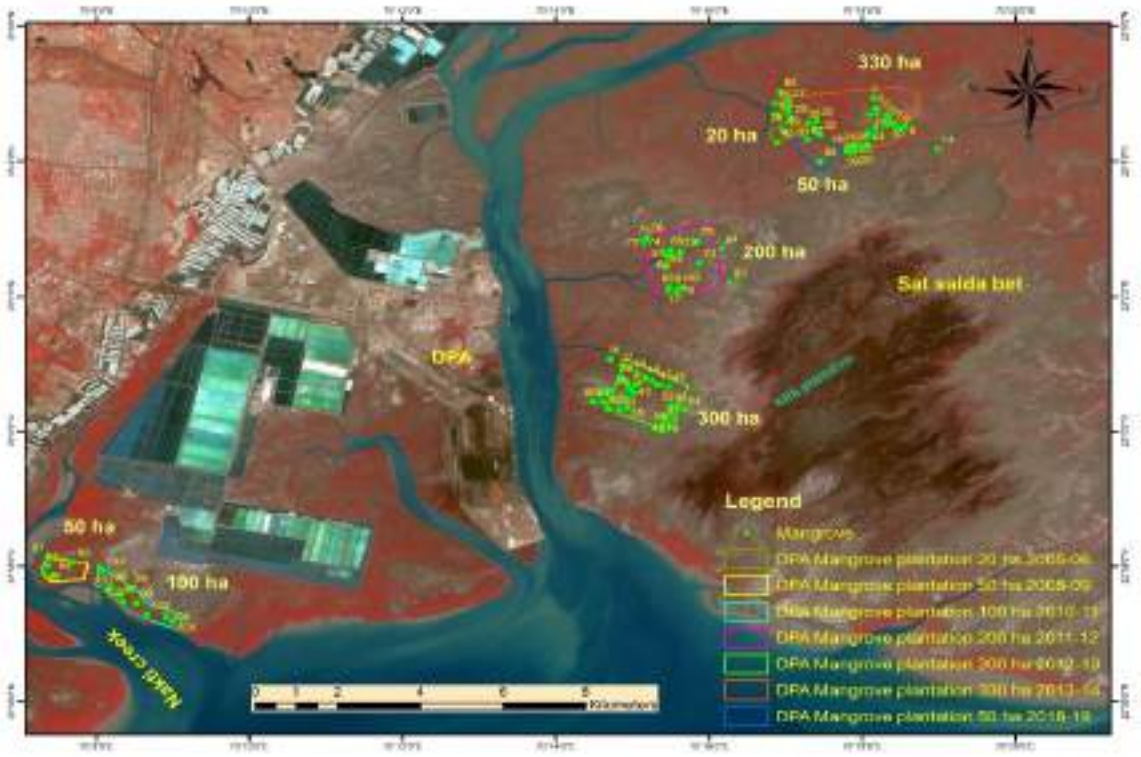


Figure 4. Location of Mangrove Plantation sites at Sat Saida Bet and Natki creek

5.3 Regular mapping through GIS & RS

Mangrove plantations in 1400 ha was regularly monitored and mapped using RS and GIS facilities as part of the conservation and management efforts. The difference in mangrove density was assessed through ArcGIS (version 9.3) and ERDAS (version 9.3) and areas having restoration priority was identified for plantation activity.

5.4 Land use/ Land cover

From April, 2017 to March, 2022 within the span of 5 years the overall mangrove area increased from 19319 ha to 24328 ha (43.7%) (Table-5). Most of the mudflat area converted to Mangrove area, and hence a decreasing trend of the mudflat is clearly observed. Good monsoon and favorable environmental conditions have positively impacted the mangroves to flourish (Saravanakumar *et. al.*, 2008, Das *et. al* 2019). The Figure -5 and 6 clearly depicts the year wise increase in mangrove area in the DPA vicinity and at present 24% of the total area is covered by mangroves.

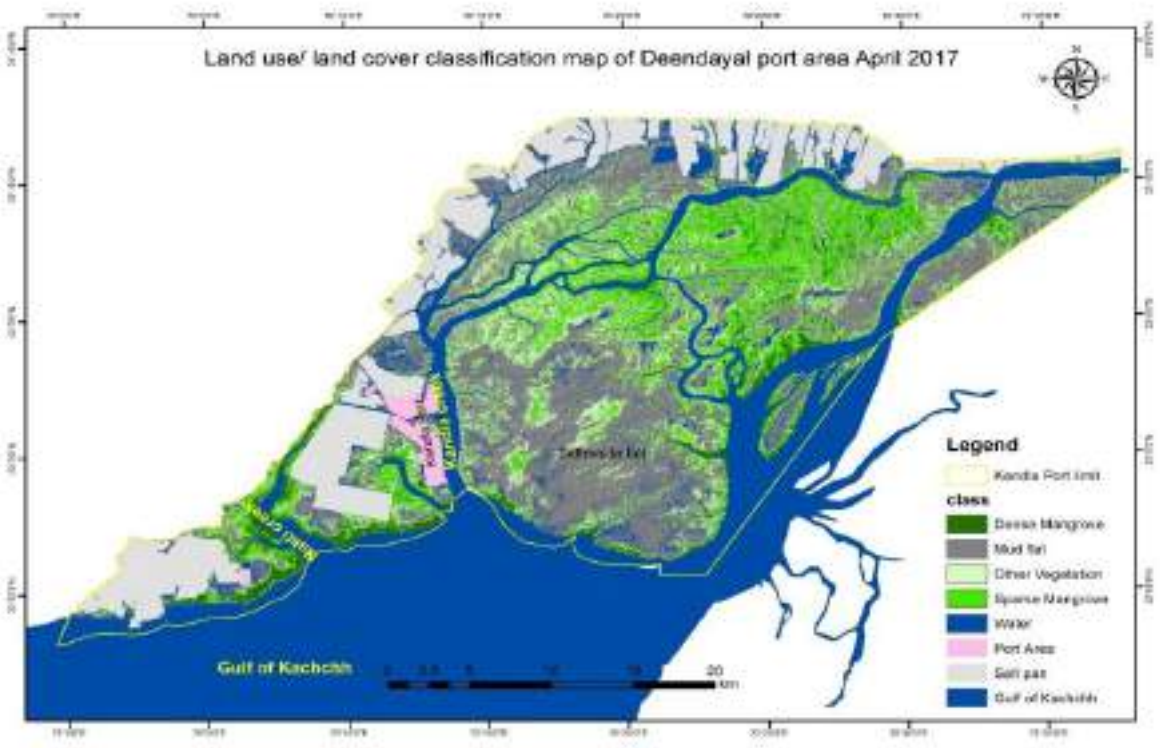


Figure 5. Land use/Land cover classification in Deendayal port area – (April 2017)

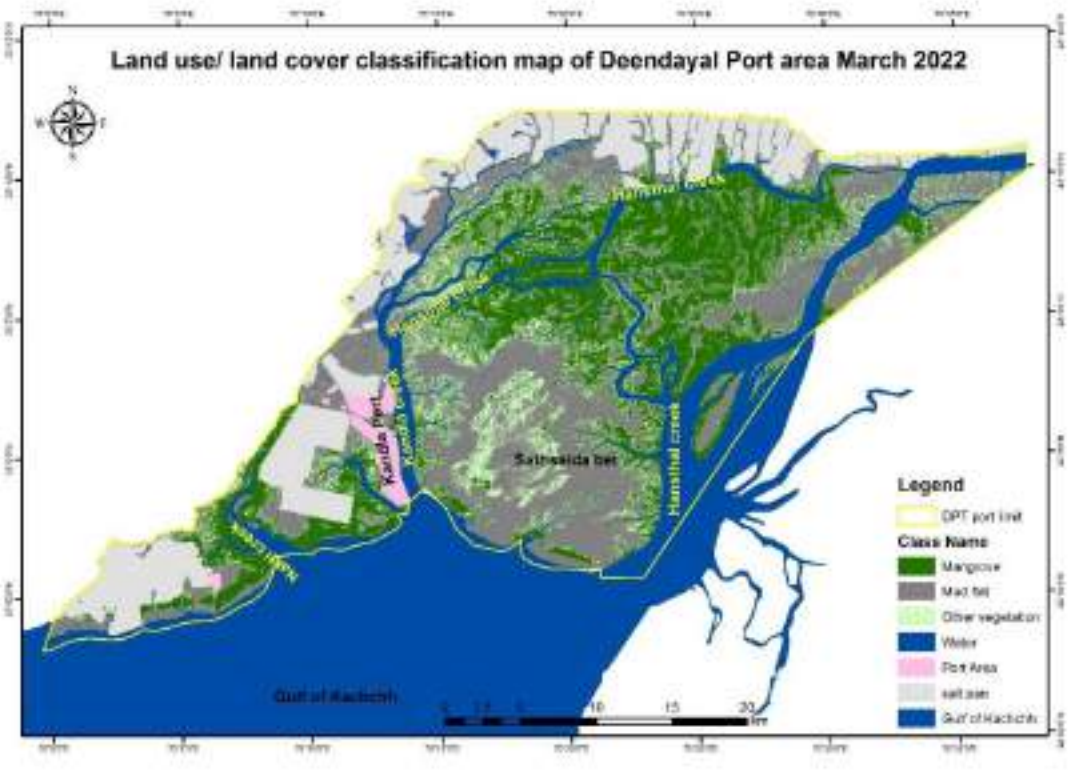


Figure 6. Land use/ land cover classification map of DPA (March-2022)

Table 3. Land use /land cover statistics in the DPA area for April-2017 and March-2022

Class name	**Area (ha) in 2017**	**Area(ha) in 2022**	**Area (ha) difference in 5 years**	**Percentage (%)**
Mangrove	19319.71	24328.7	+5009	+43.7
Mudflat	31293.43	31089.06	-204.37	-1.8
Other vegetation	12438.8	11561.2	-877.6	-7.7
Port Area	1243.67	1436.75	+193.08	+1.7
Salt pan	15016.1	15545.7	+529.6	+4.6
Water bodies	20674.3	16024.6	-4649.7	-40.6
Total	**99986.01**	**99986.01**	**11463.35**	**100**

5.5 Mangrove plantation at Nakti creek (150 ha)

A total of 150 ha of mangrove plantation was carried out in Nakti creek with two blocks with an area of 100 ha and 50 ha, by two agencies; M/s. Patel Construction Co, Gandhidham (2008-09) (Fig.6,7 & Table 4) and Gujarat Ecology Commission (2010-11), respectively. The plantation was carried out using three different techniques like transplantation of nursery raised saplings, *otla* bed, and direct seed dibbling methods. For the 50ha block in Nakti creek, *A. marina* was planted (Table 6). In the second block (other side of Nakti creek) *Ceriops tagal* was also sown. In the third block, located on the eastern side of the second block, seeds of *A. marina* were sown. The fourth block plantation was done alongside the minor creek system along the bund and road, where propagules of *Rhizophora mucronata* and *Ceriops tagal* were planted in the 100ha (Table 5). The mangrove plant density at the 100 Ha and 50 Ha plot was found increased from 2007 as deduced from the imageries as shown in Figure 8 and 11.

Table 4. Sampling location of Nakti Creek (150 ha)

Block Area covered	**Quadrate no.**	**Latitude**	**Longitude**
100ha	1	22°58’8.09”	70°7.’ 22.34”
	2	22°57’53.06”	70°7.’ 18.92”
	3	22°58’0.58”	70°7.’ 22.43”
	4	22°57’51.90”	70°7.’ 27.09”
	5	22°58’3.87”	70°7.’ 42.02”
	6	22°57’27.48”	70°8.’ 30.93”
	7	22°57’35.06”	70°8.’ 18.55”
	8	22°57’42.10”	70°8.’ 10.82”
	9	22°57’40.82”	70°8.’ 26.84”
	10	22°57’11.00”	70°8.’ 59.69”
50ha	1	22°57’39.35”	70°8.’ 8.05”
	2	22°57’28.36”	70°8.’ 20.38”
	3	22°57’15.00”	70°8.’ 54.57”
	4	22°57’56.23”	70°8.’ 4.12”
	5	22°57’17.46”	70°8.’ 39.60”

Table 5. *A marina* plantation (2010-2011) in 100 ha at Nakti creek

S. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	22˚ 57 50.0 N	70˚ 09 40.8 E	1200	55.3	14.7
Q2	22 ˚57 47.8 N	70˚ 09 42.4 E	2000	67.1	21.04
Q3	22 ˚57 46.1N	70 ˚09 42.8E	1200	70.1	29.3
Q4	22˚ 57 42.4N	70 ˚09 44.3E	2000	80.1	41.4
Q5	22˚ 57 41.6N	70˚ 09 46.2E	3200	90.9	28.3
Q6	22˚57 31.1N	70˚ 09 49.6E	2700	90.9	23.4
Q7	22˚57 39.8 N	70˚ 09 48.8E	3400	82.8	19.9
Q8	22˚57 38.6 N	70 ˚09 51.2E	3500	88.9	20.6
Q9	22˚57 38.2N	70 09 54.5 E	2500	115.9	28.2
Q10	22˚57 37.5 N	70 09 52.9 E	2000	99.5	17.8
Average			**2370**	**84**	**--**

Figure 7. Mangrove plantation 100 ha at Nakti creek during 2017-2018

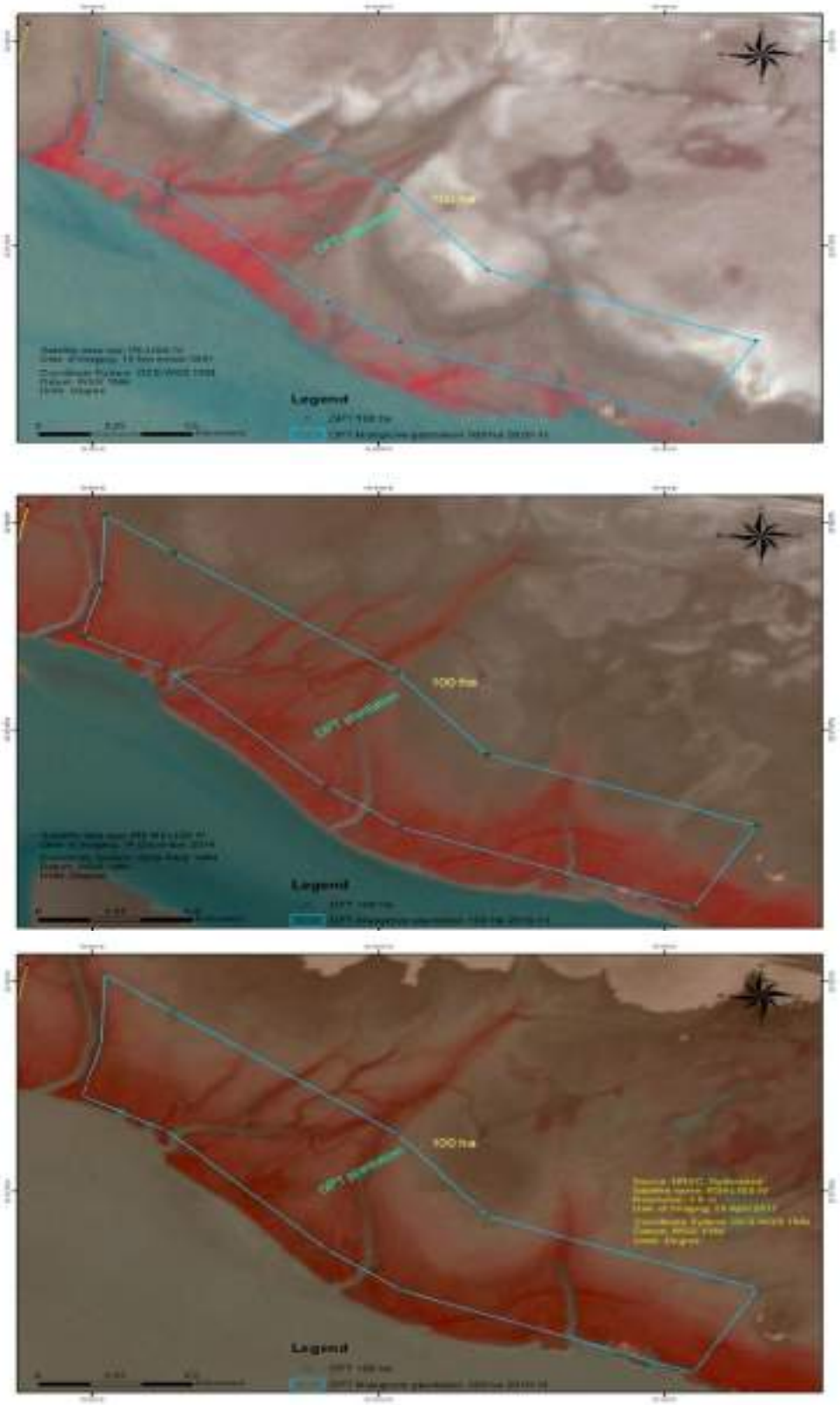


Figure 8. Satellite images of mangrove plantation at Nakti creek (2007,2014 & 2018).

Table 6. *A marina* plantation (2008-2009) in 50 ha at Nakti creek

Sl. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	22° 57' 12. 9N	70° 09' 04.9 E	3000	53.8	19.6
Q2	22°57' 11.6 N	70° 09'04.5 E	3000	64.8	18.4
Q3	22°57'10.9 N	70°09' 04.7 E	2400	70.5	24.0
Q4	22°57'10.3 N	70°09' 05.4 E	2800	65.8	19.2
Q5	22°57'09.6 N	70°09'06.2 E	2500	63.0	15.9
Q6	22°57'09.1 N	70°09'07.2 E	2700	60.2	15.2
Q7	22°57'09.1 N	70°09'08.2 E	2500	40.9	15.6
Q8	22°57'09.2 N	70°09'08.4 E	0	0.0	0.0
Q9	22°57'08.1 N	70°09'10.0 E	2700	54.1	15.6
Q10	22°57'07.7 N	70°09'10.3 E	1800	60.9	24.6
Average			**2340**	**53**	**--**

Figure 9. Mangrove plantation 50 ha at Nakti creek during 2008-2009

Figure 10. Mangrove plantation 50 ha at Nakti creek during 2017-2018

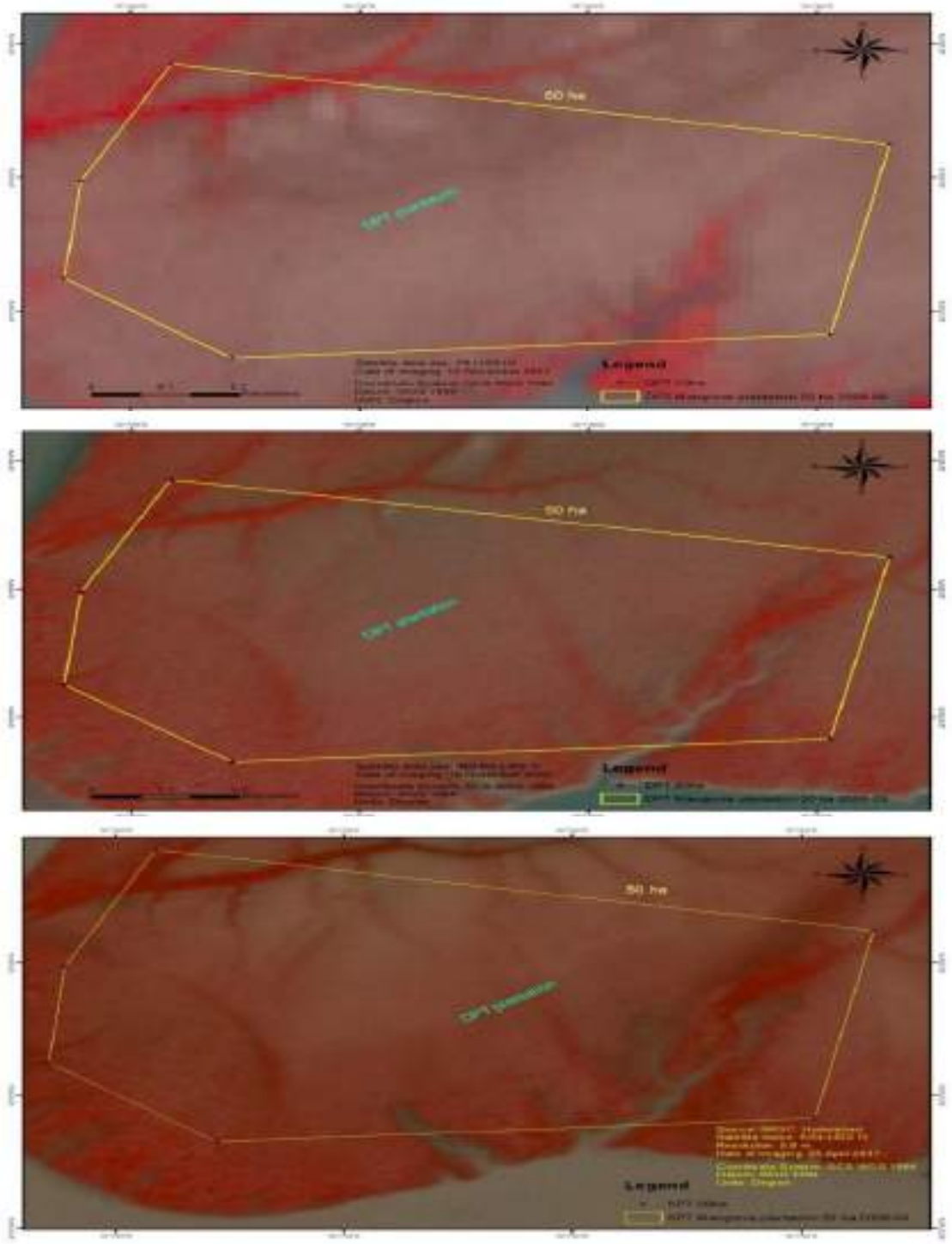


Figure 11 Satellite images of 50 ha mangrove plantation at Nakti creek during the years 2007,2014 & 2018.

5.6 Plantation at Kantiyajal (350 ha)

The plantation site at Kantiyajal has naturally growing *A. marina* extending from the lower littoral to the mid-littoral zone. The plantation site is located near (N 21°27'01.1'', to 21°26'54. 24'' and E 72°40'36.04, to 72°38'58.22'') to this luxuriantly growing mangrove patch. The site is behind the naturally growing plants away from the waterline; however, everyday tidal flushing keeps this site relatively healthy. The total 350 ha mangrove plantation was conducted in separate blocks, like 150 ha each during 2015-2016 and 2016-2017 and 50ha during 2018-2019 at Kantiyajal (Fig-12,15 & 16). Of the total 150 ha, 70 ha plantation activities were carried out following nursery raised saplings and the remaining 80 ha area by *Otla* beds of 1 x 1 x 1 m prepared to improve mangrove density. *A. marina* saplings were transplanted at a distance of 2.5 x 2 m. In total, 32,000 such beds were prepared in the 80 ha (Table 7,8 & 9). All plantation activities were taken care of by Gujarat Ecology Commission. *A. marina* was the preferred species for plantation in both blocks. The Figures 15 and 16 explains the sparse distribution of the plants as well as their stunted growth on the monitored plots.

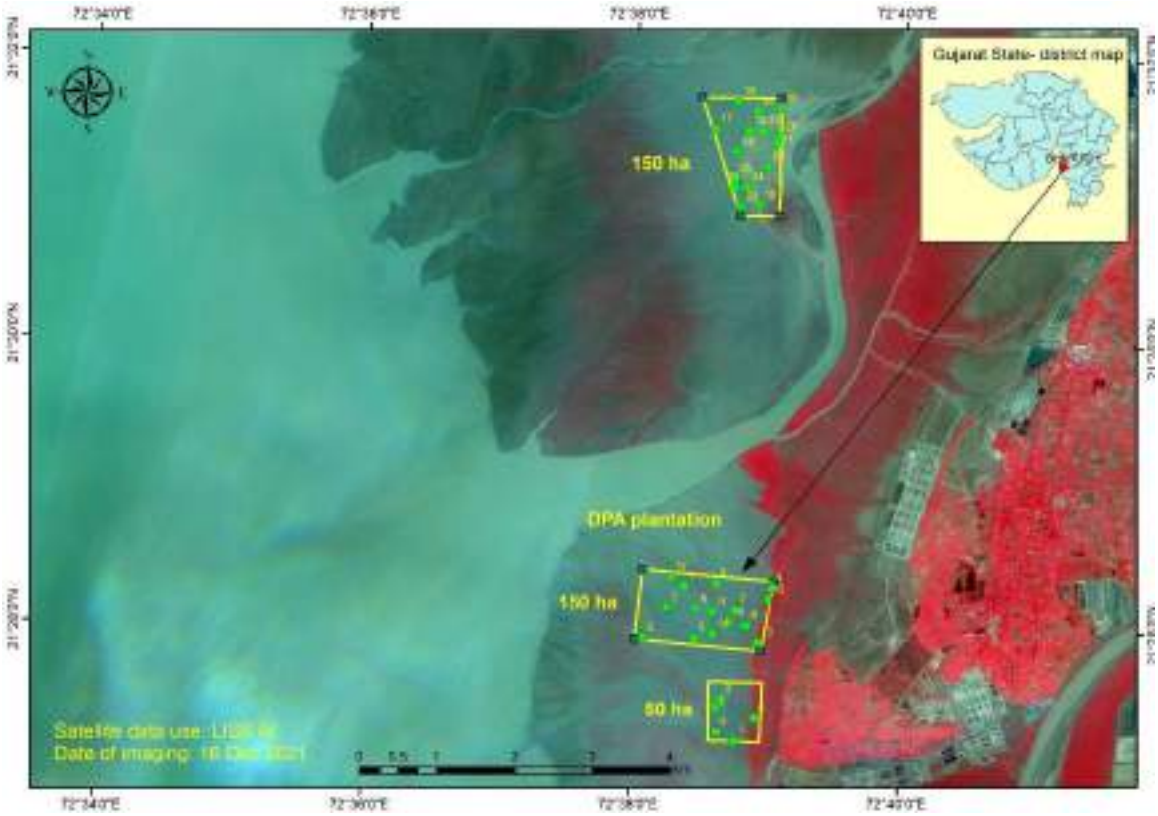


Figure 12. Mangrove plantation at Kantiyajal (350 ha)

Table 7. Sampling location of Kantiyajal (350 ha)

Block area covered	**Quadrate no.**	**Latitude**	**Longitude**
150ha	1	21°28’17.76”	72°38’24.00”
	2	21°28’9.12”	72°38’16.08”
	3	21°27’56.16”	72°38’5.64”
	4	21°28’17.76”	72°39’3.24”
	5	21°27’56.16”	72°38’28.68”
	6	21°28’8.76”	72°38’29.40”
	7	21°28’8.04”	72°38’46.68”
	8	21°28’1.56”	72°38’51.72”
	9	21°28’19.20”	72°38’38.04”
	10	21°28’3.00”	72°38’43.80”
	11	21°28’7.32”	72°38’36.24”
	12	21°28’21.72”	72°38’17.88”
	13	21°27’54.72”	72°38’56.76”
	14	27’57.96”	72°38’36.60”
	15	21°28’12.72”	72°39’1.44”
Block area covered	**Quadrate no.**	**Latitude**	**Longitude**
150 ha	1	21°30’58.68”	72°38’55.32”
	2	21°31’30.00”	72°38’35.16”
	3	21°31’29.64”	72°38’49.92”
	4	21°31’41.88”	72°38’45.24”
	5	21°31’37.56”	72°38’53.52”
	6	21°31’29.64”	72°38’56.40”
	7	21°31’5.88”	72°38’44.52”
	8	21°30’57.60”	72°38’46.68”
	9	21°31’5.88”	72°38’49.56”
	10	21°31’9.12”	72°38’43.80”
	11	21°31’14.52”	72°38’58.92”
	12	21°31’24.96”	72°39’2.52”
	13	21°31’20.64”	72°38’44.88”
	14	21°31’27.12”	72°39’4.32”
	15	21°31’39.00”	72°39’4.32”
Block area covered	**Quadrate no.**	**Latitude**	**Longitude**
50ha	1	21°27’13.32”	72°38’47.04”
	2	21°27’27.36”	72°38’38.40”
	3	21°27’30.60”	72°38’40.92”
	4	21°27’22.68”	72°38’56.04”
	5	21°27’16.92”	72°38’39.12”

Table 8 Mangrove plantation (2015-2016) in 150 ha at Kantiyajal

A. marina					
Sl. No.	**Sampling Location**		**Density (Ha)**	**Height (cm)**	**St. Dev**
Q1	21° 28'5.2″ N	72° 38'57.0" E	2000	29.8	9.0
Q2	21° 28' 22.19" N	72°38` 12. 43"	2200	42.4	10.9
Q3	21 °28'14.73"N	72°38`52. 97"	1900	41.1	13.9
Q4	21°28'05.00"N	72° 38`58. 66"	1000	38.1	7.1
Q5	21°28'56.68"N	72° 38`50.88"	0	0.0	0.0
Q6	21°28'59. 18" N	72°38`28.70"	1600	40.9	11.6
Q7	21°28'15.05"N	72°38`32.30"	1900	36.0	11.3
Q8	21°28'17.86"N	72°38`39. 86"	0	0.0	0.0
Q9	21°28'18.73"N	72°38`50.30"	2200	44.2	12.0
Q10	21°28'00.43"N	72°38` 08.02"	1800	45.8	9.7
Average			**1460**	**32**	**--**
R. mucronate					
Sl. No.	**Sampling Location**		**Density (Ha)**	**Height (cm)**	**St. Dev**
Q1	21° 28' 20.93″ N	72° 38' 22.20″E	1700	32.5	7.4
Q2	21° 28'16.56″ N	72° 38'27.88″E	1400	41.4	4.5
Q3	21° 28'19.69″ N	72° 38'11.96″E	0	0.0	0.0
Q4	21° 28'9.32″ N	72° 38'7.73″ E	700	39.4	7.4
Q5	21° 28'19.73″ N	72° 38'57.43″E	0	0.0	0.0
Q6	21° 28'11.18" N	72° 38'5.68″E	400	36.0	2.0
Q7	21° 28'5.26″ N	72° 38'4.07″E	300	26.0	1.8
Q8	21° 28'8.12″ N	72° 38'57.79″E	0	0.0	0.0
Q9	21° 28'23.34″ N	72° 38'48.32″E	800	45.6	8.6
Q10	21° 28'17.6″ N	72° 38'40.84″E	800	48.4	13.0
Q11	21°31'7.25"N	72°38'44.82"E	2800	40.6	11.5
Q12	21°31'6.76"N	72°38'52.51"E	2300	43.4	10.4
Q13	21°31'3.83"N	72°38'49.30"E	0	0.0	0.0
Q14	21°31'0.54"N	72°38'45.11"E	2200	35.9	6.8
Q15	21°31'0.58"N	72°38'39.17"E	2600	42.4	8.7
Q16	21°31'1.28"N	72°38'33.98"E	0	0.0	0.0
Q17	21°31'5.42"N	72°38'33.96"E	2300	44.9	9.8
Q18	21°31'7.28"N	72°38'38.40"E	2800	39.4	11.5
Q19	21°31'7.10"N	72°38'42.80"E	2400	42.7	12.7
Q20	21°31'3.75"N	72°38'44.30"E	2100	44.8	12.9
Average			**1280.0**	**30**	**--**

Table 9. *A marina* (2016-2017) in 150 ha at Kantiyajal

Sl. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	21˚ 30 58.13″ N	72˚ 38 59.38″ E	2600	44.4	13.9
Q2	21˚ 31 0.49″ N	72˚ 38 48.24″ E	2200	41.9	12.7
Q3	21˚ 31 11.8″ N	72˚ 38 41.61″ E	2300	42.9	14.7
Q4	21˚ 31 15.00″ N	72˚ 38 49.07″ E	3000	44.0	9.2
Q5	21˚ 31 26.22″ N	72˚ 38 46.59″ E	2800	37.3	11.8
Q6	21˚ 31 25.92″ N	72˚ 38 53.85″ E	0	0.0	0.0
Q7	21˚ 31 35.09″ N	72˚ 38 5.04″ E	2100	42.1	12.2
Q8	21˚ 3113.63″ N	72˚ 38 58.43″ E	2400	40.5	12.0
Q9	21˚ 31 5.94″ N	72˚38 53.41″ E	2500	41.2	10.4
Q10	21˚ 31 41.71″ N	72˚ 38 34.34″ E	2300	40.0	10.9
Average			**2220.0**	**37**	**--**

Figure 13. Mangrove plantation 150 ha at Kantiyajal-Block 1 during 2018

Figure 14. Mangrove plantation 150 ha at Kantiyajal-Block 2 during 2018

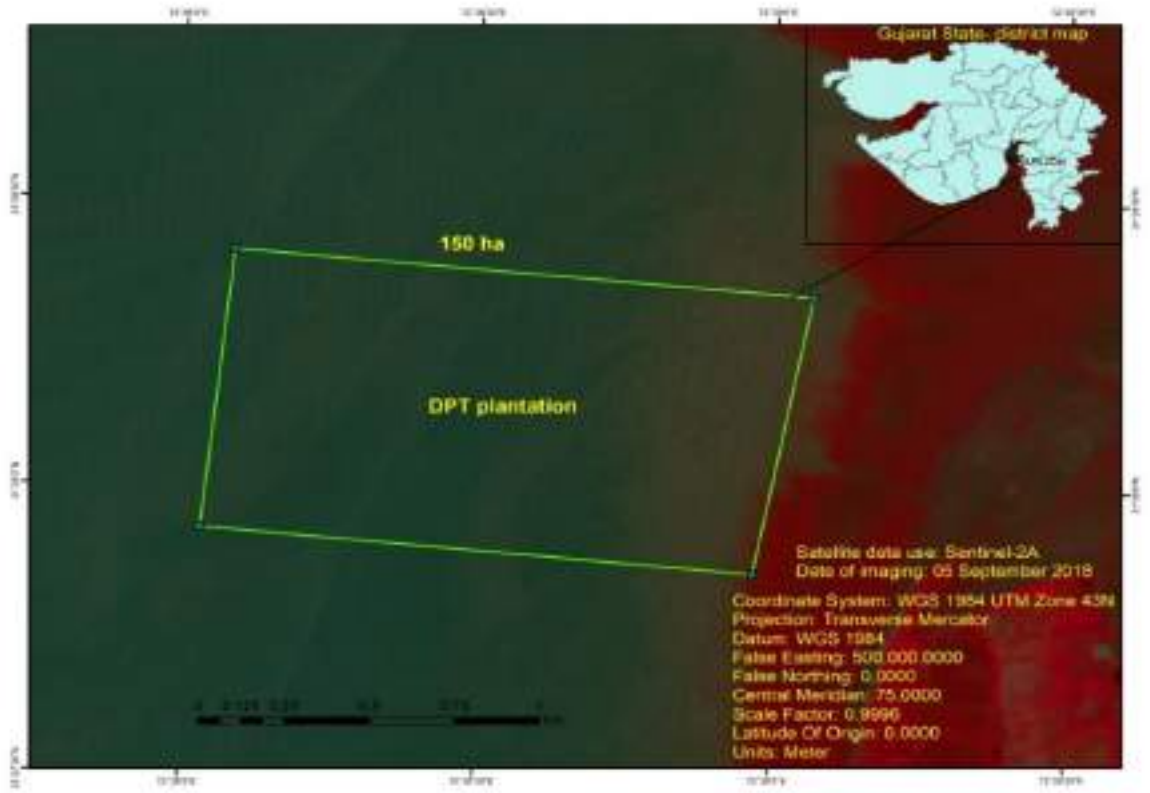


Figure 15. Satellite imageries of the plantation at Kantiyajal-block 1 (2018)

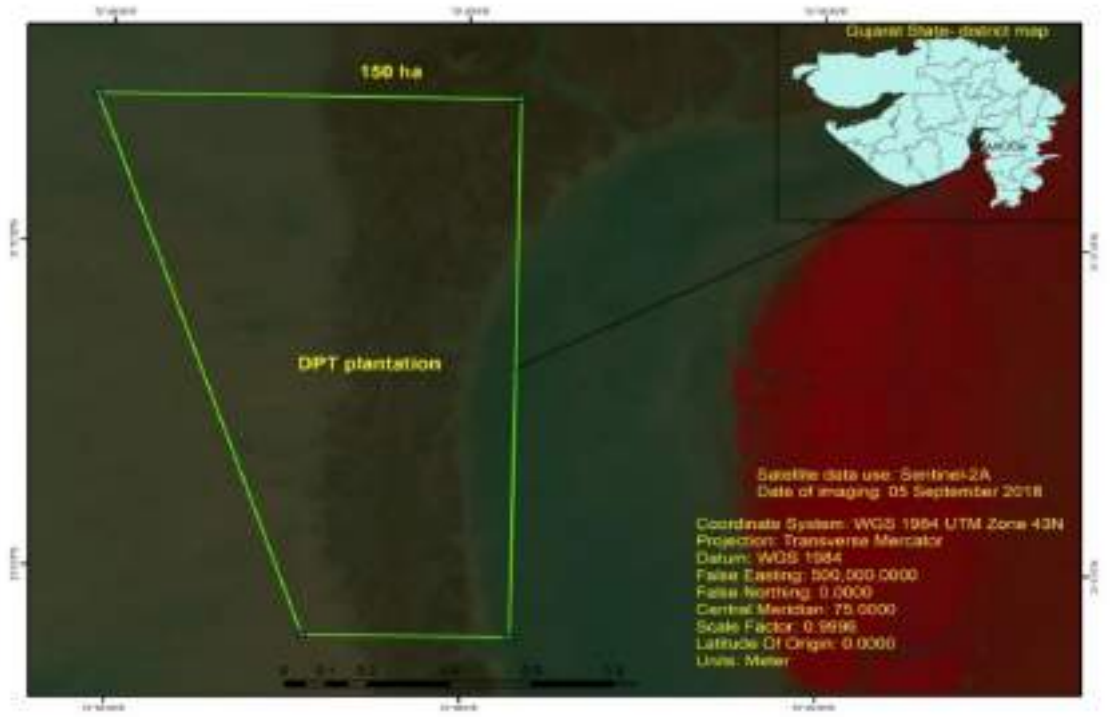


Figure 16. Satellite imageries of the plantation at Kantiyajal-block 2 (2018)

5.7 Plantation at Sat Saida bet (900 ha)

A total of 900 ha of mangrove assessment were carried out in Sat Saida bet with five blocks mentioned in Table 10 and 11 with an area of 330ha, 300 ha, 200 ha, 20 ha and 50ha by Gujarat institute of desert ecology (2005-2006), Department of Forest, Government of Gujarat (2011-2014), and Gujarat Ecology Commission during (2018-2019) the period between 2005 and 2019respectively. Sat Saida bet is situated on the eastern bank of Kandla creek of Gulf of Kachchh, the unique Island of 253.8 km^2 area is located opposite to Deendayal port, having sparse mangroves, dense mangroves, mudflats and halophytic vegetation. Surrounded by Kandla creek and its branches in the west, Navlakhi creek and its branches on the east and Sara and Phang creek on its north, Sat Saida bet is a highly potential site for mangrove plantation with its vast mudflat. Many major, medium and minor creek systems of Kandla and Navlakhi creeks ramify into this Island in varying length and dimension, supplying tidal water to the interior regions. Southern border of the Island represents the innermost end of Gulf of Kachchh with very few minor creek systems (Fig. 18,20,22 & 24). It is known that mudflats experiencing favourable tidal amplitude are suitable for mangrove plantation. Therefore, Sat Saida Bet area was chosen by DPA to carry out the mangrove plantation and restoration activities. The details showing five years (2017-2022) change in the land cover area is given in Table 12,13,14 & 15. The present study was conducted to evaluate the plantation success including the percentage of survival rate, growth, and tree density. The baseline density was fixed at the rate of 4000/ha of *A. marina* was considered for calculating survival percentage as per GEC (2015-2017). The year wise analysis of the imageries of the sites at Sat Saida Bet clearly shows the increase in the plant density at 20 Ha, 300 Ha and 330 Ha, though the survival and height of the plants are comparatively less. Whereas, at 200 Ha plantation site, the plant density has been decreased than the previous monitoring period (2018).

Table 10. Sampling locations at Sat Saida Bet (630 ha)

Block Area covered	**Quadrate no.**	**Latitude**	**Longitude**	**Block Area covered**	**Quadrate no.**	**Latitude**	**Longitude**
330 ha.	**1**	23°4'25"	70°18'4"	**300 ha.**	**1**	23°0'44"	70°15'16"
	2	23°4'41"	70°18'6"		**2**	23°0'42"	70°15'20"
	3	23°4'55"	70°18'8"		**3**	23° 1'3"	70°14'42"
	4	23°4'46"	70°18'10"		**4**	23° 0'57"	70°14'52"
	5	23°4'40"	70°18'19"		**5**	23° 0'47"	70°14'50"
	6	23°4'36"	70°18'18"		**6**	23° 0'42"	70°14'56"
	7	23°4'32"	70°18'24"		**7**	23° 0'51"	70°15'3"
	8	23°4'30"	70°18'33"		**8**	23° 0'38"	70°14'57"
	9	23°4'29"	70°18'28"		**9**	23° 0'41"	70°15'3"
	10	23°4'32"	70°18'19"		**10**	23° 0'34"	70°15'1"
	11	23°4'29"	70°18'10"		**11**	23° 0'46"	70°15'10"
	12	23°4'21"	70°18'9"		**12**	23° 0'41"	70°15'20"
	13	23°4'13"	70°18'4"		**13**	23° 0'39"	70°15'28"
	14	23°4'10"	70°18'58"		**14**	23° 0'10"	70°15'32"
	15	23°4'12"	70°17'49"		**15**	23° 0'5"	70°15'28"
	16	23°4'11"	70°17'48"		**16**	23° 0'0"	70°15'22"
	17	23°4'8"	70°17'49"		**17**	23° 0'4"	70°15'17"
	18	23°4'7"	70°17'51"		**18**	23° 0'13"	70°15'24"
	19	23°4'8"	70°17'52"		**19**	23° 0'22"	70°15'30"
	20	23°4'9"	70°17'54"		**20**	23° 0'21"	70°15'35"
	21	23°4'11"	70°17'57"		**21**	23° 0'19"	70°15'40"
	22	23°4'11"	70°17'59"		**22**	23° 0'20"	70°14'55"
	23	23°4'12"	70°17'59"		**23**	23° 0'30"	70°14'54"
	24	23°4'13"	70°17'57"		**24**	23° 0'37"	70°14'57"
	25	23°4'14"	70°17'54"		**25**	23° 0'36"	70°14'43"
	26	23°4'13"	70°17'52"		**26**	23° 0'33"	70°14'36"
	27	23° 4'53"	70°17'2"		**27**	23° 0'26"	70°14'29"
	28	23° 4'43"	70°17'1"		**28**	23° 0'26"	70°14'36"
	29	23° 4'38"	70°17'3"		**29**	23° 0'18"	70°14'40"
	30	23° 4'33"	70°17'16"		**30**	23° 0'18"	70°14'49"
	31	23° 4'28"	70°17'22"				
	32	23° 4'23"	70°17'26"				
	33	23° 4'35"	70°17'24"				

Table 11. Sampling location of Sat Saida Bet (270 ha)

Block Area covered	**Quadrate no.**	**Latitude**	**Longitude**	**Block Area covered**	**Quadrate no.**	**Latitude**	**Longitude**
200 ha.	**1**	23°2'42"	70°16'10"	**50 ha.**	**1**	23° 4'41.24"	70°16'52.19"
	2	23°2'35"	70°15'28"		**2**	23° 4'50.78"	70°16'51.53"
	3	23°2'36"	70°15'26"		**3**	23° 5'1.73"	70°16'55.65"
	4	23°2'39"	70°15'29"		**4**	23° 4'19.15"	70°17'16.46"
	5	23° 2'25.36"	70°15'26.37"		**5**	23° 3'59.06"	70°17'27.14"
	6	23°2'41"	70°15'30"				
	7	23° 2'39.21"	70°15'37.25"	**20 ha.**	**1**	23° 4'27.43"	70°16'58.03"
	8	23°2'48"	70°15'8"		**2**	23° 4'16.41"	70°16'53.03"
	9	23°2'48"	70°15'9"				
	10	23° 2'29.30"	70°15'52.53"				
	11	23°2'51"	70°15'9"				
	12	23°2'50"	70°15'8"				
	13	23°2'52"	70°15'11"				
	14	23°2'5"	70°15'28"				
	15	23° 2'48.85"	70°15'50.81"				
	16	23°2'4"	70°15'35"				
	17	23° 2'7.74"	70°15'28.60"				
	18	23°2'7"	70°15'36"				
	19	23°2'8"	70°15'40"				
	20	23°2'12"	70°16'16"				

Table 12. *Avicennia marina* plantation (2005-2006) in 20 ha at Sat Saida bet

Sl. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	23˚ 04” 43.38N	70˚ 16”47.88E	4400	109	28.34
Q2	23˚ 04” 48.18N	70˚ 16”48.18E	4900	115	24.7
Q3	23˚ 04” 43.77N	70˚ 16”48.41E	5600	110	26.2
Q4	23˚ 04” 44.38N	70˚ 16”47.99E	5700	110	27.7
Q5	23˚ 04” 44.10N	70˚ 16”48.18E	5100	124	29.2
Q6	23˚ 04” 48.17N	70˚ 16”48.17E	4900	135	30.7
Q7	23˚ 04” 44.37N	70˚ 16”48.99E	5300	103	32.2
Q8	23˚ 04” 43.49N	70˚ 16”48.69E	5300	100	34.44
Q9	23˚ 04” 44.14N	70˚ 16”48.93E	6100	121	35.2
Q10	23˚ 04” 44.99N	70˚ 16”47.63E	5200	104	36.7
Q11	23˚ 04” 43.07N	70˚ 16”49.06E	4900	136	29.2
Q12	23˚ 04” 43.85N	70˚ 16”49.88E	5200	105	28.22
Q13	23˚ 04” 44.61N	70˚ 16”48.75E	6100	102	32.15
Q14	23˚ 04” 43.53N	70˚ 16”49.25E	6300	110	33.22
Q15	23˚ 04” 44.04N	70˚ 16”50.02E	5800	110	31.2
Average			**5387**	**113**	**--**

Figure 17. Mangrove plantation at Sat Saida bet 20 ha during 2005-2006

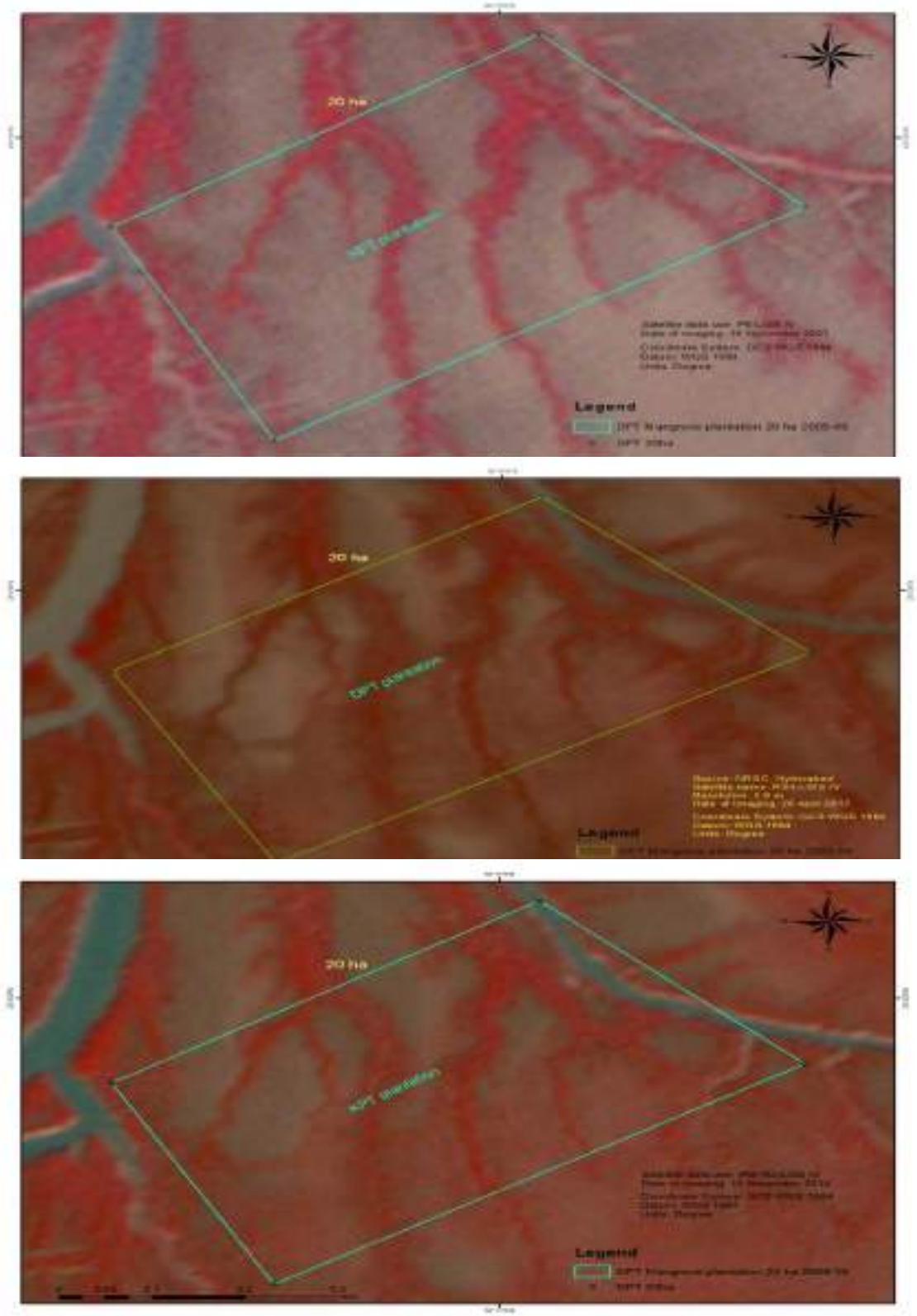


Figure 18. Satellite imageries of the plantation at Sat Saida Bet (2005-2006, 2014 & 2018)

Table 13. *Avicennia marina* plantation (2011-2012) in 200 ha at Sat Saida bet

Sl. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	23˚ 00” 48.4N	70˚ 15”49.5E	3000	33.6	9.6
Q2	23˚ 00” 50.5˚ N	70˚ 15” 50.0 E	0	0	0
Q3	23˚ 00 ”53.1˚ N	70˚15” 49.2 E	2700	55.9	9.5
Q4	23˚ 00 ”50.9˚ N	70˚ 15” 47.2 E	3300	31.8	14.9
Q5	23˚ 00 ”50.1˚ N	70˚15” 45.4 E	3500	43.7	14
Q6	23˚ 00 ”49˚ N	70˚15” 43.5 E	3500	53.5	16.6
Q7	23˚ 00” 49.3˚ N	70˚15” 41.3 E	3500	58.8	26.5
Q8	23˚ 00” 51.4˚ N	70˚15” 42E	1700	47.9	18.7
Q9	23˚ 00” 76.9˚ N	70˚13”.50 E	4000	52.7	18.9
Q10	23˚ 00 ”52.2˚ N	70˚15” 37.9E	4600	53.6	24
Q11	23˚ 00” 51.7˚ N	70˚15” 35.6E	2100	69.9	22.1
Q12	23˚ 00 ”52.4N	70˚15” 34.4E	2600	52.7	19.6
Q13	23˚ 00 ”53.2˚ N	70˚15” 33.3E	3500	63.4	19.2
Q14	23˚ 00” 55.1˚ N	70˚15” 32.4 E	4000	57.6	18.9
Q15	23˚ 00” 57.2˚ N	70˚15” 33.4 E	2500	40.8	15.7
Q16	23˚ 00 ”57.9˚ N	70˚15 ”35.6 E	0	0	0
Q17	23˚ 00” 3.6˚ N	70˚15” 35.6 E	500	46.6	14.9
Average			**2647**	**45**	**--**

Figure 19. Mangrove plantation 200 ha at Sat Saida bet during 2017-2018

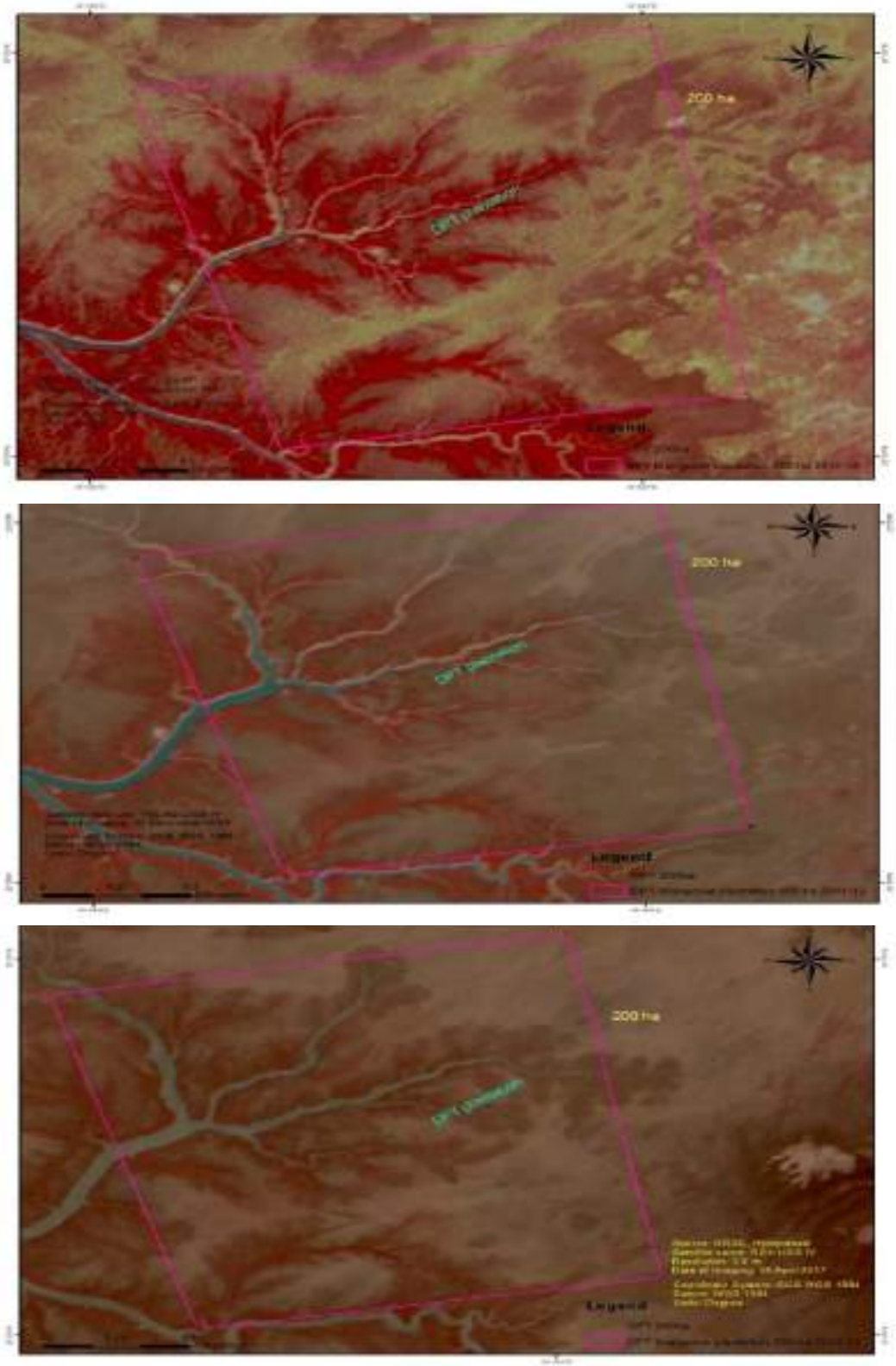


Figure 20 . Satellite imageries of the plantation at Sat Saida Bet (2007, 2014 & 2018)

Table 14. *Avicennia marina* plantation (2012-2013) in 300 ha at Sat Saida bet

Sl. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	23˚02.06604 N	70˚ 13.25285 E	3600	68.1	25.9
Q2	23˚01.93788 N	70˚13.244884 E	3700	46.1	19.7
Q3	23˚ 1.507972 N	70˚13 23.2248E	1500	40.9	10.8
Q4	23˚ 14.5986N	70˚15.2648E	1100	35.5	15.6
Q5	23˚15.948N	70˚15.28626 E	0	0	0
Q6	23˚17.128 N	70˚15. 30816 E	0	0	0
Q7	23˚19.636 N	70˚15. 29886 E	0	0	0
Q8	23˚18.814N	70˚15. 27636 E	1000	31.4	13.4
Q9	23˚18.838N	70˚15.27648 E	4200	44.5	20.5
Q10	23˚19.768N	70˚15. 26198 E	1400	31.6	13.8
Q11	23˚11.3704N	70˚15.231 E	2800	59	20.3
Q12	23˚1 1.3644N	70˚15. 231 E	3600	56	22.1
Q13	23˚11.7004N	70˚15.2334 E	2500	70.2	23.5
Q14	23˚16.61N	70˚15.25192 E	2900	59.4	21
Q15	23˚1 1.4514 N	70˚15.27484 E	500	22.2	6.4
Q16	23˚1 1.4418 N	70˚15.27336 E	3700	57.2	22.7
Average			**2031**	**39**	**--**

Figure 21. Mangrove plantation 300 ha at Sat Saida bet during 2017-2018

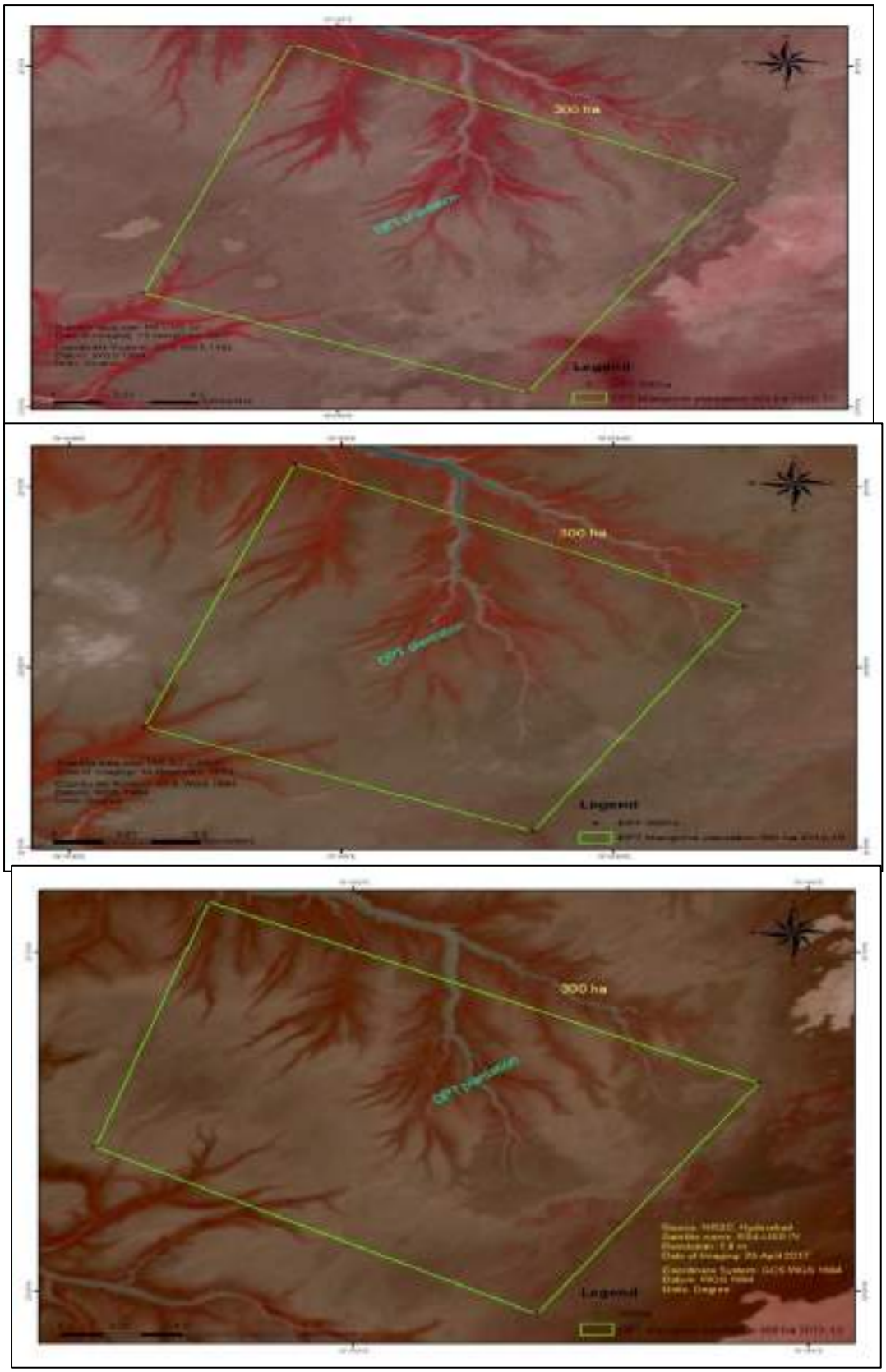


Figure 22. Satellite imageries of the plantation at Sat Saida Bet (2007, 2012-13 & 2014)

Table 15. *Avicennia marina* plantation (2013-2014) in 330 ha at Sat Saida bet

S. No.	Sampling Locations		Density (Ha)	Height (cm)	St. Dev
Q1	23°04'48.34" N	70° 17' 10.05" E	4400	109	28.34
Q2	23°04'46.55" N	70° 17' 13.94" E	4900	115	24.7
Q3	23°04'45.14" N	70° 17' 18.65" E	4100	110	26.2
Q4	23°04'41.97" N	70° 17' 16.66" E	5600	110	27.7
Q5	23°04'50.58" N	70° 17' 16.68" E	2900	124	29.2
Q6	23°04'44.43" N	70° 17' 16.54" E	4900	135	30.7
Q7	23°04'49.39" N	70° 17' 15.54" E	2800	103	32.2
Q8	23°04'45.35" N	70° 17' 06.79" E	5300	100	34.44
Q9	23°04'42.94" N	70° 17' 09.32" E	5200	121	35.2
Q10	23°04'40.49" N	70° 17' 13.53" E	2900	86	36.7
Q11	23°04'46.46" N	70° 17' 12.37" E	4900	73	29.2
Q12	23°04'44.26" N	70° 17' 15.86" E	5200	105	28.22
Q13	23°04'48.25" N	70° 17' 12.93" E	6100	102	32.15
Q14	23°04'44.174" N	70° 17' 16.32" E	6300	70	33.22
Q15	23°04'38.25" N	70° 17' 10.33" E	5800	110	31.2
Q16	23°04'40.41" N	70° 17' 12.07" E	3500	62	16.1
Q17	23°04'40.76" N	70° 17' 12.89" E	2600	51	14.7
Q18	23°04'38.16" N	70° 17' 20.60" E	3600	43	12.2
Q19	23°04'38.76" N	70° 17' 10.60" E	3300	45	11.1
Q20	23°04'40.69" N	70° 17' 06.48" E	2300	66	23.7
Q21	23°04'49.68" N	70° 17' 14.62" E	3600	72	9.3
Q22	23°04'47.10" N	70° 17' 03.65" E	3100	78	17.6
Q23	23°04'49.42" N	70° 17' 07.81" E	3300	85	19.2
Q24	23°04'49.87" N	70° 17' 10.23" E	2600	64	17.2
Average			**4133**	**89**	**--**

Figure 23. Mangrove plantation 330 ha at Sat Saida bet during 2013-2014

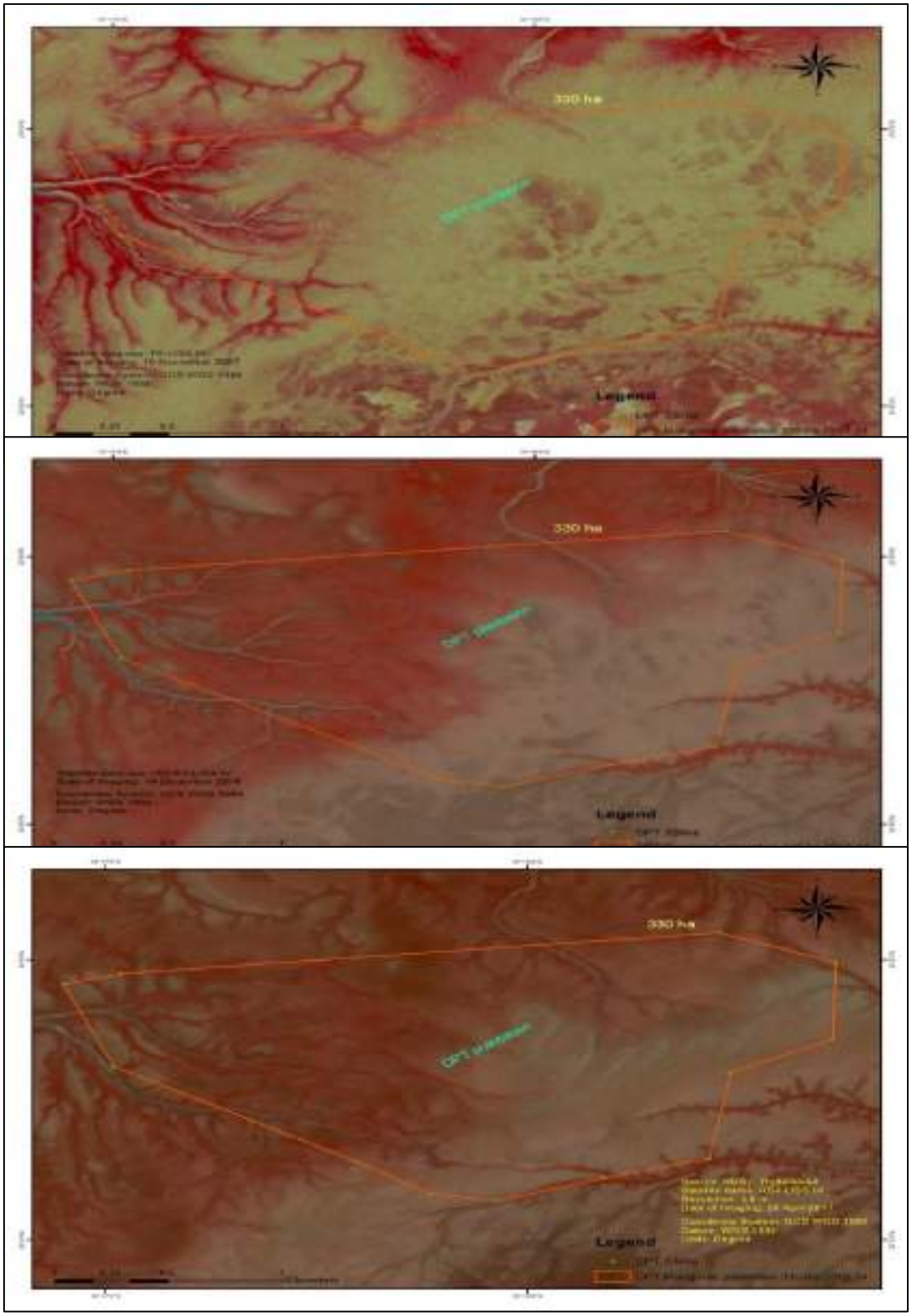


Figure 24. Satellite imageries of the plantation at Sat Saida Bet (2007, 2014 & 2018)

6 Results

The mangrove monitoring study results of the three sites, Nakti creek Kantiyajal and Sat Saida bet are presented below.

6.1 Mangrove plantation evaluation at Nakti creek

6.1.1 Evaluation of *Avicennia marina* Plantation at Nakti creek (2021-2022) 100 ha

In total, ten quadrats were laid at Nakti creek block to assess the *A. marina* survival percentage. The survival rate was recorded to be 40%, lower than the survival rate of recorded in Nakti creek within 50 ha plot. The plantation density ranged from 900 individuals/ha to 3400 individuals/ha, with an average density of 1600 individuals/ha (Table 16). In this block, the height of the plants ranged between 70- 280 cm, with an average height of 118.9 cm was recorded. The GBH in this plantation varied from 6 to 12 cm, with an average value of 6.8 cm. The minimum and maximum canopy cover in this plantation stand ranged from 0.30 to 1.5 m2 with a mean value of 0.8 m^2. Even though the plantation activities were carried out near the creek system, the poor survival of planted mangroves could be due to mixed plantation techniques. *R. mucronata* saplings were recorded outside the quadrats with heights varying from 50-60 cm. Around ten individuals were seen during the entire survey. Thus, it was apparent that the plantation of *R. mucronata* showed poor survival rate as this species needs 20-25 days of tidal flushing in a month and can tolerate only moderate salinity.

Table 16. Details of mangrove plantation at Nakti creek (100 ha)

S. No	Density (Plants/Ha)	Height (cm)			GBH (cm)			Canopy cover (m^2)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
1	2200	70	170	120	7	9	8	0.42	1.25	0.8
2	1700	100	280	190	6	11	8.5	0.42	1.5	0.96
3	2300	100	235	167.5	7	12	9.5	1.32	1.5	1.4
4	1700	70	170	120	7	11	9	0.3	0.85	0.6
5	0	0	0	0	0	0	0	0	0	0
6	3400	70	180	125	7	8	7.5	1.32	0.75	1.03
7	2900	100	190	145	8	7	7.5	1.56	1.1	1.3
8	900	80	210	145	7	10	8.5	0.56	1.25	0.9
9	900	100	252	176	7	12	9.5	0.72	1.5	1.1
10	0	0	0	0	0	0	0	0	0	0
Overall average Density (plants/ha) 1600.0		**69.0**	**168.7**	**118.9**	**5.6**	**8.0**	**6.8**	**0.7**	**1.0**	**0.8**

6.1.2 Mangrove evaluation at Nakti creek (2021-2022) 50ha

Two mangrove plantation sites with an area of 50 ha and 100 ha were developed at the north-eastern bank of Nakti creek, one of the major creek systems of Kandla. The main creek and its branches are getting inundated by 3-4 m of tidal water during the high tide period. The two mangrove plantation sites developed is adjacent to each other with a good tidal flooding area. The findings based on-site visits and subsequent data are given in Table in 17.

To evaluate the *A. marina* plantation success at Nakti creek i.e., survival percentage and growth rate, an initial plantation density of 4000 saplings/ha as a baseline density was considered. Therefore, in the present study, six quadrates of 10×10m each were laid to evaluate the growth and survival of *A. marina*. The results revealed that the survival rate of *A. marina* in this block was 55 percent. The density ranged from 900 individuals/ha as high as 2800 individuals/ha, with an average density of 2200 individuals /ha. Similarly, the plant height ranged between 70 cm and 210 cm, with an average of 129.2 cm. The canopy cover ranged between 0.3 m^2 to 1.5 m^2 with an average of 0.8 m^2. The Girth at base (here after GB) values are ranged from 7 cm to 46 cm, with an average of 20.4 cm. The larger values of GB indicate the presence of multiple stems. It is known that direct dibbling and plantation of nursery raised trees are superior to the *Otla* bed technique. Moderate survival (55%) of the planted *A. marina* could be attributed to mixed plantation techniques as more than two species, namely *Rhizophora mucronata* and *Ceriops tagal* were also planted at this site.

Table 17. Details of mangrove plantation at Nakti creek (50 ha)

S. No	Density (Plants/ Ha)	Height (cm)			GBH (cm)			Canopy cover (m^2)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
1	2400	100	175	137.5	7	37	22	0.42	1.2	0.8
2	2300	100	185	142.5	7	37	22	0.3	1.35	0.8
3	2800	100	210	155	7	46	26.5	0.3	1.5	0.9
4	2300	100	160	130	7	26	16.5	0.3	1.1	0.7
5	2500	80	120	100	7	34	20.5	0.56	0.75	0.7
6	900	70	150	110	8	22	15	1	0.8	0.9
Avg	**2200.0**	**91.7**	**166.7**	**129.2**	**7.2**	**33.7**	**20.4**	**0.5**	**1.1**	**0.8**

During the field surveys, it was recorded that the saplings were invaded by the alga *Enteromorpha* sp. and regular tidal flushing was lacking. Due to all these factors a variation of mortality of different tree species was recorded along the Nakti creek.

6.2 Kantiyajal mangrove plantation (350 ha)

The 350 ha mangrove plantation was carried out at the coastal stretch of Katpor village near Kantiyajal in Bharuch district. This plantation was carried out in two blocks of 150 ha each during the year 2015-16 and 2016-17 and 50 ha during the year 2019-20. The Gujarat Ecology Commission (GEC), Gandhinagar executed this plantation with the help of community participation by Samity at the Katpor village.

6.2.1 *Avicennia marina* and *Rhizophora mucronata* plantation (2015-2016) 150 ha

Sixteen quadrats were laid in this block for assessing mangrove species survival success. As per the earlier report by GEC (2015-2017), at this site, it was evident that this block had *R. mucronata* saplings in addition to *A. marina* (Table 18, 19 & 20). An overall average density of 3000 individuals/ha was recorded for *A. marina*. The tree density varied from 1200 to 5200 individuals/ha. The height of the plants ranged from 0.90 m to 2.20 m, with an average of 1.5 m. The GB of the plants ranged from 7.0 to 25 cm with an average of 14.2 cm. The canopy cover of the mangrove plants varied between 0.56 m^2 and 2.4 m^2 with an average of 1.3 m^2.

Plate 1. *Ceriops tagal* stands at Nakti creek Plantation site

Plate 2. *Rhizophora mucronata* stands at Nakti creek Plantation site

Plate 3. *Avicennia marina* (100 ha) plantation at Nakti creek

Table 18. Details of *A. marina* & *R. mucronata* plantation at Kantiyajal (150 ha)

Quadrate	Density	Height (m)			GBH (cm)			Canopy cover (m^2)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
Q1	5200	1	1.9	1.45	7	20	13.5	0.56	1.82	1.19
Q2	3600	1.2	2	1.6	11	25	18	1.1	2.1	1.6
Q3	4000	0.9	1.9	1.4	8	16	12	0.9	1.56	1.23
Q4	3600	1.25	1.9	1.575	9	25	17	0.72	2.4	1.56
Q5	3600	1.1	1.75	1.425	9	22	15.5	0.72	1.1	0.91
Q6	3200	1	2.1	1.55	7	20	13.5	0.72	1.82	1.27
Q7	2800	1.2	2.1	1.65	12	23	17.5	1.2	2.4	1.8
Q8	1200	1.1	1.6	1.35	7	13	10	1.1	1.2	1.15
Q9	1600	1.2	2.2	1.7	8.5	18	13.25	0.72	2.1	1.41
Q10	1200	1	1.2	1.1	8	15	11.5	0.72	1.1	0.91
Overall average	**3000**	**1.1**	**1.9**	**1.5**	**8.7**	**19.7**	**14.2**	**0.85**	**1.76**	**1.3**

6.2.2 *Rhizophora mucronata* plantation (2016-2017) 150 ha

The assessment of the *R. mucronata* plantation at this site showed an overall density of 2520 individuals/ha (Table 19). The average height of *R. mucronate* plants was 129.5 cm, and the average canopy cover was 0.9 m^2 in this block. *R. mucronata* being a frontline mangrove, its plantation was carried out towards the lower intertidal region. Continuous tidal flushing following appropriate zonation patterns during plantation could be attributed to a higher survival percentage of *R. mucronata*. The survival and growth of the mangrove plantation at this site was (63%) comparatively good because of continuous water inundation and availability of extensive intertidal mudflats.

Table 19. Details of mangrove plantation of *Rhizophora mucronata* at Kantiyajal (150 ha)

Quadrate	Density	Height (cm)			GBH (cm)			Canopy cover (m^2)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
Q1	3500	85	175	130	5	9	22	0.52	1	0.76
Q2	2500	100	185	142.5	7	11	22	0.65	1.5	1.075
Q3	2800	110	210	160	8	12.5	26.5	1.1	1.3	1.2
Q4	2000	70	160	115	5	8	16.5	0.3	1.1	0.7
Q5	1800	80	120	100	3	5	20.5	0.6	0.75	0.675
Overall average	**2520.0**	**89.0**	**170.0**	**129.5**	**5.6**	**9.1**	**21.5**	**0.6**	**1.1**	**0.9**

6.2.3 *Avicennia marina* plantation (2018-2019) 50 ha

During the field surveys at this site saplings of both *A. marina* and *R. mucronata* saplings were also noticed (Table 20). An average density of 2480 individuals/ha was recorded for *A. marina*. The plant density varied between of 2100 individuals/ha, to 2800 individuals/ha. The height of the plants ranged from13 cm to 97 cm, with an average of 57.28 cm. The survival and growth of the mangrove plantation at this site (62%) was comparatively high because of continuous water inundation on the extended intertidal mudflats.

Table 20. Evaluation of *A. marina* plantation at Kantiyajal (50 ha) during 2018-2019

Quadrate	Density	Height (cm)		
		Min	Max	Average
Q1	2700	37	52	44.5
Q2	2100	57	93	75
Q3	2200	62	97	79.5
Q4	2600	55	73	64
Q5	2800	13	34	23.4
Average	**2480**	**44.8**	**69.8**	**57.28**

Plate 4. *Avicennia marina* plantation at Kantiyajal coast

Plate 5. *Rhizophora mucronata* plantation at Kantiyajal coast

6.3 Monitoring of mangrove plantation at Sat-Saida Bet

6.3.1 Monitoring of *Avicennia marina* at Sat-Saida Bet (2021-2022) 20 ha

During 2005-2006, the mangrove plantation at Sat Saida Bet was carried out at Dharkadia creek banks in 20 ha. The two sites on both the banks of Dharkadia creek were planted with *A. marina* by Gujarat Institute of Desert Ecology through transplanting nursery-grown seedlings and direct seed sowing for gap filling.

In total, 2 quadrats were laid at this site to assess the survival percentage of the *A. marina.* The results of the growth of these plantations are presented in Table 21. .The *A. marina* plants in the 20 ha area showed tree density varying from 2100/ha to a maximum 2500/ha, and the overall average was 2300 /ha. The overall average plant height of this site was 175cm. and the survival rate was 57.5 %. The GB ranged from 7 cm to 15 cm, with an average of 10.5 cm, while the average canopy cover was 1.89 m^2. The area was moderately dense, with *A. marina* being predominant species (Plate-16).

Additionally, the area being slightly cooler due to frequent tidal exposures and is inhabited by snakes. As the area remains moist due to the tidal influx, assessment of the area becomes

difficult. This area also supports avifauna like Oriental darter (*Anhinga melanogaster*), Painted stork (*Mycteria leucocephala*), crab plovers (*Dromas ardeola*) etc.

Table 21. Evaluation of *A. marina* plantation at Sat Saida Bet (20 ha)

Quadrat	Density	Height (cm)			Girth (cm)				Canopy (m^2)	
		Min	Max	Average	Min	Max	Average	Min	Max	Average
Q-1	2100	180	200	190	8	15	11.5	1.14	3.21	2.175
Q-2	2500	110	160	160	7	12	9.5	1.1	2.1	1.6
Average	2300	180	180	175	7.5	13.5	10.5	1.12	2.66	1.89

Plate 6. Sat Saida Bet *Avicennia marina* plantation

6.3.2 Monitoring of *Avicennia marina* plantation at Sat Saida bet (2021-2022) 200 ha.

Mangrove plantation in 200 ha was initiated by Forest Department, Kachchh circle during 2011-2012 on DPA's request. Forest Department (Anjar circle) initiated the plantation activities at Sat Saida Bet during the rainy season of June 2011. The plantation site is opposite to Deendayal port oil jetty and is around 2 km from the bank of Sat Saida bet. A buffer zone of

nearly 2 km was allowed between the waterfront from the banks of Sat Saida bet and the plantation site. The seeds of *A. marina* were used for plantation activities due to the prevailing high salinity in the area. Raised bed method (*Otla*) was followed as the plantation technique, and *A. marina* seeds were collected from Kandla mangroves for plantation work.

In total, 20 quadrats were laid at this site to assess the survival percentage of the *A. marina.* The growth of these plantations was assessed, and the results were presented in Tables 22. The *A. marina* plants in the 200-ha area showed tree density varying from 1800/ha to a maximum 2800/ha, and the overall average was 2250 /ha. The overall average plant height of this site was 117.8 cm and the survival rate was 56.25 %. The GBH ranges from 7 cm to 11 cm with an average of 8.3 cm, while the average canopy cover was 1.1 m^2.

Additionally, the area supported the luxuriant growth of halophytes like *Salicornia brachiata, Sesuvium sp. and Salvadora persica*. The area becomes dry during low tides and gets converted to a hard surface, making it accessible. Interestingly, despite the dryness of the area, snakes were recorded. It was observed that they take shelter under the canopy cover and camouflage themselves by intertwining with the stem of mangroves.

6.3.3 Monitoring of *Avicennia marina* plantation (2021-2022) 300 ha.

The *A. marina* mangrove plantation carried out during 2012-2013 in 300 ha by the Range office of the Forest Department at Anjar. Initially, raised bed method was followed for mangrove plantations but was eventually replaced by direct seed sowing. In a few places, direct seed dibbling was also done.

In total, 30 quadrates were laid at this site to assess the survival percentage of the *A. marina.* The growth of these plantations was assessed, and the results are presented in Table 23. The *A. marina* plants in the 300ha area showed tree density varying from 1300/ha to a maximum 3500/ha, and the overall average was 2247/ha. The overall average plant height of this site was 125.3cm, and the survival rate was 56.17 %. The GB ranges from 0.63 cm to 19 cm with an average of 9.16 cm, while the average canopy cover was 1.44 m^2.

Table 22. Details of mangrove plantation of *A. marina* at Sat Saida Bet (200 Ha)

Quadrate	Density	Height (cm)			Girth (cm)			Canopy cover (m^2)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
Q-1	2200	110	140	125	7	10	8.5	0.34	1.24	0.79
Q-2	1800	120	110	115	7	9	8	1	1.57	1.285
Q-3	2500	100	130	115	9	11	10	1	1.34	1.17
Q-4	1800	100	110	105	7	9	8	0.59	1.24	0.915
Q-5	2400	130	140	135	7	11	9	0.89	1.95	1.42
Q-6	2200	110	120	115	7	9	8	0.98	1.4	1.19
Q-7	2400	120	130	125	7	10	8.5	1	1.49	1.245
Q-8	1800	100	120	110	7	10	8.5	0.48	0.67	0.575
Q-9	2200	100	110	105	7	8	7.5	0.34	0.59	0.465
Q-10	1800	130	140	135	7	9	8	1	1.77	1.385
Q-11	2700	120	130	125	7	10	8.5	1	1.8	1.4
Q-12	2200	80	100	90	7	9	8	0.23	1.67	0.95
Q-13	1900	120	150	135	7	8	7.5	1.29	1.78	1.535
Q-14	2800	110	120	115	7	8	7.5	1	1.3	1.15
Q-15	2200	90	110	100	8	9	8.5	1.07	1.29	1.18
Q-16	2400	110	140	125	8	11	9.5	1.2	1.5	1.35
Q-17	2200	120	140	130	8	10	9	1	1.64	1.32
Q-18	2500	80	120	100	5	8	6.5	1.04	1.34	1.19
Q-19	2200	110	130	120	7	8	7.5	0.54	0.76	0.65
Q-20	2800	120	140	130	8	11	9.5	0.72	0.9	0.81
Average	**2250**	**109**	**126.5**	**117.8**	**7.2**	**9.4**	**8.3**	**0.8**	**1.4**	**1.1**

Table 23. Details of mangroves plantation of A. *marina* at Sat Saida Bet (300 Ha)

Quadrat No	Density	Height(cm)			Girth(cm)			Canopy cover (m^2)		
		Min	Max	Avg	Min	Max	Avg	Min	Max	Average
Q-1	2200	120	160	140	9	19	14	1.32	2.7	2.01
Q-2	1500	100	120	110	11	12	11.5	1.56	1.75	1.65
Q-3	2500	90	130	110	0.99	10	5.5	0.96	1.69	1.325
Q-4	1900	120	140	130	9	12	10.5	1	1.39	1.195
Q-5	2600	90	180	135	7	18	12.5	1	1.69	1.345
Q-6	2100	90	140	115	8	9	8.5	1	2.19	1.595
Q-7	2500	100	130	115	7	11	9	1	2.56	1.78
Q-8	2500	90	120	105	0	9	4.5	0.47	1.39	0.93
Q-9	1900	100	120	110	7	12	9.5	1	1.22	1.11
Q-10	2600	110	190	150	10	16	13	1	1.38	1.19
Q-11	2100	110	190	150	12	20	16	1	2.79	1.895
Q-12	2500	120	270	195	9	24	16.5	2	4.46	3.23
Q-13	2200	130	260	195	11	21	16	3	4.39	3.695
Q-14	2200	90	120	105	5	10	7.5	0.39	2.35	1.37
Q-15	2100	130	170	150	11	13	12	0.56	1.67	1.115
Q-16	1800	90	140	115	6	10	8	0.76	1.36	1.06
Q-17	1800	120	130	125	7	9	8	1.2	1.32	1.26
Q-18	2200	80	100	90	5	7	6	0.65	1.02	0.835
Q-19	2200	90	120	105	6	7	6.5	0.89	1.29	1.09
Q-20	1300	130	140	135	7	9	8	0.9	1.34	1.12
Q-21	2200	100	120	110	6	9	7.5	0.79	1.1	0.945
Q-22	1500	80	130	105	6	10	8	0.63	1.35	0.99
Q-23	2200	110	140	125	7	9	8	1	1.45	1.225
Q-24	2800	100	110	105	5	7	6	0.56	1.06	0.81
Q-25	2900	105	130	117.5	7	11	9	1.38	2	1.69
Q-26	3500	120	150	135	9	13	11	1	2	1.5
Q-27	2200	110	130	120	0	9	4.5	1.02	1.89	1.455
Q-28	2400	100	140	120	0	9	4.5	1	1.68	1.34
Q-29	2800	110	150	130	0	10	5	0.64	1.83	1.235
Q-30	2200	70	140	105	0.63	16	8.315	1	1.45	1.225
Average	**2247**	**103.5**	**147**	**125.25**	**6.29**	**12.03**	**9.16**	**1.02**	**1.86**	**1.44**

6.3.4 Monitoring of *Avicennia marina* plantation (2021-2022) 330 ha.

During 2013-14, these sites were planted with *A. marina,* plants with nursery raised saplings and direct dibbling methods, respectively. In total, 33 quadrates were laid at this site to assess the survival percentage of the *A. marina.* The growth of these plantations was assessed, and the results are presented in Table 24. The *A. marina* plants in the 330 ha area showed the tree density varying from 1800/ha to a maximum of 3200/ha, and the overall average was 2509/ha. The overall average plant height of this site was 132.3cm, and the survival rate was 62.7 %. The girth at base ranges from 5 cm to 24 cm with an average of 9.61 cm, while the average canopy cover was 1.35 m^2.

Plate 7. Monitoring of *A. marina* on field

Table 24. Details of mangroves plantation of A. *marina* at Sat Saida Bet (300 ha)

Quadrate	Density	Height (cm)			Girth (cm)				Canopy cover(m^2)	
		Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
1	2400	70	90	80	5	6	5.5	0.4	1.2	0.8
2	3200	110	120	115	7	8	7.5	0.28	1.62	0.95
3	2200	90	110	100	7	8	7.5	0.36	1.23	0.795
4	2600	80	100	90	5	6	5.5	1.2	2.2	1.7
5	3200	100	120	110	6	8	7	0.38	1.36	0.87
6	2200	80	90	85	5	7	6	0.7	1.9	1.3
7	3000	100	110	105	4	6	5	0.5	0.9	0.7
8	2500	110	125	117.5	6	9	7.5	0.42	1.23	0.825
9	1900	110	130	120	7	10	8.5	1.08	1.23	1.155
10	2600	110	120	115	7	9	8	0.89	1.26	1.075
11	2100	120	180	150	8	12	10	0.78	1.47	1.125
12	2500	105	150	127.5	7	14	10.5	0.42	1.68	1.05
13	2700	150	190	170	10	16	13	0.8	1.59	1.195
14	2200	110	170	140	7	18	12.5	0.89	2.38	1.635
15	2900	110	180	145	7	17	12	0.54	2.1	1.32
16	3500	110	130	120	6	10	8	0.9	1.2	1.05
17	2200	130	150	140	7	15	11	1.08	2.24	1.66
18	2400	110	140	125	7	12	9.5	0.9	2.36	1.63
19	2200	120	170	145	9	15	12	1.39	2.49	1.94
20	2400	120	140	130	7	12	9.5	1.17	2.35	1.76
21	1800	90	110	100	6	9	7.5	0.89	1.02	0.955
22	2500	100	120	110	9	10	9.5	0.64	0.98	0.81
23	3200	140	170	155	9	13	11	0.9	1.39	1.145
24	2500	80	120	100	6	8	7	0.38	0.76	0.57
25	2500	110	130	120	7	8	7.5	0.34	1.24	0.79
26	1900	110	130	120	7	9	8	0.79	1.1	0.945
27	2600	100	150	125	7	10	8.5	0.88	2.89	1.885
28	2200	100	110	105	7	10	8.5	0.54	1.96	1.25
29	2100	150	250	200	10	22	16	2.34	3.5	2.92
30	2400	160	210	185	1	18	9.5	1.78	2.7	2.24
31	2500	210	260	235	16	24	20	1.98	3.86	2.92
32	2500	150	240	195	11	19	15	2.28	2.46	2.37
33	3200	160	210	185	10	16	13	0.72	1.67	1.195
Average	**2509**	**115**	**149**	**132**	**7.3**	**12**	**9.61**	**0.90**	**1.80**	**1.35**

6.3.5 Monitoring of *Avicennia marina* plantation (2021-2022) 50ha.

During 2018-19, this site was planted with A. marina, plants with nursery raised saplings and direct dibbling methods, respectively by Gujarat Ecology Commission. In total, five quadrates were laid at this site to assess the survival percentage of the A. marina. The growth of these plantations was assessed, and the results are presented in Table 25. The A. marina plants in the 50 ha area showed tree density varying from 1600/ha to a maximum of 2500/ha, and the overall average was 2060/ha. The overall average plant height of this site was 141.6cm, and the survival rate was 51.5 %. The girth ranges from 8 cm to 19 cm with an average of 12.2 cm, while the average canopy cover was 1.45 m^2.

Table 25. Details of mangroves plantation of A. *marina* at Sat Saida Bet (50 Ha)

Quadrat No	Density	Height(cm)			Girth(cm)			Canopy(m^2)		
		Max	Min	Avg	Max	Min	Average	Max	Min	Average
Q-1	1900	180	140	160	18	11	14.5	2.98	0.9	1.94
Q-2	2200	160	136	148	15	12	13.5	2.57	0.48	1.525
Q-3	2500	150	110	130	12	9	10.5	1.82	0.59	1.205
Q-4	2100	190	110	150	19	8	13.5	2.36	1.04	1.7
Q-5	1600	130	110	120	10	8	9	1.34	0.46	0.9
Avg	**2060**	**162**	**121**	**141.6**	**14.8**	**9.6**	**12.2**	**2.214**	**0.69**	**1.45**

7 Regeneration and recruitment class

The regeneration class and recruitment class density were recorded in Sat Saida bet. The overall average density of the regeneration class (saplings with a height of <50 cm) of mangroves in the sampling site recorded was 43,658 plants/ha. The highest regeneration class (62,121 plants/ha) was recorded at 330 ha block, indicating the suitability of the site for germination and survival of young plants (Fig-25, 26). The lowest density of the regeneration class (25,667 plants/ha) was recorded at the 300 Ha block. In the case of recruitment class plants, the overall average density recorded was 5071 plants/ha. The maximum recorded at 330 Ha block (6061 plants/ha), and the minimum at 300 ha block. These results indicate that the 300 Ha block is not conducive for the growth of mangroves.

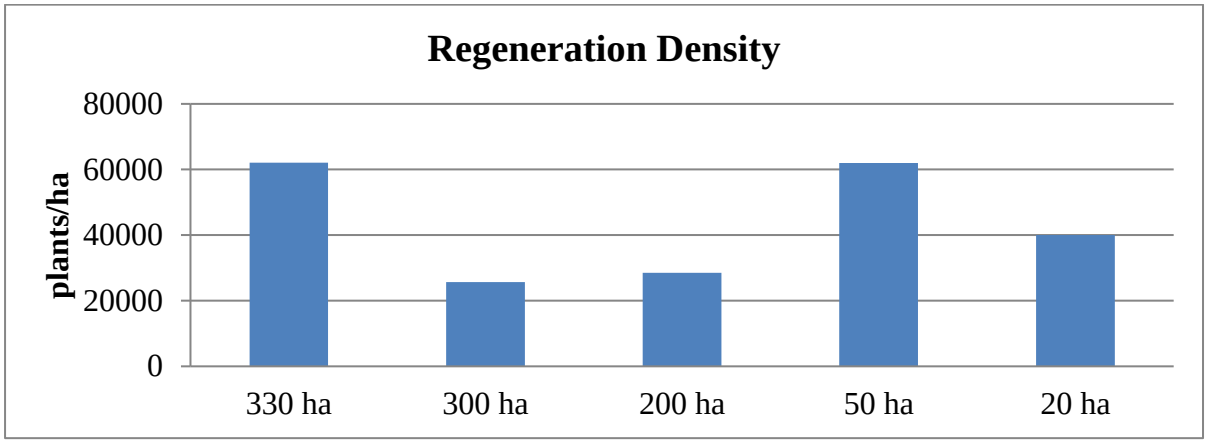


Figure 25. Regeneration class density at Sat Saida Bet

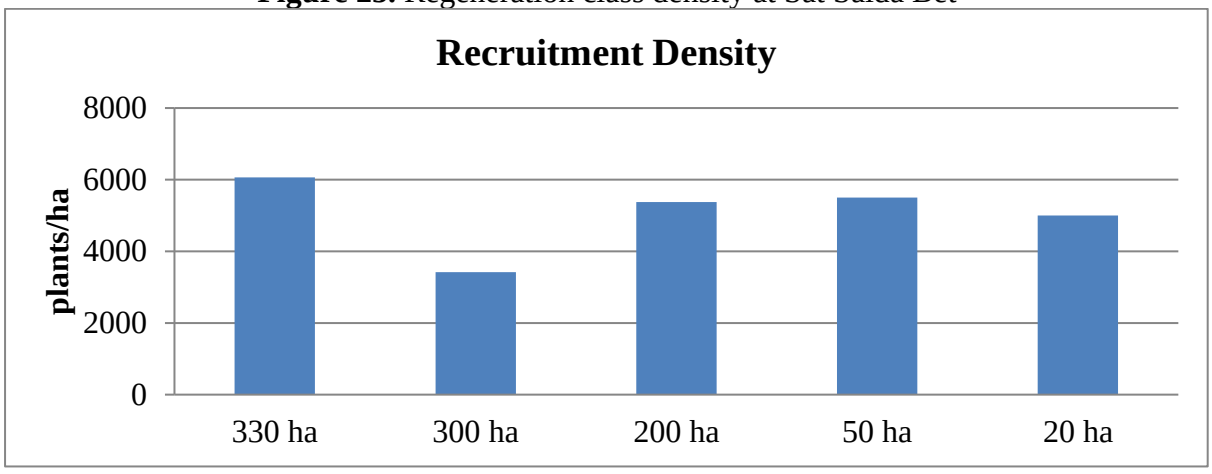


Figure 26. Recruitment class density at Sat Saida Bet

The regeneration class density was highest in 330 ha block followed by 50 ha, 20 ha, 200 ha and lowest in 300 ha. The recruitment class density was highest in 330 ha followed by 50 ha, 200 ha, 20 ha and lowest in 300 ha.

Table 26. Assessment of plant characteristics (Mean) at the plantation sites during 2017-2018

Site	Parameters	150 ha	150ha
Kantiyajal	Plant density (No/ha)	2220 (*A .marina*)	1460 (*A.marina)* 1280 *(R.mucronata)*
	Height(cm)	37	32 (*A.marina*) 30 (*R.mucronata)*
	Survival rate (%)	88.8	58.4 *(A. marina*) 64.0 (*R. mucronata)*
Nakti creek	Plant density (No/ha)	2370	-
	Height (cm)	53 – 84	-
	Survival rate	35.9	-
Sat Saida Bet	Plant density (No/ha)	4133	2031 to 5387
	Height (cm)	89	39 – 113
	Survival rate (%)	62.6%	81.6

8 Soil Biomass Carbon

8.1 Soil biomass carbon stock potential at Nakti creek mangrove site

At Nakti creek, the below ground soil carbon stock of the *A. marina* plantation was 51.76 t/ha and 62.74t/ha at 50 ha and 100ha respectively. At the 100 ha mangrove plantation area, the soil biomass carbon stock ranged from 42.36 to 84.32 t/ha with an average of 62.74 t/ha. Among the two locations, 100 ha plantation site at Nakti creek showed the higher soil Total Biomass Carbon stock (Table 27, 28).

Table 27. Soil Carbon stock in Nakti mangrove plantation site- 100 ha

Sampling Blocks	Depths	TOC (%)	Total carbon (%)	Bulk Density (g/ cm^3)	Carbon stock (%)	Carbon stock in 1 m (t/ha)
NC 1	25 cm	0.34	0.18	1.28	5.83	84.315
	50 cm	0.37	0.20	1.30	12.85	
	75 cm	0.43	0.23	1.25	21.56	
	100 cm	0.61	0.33	1.35	44.08	
NC 2	25 cm	0.43	0.23	1.33	7.66	58.63
	50 cm	0.4	0.21	1.25	13.37	
	75 cm	0.34	0.18	1.32	17.94	
	100 cm	0.28	0.15	1.31	19.65	
NC 3	25 cm	0.24	0.13	1.32	4.22	45.27
	50 cm	0.27	0.14	1.27	9.14	
	75 cm	0.21	0.11	1.28	10.80	
	100 cm	0.3	0.16	1.32	21.11	
Average Carbon stock (%)						**62.74**

Table 28. Soil Carbon stock in Nakti mangrove plantation site - 50 ha

Sampling Blocks	Different depths	TOC%	Total carbon (%)	Bulk Density (g/ m^3)	Carbon stock (%)	Carbon in 1 m stock (t/ha)
NC 1	25 cm	0.21	0.11	1.41	3.95	42.364
	50 cm	0.24	0.13	1.25	8.02	
	75 cm	0.24	0.13	1.28	12.34	
	100 cm	0.27	0.14	1.25	18.05	
NC 2	25 cm	0.33	0.18	1.37	6.04	59.12
	50 cm	0.24	0.13	1.33	8.56	
	75 cm	0.3	0.16	1.39	16.71	
	100 cm	0.39	0.21	1.33	27.81	
NC 3	25 cm	0.51	0.27	1.28	8.74	53.79
	50 cm	0.33	0.18	1.32	11.61	
	75 cm	0.27	0.14	1.33	14.44	
	100 cm	0.27	0.14	1.32	19.00	
Average of Carbon stock (%)						**51.6**

Table 29. Average Carbon Stock at Nakti Creek

Plantation (ha)	Avg. Carbon stock 1 m depth (%)
100	62.74
50	51.6
Avg	57.17

8.2 Soil biomass carbon stock potential at Kantiyajal mangrove site

At Kantiyajal creek, the average soil biomass carbon of the *A. marina* plantation was 53.13t/ha (150ha) and it ranged from 46.4 to 59.7 t/ha. Among the three locations, 150 ha *A. marina* plantation site showed the highest soil biomass carbon stock potential at Kantiyajal (Table 30,31,32 & 33). The overall average 1 meter depth soil carbon stock was 53.35t/ha**.**

Table 30. Soil Carbon stock in Kantiyajal mangrove plantation site- 150 ha (*A. marina*)

Sampling Blocks	Different depths	TOC%	Total carbon (%)	Bulk Density (g/ m^3)	Carbon stock (%)	Carbon stock in 1 m(t/ha)
KC-1	25 cm	0.30	0.15	1.27	4.8	**54.7**
	50 cm	0.42	0.21	1.20	12.6	
	75 cm	0.34	0.17	1.19	15.2	
	100 cm	0.52	0.26	1.22	22.2	
KC- 2	25 cm	0.34	0.17	1.21	5.1	**54.0**
	50 cm	0.40	0.20	1.18	11.8	
	75 cm	0.38	0.19	1.20	17.1	
	100 cm	046	0.23	1.24	20.0	
Average Carbon stock (%)						**54.4**

Table 31. Soil Carbon stock in Kantiyajal mangrove plantation site- 150 ha (*R. mucronata)*

Sampling Blocks	Different depths	TOC %	Total carbon (%)	Bulk Density (g/ m^3)	Carbon stock (%)	Carbon stock in 1 m(t/ha)
KC-1	25 cm	0.38	0.19	1.09	5.2	47.7
	50 cm	0.29	0.145	1.22	8.8	
	75 cm	0.39	0.195	1.16	17.0	
	100 cm	0.49	0.145	1.21	20.8	
KC- 2	25 cm	0.36	0.18	1.26	5.7	59.7
	50 cm	0.37	0.185	1.23	11.4	
	75 cm	0.62	0.31	1.19	27.7	
	100 cm	0.37	0.185	1.16	15.0	
Average Carbon stock (%)						**53.69**

Table 32. Soil Carbon stock in Kantiyajal mangrove plantation site- 50 ha *(A.marina*)

Sampling Blocks	Different depths	% of TOC	Total carbon (%)	Bulk Density (g/ m^3)	Carbon stock (%)	Carbon stock in 1 m(t/ha)
KC- 1	25 cm	0.29	0.145	1.24	4.5	57.5
	50 cm	0.36	0.18	1.25	11.3	
	75 cm	0.39	0.195	1.23	18.0	
	100 cm	0.54	0.27	1.26	23.8	
KC- 2	25 cm	0.32	0.16	1.24	5.0	46.4
	50 cm	0.38	0.19	1.09	10.4	
	75 cm	0.37	0.185	1.24	17.2	
	100 cm	0.32	0.16	1.24	13.9	
Average of Carbon stock (%)						**51.97**

Table 33. Average Carbon Stock at Kantiyajal Creek

Plantation (ha)	Avg. Carbon stock 1 m depth (%)
150	54.4
150	53.69
50	51.97
Avg	53.35

8.3 Soil carbon stock potential at Sat Saida bet at mangrove site

At Sat Saida bet the overall average soil biomass carbon of *A. marina* plantation site was 68.17 t/ha. Whereas, at the five blocks of mangrove plantation area, the soil biomass carbon ranged from 54.5 t/ha (50ha) to 79.5 t/ha (200ha). The soil carbon sequestration potential was highest in 200 ha plot followed by 300, 20, 330 and 50 ha plantation blocks (Table 34-39).

Table 34. Soil Carbon stock in Sat Saida bet mangrove plantation site- 300 ha

Sampling Blocks	Different depths	% of TOC	Total carbon (%)	Bulk Density (g/cm^3)	Carbon stock (%)	Carbon stock in 1 m (t/ha)
Sample-1	25 cm	0.37	0.185	1.30	6	69.3
	50 cm	0.40	0.2	1.29	12.9	
	75 cm	0.37	0.185	1.26	17.5	
	100 cm	0.53	0.265	1.24	32.9	
Sample- 2	25 cm	0.35	0.175	1.23	5.4	73.9
	50 cm	0.48	0.24	1.30	15.6	
	75 cm	0.39	0.195	1.22	17.8	
	100 cm	0.58	0.29	1.21	53.1	
Average of Carbon stock (%)						**71.5**

Table 35. Soil Carbon stock in Sat-Saida bet mangrove plantation site- 200 ha

Sampling Blocks	Different depths	% of TOC	Total carbon (%)	Bulk Density (g/cm^3)	Carbon stock (%)	Carbon stock in 1 m (t/ha)
Sample-1	25 cm	0.39	0.195	1.23	6.0	78.1
	50 cm	0.36	0.18	1.22	11.0	
	75 cm	0.67	0.335	1.13	28.4	
	100 cm	0.59	0.295	1.24	32.7	
Sample- 2	25 cm	0.42	0.21	1.21	11.6	80.9
	50 cm	0.35	0.175	1.26	11.0	
	75 cm	0.58	0.29	1.27	27.6	
	100 cm	0.52	0.26	1.18	30.7	
Average of Carbon stock (%)						**79.5**

Table 36. Soil Carbon stock in Sat Saida bet mangrove plantation site- 330 ha

Sampling Blocks	Different depths	% of TOC	Total carbon (%)	Bulk Density (g/cm^3)	Carbon stock (%)	Carbon stock in 1 m (t/ha)
Sample-1	25 cm	0.42	0.21	1.09	5.7	**64.8**
	50 cm	0.32	0.16	1.29	10.3	
	75 cm	0.37	0.185	1.24	17.2	
	100 cm	0.53	0.25	1.23	31.5	
Sample- 2	25 cm	0.48	0.24	1.13	6.8	**55.9**
	50 cm	0.34	0.17	1.24	10.5	
	75 cm	0.30	0.15	1.30	14.6	
	100 cm	0.42	0.21	1.14	23.9	
Average of Carbon stock (%)						**60.3**

Table 37. Soil Carbon stock in Sat Saida bet mangrove plantation site- 50 ha

Sampling Blocks	Different depths	% of TOC	Total carbon (%)	Bulk Density (g/cm^3)	Carbon stock (%)	Carbon stock in 1 m (t/ha)
Sample-1	25 cm	0.31	0.155	1.26	4.9	**62.8**
	50 cm	0.36	0.18	1.30	11.7	
	75 cm	0.39	0.195	1.06	15.5	
	100 cm	0.50	0.25	1.23	30.8	
Sample- 2	25 cm	0.32	0.16	1.13	5.0	**54.2**
	50 cm	0.33	0.165	1.24	10.8	
	75 cm	0.38	0.19	1.30	17.8	
	100 cm	0.34	0.17	1.14	20.6	
Average of Carbon stock (%)						**58.5**

Table 38 Soil Carbon stock in Sat Saida Bet mangrove plantation site- 20 ha

Sampling Blocks	Different depths	% of TOC	Total carbon (%)	Bulk Density (g/cm^3)	Carbon stock (%)	Carbon stock in 1 m (t/ha)
Sample-1	25 cm	0.35	0.175	1.32	5.8	74.5
	50 cm	0.37	0.185	1.18	10.9	
	75 cm	0.39	0.22	1.32	21.8	
	100 cm	0.55	0.275	1.31	36	
Sample- 2	25 cm	0.35	0.175	1.19	5.2	67.6
	50 cm	0.175	0.195	1.34	13.1	
	75 cm	0.29	0.27	1.32	26.7	
	100 cm	0.26	0.19	1.19	22.6	
Average of Carbon stock (%)						**71.0**

Table 39. Average Carbon Stock of all the sites at Sat Saida Bet

Plantation (ha)	**Avg. Carbon stock 1 m depth (%)**
300 ha	71.5
200 ha	79.5
330 ha	60.3
50 ha	58.5
20 ha	71.0
Avg	68.18

8.4 Details of carbon Sequestration at the plantation sites

The above ground biomass varied 113.30 to 210.0gm at Sat Saida Bet while at Kantiyajal it was minimum 121.74 to 164.60 gm/ha. At Nakti creek site it was minimum 133.86 and maximum 161.02 gm/ha during the present investigation (Table 40,41 & 42). The below ground biomass was comparatively less than the above ground values. At Sat Saida Bet it ranged from 22.70 to 62.80gm and that from Kantiyajal were 21.96 to 38.23gm. The below ground biomass at Nakti varied between 29.83 and 42.30gm. The Total Biomass Carbon calculated in the different plantation sites at Sat Saida varied from 112.10kg/ha to 232.74 kg/ha. The values of carbon biomass at Kantiyajal varied from 123.69 to 178.86kg/ha whereas at Nakti it varied between 142.02 and 173.46 kg/ha.

Table 40. Details of Carbon stock at Sat Saida during 2022

Carbon Sequestration - Dry weight basis (gm)										
50ha										
Sample	**Root**	**Leaves**	**Stem**	**Plant Biomass Below ground**	**Plant Biomass Above Ground**	**Total Biomass**	**Total Biomass Carbon**	**Total Biomass Carbon (mg/ha)**	**Total Biomass Carbon (kg/ha)**	**Carbon equivalent (%)**
sample-1	39.80	108.90	48.60	39.80	157.50	197.30	82.87	168325.71	168.33	617.76
sample-2	32.90	80.90	29.60	32.90	110.50	143.40	60.23	122341.14	122.34	448.99
20ha										
sample-1	29.40	80.10	37.70	29.40	117.80	147.20	61.82	125583.09	125.58	460.89
sample-2	24.60	86.40	26.90	24.60	113.30	137.90	57.92	117648.83	117.65	431.77
200ha										
sample-1	22.70	69.30	34.40	22.70	57.10	79.80	33.52	68081.05	68.08	249.86
sample-2	36.10	90.10	43.70	36.10	79.80	115.90	48.68	98879.62	98.88	362.89
300ha										
sample-1	62.80	140.30	69.70	62.80	210.00	272.80	114.58	232738.23	232.74	854.15
sample-2	39.50	93.50	32.90	39.50	126.40	165.90	69.68	141536.92	141.54	519.44
330ha										
sample-1	37.10	64.90	29.40	37.10	94.30	131.40	55.19	112103.38	112.10	411.42
sample-2	34.40	94.60	45.20	34.40	139.80	174.20	73.16	148618.03	148.62	545.43

Table 41. Details of Carbon stock at Kantiyajal during 2022

Dry weight (Gram)				Carbon Sequestration						
150ha										
Sample	**Root**	**leaves**	**stem**	**Plant Biomass Below ground**	**Plant Biomass Above Ground**	**Total Biomass**	**Total Biomass Carbon**	**Total Biomass Carbon (mg/ha)**	**Total Biomass Carbon (mg/ha)**	**Carbon equivalent (%)**
sample-1	34.29	112.30	52.30	34.29	164.60	198.89	83.53	169682.21	169.68	622.73
sample-3	38.23	124.12	47.30	38.23	171.42	209.65	88.05	178862.06	178.86	656.42
150ha										
sample-1	32.86	115.80	43.70	32.86	159.50	192.36	80.79	164111.16	164.11	602.29
sample-2	35.12	108.30	39.42	35.12	147.72	182.84	76.79	155989.21	155.99	572.48
50ha										
sample-1	21.96	84.62	38.40	21.96	123.02	144.98	60.89	123689.11	123.69	453.94
sample-2	24.30	92.14	29.60	24.30	121.74	146.04	61.34	124593.44	124.59	457.26

Table 42. Details of Carbon stock at Nakti creek during 2022

Dry weight (Gram)				Carbon Sequestration						
50 ha										
Sample	Root	leaves	Stem	Below ground	Above Ground Biomass	Total Biomass	Total Biomass Carbon	Total Biomass Carbon (mg/ha)	Total Biomass Carbon (kg/ha)	Carbon equivalent (%)
Sample-1	37.50	112.96	34.60	37.50	147.56	185.06	77.73	157883.20	157.88	579.43
Sample-2	32.90	98.63	36.94	32.90	135.57	168.47	70.76	143729.51	143.73	527.49
Sample-3	35.64	126.23	28.72	35.64	154.95	190.59	80.05	162601.10	162.60	596.75
100 ha										
Sample-1	32.61	94.35	39.51	32.61	133.86	166.47	69.92	142023.21	142.02	521.23
Sample-2	29.83	103.42	34.26	29.83	137.68	167.51	70.35	142910.49	142.91	524.48
Sample-3	42.30	129.18	31.84	42.30	161.02	203.32	85.39	173461.64	173.46	636.60

9 Phyto-sociological observation

9.1 Halophytes

Halophytes are classified based on their growth conditions as obligate halophytes, facultative halophytes, and habitat-indifferent halophytes. In the present study, four major halophytes were recorded within the selected DPA sites during the survey, *viz: Salicornia brachiata, Aeluropus lagopoides, Salvadora persica* and *Sesuvium portulacastrum*. Among the halophyte species, *Salicornia brachiata & Sesuvium portulacastrum* was found to be equally distributed in Sat Saida bet.

At the plantation site, mangroves associated plants such as *Salvadora* spp and *Ipomea* spp, were found at the high tide level; the halophytes, *Suaeda* spp, *Sesuvium* have also occurred in many sites. During the field visit, several mangroves associated fauna such as mudskippers, bivalves, crabs, gastropods and other fishes were found inside the plantation sites.

Plate 8. Mangrove associated Halophytes

10 Discussion

In the present study, the overall percentage survival of the plants on Sat Saida bet in 5 different blocks was observed between 51.5% to 62.7% at different plot size and in different geophysical condition. This indicates that *A marina* species is capable of adapting to a wide range of salinity variations and substratum types. For germination success, matured seeds should be collected and transported with proper moisture content for plantation. (Clarke and Allaway, 1993; McKee, 1995; McGuinness, 1997; Clarke *et. al*., 2001). The recruitment and growth of established mangrove seedlings and their survival to the sapling stage are mainly determined by the availability of light and nutrients (Smith, 1987; Ellison and Farnsworth, 1993) and the influence of physicochemical factors (McKee, 1995, Koch and Snedaker 1997) at Nakti creek, survival rate ranges from 40% to 54% at 100 ha and 50ha, respectively. At Kantiyajal creek, *A. marina* plantation survival rate varies from 62% to 75% within 50 ha and 150ha respectively. The survival rate of *R.mucronata* is 63% at 150 ha plantation site. This clearly indicates that *A. marina* tolerates wide ranges of temperature and salinity to withstand in extreme environmental conditions (Das *et al.*, 2019).

The results of the 1400 ha plantation study at Kantiyajal, shows higher survival rate than the Sat saida bet and Nakti creek, this is because of site to site variations in temperature, salinity and rainfall (Das *et. al*. 2019. In the plantation sites, higher survival was reported for *A. marina*, whereas the high rates of survival, for stilt-rooted *Rhizophora* species were planted as propagules as influenced by plant spacing (Kodikara *et. al*., 2017). The results of the present study are in conformity with the findings that several abiotic and biotic factors, including the local climatic conditions, determine the survival and growth of recruitment classes. It is to be highlighted that the aftercare by the local people and the management is very much important above all for achieving high survival rates of mangrove plantation efforts. The mangrove survival rates are dependent on factors like

• **Biological factors** – mangrove species and infestation of pests (e.g. algae, barnacles, insect larvae)

• **Physical factors** – tidal level and inundation, substrate, waves/typhoons, sedimentation.

• **Human factors** – harvesting of materials for fodder, grazing, fishing gear, management and enforcement.

Well-planned and executed mangrove planting efforts also results in poor survival rate because of a lack of participation by local communities, cultural barriers and adequate after-care (e.g., watering and removal of objects that are entangled with planted individuals) needed for long-term success (Blum and Herr, 2017). In most of the mangrove plantation, poor survival rate, due to restoration projects is often related to the high susceptibility of propagules, seedlings and saplings to wind and wave erosion, flooding and desiccation. The low survival of the recruitment class can be attributed by both the biotic (competition with native and planted vegetation) and abiotic factors (like erratic change in salinity, temperature wave energy and rainfall), site suitability (like high or low inundation, plantation area).

Effective coordination of multiple stakeholders in a given mangrove project was seen to have provided long-term positive impacts for both mangroves and dependent communities. Implementing agencies and community organizers could also contribute to greater success rates if well-trained and equipped by the appropriate environmental specialists (Flint *et al.,* 2018).

Mangrove rehabilitation and restoration are considered one of the most effective management options globally for dealing with lost or damaged mangrove forests (Ellison *et. al*., 2020). Although planting mangroves for restoration and afforestation has been conducted in some regions in Bangladesh (1993) and Vietnam (Hong *et. al.*, 1996) are not always successful. Many biotic and abiotic influences, including predation, seed recruitment, soil characteristics, colonization rates, salinity and temperate, can reduce the survival of the mangroves, in both early (e.g., nursery) and late stages of the planting process (Lewis, 2005). Instead, mangrove restoration projects tend to use specific success criteria; for example, mangrove restoration efforts with an 85-90% survival rate after a defined number of years of monitoring are described as successful projects (Walters *et. al*., 2008; Locatelli *et. al*., 2014).

11 Summary

Mangrove formations in the Kachchh coast are predominated by a single species, *i.e. A. marina*, with the sporadic occurrence of *R. mucronata* and *C. tagal*. The present study was carried out at Sat Saida bet and Nakti creek in Kandla and at the vicinity of Kantiyajal covering ten blocks to evaluate mangrove plantations carried out in 1400 ha during the period between 2005 to 2019. The major goal of this study was to assess the mangrove plantation survival percentage to assess the carbon sequestration potential of planted mangroves, to understand the ecological issues related to plantation success, and suggest conservation measures. The mangrove plantation was carried out in temporally from 2005 onwards. The plantation work in Sat Saida started from 2005-2006 (20 ha), followed by 200 ha in 2011-2012, 300 ha in 2012-2013, and 330 ha during the 2013-2014. The plantation work in Nakti creek was initiated in year 2008-2009 (50 ha) followed by 100 ha during 2010-2011. In Kantiyajal the plantation work initiated from 2015-2016 (150 ha) followed by 150 ha during 2016-2017 and 100 ha during 2018-2019. Due to the prevalence of high salinity in the region, *A. marina* was the preferred species for plantation. Although, *R. mucronata* and *C. tagal* were also planted in small pockets at Nakti creek, and *R. mucronata* was attempted at Kantiyajal along with *A. marina*. Among the different plantation areas, maximum density and height of plants were observed at Kantiyanjal. However, the survival rate was highest (75%) for *A. marina* plantation in 150 ha planted during 2016-2017 followed by *R. mucronata* plantation at 150 ha in Kantiyanjal (2016-2017), 330 ha of *A marina* at Sat Saida bet (62.7%) planted during 2013-2014. The lowest survival rate was observed in Nakti creek (40%) within 100 ha area carried out during 2010-2011. In this site, especially multi species plantation activity was carried out using *R. mucurata, Ceriops tagal and A. marina*. In rest of the blocks, the survival percentage did not reach the minimum expected (67%) despite of the mangrove species planted. Based on the field monitoring and evaluation data, it is advised to prefer nursery bed and direct seed sowing methods to the *Otla* method, since mangrove areas raised through the *Otla* method undergo high mortality rates even when initial survival rates are high.

The soil Total Biomass Carbon of *A. marina* plantation was lowest (42.36t/ha) in Nakti creek 100 ha plot and highest in 200 ha plot of Sat Saida bet (68.17t/ha). Among the three locations, i.e. Sat Saida bet, Nakti creek and Kantiyajal, the highest carbon sequestration potential was recorded at Sat Saida Bet.

12 Suggestions and recommendations

The Global Mangrove Alliance (GMA), a coalition of international nature conservation Organizations, has set the ambitious target of restoring 20% of mangroves over the current extent by 2030 (Quarto, 2013; Bayraktarov *et al.*, 2016; Wylie *et al.*, 2016; Kodikara *et al.*, 2017). Based on the data collected during the present and previous field survey, the following recommendations are suggested for current and future plantation activities.

12.1 Management approach

The present study indicates that ten blocks are the most suitable sites for further promoting mangrove plantation activities in Sat Saida Bet, as they have already shown survival success and there was space available for gap filling. The following conservation measures are suggested for the planted mangroves in order to improve their survival and make them a mature mangrove formation over the period of time:

- Appropriate site selection needs to be done.
- Both field observation and high-resolution mapping need to be used as a part of mangrove monitoring, conservation and management efforts.
- Site specific appropriate plantation techniques to be opted considering the hydro-geological features to avoid high mortality among mangrove plant species.
- Watering the nursery bed at some regular intervals with freshwater is required.
- Regular tidal flushing and inundation are to be ensured at the selected mangrove sites.
- Manual removal of algal entanglement and barnacle infestation on mangrove to be done periodically.
- Monitoring of existing mangrove plantation to control human interventions to avoid grazing by livestock.
- Mangrove plantation to be carried out using seed source from nearest area possible
- Restoration of mangroves, where it already exists, to be done instead of creating new plantation sites.
- Appropriate restoration efforts are needed such as deepening and de-silting and widening of canals.

- Normal tidal hydrology should not be disrupted and the availability of water-borne dispersal of seeds should be allowed.
- Awareness and outreach programmes for DPA staff and other stakeholders would strengthen the plantation efforts.
- Multispecies plantation is to be preferred while planning
- Involvement of stakeholder communities from the nearby villages to be initiated.

The most relevant suggestive measures for successful mangrove restoration efforts are described below:

12.2 Identification of suitable sites

By far, site selection within the broader landscape for a plantation is the most important criterion that determines the plantation' success. For successful plantation, it is essential that the existing bio-physical conditions of the coastal landscape in a broader and general manner are to be thoroughly understood.

12.3Identification of stress factors

It is important that in any conservation efforts, stressors acting on the mangroves are to be identified and removed in order to maintain the ecosystem balance. Mangrove environment will continue to be stable and balanced if there are no external stressors such as change in hydrology, soil, water salinity, pH, soil texture and wave energy. In addition, anthropogenic stress factors such as collection of fodder and other resources, tree felling and other habitat modification activities will severely affect the ecosystem. It would be necessary to find the factors causing stand degradation and scientifically addressing it to remove the stressors allowing mangroves to flourish.

12.4Bio-physical management

Mostly, micro-topography controls the distribution and wellbeing of mangroves, and physical processes play a dominant role in the formation and functioning of mangrove ecosystem. A list of bio-physical parameters such as the gradient of the intertidal belt, soil nature, number of days of tidal flushing, presence/absence of natural mangroves in the vicinity and availability of adequate intertidal extent are to be considered, and grades should be assigned in a scale of 1 to 10. Duration of tidal flushing, which is influenced by the gradient of the intertidal extent is very essential.

12.5Community-based management

Involving local people and fishermen living nearby and use their traditional knowledge will render the site selection easier since they are well versed with the local conditions, especially tidal flushing rate. In addition, short term and small-scale feasibility trials could be conducted in order to ascertain the suitability of the site.

To encourage both motivation and engagement, the needs of the community need to be assessed and addressed towards their socioeconomic development for the direct benefit of community members (Flint *et al.,* 2018). Ideally, mangroves within the DPA jurisdiction should be subjected to intense management regime to protect them. It was proven in many instances that involving the stakeholder communities in the surrounding villagers will yield better results in mangrove plantation and restoration activities. Effective coordination of multiple stakeholders in a given mangrove project or programme has provided long-term positive impacts for both mangroves and dependent communities. Though the population in the port surroundings has different livelihood activities, fishermen community could be targeted to involve them in community-based mangrove restoration and management. The community-based organization *i.e.,* Samithi roles and responsibilities with reference to mangrove conservation in their vicinity should be well defined and that would play a vital role in conserving these mangrove patches.

12.6Physical protection

Physical protection of natural stand is often the best conservation measure that will fetch positive results. Employees of Deendayal port need to be made aware with the environmental and ecological significance of mangroves and other coastal resources within the port limits. Licenses for salt works and other Port allied industries are awarded by port authorities without understanding the ecological and environmental rules and regulations governing them which often lead to legal and environmental bottleneck at a later stage. Short-term awareness programs in a continuous basis to port employees could be conducted by seasoned marine/mangrove ecologists.

13 Future considerations

In all future plantation activities along with *A. marina*, other compatible species like *R. mucronata*, *C. tagal* and *A. corniculatum* which are available at Sat Saida Bet shall be chosen where ever suitable environmental parameters are available during post monsoon season. Further, such efforts would serve to create a seed bank in due course of time which would eventually convert single species stand of *A. marina* into multi-species assemblages. It is suggested that in future plantation activities, nursery raised saplings along with direct dibbling of seeds and propagules should be preferred rather than following the raised bed (*Otla*) method in order to have high survival rate of the plants. Raised bed plantation are to be conducted only on the suitable sites and not everywhere, for which surveys should be conducted before the initiation of plantation activities. Mangrove restoration is possible by enhancing the natural recruitment of propagules and seeds of the species for which the hydrologic manipulation of the mangrove plantation site is to be done so as to retain them in the bottom sediment and germinate. It is necessary to make sure that tidal water inundation is sufficient for the survival of the seedlings. Through appropriate restoration measures, the existing sparse mangroves could be converted into dense patches by regular gap filling and replantation in the already established blocks. The large plants will provide a protective shield for the newly planted or emerging young plants from water currents during the tidal water movements. Thus, it is suggested to carry out restoration activities along with direct plantation to improve mangrove vegetation cover in DPA. Based on the present monitoring results, it is inferred that Sat Saida Bet could be an ideal site for all future mangrove restoration activities with bio-physical amendments such as de-silting existing creeks, joining all the existing minor creeks with one another through modified creek systems. Increased tidal flooding and hydro-period will extend the mangrove formation in this location along with converting sparse mangrove vegetation into dense mangroves over a period of time. Earlier mangrove vegetation analysis studies at Kandla and Tuna mangroves (GUIDE, 2012 and 2015) have clearly indicated that density and addition of younger classes is good enough to become mature trees. To sum up, through sustainable long -term management practices, the mangroves can be made into a fully grown and functional ecosystem with enhanced ecosystem services.

14 References

Anon., (2001). India 2001- A reference annual compiled and edited by Research, Reference and Training Division, Ministry of Information and Broad Casting, Government of India. 873

Baig, M. M., Gholam Hosseini, H., and Connolly, M. J., (2015). Mobile healthcare applications: system design review, critical issues and challenges. Australas Phys Eng Sci Med. *38*(1), 23-38.

Bayraktarov, E., Saunders, M. I., Abdullah, S., Mills, M., Beher, J., Possingham, H. P., Mumby, P. J. and Lovelock, C. E., (2016.). The cost and feasibility of marine coastal restoration. Ecol Appl, 26(4), pp. 1055–1074. doi: 10.1890/15-1077.1.

Blum, J., and Herr, D., (2017). Gender equity is key to mangrove restoration.

Clark, D. B., (2001). Net primary production in tropical forests: an evaluation and synthesis of existing field data. Ecol. Appl., 11, 371-374.

Clarke, M. A., and Bishnoi, P. R., (2001). Measuring and modelling the rate of decomposition of gas hydrates formed from mixtures of methane and ethane. Chem. Eng. Sci, *56*(16), 4715-4724.

Clarke, P. J., and Allaway, W. G., (1993). The regeneration niche of the grey mangrove (Avicennia marina): effects of salinity, light and sediment factors on establishment, growth and survival in the field. Oecologia, *93*(4), 548-556.

Das, R L., Patel, H., Salvi, R.D., Kamboj., (2019) Assessment of natural regeneration of mangrove with reference to edaphic factors and water in Southern Gulf of Kachchh, Gujarat, India.Heliyon. (5):2250.

Donato, D. C., Kauffman, J. B., Murdiyarso, D., Kurnianto, S., Stidham, M., & Kanninen, M., (2011). Mangroves among the most carbon-rich forests in the tropics. Nat. Geosci, *4*(5), 293-297.

Duraiappah, A. K., Naeem, S., Agardy, T., Ash, N. J., Cooper, H. D., Diaz, S., and Van Jaarsveld, A., (2005). Ecosystems and human well-being: biodiversity synthesis; a report of the Millennium Ecosystem Assessment.

El Wakeel, S.K. & J.P. Riley 1961. Chemical and mineralogical studies of deep-sea sediments. Geochim. Cosmochim. Acta 25, 110–46.

Ellison, A. M., & Farnsworth, E. J., (1993). Seedling survivorship, growth, and response to disturbance in Belizean mangal. Am. J. Bot, *80*(10), 1137-1145.

Ellison, A.M., Felson, A.J., and Friess, D.A., (2020). Mangrove Rehabilitation and Restoration as Experimental Adaptive Management. Front. Mar. Sci. 7:327. doi: 10.3389/fmars.2020.00327

Ezcurrra, P., Ezcurra E., Garcillan, P. P., Costa, M. T., Aburto_Oropeza, O. (2016). Coastal Landforms and accumulation of mangrove peat increase carbon sequestration and storage. Proc. Nat. Acad. Scie. 4404-4409. 10.1073/pnas.1519774113

Flint, R., Herr, D., Vorhies, F., and. Smith, J. R., (2018). Increasing success and effectiveness of mangrove conservation investments: A guide for project the purpose of these developers, donors and investors. IUCN, Geneva, Switzerland, and WWF Germany, Berlin, Germany. (106) pp.

FSI, (2021). India State of Forest Report, Dehradun.

GUIDE (2012). Development of berthing and allied facilities off-Tekra near Tuna: Mangrove preservation and management plan. Report submitted by Gujarat Institute of Desert Ecology (GUIDE) to Kandla Port Trust (KPT), Gandhidham.

GUIDE (2015). Study on present status, conservation and management plan for mangroves of Kandla Port Region. Report submitted by Gujarat Institute of Desert Ecology (GUIDE) to Kandla Port Trust (KPT), Gandhidham.

GUIDE (2018). Assessment and monitoring of Mangrove plantation (1400 ha) carried out by Deendayal Port Trust, Kandla. Final report. Submitted to DPT by Gujarat Institute of Desert Ecology, September 2018.

Hong, S. Y., & Pan, H. L., (1996). Nonlocal boundary layer vertical diffusion in a medium-range forecast model. Monthly weather review, *124*(10), 2322-2339.

IUCN and UNEP-WCMC (2017). The World Database on Protected Areas (WDPA) [0nline] Available online at: www.protectedplanet.net

IPCC (2013). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptationsn (SREX), Spec.Rep., 594pp., Cambridge Univ. Press, Cambridge, U.K.

Koch, M. S., and Snedaker, S. C., (1997). Factors influencing Rhizophora mangle L. seedling development in Everglades carbonate soils, Aquat. Bot. 59 87–98 10.1016/S0304-3770(97)00027-2

Kodikara, K. A. S., Mukherjee, N., Jayatissa, L. P., Dahdouh-Guebas, F., & Koedam, N., (2017). Have mangrove restoration projects worked? An in-depth study in Sri Lanka. Restor. Ecol, *25*(5), 705-716.

Komiyama, A., Poungparn, S., & Kato, S. (2005). Common Allometric Equations for Estimating the Tree Weight of Mangroves. Journal of Tropical Ecology, 21, 471-477.

Kumar Sahu, &, K. Kathiresan. (2019). The age and species composition of mangrove forest directly influence the net primary productivity and carbon sequestration potential. Biocatalysis and agricultural biotechnology, 20, 101235

Lasco, R. D., (2004). The clean development mechanism and LULUCF projects in the Philippines. International Symposium/Workshop on the Kyoto Mechanism and the Conservation of Tropical Forest Ecosystems, pp. 53-57, Waseda University.

Lewis, W. W., (2005). The power of productivity. In The Power of Productivity. University of Chicago Press.

Locatelli, T., Binet, T., Kairo, J. G., King, L., Madden, S., Patenaude, G., Upton, C. and Huxham, M., (2014). 'Turning the tide:how blue carbon and payments for ecosystem services (PES) might help save mangrove forests', Ambio, 43(8), pp. 981–995. doi:10.1007/s13280-014-0530-y.

Lovelock.C.E, Fernanda Adame, M., Don W. Butler, Jeffrey J. Kelleway., Sabine Dittmann., Benedikt Fest., Karen J. King., Peter I. Macreadie., Katherine Mitchell., Mark Newnham., Anne Ola., Christopher J. Owers., Nina Welti. (2022). Modeled approaches to estimating blue carbon accumulation with mangrove restoration to support a blue carbon accounting method for Australia. Limnol. Oceanogr. doi: 2022, 1–11.,10.1002/lno.12014

Maity, Swapan and Maiti, Ramkrishna. (2012). Local scour at and around vertical hydraulic structure - A case study around the piers of bridges on Rupnarayan River. Indian Science Cruiser. 26. 38-46.

Matsui, M., Suekuni, J., Nogami, M., Havanond, S. Salikul, P., (2010). Mangrove rehabilitation dynamics and soil organic carbon change as a result of full hydraulic restoration and regarding of a previously intensively managed shrimp pond. Wetland Ecol. Manag., Vol. 18: 233-242.

McGuinness, D., (1997). Why Our Children Can't Read, and what We Can Do about it: A Scientific Revolution in Reading. Simon and Schuster.

McKee, T. B., (1995). Drought monitoring with multiple time scales. In Proceedings of 9th Conference on Applied Climatology, Boston, 1995.

Miller, R. W., & Donahue, R. L. (1990). Soils: an introduction to soils and plant growth (No. Ed. 6).Prentice-Hall International Inc..

Petrokofsky, G., Kanamaru, H. et al. (2012). Comparison of methods for measuring and assessing carbon stocks and carbon stock changes in terrestrial carbon pools. How do Accuracy and precision of current methods compare? A systematic review protocol. Environ. Evi. 1-6.

Quarto, A., (2013) 'Ecological Mangrove Restoration (EMR): Re-establishing a more biodiverse and resilient coastal ecosystem with community participation', J. Chem. Inf. Model, 53(9), pp. 1689–1699. doi: 10.1017

Ragavan, R., Saxena, A., Jayaraj, R. S. C., Mohan, P. M., Ravichandran K, S. Saravanan and Vijayaraghavan, A., (2016). A review of the mangrove floristics of India. Taiwania 61:224–242.

Saravanakumar, A., Rajkumar, Serebiah, M., Thivakaran S.J, G.A., (2008). Seasonal variations in physico-chemical characteristics of water, sediment and soil texture in arid zone mangroves of Kachchh-Gujarat, J. Environ. Biol.29 (5):725-732.

Shaw,K. (2006). Determination of organic carbon in soil and plant material. Eur. J. Soil Sci 10(2):316 – 326.

Smith, R. L., (1987). Estimating tails of probability distributions. Ann. Stat., 1174-1207.

Spalding, Mark, D and Leal, Maricé (editors)., (2021) The State of the World's Mangroves 2021. Global Mangrove Alliance.

Steven, Bouillon, Alberto V, Borges, Edward Casteneda-Moya, Karen Diele, Throsten Dittmar, Norman C. Duke, Erik Kristensen, Shing Y. Lee, Cyril Marchand, Jack J. Middleberg, Victor H. Riviera-Monroy and Thomos J. Smith., (2008). Mangrove production and carbon sinks, A revision of global budget estimates. Global Biochemical Cycles, 22, 1-12.

Tandon, H.L.S., (2005). Methods of analysis of soils, plants, water and fertilizers. New Delhi: Fertilizer Development and Consultation Organization.

Twilley, R. R., Chen, R. H., and Hargis, T., (1992). Carbon sinks in mangroves and their implications to carbon budget of tropical coastal ecosystems. WAT. AIR AND SOIL POLL. *64*(1), 265-288.

Walters, B. B., Rönnbäck, P., Kovacs, J. M., Crona, B., Hussain, S. A., Badola, R., Primavera, J. H., Barbier, E. and Dahdouh-Guebas, F., (2008) 'Ethnobiology, socio-economics and

management of mangrove forests: A review', Aquat. Bot, 89(2), pp.220–236. doi: 10.1016/j.aquabot.2008.02.009.
Wylie, L., Sutton-Grier, A. E. and Moore, A., (2016) 'Keys to successful blue carbon projects: Lessons learned from global case studies', Mar. Policy, 65, pp. 76–84. doi: 10.1016/j.marpol.2015.12.020.
Yee, S. M., (2010). REDD and BLUE Carbon: Carbon Payments for Mangrove Conservation. MAS Marine Biodiversity and Conservation Capstone Project.

******

ANNEXURE F

ENVIRONMENTAL MONITORING REPORT
FOR DEENDAYAL PORT AUTHORITY

REPORT	:	DCPL/DPA/21-22/31
Mont	:	November 01
Issue	:	00
Revision	:	00
Prepare	:	DETOX CORPORATION PVT. LTD.,

Index

EXECUTIVE SUMMARY

ENVIRONMENTAL MONITORING PLAN FOR DEENDAYAL PORT ENVIRONMENTALMONITORING REPORT- NOVEMBER, 2022

1. EXECUTIVE SUMMARY

Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the national standards and any other relevant standards by GBCB/CPCB/MoEF & CC to understand status of various parameters in the Environment of the Deendayal Port. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port.

A) Ambient Air

The monitoring of Ambient Air quality at 6-locations at Deendayal Port Authority Kandla and 2- location at Vadinar Port on 24 hourly basis for TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3, CO_2, CO, C_6H_6 and NMHC in twice a week 24 hourly at uniform intervals (as per NAAQS) at Gopalpuri, Tuna Port, Marine Bhavan Building, Coal storage area, Estate building, Oil jetty and at Vadinar port, Vadinar Jetty and Vadinar colony area using respirable dust sampler, Fine particulate sampler and gaseous sampler.

The Maximum TSPM values in month of November 2022 were found 846 µg/m^3 at Coal Storage area on 25.11.2022 and minimum 107 µg/m^3 at Gopalpuri Hospital on 01.11.2022. The Maximum PM_{10} values were 654 µg/m^3 at Coal Storage area on 25.11.2022 and minimum was 67 µg/m^3 at Gopalpuri Hospital 01.11.2022. Maximum $PM_{2.5}$ values were 187 µg/m^3 at Coal Storage area on 25.11.2022 and minimum was 34 µg/m^3 at Gopalpuri on 01.11. 2022. The PM_{10} and $PM_{2.5}$ values were found for all monitoring locations (Marine Bhavan Building, Oil Jetty, Estate Office, Gopalpuri, Coal Storage Area and Tuna Port) to exceed the Standard limit (NAAQS).

At Gopalpuri location the mean concentration of PM_{10} was 127 µg/m^3 & $PM_{2.5}$ was 66 µg/m^3 which are slightly exceed the Standard limit (NAAQS).

The AAQ monitoring for Vadinar at Admin building the mean TSPM, PM_{10} and $PM_{2.5}$ were 237µg/m^3, 138 µg/m^3 and 97 µg/m^3 respectively which was exceed the Standard limit (NAAQS) the while at Signal Building the mean TSPM, PM_{10} and $PM_{2.5}$ were 113 µg/m^3 , 74 µg/m^3 and 38 µg/m^3 respectively slightly exceed the Standard limit (NAAQS).

The overall values of November for Gaseous SO_2, NO_2, NH_3, CO_2, CO, C_6H_6 concentration were within the permissible limit at all location and NMHC were found BQL (Below Quantification Limit).

B) Weather

The mean day time temperature at Deendayal Port was 27.92 °C. The day-time maximum temperature was 32.9°C and minimum was 21.1 °C. The mean night time temperature recorded was 25.47 °C. The night-time maximum temperature was 29.7°C and minimum was 20.0 °C. The mean Solar Radiation in November month was 167.27 w/m^2. The maximum solar radiation was recorded 759 w/m^2 in 4th November, 2022 and the minimum solar radiation was recorded 1.80 w/m^2 in 30th November, 2022. The mean Relative humidity was 69.00 % for the month of November. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 34.0 %. The average wind velocity for the entire month of November was 1.21 m/s. Maximum wind velocity was recorded 10.19 m/s. The wind direction was mostly West-South.

C) Marine Ecology (Flora and Fauna) / Marine Water / Sediments:

The results obtained from the study for the month of November 2022 for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.

D) Drinking Water Quality

The drinking water being supplied to Deendayal Port Authority was safe for drinking purpose. At all drinking water monitoring stations around port area were in line with the standard limit as per the drinking water specifications given in IS 10500:2012 as per tested parameters only.

The average results for 20 locations were as: pH were found Min 7.24 and maximum 7.52, TDS were found min 300.0 mg/l and Max found 1060.0 mg/l, Chloride were found Min 140.31 mg/l and Max 576.28 mg/l, Total Hardness were found Min 270.0 mg/l and Max 380.0 mg/l and Calcium were found Min 34.47 mg/l and Max 43.29 mg/l, color were colorless and odor were odorless. In all water samples BOD, Heavy metal like manganese, Hexavalent chromium, Copper, Cadmium, Arsenic, Mercury, Lead, zinc all are found BQL (Below Quantification Limit). The bacterial count (E-coli & Coliform) is absent in all drinking water samples.

E) Monitoring Performance of Sewage Treatment Plant

It was seen that the performance of STP at Deendayal Township Gopalpuri, DPA STP Plant Kandla and Vadinar STP plant was satisfactory by overall. The treatment plant was well maintained during [November 2022] with considerable removal efficiency achieving the standards prescribed for final disposal. At Gopalpuri STP, the pollutant removal efficiency for TSS, BOD and COD was ranged from 49.66-81.04%, 58.97-68.42% and 45.45-73.33% respectively. At Kandla STP, removal efficiency for TSS, BOD and COD was ranged from 53.47-73.49%, 46.15-76.74% and 50.00-82.35% respectively & at Vadinar STP removal efficiency for TSS, BOD and COD was ranged from 42.09-56.69%, 50.00-78.12% and 60.00-84.61% respectively. At all STP location treated waste water the pH were ranged from 7.21-7.42,Total Suspended Solids were found 16.9-67.9 mg/l , Residual Chlorine were below Detection Limit (< 0.5) , COD were found 20-60 mg/l and 3day BOD @ 27 °C were found 7.0-16.0 mg/l.

F) Noise

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 10 locations at Deendayal Port Authority ranged from 53.2 dB(A) to 70.4 dB(A) while at Vadinar port 3 location ranged from 52.5 dB(A) to 60.6 dB(A) which was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all locations of Deendayal Port Authority ranged from 45.4 dB to 61.7 dB(A) while at Vadinar port ranged from 52.5 dB (A) to 60.6 dB(A) which was within the permissible limits of 70 dB(A) for the industrial area for the night time.

CHAPTER-1

INTRODUCTION

DEENDAYAL PORT AUTHORITY

1.0 Introduction

About Deendayal Port

The Deendayal Port is situated in the Kandla Creek and is 90 Kms. From the mouth of Gulf of Kachchh. Latitude: 23° 01" N Longitude: 70° 13"E. Deendayal Port's journey began in 1931 with construction of RCC Jetty by Maharao Khengarji. After partition, Deendayal Port's success story has continued and it rise to the No. 1 Port in India in the year 2007-08 and since then retained the position for the 15 consecutive year. On 31.03.2016, Deendayal Port created history by handling 100 MMT cargoes in a year, the first Major Port to achieve the milestone. Kandla, also known as the Deendayal Port Authority is a seaport in Kutch District of Gujarat state in western India, near the city of Gandhidham. 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, after the partition of India from Pakistan left the port of Karachi in Pakistan. The Port of Deendayal is located on the Gulf of Kutch on the northwestern coast of India some 256 nautical miles North West 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. Kandla history Deendayal Port Authority, India's busiest major port in recent years, is gearing to add substantial cargo handling capacity with private sector participation. Deendayal port Authority creates a new record by handling 127.10 million metric tons of cargo during the FY 2021-22, as against 117.566 million metric tons in FY 2020-21. Showing a growth of 8.11 %. Incidentally, DPA is the only major Indian port of handle more than 127 MMT cargo throughout and it has also registered the highest cargo throughput in its history. 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 Sept. 2021. Even as much of this growth has come from handling of crude oil imports, mainly for Essar Oil's Vadinar refinery in Gujarat, the port is also taking measures to boost non-POL cargo. Last fiscal, POL traffic accounted for 63 per cent of the total cargo handled at Deendayal Port, as against 59% in 2007-08. 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 up-gradation has been affected & excellent maritime infrastructure been created at Vadinar for the 32 MMTPA Essar Oil Refinery in Jamnagar District. Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the prescribed standards by GPCB/CPCB/MoEF& CC. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port. The environmental monitoring is carried out as per the Environment Management and Monitoring Plan submitted by Detox Corporation Pvt. Ltd.

CHAPTER-2

AMBIENT AIR QUALITY MONITORING

2. Introduction

Air pollutants are added in the atmosphere from variety of sources that change the composition of atmosphere and affect the biotic environment. The concentration of air pollutants depend not only on the quantities that are emitted from air pollution sources but also on the ability of the atmosphere to either absorb or disperse these emissions. The air pollution concentration vary spatially and temporarily causing the air pollution pattern to change with different locations and time due to changes in meteorological and topographical condition. Air pollution occurs when harmful substances including particulates and biological molecules are introduced into earth's atmosphere. It may cause diseases, allergies or death of humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment. Human activity and natural processes can both generate air pollution. A physical, biological or chemical alteration to the air in the atmosphere can be termed as pollution. It occurs when any harmful gases, dust, smoke enters into the atmosphere and makes it difficult for plants, animals and humans to survive as the air becomes dirty. The consequences of industrialization and the demand for improved quality of life has been increased exposure to air pollution (Vallero, 2014). An air pollutant is a substance in the air that can have adverse effects on humans and the ecosystem. The substance can be solid particles, liquid droplets, or gases. A pollutant can be of natural origin or man-made. Pollutants are classified as primary or secondary. Any gas could qualify as pollution if it reached a high enough concentration to do harm. Theoretically, that means there are dozens of different pollution gases. In practice, about ten different substances cause most concern. Heavy metals represent a class of omnipresent pollutants, with toxic potential, in some cases even at low exposure levels. They concentrate in each tropic level because of their weak mobility, so the concentration in plants is higher than in soil, in herbivore animals higher than in plants, in carnivores' tissues higher than in herbivore, the highest concentration being reached at the end of the tropic chain, at big predacious and human bodies.

Globally, one of the main contributors to emissions of atmospheric pollutants and a significant user of energy is the industrial sector (Conti et al. 2015).

The concentration of air pollutants depends not only on the quantities that are emitted from the polluting sources, but also on the ability of the atmosphere to either absorb or disperse such emissions (USEPA, 2008).

Nowadays, the shipping sector provides low-cost and reliable delivery services in the economic field (Arunachalam et al. 2015). Nevertheless, shipping-related activities have a considerable impact on air pollution, especially in coastal areas but also globally (Buccolieri et al. 2016). The primary air pollutants are PM, VOCs, NOx, O_3, SO_2, and CO (Bailey and Solomon 2004). As a consequence, a wide range of options toward "greener" seaports is needed (Bailey and Solomon 2004). Some of these measures are easy to adopt such as the regulation of fuel quality (by using low-sulfur alternative fuels), the speed reduction (Lack et al. 2011), and the use of alternative transportation equipment (Lai et al. 2011).

Clean air is the basic requirement of all living organisms. In recent times, due to population growth, urban sprawl, industrial development, and vehicular boom, the quality of air is deteriorating and being polluted. Pollutants of major public health concerns include particulate matter, carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide, which pose serious threats to human health and hygiene. In the present study, prime particulate pollutants (PM_{10}, $PM_{2.5}$), and gaseous pollutants (SO_2, and NO_2) were estimated at seven stations in and around Dahej Port, Gujarat, India (Soni and Jagruti Patel, 2017).

Among particulate pollutants, particulate matter (PM) is a ubiquitous entity, and is especially a grave problem due to its higher suspension rate into the atmosphere, and adverse health effects on plants, animals, humans, and materials in the form of visibility reduction, soiling of buildings, etc. (Horaginamani and Ravichandran, 2010; Chaurasia *et al*., 2013).

The sources of air pollutants include vehicles, industries, domestic sources and natural sources. Because of the presence of high amount of air pollutants in the ambient air, the health of the population and property is getting adversely affected. In order to arrest the deterioration in air quality, Govt. of India has enacted Air (Prevention and Control of Pollution) Act in 1981. The responsibility has been further emphasized under Environment (Protection) Act, 1986. It is necessary to assess the present and anticipated air pollution through continuous air quality survey/monitoring programs. Therefore, Central Pollution Control Board had started National Ambient Air Quality Monitoring (NAAQM) Network during 1984 - 85 at national level. The programme was later renamed as National Air Quality Monitoring Programme (NAMP).

2.1 Ambient Air Quality Monitoring

As per the Environmental Monitoring Plan of Deendayal Port Authority, Air monitoring was carried out at six identified locations at Deendayal Port and two locations at Vadinar Port.

Table: 1. Ambient Air Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude	Remarks
1.	Marine Bhavan	AL-1	23° 0' 26.524"N	70° 13' 22.414"E	**DPA-Kandla**
2.	Oil Jetty	AL-2	23° 1' 45.613"N	70° 13' 11.052"E	
3.	Estate Office	AL-3	23° 1' 11.273"N	70° 12' 48.657"E	
4.	Gopalpuri Hospital	AL-4	23° 4' 53.551"N	70° 8' 7.047"E	
5.	Coal Storage Area	AL-5	22° 59' 31.812"N	70° 13' 9.979"E	
6.	Tuna Port	AL-6	22° 59' 15.291"N	70° 58' 57.018"E	
7.	Signal Building	AL-7	22° 26' 26.750"N	69° 40' 22.127"E	**DPA-Vadinar**
8.	Admin Building	AL-8	22° 26' 25.223"N	69° 40' 19.358"E	

- **Air Quality Monitoring Methodology**

  Air quality is measured in all the stations, for 24 hour for Total Suspended Particulate Matter (TSPM), PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3 & Benzene and Grab-sampling for CO & CO_2 measurements. The Air samplers are operated for a period of 24 hours and after a continuous operation of 8 hours for gaseous parameters. The absorbing reagents for SO_2:- Absorbing Reagent TCM (Potassium Tetrachloromercurate 0.04M): Mercuric Chloride, Potassium Chloride and EDTA used. For NO_2:- Absorbing Reagent Sodium Hydroxide (NAOH): Sodium Hydroxide and Sodium Arsenite used. For NH_3 need Conc. Sulphuric Acid and Distilled water was used. By replacing 3 times the reagents per day for each parameter namely, SO_2, NO_2, NH_3. The GFA filter paper and PTFE Membrane bound filter paper are used for a period of 24 hours to obtain one sample each of TSPM, PM_{10} & $PM_{2.5}$. The AAQ samples are collected two consecutive days a week as per CPCB guidelines, from all the eight locations as mentioned in the EMP.

2.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony, Gopalpuri Hospital, Tuna Port and Nr. Coal Storage Area for the month of November 2022 are given in Tables 2 to 7. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building & Nr. Signal Building) are given in Tables 8 to 9.

The Movement of heavy transport with uncovered coal transportation, raw road around ambient location may be causes fugitive dust emission from dry conditions. Particulate Matter then enters the atmosphere through the action of wind, vehicular movement, or other activities. The dust produces tends to float in air and spread all around the vicinity. Direction and speed of wind affect the dispersion of the dust particulate matter. Humidity of air also has strong effect on the spreading of particulate matter. With increasing humidity, moisture particles eventually grow in size to a point where 'dry deposition' occurs, reducing PM_{10} concentrations in the atmosphere.

Location 1: Marine Bhavan (AL1)

Table 2 : Results of Air Pollutant Concentration at Marine Bhavan										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL1 – 1	01.11.2022	435	302	121	3.93 6.04 1.81	3.93	5.19 23.66 14.43	14.43	2.07 6.33 3.91	4.11
AL1 – 2	04.11.2022	344	228	106	3.32 2.72 1.51	2.52	17.31 8.66 12.12	12.70	2.42 5.18 3.57	3.72
AL1 – 3	08.11.2022	398	281	116	2.31 6.34 2.88	3.84	25.39 17.89 8.66	17.31	4.72 2.42 3.57	3.57
AL1 – 4	11.11.2022	445	315	124	3.63 9.07 6.35	6.35	17.89 12.70 8.66	13.08	4.03 4.72 2.07	3.61
AL1 – 5	15.11.2022	364	253	110	4.53 6.35 2.72	4.53	11.54 19.62 10.39	13.85	4.60 2.88 1.73	3.07
AL1 - 6	18.11.2022	442	315	121	8.46 3.32 2.72	4.84	23.08 8.66 17.89	16.54	3.22 5.87 4.03	4.37
AL1 - 7	22.11.2022	375	266	106	3.32 7.55 2.42	4.43	17.89 25.97 11.54	18.47	4.83 5.87 2.65	4.45
AL1 – 8	25.11.2022	483	350	129	4.53 6.95 2.42	4.63	23.66 28.86 12.12	21.55	3.22 5.29 2.53	3.68
AL1 – 9	29.11.2022	534	383	142	6.35 8.46 2.72	5.84	17.89 25.97 13.27	19.04	3.57 4.95 2.19	3.57
Monthly Average		424	299	119		4.55		16.33		3.79
Standard Deviation		61	48	12		1.12		3.03		0.44

Table 2 : Results of Air Pollutant Concentration at Marine Bhavan					
	Date	**C6H6 [µg/m3]**	**HC**	**CO [mg/m3]**	**CO2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**	**ppm**	**4.0 mg/m3**	**-**
AL1 – 1	01.11.2022	1.09	BQL	1.44	444
AL1 – 2	04.11.2022	1.2	BQL	1.54	374
AL1 – 3	08.11.2022	1.17	BQL	1.08	538
AL1 – 4	11.11.2022	1.1	BQL	1.14	470
AL1 – 5	15.11.2022	1.11	BQL	1.26	481
AL1 - 6	18.11.2022	1.1	BQL	1.64	500
AL1 - 7	22.11.2022	1.12	BQL	1.35	620
AL1 - 8	25.11.2022	1.16	BQL	1.69	511
AL1 - 9	29.11.2022	1.21	BQL	1.16	522
Monthly Average		**1.14**	**-**	**1.37**	**495.56**
Standard Deviation		**0.05**	**-**	**0.22**	**67.59**

* NMHC- Non- Methane Hydrocarbons

BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 424 µg/m^3, the mean PM_{10} value was 299 µg/m^3, and $PM_{2.5}$ value was 119 µg/m^3 which is above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 4.55 µg/m^3, 16.33 µg/m^3 & 3.79 µg/m^3 respectively; these values were within the standard limit prescribed by NAAQS.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.14 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.37 mg/m^3, well below the permissible limit of 4.0 mg/m^3 prescribed by NAAQS.

Location 3: Oil Jetty (AL2)

Table 2 : Results of Air Pollutant Concentration at Oil Jetty										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL2 -1	01.11.2022	150	99	50	2.42 4.53 2.72	3.22	6.35 13.27 21.35	13.66	2.88 6.79 3.91	4.53
AL2 -2	04.11.2022	253	180	70	2.72 3.32 4.53	3.53	5.77 17.89 11.54	11.73	0.81 4.03 4.72	3.18
AL2 -3	08.11.2022	235	166	67	2.59 3.46 1.44	2.50	5.19 13.27 23.66	14.04	2.19 2.65 3.57	2.80
AL2 -4	11.11.2022	275	194	76	6.35 4.53 2.72	4.53	10.39 20.20 12.12	14.24	2.42 3.80 1.04	2.42
AL2 – 5	15.11.2022	245	169	71	3.02 6.65 3.93	4.53	8.66 16.16 17.31	14.04	3.57 2.30 1.27	2.38
AL2 – 6	18.11.2022	185	119	53	5.74 2.72 6.35	4.94	14.43 17.31 8.66	13.47	4.95 3.57 2.99	3.84
AL2 – 7	22.11.2022	373	252	109	3.02 6.35 2.72	4.03	20.20 12.12 10.39	14.24	3.80 5.53 2.07	3.80
AL2 -8	25.11.2022	292	199	86	1.81 6.35 3.32	3.83	14.43 19.62 9.23	14.43	3.57 4.72 5.99	4.76
AL1 – 9	29.11.2022	299	194	97	3.63 7.55 2.72	4.63	5.19 23.66 11.54	13.47	2.88 4.95 2.65	3.49
Monthly Average		256	175	75		3.97		13.70		3.47
Standard Deviation		65	45	19		0.79		0.81		0.85

Table 3 : Results of Air Pollutant Concentration at Oil Jetty					
	Date	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL2-1	01.11.2022	1.17	BQL	1.22	467
AL2-2	04.11.2022	1.01	BQL	1.53	451
AL2-3	08.11.2022	1.1	BQL	1.65	502
AL2-4	11.11.2022	1.19	BQL	1.04	447
AL2 –5	15.11.2022	1.24	BQL	1.27	634
AL2 –6	18.11.2022	1.16	BQL	1.22	531
AL2-7	22.11.2022	1.2	BQL	1.28	800
AL2-8	25.11.2022	1.06	BQL	1.89	1023
AL2-9	29.11.2022	1.22	BQL	1.46	576
Monthly Average		**1.15**	**-**	**1.40**	**603.44**
Standard Deviation		**0.08**	**-**	**0.26**	**193.07**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

Oil Jetty Area, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 was mainly by motor vehicle emission produced from various types of vehicles at Oil Jetty Area. The mean TSPM value at Oil Jetty was 256 µg/m^3. The mean PM_{10} value was 175 µg/m^3 and mean $PM_{2.5}$ value was 75 µg/m^3 which was above the permissible limit. The average values of SO_2, NO_2 and NH_3 were within the permissible limit prescribed by NAAQS. The mean concentration of SO_2, NO_2 and NH_3 were 3.97 µg/m^3, 13.70 µg/m^3 and 3.47 µg/m^3 respectively.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Oil Jetty. The mean Benzene concentration was 1.15 µg/m^3 which was well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.40 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 3: Kandla Colony – Estate Office (AL-3)

Table 4 : Results of Air Pollutant Concentration at Estate Office										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL3 – 1	01.11.2022	245	172	69	1.51	2.32	10.39	9.62	3.68	5.10
					3.32		13.27		7.02	
					2.12		5.19		4.60	
AL3 – 2	04.11.2022	577	445	130	4.53	2.32	5.19	10.39	3.57	2.49
					1.51		17.31		2.88	
					0.91		8.66		1.04	
AL3 – 3	08.11.2022	440	321	109	6.05	3.94	19.04	12.31	4.72	3.64
					2.59		12.12		2.42	
					3.17		5.77		3.80	
AL3 – 4	11.11.2022	518	403	111	3.32	4.23	18.47	10.58	1.38	2.42
					2.72		8.66		3.57	
					6.65		4.62		2.30	
AL3 – 5	15.11.2022	451	340	107	1.81	3.73	23.08	15.97	3.22	2.42
					6.04		14.43		2.30	
					3.32		10.39		1.73	
AL3 – 6	18.11.2022	459	346	112	4.53	4.43	16.16	15.97	5.76	4.14
					2.72		8.66		4.72	
					6.04		23.08		1.96	
AL3 – 7	22.11.2022	453	325	116	2.42	4.33	19.62	17.31	3.91	3.84
					4.23		23.66		5.18	
					6.35		8.66		2.42	
AL3 – 8	25.11.2022	337	252	83	6.04	3.93	15.00	15.58	3.80	3.91
					3.32		23.08		5.76	
					2.42		8.66		2.19	
AL1 – 9	29.11.2022	491	359	129	4.84	4.63	17.89	16.16	3.57	3.57
					6.95		24.24		5.18	
					2.12		6.35		1.96	
Monthly Average		441	329	107		3.76		13.77		3.50
Standard Deviation		98	80	20		0.87		3.00		0.91

Table 4 : Results of Air Pollutant Concentration at Estate Office					
Sampling Period	**Date**	**C_6H_6 [µg/m³]**	***NMHC**	**CO [mg/m³]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL3 -1	01.11.2022	1.06	BQL	1.27	508
AL3 -2	04.11.2022	1.1	BQL	1.19	508
AL3 -3	08.11.2022	1.1	BQL	1.65	502
AL3 -4	11.11.2022	1.09	BQL	1.83	429
AL3 – 5	15.11.2022	1.09	BQL	1.76	813
AL3 – 6	18.11.2022	1.2	BQL	1.14	559
AL3 – 7	22.11.2022	1.19	BQL	2.18	1022
AL3 – 8	25.11.2022	1.11	BQL	2	1026
	29.11.2022	1.06	BQL	1.22	537
Monthly Average		**1.11**	**-**	**1.58**	**656.00**
Standard Deviation		**0.05**	**-**	**0.39**	**234.02**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Kandla Port Colony (Estate Office) was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Estate Office were 441 µg/m³, the mean PM_{10} value was 329 µg/m³, and $PM_{2.5}$ value was 107 µg/m³ which was above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 3.76 µg/m³, 13.77 µg/m³ and 3.50 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.11 µg/m³, well below the permissible limit of 5.0 µg/m³. NMHC's were below the detectable limit and Carbon Monoxide was 1.58 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 4: Gopalpuri Hospital (AL-4)

Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL4 -1	01.11.2022	107	67	34	1.21	2.22	5.77	6.93	2.42	2.53
					3.02		10.39		4.14	
					2.42		4.62		1.04	
AL4 -2	04.11.2022	177	117	54	0.91	2.22	5.19	10.00	1.61	2.49
					4.53		8.66		2.42	
					1.21		16.16		3.45	
AL4 -3	08.11.2022	148	101	44	1.15	2.21	6.93	9.81	1.73	1.69
					2.88		17.31		2.42	
					2.59		5.19		0.92	
AL4 -4	11.11.2022	184	111	68	1.51	2.62	6.93	12.89	1.04	2.30
					3.63		14.43		2.42	
					2.72		17.31		3.45	
AL4 – 5	15.11.2022	202	125	72	2.12	2.42	12.12	12.70	2.42	2.49
					3.63		8.66		3.45	
					1.51		17.31		1.61	
AL4 – 6	18.11.2022	233	153	78	1.21	2.92	8.66	12.89	2.42	2.49
					4.84		17.89		1.61	
					2.72		12.12		3.45	
AL4 – 7	22.11.2022	268	168	94	0.60	2.22	5.77	12.70	1.73	2.88
					3.32		14.43		3.68	
					2.72		17.89		3.22	
AL4 – 8	25.11.2022	202	142	56	2.12	3.42	14.43	12.50	2.07	2.99
					5.14		17.89		4.03	
					3.02		5.19		2.88	
AL1 – 9	29.11.2022	249	157	91	3.02	4.03	8.66	11.54	1.38	2.49
					6.35		20.20		3.80	
					2.72		5.77		2.30	
Monthly Average		197	127	66		2.70		11.33		2.49
Standard Deviation		50	32	20		0.65		2.05		0.37

Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital					
Sampling Period	**Date**	**C_6H_6 [µg/m³]**	***NMHC**	**CO [mg/m³]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL4 -1	01.11.2022	1.14	BQL	1.26	503
AL4 -2	04.11.2022	1.15	BQL	1.26	450
AL4 -3	08.11.2022	1.03	BQL	1.73	506
AL4 -4	11.11.2022	1.02	BQL	1.82	462
AL4 – 5	15.11.2022	1.09	BQL	1.04	1048
AL4 – 6	18.11.2022	1.14	BQL	1.32	543
AL4 – 7	22.11.2022	1.16	BQL	1.83	758
AL4 – 8	25.11.2022	1.22	BQL	1.8	816
AL4 – 9	29.11.2022	1.16	BQL	1.36	665
Monthly Average		**1.12**	**-**	**1.49**	**639.00**
Standard Deviation		**0.07**	**-**	**0.30**	**201.83**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Gopalpuri Hospital were 197 µg/m³, the mean PM_{10} value was 127 µg/m³ and $PM_{2.5}$ was 66 µg/m³ which was exceed the standard limit. The average values of SO_2, NO_2 and NH_3 were 2.70 µg/m³, 11.33 µg/m³ and 2.49 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.12 µg/m³, well below the permissible limit of 5.0 µg/m³. NMHC's were below the detectable limit and Carbon monoxide concentration was 1.49 mg/m³ which is well below the permissible limit of 4.0 mg/m³.

Location 5: Coal Storage Area (AL-5)

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL6 – 1	01.11.2022	779	598	175	2.72 6.65 3.63	4.33	6.35 25.97 17.31	16.54	3.68 8.17 3.34	5.06
AL6 – 2	04.11.2022	635	492	137	2.12 5.44 3.02	3.53	23.08 12.12 17.89	17.70	6.79 8.17 4.83	6.60
AL6 – 3	08.11.2022	538	412	125	8.94 3.46 2.59	5.00	23.66 12.12 29.43	21.74	2.53 2.07 7.02	3.88
AL6 – 4	11.11.2022	815	635	178	4.53 2.72 6.95	4.73	18.47 8.66 25.97	17.70	5.87 2.65 4.72	4.41
AL6 – 5	15.11.2022	792	614	176	6.35 9.07 4.53	6.65	18.47 10.39 12.12	13.66	4.72 3.68 3.22	3.88
AL6 – 6	18.11.2022	771	595	171	9.37 5.74 6.35	7.15	20.20 8.08 23.08	17.12	4.83 2.53 5.76	4.37
AL6 – 7	22.11.2022	706	543	156	4.84 6.04 2.72	4.53	10.39 23.66 21.35	18.47	4.83 5.99 4.26	5.03
AL6 – 8	25.11.2022	846	654	187	3.32 7.86 4.53	5.24	17.31 25.97 16.16	19.81	3.91 6.91 4.03	4.95
AL1 – 9	29.11.2022	801	621	172	5.14 9.07 2.72	5.64	16.16 28.86 9.81	18.28	3.57 6.22 3.11	4.30
Monthly Average		743	574	164		5.20		17.89		4.72
Standard Deviation		99	78	21		1.14		2.22		0.84

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL5 – 1	01.11.2022	1.1	BQL	1.12	483
AL5 – 2	04.11.2022	1.06	BQL	1.48	475
AL5 – 3	08.11.2022	1.08	BQL	1.66	421
AL5 – 4	11.11.2022	1.06	BQL	1.69	492
AL5 – 5	15.11.2022	1.06	BQL	1.06	702
AL5 – 6	18.11.2022	1.22	BQL	1.18	483
AL5 – 7	22.11.2022	1.11	BQL	1.86	564
AL5 – 8	25.11.2022	1.2	BQL	1.54	777
AL5 – 9	29.11.2022	1.22	BQL	1.89	895
Monthly Average		**1.12**	**-**	**1.50**	**588.00**
Standard Deviation		**0.07**	**-**	**0.31**	**164.11**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 743 µg/m^3, the mean PM_{10} value was 574 µg/m^3, and the $PM_{2.5}$ value was164 µg/m^3 which was above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 5.20 µg/m^3, 17.89 µg/m^3 and 4.72 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was1.12 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.50 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 6: Tuna Port (AL-6)

Table 7 : Results of Air Pollutant Concentration at Tuna Port										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL5 -1	01.11.2022	141	88	47	0.91	1.61	2.89	6.16	2.07	2.84
					2.72		12.12		4.03	
					1.21		3.46		2.42	
AL5 – 2	04.11.2022	232	166	64	1.51	2.22	6.35	7.89	1.38	2.76
					3.02		5.19		4.49	
					2.12		12.12		2.42	
AL5 – 3	08.11.2022	184	120	55	1.44	2.40	10.39	13.08	1.73	2.61
					3.46		11.54		2.65	
					2.31		17.31		3.45	
AL5 – 4	11.11.2022	233	153	78	2.12	2.32	11.54	11.54	1.27	1.57
					3.93		17.89		1.04	
					0.91		5.19		2.42	
AL5 – 5	15.11.2022	221	145	74	1.21	2.32	6.35	12.12	3.57	2.49
					3.32		12.12		2.30	
					2.42		17.89		1.61	
AL5 – 6	18.11.2022	248	162	83	1.81	2.01	17.31	17.12	2.30	10.21
					1.21		23.66		15.57	
					3.02		10.39		12.76	
AL5 – 7	22.11.2022	214	139	74	1.51	2.52	8.66	8.46	3.57	2.84
					2.72		12.70		2.88	
					3.32		4.04		2.07	
AL5 – 8	25.11.2022	255	175	77	2.72	3.02	8.66	8.08	3.45	3.30
					4.84		11.54		4.72	
					1.51		4.04		1.73	
AL1 – 9	29.11.2022	245	155	87	1.51	3.63	12.70	11.73	1.04	2.88
					6.04		17.31		5.18	
					3.32		5.19		2.42	
Monthly Average		219	145	71		2.45		10.69		3.50
Standard Deviation		36	27	13		0.58		3.37		2.56

Table 7 : Results of Air Pollutant Concentration at Tuna Port					
	Date	C_6H_6 [µg/m^3]	*NMHC	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL6 -1	01.11.2022	1.12	BQL	1.43	543
AL6 – 2	04.11.2022	1.17	BQL	1.41	463
AL6 – 3	08.11.2022	1.13	BQL	1.39	410
AL6 – 4	11.11.2022	1.13	BQL	1.74	509
AL6 – 5	15.11.2022	1.17	BQL	1.08	911
AL6 – 6	18.11.2022	1.17	BQL	1.1	528
AL6 – 7	22.11.2022	1.06	BQL	1.88	565
AL6 – 8	25.11.2022	1.1	BQL	1.89	999
	29.11.2022	1.22	BQL	1.89	895
Monthly Average		1.14	-	1.53	647.00
Standard Deviation		0.05	-	0.33	222.45

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The mean TSPM values at Tuna Port was 219 µg/m^3, the mean PM_{10} value was 145 µg/m^3 and the mean $PM_{2.5}$ value was 71 µg/m^3 which was exceed the standard limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 2.45 µg/m^3, 10.69 µg/m^3 and 3.50 µg/m^3 respectively and were all within the standard limit prescribed by NAAQS.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.14 µg/m3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.53 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 7: Admin Building (Vadinar) (AL-7)

Table 8 : Results of Air Pollutant Concentration at Admin Building										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL7 -1	01.11.2022	150	98	51	2.20 4.84 3.52	3.52	9.53 16.51 5.72	10.59	5.36 2.81 7.66	5.28
AL7 -2	04.11.2022	177	115	61	3.08 7.03 3.96	4.69	17.78 21.60 26.04	21.81	2.81 8.93 6.64	6.13
AL7 -3	08.11.2022	193	113	73	6.15 8.79 3.96	6.30	6.99 20.96 6.35	11.43	3.83 10.47 8.17	7.49
AL7 -4	11.11.2022	200	121	78	3.96 5.28 8.79	6.01	17.78 22.23 5.72	15.24	10.47 5.87 4.08	6.81
AL7 -5	15.11.2022	179	108	69	1.76 5.71 8.35	5.28	7.62 26.04 20.33	18.00	3.06 5.87 7.91	5.62
AL7 -6	18.11.2022	223	121	96	2.64 4.40 6.59	4.54	8.89 16.51 19.69	15.03	5.62 8.17 3.32	5.70
AL1 -7	22.11.2022	162	104	57	4.84 7.03 3.96	5.28	14.61 5.72 23.50	14.61	13.02 8.68 5.62	9.10
AL1-8	25.11.2022	237	138	97	6.59 3.96 2.64	4.40	9.53 14.61 21.60	15.24	7.91 5.62 10.47	8.00
AL1-9	28.11.2022	203	112	87	3.96 2.20 4.84	3.66	6.99 14.61 19.69	13.76	5.62 7.91 4.60	6.04
Monthly Average		191	114	74		4.85		15.08		6.68
Standard Deviation		28	12	17		0.96		3.34		1.28

Table 8 : Results of Air Pollutant Concentration at Admin Building Vadinar					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL7 -1	01.11.2022	1.08	BQL	1.43	225
AL7 -2	04.11.2022	1.13	BQL	1.54	236
AL7 -3	08.11.2022	1.17	1.81	1.53	455
AL7 -4	11.10.2022	1.14	BQL	1.61	443
AL7 -5	15.10.2022	1.03	BQL	1.1	347
AL7 -6	18.10.2022	1.06	BQL	1.57	416
AL7 -7	22.10.2022	1.10	BQL	1.05	372
AL7 -8	25.10.2022	1.20	BQL	1.79	464
AL7 -9	28.10.2022	1.13	BQL	1.42	487
Monthly Average		**1.12**	**-**	**1.46**	**388**
Standard Deviation		**0.06**	**-**	**0.25**	**75**

*NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Admin Building, Vadinar the mean TSPM value was 191 µg/m^3, the mean PM_{10} value was 114 µg/m^{3}and the mean $PM_{2.5}$ value was 74 µg/m^3 which was slightly exceed the standard limit. The average values of SO_2, NO_2 and NH_3 concentrations were 4.85 µg/m^3, 15.08 µg/m^3 and 6.68 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.12 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.46 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 8: Signal Building (Vadinar) (AL-8)

Table 9 : Results of Air Pollutant Concentration at Signal Building, Vadinar										
	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS Limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL8 -1	01.11.2022	113	74	38	3.96	4.40	6.99	13.34	2.30	7.15
					6.59		19.05		8.68	
					2.64		13.97		10.47	
AL8 -2	04.11.2022	146	93	49	2.64	4.40	14.61	15.88	5.36	6.13
					4.84		22.23		8.42	
					5.71		10.80		4.60	
AL8 -3	08.11.2022	124	82	42	3.08	3.52	14.61	16.73	5.62	5.62
					5.28		26.04		7.91	
					2.20		9.53		3.32	
AL8 -4	11.11.2022	175	105	67	2.20	4.40	8.26	13.76	8.93	9.02
					7.03		19.05		12.76	
					3.96		13.97		5.36	
AL8 -5	15.11.2022	152	97	52	3.52	4.98	5.72	13.13	6.89	7.57
					4.84		13.34		10.98	
					6.59		20.33		4.85	
AL8 -6	18.11.2022	176	111	61	3.08	3.81	15.24	17.57	7.15	8.42
					3.96		26.04		7.91	
					4.40		11.43		10.21	
AL8 -7	22.11.2022	214	118	93	3.52	5.71	5.72	12.91	7.91	8.25
					5.28		13.34		6.38	
					8.35		19.69		10.47	
AL8-8	25.11.2022	219	125	92	3.08	4.54	9.53	11.01	5.36	6.04
					4.84		17.78		8.17	
					5.71		5.72		4.60	
AL8-9	28.11.2022	154	97	57	5.71	3.81	10.80	16.94	7.15	8.76
					3.96		22.23		8.93	
					1.76		17.78		10.21	
Monthly Average		164	100	61		4.40		14.59		7.44
Standard Deviation		36	16	20		0.67		2.25		1.27

Table 9 : Results of Air Pollutant Concentration at Signal Building Vadinar					
	Date	C_6H_6 [µg/m^3]	*NMHC	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL8 -1	01.11.2022	1.06	BQL	1.5	467
AL8 -2	04.11.2022	1.05	BQL	1.46	501
AL8 -3	08.11.2022	1.14	1.81	1.31	489
AL8 -4	11.11.2022	1.16	BQL	1.38	439
AL8 -5	15.11.2022	1.17	BQL	1.29	231
AL8 -6	18.11.2022	1.10	BQL	1.31	244
AL8 -7	22.11.2022	1.00	BQL	1.34	227
AL8 -8	25.11.2022	1.05	BQL	1.37	261
AL8 -9	28.11.2022	1.02	BQL	1.29	234
Monthly Average		**1.16**	**-**	**1.46**	**442**
Standard Deviation		**0.05**	**-**	**0.27**	**63**

* NMHC- Non- Methane Hydrocarbon
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Signal Building, Vadinar the mean TSPM value was 164 µg/m^3, the mean PM_{10} value was 100 µg/m^3 which was boundary line of the permissible limit, the mean $PM_{2.5}$ value was 61 µg/m^3 which was within the permissible limit. The average values of SO_2, NO_2 and NH_3 concentrations were 4.40 µg/m^3, 14.59 µg/m^3 and 7.44 µg/m^3 respectively and were all within the standard limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.16 µg/m^3, well below the standard limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.46 mg/m^3, well below the standard limit of 4.0 mg/m^3.

Fig. No:-1 Average ambient air qulaity (PM) month of November-2022 at DPA and Vadinar Sampling Station

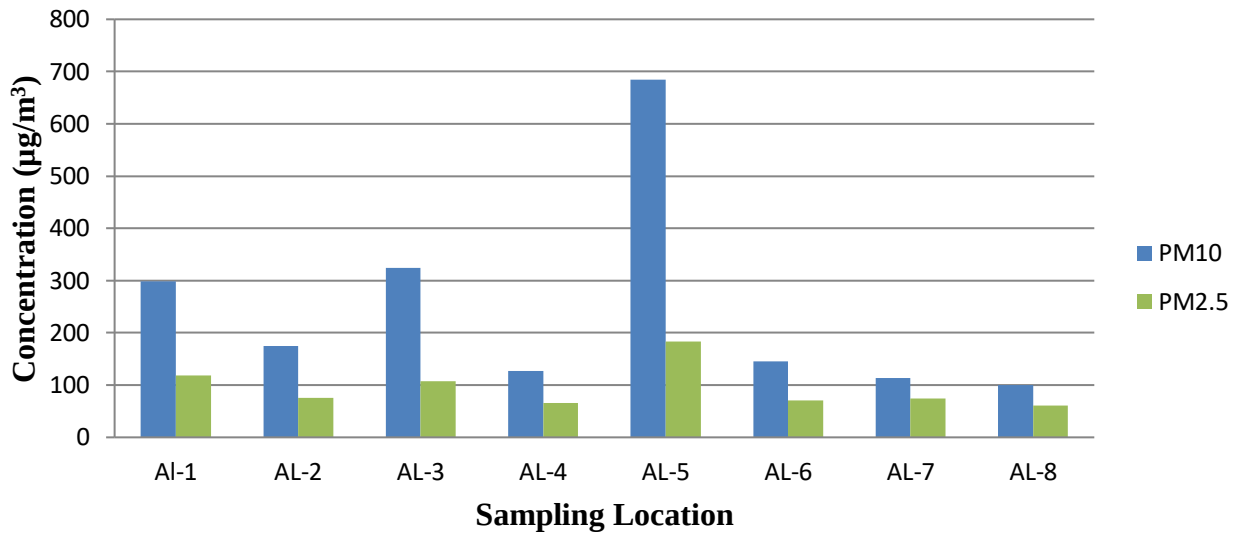


Fig. No:-2. Average ambient air qulaity (Gaseous) month of November-2022 at DPA and Vadinar sampling location

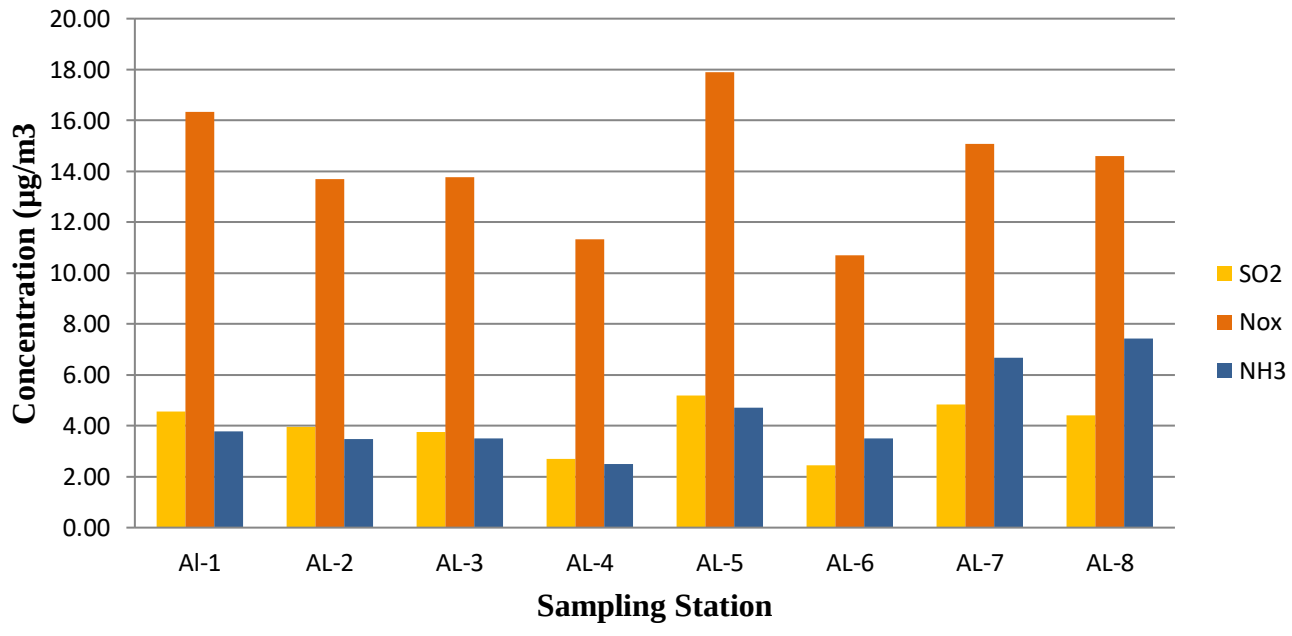


Fig. No:-3. Average ambient air qulaity (Gaseous) month of November-2022 at DPA and Vadinar sampling location

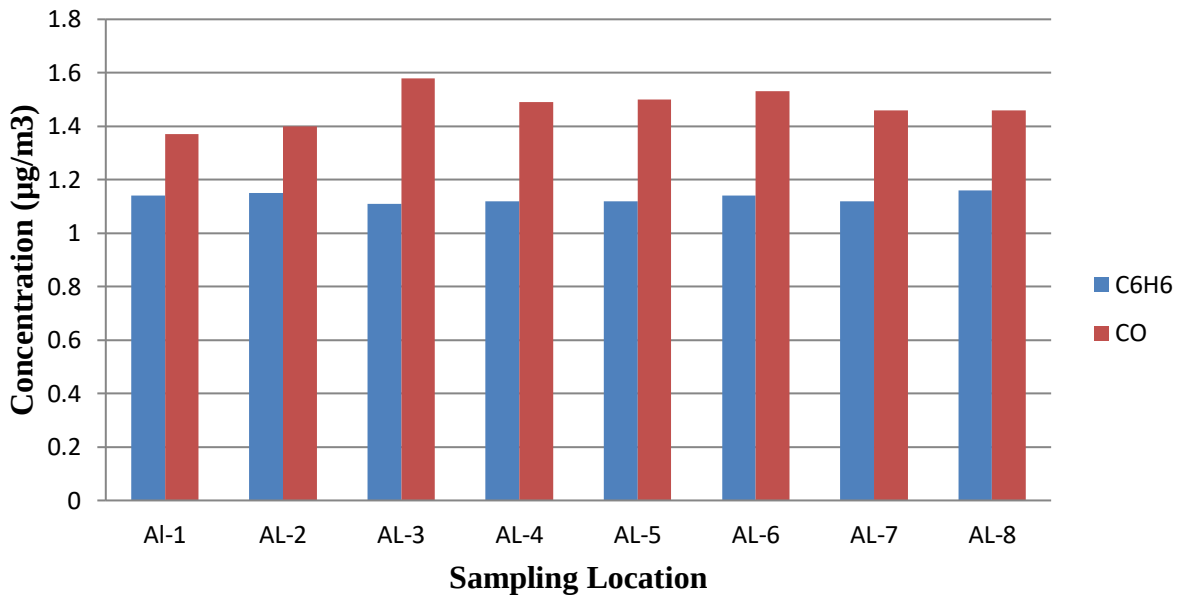
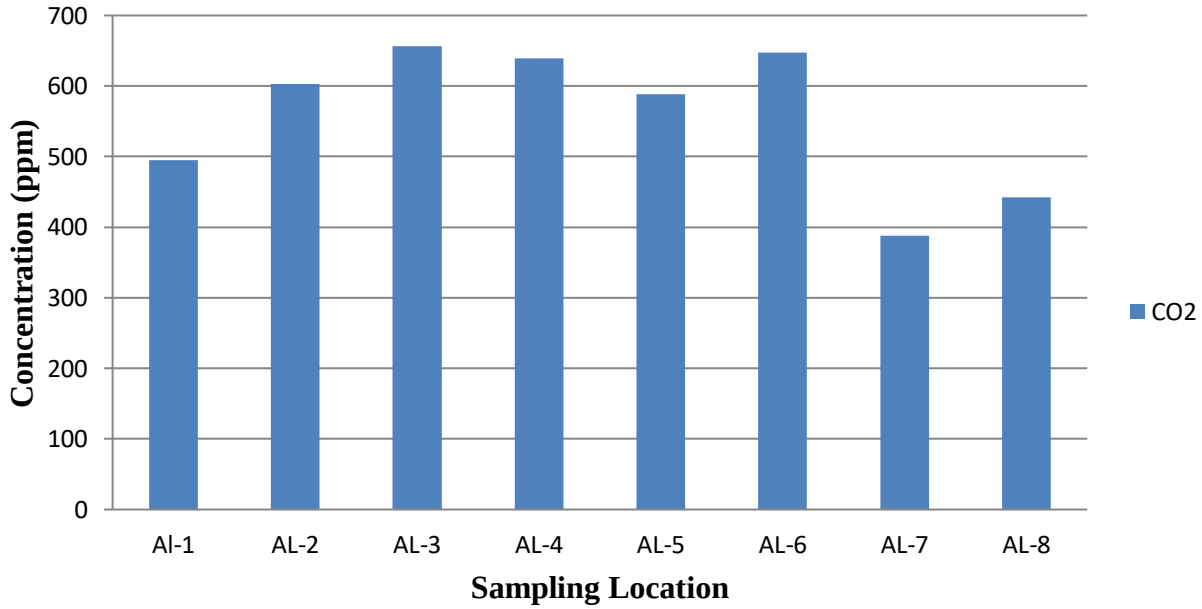


Fig. No:-4. Average ambient air qulaity (Gaseous) month of November-2022 at DPA and Vadinar sampling location



2.3 Observations and Conclusion

During the monitoring period, the overall Ambient Air Quality of the port area was found within permissible levels for various gaseous pollutants. However, Total Suspended Particulate matter as TSPM, Particulate matter as PM_{10} and $PM_{2.5}$ was found to exceed the limits at locations at all ambient air sampling location.

The concentration of PM_{10} and $PM_{2.5}$ were slightly exceeded at Gopalpuri and Tuna Port.

The mean concentration of PM_{10} and $PM_{2.5}$ were slightly exceeded at Admin building Vadinar & at Signal building Vadinar was very close to the standard limit.

CHAPTER-3

METEOROLOGICAL OBSERVATIONS

4.1 Meteorological Data

Automatic Weather station (ID KAZPHOEN424) have been installed in Seva Sadan-3 at the Deendayal Port which records the data on Temperature (°C), Relative Humidity (%),Wind speed (m/s),Wind Direction (°), Solar radiation (w/m^2) and Rainfall mm.

Meteorological factors play an important role in environmental pollution studies particularly in pollutant transport irrespective of their entry into the environment. The wind speed and direction play a major role in dispersion of environment pollutants. Effects of pollution on receptors animate and inanimate depends on atmospheric condition.

Temperature

At Deendayal Port, the day time temperature was found range 21.1-32.9^{0}C. The average day time temperature was 27.92°C. The night time temperature was range from 20.0-29.7^{0}C. The mean night time temperature recorded was 25.47 °C.

Solar Radiation

The mean Solar Radiation in November month was 167.27 w/m^2. The maximum solar radiation was recorded 759.0 w/m^2 in 4th November, 2022 and the minimum solar radiation was recorded 1.80 w/m^2 in 30th November, 2022.

Rainfall

Rain fall of November month was recorded 0.00 mm.

Relative Humidity

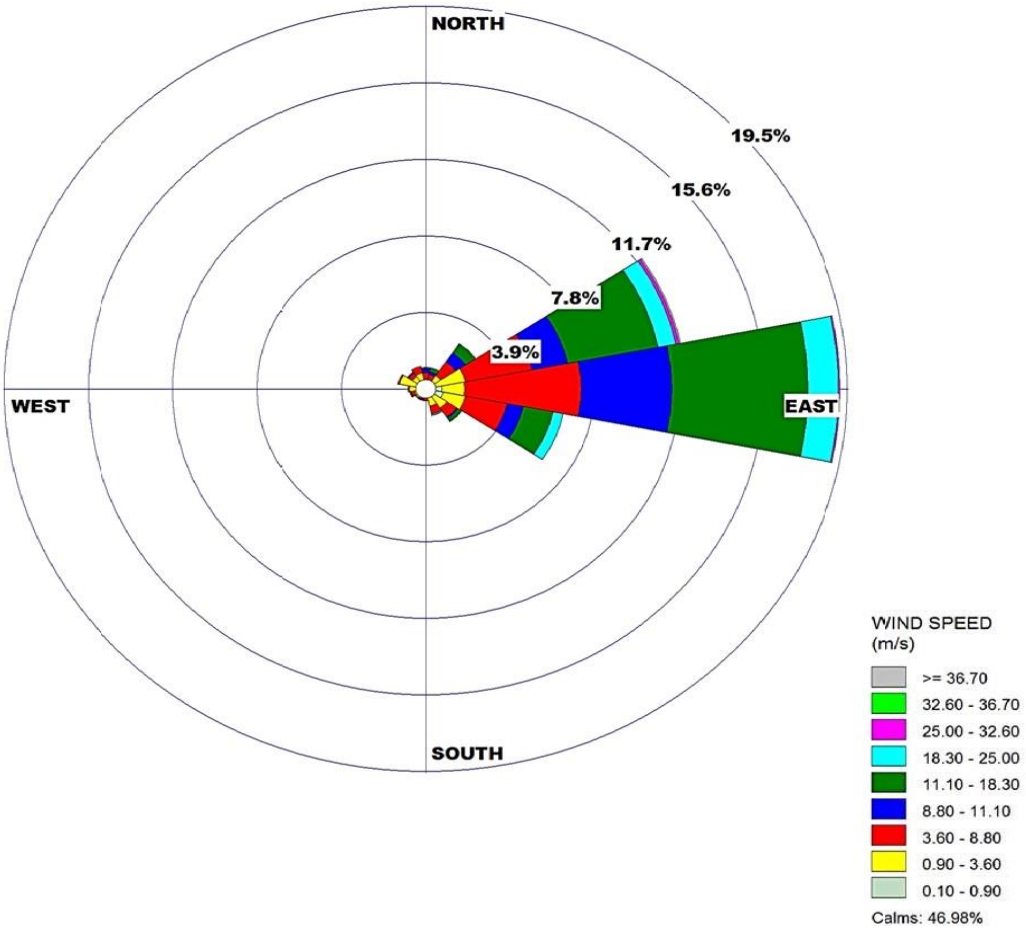
The mean Relative humidity was 69.00 % for the month of November. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 34.0 %.

Wind Velocity and Wind Direction

Velocity and direction of wind have a significant role in the dispersion of air borne materials and therefore determines the air quality of the area. The average wind velocity for the entire month of November was 1.21 m/s. Maximum wind velocity was recorded 10.19 m/s. The wind direction was mostly North-East.

WIND ROSE PLOT:
M/s. Deendayal Port Authority (DPA)
Project Site, Sevasadan-3, Kandla Port.

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:	**DATA PERIOD:** Start Date: 01-11-2022 - 00:00 End Date: 30-11-2022 - 23:00	**COMPANY NAME:** M/s. Deendayal Port Authority (DPA)	
		MODELER: M/s. Eco Chem Sales & Services	
	CALM WINDS: 46.98%	**TOTAL COUNT:** 1438 hrs.	
	AVG. WIND SPEED: 4.33 m/s	**DATE:** 09-12-2022	**PROJECT NO.:**

WRPLOT View - Lakes Environmental Software

CHAPTER-4

DRINKING WATER QUALITY MONITORING

4.0 Drinking Water Quality Monitoring

Drinking Water Quality Monitoring was carried out at twenty stations at Kandla, Vadinar & Township Area of Deendayal Port.

Table No:-10. Drinking Water Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude
1.	Nirman Building	DL-1	23° 0' 27"N	70° 13' 21"E
2.	P & C Building	DL-2	23° 0' 33"N	70° 13' 20"E
3.	North Gate	DL-3	23° 0' 26.97"N	70° 13' 21.87"E
4.	KPT-Canteen	DL-4	23° 2' 17.2674"N	70° 13'18.2814"E
5.	West Gate	DL-5	23° 59' 40.48"N	70° 12' 50.96"E
6.	Wharf Area	DL-6	22° 59' 52.2"N	70° 13' 22.95"E
7.	Sevasadan-3	DL-7	23° 0' 22.55"N	70° 13' 15.34"E
8.	Workshop	DL-8	23° 0' 33.74"N	70° 13' 20.05"E
9.	Custom Building	DL-9	23° 1' 8.70"N	70° 12' 52.0"E
10.	Kandla Colony	DL-10	23° 11' 14.9"N	70° 12' 48.4"E
11.	KPT Hospital	DL-11	23° 1' 5.02"N	70° 12' 44.38"E
12.	A.O. Building	DL-12	23° 3' 42.89"N	70° 8' 41.5"E
13.	Gopalpuri School	DL-13	23° 5' 1.03"N	70° 7' 55.42"E
14	Gopalpuri Guest House	DL-14	23° 4' 43.14"N	70° 7' 51.92"E
15.	E-Type Quarters	DL-15	23° 4' 59.90"N	70° 7' 56.72"E
16.	F-Type Quarters	DL-16	23° 4' 38.45"N	70° 8' 8.63"E
17.	Gopalpuri Hospital	DL-17	23° 4' 54.09"N	70° 8' 7.5"E
18.	Tuna Port	DL-18	23° 58' 23.06"N	70° 5' 35.6"E
19.	Vadinar Jetty	DL-19	22° 25' 51.73"N	69° 41' 36.62"E
20.	Vadinar Colony	DL-20	22° 30' 26.25"N	69° 39' 45.03"E

4.1 Drinking Water Monitoring Methodology

Samples for physico-chemical analysis were collected in 2 Carboys and samples for microbiological parameters were collected in sterilized bottles. These samples were then analyzed in laboratory for various drinking water parameters at Kandla Lab/Surat.

The Sampling was done as per IS: 3025 Part-1, analysis was done as per IS: 3025/APHA standard methods and, the analysis results compare with IS 10500:2012. The water samples were analyzed for various parameters, viz. Color , Odor, Turbidity , Conductivity , pH , Chlorides , TDS, Total Hardness, Iron , Sulphate, Salinity , DO, BOD, Na, K, Ca, Mg, F, NO_3, NO_2, Mn, Cr-6, Cu, Cd, As, Hg, Pb, Zn, Bacterial Count (CFU) .

4.2 Results

The Drinking Water Quality monitoring data for 20 stations are given in below from table No. 11 to Table No. 17

Table 11: Drinking Water Quality Monitoring Parameters for Nirman Building, P & C Building and Main Gate (North) at Kandla.

Sr. No.	Parameter	Unit	Nirman Building 1	P & C Building	Main Gate North	Acceptable Limits as per IS 10500 :2012 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.35	7.33	7.41	7.35	6.5 to 8.5
2	Total Dissolved Solids	mg/l	690	670	670	690	2000
3	Turbidity	NTU	0	1	1	0	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1229	1194	1211	NS*	NS*
7	Biochemical Oxygen	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	576.28	355.79	340.76	250	1000
9	Ca as Ca	mg/l	43.29	41.68	39.28	75	200
10	Mg as Mg	mg/l	58.8060	57.3480	56.3760	30	100
11	Total Hardness	mg/l	350	340	330	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.35	0.37	0.31	1	1.5
14	Sulphate as SO_4	mg/l	35.80	30.20	28.30	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	12.70	16.70	15.50	45	No Relaxation
17	Salinity	‰	1.04	0.64	0.62	NS*	NS*
18	Sodium as Na	mg/l	204.00	180.00	192.00	NS*	NS*
19	Potassium as K	mg/l	3.22	3.15	3.18	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe- 0.009 mg/l, Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu- 0.004 mg/l, Cd- 0.003 mg/l, As- 0.003mg/l, Hg- 0.001 mg/l, Pb- 0.006mg/l, Zinc- 0.021 mg/l).

Table 12: Drinking Water Quality Monitoring Parameters for Canteen, West Gate – I & Wharf Area at Kandla

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as per IS 10500 :	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.48	7.52	7.36	7.48	6.5 to 8.5
2	Total Dissolved Solids	mg/l	640	650	680	640	2000
3	Turbidity	NTU	0	1	0	0	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1166	1152	1196	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	335.75	360.80	350.78	250	1000
9	Ca as Ca	mg/l	40.88	38.48	40.08	75	200
10	Mg as Mg	mg/l	62.6940	66.5820	53.4600	30	100
11	Total Hardness	mg/l	360	370	320	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.32	0.30	0.35	1	1.5
14	Sulphate as SO4	mg/l	31.20	28.30	26.00	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	6.60	11.40	5.80	45	No Relaxation
17	Salinity	‰	0.61	0.65	0.63	NS*	NS*
18	Sodium as Na	mg/l	202.00	200.00	-	NS*	NS*
19	Potassium as K	mg/l	3.38	3.48	3.16	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 13: Drinking Water Quality Monitoring Parameters for Sewa sadan–3, Workshop I and Custom Building at Kandla

Sr. No.	Parameter	Unit	Sewa Sadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.45	7.38	7.29	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	700	670	910	500	2000
3	Turbidity	NTU	0	1	1	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1213	1164	1564	NS*	NS*
7	Biochemical	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	365.81	370.82	340.76	250	1000
9	Ca as Ca	mg/l	42.48	37.68	39.28	75	200
10	Mg as Mg	mg/l	59.2920	59.7780	53.9460	30	100
11	Total Hardness	mg/l	350	340	320	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.41	0.30	0.35	1	1.5
14	Sulphate as SO_4	mg/l	24.90	34.20	27.2	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	6.90	3.90	11.00	45	No Relaxation
17	Salinity	‰	0.66	0.67	0.62	NS*	NS*
18	Sodium as Na	mg/l	-	-	-	NS*	NS*
19	Potassium as K	mg/l	3.26	4.03	3.29	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l, Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 14: Drinking Water Quality Monitoring Parameters for Port Colony Kandla, Hospital Kandla and A.O. Building at Gandhidham.

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 :
1	pH	-	7.39	7.31	7.24	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	760	710	1060	500	2000
3	Turbidity	NTU	1	0	0	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1328	1251	1821	NS*	NS*
7	Biochemical	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	335.75	345.77	365.81	250	1000
9	Ca as Ca	mg/l	41.68	42.48	40.88	75	200
10	Mg as Mg	mg/l	50.0580	54.4320	62.6940	30	100
11	Total Hardness	mg/l	310	330	360	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.35	0.32	0.46	1	1.5
14	Sulphate as SO_4	mg/l	28.10	24.50	24.50	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	20.20	7.40	15.60	45	No Relaxation
17	Salinity	‰	0.61	0.62	0.66	NS*	NS*
18	Sodium as Na	mg/l	192.80	193.60	194.50	NS*	NS*
19	Potassium as K	mg/l	4.13	4.18	3.26	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 15: Drinking Water Quality Monitoring Parameters for School Gopalpuri, Guest House) and E - Type Quarter at Gopalpuri, Gandhidham

Sr. No.	Parameter	Unit	Gopalpuri School	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.3	7.24	7.26	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	830	950	1030	500	2000
3	Turbidity	NTU	1	1	0	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1435	1638	1769	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	355.79	350.78	340.76	250	1000
9	Ca as Ca	mg/l	39.28	43.29	39.28	75	200
10	Mg as Mg	mg/l	61.2360	61.2360	51.5160	30	100
11	Total Hardness	mg/l	350	360	310	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.45	0.42	0.47	1	1.5
14	Sulphate as SO_4	mg/l	24.90	26.00	30.20	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	7.10	8.30	12.60	45	No Relaxation
17	Salinity	‰	0.64	0.63	0.62	NS*	NS*
18	Sodium as Na	mg/l	199.00	193.80	193.00	NS*	NS*
19	Potassium as K	mg/l	3.90	3.26	3.18	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 16: Drinking Water Quality Monitoring Parameters for F-Type Quarter, Hospital Gopalpuri and Tuna Port.

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.28	7.42	7.51	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1050	990	600	500	2000
3	Turbidity	NTU	1	1	-	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1796	1700	1044	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	345.77	360.80	380.85	250	1000
9	Ca as Ca	mg/l	38.48	40.88	32.87	75	200
10	Mg as Mg	mg/l	61.7220	62.6940	72.41	30	100
11	Total Hardness	mg/l	350	360	380	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.42	0.45	0.43	1	1.5
14	Sulphate as SO_4	mg/l	26.00	26.10	24.50	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	10.30	6.80	3.00	45	No Relaxation
17	Salinity	‰	0.62	0.65	0.69	NS*	NS*
18	Sodium as Na	mg/l	201.00	201.00	193.60	NS*	NS*
19	Potassium as K	mg/l	3.15	3.16	3.21	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified, BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6-0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 17: Drinking Water Quality Monitoring Parameters for Vadinar Jetty and Port Colony at Vadinar.

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.4	7.43	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	320	300	500	2000
3	Turbidity	NTU	0.00	1.00	1	5
4	Odor	-	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	5	15
6	Conductivity	µs/cm	570	300	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	160.36	140.31	250	1000
9	Ca as Ca	mg/l	36.87	34.47	75	200
10	Mg as Mg	mg/l	43.25	52.00	30	100
11	Total Hardness	mg/l	270	300	200	600
12	Iron as Fe	mg/l	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.25	0.22	1	1.5
14	Sulphate as SO_4	mg/l	0.75	0.24	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	15.60	12.70	45	No Relaxation
17	Salinity	‰	0.29	0.25	NS*	NS*
18	Sodium as Na	mg/l	191.6	192.0	NS*	NS*
19	Potassium as K	mg/l	BQL	BQL	NS*	NS*
20	Manganese	mg/l	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

4.3 Results & Discussion

The colour of all drinking water samples was found Colourless and odour of the samples also agreeable. All parameters were found within the specified limit as per the Drinking water Standard.

pH

The pH is measure of the intensity of acidity or alkalinity and the concentration of hydrogen ion in water. At DPA Site the pH values for drinking water samples ranged from 7.24-7.52 and mean value was 7.36 while at Vadinar pH ranged from 7.40-7.43 and mean value was 7.42. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Turbidity

The selected drinking water sample location turbidity range from 0-1NTU at all location of DPA and Vadinar in month of November. The Turbidity values were within the permissible limit at all sampling location prescribed limit by Indian standards.

Total Dissolved Solids (TDS)

Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates etc.

TDS values at DPA varied between 600-1060 mg/l. The average TDS value was found 792 mg/l. The minimum value for TDS was 600 mg/l at Hospital Gopalpuri and maximum was 980 mg/l at Tuna Port while at Vadinar TDS ranged from 280-300 mg/l and mean was 290.0 mg/l. The TDS values were within the permissible limit at all sampling location prescribed limit by Indian standards.

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of November DPA ranged from 1044.0 µs/cm at Tuna Port to1821.0 µs/cm at A.O. Building and mean value was 1381.72 µs/cm while at Vadinar ranged from 300-570 µs/cm and mean was 435 µs/cm.

BOD

BOD value in the studied area of DPA and Vadinar was found Below Quantification Limit (<2.0 mg/l). IS 10500:2012 does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. The Chloride value in the studied area of DPA ranged from 335.75-576.28 mg/l. The mean value was 365.53 mg/l. The minimum chloride was 335.75 mg/l at Port colony and maximum was 576.28 mg/l at Nirmal Building while at Vadinar location chloride ranged from 140.31-160.36 mg/l and mean was 150.33 mg/l. The Chloride was found within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium is most abundant element on the earth crust and is very important for human cell physiology and bones. About 95% calcium in human body stored in bones and teeth. The high deficiency of calcium in humans may caused rickets, poor blood clotting, bones fracture etc. and the exceeding limit of calcium produced cardiovascular diseases.

The Calcium value in the studied area of DPA ranged from 32.87-43.29 mg/l. The mean value was 40.12 mg/l. The minimum calcium was 32.87 mg/l at Tuna Port and maximum was 43.29 mg/l at Gopalpuri Hospital while at Vadinar location Calcium ranged from 34.47-36.87 and mean was 35.67 mg/l. All the locations had calcium within the prescribed limits of 75-200 mg/L.

Magnesium

The magnesium value in the studied area of DPA ranged from 50.06-72.41 mg/l. The mean value was 59.24 mg/l. The minimum magnesium was 50.06 mg/l at Port Colony and maximum was 74.41 mg/l at Tuna Port while at Vadinar location magnesium ranged from 43.25-52.00 and mean was 47.61 mg/l. All the locations had magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Total Hardness value in the studied area of DPA ranged from 310.0 mg/l at Port Colony to 380.0 mg/l at Tuna Port and mean value was 343.89 mg/l while at Vadinar location total hardness ranged from 270.0-300.00 mg/l and mean was 285.0 mg/l. The values of total

hardness were found within the Permissible limit of the Drinking Water Standard (200-600 mg/L). These results clear, that hardness of water is according to the IS standards and it is not harmful for local inhabitants.

Iron

Iron values in the studied area of DPA & Vadinar were Below Quantification Limit (0.009 mg/l) and hence well below the permissible limit as per Indian Standards are 0.3 mg/L.

Fluoride

Fluoride value in the studied area of DPA varied between 0.3-0.47 mg/l and mean was 0.38 mg/l. The minimum value was 0.3 mg/ at West gate workshop and maximum was 0.47 mg/l at E-Type and mean was 0.38 mg/l while at Vadinar location fluoride ranged from 0.22-0.25 mg/l and mean was 0.24 mg/l. The Fluoride values were well below the permissible limit as per Indian Standards is 1.0-1.5 mg/L. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems.

Sulphate

Sulphate value in the studied area of DPA varied between 24.5–35.8 mg/l and mean was 27.83 mg/l. The minimum value was 24.5 mg/ at A.O. Building, Hospital Kandla and Tuna Port and maximum was 35.8 mg/l at Nirmal Building while at Vadinar location Sulphate ranged from 0.24-0.75 mg/l and mean was 0.50 mg/l. All the sampling points showed Sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

The all values of Nitrite were found BQL (<0.05 mg/l) and Nitrate were well within the permissible limit of the Drinking water Standard.

Salinity

Salinity in drinking water in the present samples collected at DPA ranged from 0.61 ‰ at Canteen to 1.04 ‰ at Nirmal Building and average salinity was 0.66 ‰ while at Vadinar sampling location salinity ranged from 0.25-0.29 ‰. There are no prescribed Indian standards for salinity in Drinking water**.**

Sodium and Potassium Salts

Sodium values in the samples collected at DPA ranged from 180 - 204 mg/l and average was 195.74 mg/l while at Vadinar sodium ranged from 191.6- 192.0 mg/l and average was191.8 mg/l . Potassium salts ranged at DPA ranged from 3.15 to 4.18 mg/l while average was 3.42 mg/l while at Vadinar sampling locations potassium were BQL (<2.0 mg/l). There are no prescribed limits of Sodium and Potassium in Indian standards for Drinking water**.**

Heavy Metals in Drinking Water

In the present study period drinking water samples were analyzed for Mn, Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards.

Bacteriological Study

Analysis of the bacteriological parameter (E-coli and total coliform) at all location shows that Bacteria were not detectable. This shows that drinking water samples were safe for human consumption as per tested parameters.

4.4 Conclusions

These results were compared with permissible limits as prescribed in IS 10500:2012 – Drinking Water Specification. It was seen from the analysis data that during the study period at selected sampling location the water was safe for human consumption as per analyzed parameters at all drinking water monitoring stations.

CHAPTER-5

NOISE MONITORING

5.0 Noise Level Monitoring

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. Noise Monitoring was done at 13 stations at Kandla, Vadinar and Township area.

5.1 Method of Monitoring

Sampling was done at all stations for 24 hour period. Data was recorded using automated sound level meter. The intensity of sound was measured in sound pressure level (SPL) and common unit of measurement is decibel (dB).

5.2 Results

Table 18: Noise Monitoring data for ten locations of Deendayal Port and three locations of Vadinar Port

Sr. No.	Location	Day Time Average Noise Level (SPL) in dB(A)	Night Time Average Noise Level (SPL) in dB(A)
	Sampling Time	**6:00 am to 10:00 PM**	**10:00PM to 6:00 AM**
1	Marine Bhavan	60.8	51.9
2	Nirman Building 1	69.9	52.0
3	Tuna Port	53.2	45.4
4	Main Gate North	63.3	51.9
5	West Gate I	67.7	58.1
6	Canteen Area	68.2	51.2
7	Main Road	66.3	52.2
8	ATM Building	69.1	51.1
9	Wharf Area /Jetty Area	70.4	61.7
10	Port & Custom Office	54.7	50.2
Vadinar Port			
11	Entrance Gate of Vadinar Port	55.0	53.5
12	Nr. Port Colony, Vadinar	60.6	57.6
13	Nr. Vadinar Jetty	52.5	51.0

5.3 Conclusions

Transportation systems are the main source of noise pollution in urban areas. Construction of buildings, highways, and roads cause a lot of noise, due to the usage of air compressors, bulldozers, loaders, dump trucks, and pavement breakers. Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships.

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 10 locations at Deendayal Port Authority ranged from 53.2 dB(A) to 70.4 dB(A) while at Vadinar port 3 location ranged from 52.5 dB(A) to 60.6 dB(A) which was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all locations of Deendayal Port Authority ranged from 45.4 dB to 61.7 dB(A) while at Vadinar port ranged from 52.5 dB (A) to 60.6 dB(A) which was within the permissible limits of 70 dB(A) for the industrial area for the night time.

CHAPTER-6

SOIL MONITORING

6.0 Soil Monitoring

Sampling and analysis of soil samples were undertaken at six locations within the study area (Deendayal Port and Vadinar Port) as a part of EMP. The soil sampling locations are initially decided based on the locations as provided in the tender document of the Deendayal Port.

Table No.:-19. Soil Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude	Remarks
1.	Tuna Port	SL-1	22° 58' 10.18"N	70° 6' 3.7"E	Near main gate of Port
2.	IFFCO Plant	SL-2	23° 26' 8.37"N	70° 13' 4.4"E	10 m away from main gate
3.	Khori creek	SL-3	22° 58' 10.18"N	70° 6' 3.7"E	Sand from creek after tide
4.	Nakti Creek	SL-4	23° 2' 1.10"N	70° 9' 33.6"E	
5.	DPA admin site	SL-5	22° 26' 30.9"N	69° 40' 37.03"E	Vadinar
6.	DPA colony	SL-6	22° 23' 57.09"N	69° 42' 49.42"E	

6.1 Methodology

The soil samples were collected in the month of November 2022. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

6.2 Results

Table-20: Chemical Characteristics of Soil in the Study Area for Tuna port, IFFCO, Khori Creek, Nakti Creek, DPA admin site, DPA colony.

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	DPA Admin Site	DPA Colony
			Near main gate of Port	10 m away from main	Sand from creek after tide		Vadinar	
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	7.79	7.80	7.54	7.58	8.14	7.54
3	Electrical Conductivity	µs/cm	35000.0	36100.0	26,820.00	12,700.0	155.0	594.0
4	Phosphorus	mg/kg	10.3	10.5	9.19	8.49	6.00	4.80
5	Moisture	%	15.9	20.3	20.90	3.50	7.20	10.10
6	Total Organic	%	4.04	1.7	3.64	7.80	2.30	2.00
7	Alkalinity	mg/kg	900.0	1000.0	800.0	500.0	800.0	600.0
8	Total Nitrogen	%	BQL	BQL	BQL	BQL	BQL	BQL
9	Sulphate	mg/kg	820.00	982.00	1,080.00	810.00	30.0	70.0
10	Chloride	mg/kg	15598.0	14275.0	12,600.00	2,950.00	140.00	525.00
11	Calcium	mg/kg	2,605.00	2,505.00	31,600.00	3,086.00	1,729.00	1,849.00
12	Sodium	mg/kg	5657	7136.0	7,649.00	4,675.00	33.02	116.90
13	Potassium	mg/kg	552	694	708.00	437.00	44.60	44.52
14	Copper as Cu	mg/kg	27.4	15.5	30.50	14.50	54.10	31.60
15	Lead as Pb	mg/kg	7.4	7.4	9.50	6.30	74.10	75.30
16	Nickel as Ni	mg/kg	39.40	32.70	44.40	27.20	30.30	32.00
17	Zinc as Zn	mg/kg	62.4	77.40	79.20	56.50	50.60	86.00
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (TN: 0.001%, Cd: 1.0mg/kg)

6.3 Discussion

- DPA Kandla soil sampling data shows that value of pH ranges from 7.54 at Khori Creek to 7.80 at IFFCO Plant while the average value was 7.68. At Vadinar sampling location pH were 7.54 at DPA colony and 8.14 at DPA Admin Site.
- The Electrical Conductivity of DPA Kandla soil sample ranged from 12700.0 µs/cm at Nakti Creek (Sand from creek after tide) to 36100 µs/cm at IIFCO Plant and mean was 27655 µs/cm while Vadinar soil sampling location conductivity were 155 µs/cm at DPA Admin Site and 594 µs/cm at DPA Colony site.
- Total organic Carbon of DPA Kandla soil sample ranged from 1.7 % at IFFCO Plant to 7.80 % at Nakti Creek (Sand from creek after tide) and mean was 4.30 % while Vadinar soil sample were 2.0 % at DPA Colony and 2.30 % at DPA admin Site.
- The concentration of Phosphorus in the soil samples of DPA Kandla varies from 8.49 mg/kg at Nakti Creek (Sand from creek after tide) and 10.5 mg/kg at IIFCO Plant and mean was 9.62 mg/kg while the Vadinar soil sample for Phosphorus were 4.80 mg/kg at DPA Colony and 6.00 mg/kg at DPA Admin Site.
- Chloride in soil sample of DPA ranged from 2950.00 mg/kg at Nakti Creek (Sand from creek after tide) to 15598 mg/kg at Tuna Port and mean was11356 mg/kg while Vadinar soil sample were 140 mg/kg at DPA admin and 525 mg/kg at DPA Colony.
- The Concentration of Potassium in the soil samples of DPA Kandla ranged from 437 mg/kg at Nakti creek and 708 mg/kg at Khori Creek and mean was 597.75 mg/kg while the Vadinar soil sample for Potassium were 44.52 mg/kg at DPA Colony Site and 44.60 mg/kg at DPA Admin Site.
- The concentration of Sodium in the soil samples of DPA Kandla ranged from 4675.0 mg/kg at Nakti creek and 7649.0 mg/kg at Khori Creek and mean was 6279 mg/kg while the Vadinar soil sample for Sodium were 33.00 mg/kg at DPA Admin Site and 117 mg/kg at DPA Colony.

These differences in NPK in soil at different locations are due to the dissimilar nature of soil at each of the locations. Samples SL3 & SL4 (Khori Creek & Nakti Creek) were coastal soil; where as other locations are inland locations and have different chemical properties.

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel and Zinc were observed in the soil samples collected from all the four locations of Deendayal Port Authority Kandla and two locations of Vadinar Port. Cadmium metal was below detection limit in the Soil.

6.4 Conclusion

The soils of Deendayal Port Authority Kandla and Vadinar Port appears to be neutral to basic with varying levels of Chloride, Sulphate, NPK and Calcium. As the nature of soil at different locations are different with respect to its proximity to the sea, the samples showed high degree of variations in their chemical properties.

CHAPTER-7

SEWAGE TREATMENT PLANT MONITORING

7.0 Sewage Treatment Plant Monitoring

This involves safe collection of waste water (spent/used water) from wash areas, bathroom, industrial units, etc., waste from toilets of various buildings and its conveyance to the treatment plant and final disposal in conformity with the requirement and guidelines of State Pollution Control Board and other statutory bodies.

7.1 Methodology for STP Monitoring

To monitor the working efficiency of Sewage Treatment Plant (STP), STP Inlet and Outlet Samples were collected once a week. Locations selected are namely Gopalpuri Township, Deendayal Port and Vadinar. Samples were collected in 1 lit. Carboys and were analyzed in laboratory for various parameters.

A new STP with an improved capacity of 1 MLD is being constructed at Gopalpuri Colony.

Table No. 21. Sewage Treatment Plant

Sr. No.	Location of STP	Types of Treatment	STP Capacity	Treated water Utilization
1.	Gopalpuri Township	MBBR	450 KLD	Plantation and Gardening
2.	Deendayal Port, Kandla	MBBR	600 KLD	Discharge to marine through pipeline, Plantation, Gardening
3.	Vadinar Port Colony	MBBR	1.5 MLD	Plantation and Gardening

7.2 Results

Table 22: Sewage Water Monitoring at Kandla STP (1st Week)

Date of Sampling	03.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.55	7.42	6.5 - 8.5
2	Total Suspended Solids	mg/l	100.6	46.8	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	80.8	30.3	100
5	BOD @ 27 °C	mg/l	22	11	30
Aeration Tank					
6	MLSS	mg/l	14.0		
7	MLVSS	%	99.73		

Table 23: Sewage Water Monitoring at Kandla STP (2nd Week)

Date of Sampling	10.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.41	7.36	6.5 - 8.5
2	Total Suspended Solids	mg/l	127	52.6	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	90.9	40.4	100
5	BOD @ 27 °C	mg/l	23	11	30
Aeration Tank					
6	MLSS	mg/l	18.0		
7	MLVSS	%	85.00		

Table 24: Sewage Water Monitoring at Kandla STP (3rd Week)

Date of Sampling	17.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**CPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.48	7.29	6.5 - 8.5
2	Total Suspended Solids	mg/l	86.4	22.9	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	101	50.5	100
5	BOD @ 27 °C	mg/l	26	14	30
Aeration Tank					
6	MLSS	mg/l	20.0		
7	MLVSS	%	98.0		

Table 25: Sewage Water Monitoring at Kandla STP (4th Week)

Date of Sampling	24.10.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.41	7.29	6.5 - 8.5
2	Total Suspended Solids	mg/l	164.2	58.7	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	171.7	30.3	100
5	BOD @ 27 °C	mg/l	43	10	30
Aeration Tank					
6	MLSS	mg/l	20.0		
7	MLVSS	%	89.0		

Table 26: Sewage Water Monitoring at Gopalpuri STP (1st Week)

Date of Sampling	03.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.47	7.31	6.5 - 8.5
2	Total Suspended Solids	mg/l	121.2	61	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	111.1	60.6	100
5	BOD @ 27 °C	mg/l	32	13	30
Aeration Tank					
6	MLSS	mg/l	22.0		
7	MLVSS	%	97.16		

Table 27: Sewage Water Monitoring at Gopalpuri STP (2nd Week)

Date of Sampling	10.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.35	7.27	6.5 - 8.5
2	Total Suspended Solids	mg/l	189	67.9	100
3	Residual Chlorine	mg/l			-
4	COD	mg/l	141.4	60.6	100
5	BOD @ 27 °C	mg/l	37	15	30
Aeration Tank					
6	MLSS	mg/l	16.0		
7	MLVSS	%	89.6		

Table 28: Sewage Water Monitoring at Gopalpuri STP (3rd Week)

Date of Sampling	17.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			Gopalpuri STP I/L	**Gopalpuri STP O/L**	
1	pH	-	7.41	7.36	6.5 - 8.5
2	Total Suspended Solids	mg/l	127	52.6	100
3	Residual Chlorine	mg/l			-
4	COD	mg/l	90.9	40.4	100
5	BOD @ 27 °C	mg/l	23	11	30
Aeration Tank					
6	MLSS	mg/l	08.0		
7	MLVSS	%	98.0		

Table 29: Sewage Water Monitoring at Gopalpuri STP (4th Week)

Date of Sampling	24.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			Gopalpuri STP I/L	**Gopalpuri STP O/L**	
1	pH	-	7.48	7.28	6.5 - 8.5
2	Total Suspended Solids	mg/l	110.2	42.1	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	78	40	100
5	BOD @ 27 °C	mg/l	24.0	12.0	30
Aeration Tank					
6	MLSS	mg/l	18.0		
7	MLVSS	%	90.0		

Table 30: Sewage Water Monitoring at Vadinar STP (1st Week)

Date of Sampling	03.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			Vadinar STP I/L	**Vadinar STP O/L**	
1	pH	-	7.35	7.25	6.5 - 8.5
2	Total Suspended Solids	mg/l	74.9	39.5	100
3	Residual Chlorine	mg/	-	<0.5	-
4	COD	mg/l	101	40.4	100
5	BOD @ 27 °C	mg/l	26.0	10.0	30

Table 31: Sewage Water Monitoring at Vadinar STP (2nd Week)

Date of Sampling	10.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			Vadinar STP I/L	**Vadinar STP O/L**	
1	pH	-	7.38	7.21	6.5 - 8.5
2	Total Suspended Solids	mg/l	69.6	40.3	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	131.3	50.5	100
5	BOD @ 27 °C	mg/l	32.0	7.0	30

Table 32: Sewage Water Monitoring at Vadinar STP (3rd Week)

Date of Sampling	17.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			Vadinar STP I/L	**Vadinar O/L**	
1	pH	-	7.51	7.42	6.5 - 8.5
2	Total Suspended Solids	mg/l	38.6	16.9	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	80.8	20.2	100
5	BOD @ 27 °C	mg/l	24.0	12.0	30

Table 33: Sewage Water Monitoring at Vadinar STP (4th Week)

Date of Sampling	24.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			Vadinar STP I/L	**Vadinar STP O/L**	
1	pH	-	7.61	7.42	6.5 - 8.5
2	Total Suspended Solids	mg/l	76.9	33.3	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	131.3	20.2	100
5	BOD @ 27 °C	mg/l	20.0	8.0	30

Table No. 34. General Standards for discharge of Environmental Pollutant Part-A

Sr. No.	Parameter	Inland Surface Water	Land Irrigation	Marine Coastal Areas
1.	pH	5.5-9.0	5.5-9.0	5.5-9.0
2.	Total Suspended Solids (mg/l)	100	200	100
3.	Residual Chlorine (mg/l)	1.0	-	1.0
4.	BOD (mg/l)	30	100	100
5.	COD (mg/l)	250	-	250

Sources:-CPCB

7.3 Results & Discussion

The STP Sample carried out to evaluate the efficiency and performance of the wastewater treatment plant at Gopalpuri, Kandla and Vadinar STP. The performance of these plants is an essential parameter to monitor because the treated sewage water is discharged for irrigation purposes and discharge into marine. Wastewater samples were collected from different unit operations of the plant i.e, the inlet, aeration tank and the final treated outlet. These samples were analyzed for various physico-chemical characteristics such as pH, TSS, Residual Chlorine, COD, BOD, MLSS and MLVS.

The final treated outlet observed pH values were within the allowed range at STP Gopalpuri, STP Kandla & STP Vadinar ranged from 7.22 -7.35, 7.29-7.42 & 7.21-7.42 respectively. The wastewater treatment makes it suitable for irrigation. These values are below the allowed limit of the GPCB.

- The final treated outlet observed Total suspended solid values at Gopalpuri, DPA Kandla & Vadinar ranged from 27.10-67.90 mg/l, 22.90-58.70 mg/l & 16.60-40.30 mg/l respectively. These values are below the allowed limit of the GPCB.
- The final treated outlet observed Residual Chlorine values were <0.5 at Gopalpuri, DPA Kandla & Vadinar. These values are below the allowed limit of the CPCB.
- The final treated outlet observed COD values were at Gopalpuri, DPA Kandla & Vadinar ranged from 40.40-60.60 mg/l, 30.30-50.50 mg/l & 20.20-50.50 mg/l respectively. These values are below the allowed limit of the CPCB.

- The main focus of wastewater treatment plants is supposed to reduce the BOD in the effluent discharged to natural waters. Wastewater treatment plants are designed to function as bacteria farms, where bacteria are fed oxygen and organic waste. The final treated outlet observed BOD values were at Gopalpuri, DPA Kandla & Vadinar ranged from 12.0-16.0 mg/l, 10.0-14.0 mg/l & 7.0-12.0 mg/l respectively. These values are below the allowed limit of the GPCB.

7.4 Conclusions:

All parameters for STP outlet are within limit prescribed by CPCB. After the final treatment, it is found that the treated water is satisfactory.

CHAPTER-8

MARINE WATER MONITORING

8.0 Marine Water Monitoring

Marine Water Quality

The Forty Second Amendment to the Constitution in 1976 underscored the importance of 'green thinking'. Article 48A enjoins the state to protect and improve the environment and safeguard the forests and wildlife in the country. Further, Article 51A (g) states that the "fundamental duty of every citizen is to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

Policy Statement for Abatement of Pollution (1992) has suggested developing relevant legislation and regulation, fiscal incentives, voluntary agreements and educational programs and information campaigns. It emphasizes the need for integration by incorporating environmental considerations into decision making at all levels by adopting frameworks namely, pollution prevention at source, application of best practicable solution, ensure polluter pays for control of pollution, focus on heavily polluted areas and river stretches and involve public in decision-making. The National Conservation Strategy and Policy Statement on Environment and Development, (1992) aimed at "integrating environmental concerns with developmental imperatives to meet the challenges by redirecting the thrust of our developmental process so that the basic needs of our people could be fulfilled by making judicious and sustainable use of natural resources." The priorities mentioned in this policy document include the sustainable use of land and water resources, prevention and control of pollution and preservation of biodiversity.

The National Water Policy, (2002) contains provisions for developing, conserving, sustainable utilizing and managing this important water resources and need to be governed by national perspectives.

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 01st & 02nd November-2022 in harbor regions of DPA & Vadinar during Neap tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 8th & 9th November-2022 in harbor regions of DPA & Vadinar during Spring tide period first quarter of Lunar Cycle.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPA harbor area and two stations in Nakti creek and one station in Khori creek. The same sampling schedule was repeated during consecutive spring tide and neap tide in same month. Plankton samples from sub surface layer was collected both during high tide period and low tide period from 1 water quality monitoring stations near Vadinar jetty area during spring tide and neap tide in this month. Collected water samples were processed for estimation

of Chlorophyll- a, Pheophytin- a, qualitative & quantitative evaluation of phytoplankton, qualitative & quantitative evaluation zooplanktons (density and their population).

Sampling Locations

Offshore monitoring requirement	Number of locations
Offshore Installations	3 in Kandla creek 2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty 1 near 1st SBM
Total Number of locations	**8**

8.1 Marine Water Quality and Results

Marine water quality of marine waters of Deendayal Port Harbor waters, Khori & Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The results of marine water quality from table no 35 to 42. *During low tide DPA-6 Nakti-II location monitoring was not possible due to non-availability of marine water.*

Table 35: Marine Water Quality Monitoring Parameters for Location Near DPA Colony

Sr. No.	Parameters	Unit	Kandla Creek Near DPA Colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.61	7.58	7.55	7.46
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	19.0	19.9	20.4	19.0
5	Turbidity	NTU	38	35	42	35
6	Total Dissolved Solids	mg/l	34152.0	30868.0	30941.0	31974.0
7	Total Suspended Solids	mg/l	639.6	600.6	646.4	595.6
8	Total Solids	mg/l	34791.6	31468.6	31587.4	32569.6
9	DO	mg/l	5.8	5.6	5.7	5.5
10	COD	mg/l	88.0	79.0	82.0	86.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.06	0.82	0.99	0.91
13	Phosphate	mg/l	0.48	0.31	0.09	0.04
14	Sulphate	mg/l	3580	3407	3708.0	3658
15	Nitrate	mg/l	4.70	0.50	0.75	0.42
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	521.04	440.88	561.12	480.96
18	Magnesium	mg/l	1773.9	1749.6	1701	1773.9
19	Sodium	mg/l	8011.0	8399.0	8396.0	8699.0
20	Potassium	mg/l	299.0	385.0	391.0	395.0
21	Iron	mg/l	BQL	BQL	0.88	0.57
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 36: Marine Water Quality Monitoring Parameters for Location Near Passenger Jetty One at Kandla

Sr. No.	Parameters	Unit	Near passenger Jetty One (2)			
			23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.43	7.28	7.33	7.41
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	20.8	20.4	19.9	18.6
5	Turbidity	NTU	43	48	36	41
6	Total Dissolved Solids	mg/l	35468.0	37102.0	34662.0	33398.0
7	Total Suspended Solids	mg/l	679.7	665.5	703.7	663.8
8	Total Solids	mg/l	36147.7	37767.5	35365.7	34061.8
9	DO	mg/l	5.9	6.2	5.6	5.2
10	COD	mg/l	86.0	94.0	90.0	92.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.26	0.86	1.33	0.85
13	Phosphate	mg/l	0.29	0.13	0.33	0.19
14	Sulphate	mg/l	3571	3470	4072	3407
15	Nitrate	mg/l	3.40	2.70	1.17	4.36
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	561.12	601.20	601.2	521.04
18	Magnesium	mg/l	1701	1603.8	1749.6	1701
19	Sodium	mg/l	9142.0	9345.0	9247.0	9219.0
20	Potassium	mg/l	370.0	385.0	370.0	380.0
21	Iron	mg/l	0.47	BQL	1.76	0.30
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Nitrite: 0.05mg/lCu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 37: Marine Water Quality Monitoring Parameters for location Near Coal Berth

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.37	7.51	7.53	7.25
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	18.6	18.1	19.5	20.8
5	Turbidity	NTU	33	42	38	45
6	Total Dissolved Solids	mg/l	39222.0	37586.0	37123.0	36668.0
7	Total Suspended Solids	mg/l	540.2	638.4	620.6	580.2
8	Total Solids	mg/l	39762.2	38224.4	37743.6	37248.2
9	DO	mg/l	7.3	6.4	7.1	6.5
10	COD	mg/l	81.0	874.0	88.0	84.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.56	0.98	0.69	1.76
13	Phosphate	mg/l	0.06	0.56	0.12	0.61
14	Sulphate	mg/l	4222	3458	2981	3758
15	Nitrate	mg/l	2.20	4.60	2.68	4.70
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	480.96	641.28	641.28	721.44
18	Magnesium	mg/l	1628.1	1628.1	1676.7	1603.8
19	Sodium	mg/l	8346.0	9380.0	9245.0	9814.0
20	Potassium	mg/l	391.0	300.0	392.0	384.0
21	Iron	mg/l	BQL	BQL	BQL	1.34
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 38: Marine Water Quality Monitoring Parameters for location Khori creek at Kandla

Sr. No.	Parameters	Unit	Khori creek			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.48	7.27	7.34	7.21
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	20.4	19.5	18.6	17.7
5	Turbidity	NTU	35	31	43	39
6	Total Dissolved Solids	mg/l	32557.0	34294.0	30473.0	33329.0
7	Total Suspended Solids	mg/l	641.2	616.3	594.7	731.2
8	Total Solids	mg/l	33198.2	34910.3	31067.7	34060.2
9	DO	mg/l	7.6	6.3	7.3	6.8
10	COD	mg/l	85.0	96.0	92.0	96.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.78	1.04	1.39	1.18
13	Phosphate	mg/l	0.44	0.67	0.35	0.42
14	Sulphate	mg/l	4047	3646	3157	3170
15	Nitrate	mg/l	3.70	1.10	1.34	5.20
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	561.12	480.96	480.96	561.12
18	Magnesium	mg/l	1725.3	1676.7	1701	1628.1
19	Sodium	mg/l	9112.0	8436.0	7966.0	8696.0
20	Potassium	mg/l	299.0	385.0	382.0	377.0
21	Iron	mg/l	0.44	BQL	0.17	0.31
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	0.02
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 39: Marine Water Quality Monitoring Parameters for location Nakti Creek near Tuna Port

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.41	7.36	7.48	7.23
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	19.0	18.6	19.0	19.5
5	Turbidity	NTU	45	36	40	42
6	Total Dissolved Solids	mg/l	30214.0	28996.0	31047.0	31957.0
7	Total Suspended Solids	mg/l	642.7	526.2	682.5	606.8
8	Total Solids	mg/l	30856.7	29522.2	31729.5	32563.8
9	DO	mg/l	8.1	7.5	6.4	7.2
10	COD	mg/l	94.0	112.0	98.0	100.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.12	1.20	1.42	1.22
13	Phosphate	mg/l	0.71	0.37	0.46	0.12
14	Sulphate	mg/l	4172	3846	3445	3433
15	Nitrate	mg/l	1.50	1.70	5.12	1.69
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	440.88	641.28	601.2	521.04
18	Magnesium	mg/l	1725.3	1555.2	1701	1773.9
19	Sodium	mg/l	8639.0	9143.0	8655.0	7939.0
20	Potassium	mg/l	395.0	386.0	384.0	386.0
21	Iron	mg/l	BQL	0.33	0.34	0.18
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 40: Marine Water Quality Monitoring Parameters for location Nakti Creek Near NH-8A at Kandla

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.45	Sampling not possible during Low Tide	7.45	Sampling not possible during Low Tide
2	Color	-	Agreeable		Agreeable	
3	Odor	-	Agreeable		Agreeable	
4	Salinity	‰	19.9		20.8	
5	Turbidity	NTU	45		44	
6	Total Dissolved Solids	mg/l	30288.0		32796.0	
7	Total Suspended Solids	mg/l	529.6		595.7	
8	Total Solids	mg/l	30817.6		33391.7	
9	DO	mg/l	7.4		6.9	
10	COD	mg/l	118.0		110.0	
11	BOD	mg/l	BQL		BQL	
12	Silica	mg/l	1.02		0.16	
13	Phosphate	mg/l	0.75		0.46	
14	Sulphate	mg/l	4109		4961	
15	Nitrate	mg/l	2.70		3.52	
16	Nitrite	mg/l	<0.05		BQL	
17	Calcium	mg/l	681.36		641.28	
18	Magnesium	mg/l	1506.6		1628.1	
19	Sodium	mg/l	9280.0		8528.0	
20	Potassium	mg/l	427.0		427.0	
21	Iron	mg/l	BQL		0.54	
22	Chromium	mg/l	BQL		BQL	
23	Copper	mg/l	BQL		BQL	
24	Arsenic	mg/l	BQL		BQL	
25	Cadmium	mg/l	BQL		0.01	
26	Mercury	mg/l	BQL		BQL	
27	Lead	mg/l	BQL		BQL	
28	Zinc	mg/l	BQL		BQL	

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 41: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar Jetty

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty			
			22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.43	7.26	7.36	7.29
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	20.4	20.8	19.0	19.9
5	Turbidity	NTU	39	42	38	42
6	Total Dissolved Solids	mg/l	35265.0	37685.0	36325.0	36681.0
7	Total Suspended Solids	mg/l	585.3	590.8	681.4	657.6
8	Total Solids	mg/l	35850.3	38275.8	37006.4	37338.6
9	DO	mg/l	5.7	5.4	6.3	5.8
10	COD	mg/l	87.0	89.0	96.0	92.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.55	0.45	0.36	0.28
13	Phosphate	mg/l	0.18	0.42	0.33	0.19
14	Sulphate	mg/l	3608	3558	3683	3645
15	Nitrate	mg/l	2.35	1.09	1.00	2.43
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	480.96	601.20	521.04	480.96
18	Magnesium	mg/l	1603.8	1652.4	1676.7	1749.6
19	Sodium	mg/l	9448.0	7368.0	7810.0	8912.0
20	Potassium	mg/l	371.0	354.0	452.0	456.0
21	Iron	mg/l	BQL	BQL	0.31	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	0.29	BQL	0.77	0.35

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 42: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar SPM

Sr. No.	Parameters	Unit	Nr. Vadinar SPM			
			22°30'56.15"N 69°42'12.07"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.37	7.22	7.41	7.35
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	19.0	17.7	19.5	18.6
5	Turbidity	NTU	37	40	37	39
6	Total Dissolved Solids	mg/l	39961.0	39198.0	42642.0	40730.0
7	Total Suspended Solids	mg/l	545.5	493.6	714.3	657.9
8	Total Solids	mg/l	40506.5	39691.6	43356.3	41387.9
9	DO	mg/l	6.1	5.5	5.6	6.1
10	COD	mg/l	95.0	98.0	96.0	94.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.47	0.37	0.34	0.30
13	Phosphate	mg/l	1.08	0.19	0.46	0.28
14	Sulphate	mg/l	3495	3796	3745	4008
15	Nitrate	mg/l	3.86	2.18	4.95	2.10
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	561.12	400.80	681.36	641.28
18	Magnesium	mg/l	1628.1	1676.7	1555.2	1628.1
19	Sodium	mg/l	8473.0	10386.0	9131.0	8526.0
20	Potassium	mg/l	452.0	406.0	413.0	441.0
21	Iron	mg/l	BQL	BQL	0.24	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	0.28	BQL	0.40	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l)

8.2 Results & Discussion for Marine water samples

Marine water quality of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and mostly found below quantification limit.

pH

During spring tide the pH values was ranged from 7.27-7.61 at DPA Kandla and 7.22-7.43 at Vadinar while during Neap Tide pH values was ranged from 7.21-7.55 at DPA Kandla and 7.29-7.41 at Vadinar.

Color and Odor

All marine samples for Odor and Color were found agreeable at all sampling locations.

Turbidity

During spring tide the Turbidity values was ranged from 31-48 NTU at DPA Kandla and 37-42 NTU at Vadinar while during Neap Tide Turbidity values was ranged from 35-45 NTU at DPA Kandla and 37-42 NTU at Vadinar. Turbidity is the amount of particulate matter that is suspended in water. Turbidity measures the scattering effect that suspended solids have on light: the higher the intensity of scattered light, the higher the turbidity (Yap et al, 2011). Materials that cause water to be turbid include clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton and microscopic organisms (Lawler, 2004). The turbidity affects the amount of light penetrating to the plants for photosynthesis.

Total Dissolved Solids (TDS)

TDS values in the studied area during Spring Tide varied between 28966- 39222 mg/l at DPA Kandla and 35265-39961 mg/l at Vadinar while during Neap Tide TDS values was varied 30473-37123 mg/l at DPA Kandla and 36325-42642 mg/l at Near Vadinar.

Calcium

Calcium value in the studied area during Spring Tide varied between 440.9-681.4 mg/l at DPA Kandla and 400.8-601.2 mg/l at Vadinar while during Neap Tide calcium values between 481.0-721.4 mg/l at DPA Kandla and 481.0-681.4 mg/l at Vadinar.

Magnesium

Magnesium value in the studied area during Spring Tide varied between 1506.6-1773.9 mg/l at DPA Kandla and 1603.8-1676.7 mg/l at Vadinar while during Neap Tide magnesium values between 1603.80-173.9 mg/l at DPA Kandla and 1555.2 -1749.60 at Vadinar. Calcium and magnesium both play an important role in antagonizing the toxic effects of various ions and neutralizing the excess acid produced (Narayan R. et. al., 2007)

Nitrate

Nitrate value in the studied area during Spring Tide varied between 0.5-4.7 mg/l at DPA Kandla and 1.09-3.86 mg/l at Vadinar while during Neap Tide Nitrate values between 0.42-5.2 mg/l at DPA Kandla and 1.0-4.95 at Vadinar.

The variations were observed due to variation in phytoplankton excretion, oxidation of ammonia, reduction of nitrate and by recycling of nitrogen and bacterial decomposition of planktonic detritus (Asha and Diwakar, 2007).

Iron

Iron values in the studied area during Spring Tide ranged from 0.33-0.47 mg/l at DPA Kandla and at Vadinar were BQL (<0.10) while during Neap Tide Iron values ranged from 0.17-1.76 mg/l at DPA Kandla and 0.24-0.31 mg/l at Vadinar.

Sulphates

Sulphate values in the studied area during Spring Tide ranged from 3407-4222 mg/l at DPA Kandla and 3495-3796 mg/l at Vadinar while during Neap Tide the Sulphate values was varied 2981-4961 mg/l at DPA Kandla and 3645-4008mg/l at Vadinar.

Salinity

Salinity values in the studied area during Spring Tide varied ranged 18.11 to 20.82 ‰ at DPA Kandla and 17.65 to 20.82 ‰ at Vadinar while during Neap Tide the Salinity values was varied 17.65 to 20.82 ‰ at DPA Kandla and 18.55 to 19.92 ‰ at Vadinar.

Sodium and Potassium Salts

During Spring Tide the Sodium values ranged from 8011-9380 mg/l at DPA Kandla & 7368-10386 mg/l at Vadinar and Potassium salts ranged from 299-427 mg/l at DPA Kandla & 354-452 mg/l at Vadinar while during Neap Tide the Sodium values was ranges from 7939-

9814 mg/l at DPA Kandla & 7810-9131 mg/l at Vadinar and Potassium salts ranged from 370-427 mg/l at DPA Kandla & 413-456 mg/l at Vadinar.

DO

The DO refers to the amount of oxygen dissolved in the water and it is particularly important in limnology {(aquatic ecology) (Weiss 1970)}. The fate and behavior of DO is of critical importance to marine organisms in determining the severity of adverse impacts (Best et al. 2007). The major factor controlling dissolved oxygen concentration is biological activity: photosynthesis producing oxygen while respiration and nitrification consume oxygen (Best et al. 2007). From the studied samples, DO in marine water during Spring Tide was found in ranges from 5.6-8.1 mg/l at DPA Kandla and 5.4-6.1 mg/l at Vadinar while during Neap Tide 5.2-7.3 mg/l at DPA Kandla and 5.6-6.3 mg/l at Vadinar.

BOD

BOD in marine water at all sampling location in the studied samples were found BQL (<2.0 mg/l).

Heavy Metals in Marine Water

In the present study period marine water samples were analyzed for Cr, Cu, Cd, As, Hg, Pb and Zn. Maximum heavy metals parameters were well Below the Quantification limits.

9.3 Conclusion

In the present study period marine water samples were analyzed and found inline as per Primary Water Quality criteria for class-IV WATERS (For Harbour Waters).

CHAPTER-9

MARINE SEDIMENT MONITORING

9.0 Marine Sediments

The deep-sea ocean floor is made up of sediment. This sediment is composed of tiny particles such as fine sand, silt, clay, or animal skeletons that have settled on the ocean bottom. Over long periods of time, some of these particles become compressed and form stratified layers. Scientists that study these layers look at particle size, particle composition, and origin to help them create historical records of the deep ocean floor. This process is called weathering. Weathering can be either mechanical or chemical. Mechanical weathering can occur as ice, wind, or water wears away the rock's surface. Chemical weathering can occur as rocks are dissolved by a chemical such as acid rain. The particles created as a result of weathering are called terrigenous sediments. These particles are transported to the ocean by wind and by rivers and streams. Once the particles enter the ocean, they are dispersed by waves, currents, and tides. The heaviest and largest particles that reach the oceans, such as sand, settle very quickly to the bottom as a result of gravity. Sand is deposited near the coast whereas the smaller silt and clay particles are transported farther distances offshore before they settle to the bottom. Sediments are an important component of aquatic ecosystems because they provide nutrients and habitat for aquatic organisms (Benhamed et al. 2016). However, human activities result in accumulation of toxic substances such as heavy metals in marine sediments. Heavy metals are well-known environmental pollutants due to their toxicity, persistence in the environment, and bioaccumulation. Metals affect the ecosystem because they are not removed from water by self-purification, but accumulate in sediments and enter the food chain (Astakhov et al. 2015).

Sediment samples were collected with Van Veen Grab from the six locations in Kandla Port Waters and two locations in Vadinar Port. Benthic surface grab samplers look like giant metal jaws. They dig into the bottom and take a bite of the sediment. These samplers are good for collecting softer, sandy or silty sediments that do not contain rocks. A box corer is a cross between a surface sampler and a sediment corer. It is a special device that is used to collect an undisturbed sample of the very top surface layers and the sediment underneath. Samples were collected and preserved in silver foil in ice box to prevent the contamination/decaying of the samples.

10.1 Results

The Sediment Quality results are given in below from table no. 43 & 44.

Table 43: Results of Analysis of Sediment of Kandla & Vadinar Port (Neap Tide)

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.32	0.6	0.1	0.1	0.16	1.14	1.59
3	Organic Carbon	mg/kg	0.76	0.35	0.07	0.06	0.09	0.66	0.91
4	Inorganic Phosphate	mg/kg	89.00	90.00	101.00	92.00	100.00	90.00	100.00
5	Moisture	%	3.90	2.37	4.12	3.00	4.10	3.40	4.00
6	Aluminum	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	7.30	7.68	8.90	9.30	9.10	8.90	9.60
8	Phosphate	mg/kg	5.20	4.99	4.09	5.25	9.00	3.28	10.40
9	Sulphate	mg/kg	759.00	849.00	555.00	496.00	768.00	732.00	496.00
10	Nitrite	mg/kg	0.11	0.11	0.10	0.10	0.12	0.10	0.11
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12	Calcium	mg/kg	2765.00	1523.00	861.00	961.00	981.00	1162.00	2485.00
13	Magnesium	mg/kg	1372.00	1300.00	1020.00	1263.00	1032.00	1089.00	2065.00
14	Sodium	mg/kg	2410.0	2760.0	2644.0	2940.0	2722.0	1394.00	1082.00
15	Potassium	mg/kg	404.00	459.00	390.00	510.00	447.00	811.0	560.0
16	Chromium	mg/kg	61.30	71.90	66.00	53.30	56.40	42.80	49.70
17	Nickel	mg/kg	26.80	31.70	29.00	23.00	24.10	13.80	29.20
18	Copper	mg/kg	17.40	19.40	17.80	15.50	15.80	13.80	47.10
19	Zinc	mg/kg	43.40	55.80	49.80	41.80	46.00	32.00	64.30
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	5.20	6.20	5.70	9.80	8.40	12.00	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg, Cd: 1.0mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg).

Table 44 : Results of Analysis of Sediment of Kandla & Vadinar Port (Spring Tide)

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	0.91	0.50	1.52	0.37	0.27	1.45	1.68
3	Organic Carbon	mg/kg	0.52	0.29	0.87	0.21	0.15	0.83	0.97
4	Inorganic Phosphate	mg/kg	98.00	90.00	80.00	78.00	100.00	88.00	90.00
5	Moisture	%	17.00	8.70	15.00	6.60	4.80	14.24	13.14
6	Aluminum	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	7.20	8.26	9.02	5.50	7.80	9.20	10.02
8	Phosphate	mg/kg	7.87	9.29	6.16	5.75	9.49	11.61	10.80
9	Sulphate	mg/kg	745.00	862.00	585.00	490.00	510.00	590.00	396.00
10	Nitrite	mg/kg	0.11	0.12	0.12	0.11	0.10	0.10	0.11
11	Nitrate	mg/kg	BQL	BQL	12.00	16.6	26.2	BQL	BQL
12	Calcium	mg/kg	1723.00	1057.00	1320.00	1220.00	1390.00	1907.00	1643.00
13	Magnesium	mg/kg	1044.00	716.00	1090.00	690.00	896.00	1563.00	2320.00
14	Sodium	mg/kg	2733.00	2720.00	2578.00	2107.00	1558.00	1042.00	952.00
15	Potassium	mg/kg	302.00	332.00	378.0	357.0	87.8	384.00	325.00
16	Chromium	mg/kg	38.00	24.40	51.70	16.10	60.00	48.90	69.20
17	Nickel	mg/kg	15.60	9.50	21.70	6.00	24.70	19.70	28.30
18	Copper	mg/kg	7.80	BQL	11.30	31.40	16.40	12.10	19.90
19	Zinc	mg/kg	30.10	21.90	35.70	13.70	44.90	31.50	51.90
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0 mg/kg,Cd: 1.0 mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg)

9.2 Discussion of Marine Sediment samples

Marine Sediments of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and found below quantification limit.

9.3 Conclusion

The sediment types are majority Sandy loamy. Also maximum heavy metals parameters found below Quantification limit wise, Pb, Cd, Hg , As, Al was not Detected and Nitrate for some locations.

CHAPTER-11

MARINE ECOLOGICAL MONITORING

10.0 INTRODUCTION:

10.1 Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on 01st November 2022 in harbour region of DPA at Kandla Creek, and on 02nd November 2022 in creeks near by the port during Neap tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 08th November, 2022 in harbour region of DPA at Kandla Creek and on 09th November, 2022 in creeks near by the port during spring tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPA harbour area and two stations in Nakti creek and one station in Khori creek. Sampling at second sampling station of Nakti creek was possible only during high tide period.

Plankton samples from sub surface layer were collected during high tide period and low tide period from monitoring station near Vadinar Jetty at Path Finder Creek during Neap tide on 01/11/2022 and Spring tide period on 08/11/2022.Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative and quantitative evaluation of phytoplankton, qualitative and quantitative evaluation of zoo plankton density and their population.

TABLE 43. SAMPLING LOCATIONS

monitoring requirement	**Number of locations**
Kandla creek	3 in Kandla creek
Nakti creek	2 in Nakti creek
Khori Creek	1 in Khori creek
Vadinar jetty	1 near Vadinar Jetty
SPM	1 near I stSPM
Total Number of locations	**8**

Sampling methodology adopted:

A marine sampling is an estimation of the body of information in the population. The theory of the sampling design is depending upon the underlying frequency distribution of the population of interest. The requirement for useful water sampling is to collect a representative sample of suitable volume from the specified depth and retain it free from contamination during retrieval.

50 litres of the water sample were collected from Sub surface by using bucket. From the collected water sample 1 litres of water sample was taken in an opaque plastic bottle for chlorophyll estimation, thereafter plankton samples were collected by using filtration assembly with Nylobolt cloth of 20µm mesh size. . During low tide DPA-6 Nakti-II location monitoring was not possible due to non-availability of marine water.

Samples Processing for chlorophyll estimation:

Samples for chlorophyll estimation were preserved in ice box on board in darkness to avoid degradation in opaque container covered with aluminium foil. Immediately after reaching the shore after sampling, 1 litre of collected water sample was filtered through GF/F filters (pore size 0.45 µm) by using vacuum filtration assembly. After vacuum filtration the glass micro fiber filter paper was grunted in tissue grinder, macerating of glass fiber filter paper along with the filtrate was done in 90% aqueous Acetone in the glass tissue grinder with glass grinding tube. Glass fiber filter paper will assist breaking the cell during grinding and chlorophyll content was extracted with 10 ml of 90% Acetone, under cold dark conditions along with saturated magnesium carbonate solution in glass screw cap tubes. After an extraction period of 24 hours, the samples were transferred to calibrated centrifuge tubes and adjusted the volume to original volume with 90% aqueous acetone solution to make up the evaporation loss. The extract was clarified by using centrifuge in closed tubes. The clarified extracts were then decanted in clean cuvette and optical density was observed at wavelength 664, 665 nm. By using corrected optical density, Chlorophyll-a value was calculated as given in (APHA, 2017).

PLANKTON:

The entire area open water in the sea is the pelagic realm. Pelagic organisms live in the open sea. In contrast to the pelagic realm, the benthic realm comprises organisms and zone of the bottom of the sea. Vertically the pelagic realm can be dividing into two zones based on light penetration; upper photic or euphotic zone and lower dark water mass, aphotic zone below the photic zone.

The term plankton is a general term for organisms which have such limited powers of locomotion that they are at the mercy of the prevailing water movement. Plankton is subdivided to phytoplankton and zooplankton. Phytoplanktons are free floating organisms that are capable of photosynthesis and zooplankton is the various free-floating animals.

Pelagic zone, represents the entire ocean water column from the surface to the deepest depths, is home to a diverse community of organisms. Differences in their locomotive ability categorize the organisms in the pelagic realm into two, ***plankton*** and ***nekton*** (Lalli and Parsons, 1997). ***Plankton*** consists of all organisms drifting in the water and is unable to swim against water currents, whereas ***Nekton*** includes organisms having strong locomotive power. Ecological studies on the plankton community, which form the base of the aquatic food chain, help in the better understanding of the dynamics and

functioning of the marine ecosystem. The term 'Plankton' first coined by Victor Hensen (1887), Plankton, (Greek word: *planktos*meaning "passively drifting or wandering") is defined as drifting or free-floating organisms that inhabit the pelagic zone of water. Based on their mode of nutrition planktonic organisms are categorised into phytoplankton (organisms having an autotrophic mode of nutrition) and zooplankton (organisms having a heterotrophic mode of nutrition).

Phytoplankton in the marine environment:

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

The phytoplankton includes a wide range of photosynthetic and phototrophic organisms. Marine phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are Diatoms (Bacillariophyceae) and Dinoflagellates (Dinophyceae).The phytoplankton those normally captured in the net from the Gulf of Kutch is normally dominated by these two major groups; Diatoms and Dinoflagellates. Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as and Cyanophytes (Blue-green algae).

Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts.

Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of deterioration of water quality, and many algal indicators have been used to assess environmental status.

Zooplankton in the marine environment:

Zooplankton includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community are a prerequisite to delineate the ecological processes active in the marine ecosystem. Zooplankton community plays a pivotal role in the pelagic food web as the primary consumers of phytoplankton and act as the food source for organisms in the higher trophic levels, particularly the economically essential groups such as fish larvae and fishes. They also function in the cycling of elements in the marine ecosystem. The dynamics of the zooplankton community, their reproduction, and growth and survival rate are all significant factors determining the recruitment and

abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes (Beaugrand et al., 2004). Zooplankton grazing in the marine environment controls the primary Production and helps in determining the pelagic ecosystem (Banse, 1995). Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of organic carbon to deep ocean layers and thus act as key drivers of 'biological pump' in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean's interior.

The categorisation of zooplankton into various ecological groups is based on several factors such as duration of planktonic life, size, food preferences and habitat. As they vary significantly in size from microscopic to metazoic forms, the classification of zooplankton based on size has paramount importance in the field of quantitative plankton research.

Based on the duration of planktonic life, zooplankton are categorised into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives such as the larval stages of benthic and nektonic organisms). Tychoplankton are organisms which live a brief planktonic life, such as the benthic crustaceans (Cumaceans, mysids, isopods) which ascend to the water column at night for feeding and certain ectoparasitic copepods, they leave the host and spend their life as plankton during their breeding cycle.

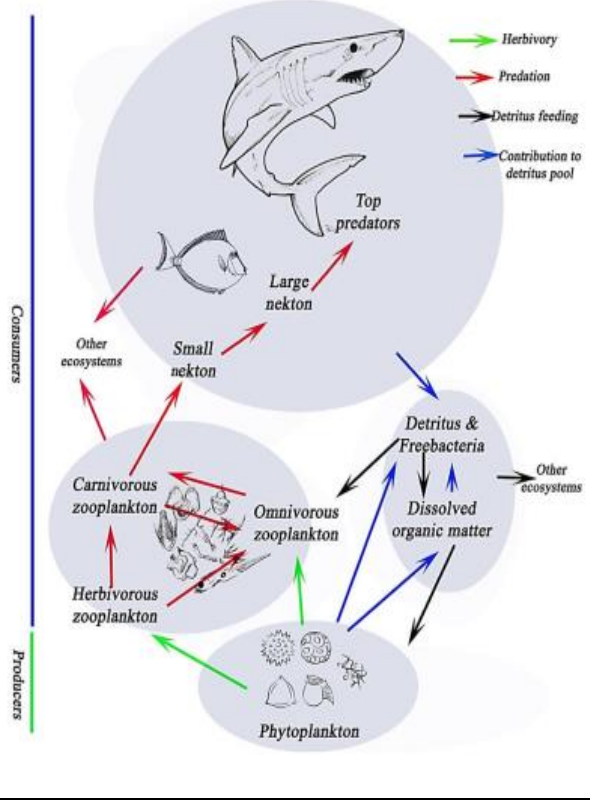
Zooplankton can be subdivided into holoplankton, i.e., permanent members of the plankton (e.g., Calanoid copepods), and meroplankton, i.e., temporary members in the plankton e.g., larvae of fish, shrimp, and crab). The meroplankton group consists of larval and young stages of animals that will adopt a different lifestyle once they mature. In contrast to phytoplankton which consist of a relatively smaller variety of organisms, Zooplankton are extremely divers, consist of a host of larval and adult forms representing many animal phylum.

Among the zooplankton one group always dominate than others; members of sub class copepods (Phylum Athropoda) and Tintinids (Phylum Protozoa) among the net planktons. These small animals are of vital importance in marine ecosystem as one of the primary herbivores animals in the sea, and it is they provide vital link between primary producer (autotrophs) and numerous small and large marine consumers.

As their community structure and function are highly susceptible to changes in the environmental conditions regular monitoring of their distribution as well as their interactions with various physicochemical parameters is inevitable for the sustainable management of the ecosystem (Kusum et al., 2014). Of all the marine zooplankton groups, copepods mainly Calanoid copepods are the

dominant groups in marine subtropical and tropical waters and exhibit considerable diversity in morphology and habitats they occupy (Madhupratap, 1991 ;)

It has been well established that potential of pelagic fishes viz. finfishes, crustaceans, molluscs and marine mammals either directly or indirectly depend on zooplankton. The herbivorous zooplanktons are efficient grazers of the phytoplankton and are referred to as living machines transforming plant material into animal tissue. Hence they play an essential role as the intermediaries for nutrients/energy transfer between primary and tertiary trophic levels. Due to their large density, shorter lifespan, drifting nature, high group/species diversity and different tolerance to the stress, they used as the indicator organisms for the physical, chemical and biological processes in the aquatic ecosystem (Ghajbhiye, 2002).



Simplified marine food web

Spatial distribution of Plankton:

A characteristic of plankton population is that they tend to occur in patches, which are varying spatially on a scale of few meters to far as few kilo metres in distance. They also vary in time scale, season as well as vertically in the water column. It is this patchiness and its constant changes in time and spot, that has made it so difficult for plankton biologist to learn about the ecology of plankton. The biological factors that causes this patchiness is due to the ability of zooplankton to migrate vertically and graze out the phytoplankton at a rapid rate that can create patchiness. Similarly the active swimming ability by certain zooplankton organisms can cause to aggregate in dense group.

At its most extreme, because the water in which plankton is suspended is constantly moving, each sample taken by the plankton biologists remain a different volume of water, so each sample is unique and replicate does not exist.

Plankton in the month of Novemberalso exhibit vertical patchiness. Physical factors contribute to this type of patchiness include light intensity, nutrients and density gradients in the water column.

Phytoplankton in particular tends to be unequally distributed vertically, which leads to the existence of different concentration of a chlorophyll value between photic zone and below the photic zone.

Methodology adopted for Plankton sampling:

Preservation and storage:

Both filtered plankton and those collected from the plankton net were preserved with 5% buffered formalin and stored in 1L plastic container for further processing in the laboratory.

Sample concentration:

The collected plankton samples were concentrated by using centrifuge and made up to 50 ml with 5% formalin -Glycerine mixture.

Taxonomic evaluation:

Before processing, the sample was mixed carefully and a subsample was taken with a calibrated Stempel-pipette. 1 ml of the concentrated plankton samples were transferred on a glass slide with automatic pipette. The plankton sample on the glass slides were stained by using Lugol's iodine and added glycerin to avoid drying while observation. The plankton samples were identified by using Labex triangular Research microscope with photographic attachment. Microphotographs of the plankton samples were taken for record as well as for confirming the identification. The bigger sized zooplankton was observed through dissecting stereomicroscope with magnification of 20-30 x. Plankton organisms in the whole slide were identified to the lowest taxon possible. A thorough literature search was conducted for the identification of the different groups of phytoplankton and zooplankton that were encountered

Cell counts by drop count method:

The common glass slide mounted with a 1ml of concentrated phytoplankton/zooplankton sample in glycerol and covered with cover slip 22 mm x 60 mm was placed under the compound microscope provided with a mechanical stage. The plankton was then counted from the microscopic field of the left top corner of the slide. Then slide is moved horizontally along the right side and plankton in each microscopic field was thus counted. When first microscopic field row was finished the next consecutive row was adjusted using the mechanical device of the stage. In this way all the plankton present in entire microscopic field are counted. From this total number in 1ml of the concentrated plankton, total amount of phytoplankton in the original volume of sample filtered was calculated as units/L and Zooplankton as N/m^3.

BENTHIC ORGANISMS:

Benthos is those organisms that are associated with the sea bed or benthic habitats. Epi- benthic organisms live attached to a hard substratum or rooted to a shallow depth below the surface. In fauna organisms live below the sediment–water interface. Interstitial organisms live and move in pore water among sedimentary grains.

Because the benthic organisms are often collected and separated on sieves, a classification based on the overall size is used. Macro benthos include organisms whose shortest dimension is greater than or equal to 0.5 mm. Meio benthos are smaller than 0.5mm but larger than 42µ in size.

The terms such as macro fauna and Meio fauna generally have little relevance with taxonomic classification. The terms Meio fauna and macro fauna depend on the size. Meio fauna were considered as good bioassay of community health and rather sensitive indicators of environmental changes

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

Van veen sampler ($0.09m^2$) was used for sampling bottom sediments. Two sets of sediments were sampled from each location, one for macro fauna and other for Meio fauna. The macro fauna in the sediments were sieved on board to separate out the organisms. The fixation of Meio fauna is normally done by bulk fixation of the sediment sample. The bulk fixation is done by using 10% formalin (Buffered with borate). The organisms were preserved with seawater as diluting agent.

Sample sieving:

Sediments samples were sieved to extract the organisms. Sieving was performed carefully as possible to avoid any damage to the animals. The large portion of the sediment was split in to smaller portions and mixed with sea water in a bucket. The cohesive lumps were broken down by continuous stirring. The disaggregated sediments were then passed through the sieves.

Sample staining:

Sorting of the Meio fauna from the sieve is difficult task especially in the preserved material, because organisms are not easily detectable. To facilitate the animal detection the entire sample retained on the sieve after sieving operation were stained by immersing the sieve in a flat bottom tub with 1% Rose Bengal stain; a protein stain. A staining period of 10-30 minutes is sufficient for sample detection.

DIVERSITY INDICES:

On the whole, diversity indices provide more information about community composition than simply species richness (number of species present); they also, take the relative abundances of different species into account. Based on this fact, diversity indices therefore depend not only on species richness but on the evenness, or equitability, with which individuals are distributed among the different species (Magurram, A. E. (1988)

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

The basic idea of diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities composed of discrete components in space and time (Carol H. R. *etal*. 1998). Biodiversity is commonly expressed through indices based on species richness and species abundances (Whittaker 1972, Lande 1996, Purvis and Hector 2000). Biodiversity indices are a non-parametric tool used to describe the relationship between species number and abundance. The most widely used bio diversity indices are Shannon Weiner index and Simpson's index.

A diversity Index is a single statistic that incorporates information on richness and evenness. Any study intended to interpret causes and effect of adverse impact on Biodiversity of communities require suitable measures to evaluate specie richness and Diversity. The former is number of species in community, while latter is a function of relative frequency of different species. Species richness is the iconic measure of biological diversity (Magurran, 2004). Several indices have been created to measure the diversity of species; however, the most widely used in the last decades are the Shannon (1948) and Simpson (1949) (Buzas and Hayek 1996; Gorelick 2006), with the components of diversity: richness (*S)* and evenness (*J)*

Simpson's diversity index

Simpson's index (**D**) is a measure of diversity, which takes into account both species richness, and evenness of abundance among the species present. The Simpson index is one of the meaningful and robust biodiversity measures available. (Magurran , 2004).

The formula for calculating D is presented as:

$$D = \frac{\sum n_i(n_i - 1)}{N(N-1)}$$

Where n_i = the total number of organisms of each individual species

N = the total number of organisms of all species

The value of D ranges from 0 to 1. With this index, 0 represents infinite diversity and, 1, no diversity. When D increases diversity decreases. Simpson's index is therefore usually expressed as 1-D or 1/D. (Magurran, 2004)

Low species diversity suggests:

- relatively few successful species in the habitat
- the environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment

- food webs which are relatively simple
- change in the environment would probably have quite serious effects

High species diversity suggests:

- a greater number of successful species and a more stable ecosystem
- more ecological niches are available and the environment is less likely to be hostile complex food webs
- environmental change is less likely to be damaging to the ecosystem as a whole

Species richness indices

The species richness***(S)*** is simply the number of species present in an ecosystem. Species richness Indices of species richness are widely used to quantify or monitor the effects of anthropogenic disturbance. A decline in species richness in may be concomitant with severe or chronic human-induced perturbation (Fair Fair weather 1990) Species richness measures have traditionally been the mainstay in assessing the effects of environmental degradation on the biodiversity of natural assemblages of organisms (Clarke &Warwick, 2001)

Species richness is the iconic measure of biological diversity (Magurran, 2004). The species richness***(S)*** is simply the number of species present in an ecosystem. This index makes no use of relative abundances. The term species richness was coined by Mc Intosh (1967) and oldest and most intuitive measure of biological diversity (Magurran, 2004).

Margalef's diversity index is a species richness index. Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, were derived.

The value of a diversity index increases both when the number of types increases and when evenness increases. For a given number of types, the value of diversity index is maximised when all types are equally abundant [Rosenzweig, M. L. (1995)]

Shannon-Wiener's index:

An index of diversity commonly used in plankton community analyses is the Shannon-Wiener's index **(H),** which emphasizes not only the number of species (richness or variety), but also the apportionment of the numbers of individuals among the species (Odum 1971 and Reish 1984). Shannon-Wiener's index **(H)** reproduces community parameters to a single numberby using an equation.

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxan. It varies from 0 for communities with only single taxa to high values for community with many taxan each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range

of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than

3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

10.2:- RESULTS:

CHLOROPHYLL-a:

$$H' = -\sum_{j=1}^{s} \frac{n_j}{N} \ln\left(\frac{n_j}{N}\right)$$

In the sub surface water chlorophyll-a was varying from 0.472-0.969 mg/m^3 with an average value 0.645 mg/m^3 in harbour region of DPA in Kandla Creek during sampling done in spring tide period of November 2022. In the nearby creeks chlorophyll-a was varying from 0.359-0.717 mg/m^3 with an average value 0.552 mg/m^3 Pheophytin –a level was below detectable limit- the all the sampling stations during springtide. Even though the plankton diversity and abundance were more during the spring tide sampling,the chlorophyll-content was detected lesser than expected because, the phytoplankton communities were mainly represented by diatoms *Skeletonema* sp. *Coscinodiscus sp.* and *Chaetoceros* sp.

In the sub surface water chlorophyll-a was varying from 0.338-0.547 mg/m^3 with an average value 0.437 mg/m^3 in harbour region of DPA in Kandla Creek during sampling done in Neap tide period of November2022. In the nearby creeks chlorophyll-a was varying from 0.205- 0.440mg/m^3 with an average value 0.370 mg/m^3. Pheophytin–a level was below detectable limit- the all the sampling stations. During neap tide sampling phytoplankton communities were mainly represented by *Coscinodiscus sp. and Ditylum sp.*

In the sub surface water chlorophyll-a was varying from 0.598-0.968 mg/m^3 in harbour region of DPA OOT in path finder Creek during sampling done in spring tide period of November 2022. In the sub surface water chlorophyll-a was varying from 0.709 - 0.987mg/m^3 in harbour region of DPA OOT in path finder Creek during sampling done in Neap Tide period of November 2022

TABLE:-45 VARIATIONS IN CHLOROPHYLL–a PHEOPHYTIN-a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPA HARBOUR AREA IN KANDLA CREEK ,NEAR BY CREEKS AND DPA OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINARDURING SPRING TIDE IN NOVEMBER 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPA HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.969	BDL	64.92
		Low tide	0.647	BDL	43.35
2	KPT 2	High tide	0.511	BDL	34.24
		Low tide	0.521	BDL	34.91
3	KPT 3	High tide	0.749	BDL	50.18
		Low tide	0.472	BDL	31.62
CREEKS					
4	KPT-4 Khori-I	High tide	0.638	BDL	42.75
		Low tide	0.359	BDL	24.05
5	KPT-5 Nakti-I	High tide	0.717	BDL	48.04
		Low tide	0.493	BDL	33.03
6	KPT-6 Nakti-II	High tide	ND	ND	ND
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.968	BDL	64.86
8		Low tide	0.732	BDL	49.04
9	SPM	High tide	0.953	BDL	63.85
10		Low tide	0.598	BDL	

BDL: Below Detectable Limit., ND: Not detected

TABLE:-46. VARIATIONS IN CHLOROPHYLL–a PHEOPHYTIN-a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPA HARBOUR AREA, NEAR BY CREEKS AND DPA OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINARDURING NEAP TIDE IN NOVEMBER 2022

Sr.No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPA HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.547	BDL	
		Low tide	0.450	BDL	
2	KPT 2	High tide	0.338	BDL	
		Low tide	0.409	BDL	
3	KPT 3	High tide	0.354	BDL	
		Low tide	0.523	BDL	
CREEKS					
4	KPT-4 Khori-I	High tide	0.440	BDL	
		Low tide	0.408	BDL	
5	KPT-5 Nakti-I	High tide	0.205	BDL	
		Low tide	0.426	BDL	
6	KPT-6 Nakti-II	High tide	ND	ND	ND
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.799	BDL	
8		Low tide	0.709	BDL	
9	SPM	High tide	0.857	BDL	
10		Low tide	0.987	BDL	

BDL: Below Detectable Limit.ND: Not detected

PHYTOPLANKTON POPULATION:

For the evaluation of the Phytoplankton population in DPA harbour area and within the immediate surroundings of the port, sampling was conducted from 5 sampling locations (3 in harbour area and two in Nakti creek) during high tide period and low tide period of spring tide and neap tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by, Diatoms, blue green algae and Dinoflagellates during spring tide period. Diatoms were represented by 26 genera, Blue green algae were represented by 2 genera and Dinoflagellates were represented by 6 genera during the sampling conducted in spring tide in November, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 39-243units/ L during high tide period and115-199 units/L during low tide of Spring Tide. During spring tide sampling phytoplankton communities were dominated by *Skeletonema* sp almost forming a bloom in the Kandla creek and other nearby creek area and abundant population of *Coscinodiscus sp.* and *Chaetoceros* sp.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms, Blue green algae and DinoflagellatesduringNeap tide period. Diatoms were represented by 24 genera, Blue green algae were represented 2 genera and Dinoflagellates with 5 genera during the sampling conducted in Neap tide in November, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 43-299 units/ L during high tide period and 143-193 units/L during low tide of Neap Tide. During Neap tide sampling phytoplankton communities were dominated by, *Ditylum sp and Coscinodiscus sp.*

For the evaluation of the Phytoplankton population in DPA OOT jetty area in Path Finder creek sampling was conducted from two sampling locations; Jetty area and SPM area during high tide period and low tide of spring tide and Neap tide period.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green algae and Dinoflagellates during spring tide period. Diatoms were represented by 25 genera, Blue Green algae by 5 genera and Dinoflagellates by 6 genera during the sampling conducted in spring tide in November, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty area was 209 units/L during high tide period and 177 units/L during low tide of Spring Tide. Phytoplankton of the sampling stations at sub surface layer in the SPM area was varying from 206 units/ L during high tide period and 131 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green and Dinoflagellates during Neap tide period. Diatoms were represented by 32 genera and Blue green algae by 4 genera and Dinoflagellates by 6 genera during the sampling conducted in Neap tide in November, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty was varying from 244units/ L during high tide period and 200

units/L during low tide of Neap Tide. Phytoplankton of the sampling stations at sub surface path finder creek near SPM area was varying from 259 units/L during high tide period and 294 units/L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)

Margalef's diversity index (Species Richness) of phytoplankton communities in the Kandla creek and nearby creeks sampling stations was varying from 2.184- 4.688 with an average of 3.346 during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from1.963- 3.589 with an average of 2.835during the consecutive low tide period.

Margalef's diversity index (Species Richness) of phytoplankton communities in the stations in Kandla creek and nearby creeks was varying from 2.393-4.279 with an average of 3.586during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) of phytoplankton communities in the Kandla creek region and nearby creeks was varying from 2.821-3.86 with an average of 3.357during consecutive low tide.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 4.867 at OOT jetty area and 4.129 at SPM area during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 4.443 and 3.692 at SPM during the consecutive low tide period.

Margalef's diversity index (Species Richness) of phytoplankton communities in the stations was 4.73 at OOT jetty area and 4.139 at SPM area during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) of phytoplankton communities in the path finder creek near OOT jetty was 4.152 and SPM area was 5.454 during the consecutive low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.786- 1.034 between selected sampling stations with an average value of 0.925 during high tide period of spring tideat Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.790-0.915 between selected sampling stations with an average value of 0.855 during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.867–1.022 between selected sampling stations with an average value of 0.932 during high tide period of neap tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton

communities in the sampling stations was in the range of 0.926- 1.001 between selected sampling stations with an average value of 0.951during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was1.037 at OOT jetty area and 0.946 at SPM area during the sampling conducted in High tide period of spring tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 1.043 and 0.982 at SPM during the consecutive low tide period of spring tide.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.998 at OOT jetty area and1.035 at SPM area during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 0.942 and at SPM area was1.036 during the consecutive low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.778-0.851 between selected sampling stations with an average of 0.823 during high tide period of spring tide. Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks except few, which was varying from 0.787-0.842 between selected sampling stations with an average of 0.814 during consecutive low tide.

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations except few in Kandla Harbour region and nearby creeks, during high tide period and low tide period during Neap tide also, which was varying from 0.813-0.874 with an average value of 0.847 between selected sampling stations during high tide period and 0.840-0.871 varying from with an average value of 0.858 between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Simpson diversity index (1-D) of phytoplankton communities in the stations was0.863 at OOT jetty area and 0.820 at SPM area during the sampling conducted in High tide period of spring tide at Path finder creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.876 and 0.867 at SPM during the consecutive low tide period in the path finder creek.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.838 at OOT jetty area and 0.881 at SPM area during the sampling conducted in High tide period of Neap tide at Path

finder Creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.832 and at SPM area was 0.867 during the consecutive low tide period.

Table:-47 4PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND , NEAR BY CREEKS DURING SPRING TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% Of diversity	Margalef's diversity index (Species Richness)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	207	26/34	76.47	4.688	1.034	0.8511
	2	183	22/34	64.71	4.031	1.005	0.8437
	3	193	13/34	38.24	2.28	0.811	0.7778
	4	243	18/34	52.94	3.095	0.9391	0.8192
	5	193	21/34	61.76	3.8	0.9777	0.8281
	6	39	9/34	26.47	2.184	0.786	0.8178
LOW TIDE	1	178	14/34	41.18	2.509	0.8042	0.787
	2	199	20/34	58.82	3.589	0.8982	0.8075
	3	115	14/34	41.18	2.74	0.8696	0.8365
	4	154	18/34	52.94	3.375	0.915	0.8416
	5	163	11/34	32.35	1.963	0.7895	0.7957

Table:-48 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	216	24/31	77.42	4.279	0.98	0.8568
	2	229	22/31	70.97	3.865	0.958	0.853
	3	228	22/31	70.97	3.868	1.022	0.8743
	4	299	23/31	74.19	3.859	0.8667	0.8127
	5	254	19/31	61.29	3.251	0.8929	0.8307
	6	43	10/31	32.26	2.393	0.8712	0.8571
LOW TIDE	1	183	18/31	58.06	3.263	0.9504	0.8636
	2	143	15/31	48.39	2.821	0.946	0.8666
	3	178	21/31	67.74	3.86	1.001	0.8708
	4	193	19/31	61.29	3.42	0.931	0.84
	5	193	19/31	61.29	3.42	0.9259	0.8469

Table:-49 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING SPRING TIDE IN NOVEMBER2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Species Composition % (Group level)
HIGH TIDE	Sub surface	6	BLUE GREEN ALGAE	0-8	2/34	5.88
			DIATOMS	38-238	26/34	76.47
			DINOFLAGELLATES	0-11	6/34	17.65
			TOTAL PHYTO PLANKTON	**39-243**	**34**	
LOW TIDE	Sub surface	5	BLUE GREEN ALGAE	1-6	2/34	5.88
			DIATOMS	110-190	26/34	76.47
			DINOFLAGELLATES	1-7	6/34	17.65
			TOTAL PHYTO PLANKTON	**115-199**	**34**	

TABLE:-50 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN NOVEMBER 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Species Composition % (Group level)
HIGH TIDE	Sub surface	6	BLUE GREEN ALGAE	0-6	2/31	6.45
			DIATOMS	43-293	24/31	77.42
			DINOFLAGELLATES	0-9	5/31	16.13
			TOTAL PHYTO PLANKTON	**43-299**	**31**	
LOW TIDE	Sub surface	5	BLUE GREEN ALGAE	2-6	2/31	6.45
			DIATOMS	133-186	24/31	77.42
			DINOFLAGELLATES	3-8	5/31	16.13
			TOTAL PHYTO PLANKTON	**143-193**	**31**	

TABLE:-51 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR &NEAR BY SPM, DURING SPRING TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	209	27/36	75.00	4.867	1.037	0.863
	SPM	206	23/36	63.89	4.129	0.946	0.820
LOW TIDE	Jetty	177	24/36	66.67	4.443	1.043	0.876
	SPM	131	19/36	52.78	3.692	0.982	0.867

TABLE:-52 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	244	27/42	64.29	4.73	0.998	0.838
	SPM	259	24/42	57.14	4.139	1.035	0.881
LOW TIDE	Jetty	200	23/42	54.76	4.152	0.942	0.832
	SPM	294	32/42	76.19	5.454	1.036	0.867

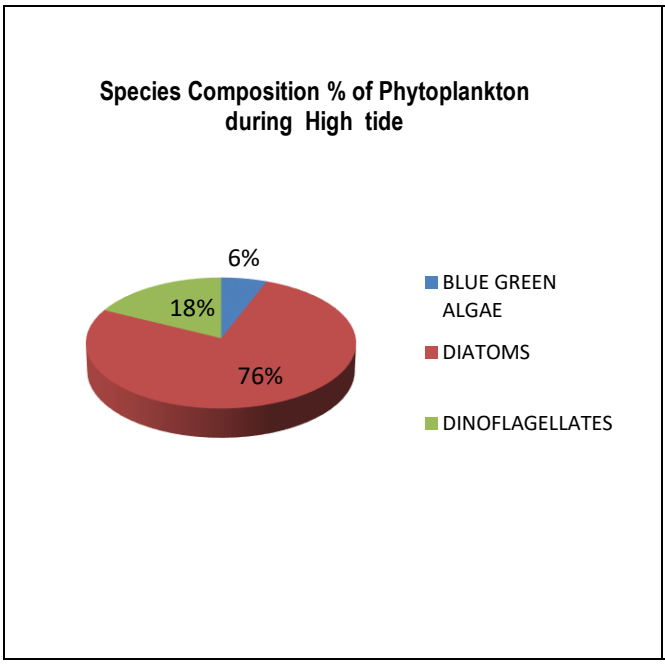
TABLE:-53 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPAOOT AT PATH FINDER CREEK, VADINAR & NEAR BY SPM, DURING SPRING TIDE IN NOVEMBER 2022

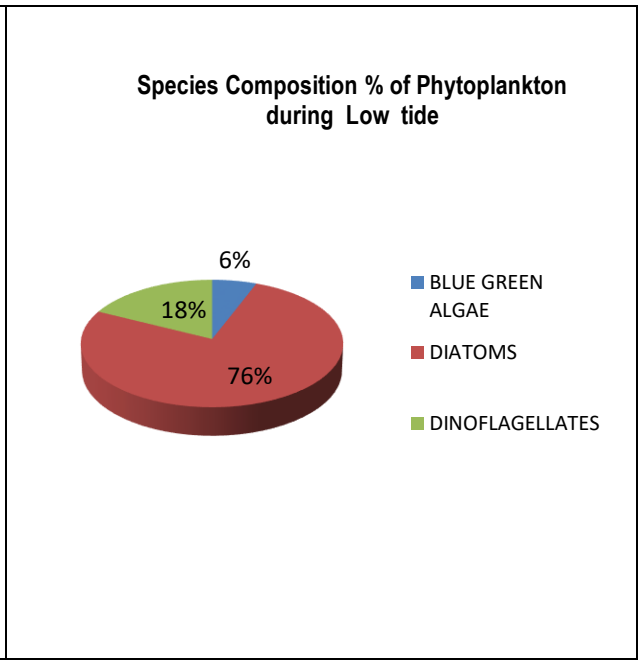
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN ALGAE	14-20	5/36	13.89
			DIATOMS	180-192	25/36	69.44
			DINOFLAGELLATES	3-6	6/36	16.67
			TOTAL PHYTO PLANKTON	**206-209**	**36**	
LOW TIDE	Sub surface	2	BLUE GREEN ALGAE	12-19	5/36	13.89
			DIATOMS	118-156	25/36	69.44
			DINOFLAGELLATES	1-2	6/36	16.67
			TOTAL PHYTO PLANKTON	**131-177**	**36**	

Table:- 54 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN NOVEMBER 2022

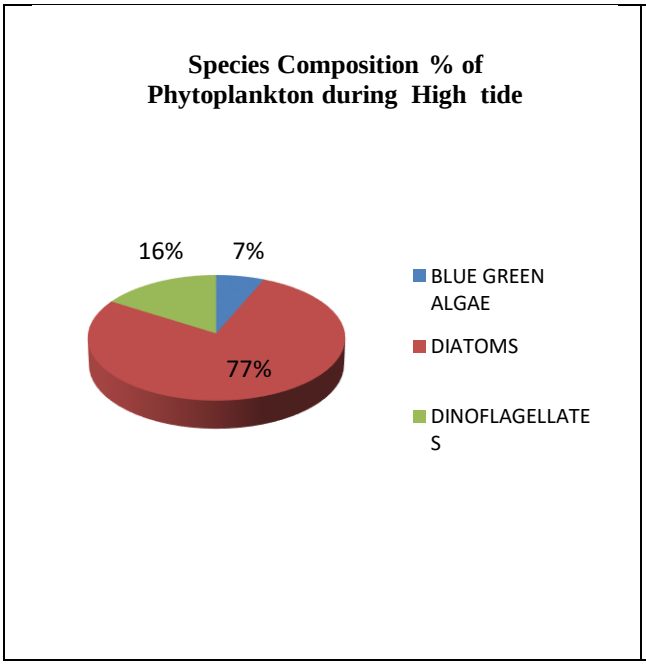
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Species Composition % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN ALGAE	5-7	4/42	9.52
			DIATOMS	238-248	32/42	76.19
			DINOFLAGELLATES	1-4	6/42	14.29
			TOTAL PHYTO PLANKTON	**244-259**		
LOW TIDE	Sub surface	2	BLUE GREEN ALGAE	4-8	4/42	9.52
			DIATOMS	194-282	32/42	76.19
			DINOFLAGELLATES	2-4	6/42	14.29
			TOTAL PHYTO PLANKTON	**200-294**		

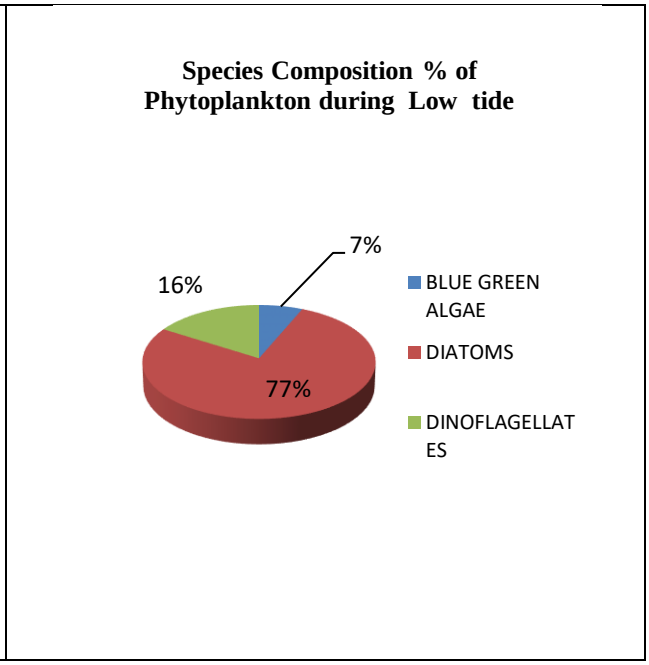
Species Composition % of Phytoplankton during High tide and Low tide period during spring tide in Kandla creek and nearby creeks



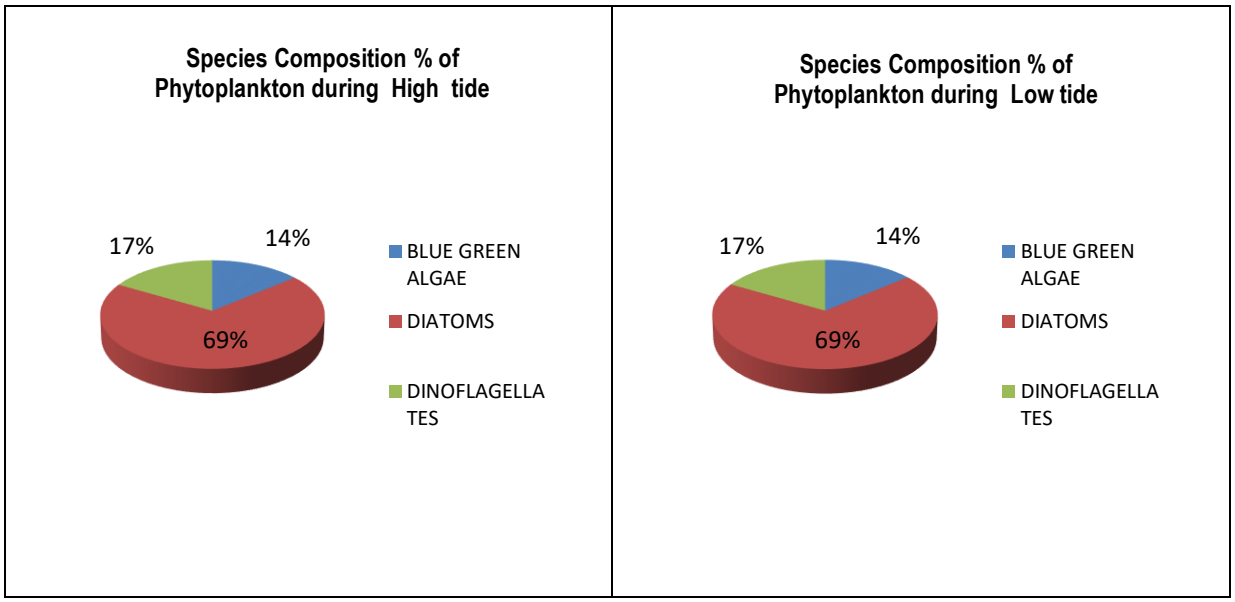


Species Composition % of Phytoplankton during High tide and Low tide period during Neap tide in Kandla creek and nearby creeks

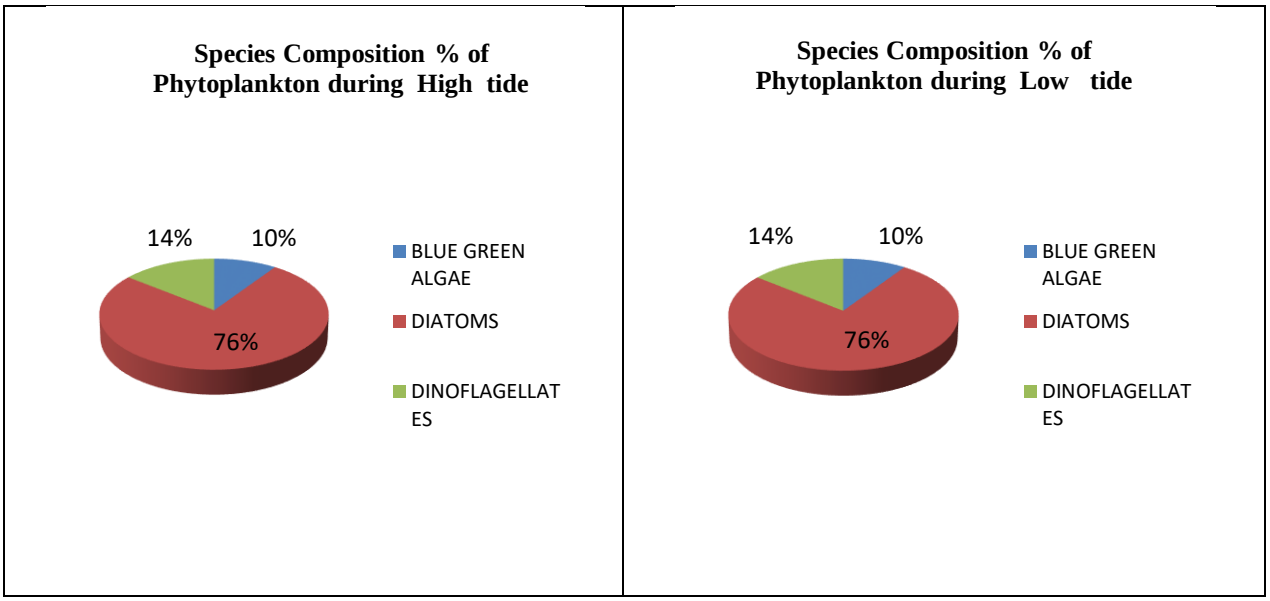




Species Composition % of Phytoplankton during High tide and Low tide period during spring tide in Path Finder Creek, Vadinar



Species Composition % of Phytoplankton during High tide and Low tide period during Neap tide in Path Finder Creek, Vadinar



ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPA harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khoricreek) during high tide period and low tide period of spring tide and Neap tide in November, 2022. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was representedby mainly six groups;Tintinnids, Copepods,Arrow worms,Mysids, Urochordata,Ciliates and 8 larval forms.The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly six groups;Tintinnids, Copepods,Arrow worms, Mysids, Urochordata, Ciliatesand 6 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPA harbour area and nearby creek was varying from 25-128 $x10^3$ N/m^3 during high tide and 103-144$x10^3$ N/m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPA harbour area and nearby creek was varying from 19-114$x10^3$ N/m^3 during high tide and 76-106$x10^3$ N/ m^3 during low tide of Neap Tide period.

For the evaluation of the Zooplankton population in DPA OOT jetty area in Path Finder creek and SPM in Vadinar selected 2 sampling locations (1 in jetty area and one near SPM).

During spring tide sampling plankton sample were collected at Jetty area and near SPM during consecutive high tide period and low tide period. During Neap tide sampling Plankton samples were collected from jetty area and SPM during consecutive high tide period and low tide period.

The Zooplankton community of the sub surface water in the path finder creek during spring tide was represented by mainly four groups Tintinnids, Copepods, Urochordata, Ciliatesand 4 larval forms. While the Zooplankton community of the sub surface water in the path Finder creeks at Jetty region and SPM during neap tide was represented by four groups, Tintinnids, Copepods, Arrow worms, Urochordataand 5 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPA OOT Jetty area of path finder creek was 91$x10^3$ N/m^3 during high tide and 86$x10^3$ N/m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPA SPM area of path finder creek was 101$x10^3$ N/m^3 during high tide and 70$x10^3$ N/ m^3 during low tide of spring Tide period.

Zooplankton of the sampling stations at sub surface layer in the DPA OOT jetty area in path finder creek was recorded 87$x10^3$ N/m^3 during high tide and 65$x10^3$ N/ m^3 during consecutive low tide period of Neap tide. Zooplankton of the sampling stations at sub surface layer in the DPASPM area in path finder creek was recorded 64$x10^3$ N/m^3during high tide and 87$x10^3$ N/ m^3 during consecutive low tide period of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)

Margalef's diversity index (Species Richness) of Zooplankton communities in the stations Kandla creek region and nearby creeks was varying from 2.175- 5.186 with an average of 3.450 during the sampling conducted in High tide period. Margalef's diversity index (Species Richness) of Zooplankton communities varying from 2.373-3.823 with an average of 3.261 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) of Zooplankton communities in the Kandla creek region and nearby creeks sampling stations were varying from1.358-3.858 with an average of 2.930 during the sampling conducted in high tide and varying from 2.289- 4.618 with an average of 3.513 during the sampling conducted in low tide during Neap tide period.

Margalef's diversity index (Species Richness) of Zooplankton communities in the sampling stationnear jettyat Path Finder Creek, Vadinar during the sampling conducted inconsecutive high tide period and low tide of spring tide was recorded as 1.995 and 1.796 respectively. Margalef's diversity index (Species Richness) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive high tide period and low tide of spring tide was recorded as 2.600 and 2.118 respectively.

Margalef's diversity index (Species Richness) of Zooplankton communities near Jetty at Path finder creek were varying from 3.807 and 2.396 respectivelyduring the sampling conducted in consecutive high tide period and Low tide period of Neap tide. While Margalef's diversity index (Species Richness) of Zooplankton communities near SPM at Path finder creek were varying from 2.645-3.135 respectively during the consecutive high tide and low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.778-1.164 between selected sampling stations with an average value of0.939 during high tide period of spring tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.795-1.015 between selected sampling stations with an average value of0.938 during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.490-0.914 between selected sampling stations with an average value of 0.805 during high tide period of Neap tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range 0.797-1.041 of between selected sampling stations with an average value of 0.928 during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.816-0.793 respectively. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.834-0.808 respectively.

Shannon-Wiener's Index (H) of Zooplankton communities near jetty at Path finder creek was varying from 0.956-0.755 respectively during the sampling conducted consecutive high tide period and low tide period of Neap tide. While Shannon-Wiener's Index (H) of Zooplankton communities near SPM at Path finder creek was varying from 0.775-0.751during the consecutive high tide and low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of Zooplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 most of sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide of spring tide period except few stations, which was varying from 0.780-0.909 between selected sampling stations with an average of 0.837 during high tide period and was varying from 0.785- 0.864 with an average value of 0.837 between selected sampling stations during low tide.

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide period of Neap tide except few, which was varying from 0.591-0.827 between selected sampling stations with an average of 0.753 during high tide period and was varying from 0.793-0.852 with an average value of 0.820 between selected sampling stations during consecutive low tide. This species diversity suggests a relatively few successful species in this habitat during November, 2022 sampling.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.821 and 0.815 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.812 and 0.828 respectively.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of Neap tide was recorded as 0.836- 0.766 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.768 and 0.719 respectively.

TABLE:-55 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDEIN NOVEMBER 2022

Tide	Sampling Station	Abundance In $Nx10^3/m^3$	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	124	26/33	78.79	5.186	1.164	0.9089
	2	114	18/33	54.55	3.589	0.8655	0.7802
	3	102	16/33	48.48	3.243	0.9207	0.8189
	4	128	17/33	51.52	3.298	0.9062	0.8124
	5	107	16/33	48.48	3.21	0.997	0.8686
	6	25	8/33	24.24	2.175	0.7777	0.83
LOW TIDE	1	117	16/33	48.48	3.15	0.9709	0.8609
	2	144	20/33	60.61	3.823	0.9468	0.8238
	3	121	19/33	57.58	3.753	1.015	0.8639
	4	108	16/33	48.48	3.204	0.9609	0.8505
	5	103	12/33	36.36	2.373	0.7949	0.7853

TABLE:-56 ZOOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREAAT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE INNOVEMBER 2022

Tide	Sampling Station	Abundance In No $x10^3/m^3$	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	82	18/32	56.25	3.858	0.9017	0.7814
	2	99	16/32	50.00	3.264	0.9138	0.8273
	3	89	13/32	40.63	2.673	0.8264	0.7763
	4	114	18/32	56.25	3.589	0.8478	0.7645
	5	98	14/32	43.75	2.835	0.8503	0.7766
	6	19	5/32	15.63	1.358	0.4901	0.5906
LOW TIDE	1	79	11/32	34.38	2.289	0.797	0.7932
	2	76	21/32	65.63	4.618	1.041	0.8516
	3	106	21/32	65.63	4.289	1.026	0.8446
	4	90	15/32	46.88	3.111	0.9087	0.8177
	5	100	16/32	50.00	3.257	0.865	0.7939

Table:-57 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREAATKANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN NOVEMBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3/ m^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	tintinnids	9-26	11/33	33.33
			Copepods	11-51	9/33	27.27
			Arrow worms	0-1	1/33	3.03
			Mysids	0-2	1/33	3.03
			Urochordata	1-6	2/33	6.06
			Ciliates	0-2	1/33	3.03
			Larval forms	4-50	8/33	24.25
			TOTAL ZOOPLANKTON N/ M^3	**25-128**	**33**	
LOW TIDE	Sub surface	5	Tintinnids	18-33	11/33	33.33
			Copepods	37-49	9/33	27.27
			Arrow worms	0-4	1/33	3.03
			Mysids	0-2	1/33	3.03
			Urochordata	0-2	2/33	6.06
			Ciliates	0-2	1/33	3.03
			Larval forms	41-65	8/33	24.25
			TOTAL ZOOPLANKTON N/M^3	**103-144**	**33**	

TABLE:-58 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA IN KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN NOVEMBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^{3}/ m^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinnids	0-14	10/32	31.25
			Copepods	6-49	10/32	31.25
			Arrow worms	0	1/32	3.13
			Mysids	0-6	2/32	6.25
			Urochordata	0-4	2/32	6.25
			Ciliates	0-2	1/32	3.13
			Larval forms	13-50	6/32	18.74
			TOTAL ZOOPLANKTON N/M^3	**19-114**	**32**	
LOW TIDE	Sub surface	5	tintinnids	4-17	10/32	31.25
			Copepods	25-45	10/32	31.25
			Arrow worms	0-2	1/32	3.13
			Mysids	0-6	2/32	6.25
			Urochordata	0-5	2/32	6.25
			Ciliates	0-1	1/32	3.13
			Larval forms	27-47	6/32	18.74
			TOTAL ZOOPLANKTON N/M^3	**76-106**	**32**	

Table:-59 ZOOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In x10^{3}N / m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	91	10/20	50.00	1.995	0.816	0.821
	SPM	101	13/20	65.00	2.6	0.834	0.812
LOW TIDE	Jetty	86	9/20	45.00	1.796	0.793	0.815
	SPM	70	10/20	50.00	2.118	0.808	0.828

TABLE:-60 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURINGNEAP TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In N$x10^3/m^3$	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	87	18/21	85.71	3.807	0.956	0.836
	SPM	64	12/21	57.14	2.645	0.775	0.768
LOW TIDE	Jetty	65	11/21	52.38	2.396	0.755	0.766
	SPM	87	15/21	71.43	3.135	0.751	0.719

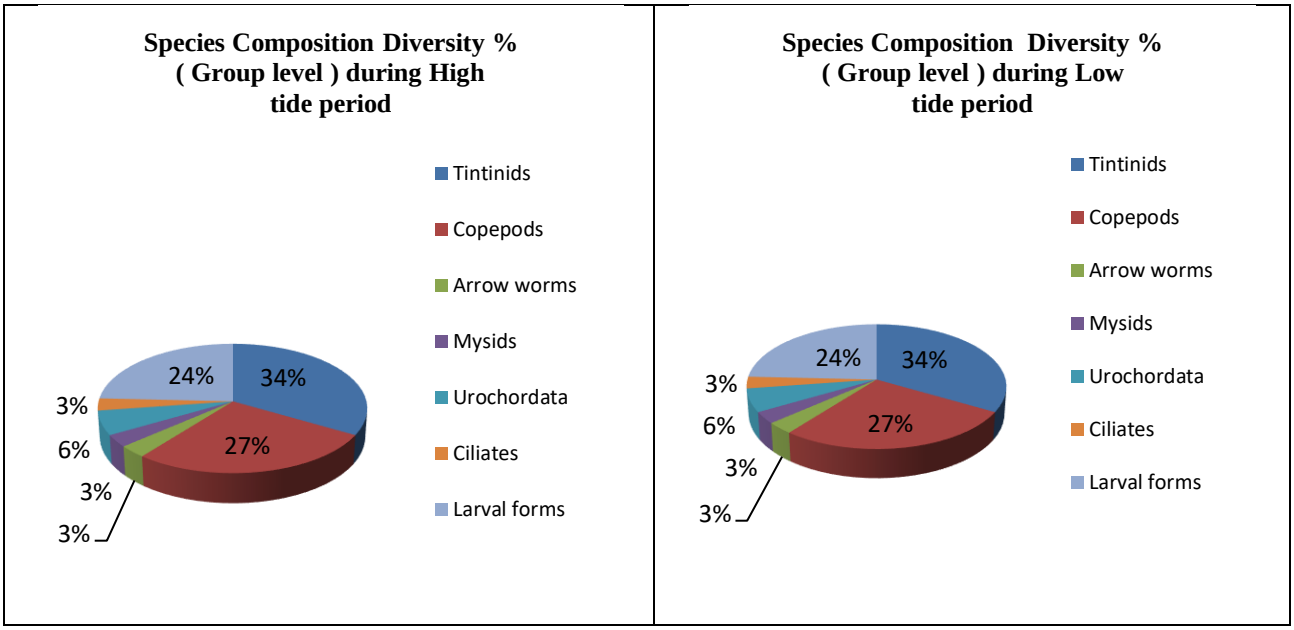
Table:-61 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREAAND PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN NOVEMBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3/m^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinnids	24-32	5/20	25.00
			Copepods	28-38	8/20	40.00
			Urochordata	1-2	2/20	10.00
			Ciliates	0-1	1/20	5.00
			Larval forms	30-36	4/20	20.00
			TOTAL ZOOPLANKTON	**91-101**	**20**	
LOW TIDE	Sub surface	2	Tintinnids	17-21	5/20	25.00
			Copepods	30-37	8/20	40.00
			Urochordata	0	2/20	10.00
			Ciliates	0	1/20	5.00
			Larval forms	19-32	4/20	20.00
			TOTAL ZOOPLANKTON	**70-86**	**20**	

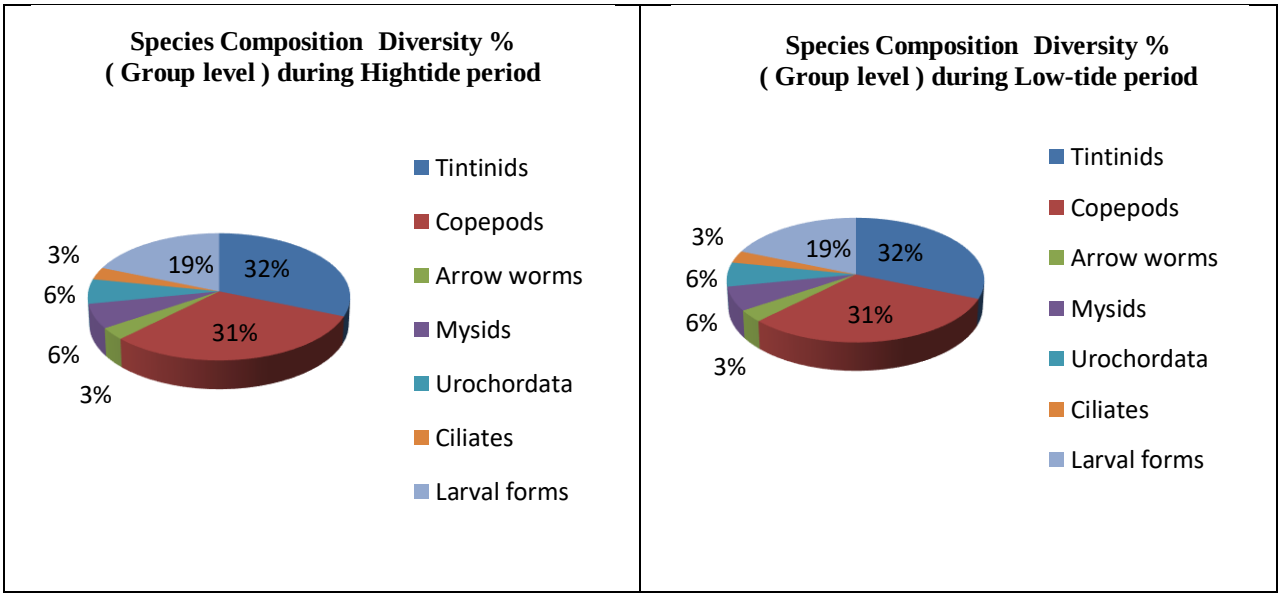
TABLE:-62 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN NOVEMBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3/ m^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	tintinnids	9-16	7/21	33.33
			Copepods	23-34	6/21	28.57
			Arrow worms	0	1/21	4.76
			Urochordata	0-2	2/21	9.52
			Larval forms	32-35	5/21	23.82
			TOTAL ZOOPLANKTON	**64-87**	**21**	
LOW TIDE	Sub surface	2	tintinnids	6-9	7/21	33.33
			Copepods	29	6/21	28.57
			Arrow worms	0-1	1/21	4.76
			Urochordata	0-3	2/21	9.52
			Larval forms	27-48	5/21	23.82
			TOTAL ZOOPLANKTON	**65-87**	**21**	

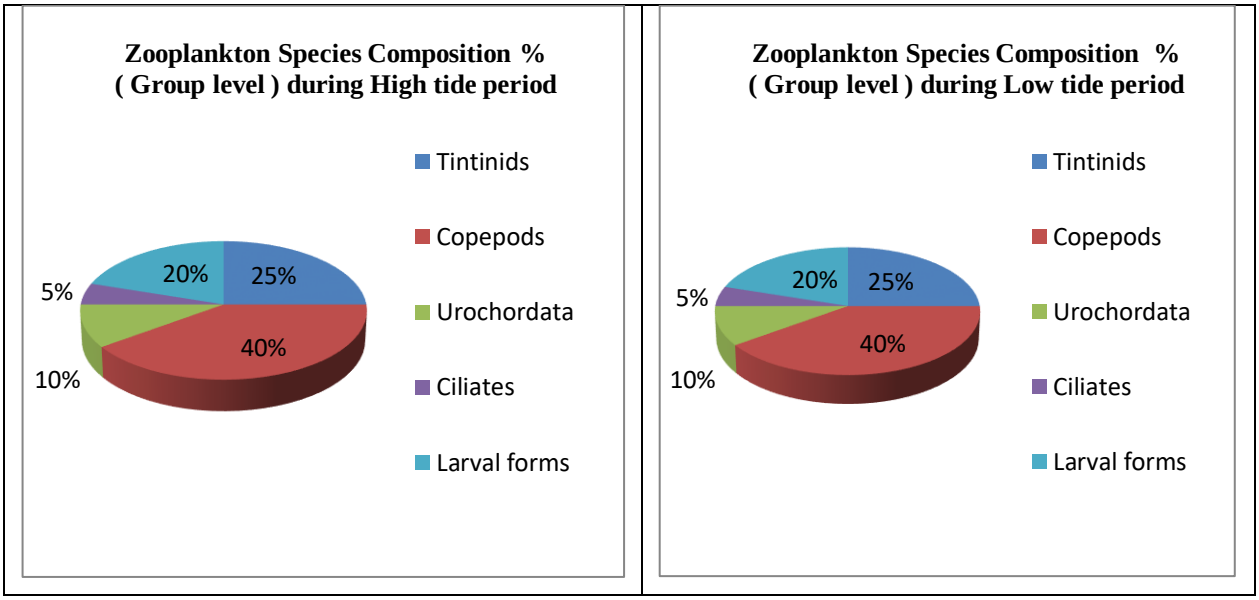
Species Composition % of Zooplankton during High tide and Low tide period of spring tide In Kandla Creek and nearby Creeks



Species Composition % of Zooplankton during High tide and Low tide period of Neap tide In Kandla Creek and nearby Creeks



Species Composition % of Zooplankton during High tide and Low tide period of Spring tide In Path Finder Creek and near Jetty



Species Composition % of Zooplankton during High tide and Low tide period of Neap tide In Path Finder Creek near jetty and nearby SPM

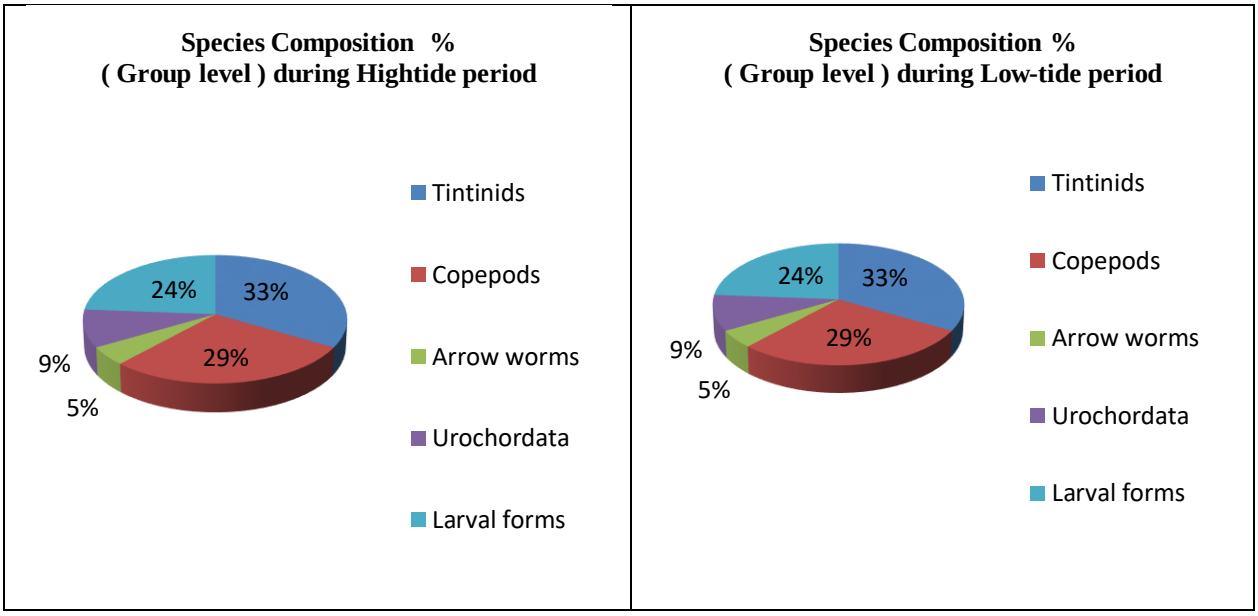


TABLE:-63 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING NEAP TIDE OF NOVEMBER 2022

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B2	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Abundant
	Chaetocerotales	Chaetocerotaceae	*Bacteriastrum sp*	D2	Very sparse
			Chaetoceros sp.	D3	Scattered
	Corethrales	Corethraceae	*Corethron* sp	D4	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D5	Dominant
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D6	Very sparse
		Streptothecaceae	*Helicotheca sp*	D7	Very sparse
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D8	Sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D9	Dominant
	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D10	Very sparse
		Skeletonemataceae	*Skeletonema*sp	D11	Abundant
	Triceratiales	Triceratiaceae	*Odontella* sp.	D12	Very sparse
			Triceratium sp.	D13	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D14	Very sparse
			Nitzschia sp	D15	Sparse
			Pseudo-nitzschia sp.	D16	Very sparse
	Naviculales	Pleurosigmataceae	*Pleurosigma* sp.	D17	Very sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D18	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D19	Scattered
			*Fragilaria*sp	D20	Very sparse
			*Synedra*sp	D21	Very sparse

	Striatellales	Striatellaceae	*Grammatophora sp*	D22	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D23	Sparse
			Thalassiothrix sp.	D24	Very sparse
Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF1	Sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF2	Very sparse
	Gonyaulacales	Pyrophacaceae	*Pyrophacus sp.*	DF3	Very sparse
		Ceratiaceae	*Ceratium furca*	DF4	Very sparse
			Ceratium tripos	DF5	Very sparse

TABLE:-64 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING SPRING TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B2	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Sparse
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp.	D2	Abundant
	Corethrales	Corethraceae	*Corethron* sp	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Abundant
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D5	Sparse
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D6	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D7	Scattered
	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D8	Very sparse
		Lauderiaceae	*Lauderia* sp	D9	Very sparse
		Skeletonemataceae	*Skeletonema*sp	D10	Dominant
	Triceratiales	Triceratiaceae	*Odontella* sp.	D11	Very sparse
			Triceratium sp.	D12	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D13	Very sparse
			Nitzschia sp	D14	Very sparse
			Pseudo-nitzschia sp.	D15	Very sparse
	Naviculales	Naviculaceae	*Navicula* sp.	D16	Very sparse
		Plagiotropidaceae	*Plagiotropis sp*	D17	Very sparse
		Pleurosigmataceae	*Pleurosigma* sp.	D18	Sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D19	Very sparse
		Surirellaceae	*Surirella sp.*	D20	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D21	Sparse

			*Fragilaria*sp	D22	Very sparse
			*Synedra*sp	D23	Sparse
	Striatellales	Striatellaceae	*Grammatophora sp*	D24	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D25	Scattered
			Thalassiothrix sp.	D26	Sparse
Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF1	Sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF2	Very sparse
	Gonyaulacales	Ceratiaceae	*Ceratium breve*	DF3	Very sparse
			Ceratium furca	DF4	Very sparse
			Ceratium fusus	DF5	Very sparse
			Ceratium tripos	DF6	Very sparse

TABLE:-65 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINARDURING NEAP TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B1	Very sparse
			Oscillatoria sp.	B2	Very sparse
			Spirulina sp.	B3	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B4	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Scattered
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D2	Scattered
	Corethrales	Corethraceae	*Corethron* sp	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Dominant
	Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D5	Very sparse
		Hemiaulaceae	*Cerataulina sp.*	D6	Very sparse
			Eucampia sp	D7	Very sparse
		Streptothecaceae	*Helicotheca sp*	D8	Very sparse
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D9	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylumsp*	D10	Abundant
	Rhizosoleniales	Rhizosoleniaceae	*Dactyliosolen sp.*	D11	Very sparse
			Rhizosolenia sp.	D12	Sparse
	Thalassiosirales	Skeletonemataceae	*Skeletonema sp.*	D13	Abundant
		Lauderiaceae	*Lauderia sp*	D14	Very sparse
		Thalassiosiraceae	*Planktoniella*sp	D15	Very sparse
	Triceratiales	Triceratiaceae	*Odontellasp*	D16	Very sparse
			*Triceratium*sp	D17	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria*sp.	D18	Abundant
			Nitzschia sp	D19	Very sparse

			*Pseudo-nitzschia*sp	D20	Scattered
	Naviculales	Naviculaceae	*Meuniera sp.*	D21	Very sparse
			Navicula sp	D22	Very sparse
		Pinnulariaceae	*Pinnulariasp*	D23	Very sparse
		Pleurosigmataceae	*Pleurosigma* sp	D24	Very sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D25	Very sparse
		Surirellaceae	*Surirella*sp	D26	Very sparse
Fragilariophyceae	Climacospheniales	Climacospheniaceae	*Climacosphenia sp.*	D27	Very sparse
	Fragilariales	Fragilariaceae	*Asterionellopsis sp.*	D28	Very sparse
			Synedra sp.	D29	Very sparse
	Striatellales	Striatellaceae	*Striatella*sp	D30	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D31	Sparse
			Thalassiothrix sp.	D32	Sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
	Dinophysales	Dinophysaceae	*Dinophysis sp.*	DF2	Very sparse
	Gonyaulacales	Pyrophacaceae	*Pyrophacus sp.*	DF3	Very sparse
		Ceratiaceae	*Ceratium furca*	DF4	Very sparse
			Ceratium fusus	DF5	Very sparse
			Ceratium tripos	DF6	Very sparse

TABLE:-66 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPAOOT AREA AT PATH FINDER CREEKAND NEARBY SPM AT VADINAR DURING AND SPRING TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Chroococcales	Chroococcaceae	*Merismopedia sp.*	B1	Very sparse
	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B2	Very sparse
			Oscillatoria sp.	B3	Sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B4	Very sparse
	Stigonematales	Stigonemataceae	*Stigonema sp.*	B5	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Sparse
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp.	D2	Dominant
	Corethrales	Corethraceae	*Corethron* sp	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Abundant
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D5	Very sparse
		Hemiaulaceae	*Cerataulina sp.*	D6	Very sparse
		Streptothecaceae	*Helicotheca sp*	D7	Very sparse
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D8	Scattered
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D9	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D10	Abundant
	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D11	Very sparse
		Lauderiaceae	*Lauderia* sp	D12	Very sparse
	Triceratiales	Triceratiaceae	*Odontella* sp.	D13	Sparse
			Triceratium sp.	D14	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D15	Scattered
			Nitzschia sp	D16	Very sparse
			Pseudo-nitzschia sp.	D17	Sparse
	Naviculales	Pinnulariaceae	*Pinnulariasp*	D18	Very sparse

		Pleurosigmataceae	*Pleurosigma* sp.	D19	Very sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D20	Very sparse
		Surirellaceae	*Surirella sp.*	D21	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D22	Sparse
			*Synedra*sp	D23	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D24	Sparse
			Thalassiothrix sp.	D25	Very sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
	Dinophysales	Dinophysaceae	*Dinophysis sp.*	DF2	Very sparse
	Gonyaulacales	Pyrophacaceae	*Pyrophacus sp.*	DF3	Very sparse
		Ceratiaceae	*Ceratium furca*	DF4	Very sparse
			Ceratium fusus	DF5	Very sparse
			Ceratium tripos	DF6	Very sparse

TABLE:-67 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING NEAP TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Very sparse
		Codonellidae	*Tintinnopsis dadayi*	T2	Very sparse
			Tintinnopsisfailakkaensis	T3	Very sparse
			Tintinnopsis gracilis	T4	Very sparse
			Tintinnopsis mortensenii	T5	Very sparse
			Tintinnopsis radix	T6	Very sparse
			Tintinnopsis tocantinensis	T7	Very sparse
		Tintinnidae	*Amphorellopsis sp.*	T8	Very sparse
			Eutintinnus sp.	T9	Very sparse
		Xystonellidae	*Favella sp.*	T10	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Sparse
			Parvocalanus sp.	C2	Very sparse
		Acartiidae	*Acartia sp.*	C3	Very sparse
		Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
		Centropagidae	*Centropages sp.*	C5	Very sparse
		Temoridae	*Temora sp.*	C6	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C7	Abundant
	Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C8	Scattered
		Euterpinidae	*Euterpina sp.*	C9	Sparse
	Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C10	Very sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeussp.*	M1	Very sparse
		Solenoceridae	*Solenocera sp.*	M2	Very sparse

Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea	L2	Very sparse
Maxillopoda Thecostraca			Cirripede larvae	L3	Very sparse
			Cyphonautes larvae	L4	Very sparse
			Ophiopluteus larvae	L5	Very sparse
Polychaeta			Trochophore larvae	L6	Very sparse

TABLE:-68 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING SPRING TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Scattered
		Codonellidae	*Tintinnopsis dadayi*	T2	Very sparse
			Tintinnopsisfailakkaensis	T3	Very sparse
			Tintinnopsis gracilis	T4	Very sparse
			Tintinnopsis mortensenii	T5	Very sparse
			Tintinnopsis radix	T6	Sparse
			Tintinnopsis tocantinensis	T7	Very sparse
		Metacylididae	*Metacylis*sp.	T8	Very sparse
		Tintinnidae	*Amphorellopsis sp.*	T9	Very sparse
			Eutintinnus sp.	T10	Very sparse
		Xystonellidae	*Favella sp.*	T11	Sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
			Parvocalanus sp.	C2	Very sparse
		Acartiidae	*Acartia sp.*	C3	Very sparse
		Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
		Centropagidae	*Centropages sp.*	C5	Very sparse
		Eucalanidae	*Subeucalanus sp.*	C6	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C7	Abundant
	Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C8	Sparse
		Euterpinidae	*Euterpina sp.*	C9	Sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Malacostraca	Mysida, Decapoda	Solenoceridae	*Solenocera sp.*	M1	Very sparse

Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea	L2	Sparse
Maxillopoda Thecostraca			Cirripede larvae	L3	Very sparse
			Cyphonautes larvae	L4	Very sparse
			Ophiopluteus larvae	L5	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L6	Very sparse
Polychaeta			Trochophore larvae	L7	Sparse
Pelecypoda			Veliger larvae of bivalves	L8	Very sparse

TABLE:-69 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINARDURING NEAP TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Sparse
		Codonellidae	*Tintinnopsisfailakkaensis*	T2	Very sparse
			Tintinnopsis gracilis	T3	Very sparse
			Tintinnopsis radix	T4	Very sparse
			Tintinnopsis tocantinensis	T5	Very sparse
		Tintinnidae	*Amphorellopsis sp.*	T6	Very sparse
		Xystonellidae	*Favella sp.*	T7	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
			Parvocalanus sp.	C2	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C3	Abundant
	Harpacticoida	Euterpinidae	*Euterpina sp.*	C4	Very sparse
		Ectinosomatidae	*Microsetella*sp.	C5	Very sparse
	Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C6	Very sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Maxillopoda Thecostraca			Cirripede larvae	L2	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L3	Very sparse
Polychaeta			Trochophore larvae	L4	Very sparse
Pelecypoda			Veliger larvae of bivalves	L5	Very sparse

TABLE:-70 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING SPRING TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Abundant
		Codonellidae	*Tintinnopsisgracilis*	T2	Very sparse
			Tintinnopsis mortensenii	T3	Very sparse
			Tintinnopsis radix	T4	Very sparse
		Xystonellidae	*Favella sp.*	T5	Scattered
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Sparse
			Parvocalanus sp.	C2	Very sparse
		Centropagidae	*Centropages sp.*	C3	Very sparse
		Tortanidae	*Tortanus sp.*	C4	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C5	Abundant
		Euterpinidae	*Euterpina sp.*	C6	Very sparse
	Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C7	Scattered
	Poicilostomatatoida	Corycaeidae	*Corycaeus sp.*	C8	Very sparse
Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea	L2	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L3	Very sparse
Pelecypoda			Veliger larvae of bivalves	L4	Very sparse

BENTHIC ORGANISMS:

Few Benthic organisms were observed in the collected sediments by using the Van-Veen grabs during the sampling conducted during spring tide period and Neap tide period from DPA harbour region and nearby creek. The Meio-benthic organisms during spring tide were represented by Polychaetes *Tharyx sp*and *Nereis sp.*, during Neap tide *by Neries sp.* and few Amphipods. Population of benthic fauna was varying from 10-60- N/m^2 during spring tide and 0-80 N/m^2 during Neap tide. The benthic communities at path finder Creek were represented by Polychaetes *Glycera* sp. *Cirratulus* sp. *Nereis sp*. and few Amphipods. Their population was varying as 60 N/m^2 at OOT jetty premises and 80 $N/m^{2\ near}$ the SPM area during spring tide and 50 N/m^2 at OOT jetty premises and 50 N/m^2 near the SPM area during Neap tide period.

Table:-71 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA HARBOUR AREA CREEKS DURING SPRING TIDE IN NOVEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	DPA HARBOUR			CREEKS		
Benthic fauna						
POLYCHAETES	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6
Family : CIRRATULIDAE *Tharyxsp.*	20	10	10	0	0	NS
Family :NEREIDAE *Nereis sp.*	0	0	0	20	40	NS
AMPHIPODA	0	0	0		20	NS
TOTAL Benthic Fauna NUMBER/ M^2	20	10	10	20	60	NS

NS: No sample

Table:-72 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA HARBOUR AREA CREEKS DURING NEAP TIDE IN NOVEMBER 2022

ABUNDANCE IN NO/M^2 DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	DPA HARBOUR			CREEKS		
Benthic fauna						
POLYCHAETES	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6
Family :NEREIDAE *Nereis sp.*	0	0	0	40	60	NS
Amphipoda	0	20	10	10	20	NS
TOTAL Benthic Fauna NUMBER/M^2	0	20	10	50	80	NS

Table:-73 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA OOT JETTY AREA, VADINAR DURING SPRING TIDE IN NOVEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	OOT Jetty Area	SPM area
POLYCHAETES		
Family : Glyceride *Glycera*sp.	20	40
Family : CIRRATULIDAE *Cirratulus*sp.	0	20
Family: *NEREIDAE* *Nereis sp.*	30	10
Amphipoda	10	20
TOTAL Benthic Fauna NUMBER/ M^2	60	80

Table:-74 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA OOT JETTY AREA, VADINAR DURING NEAP TIDE IN NOVEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	OOT Jetty Area	SPM area
POLYCHAETES		
Family : Glyceridase *Glycera* sp.	20	40
Family: *NEREIDAE* *Nereis sp.*	30	10
TOTAL Benthic Fauna NUMBER/ M^2	50	50

CHAPTER-11

CONCLUSIVE SUMMARY & REMEDIAL MEASURES

11.0 Conclusive Summary and Remedial measures Suggested

- The AAQ monitoring of six locations at Deendayal Port Authority indicates that the mean PM_{10} and $PM_{2.5}$ values for four locations viz. Marine Bhavan, Oil Jetty, Estate Office and Coal storage area were found higher than the permissible limit (standards100 µg/m^3, 60 µg/m^3). The higher concentration of Particulate matter at Marine Bhavan may be due to vehicles emissions during loading-unloading of food grains and timbers; at Estate office due to construction work, vehicles emission produced from trucks, heavy duty vehicles that pass through the road outside Kandla port and Oil jetty area; while at Coal Storage area lifting of coal from grab yard and other coal handling processes. Moreover, the transportation of coal produces pollution from heavy vehicles. At Tuna Port location, concentration of PM_{10} varied from 88-175 µg/m^3 and mean value was observed 145 µg/m^3 which was exceed the prescribed standard limit (100 µg/m^3), concentration of $PM_{2.5}$ was ranged from 47-87 µg/m^3 and mean was found 71 µg/m^3 which was exceed the standard limit (60 µg/m^3). At Gopalpuri PM_{10} concentration ranged from 67-168 µg/m3 and mean was 127 µg/m3 while $PM_{2.5}$ concentration ranged from 34-94 µg/m3 and mean was 66 µg/m3 were found exceed standard limit prescribed by NAAQS.
- At Vadinar, the average concentration of PM_{10} was 114 µg/m^3 and $PM_{2.5}$ was 74 µg/m^3 at Admin Colony which was slightly exceed the standard limit while at Signal building the mean concentration PM_{10} was 100 µg/m3 and $PM_{2.5}$ was 61 µg/m^3 which were very close to standard limit.
- During winter, the concentration of PM_{10} and $PM_{2.5}$ has been slowly augmented and reached a peak in the evening due to surface inversion of temperature after sunset. Thus, the pollutants are subsequently trapped in the lower layer of the atmosphere due to high atmospheric air pressure.
- Further, precautionary measures and management strategies to minimize the effect of particulate as well as gaseous pollutants have also been suggested for achieving its ambient levels in and around Kandla Port and Vadinar Port, Gujarat, India.

- Drinking water at all the twenty locations was found potable and it was found within in line of BIS standards (IS: 10500-2012).
- Transportation systems are the main source of noise pollution in project areas. Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading

containers and ships. All sampling location were within the permissible limit day time 75 dB (A) and night time 70 dB (A) for the industrial area.

- The treated sewage water of Kandla STP, Deendayal Port Colony (Gopalpuri) STP and Vadinar were in line with the standards set by the Central Pollution Control Board.
- It was suggested to monitor the STP performance on regular basis to avoid flow of contamination / Polluted water into the sea.
- Good species diversity suggests a relatively successful species in this habitat. A greater number of successful species and a more stable ecosystem. More ecological niches are available and the environment is less likely to be hostile complex food webs environmental change is less likely to be damaging to the ecosystem as a whole.
- The results obtained from the study for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.
- The mean day time temperature at Deendayal Port was 27.92 °C. The day-time maximum temperature was 32.9°C and minimum was 21.1 °C. The mean night time temperature recorded was 25.47 °C. The night-time maximum temperature was 29.7°C and minimum was 20.0 °C. The mean Solar Radiation in November month was 167.27 w/m^2. The maximum solar radiation was recorded 759 w/m^2 in 4th November, 2022 and the minimum solar radiation was recorded 1.80 w/m^2 in 30th November, 2022. The mean Relative humidity was 69.00 % for the month of November. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 34.0 %. The average wind velocity for the entire month of November was 1.21 m/s. Maximum wind velocity was recorded 10.19 m/s. The wind direction was mostly North-East.
- The results obtained from the study for the month of November 2022 for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.

Reasons for higher Values of PM_{10}

- The unloading of coal directly in the truck, using grabs cause coal to spread in air as well as coal dust to fall on ground. This settled coal dust again mixes with the air while trucks travel through it.

- Also, the coal loaded trucks were not always covered with tarpaulin sheets and these results in spillage of coal from trucks/dumpers during its transit from vessel to yard or storage site. This also increased PM values around marine Bhavan & Coal storage area.

Remedial Measures

The values of PM_{10} & $PM_{2.5}$ during the month of November, 2022 were beyond the standard limit at all locations (Coal Storage, Marine Bhavan, Oil Jetty and Estate office, Tuna Port) except Gopalpuri the concentration of particulate matter was slightly exceed. Given below are the remedial measures suggest to minimize the Air pollution.

- During November, 2022 overall ambient air quality of the DPA was within CPCB permissible limits except TSPM, PM_{10}, $PM_{2.5}$ at Coal storage area, Marine Bhavan, Oil Jetty and Estate Office. To improve air quality the port was using number of precautionary measures, such as maintained a wide expanse of Green zone, initiated Inter-Terminal Transfer (ITT) of tractor-trailers, Centralized Parking Plaza, providing shore power supply to tugs and port crafts, the use of LED lights at DPA area helps in lower energy consumption and decreases the carbon foot prints in the environment, time to time cleaning of paved and un paved roads, use of tarpaulin sheets to cover dumpers at project sites etc. are helping to achieve the cleaner and green future at port.

Solution towards the Green port:

Today, it is increasingly recognized that air pollution hurts human health. Consequently, efficient mitigation strategies need to be implementation for substantial environmental and health co-benefits.

The guidelines can be considered a basis for governments for the implementation of a strategic plan focused on the reduction of multi pollutant emission, as well as of the overall air pollution related risk.

- The plantation should be all along the periphery of the port and inside and outside the port along with the road. Trees having high dust trapping efficiency (*Azadirachta indica, Cassia fistula, Delonix regia, Ficus religiosa, Pterocarpus marsupium*) are to be grown alongside the roads.
- The water sprinkling should be use at each and every stage of transporting coal up the loading of truck to avoid generation of coal dust.

- The vehicles should be covered during transportation and the vehicle carrying the coal should not be overloaded by raising the height of carriage.
- The water sprinklers should be use during transportation of loaded heavy vehicles on raw road.
- It should be ensure that regular sweeping of coal internal, main road and space a free circulation.
- Practice should be initiated for using mask as preventative measure, to avoid Inhalation of dust particle- Mask advised in sensitive areas.
- Department for use maintenance should have a routine checkup noise level by replacing bearings, tights of all loose parts that can vibrate.
- Speed control is also an effective way to mitigate noise pollution, the lowest sound emission arise from vehicles moving smoothly.
- Use of renewable energy like solar energy should be optimal and ensure to work continuously.
- Keep neat and clean public transport and all basic items at public interaction places as much as possible.
- Technology like Electric cart, Inter-Terminal Transfer (ITT) are worthy selection to reduce Port operation efficiency and fuel cost.
- Conventional RTGCs should be altered as E-RTGCs counting inside the port completely.
- Initiate Natural Gas (CNG) as fuel by all buses and trucks.

Green Ports Initiative

- Deendayal Port 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 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 has also appointed GEMI as an Advisor for "Making Deendayal Port a Green Port - Intended Sustainable Development under the Green Port Initiatives.
- Deendayal Port 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 Trust. The plantation is being carried out by the Social Forestry division of Kachchh.

CHAPTER-12

REFERENCES

12.0 SOURCE OF LITERATURE AND ADDITIONAL REFERENCE

1) ALBERT WEST PHAL (1976) Protozoa Blackwell , London
2) Arunachalam S, Brantley H, Barzyk TM, Hagler G, Isakov V, Kimbrough E, Naess B, Rice N, Snyder MG, Talgo K, Venkatram A (2015) Assessment of port-related air quality impacts: geographic analysis of population. Int J Environ Pollut 58(4):231–250
3) Asha, P. S. and Diwakar (2007). Hydrobiology of the inshore waters off Tuticorin in the Gulf. J. Mar. Biol. Ass. India, 49: 7-11.
4) Astakhov AS, Kalugin IA, Aksentov KI, Daryin AV (2015) Geochemical indicators of paleo typhoons in shelf sediments. Geochemistry 4:387–392.
5) Bailey D, Solomon G (2004) Pollution prevention at ports: clearing the air. Environ Impact Assess Rev 24(7):749–774.
6) BANERJEE R.K. (1989) Heavy metals and Benthic foraminiferal distribution along Bombay coast India. Studies in benthic foraminifera. *Tokyo University Press* Tokyo pp 151-157
7) Banse K (1995) Zooplankton: Pivotal role in the control of ocean production: I. Biomass and production. ICES J Mar Sci 52: 265–277.
8) BeaugrandG, and Ibanez F (2004) Monitoring marine plankton ecosystems. II:ong-term changes in North Sea calanoid copepods in relation to hydroclimatic variability. Inter Res Mar EcolProgSer 284:35-47.
9) Benhamed S, Guardiola FA, Martinez S, Sanchez MJM, Sirvent CP, Mars M, Esteban MA (2016) Exposure of the gilthead seabream (Sparus aurata) to sediments contaminated with heavy metals down-regulates the gene expression of stress biomarkers. Toxicol Rep 3:364–372.
10) Best, M. A., Wither, A.W. and Coates, S. (2007). Dissolved oxygen as a physicochemical supporting element in the Water Framework Directive. Marine Pollution Bulletin 55(1-6): 53-64.
11) Buccolieri R, Cesari R, Dinoi A, Maurizi A, Tampieri F, Di Sabatino S (2016) Impact of ship emissions on local air quality in a Mediterranean City's harbour after the European sulphur directive. Int J Environ Pollut 59(1):30–42.
12) Chaurasia, S, Singh, S. and Gupta, A.D., 2013. Study on air quality of SKS Ispat and Power Ltd. Raipur (CG), India. Asian Journal of Science and Technologies, 4 (4), 48-50.

13) Conti ME, Ciasullo R, Tudino MB, Matta EJ (2015) "The industrial emissions trend and the problem of the implementation of the industrial emissions directive (IED)" Air Quality. Atmosph Health 8(2): 151–161.

14) CPCB (2013): Guidelines for Manual Sampling & Analyses. (Guidelines for the Measurement of Ambient Air Pollutants, Vol. I), Central Pollution Control Board, National Ambient Air Quality Series: NAAQMS/36/2012-13.

15) DAY F. (1889) The fauna of British India Ceylon and Burma- Fishes Vol-1- Vol-2 *Taylor and Francis* London

16) DESIKACHARYT.V. (1989) Atlas of diatoms, Madras Science Foundation

17) DESIKACHARYT.V.(1959) CyanophytaICAP Monographs on Algae *Indian Council of Agricultural research* New Delhi

18) FAIZAYOUSIF AL-YAMANI& MARIA A. SABUROVA(2010) illustrative guide on the flagellates of Intertidal soft sediment *Kuwait Institute for scientific Research* Kuwait

19) FAIZAYOUSIF AL-YAMANI, VALERIYSKRYABIN, ALEKSANDRA GUBANOVA, SERGEY KHVOROV AND IRINA PRUSOVA (2011), Marine zooplankton Practical guide from North western Arabian gulf Vol-1 and vol-2 *Kuwait Institute for scientific Research* Kuwait

20) FAUVEL P. (1953), The fauna of India Annelida - Polychaeta Indian Press Allahabad

21) GajbhiyeSN, Nair VR, and Desai BN (1984). Diurnal variation of zooplankton in Malad creek, Bombay. Indian Journal of Marine Science. 13:75-79.

22) Guidelines for the Measurement of Ambient Air Pollutants: National Ambient Air Quality Series/NAAQMS/36/2012-13,Volume-I.

23) Gujrat Pollution Control Board Inward No. 143215 dated o6.09.2018.

24) HAYWARD P.J AND RYLAND J.S. (1995) Handbook of Marine fauna of north –West Europe oxford University Press London

25) Hefmi R., Tanjung1 R., Hamuna B., and Alianto(2019).Assessment of Water Quality and Pollution Index in Coastal Waters of Mimika, Indonesia. *Journal of Ecological Engineering, 20(2);87-94*

26) HIGGINS R.P. HAJAMARTHIEL Eds. (1998) Introduction to the study of Meio Fauna

27) HORACE G. BARBER AND ELIZABETH Y. HAWORTH 91981) A guide to the Morphology of DIATOMS FRUSTULES.

28) Horaginamani, S.M. and Ravichandran, M., 2010. Ambient air quality an urban area and its effects on plants and human beings: A case study of Tiruchirappalli, India. Kathmandu University Journal of Science, Engineering and Technology, 6 (2), 13-19.

29) INGRAM HENDEY (1964) An introductory account of smaller Algae of British coastal waters part-V. Bacillariophyceae

30) IS1050:2012 Drinking Water-Specification: (second Revision).

31) JOHN H. WICKSTEAD(1965) an Introduction to the study of Tropical Plankton .Hutchinson Tropical Monographs

32) JOYOTHIBABU,R. MADHU, N.V. MAHESHWARAN, P.A.,NAIRK.K.C., VENUGOPL,P. BALASUBRAMANIAN T.2005) Dominance of Dinoflagellates in micro zooplankton communities in the oceanic region Bay of Bengal and Andaman sea Current science vol.84. 10thNOVEMBER2003

33) KASTURIRANGANL.R. (1963) A key for the identification of the Common Planktonic Copepoda of Indian Coastal water

34) KusumKK, Vineetha G, Raveendran TV, Nair VR, Muraleedharan KR, Achuthankutty CT and Joseph T (2014) Chaetognath community and their responses to varying environmental factors in the northern Indian ocean. J Plankton Res 36(4): 1146- 1152.

35) Lack DA, Cappa CD, Langridge J, Bahreini R, Buffaloe G, Brock C, Cerully K, Coffman D, Hayden K, Holloway J, Lerner B, Massoli P, Li SM, McLaren R, Middlebrook AM, Moore R, Nenes A, Nuaaman I, Onasch TB, Peischl J, Perring A, Quinn PK, Ryerson T, Schwartz JP, Spackman R, Wofsy SC, Worsnop D, Xiang B, Williams E (2011) Impact of fuel quality regulation and speed reductions on shipping emissions: implications for climate and air quality. Environ Sci Technol 45(20):9052–9060.

36) Lai KH, Lun VYH, Wong CWY, Cheng TCE (2011) Green shipping practices in the shipping industry: conceptualization, adoption, and implications. Resour Conserv Recycl 55(6):631–638.

37) Lalli CM and Parsons TR (1997) Biological Oceanography: An Introduction. DOIhttps://doi.org/10.1016/B978-0-7506-3384-0.X5056-7.

38) Lawler, D.M. 2004. Turbidimetry and nephelometry. In:Townshend, A. (Ed.) Encyclopedia of Analytical Science, 2nd edition. London: Academic Press (pp. 343-351).

39) Madhu D. Nathani, Mrugesh H. Trivedi (2015). Pre Monsoon Study of Water Quality with reference to Rapid Industrial Development in and around Gandhidham, Kachchh, Gujarat, International Journal of Scientific & Engineering Research, 6(9):1851-1862.

40) Madhupratap M (1978) Studies on ecology of zooplankton of Cochin backwaters. Mahasagar Bull Nat InstOceanogr 11: 45-56.

41) Madhupratap M (1979) Distribution, community structure and species succession of copepods from Cochin Backwaters. Indian J Ma Sci 8: 1-8.

42) Madhupratap M (1987) Status and strategy of zooplankton of tropical Indian estuaries: A review. Bull Plank SocJpn 34: 65-81.

43) Madhupratap M (1999). Free living copepods of the Arabian Sea, Distribution and Research Perspectives. I J Mar Sci 146-149.

44) Madhupratap M and Haridas P (1986) Epipelagic calanoid copepods of the northern Indian Ocean. OceanologicaActa 9(2):105-117.

45) MANAL AL-KANDARI, FAIZA Y. AL-YAMANI , KHOLOOD AL-RIFAIE (2009) Marine phytoplankton Atlas of Kuwait's water *Kuwait Institute for scientific Research*

46) Meiaraj C. & Jeyapriya S.P. (2019). Marine water quality studies at Tuticorin harbour coastal area. Indian Journal of Geo Marine Sciences48 (06): 943-946.

47) MPEDA (1998) Commercial Fishes and shell fishes of India

48) Murtini J.T., Ariyani F., Wahyuni I.S., Hak N., Suherman M., Dolaria N., Nurwiyanto. 2001. Inventory research and identification of heavy metal pollution in waters and fish. Technical Report. Pusat Riset Pengolahan Produk dan Bioteknologi Kelautan dan Perikanan. Jakarta. (in Indonesian).

49) Narayan R, Saxena K.K. and Chauhan S. (2007). Limnological investigations of Texi Temple pond in district Etawah (U.P.), Journal of Environmental Biology, January 28(1):155-157.

50) NEWEL G.E. & NEWELL R.C. (1963) Marine plankton a Practical Guide Hutchinson Educational

51) NIGAM R.C. AND CHATURVEDIS.K. (2000) Foraminiferal Study from KharoCreek , Kachchh (Gujarat) North west coast of *India. Indian Journal of marine science* Vol.29 133-189

52) OLAV GIERE (1993) Meiobenthology , Microscopic Fauna in Aquatic Sediments m Springer London

53) PERRAGALLO (1965) Diatomees marines de france *A. Asher & Co*. Amsterdam

54) Robert P.Higgins (Eds.), (1985) An introduction to the study of Meuio fauna Smithsons Institution press Washington DC

55) Salmin (2005). Dissolved oxygen (DO) and biological oxygen demand (BOD) as indicator to determine water quality. Oseana, 30(3):21–26.

56) Salvi H., Patel R., Thakur B., Shah K.and Parmar D. (2014). Assessment of Coastal Water Quality Parameters of Selected Areas of Marine National Park & Sanctuary (Okha, Sikka & Khijadiya), SSRN Electronic Journal, (pg 1-16)

57) STERRER W. STERRERC.S Eds. Marine fauna and flora of Bermuda A systematic Guide to the identification of Marine Organisms. *John Wiely and Sons*New York

58) Suresh Gandhi. M. (2009) Distribution of certain ecological parameters and Foraminiferaldistribution in the depositional environment of Pak strait east coast of India .*Indian J. of Marine Science* Vol.33 pp 287-295

59) USEPA, 2008. Air Quality Index: A Guide to Air Quality and Your Health. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, USA. 12 pp.

60) Vallero (2014): Fundamental of Air Pollution 5th Edition 2014.

61) Venktaraman (1993 A systematic account of some south Indian diatoms. Proceeding of Indian Academy of Science Vol. X No.6 Sec.B.

62) Weiss, R.F., (1970): The solubility of nitrogen, oxygen and argon in water and seawater. Deep Sea Research and Oceanographic Abstracts 17(4): 721-735.

63) Yap C.K., Chee M.W., Shamarina S., Edward F.B., Chew W. and Tan S.G. (2011). Assessment of Surface Water Quality in the Malaysian Coastal Waters by Using Multivariate Analyses, Sains Malaysiana 40 (10)1053–1062

Annexure G

DEENDAYAL PORT AUTHORITY

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

www.deendayalport.gov.in

NO.EG/WK/4751/Part (Greenbelt-GUIDE) 196 Dated : 31/5/2022

M/S Gujarat Institute of Desert Ecology,
P.O.Box No. 83,
Opp. Changleshwar Temple, Mundra Road,
Bhuj (Kachchh)- 370 001,Gujarat (India).
Tel.: 02832-329408, 235025.
Tele/Fax: 02832-235027
Email: desert_ecology@yahoo.com

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

Sub: Greenbelt Development in Deendayal Port Authority and its Surrounding Areas Charcoal site (Phase-I).

Ref.: M/s GUIDE, Bhuj offer vide letter no. M/s GUIDE, Bhuj vide communication no. GUIDE/DPA/GRN/080/2022-23 dated 24/5/2022.

Sir,

Your offer for the subject work submitted vide above referred letter dated 24/5/2022 amounting to Rs. 38,22,900.00 + applicable GST (Rupees Thirty-Eight Lakhs Twenty-Two Thousand and Nine Hundred Only Plus Eighteen Percent GST), with all terms & conditions mentioned in the offer letter, has been accepted **(Copy of offer letter M/s GUIDE attached)**.

2. Scope of work:

Development of Greenbelt in Charcoal site – Kandla, DPA and its surrounding areas. The activities under the Greenbelt Development include; inventory of suitable sites for greenbelt development in DPA, soil & Moisture conservation and management at Plantation sites, selection of suitable species of Plants for plantation, Procurement and plantation of plant saplings and seeds (5000 plants), along with management and monitoring of plantation, including drip/tanker water supply for a period 1 year.

.....Cont.....

3. Obligation of Deendayal Port Authority :

- Assistance regarding the statutory clearance from authorities concerned to be rendered by DPA for field visits/plantation activities.

4. The Terms of Payment:

1. 50% of the project budget to be paid to GUIDE within 15 days from the date of acceptance of Work order by GUIDE.
2. 20% of the project budget to be paid to GUIDE within 15 days from the date of completion of plantation works.
3. 20% of the project budget to be paid to GUIDE within 15 days from the date of submission Progress Report (December 2022).
4. 10% of the project budget to be paid to GUIDE within 15 days from the date of submission of Final Completion Report (May 2023).

5. Time Period : One year (from 5/6/2022 to 4/6/2023).

6. Kindly send the acceptance of this work order & start the work w.e.f. 5/6/2022 .

Thanking you.

Yours faithfully,

Superintending Engineer (PL) & EMC (I/c)
Deendayal Port Authority

Copy To :1) A.O.(W/A) - The proposal has been approved by the Board in its meeting held on 27/5/2022.

The expenditure shall be charged to the scheme Environmental Services & Clearance thereof (Allocation: 841/587/9744 WC – 5-13001).

2) TPA to CE for kind information of the Chief Engineer, please.

3) DA (PL) for further necessary action.

4) M/s Precitech Laboratorie ,Vapi, Environmental Management Cell to coordinate with M/s GUIDE,Bhuj.

5) RAO, DPA

ANNEXURE H

MARINE PORT PACKAGE POLICY

FOR

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY

DEENDAYAL PORT AUTHORITY

PERIOD : FROM 24-07-2022 (00:00 HRS)

TO 23-07-2023 (23:59 HRS)

Issued by

THE NEW INDIA ASSURANCE CO. LTD.

Regd. & Head Office	**New India Assurance Building, 87, Mahatma Gandhi Road, Fort, Mumbai–400001**
LCBO – I - 920000	**New India Centre, 11th floor, 17-A, Cooperage Road, Mumbai – 400001**
Tel.	**022-22044976 / 77**
E-mail	**nia.920000@newindia.co.in claims92@newindia.co.in**
Website	**www.newindia.co.in**

CONTENTS

RISK DETAILS

TYPE:	MARINE PORT PACKAGE INSURANCE POLICY
INSURER:	**The New India Assurance Co. Ltd.** Large Corporate & Brokers Office 1 New India Centre, 11th Floor, Mumbai - 400001
INSURED:	**DEENDAYAL PORT AUTHORITY,** (hereinafter referred as DPA) and/ or associated and/ or affiliated and/ or interrelated and/ or subsidiary companies and/ or corporations as they now are or may hereafter be created and/ or constituted and/ or for whom the Assured receive instructions to insure and/ or for whom the Assured have or assume a responsibility to arrange insurance, whether contractually or otherwise, as their respective rights and interests may appear hereinafter known as the Assured and/ or as original
PRINCIPAL ADDRESS:	Address of the Insured Administrative Office Building, Near Madhuban Hotel, Gandhidham, Kutch, Gujarat.
PERIOD:	12 months with effect from 24th July 2022 till 23rd July 2023, both days included
INTEREST:	Section 1 Port Authority Liabilities including liability of contractor and subcontractors and wreck removal. Section 2 Real and Personal Property - In respect of all properties, owned by / under custody of Insured(s) hereunder including adjacent warehouses associate structures. Section 3 Port Equipment including all Cargo Handling Equipment /Vehicles, Machineries and spares Section 4

Business Interruption consequent upon Property damage (including cargo handling equipment, machineries etc.) -

For Business interruption of the Port operation (wholly or partly) due to/consequent upon or arising out of:

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

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

(c) Blockage of any land access within the immediate Vicinity* of the Port/ Terminals.

*(immediate vicinity will mean at least 8 km radii from main entrance of Port's operational area applicable for both Kandla as well as for Vadinar)

LIMIT OF LIABILITY

Section 1

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

Sections 2 & 3

Loss Limit: INR 573,00,00,000 any one accident or occurrence and in the aggregate

TOTAL SUM INSURED FOR PROPERTIES (excludes owned vessels): INR 55,406,941,124.

Sections 4

Indemnity Period: 2 Months
Annual Revenue – INR 2007,53,00,000
Annual Gross Profit – INR 1864,26,00,000
Loss limit – INR 100,00,00,000

Combined Single Limit for PD /BI / Liability across all sections is INR 713,00,00,000

LOCATION:

Insured Location addresses as under:

1. Administrative Office Buildng, Near Madhuban Hotel, Gandhidham, Kutch, Gujarat -370201
2. Custom Bounded Area Port of Kandla – 370210.
3. Port Colony, Gopalpuri, Gandhidham -370201.
4. Office Buildings and Residential Quarters outside port area, Kandla – 370210
5. Jetty Area, Vadinar-361010 – Latitude : 220 44' N ; Longitude : 690 67' E
6. Port Colony, Vadinar-361010 – Latitude : 230 01' N ; Longitude : 700 13' E

POLICY CONDITIONS:

Section 1

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

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

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

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

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

Section 2

Ports and Terminals Consortium Section 2 – Property Damage Wording Amended.
Clause 2.1 (Insuring Clause) amended to include electrical and machinery breakdown.
Exclusion 4.8 (Safe working load) amended.
Exclusion 5.2 (Road) deleted.
Exclusion 5.4 (Stock) does not apply to stock of spare parts.
Exclusion 4.9 (Communication Equipment) deleted.

Clause 5.1 amended to include land development cost
Clause 8.1 (Automatic Acquisition) amended to 90 days. Clause 8.2 (Automatic Acquisition) amended to 10%.

Ports and Terminals Consortium Earthquake Extension Clause (Property) Amended, 1/04 LSW151.
Clause A amended to include Tsunami. Clause B amended to include Tsunami.
48 hours amended to 72 hours.

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

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

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

Section 3
Ports and Terminals Consortium Section 3 – Handling Equipment Wording Amended.

Clause 2.1 (Insuring Clause) amended to include electrical and machinery breakdown.

Exclusion 4.7 (Communication Equipment) deleted.

Exclusion 4.9 (Safe working load) amended.

Exclusion 4.15 (Mechanical or Electrical Breakdown) deleted.

Clause 8 (Protective Maintenance) amended.

Clause 9.1 (Automatic Acquisition) amended to 90 days Clause 9.2 (Automatic Acquisition) amended to 10%

Ports and Terminals Consortium Earthquake Extension Clause (Handling Equipment) Amended 1/04 LSW1520. Clause A amended to include Tsunami.
Clause B amended to include Tsunami.
48 hours amended to 72 hours.

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

Section 4

Ports and Terminals Consortium Section 4 Business Interruption Wording Amended 1/04 LSW1522.

Clause 2.3 (Interruption to Utility Supply) amended to include gas, fuel or water supply.

Additional Clause 2.4 interruption due to damage and/or blockage of pipeline.

Deductible: 7days

Applicable to Sections 2, 3 & 4

Subject to Expediting Expenses Clause

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

Subject to Minor Works Clause

Subject to Public Authority Clause

Subject to Reinstatement Clause

Subject to Temporary Removal Clause

Subject to Additional Increased Cost of Working Clause.

Subject to Prevention of Ingress/Egress Clause. Subject to Professional Accountants Fees Clause Subject to Average Clause (85%)

Pollution Clean-up Costs Clause

Claims Preparation Costs Clause

Minimization of Loss Clause

Designation of Property Clause

Listed Perils resulting from seepage and/or pollution and/or contamination clause

Limited seepage &/or pollution &/or contamination resulting from physical damage caused by listed perils clause

Waiver of under-insurance upto 15% of Sum Insured under property damage and BI Sum Insured

Marine Impact Insurance Clause

Specialized / Heavy Lift/ Oversize Lifting clause

Toxic Mould Exclusion Clause

Claims Control Clause

NMA 2919 War and Civil War and Terrorism Exclusion Clause

Applicable to All Sections

General Policy Provisions LSW1524 01/04 Amended.

Clause 5 (Radioactive Contamination, etc) deleted Clause 6.1 B. amended to delete 'strike, lock-out, labour disturbance, riot, civil commotion'.

Clause 11 (Notice of Potential Claims) amended.

Clause 18 (Premium Payment Clause) deleted.

Clause 21 (Governing Law) amended to India.

Clause 10 (Electronic Exclusion Clause) deleted.

Employment Practices Clause

Simultaneous Payment Clause (Losses)

Waiver of Subrogation and Additional Assured Clause

Special Termination Clause.

Continuity Clause

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

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

Subject to Sanction Limitation and Exclusion Clause LMA3100 15th

September 2010.

Subject to Unintentional Errors and Omission Clause. Notwithstanding anything contained elsewhere, insurance shall be governed by and construed in accordance with the laws of India and the exclusive jurisdiction of India.

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

Paneled surveyor clause: In the event of a claim, the surveyors shall be appointed only from the panel of agreed surveyors as mentioned below:
a) Proclaim Insurance Surveyors and Loss Assessors Private Limited

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

c) Alex Stewart International (India) Private Limited

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

EXPRESS WARRANTIES:	None
CONDITIONS PRECEDENT:	None
SUBJECTIVITIES:	None
PREMIUM:	As per policy schedule. Paid in full prior to inception

Underwriting Information/ Documents

1. Port Questionnaires – Kandla and Vadinar locations - (Year 2022-23)
2. Valuation report dated 31 June 2021 from LSI Engineering and Consultants
3. Marsh Risk Inspection Report
4. Crisis Management Plan

Sum Insured details of assets to be insured under Port Package			
all numbers in INR			
Particulars	**Kandla**	**Vadinar**	**Total**
Building, Shades & Other Structures	7,299,279,818	598,263,926	7,897,543,744
Wharves, Roads & Boundaries	16,545,413,823	157,258,945	16,702,672,768
Railway & Rolling Stock	2,542,721,153	-	2,542,721,153
Docks, Sea Walls, Navigational Aids	19,340,478,732	394,577,381	19,735,056,113
Cranes & Vehicles	3,352,080,645	981,103	3,353,061,748
Plant & Machinery	959,288,374	24,059,097	983,347,471
Installations of Water, Electricity, Telecom & Fire Fighting	3,516,060,122	213,941,882	3,730,002,004
Oil Installation	391,725,616	70,810,508	462,536,124
TOTAL	**53,947,048,283**	**1,459,892,841**	**55,406,941,124**

Port Package Assert bifurcation between section 2 and section 3			
Section 2: Real and Personal Property			
Particulars	**Kandla**	**Vadinar**	**Total**
Building, Shades & Other Structures	7,299,279,818	598,263,926	7,897,543,744
Wharves, Roads & Boundaries	16,545,413,823	157,258,945	16,702,672,768
Railway & Rolling Stock	2,542,721,153	-	2,542,721,153
Docks, Sea Walls, Navigational Aids	19,340,478,732	394,577,381	19,735,056,113
Installations of Water, Electricity, Telecom & Fire Fighting	3,516,060,122	213,941,882	3,730,002,004
Oil Installation	391,725,616	70,810,508	462,536,124
TOTAL	**49,635,679,264**	**1,434,852,641**	**51,070,531,906**
Section 3: Handling Equipment			
Particulars	**Kandla**	**Vadinar**	**Total**
Cranes & Vehicles	3,352,080,645	981,103	3,353,061,748
Plant & Machinery	959,288,374	24,059,097	983,347,471
TOTAL	**4,311,369,019**	**25,040,200**	**4,336,409,219**

For The New India Assurance Company Ltd

Duly Constituted Attorney(s)

Place: **Mumbai** **Date:** 24/07/2022

SANCTION LIMITATION AND EXCLUSION CLAUSE

No (re)insurer shall be deemed to provide cover and no (re)insurer shall be liable to pay any claim or provide any benefit hereunder to the extent that the provision of such cover, payment of such claim or provision of such benefit would expose that (re)insurer to any sanction, prohibition or restriction under United Nations resolutions or the trade or economic sanctions, laws or regulations of the European Union, United Kingdom or United States of America.

LMA3100
15 September 2010
10/11/03

INSTITUTE RADIOACTIVE CONTAMINATION, CHEMICAL, BIOLOGICAL, BIO- CHEMICAL AND ELECTROMAGNETIC WEAPONS EXCLUSION CLAUSE.

This clause shall be paramount and shall override anything contained in this insurance inconsistent therewith

1. In no case shall this insurance cover loss damage liability or expense directly or indirectly caused by or contributed to by or arising from

   1.1 ionising radiations from or contamination by radioactivity from any nuclear fuel or from any nuclear waste or from the combustion of nuclear fuel

   1.2 the radioactive, toxic, explosive or other hazardous or contaminating properties of any nuclear installation, reactor or other nuclear assembly or nuclear component thereof

   1.3 any weapon or device employing atomic or nuclear fission and/or fusion or other like reaction or radioactive force or matter

   1.4 the radioactive, toxic, explosive or other hazardous or contaminating properties of any radioactive matter. The exclusion in this sub-clause does not extend to radioactive isotopes, other than nuclear fuel, when such isotopes are being prepared, carried, stored, or used for commercial, agricultural, medical, scientific or other similar peaceful purposes.

   1.5 any chemical, biological, bio-chemical, or electromagnetic weapon. CL.370

MARINE CYBER EXCLUSION

This clause shall be paramount and shall override anything in this insurance inconsistent therewith.

1. In no case shall this insurance cover any loss, damage, liability or expense directly or indirectly caused by, contributed to by or arising from:
   1.1 the failure, error or malfunction of any computer, computer system, computer software programme, code, or process or any other electronic system, or

   1.2 the use or operation, as a means for inflicting harm, of any computer, computer system, computer software programme, malicious code, computer virus or process or any other electronic system.

LMA5402
11 November 2019

MARINE CYBER ENDORSEMENT

1. Subject only to paragraph 3 below, in no case shall this insurance cover loss, damage, liability or expense directly or indirectly caused by or contributed to by or arising from the use or operation, as a means for inflicting harm, of any computer, computer system, computer software programme, malicious code, computer virus, computer process or any other electronic system.

2. Subject to the conditions, limitations and exclusions of the policy to which this clause attaches, the indemnity otherwise recoverable hereunder shall not be prejudiced by the use or operation of any computer, computer system, computer software programme, computer process or any other electronic system, if such use or operation is not as a means for inflicting harm.

3. Where this clause is endorsed on policies covering risks of war, civil war, revolution, rebellion, insurrection, or civil strife arising therefrom, or any hostile act by or against a belligerent power, or terrorism or any person acting from a political motive, paragraph 1 shall not operate to exclude losses (which would otherwise be covered) arising from the use of any computer, computer system or computer software programme or any other electronic system in the launch and/or guidance system and/or firing mechanism of any weapon or missile.

LMA5403
11 November 2019

COMMUNICABLE DISEASE ENDORSEMENT

1. This policy, subject to all applicable terms, conditions and exclusions, covers losses attributable to direct physical loss or physical damage occurring during the period of insurance. Consequently and notwithstanding any other provision of this policy to the contrary, this policy does not insure any loss, damage, claim, cost, expense or other sum, directly or indirectly arising out of, attributable to, or occurring concurrently or in any sequence with a Communicable Disease or the fear or threat (whether actual or perceived) of a Communicable Disease.

2. For the purposes of this endorsement, loss, damage, claim, cost, expense or other sum, includes, but is not limited to, any cost to clean-up, detoxify, remove, monitor or test:
   2.1. for a Communicable Disease, or

   2.2. any property insured hereunder that is affected by such Communicable Disease.

3. As used herein, a Communicable Disease means any disease which can be transmitted by means of any substance or agent from any organism to another organism where:
   3.1. the substance or agent includes, but is not limited to, a virus, bacterium, parasite or other organism or any variation thereof, whether deemed living or not, and

   3.2. the method of transmission, whether direct or indirect, includes but is not limited to, airborne transmission, bodily fluid transmission, transmission from or to any surface or object, solid, liquid or gas or between organisms, and

   3.3. the disease, substance or agent can cause or threaten damage to human health or human welfare or can cause or threaten damage to, deterioration of, loss of value of, marketability of or loss of use of property insured hereunder.

4. This endorsement applies to all coverage extensions, additional coverages, exceptions to any exclusion and other coverage grant(s).

All other terms, conditions and exclusions of the policy remain the same.
LMA5393
25 March 2020

CORONAVIRUS EXCLUSION

This clause shall be paramount and shall override anything contained in this insurance inconsistent therewith.
This insurance excludes coverage for:
1) any loss, damage, liability, cost, or expense directly arising from the transmission or alleged transmission of:
   a) Coronavirus disease (COVID-19);
   b) Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2); or

c) any mutation or variation of SARS-CoV-2;
or from any fear or threat of a), b) or c) above;

2) any liability, cost or expense to identify, clean up, detoxify, remove, monitor, or test for a), b) or c) above;

3) any liability for or loss, cost or expense arising out of any loss of revenue, loss of hire, business interruption, loss of market, delay or any indirect financial loss, howsoever described, as a result of any of a), b) or c) above or the fear or the threat thereof.

All other terms, conditions and limitations of the insurance remain the same.

LMA5395
09 April 2020

WAR AND TERRORISM EXCLUSION (NMA 2919)

Notwithstanding any provision to the contrary within this reinsurance or any endorsement thereto it is agreed that this reinsurance excludes loss, damage, cost or expense of whatsoever nature directly or indirectly caused by, resulting from or in connection with any of the following regardless of any other cause or event contributing concurrently or in any other sequence to the loss;

(1) war, invasion, acts of foreign enemies, hostilities or warlike operations (whether war be declared or not), civil war, rebellion, revolution, insurrection, civil commotion assuming the proportions of or amounting to an uprising, military or usurped power; or

(2) any act of terrorism.

For the purpose of this exclusion, an act of terrorism means an activity, including the threat of an activity or the preparation for an activity, whether violent or nonviolent, that appears to be intended to

(i) intimidate, coerce, or retaliate against any segment of the civilian population, or
(ii) disrupt any segment of the economy, or
(iii) influence the policy of a government by intimidation, coercion, or retaliation, or
(iv) advance a political, religious, ideological, or ethnic cause.

This endorsement also excludes loss, damage, cost or expense of whatsoever nature directly or indirectly caused by, resulting from or in connection with any action taken in controlling, preventing, suppressing or in any way relating to (1) and/or (2) above.

In the event any portion of this endorsement is found to be invalid or unenforceable, the remainder shall remain in full force and effect.

POLICY CONDITIONS

PORTS AND TERMINALS CONSORTIUM

SECTION 1 - LIABILITY WORDING

1. LOSS, IF ANY, PAYABLE to Assured or Loss Payee as set out in the Insurance Schedule.

2. INSURING CLAUSES

In consideration of the payment of the premium, Underwriters agree, subject to the provisions of this Policy and the Section 1 limit as set out in the Insurance Schedule, to indemnify the Assured in respect of their legal or contractual liabilities to third parties arising from an Accident which the Assured may incur by reason of their Insured Operations as Port Authorities or Terminal Operators for:

2.1 Physical loss or physical damage to the real or personal property of any third party, including resultant loss of use or demurrage, provided that such loss or damage directly results from an Insured Operation performed by the Assured within the Confines of the Port, Terminal or Insured Location(s); and

2.2 Bodily Injury to any third party provided that such Bodily Injury directly results from an Insured Operation performed by the Assured within the Confines of the Port, Terminal or Insured Location; and.

2.3 Any liability of the Assured in connection with any tenant of the Assured for Operations performed by any sub-contractor appointed by the Assured, but being subject to the terms, conditions and exclusions of this Policy. It is a condition of cover being given under this clause 2.3 that the Assured must *use their best endeavours to* ensure that any such tenant and/or sub-contractor purchases and maintains adequate liability insurance. Such policy must also stipulate that it will respond first to any liability loss prior to any other policy of insurance which may cover the same liability.

2.4 Costs and expenses incurred in the defence of any claim(s) arising from an Accident covered under Section 1, and the costs and expenses of litigation awarded to any claimant in any competent Court or arbitration proceedings against the Assured by way of interest on judgements, investigation, adjustment, appraisal, appeal and legal costs and expenses subject to the overall limit of this Section 1. Indemnifiable legal costs and expenses shall exclude, all fees, salaries, or retainers for salaried employees and employed counsel and all office expenses of the Assured unless prior agreement has been obtained from Underwriters. Such costs and expenses shall be subject to clause 2 of the General Policy Provisions

2.5 Costs and expenses incurred by the Assured in disposing of the cargo or property of an Assured's customer, including the removal of any wreck or debris thereof,

following an Accident to such cargo or property during the Policy period for which the Assured is legally liable within the Confines of the Port, Terminal or Insured Location subject to the overall limit for this Section. This clause does not provide cover for costs and expenses relating to seepage, pollution or contamination.

2.6 In respect of Port Authorities only, costs and expenses incurred either voluntarily or in the exercise of the Assured's statutory right or legal obligation to remove any wreck or debris thereof following an Accident during the Policy period. Subject to the overall limit for this Section 1, and providing such costs and expenses are incurred by the Assured for the purpose of avoiding or minimising a claim under this Section. Such wreck or debris removal must not be undertaken without the prior approval of Underwriters, or the costs and expenses will not be recoverable under this Policy.

2.7 Notwithstanding any other terms and condition, this policy is extended for such expenses and costs incurred by the assured to extract and remove pollutants from land or water where the discharge or escape of the pollutants is sudden and unforeseen and caused by insured peril that occurs during the policy period

3. EXCLUSIONS

This Section does not cover any actual or alleged liability howsoever arising:

3.1 To employees of the Assured, except as insured under clause 4, or 6 of this Section;

3.2 Directly or indirectly under Workmen's Compensation or Employers Liability Acts or any other statutory or Common Law Liability to any employee of the Assured when such Bodily Injury arises out of or in the course of the employment of such employees;

3.3 Directly or indirectly caused by any continuous, intermittent or repeated exposure to or ingestion, inhalation or absorption of the following substances or condition(s) in any form:

asbestos, tobacco, coal dust, polychlorinated biphenyls, silica, benzene, lead, talc, dioxin, pharmaceutical products or drugs of any type, pesticides or herbicides, mould, human immune virus or acquired immune deficiency syndrome or electro magnetic fields;

3.4 For any repetitive motion, repetitive stress, repetitive strain and/or cumulative trauma disorder, including, without limitation, (i) liability or alleged liability arising from alleged improper design of goods, equipment or machinery or operations, (ii) failure to warn or properly instruct as to the use of goods, equipment or machinery or conduct of operations, (iii) improper supervision of use of the goods, equipment or machinery or conduct of operations, or (iv) without limiting the foregoing, carpal tunnel syndrome;

3.5 For loss, damage or expense to any property or equipment owned, leased, hired, occupied or rented by the Assured;

3.6 For loss, damage or expense caused by wear, tear or gradual deterioration;

3.7 From the release of cargo without the original bill of lading, unless otherwise endorsed by Underwriters;

3.8 For loss, damage or expense to ad valorem or valuable cargo (including but not limited to bullion, precious metals or precious object(s), jewellery, cash, securities, fine art or thoroughbred horses) unless the Assured was not informed and could not reasonably have known such cargo was being handled.

Underwriters may agree to insure such liability for a limit of INR 15 crs subject to terms and conditions to be agreed in advance by Underwriters;

3.9 As the owner, operator or user of any vehicle(s) or conveyance(s) of any description required to be licensed under any statutory provision(s) or regulation(s), or any Accident involving a vehicle, chassis, trailer, conveyance or the like on public roads or outside the Confines of the Port, Terminal or Insured Location;

3.10 In respect of any interest the Assured may have in any vessel, aircraft or helicopter whether owned, leased, rented, hired, chartered or operated by the Assured, including any management or operation of any airport, area or building upon which aircraft or helicopter(s) land or manoeuvre, or in which they are housed, maintained or repaired;

3.11 Directly or indirectly caused by, or arising out of seepage, pollution or contamination howsoever caused whenever or wherever happening unless the Assured establishes that all of the following conditions have been met:

A. The seepage, pollution or contamination was caused by an Accident.

B. The Accident occurred during the Policy period on an identified specific date.

C. The Accident was first discovered by the Assured within 72 hours of the commencement of the Accident.

D. Written notification of the accident was first received from the Assured by Underwriters within 30 days of the Assured's first discovery of the Accident.

E. The Accident did not result from the Assured's intentional or wilful violation of any statute, rule, ordinance or regulation.

Even if the above conditions A to E are satisfied, this Policy does not apply to, or provide cover for, any actual or alleged liability howsoever arising:

(i) To abate or investigate any threat of seepage onto or pollution or contamination of the property of a third party.

(ii) ~~For seepage, pollution or contamination of property which is or was, at any time, owned, leased, rented or occupied by any Assured, or which is or was, at any time, in the care, custody or control of any Assured (including the soil, minerals, water or any substance on, in or under such owned, leased, rented or occupied property or property in such care, custody or control).~~

(iii) ~~For loss of, damage to or loss of use of property directly or indirectly resulting from subsidence caused by sub-surface operations of the Assured.~~

(iv) For fines, penalties, punitive damages, exemplary damages, or any other damages resulting from the multiplication of compensatory damages

3.12 From the disposal, handling, processing, treatment, storage or dumping of any waste materials, spoil or substances or during transportation, including the operation of any land fill, dump site and/or location used for such. In the event of a conflict between this exclusion and exclusion 3.11, this exclusion shall prevail;

3.13 Out of dredging operations, while such operations are being performed;

3.14 For fines, penalties, punitive or exemplary damages howsoever awarded or described, or any additional damages resulting from the multiplication of compensatory damages;

3.15 For failure or delay in performance of any contractual obligation or guarantee, including failure to supply or from fluctuations in supply of any substance, product or service whatsoever;

3.16 Under any contract or agreement to compensate another party unless:

A. Such liability would have attached to the Assured in the absence of such contract or agreement or as specifically agreed by Underwriters prior to such Accident, and

B. Such liability was caused by or contributed to by the Assured's fault or negligence;

3.17 As a result of the Safe Working Load of any equipment being overloaded other than for the purpose of inspecting or testing;

3.18 From the transit, movement, erection or dismantling of an item of handling

equipment other than during the course of inspection, maintenance, repair or removal to another working position within the Confines of the Port, Terminal or Insured Location;

3.19 Out of goods or products, manufactured, processed, graded, blended, or sold by the Assured or by others trading under the name of the Assured where loss or damage occurs away from the premises owned, leased, rented or controlled by the Assured and after physical possession of such goods or products has been relinquished to others. This exclusion shall also apply to reliance upon a representation or warranty made in connection with such goods or products at any time;

3.20 From any negligent act, error or omission of any Assured , or any other person for whose acts the Assured is legally liable, in the administration of any Assured's employee benefits programme or pension programme. Employee benefits programme includes but is not limited to group life insurance, group accident or health insurance, profit sharing plans, employee stock subscription plans and social benefits;

3.21 Under any statute, law, rule or regulation relating to:

A. the purchase, sale or distribution, or offer of securities, or investment counselling:

B. monopolies, activities in restraint of trade, unfair competition, or deceptive acts or practices;

C. copyright, patent or trademark infringement;

D. disclosure relating to sales or offers to sell real property;

E. employee, officer or director dishonesty, or improper conduct or conflict of interest in the performance of the Assured's operations, or any action taken outside the scope of an employee, officer, or director's authority as granted by the Assured.

4. CROSS LIABILITY

Always subject to the exclusions in this Section, in the event of claim(s) being made against the Assured for Bodily Injury suffered by any employee of the Assured which does not arise out of the injured employee's employment, and for which another Assured, is legally liable for causing the Bodily Injury, then this Section shall cover the Assured against such claim provided it is made in the same manner as if separate policies had been issued to each Assured. Nothing contained herein shall operate to increase Underwriters liability as specified in the Insurance Schedule, and subject to the sub-limit specified in the Insurance Schedule.

5. CONTRACTS AND AGREEMENTS

Always subject to the exclusions in this Section, Underwriter's, shall only cover liability to third parties contracting with the Assured:

5.1 in the case of contracts existing at inception of this Policy, when the Assured has informed Underwriters of the contract(s) by means of the questionnaire and if requested by Underwriters, supplied copies of the contracts for Underwriter's approval; or

5.2 if the contract(s) is entered into after inception of this Policy, the Assured must inform Underwriters of such contract(s) if the terms are substantially different from the terms of the contract(s) advised to Underwriters under 5.1 and if requested by Underwriters supply copies of the contract(s) for Underwriter's approval.

Underwriters reserve the right to charge additional premium and impose such terms and conditions or exclusions as they deem appropriate to any new or amended contractual arrangement.

6. ACTION OVER INDEMNITIES

Always subject to the exclusions in this Section, Underwriters agree to include claim(s) for Bodily Injury to third parties where responsibility is assumed by the Assured for such claims in connection with their Operations as a Port Authority and/ or Terminal Operator under any written contract. Nothing in this Clause shall operate to increase Underwriter's liability as specified in the Insurance Schedule, and liability under this clause is limited to the sub-limit specified in the Insurance Schedule.

7. UNITED STATES OIL POLLUTION ACT DISCLAIMER

This Policy of Insurance is not evidence of financial responsibility under the Oil Pollution Act of 1990 or any similar federal or state laws. Any showing or offering of this Policy by the Assured as evidence of insurance shall not be taken as any indication that the Underwriters consent to act as guarantor or to be sued directly in any jurisdiction whatsoever. The Underwriters do not consent to be guarantors or to be sued directly.

THIS SECTION IS TO BE READ IN CONJUNCTION WITH THE GENERAL POLICY PROVISIONS, THE INSURANCE SCHEDULE AND THE QUESTIONNAIRE, ALL OF WHICH FORM PART OF THE POLICY

01/04
LSW1510

PORTS AND TERMINALS CONSORTIUM

FIRE EXTENSION (LIABILITY)

This extension is to be read in conjunction with the Ports and Terminals Consortium Liability Wording and the provisions that apply therein.

In consideration of the payment of an additional premium to be agreed by Underwriters, this
Policy shall be extended to indemnify the Assured for:

1. Legal liability of the Assured, arising from an Accident resulting in physical loss or physical damage to buildings leased or rented and used by the Assured where such physical loss or physical damage has been caused by fire.

2. Contractual liability of the Assured arising from an Accident resulting in physical loss or physical damage to premises leased or rented and used by the Assured where such physical loss or physical damage has been caused by fire, but only to the extent that such contractual liability is no greater than the Assured's liability would have been in the absence of such contract.

EXCLUSIONS

This extension does not cover any actual or alleged liability howsoever arising:

(a) If the Assured has a contractual obligation to insure the leased or rented premises against the risk of fire.

(b) If the Assured has any other insurance which includes the risks set out in 1 or 2 above, this coverage shall not extend to cover any risk that would otherwise be covered under such insurance by reason of any exclusion, qualification or provision whatsoever, including any differential amount by reason of any deductible, limit of liability or the like whatsoever.

This extension shall be subject to clause 2 of the General Policy Provisions and nothing contained in this extension shall operate to increase the overall Section 1 limit as specified in the Insurance Schedule.

This extension is subject to a section sub-limit as specified in the Insurance Schedule.

1/04
LSW1511

PORTS AND TERMINALS CONSORTIUM

ADVICE AND INFORMATION EXTENSION (LIABILITY)

This extension is to be read in conjunction with the Ports and Terminals Consortium Liability Wording and the provisions that apply therein.

Notwithstanding exclusions 3.15 and 3.16, and in consideration of payment of an additional premium to be agreed by Underwriters, this Policy shall be extended to indemnify the legal or contractual liability of the Assured:

For loss of income, less any savings, to any individual or organisation by whom the Assured is engaged for the supply of advice or information on the management of Operation(s) for which the Assured is insured under the Ports and Terminals Consortium Liability Wording whereby the Assured incurs such liability in consequence of the Assured's negligent act, error or omission in the provision of such advice or information during the period of this insurance.

EXCLUSIONS

Notwithstanding anything to the contrary contained herein or otherwise, this Extension does not cover any actual or alleged acts of medical malpractice.

This extension shall be subject to clause 2 of the General Policy Provisions and nothing contained herein shall operate to increase the overall Section limit as specified in the Insurance Schedule.

This extension is subject to a section sub-limit as specified in the Insurance Schedule.

1/04
LSW1512

PORTS AND TERMINALS CONSORTIUM

FINES AND DUTY EXTENSION (LIABILITY)

This extension is to be read in conjunction with the Ports and Terminals Consortium Liability Wording and the provisions that apply therein.

In consideration of the payment of an additional premium to be agreed by Underwriters, this Policy shall be extended to indemnify the Assured's legal liability arising from an unintentional breach of any regulation, legal or statutory provision resulting in:

(a) Fines, customs duty, sales, excise tax, value added tax or similar fiscal charges or other penalty imposed by an Authority on the Assured or any other person acting within their authority on the Assured's behalf, or

(b) Confiscation by an Authority of any property, including the handling equipment of the Assured.

Authority shall mean any government, State or local body, organisation or agency thereof.

Provided that such breach directly relates to:

1. The import or export of cargo or the equipment of the Assured's customers; or
2. Immigration; or
3. The safety of working conditions of the Assured’s operations; or
4. Pollution.

EXCLUSIONS

This Extension does not cover any actual or alleged liability howsoever arising:

(i) That has not been properly established, proved or held by a competent court or tribunal acting within its powers.

(ii) For any illegal or criminal acts of the Assured.

(iii) For commercial fines or penalties in respect of freight tariffs, competition or the structure or operation of the Assured's business or that of any person acting on the Assured's behalf.

(iv) For any breach of any regulation, at Underwriters discretion, arising from the weight of

cargo or carrying equipment on a public road if such breach appears to have been caused recklessly or intentionally by the Assured or the Assured's employees.

(v) If any court or tribunal determines that it is illegal for the Assured to be insured for any cover given under this extension, then the other parts of this extension shall remain effective, although no indemnity will be given with respect to any loss or claim arising from the coverage under this extension which is held to be illegal.

(vi) For any amount that would have been payable by the Assured notwithstanding any breach.

(vii) In the case of the United States - enforced by the Federal Maritime Commission, Department of Justice or Federal Trade Commission of the United States of America or the Drug Enforcement Agency or any successors.

(viii) For any fine or duty associated with the non-compliance of the ISPS Code.

This extension shall be subject to clause 2 of the General Policy Provisions and nothing contained in this extension shall operate to increase the overall Section 1 limit as specified in the Insurance Schedule.

This extension is subject to a section sub-limit as specified in the Insurance Schedule.

1/04
LSW1513

PORTS AND TERMINALS CONSORTIUM

INFRINGEMENT OF PERSONAL RIGHTS EXTENSION (LIABILITY)

This extension is to be read in conjunction with the Ports and Terminals Consortium Liability Wording and the provisions that apply therein.

In consideration of the payment of an additional premium to be agreed by Underwriters, this Policy shall be extended to indemnify the legal liability of the Assured:

1. Resulting from false arrest, detention or imprisonment of any person.

2. Resulting from the publication or utterance of a libel or slander or of any other defamatory or disparaging material, or a publication or utterance in violation of an individual's right of privacy.

3. Resulting from wrongful entry or eviction, or other invasion of the right of private occupancy.

EXCLUSIONS

This extension does not cover any actual or alleged liability howsoever arising:

(a) Out of the wilful violation of a statute, law or regulation committed by or with the knowledge or consent of the Assured.
(b) In connection with any party relating to the Assured's past, present or future employment of such party.
(c) Under any contract or written provision.
(d) From a liability covered hereunder but commencing prior to the attachment date of this Extension.
(e) Out of any publication or utterance in connection with any organisation or business enterprise, or its products or services made by or at the direction of the Assured, made recklessly or with the knowledge that such was false.
(f) Out of any publication or utterance in connection with or related to advertising, broadcasting or telecasting conducted by the Assured.
(g) From the arrest, detention or imprisonment of any vessel, cargo or property whatsoever.
(h) From any criminal or illegal act or omission

This extension shall be subject to clause 2 of the General Policy Provisions and nothing contained in this extension shall operate to increase the overall Section 1 limit as specified in the Insurance Schedule.

This extension is subject to a section sub-limit as specified in the Insurance Schedule.

1/04
LSW1514

PORTS AND TERMINALS CONSORTIUM

WRONGFUL DELIVERY OF CARGO EXTENSION (LIABILITY)

This extension is to be read in conjunction with the Ports and Terminals Consortium Liability Wording and the provisions that apply therein.

Notwithstanding exclusion 3.7 and in consideration of the payment of an additional premium to be agreed by Underwriters, this Policy shall be extended to indemnify the Assured for wrongful delivery by the Assured of cargo (for which there is a contractual obligation for delivery on the part of the Assured or the Assured's sub-contractor(s)) contrary to instructions to withhold delivery or without taking in exchange payment or the relevant document of title.

In the event that the wrongful delivery was caused intentionally or recklessly by the Assured or the Assured's sub-contractor(s), Underwriters may in their absolute discretion decline or reduce the claim.

The Assured's supervision, control and loss prevention systems and practices will be amongst the factors taken into account by Underwriters.

This extension shall be subject to clause 2 of the General Policy Provisions and nothing in this extension shall operate to increase the overall Section 1 limit as specified in the Insurance Schedule.

This extension is subject to a section sub-limit as specified in the Insurance Schedule.
1/04
LSW1515

JOINT LIABILITY COMMITTEE WAR AND TERRORISM EXCLUSION CLAUSE (JL 2002/002)

THIS ENDORSEMENT MODIFIES THE POLICY. PLEASE READ IT CAREFULLY

War and Terrorism Exclusion

This policy excludes any actual or alleged liability, costs or expenses arising directly or indirectly out of one or more of the following:-

(a) war, civil war, revolution, rebellion, insurrection or civil strife arising therefrom, or any hostile act by or against a belligerent power;

(b) confiscation or expropriation;

(c) capture, seizure, arrest, restraint or detainment and the consequences thereof or any attempt thereat;

(d) any terrorist act or any person(s) acting maliciously or from a political motive;

(e) ~~strikers, locked-out workmen, or persons taking part in labour disturbance, riots or civil commotions;~~

(f) derelict mines, torpedoes, bombs or other derelict weapons of war. All other terms and conditions remain unchanged.

JL 2002/002
17/01/02

JOINT LIABILITY COMMITTEE TERRORISM WRITE BACK CLAUSE

(JL2011/004)

THIS CLAUSE MODIFIES THE POLICY. PLEASE READ IT CAREFULLY

Exclusion (d) of The Joint Liability Committee War & Terrorism Exclusion Clause (JL2002/002) shall not apply to the following but only where these are directly caused by or directly arise from Terrorism as defined below:

Liability arising from the operation, ownership, management or chartering of

1.1 Vessels, craft and units, whilst offshore, afloat, under construction or repair, in dock or in store ashore.

1.2 Seawalls, wharves, piers, jetties, docks, berths, pontoons and associated dockside equipment all whilst within the confines of the port, terminal, shipyard harbour or marina.

1.3 Platforms, facilities and associated equipment, whilst offshore, or whilst in, on or under any navigable waters, including related construction or repair operations.

Liability arising from the carriage, shipment or storage of:

1.4 Cargo in the ordinary course of transit in accordance with the Joint Cargo Committee Termination of Transit Clause (Terrorism) JC2001/056.

For the purpose of this clause, 'Terrorism' means any act(s) of any person(s) or organisation(s) involving the causing, occasioning or threatening of harm whatever nature and by whatever means or putting the public or any section of the public in fear, in circumstances in which it is reasonable to conclude that the purpose(s) of the person(s) or organisation(s) concerned are wholly or partly of a political, religious or ideological nature.

All other terms and conditions of the insurance remain unchanged. JL 2011/004

05 October 2011

PORTS AND TERMINALS CONSORTIUM

SECTION 2 - PROPERTY DAMAGE WORDING

1. **LOSS, IF ANY, PAYABLE** to Assured or Loss Payee, as set out in the Insurance Schedule.

2. **INSURING CLAUSES**

In consideration of the payment of the premium, Underwriters hereby agree, subject to the provisions of this Policy and the limits of this Section 2 as set out in the Insurance Schedule to indemnify the Assured in respect of:

2.1. Physical loss or physical damage to Insured Property *including electrical and machinery breakdown* as set out in the Insurance Schedule, within the Confines of the Port, Terminal or Insured Location, arising from an Accident occurring during the Policy period.

2.2 Costs or expenses incurred in the removal of wreckage of Insured Property and/or debris of Insured Property following loss or damage recoverable elsewhere under this Policy, but subject to a sub-limit of twenty-five percent of the insured value of the Insured Property, unless Underwriters agree otherwise.

In the event of a claim under 2.1 and 2.2 for the same Insured Property, the indemnity payable by Underwriters under both these clauses shall not exceed the insured value of that Insured Property or Section 2 limit as set out in the Insurance Schedule.

2.3 Physical loss or physical damage to Insured Property arising from strikes or riots, notwithstanding clause 6 of the General Policy Provisions and subject to clause 6 of this Section 2. Coverage under this clause may be terminated by Underwriters at any time giving the Assured or Assured's brokers 7 days' notice by mail, facsimile or e- mail.

3. **FIRE FIGHTING EXPENSES**

This Section covers the Assured's loss of fire extinguishing materials or equipment if used to safeguard the Insured Property from a peril covered under this Section, and reasonable fire brigade charges for which the Assured is liable, and other extinguishing expenses incurred by the Assured to safeguard the Insured Property from a peril covered under this Section.

4. EXCLUSIONS

This Section does not cover loss or damage caused by or to:

4.1 wear, tear, marring, scratching, gradual deterioration, wet rot, dry rot, mould, spoilage, decay, decomposition, settling, shrinkage, expansion in building structures or foundations, subsidence, corrosion, rust, discoloration, electrolyte action, oxidation, erosion, leakage, evaporation, loss of weight, breakage of glass or other fragile articles;

4.2 vermin; moths, termites or other insects;

4.3 atmospheric dampness or dryness, condensation, smog, fog, extremes or changes in atmospheric temperature;

4.4 ~~seepage of any substance whatsoever, backing up of sewers or drains, pollution or contamination;~~

4.5 earthquake, tsunami, tidal wave, seaquake or volcanic eruption unless agreed by Underwriters;

4.6 inherent vice, latent defect, error in design, fault or error in workmanship, manufacture or use of unsuitable materials. Costs of remedying or repairing inherent vice, latent defect, defects in design or manufacture;

4.7 confiscation, requisition, detention, occupation, embargo, quarantine, or arising from any order of public or government authority or arising from acts of contraband or illegal transportation or illegal trade;

4.8 the Safe Working Load being exceeded;

~~4.9 mechanical or electrical breakdown or derangement of any communication equipment or alarm system or computer system;~~

4.10 error or fault in computer or machinery programming or from data processing, media failure or breakdown;

4.11 ~~boilers, steam pipes, steam turbines, steam engines, pressure or vacuum vessels, caused by explosion, implosion, rupture or bursting where such are owned or operated by the Assured~~;

4.12 cessation, fluctuation or variation in, or insufficiency of water, gas or electricity supplies;

4.13 loss of market, loss of use, loss of income, interruption of business, or any other consequential loss or damage whatsoever;

4.14 unexplained loss or mysterious disappearance, inventory shortage or loss due to book keeping, accounting or billing errors or omissions;

4.15 infidelity, dishonesty, theft, fraud or pilferage of the Assured or the Assured's employees or others to whom the Assured has entrusted responsibility;

4.16 the Assured and/ or the Assured's employees voluntarily parting with title or possession of property;

4.17 processing, renovating, repairing, or working upon any Insured Property.

5. EXCLUDED PROPERTY

This Section does not cover the following:

5.1 Land or land values, air, water or other naturally occurring substance(s); other than land development values

5.2 ~~Roads~~, driveways, pavements, curbing, culverts or sidewalks if outside the confines of the terminal or insured location;

5.3 Buildings or structures in the process of construction including materials or supplies for such construction;

5.4 ~~Stock, whether owned by the Assured, or in the care, custody or control of the Assured~~;

5.5 Property in transit, unless within the Confines of the Port, Terminal or Insured Location;

5.6 Accounts, bills, currency, money, notes, securities, deeds, evidence of debt and valuable papers;

5.7 Jewelry, precious stones, precious metals and alloys, fine arts, furs, garments, animals or plants;

5.8 Aircraft or any other aerial device, watercraft, vehicles designed for highway use or locomotives or rolling stock designed for railroad use, ~~or cargo handling equipment~~

6. STRIKES / RIOTS

Strikes or riots shall not include any of the other acts excluded in clause 6 of the General Policy Provisions.

7. PROTECTIVE MAINTENANCE

The Assured shall maintain in good order, proper and adequate protection for the safety of the Insured Property, including any additional measures required by Underwriters, throughout the period of this Policy. Such protection shall not be withdrawn or reduced unless prior agreement has been obtained from Underwriters. If the Assured fails to comply with this clause, Underwriters will not be liable for any claims arising partly or solely from the Assured's breach of this clause.

8. AUTOMATIC ACQUISITIONS

This Section automatically holds covered property acquired by the Assured after the inception date of the Policy period for a period of up to 90 days after acquisition, provided:

8.1 Satisfactory advice and information regarding such property is given to Underwriters within 90 days of acquisition; and

8.2 The property value is not more than 10% of the overall limit for this Section as set out in the Insurance Schedule, and

8.3 The property is similar to that already scheduled and is within the Confines of the Port, Terminal or Insured Location, and

Underwriters reserve the right to charge additional premium and impose such terms, conditions and exclusions as they deem appropriate, or to decide not to continue to insure the property after the 90 days have elapsed.

9. VALUES DECLARED AND INCORRECT DECLARATION PENALTY

If property values declared to the Insurance Schedule are less than the actual market values, then any recovery hereunder shall be reduced by the same proportion that the scheduled value bears to the actual value for that particular item.

10. SETTLEMENT OF CLAIMS

Settlement of claims under this Section shall be calculated on the basis of the cost of repairing, replacing or reinstating (whichever is the least) the Insured Property with material of like kind and quality, subject to the following provisions:

The repair, replacement or reinstatement is carried out with due diligence and dispatch; Underwriter's liability is limited to the actual amount necessarily spent by the Assured in repairing, replacing or reinstatement of the Insured Property, and will not in any event exceed the limits declared in the Insurance Schedule and overall limits for this Section 2.

THIS SECTION IS TO BE READ IN CONJUNCTION WITH THE GENERAL POLICY PROVISIONS, AND THE INSURANCE SCHEDULE AND THE QUESTIONNAIRE ALL OF WHICH FORM PART OF THE POLICY

1/04
LSW1516

PORTS AND TERMINALS CONSORTIUM EARTHQUAKE EXTENSION CLAUSE (PROPERTY)

This extension is to be read in conjunction with the Ports and Terminals Consortium Property Damage Wording and the provisions that apply therein.

Notwithstanding exclusion 4.5 and in consideration of the payment of an additional premium to be agreed by Underwriters, this Policy shall be extended to cover physical loss or physical damage to Insured Property:

A. Directly caused by earthquake, *tsunami,* tidal wave, seaquake or volcanic eruption

B. By fire or explosion directly caused by earthquake, *tsunami,* tidal wave, seaquake or volcanic eruption.

In respect of loss covered under part A of this extension, Underwriters shall only be liable for the amount by which such loss or damage during any one period of seventy two consecutive hours exceeds the underlying amount/deductible as specified in the Insurance Schedule.

The Assured may choose the date and time when any such period of 72 consecutive hours commences.

This extension shall be subject to clause 2 of the General Policy Provisions and nothing contained herein shall operate to increase the overall Section 2 limit as specified in the Insurance Schedule.

This extension is subject to a section sub-limit as specified in the Insurance Schedule.

1/04
LSW1517

PORTS AND TERMINALS CONSORTIUM

SECTION 3 - HANDLING EQUIPMENT WORDING

1. LOSS, IF ANY, PAYABLE to Assured, or Loss Payee as set out in the Insurance Schedule.

2. INSURING CLAUSES

In consideration of the payment of the premium, Underwriters hereby agree, subject to the provisions of this Policy and the limits of this Section as set out in the Insurance Schedule, to indemnify the Assured in respect of:

2.1 Physical loss or physical damage to Insured Handling Equipment *including electrical and machinery breakdown* as set out in the Insurance Schedule, within the Confines of the Port, Terminal or Insured Location arising from an Accident occurring during the Policy period.

2.2 Physical loss or physical damage to Insured Handling Equipment arising from strikes or riots, notwithstanding clause 6 of the General Policy Provisions and subject to clause 6 of this Section 3. Coverage under this clause may be terminated by Underwriters at any time by giving the Assured or the Assured's brokers 7 days' notice by mail, facsimile or e-mail.

2.3 Daily lease charges for an item of Insured Handling Equipment, leased to the Assured and where such charges have been incurred by reason of an Accident insured under this Section, (subject to clause 7) and resulting in:

A. The prevention of the redelivery of the Insured Handling Equipment to the lessor by the originally intended date due to that item being an actual or constructive total loss;

B. Delay in redelivery of the Insured Handling Equipment to the lessor by reason of obligation to effect repairs to the item.

In the event of a claim under this Section 3, the indemnity payable by Underwriters under all sections for the same Insured Handling Equipment shall not exceed the insured value of that item as identified in the Insurance Schedule.

3. FIRE FIGHTING EXPENSES

This Section covers the Assured's loss of fire extinguishing materials and equipment if used to safeguard the Insured Handling Equipment from a peril covered under this Section. Furthermore, this Section is extended to cover reasonable fire brigade charges for which the Assured is liable or other extinguishing expenses incurred by the Assured to safeguard the Insured Handling Equipment from a peril covered under this Section.

4. EXCLUSIONS

This Section does not cover loss or damage caused by:

4.1 wear, tear, marring, scratching or gradual deterioration, wet rot, dry rot mould, spoilage, decay or decomposition, settling, shrinkage or expansion, corrosion, rust, electrolyte action, discoloration, oxidation or erosion, leakage, subsidence, evaporation, loss of weight, breakage of glass or other fragile articles;

4.2 vermin, moths, termites or other insects;

4.3 atmospheric dampness or dryness, condensation, smog, fog, extremes or changes in atmospheric temperature;

~~4.4 seepage of any substance whatsoever, backing up of sewers or drains, pollution or contamination;~~

4.5 inherent vice, latent defect, error in design, fault or error in workmanship, manufacture or use of unsuitable materials. Costs of remedying or repairing inherent vice, latent defect, defects in design or manufacture;

4.6 earthquake, tsunami, tidal wave, seaquake or volcanic eruption, unless agreed by Underwriters;

~~4.7 mechanical or electrical breakdown or derangement of any communication equipment or alarm system or computer external to an item of Insured Handling Equipment;~~

4.8 confiscation, requisition, detention, occupation, embargo, quarantine, or arising from any order of public or government authority, or arising from acts of contraband or illegal transportation or illegal trade;

4.9 the Safe Working Load of any Insured Handling Equipment being exceeded;

4.10 loss of market, loss of use, loss of income, interruption of business, or any other consequential loss or damage whatsoever ;

4.11 cessation, fluctuation or variation in, or insufficiency of water, gas or electricity supplies;

4.12 artificially generated electrical current to electrical appliances, fixtures or wiring;

4.13 processing, erecting, dismantling, renovating, repairing (which shall not include general maintenance), or working upon any Insured Handling Equipment;

4.14 ~~error or fault in computer or machinery programming or from data processing media failure or breakdown~~;

~~4.15 mechanical or electrical breakdown or derangement; however, this exclusion shall not apply to physical loss or physical damage arising from or caused by such mechanical or electrical breakdown or derangement provided that such loss or damage is not otherwise excluded elsewhere in this Policy;~~

4.16 unexplained loss, mysterious disappearance, inventory shortage or loss due to book keeping, accounting or billing errors or omissions;

4.17 infidelity, dishonesty, theft, fraud or pilferage of the Assured or the Assured's employees or others to whom the Assured has entrusted responsibility;

4.18 the Assured or the Assured's employees voluntarily parting with title or possession of Insured Handling Equipment;

4.19 transit of Insured Handling Equipment unless within the Confines of the Port, Terminal or Insured Location.

5. EXCLUDED HANDLING EQUIPMENT

This Section does not cover
- any aircraft, helicopter, watercraft, vessels, vehicles designed for highway use,
- locomotives or rolling stock designed for railroad use if outside the confines of terminal or Insured location

6. STRIKES / RIOTS

Strikes or riots shall not include any of the other acts excluded in clause 6 of the General Policy Provisions

7. DAILY CHARGES

This Policy does not apply to daily lease charges where the item of handling equipment leased to the Assured is subject to a purchase option exercisable by the Assured or for the benefit of the Assured. Underwriters shall only be liable for a maximum amount of thirty days daily lease charges, from and including the original intended redelivery date, unless otherwise agreed by Underwriters.

8. PROTECTIVE MAINTENANCE

It is a condition precedent of liability under this Policy that the Assured shall maintain in good order proper and adequate protection for the safety of the Insured Handling Equipment, including any additional measures required by Underwriters, throughout the period of this Policy. Such protection shall not be withdrawn or reduced unless prior agreement has been obtained from Underwriters. If the Assured fails to comply with

this clause, Underwriters will not be liable for any claims arising in whole or in part from the Assured's breach.

9. AUTOMATIC ACQUISITIONS

This Section automatically holds covered handling equipment, similar to that already scheduled, acquired by the Assured after the inception date of the Policy period for a period of up to 90 days after acquisition, provided:

9.1 satisfactory advice and information regarding such handling equipment is given to Underwriters within 90 days of acquisition; and

9.2 the handling equipment value is not more than 10% of the overall limit of this Section set out in the Insurance Schedule.

9.3 the handling equipment is similar to that already Scheduled and is within the Confines of the Port, Terminal or Insured Location.

Underwriters reserve the right to charge additional premium and impose such terms, conditions and exclusions as they deem appropriate or to decide not to insure the handling equipment after the period of 90 days elapses.

10. VALUES DECLARED AND INCORRECT DECLARATION PENALTY

If Insured Handling Equipment values declared to the Insurance Schedule are less than the actual market values, then any recovery hereunder shall be reduced by the same proportion that the scheduled value bears to the actual value for that particular item.

11. SETTLEMENT OF CLAIMS

Settlement of claims under this Section will be calculated as follows subject to a maximum of the amount declared for the item of Insured Handling Equipment in the Insurance Schedule:

11.1 Where the equipment can be repaired at a cost less than the cost of replacement of the equipment, Underwriters will pay the costs necessarily incurred to restore the equipment to the same condition as the equipment was in prior to the physical loss or damage occurring. Due allowance will be made for depreciation in respect of parts replaced, and the value of any savage will be taken into account.

11.2 Where (11.1) does not apply Underwriters will pay the limit declared in the Insurance Schedule.

THIS SECTION IS TO BE READ IN CONJUNCTION WITH THE GENERAL POLICY PROVISIONS, THE INSURANCE SCHEDULE AND THE QUESTIONNAIRE ALL OF WHICH FORM PART OF THE POLICY

1/04

LSW1519

PORTS AND TERMINALS CONSORTIUM

EARTHQUAKE EXTENSION CLAUSE (HANDLING EQUIPMENT)

This extension is to be read in conjunction with the Ports and Terminals Consortium Handling Equipment Wording and the provisions that apply therein.

Notwithstanding exclusion 4.6 and in consideration of the payment of an additional premium to be agreed by Underwriters, this Policy shall be extended to cover physical loss or physical damage to Insured Handling Equipment:

A. Directly caused by earthquake, *tsunami,* tidal wave, seaquake or volcanic eruption;
B. By fire or explosion directly caused by earthquake, *tsunami,* tidal wave, seaquake or volcanic eruption.

EXCESS

In respect of loss covered under A of this extension, Underwriters shall only be liable for the amount by which such loss or damage during any one period of seventy two consecutive hours exceeds the underlying amount/deductible as specified in the Insurance Schedule.

The Assured may choose the date and time when any such period of 72 hours commences.

This extension shall be subject to clause 2 of the General Policy Provisions and nothing contained herein shall operate to increase the overall Section 3 limit as specified in the Insurance Schedule.

This extension is subject to a section sub-limit as specified in the Insurance Schedule.

1/04
LSW1520

PORTS AND TERMINALS CONSORTIUM

SECTION 4 - BUSINESS INTERRUPTION WORDING

1. LOSS, IF ANY, PAYABLE to Assured or Loss Payee, as identified in the Insurance Schedule.

2. INSURING CLAUSES

In consideration of the payment of the premium, Underwriters hereby agree, subject to the General Policy Provisions and the Section 4 limits as set out in the Insurance Schedule, to indemnify the Assured for loss of profit, increased cost of working and costs and expenses as set out in clause 3, arising from an interruption to the Assured's Operations caused by:

2.1 physical loss or physical damage to Insured Property or Insured Handling Equipment;

2.2 an Accident causing a blockage of:

A. An insured berth or insured quay (as specified in the Insurance Schedule) owned by or leased to the Assured and used in the Assured's Insured Operations for the purpose of mooring vessels.

B. Any approach channel or waterway;

C. Any land access immediately adjacent to the Confines of the Port, Terminal or Insured Location as specified in the Insurance Schedule.

2.3 interruption to electrical, *gas, fuel or water* supply to Insured Property or Insured Handling Equipment which is beyond the control of the Assured

2.4 interruption due to damage and/or blocked pipeline.

Provided that such interruption results in the Assured being wholly or partially unable to perform their Insured Operation(s) for a period commencing within the Policy period. This applies to paragraph 2.1 to 2.3.

3. CALCULATION OF LOSS

3.1 Loss of Profit. This shall be calculated by taking the reduction in the Assured's revenue derived from their Insured Operation(s) during the Loss Period less any savings the Assured may have, including but not limited to savings in working expenses, standing charges, taxes or the like, and less any increase in revenue at another of the Assured's location(s); and

3.2 Increased Cost of Working. This being costs and expenses reasonably and necessarily incurred by the Assured during the Loss Period for averting or minimising a loss covered under this Section 4. Such costs and expenses must not exceed the potential loss that the Assured is seeking to avert or minimise; and

3.3 Costs and expenses incurred by the Assured while investigating an Accident covered under this Section 4 and incurred protecting the interests of the Assured provided that such costs and expenses have been agreed by Underwriters,

4. EXCLUSIONS

This Section 4 does not cover:

4.1 The Assured's liability for any tax of any description;

4.2 Any loss arising from subsidence, landslip, avalanche or volcanic eruption or any excluded peril contained within the Property Damage or Handling Equipment Sections or the exclusions contained within the General Policy Provisions ;

~~4.3 Any loss arising from strikes or riots~~;

4.4 Any loss arising from faulty workmanship occurring during the execution of repairs;

4.5 Any loss arising from failure or delay in performance of any contractual obligation or guarantee;

4.6 Any loss for any period during which the Assured's Operations would not have continued for any reason other than the covered loss or damage;

4.7 Any increase in cost resulting from the suspension, lapse or cancellation of any lease, licence, contract or order;

4.8 Any increase in loss caused by the enforcement of a law or regulation regulating the use, construction, repair or demolition of any Insured Property or Insured Handling Equipment ;

4.9 Any loss arising as a consequence of insolvency or appointment of an administrative receiver or similar circumstance.

5. LOSS PERIOD

The Loss Period, as set out in the Insurance Schedule, shall be the period commencing when the Loss of Profit or Increased Cost of Working starts by reason of an Accident for which the Assured is insured under this Policy, or in the case of clause 2.3 the interruption to the electrical supply, and not exceeding the lesser of:

(a) such length of time as is reasonably required to repair or replace the lost or

damaged Insured Property, or Insured Handling Equipment; or in the case of 2.2 end the blockage; or

(b) the Loss Period specified in the Insurance Schedule.

Should the business interruption continue after the expiry of the Policy, Underwriters will nevertheless make payment for the continuing interruption up to the limit of indemnity set out in this clause, and the Insurance Schedule.

6. MATERIAL DAMAGE PROVISON

It is a condition precedent to Underwriter's liability under clause 2.1. that payment has been made or liability admitted under the Property Damage or Handling Equipment Sections of the Policy. If payment has not been made or liability accepted, then Underwriters will not make any payment, or consider a claim under clause 2.1.

7. BLOCKAGE OF OPERATION(S)

Underwriters hereby agree, subject to the provisions of this Policy, to indemnify the Assured for any interruption to the Assureds' Operation(s) arising from an Accident causing a blockage of:

7.1.1 An insured berth and/or insured quay/ pipelines (as specified in the insurance schedule) owned by or leased to the Assured used for the purpose of mooring vessels.

7.1.2 Any approach channel and/or waterway or berth/quay/ pipelines caused by own and / or calling vessels / dropping object from Air/Land by own / hired property, equipment etc. whether covered under property section of the policy or not and consequent upon operation of insured perils or not irrespective of material damage to insured property.

7.1.3. Any land access within the immediate vicinity of the Port and/or Terminal and/or insured location as specified in the insurance schedule, irrespective of material damage to insured property or not.

7.2 Provided that:

7.2.1 Such blockage of Operation(s) results in the Assured being wholly and/or partially unable to perform their Operation(s) for any period within the Policy period as identified in the insurance schedule; and,

7.2.2 In respect of clause 7.1.1., such blockage of Operation(s) is also the subject of a physical loss and/or physical damage claim the Assured has under the Property Damage Section of this Policy arising from the same Accident in excess of the deductible applicable to that item as specified in the insurance schedule.

THIS SECTION IS TO BE READ IN CONJUNCTION WITH THE GENERAL POLICY PROVISIONS, AND THE INSURANCE SCHEDULE AND THE QUESTIONNAIRE ALL OF WHICH FORM PART OF THE POLICY

1/04

LSW1522

EXPEDITING EXPENSES

This Policy covers the reasonable extra costs of temporary repair and the extra costs of expediting the permanent repair or replacement of lost, damaged or destroyed property, including overtime and express freight or other rapid means of transportation.

ARCHITECTS', SURVEYORS', LEGAL AND CONSULTING ENGINEERS' FEES CLAUSE

It is hereby agreed that within the limit(s) of the Sum(s) Insured on Buildings and Machinery, this Policy covers Architects', Surveyors', Legal, Consulting Engineers' and other Fees necessarily incurred by the Assured in the reinstatement of the property insured following upon its destruction or damage by any peril hereby insured against (but not any fees for the preparation of a claim or estimate of loss) not exceeding the amounts authorized under the Scales of the various Institutions regulating such charges prevailing at the time of the destruction or damage.

This Clause is subject otherwise to all the terms and conditions of the Policy to which it is attached.

MINOR WORKS

It is hereby noted and agreed that this policy covers destruction of and or damage to property in the course of construction or erection, alteration, dismantling, installation and all miscellaneous works.

PUBLIC AUTHORITY

The indemnity provided by this policy extends to include such additional cost of reinstatement of the destroyed or damaged property as may be incurred solely by reason of the necessity to comply with Building or other Regulations under or framed in pursuance of any legislation or with the Bye-Laws of any Municipal or Local Authority, or other properly constituted body charged with regulating building matters, provided that:

I. The amount recoverable under this extension shall not include:

a) the cost incurred in complying with any of the aforesaid Regulations or Bye-Laws

(i) In respect of damage occurring prior to the granting of this extension

(ii) In respect of destruction or damage not insured by this policy

(iii) Under which notice has been served upon the Insured prior to the happening of the destruction or damage

(iv) In respect of undamaged property or undamaged portions of property other than foundations (unless foundations are specifically excluded from the insurance provided by this policy) of that portion of the property destroyed or damaged

b) the amount of any rate tax duty development or other charge or assessment arising out of capital appreciation which may be payable in respect of the property by the owner thereof by reason of compliance with any of the aforesaid Regulations or Bye- Laws.

CLAIMS PREPARATION COSTS CLAUSE

The insurance under this Item is to cover:
(a) such professional fees as may be payable by the Insured;
(b) such other expenses incurred by the Insured and not otherwise recoverable, for preparation, proving and/or verification of claims made by the Insured under this Policy;
(c) the costs of arbitration if incurred and such reasonable professional fees and other reasonable expenses related thereto.

For the purpose of this Clause such reasonable professional fees shall include but not be limited to fees for financial advisors, accountants, loss adjusters, insurance intermediary, business interruption claims advocates and preparers and valuers appointed by the Insured.

MINIMIZATION OF LOSS CLAUSE

Loss Minimization Expenses/Protection And Preservation Of Property Clause - It is hereby understood and agreed, subject otherwise to the terms, conditions and exclusions of the Policy and endorsed hereon and subject to the Insured having paid the agreed additional premium, that the insurance by this Policy extends to cover expenses for loss minimisation necessarily and reasonably incurred by the Insured to prevent any aggravation of an insured loss following a loss or damage at any Insured's Premises specified in the Schedule, including moving or shifting of property if this contributes to loss minimization.

REINSTATEMENT CLAUSE

Subject to the following conditions, the basis upon which the amount payable in respect of property insured by this Policy is to be calculated shall be the reinstatement of the property lost, destroyed or damaged.

For this purpose "Reinstatement" means:
a) the rebuilding or replacement of property lost, destroyed or damaged which, provided the liability of the Insured is not increased may be carried out.
i) in any manner suitable to the requirement of the Insured ii) upon another site

b) the repair or restoration of property damaged

In either case to a condition equivalent to or substantially the same as but not better or more extensive than its condition when new.

Special Conditions

1. The liability of the Insurer for the repairs or restoration of property damaged in part only shall not exceed the amount which would have been payable had such property been wholly destroyed

2. If at the time of reinstatement the sum representing 85% of the cost which would have been incurred in reinstating the whole of the property covered by any item subject to this memorandum exceed its Sum Insured at the commencement of any damage, the liability of the Insurer shall not exceed the proportion of the amount of the damage which the said Sum Insured shall bear to the sum representing the total cost of t reinstating the whole of such property at the time.

3. No payment beyond the amount which would have been payable in the absence of this memorandum shall be made

   a) unless reinstatement commences and proceeds without unreasonable delay b) until the cost of reinstatement shall have been actually incurred

c) if the property insured at the time of its loss, destruction or damage shall be insured by any other insurance effected by or on behalf of the Insured which is not on the same basis of reinstatement.

4. All the terms and conditions of this Policy shall apply

   a) in respect of any claim payable under the provisions of this memorandum except insofar as they are varied hereby
   b) where claims are payable as if this memorandum had not been incorporated

5. This memorandum shall apply to Sections 2 and 3 of the policy

Average Clause (85%)

"This policy is subject to the condition of average, that is to say, if the property covered by this insurance shall at the time of the loss be greater value than the declared value the assured shall only be entitled to recover hereunder such proportion of the said loss as declared value by this policy bears to the total values of the said property. In the case the total values declared at the time of loss are not lower than 85% of the total value of the goods, the average clause will not apply, this stipulation will apply to each one of the items separately."

PREVENTION OF INGRESS/EGRESS CLAUSE

This Policy is extended to cover loss as insured by this Policy resulting from the necessary interruption of business at a location owned or operated by the Insured, at which ingress or egress is prevented due to physical loss or damage by an insured peril hereunder, at the location to which ingress or egress is prevented or within ten kilometres thereof.

PROFESSIONAL ACCOUNTANTS FEES CLAUSE

The insurance under Section 4 - Business Interruption includes provision for Accountants'/Auditors' Fees, which shall be limited to reasonable fees payable by the Insurer to their Accountants/Auditors for producing and certifying any particulars or details contained in the Insureds' books of accounts or other business books of documents or such proofs, information or evidence as may be required by the Insurer.

DESIGNATION OF PROPERTY CLAUSE

For all purpose of determining, where necessary, the item under which any property is insured, the insurers agree to accept the designation under which the property has been entered in the insured's books.

POLLUTION CLEAN UP COSTS CLAUSE

DELIBERATE DAMAGE – POLLUTION HAZARD CLAUSE - This contract is extended to cover loss of or damage to the property insured hereunder directly caused by governmental authorities acting for the public welfare to prevent or mitigate a pollution hazard or threat thereof, provided the accident or occurrence , which required governmental action, constitute a peril insured herein. This coverage shall not increase the limits of liability provided for in this contract.

TEMPORARY REMOVAL CLAUSE

Subject to the following provisions, the property insured by this Policy (other than stock in trade or merchandise if insured hereby) is covered whilst temporary removed for cleaning, renovation, repair or other similar purpose, elsewhere on the same or to other premises and in transit thereto and therefrom by road, rail or inland waterway.

The amount recoverable under this extension in respect of each item of the Policy shall not exceed the amount which would have been recoverable had the loss occurred in that part of the premises from which the property is temporarily removed, nor, in respect of any loss occurring elsewhere than at the said premises, 10% of the Sum Insured by the item after deducting therefrom the value of any building (exclusive of fixtures and fittings), stocks in trade or merchandise insured thereby.

This extension does not apply to property if and so far as it is otherwise insured nor, as regards losses occurring elsewhere than at the premises from which the property is temporarily removed to

a) Motor Vehicles and Motor Chassis licensed for normal use
b) Property held by the Insured in trust, other than machinery and plant.

ADDITIONAL INCREASED COST OF WORKING CLAUSE

Notwithstanding anything contained elsewhere in the Policy, the insurance is hereby extended to include the increased cost of working following loss or damage to an insured asset by one of the perils insured by this Policy.

The indemnity provided hereunder shall be the additional expenditure necessarily and reasonably insured for the sole purpose of avoiding or diminishing the disruption to the business airing from the insured loss. Such over will include but not be limited to expediting expenses in the effecting of repair of replacement alternate hire charges and additional transportation costs and the like. It is specifically agreed that all such expenses must be reasonable incurred and relate directly to the insured damage.

SPECIALISED/ HEAVY LIFT/ OVER-SIZED LIFTING CLAUSE

Where the Insured is engaged to perform &/or supervise a lifting of an oversize (dimensions greater than one FEU HIGH CUBE) &/or overweight load (weight exceeding 40 tonnes) or a special cargo that may require a special rig different to a standard rig for its lifting &/or cargoes requiring a tandem lift (use of two cranes simultaneously) and by way of example shall include but not be limited to construction, machines, cranes, front loaders, backhoes, pre-built homes, bridge beams, generators windmill propellers and towers, industrial equipment and agricultural machines.

Then it shall be necessary for such a lift to be subjectto.an Independent.survey by a competent surveyor.

Surveyor to review lift plan, equipment to be used including cranes, rigs, slings and hooks, attachment points and be in attendance prior to, during and post lift.

All recommendations by surveyor to be complied with prior to commencement of lift.

Cost of survey payable by the Insured.

Lifting of cargoes In &/or on a box container, flat rack container, open top container or any similar type container, pipers/pipelines shall not be subject to the special requirements above.

TOXIC MOULD EXCLUSION CLAUSE

Notwithstanding anything to the contrary contained in this policy, insurers will not pay for any loss, damage, cost or expenses caused directly or indirectly by, arising out of, resulting from, contributed to by, or related in any way to "mould". Loss, damage, cost or expenses caused directly or indirectly by, arising out of, resulting from, contributed to by, or related in any way to "mould" is excluded regardless of any other cause or event that contributes concurrently, or in sequence with the loss, damage, cost or expenses.

For the purpose of this exclusion, the following definition is added to the policy:

"Mould" means any species of fungi, Including, but not limited to, mould, yeast, mildew, spores, mould toxins, mycotoxlns, mould metabolites, mould antigens,. mould allergens, smut, wet or dry rot, mould produced antibiotics, or dust or fumes containing any of the foregoing, individually, or in any combination therewith or with another substance .

MARINE IMPACT INSURANCE CLAUSE

This insurance is only to indemnify the Assured for loss or damage to the above interest up to the amount shown but only in respect of loss or damage directly caused by Impact by Vessels or Floating Objects of any description or Aircraft or Articles dropped therefrom.

This insurance is only to pay in excess of the amount of deductible shown in the Schedule in respect of each claim or series of claims arising from one occurrence

This insurance does not cover:

i) Loss or damage arising from Inherent vice, wear, tear, depreciation, faulty design, electrical or mechanical derangement, rust or corrosion of piling and/or metal work and/or cost of painting or repainting same or erosion of river bed or loss of sea bed

il) Any claim directly or indirectly occasioned by or happening through or in consequence of:
   a) War, Invasion acts of foreign enemies, hostilities (whetber war be declared or not), civil war, rebellion, revolution, insurrection, military or usurped power or confiscation or nationalisation or requisition or piracy.

   b) Destructlon of or damage to property by or under the order of any Government or Public-or Local Authority.

Warranted the Assured undertakes maintenance Inspections at Intervals not exceeding 12 months.

INSURANCE SCHEDULE

RISK DETAILS:

1. **TYPE:**
   PORTS AND TERMINALS PACKAGE INSURANCE CONSORTIUM

2. **POLICY PERIOD:**
   As herein

3. **ASSURED NAME & ADDRESS:**
   Including full post code or zip code: As herein

4. **INSURED LOCATIONS:**
   Port Premise & adjacent Warehouse

5. **INSURED OPERATIONS:**
   As herein

6. **OVERALL SECTION LIMIT /SECTION SUB LIMIT/ SUM INSURED:**
   As herein

7. **DEDUCTIBLE:**
   As herein

8. **CONDITIONS:**
   As herein

9. **SEVERAL LIABILITY:**
   As herein

10. **CHOICE OF LAW AND JURISDICTION:**
    As herein

11. **Insured Property:**
    As per the valuation report submitted.

Operations for which the Assured is insured as a **Port Authority**:

Port Authority includes Port operator, harbour board, harbour authority and harbour operator.

Cargo and Equipment Handling:

(a) Lighter age operations

(b) Terminal or Depot Operations;
(c) Storage, including Warehousing of Cargo, Containers and Trailers; (d) Equipment Repair Operations;
(e) Local Collection and Delivery of Cargo, Containers and Trailers, ancillary to any other services for which the Assured is insured under (a) to (d) above.

Navigational Aids, Information and Control:

(a) Provision and Maintenance of Marine Navigational Aids;

(b) Provision and Maintenance of Charted and Advertised Water Depths;

(c) Provision and Maintenance of Buoyage and Lighting for Fairways, Wrecks and Obstructions;

(d) Provision of Navigational Information and Warnings; (e) Provision of Pilots and Pilotage;

(f) Control of the Movement, Berthing and Anchoring of Marine Traffic.

Shoreside Facilities:

(a) Provision and Maintenance of Wharves, Quays, Docks, Slipways and Moorings; (b) Provision and Maintenance of Passenger Terminals;
(c) Provision and Maintenance of Buildings, Structures and Equipment;

(d) Provision and Maintenance of road and rail systems within the Port area; (e) Provision of Security Services;

Additional Insurance:

(a) Provision and Maintenance of Port Emergency Services, including facilities for firefighting, rescue work, ambulance services and/or first aid;

(b) Leasing to, or permitting the use by another person of any Port Facility or Equipment;

(c) Provision of Advice and Information on the Management of Ports and Operations referred to above, to persons by whom the Assured is engaged to provide such advice and information, provided that such operations are of a type for which the Assured is otherwise insured;

GENERAL POLICY PROVISIONS

These General Policy Provisions apply to and form part of the Ports and Terminals Consortium Policy, Insurance Schedule, Questionnaire and to all Sections of the Policy purchased by the Assured

1. All payments under this Policy will be made to the Assured, or any loss payee identified in the insurance schedule.

2. SECTION LIMIT(S) / SUB-LIMIT(S) / SUM INSURED

2.1 **Overall Section Limit**(s) - Underwriters maximum limit payable for any claim under each section of this Policy arising from any one Accident or series of Accidents arising out of any one event is set out in the overall section limit(s) of the Insurance Schedule. Such overall section limit(s) shall be inclusive of any costs and defence expenses.

2.2 **Section Sub-Limit(s)** - In the case of section sub-limit(s) under this Policy, such section sub-limit(s) shall apply to any claim arising under that section, clause, extension or Operation in respect of any one Accident or series of Accidents arising out of any one event, and shall be inclusive and not in addition to the Overall Section Limit(s) as set out in the Insurance Schedule. Such section sub-limit(s) shall be inclusive of any costs and defence expenses arising from the claim(s) under that section, clause, extensions/or Operation. Where indicated in the Insurance Schedule all section sub-limit(s) apply in respect of any one Accident or series of Accidents arising out of any one event and in the aggregate for each 12 month period from the inception date of this Policy.

2.3 **Sum Insured** - The sum insured shall mean the insured value of the Insured Property and/or Insured Handling Equipment or the limit of Liability or Loss Period as identified in the Insurance Schedule.

3. JOINT ASSUREDS AND CO-ASSUREDS

3.1 Underwriters may accept an application from an Assured for another person or persons to become Joint Assureds in respect of that Assured's Policy. Each Joint Assured shall have an independent right of recovery from the Underwriters in respect of any liabilities, costs or expenses arising out of a particular casualty or event.

3.2 Unless otherwise agreed in writing with the Underwriters, the Assured and all Joint Assureds shall be jointly and severally liable to pay all amounts due to the Underwriters in respect of this Policy.

3.3 The Underwriters may accept an application from an Assured for another person or persons to become Co-assureds. The liability of Underwriters to all Co-assureds shall only extend insofar as the Co-Assured may be found liable to pay in the first instance for liabilities which are properly the responsibility of the Assured and are insured under this Policy. Once Underwriters have indemnified such Co-assureds, Underwriters shall not be under any further liability and shall not make any further payment to any person or company whatsoever, including the Assured, in respect of that claim.

3.4 Payment by Underwriters to the Assured or any one Joint Assured, or Co- assured in respect of any claim under this Policy shall fully discharge Underwriters of all liability arising out of that claim.

3.5 Any provision of this Policy by which an Assured or Joint Assured or Co-assured ceases to be insured or ceases to be entitled to recover from Underwriters in respect of any liability, loss or damage shall be deemed to apply to all Assureds, Joint Assureds and Co-assureds. Failure by the Assureds or any Joint Assured or Co-assureds to comply with any of the obligations under this Policy is deemed to be the failure of the Assured and all Joint Assureds and all Co-assureds. Conduct of an Assured or any Joint Assured or Co-assured which would have entitled the Underwriters to decline to indemnify it shall be deemed to be the conduct of all Assureds, Joint Assureds, and Co-assureds.

3.6 The contents of any communication between the Assured or any Joint Assured or Co-assured and the Underwriters, their servants or agents, shall be deemed to be within the knowledge of the Assured and all Joint Assureds or Co-assureds.

3.7 The Assured, Joint Assureds and Co-assureds agree that (subject to any express coverage in this Policy) no disputes arising amongst them shall be the subject of any insurance or recovery from the Underwriters and Joint Assured and Co-assureds shall only be insured on this basis.

3.8 Where there are Joint Assureds or Co-assureds, any reference to the Assured in this Policy will be deemed to include any Joint Assured or Co-assured, so far as applicable.

4. UNDERLYING AMOUNT(S) / DEDUCTIBLE(S)

This Policy shall only pay in excess of deductible(s) specified in the Insurance Schedule in respect of claim(s) resulting from any one Accident or series of Accidents arising out of one event. Costs and defence expenses shall also be subject to such deductible(s).

~~**5. RADIOACTIVE CONTAMINATION \ CHEMICAL \ BIOLOGICAL \ BIO CHEMICAL \ ELECTROMAGNETIC WEAPONS AND CYBER ATTACK EXCLUSION CLAUSE**~~

~~In no case shall this Policy cover loss, damage or expense directly or indirectly caused by or contributed to by or arising from:~~

~~A. Ionising radiations from or contamination by radioactivity from any nuclear fuel or from any nuclear waste or from the combustion of nuclear fuel;~~

~~B. The radioactive, toxic, explosive or other hazardous or contaminating properties of any nuclear installation, reactor or other nuclear assembly or nuclear component thereof;~~

~~C. Any weapon employing atomic or nuclear fission and/or fusion or other like reaction or radioactive force or matter.~~

~~D. Any chemical, biological, bio chemical or electromagnetic weapon;~~

~~E. The use or operation as a means for inflicting harm, of any computer, computer system, computer software programme, computer virus or process or any other electronic system.~~

6. WAR, STRIKES AND TERRORISM EXCLUSION

6.1 This Policy excludes:

A. loss damage, cost or expense directly or indirectly caused by, contributed to or arising from or in consequence of any of the following regardless of any other cause or event contributing concurrently or in any other sequence to the loss;

B. ~~strike, lock-out, labour disturbance, riot, civil commotion,~~ war, invasion, acts of foreign enemies, hostilities (whether war be declared or not), civil war, rebellion, revolution, insurrection, civil strife, military or usurped power or confiscation or nationalisation or requisition or destruction of or damage to property by or under the order of any government or public or local authority;

C. any act of terrorism, which means an act, including but not limited to the use of force or violence or the threat of violence, of any person or group of persons whether acting alone or on behalf of or in connection with any organisation or government, committed for political, religious, ideological or similar purposes including the intention to influence any government and/ or to put the public or any section of the public in fear;

D. this Policy also excludes loss, damage, cost or expense of whatsoever nature directly or indirectly caused by resulting from or in connection with any action taken in controlling, preventing, suppressing or in any way related to 6.1.

6.2 The burden of proving that this exclusion does not apply (if it is alleged to apply by Underwriters) shall be upon the Assured;

6.3 If any part of this exclusion is found to be invalid or unenforceable, the remainder will remain in full force and effect.

7. DANGEROUS CARGOES

It is a condition precedent of liability under this Policy that the Assured shall take all reasonable and proper steps to ensure compliance with all relevant and applicable regulations and/or statutory provisions relating to the carriage, handling and storage of dangerous cargoes. Underwriters will not be liable for any claims arising out of the Assured's breach of this condition.

8. DUE DILIGENCE/ PRECAUTIONARY MEASURES (ASSURED'S DUTY TO MINIMISE LOSS)

8.1 It is a condition of this Policy that the Assured shall act as if a prudent uninsured at all times and at their own expense take such measures as may be reasonable for the purpose of averting or minimising a loss. The Assured shall not admit liability or assume any obligation without prior agreement by Underwriters. In the event of a breach of this condition, Underwriters shall be entitled to cancel this Policy from inception, and shall not be liable for any claims arising under the Policy.

8.2 The Assured shall maintain all precautionary measures given as information to Underwriters with regard to loss prevention and risk management. The Assured shall, in addition, implement any measures required by Underwriters and notify Underwriters of any material change in or affecting the Assured's Operation(s). In the event of any material change, Underwriters will be entitled to amend the terms and conditions of this Policy, or cancel this Policy with effect from the date of the material change.

9. SURVEY / ISPS

It is a condition of this Policy that in the event Underwriters require a survey to be carried out, the Assured shall comply with any recommendations, requirements or restrictions imposed as a consequence of the survey by the date required by the survey or by the date set by Underwriters. The Assured must comply with the International Ship and Port Facility Security Code (ISPS).

In the event of a breach of this condition, Underwriters shall be entitled to cancel this Policy, with from inception, and shall not be liable for any claims arising under the Policy.

~~**10. ELECTRONIC EXCLUSION CLAUSE**~~

~~10.1 Notwithstanding anything to the contrary contained within this Policy, it shall not provide cover in respect of claims, losses, expenses or costs arising by reason of any defect in the operation of any Computer Equipment, the operation or any function of such Computer Equipment, or the sending, receipt, processing or manipulation of data (including e-mails and data accessible via the internet). For this purpose, "Computer Equipment" includes any combination of software and hardware.~~

~~10.2 This clause applies regardless of any other cause and/or event that contributes concurrently or in any sequence to any loss, damage, cost, claim, and/or expense.~~

11. NOTICE OF POTENTIAL CLAIMS

The Assured shall give to Underwriters, directly or via Underwriters representatives (as identified in the Insurance Schedule), immediate notice of an Accident which may give rise to a loss which could result in a claim under this Policy. The Assured shall then promptly deliver by mail or facsimile or e-mail to Underwriters, directly or via Underwriters' representatives, a written account of the nature of the Accident stating the cause, if known, the extent of any damage, liability or expense and the nature of the interest of the Assured. ~~Should notice not be given within 30 days of the Assured becoming aware of the Accident, Underwriters will have the option to decide whether they have been prejudiced by the delay, and if so, to reduce the amount paid in respect of the claim, or not pay the claim at all.~~

12. ASSISTANCE OF THE ASSURED

12.1 The Assured shall assist Underwriters in all matters relating to claim(s) and provide Underwriters with all information Underwriters or their agents may reasonably request in respect of a claim. The Assured will also allow Underwriters or their agents to interview witnesses and access to evidence supporting the claim(s).

12.2 The Assured is obliged under the due diligence obligation in clause 8.1 to take all reasonable steps to defend claim(s) made against the Assured which could become a claim under this Policy. Underwriters shall have the right, but not the duty, to participate with the Assured in the defence, settlement or litigation of any claim(s) made against the Assured, or to appeal against any judgement or award. Underwriters agree, provided prior written consent is obtained from Underwriters, subject to any terms imposed by Underwriters such as selection of lawyers, and subject to any deductible/underlying amount, to indemnify the legal costs and expenses in relation to any claim(s) against the Assured arising out of an insured Accident. However, Underwriter's liability including such legal costs and expenses shall in no event exceed the relevant Overall Section Limit(s) and/or Section Sub-Limit(s) as identified in the Insurance Schedule.

12.3 Underwriters shall have the right to elect at any time to take over the conduct of the defence, settlement or litigation of any claim(s) from the Assured upon giving notice to the Assured or the Assured's Broker by mail, facsimile or e-mail. Should Underwriters make such an election, the Assured agrees to continue to provide Underwriters with all reasonable assistance in handling the claim(s).

12.4 Underwriters shall be entitled at any time to elect not to continue to support the defence, settlement or litigation of any proceedings and any liability for legal costs and expenses shall cease at the time of their election.

13. SUBROGATION

The Assured is not authorised to waive any rights of recovery in relation to any other party without prior written agreement from Underwriters. Where an amount is paid by Underwriters under this Policy, the Assured's rights of recovery against any other party in respect of such amount shall be exclusively subrogated to Underwriters. At Underwriters' request the Assured will assist (including attendance at hearings and ensuring attendance of witnesses), co-operate and lend its name to the exercise of Underwriters' rights of subrogation. In the event that any subrogated recovery is made, Underwriters will be entitled to reimbursement of all sums they have paid under the Policy before the Assured is entitled to receive any uninsured losses or deductible that has been applied.

14. AUDIT

Underwriters may on reasonable notice examine and audit the Assured's books and records at any time relating to the subject matter of this Policy.

15. PRIOR KNOWLEDGE / OTHER INSURANCES

15.1 Underwriters will have no liability under this Policy arising from any Accident, of which the Assured had knowledge, prior to the inception date of this Policy.

15.2 Where the Assured has given notice to insurers under any other insurance or is, irrespective of this Policy, entitled to be indemnified in whole or in part by any other insurance in respect of any damages or loss which would otherwise be indemnifiable in whole or in part by the Underwriters of this Policy, there shall be no contribution or participation by the Underwriters of this Policy on the basis of any deficiency, concurrent or double insurance for such loss or damage for which the Assured is entitled to be indemnified by such other insurance. This condition will apply whether or not the Assured is actually indemnified by such other insurance.

16. INSOLVENCY OR BANKRUPTCY

16.1 The insolvency, liquidation, bankruptcy, receivership, administration or the like, or any refusal or inability to pay of the Assured or any Underwriter shall not operate to:

A. Increase Underwriter's liability under this Policy, or;

B. To increase any Underwriter's share of liability under this Policy, or; C. To deplete any underlying amount(s).

16.2 Upon any of the circumstances described in 16.1 occurring to the Assured, then this Policy shall immediately terminate. The Assured will not be entitled to any return of premium, and will remain liable for premium due up to the date of cancellation.

16.3 In no event shall any Underwriter of this Policy assume the responsibilities or obligations of the Assured or any insurer or any Underwriter upon any of the circumstances described in 16.1 occurring to the Assured

17. CANCELLATION

17.1 Cancellation of this Policy may be effected by the Assured, or by Underwriters or their representatives (as identified in the Insurance Schedule) sending notice by mail or facsimile, or e-mail to the other party(s) stating when, not less than 30 days thereafter, cancellation shall be effective.

17.2 If this policy is cancelled by the Assured, Underwriters will retain the short rate proportion of the premium for the period this Policy has been in force calculated in accordance with the standard London Market Short Rate Cancellation Table. If Underwriters cancel this Policy, they shall retain the pro rata proportion of the premium for the period this policy has been in force until the effective date of cancellation.

17.3 Notice of cancellation by the Underwriters shall be effective whether or not Underwriters have returned or tendered the return of any premium with such notice.

18. ASSIGNMENT

No assignment of any interest under this Policy shall be valid except with the written consent of Underwriters.

19. SEVERAL LIABILITY NOTICE

The subscribing Underwriters' obligations under this Policy are several and not joint and are limited solely to the extent of their individual subscriptions. The subscribing Underwriters are not responsible for the subscription of any co-subscribing Underwriter who for any reason does not satisfy all or part of its obligations.

20. GOVERNING LAW

This Policy shall be subject to and governed by ~~English~~ the Laws of India.

21. ARBITRATION

All matters in difference between the parties arising under, out of or in connection with this Policy, including formation and validity, and whether arising during or after the period of this Policy, shall be referred to an arbitration tribunal as set out below.

21.1 Unless the parties appoint a sole arbitrator within 14 days of one receiving a written request from the other for arbitration, the party requesting arbitration (the Claimant) shall appoint an arbitrator and give written notice to the other party (the Respondent). Within 30 days of receiving such notice the Respondent shall appoint his arbitrator and give written notice to the Claimant, failing which the arbitrator appointed by the Claimant shall act as sole arbitrator, in which case paragraph 22.2 shall not apply.

21.2 Before they enter upon a reference the two arbitrators shall appoint a third arbitrator. Should they fail to appoint such a third arbitrator within 30 days of the appointment of the Respondent's arbitrator then either of them or either of the parties may apply to the appointor for the appointment of the third arbitrator. The three arbitrators shall decide by majority. If no majority can be reached the verdict of the third arbitrator shall prevail. He shall also act as chairman of the tribunal. The appointor shall be the Chairman of the London Court of International Arbitration.

21.3 Unless the parties otherwise agree the arbitration tribunal shall consist of persons (including those who have retired) with not less than ten years' experience of insurance or reinsurance as persons engaged in the industry itself or as lawyers or other professional advisors.

21.4 The arbitration tribunal shall have power to fix all procedural rules for the holding of the arbitration.

21.5 The place of arbitration shall be London unless an alternative place is agreed between the parties.

22. THIRD PARTY RIGHTS

No party other than the Underwriters and the Assured specified in the Insurance Schedule shall have any right to enforce any part of this Policy.

23. DEFINITIONS

23.1 ACCIDENT - wherever used means a sudden event which was neither expected nor intended by the Assured and which first occurred or commenced on an identifiable specific date during the Policy period.

23.2 ASSURED - wherever used shall mean the Assured (as identified in the Insurance Schedule) and any, executive officer, managing employee, director or trustee thereof while acting within the scope of the duties bestowed on that person by the Assured.

23.3 BODILY INJURY - wherever used shall mean all physical injury to a third party including death, sickness, disease, mental injury, anguish or shock resulting from such physical injury.

23.4 CO-ASSURED – wherever used shall mean any party defined in the Insurance Schedule as a Co-assured.

23.5 COMPUTER EQUIPMENT - wherever used shall mean computer hardware and/or software.

23.6 CONFINES OF THE PORT AND/OR CONFINES OF THE TERMINAL AND/OR CONFINES OF THE INSURED LOCATION wherever used shall mean those areas within the limits of the Port as set out in the Insured Operations Clause of the Insurance Schedule, and in the case of local collection and delivery within a 10 kilometre radius of the Confines of the Port or Terminal or Insured Location.

A Port includes ports, marine terminals, warehouses, container freight stations, container or trailer repair or storage depots, inland clearance depots and rail freight intermodal transfer depots.

23.7 INSURANCE SCHEDULE - wherever used shall mean the schedule to the Insurance Policy.

23.8 INSURED HANDLING EQUIPMENT - wherever used shall mean the handling equipment specified in the Handling Equipment Schedule of the Insurance Schedule.

23.9 INSURED LOCATION - shall mean those locations specified in the Insurance Schedule.

23.10 INSURED PROPERTY - shall mean the insured property set out in the Property Schedule of the Insurance Schedule.

23.11 JOINT ASSURED - wherever used shall mean any party defined in the Insurance Schedule as a Joint Assured

23.12 INSURED OPERATIONS - wherever used shall mean the insured operations which the Assured has requested to be insured for and has been granted coverage for by Underwriters as identified in the Insurance Schedule.

23.13 OVERLOADED - wherever used shall mean when the safe working load specified for the equipment by the manufacturer or by any other similarly qualified party is exceeded.

23.14 POLICY - wherever used shall mean all Sections, including extensions to those Sections, General Policy Provisions, Insurance Schedule, and Questionnaire.

23.15 PORT AUTHORITY - wherever used shall mean the party stipulated in the Port Authority Questionnaire and the operator or owner of the port specified in the Insurance Schedule.

23.16 TERMINAL OPERATOR - wherever used shall mean the party(s) stipulated in the Terminal Operator Questionnaire and the operator of any terminal operations specified in the Insurance Schedule.

01/04
LSW1524

UNINTENTIONAL ERRORS AND OMISSIONS CLAUSE

This insurance shall not be prejudiced by any unintentional and/or inadvertent:

A. Error or omission by the Assured and/or

B. Incorrect description and/or

C. Error in the name or title of the Assured

However, underwriters retain their rights to collect additional premium or exercise the right of cancellation or non-renewal.

For The New India Assurance Company Ltd

Duly Constituted Attorney(s)

Place: **Mumbai** **Date:** 24/07/2022