MORMUGAO PORT TRUST

Environmental Impact Assessment Study for Re-development of Berth 8,9 & Barge Berth at MPT, Goa

DRAFT REPORT

WAPCOS LIMITED

(A Government of India Undertaking)

76 C, Sector 18, Gurgaon - 122015, Haryana, INDIA

Tel. +91-124-2397396,

Email: environment@wapcos.gov.in

NABET Accreditation No.146

October 2016

CONTENTS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ANNEXURE

Annexure-I	: Approved Terms Reference (TOR) for the EIA study
Annexure-II	: HTL/LTL Demarcation
Annexure-III	: Ambient Air Quality Standards
Annexure-IV	: Ambient Noise Standards

CHAPTER-1
INTRODUCTION

CHAPTER-1

INTRODUCTION

1.1 GENERAL

The Mormugao Port Trust, Goa is a major port on the west coast of the country, located in the state of Goa. The coordinates of the port are 15º25'North and 73º47' East. The Mormugao Port was established in 1885 and the traffic handled at the port has increased significantly. Once known as the premier iron-ore exporting port of India, today the port is set to diversify into other commodities as well as containers. Coal/Coke is a major commodity handled at the port.

During the year 2014-15, more than 7.5 million tons of coal was handled at Mormugao Port. There are two dedicated coal terminals (berth 6 & 7) which are being operated by private operators. The demand for coal imports through Mormugao Port remains very strong (Additional 20 million tonnes in the next 8 to 10 years). This has been confirmed by the Boston Consulting Group (BCG) in their report submitted in October 2015.

Similarly the demand for General cargo is also expected to increase. On the back of the strong demand for coal imports and general cargo import/export, during the year 2014-15, the port witnessed a growth of 25% over the previous year. For the current year too, the growth recorded so far is over 27% over the previous year.

1.2 NEED FOR THE PROJECT

Mormugao Port is an excellent natural harbor and over the years, the Port has developed a deep draft channel (-14.4m below Chart Datum). It has good rail and road connectivity. The doubling of Rail Line between Vasco to Hospet is progressing well. Survey has been completed by South Western Railway in the mountainous section between Kulem and Castle Rock for the alternate alignment of the second line. The total construction period is envisaged to be 30 months excluding preconstruction activities

The demand for handling facilities for coal and general cargo traffic has made capacity addition a priority. Berth No.8 is a Liquid cargo handling berth, however the berth utilization is low. Therefore the port plans to shift

this operation to Berth No.10/Berth no.11. Also Berth No.9, is a dedicated iron ore export berth.

This berth alongwith the barge berths and the Mechanical Ore Handling Plant (MOHP) is also practically under - utilized on account of recession in the iron ore export market. The port therefore intends to put all these underutilized facilities to alternate use capable of handling Capesize Vessel. Hence, as a part of its endeavour to serve the Trade and the Nation, it has been decided to undertake the 'Redevelopment of Berths 8, 9, Barge Berths and Mechanical Ore Handling Plant at the Port of Mormugao' (the "Project") on Develop, Build, Finance, Operate and Transfer (the "DBFOT") basis, and also to carry out the bidding process for selection of the bidder to whom the Project will be awarded.

1.3 PROJECT DESCRIPTION

Propose project envisages the redevelopment of Berths 8th, 9th and barge berth at the Port of Mormugao, Goa. Entire facility will come within existing Port area. Existing structures will be dismantled for the proposed development. Propose project involves the covered storage for coal cargo and open storage for general cargo, construction of Bund, extension of Berth face, Reclamation is proposed in an area of 11.40 ha. Capital dredging for deepening of turning circle from 14.40 up to -19.50 m near the Berth face is proposed as part of the project, total quantity of dredged material has been estimated as 2.44 Mm^3. The total Berth front now available after shifting of liquid handling from berth 8 and dismantling Iron Ore handling from berth 9 and Barge berth area is 950 m. The total backup area after reclamation of berth face up 50 m and entire barge berth area will be around 27 ha. Which includes the reclamation in an area of 11.40 ha including berth face and barge berth area.

Berth 8 will be converted in to a bulk berth for handling of coal with all required mechanization facilities and stackyard. The total length of the berth will be 350 m and optimal capacity of the terminal is found to be 6.99 MTPA. An area of 7.97 ha has been earmarked as a backup area for the coal stackyard. The berth structure is proposed to be designed for 175000 DWT vessel. Berth no. 8 will be fully mechanized with in motion Rail

loading, covered shed, dust suppression system, etc. All the three berths will be provided with rail and road connectivity

Berth 9 is proposed to be developed as container and general cargo berth with a total length of 260 m. The total area proposed for the container stack yard is 5.46 ha. The berth capacity of 4.18 MTPA has been considered for equipment planning as well as for estimation of tariff for various cargo types. The design vessel considered for the container cum general cargo berth is 40,000 DWT vessels.

Berth 9 A will be dedicated for handling iron ore export. The length of the berth shall be 340 m. The reclaimed barge berth area will be utilised for berthing and handling of iron ore. The area available for the storage is around 13.22 Ha. The stockyard capacity has been found to be 8.00 MTPA considering 20 as turnaround ratio. The barge unloaders will unload the iron ore from barges and will convey it to the connecting conveyor system. Iron ore will be conveyed through the conveying system and will be stacked in the stockyard using stackers. Reclaimers will reclaim the Iron ore from stockyard and convey to ship loaders through conveying system.

The total cost of the project will be Rs.1145.36 crores. The project location is depicted in Figure-1.1. The layout of Mormugao port is given in Figure-1.2.

1.4 NEED FOR THE EIA STUDY

The proposed project require CRZ clearance under Coastal Regulation Zone (CRZ) Notification (January 2011) and Environmental clearance as per the clause No. 7 (e) of the schedule of EIA notification of September 2006 and subsequent amendments. Environmental Impact Assessment (EIA) study needs to be conducted guidelines stipulated in the EIA notification of September 2006 and CRZ Notification of January 2011. It is proposed to conduct an EIA study to assess the impacts likely to accrue as a result of various activities of the proposed projects.

A suitable Environmental Management Plan (EMP) will then be suggested to ameliorate the adverse impacts and enhance the positive impacts. An

Environmental Monitoring Programme covering dredging and dumping operation will also be suggested as a part of the EIA study.

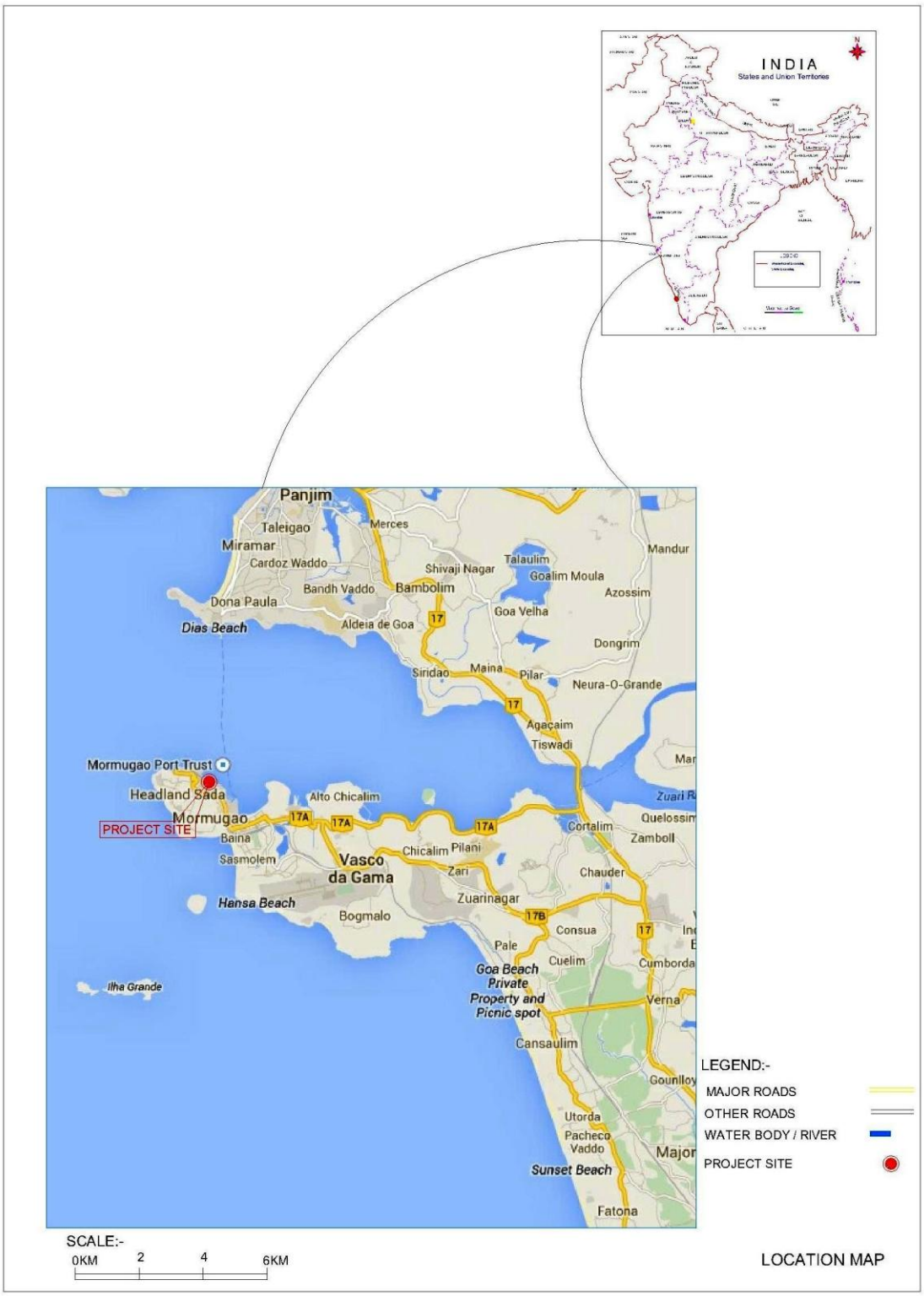


Figure-1.1 Location Map

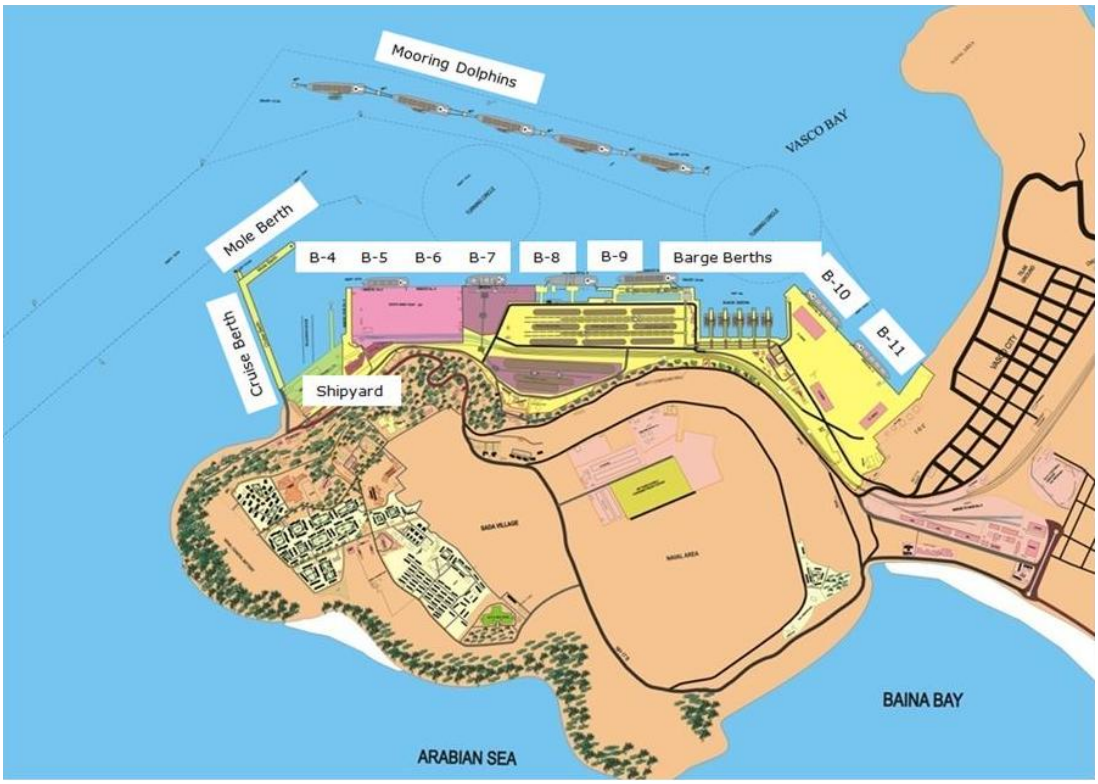


Figure-1.2 Layout of Mormugao Port

1.5 OBJECTIVES OF THE EIA STUDY

The major thrust of the EIA study shall be to assess the impacts of various activities of proposed project on various aspects of environment. The study shall cover the impacts on water quality, noise, air quality, terrestrial ecology, wildlife, aquatic ecology including fisheries, etc. The study will include collection of baseline data, prediction of impacts and formulation of Environmental Management Plan (EMP) for amelioration of adverse impacts. The Study Area for the EIA Study shall be the area within 10 km radius of the proposed navigation channel at the Centre. The objectives of the Environment Impact Assessment study are to:

- determine the baseline status of the marine ecology, terrestrial environmental conditions, Ambient Air Quality, Land use, Noise levels, Socio-economic aspects of the study area.
- identify and assess the probable impacts of the project on marine and terrestrial environment in the study area during dredging and dumping operation of the project.

- suggest adequate mitigation measures to minimize the negative impacts during dredging operation and operational phases of the project.
- recommend Environment Management Plan to ensure that the project implementation does not impact the environment adversely.
- formulate Risk assessment and Disaster Management Plan considering the project activity.
- suggest Environmental Monitoring Programme for monitoring of key parameters during construction and operation phases.

1.6 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

The principal Environmental Regulatory Agency in India is the Ministry of Environment and Forests (MOEF), Government of India. MOEF formulates environmental policies and accords environmental clearance for the projects. The State Pollution Control Board (SPCB) accords No Objection Certificate (NOC) Consent for Establishment and consent for Operation for the projects. As per the list of projects or activities requiring prior environmental clearance given in the EIA Notification issued by MoEF on 14th September 2006, proposed project is listed on S.No. 7e and requires Environmental Clearance from MoEF. Since, the project is proposed in the coastal area, CRZ Clearance would also be required as per the CRZ Notification of January 2011.

As per the guidelines, pertaining to Environmental Clearance issued by Ministry of Environment and Forests (MoEF) dated September 14, 2006, the Terms of Reference (TOR) for the EIA study is to be approved by MoEF. In this connection, Form-I along with TOR in the prescribed format was submitted to MoEF. TOR for the proposed study was approved by the Expert Appraisal Committee (Infrastructure -2) for Projects related to All ship breaking yard including ship breaking unit, Common Hazardous Waste Treatment, Storage and Disposal Facilities, Ports and Harbours, Aerial Ropeways, CETPs, Common Municipal Solid Waste Management Facility, Building/Construction Project, Townships and Area Development projects held on 21st - 22nd December, 2015. TOR was communicated to

Mormugao Port Trust vide letter dated 16.02.2016. A copy of the same is enclosed as Annexure-I.

1.7 STUDY AREA

As per the Ministry of Environment & Forests (MOEF) guidelines, the Study Area for the EIA study has been considered as the 10 km radius keeping the proposed project site at the centre.

1.8 STAGES IN AN EIA STUDY

The purpose of this section is to enumerate the steps involved in an Environmental Impact Assessment (EIA) Study. The same are given in following paragraphs.

Scoping: An exhaustive list of all likely impacts drawing information from as many sources as possible shall be prepared to assess the impacts due to various activities of proposed port. The next step shall be to select a manageable number of attributes, which are likely to be affected as a result of the proposed project.

Various criteria applied for selection of the important impacts are as follows:

- magnitude
- extent
- significance
- special sensitivity

Baseline study: Before the start of the project, it is essential to ascertain the baseline levels of appropriate environmental parameters, which could be significantly affected by the implementation of the project. The planning of baseline survey shall emanate from short listing of impacts prepared during identification. The baseline study shall involve both field work and review of existing documents, which is necessary for identification of data which may already have been collected for other purposes.

Impact prediction: is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur as a result of the proposed project. An attempt shall generally made to forecast future environmental conditions quantitatively to the extent possible. But for certain parameters which cannot be quantified, the

general approach shall be to discuss such intangible impacts in quantitative terms so that planners and decision makers are aware of their existence as well as their possible implications.

Environmental Management Plan: For the proposed coastal development projects an Environmental Management Plan (EMP) shall be formulated to maximize the positive environmental impacts and minimize the negative ones. After selection of suitable environmental mitigation measures, the cost required for implementation of various management measures will be estimated, to have an idea of their cost-effectiveness.

Risk Analysis and Disaster Management Plan: Suitable Risk Analyses and Outlines the Disaster Management Plan (DMP) shall be prepared considering the proposed project activities.

Environmental monitoring programme: An Environmental Monitoring Programme for implementation during project dredging operation and operation phases shall be suggested to oversee the environmental safeguards, to ascertain the agreement between prediction and reality and to suggest remedial measures not foreseen during the planning stage but arising during operation and to generate data for further use.

1.9 IMPACT ASSESSMENT

With the knowledge of the baseline conditions of various environmental parameters, positive and negative impacts likely to accrue as a result of various activities of the proposed project have been identified and assessed.

1.10 ENVIRONMENTAL MANAGEMENT PLAN

The purpose of the EIA is to quantify the impact and to prepare an Environment Management Plan (EMP) to ensure that changes to the environment fall within acceptable limits and to give the environment its due place in the decision making process by clearly evaluating the environmental consequences of the proposed activity before action is taken. The potential adverse effects of dredging activity encompass land, water pollution, contamination of bottom sediments, loss of bottom habitat, damage to marine ecology, current pattern changes, waste disposal, oil leakage and spillage, etc. by suitable means including modeling where

necessary; the impact of all the identified environmental concerns of ongoing dredging activities on each facet of the environment should be assessed and suitable mitigation measures against the potential adverse impacts should be considered such that an effective EMP can be prepared and adhered to during dredging operations.

Based on the identified potential impacts associated with the project, an EMP shall be framed for the construction and operations phases of the project. The EMP will be based on the following considerations;

- Management of effluent from various sources during construction phase
- Solid waste management and disposal during construction phase
- Control of air pollution during construction phase
- Control of noise during construction phase
- Green belt development
- Mitigation of impacts on marine ecology
- Dust control measures at different cargo handling
- Noise control measures during operation phase
- Treatment and disposal of effluents from berth, back up area & other related areas
- Management of impacts due to dredging.
- Management of impacts due to reclamation works
- Details of the proposed green belt, with suitable plan
- Mitigation measures shall be submitted project-wise.

1.11 ENVIRONMENTAL MONITORING PROGRAMME

It is necessary to monitor certain environmental parameters identified as critical or as required by regulatory agencies. Considering the requirements of Regulatory Agencies and identified critical parameters, a post project environmental monitoring programme will be designed for dredging and dumping operation as a part of the EIA study. All the equipment and manpower required for the implementation of this programme and cost involved will also be estimated.

1.12 OUTLINE OF THE REPORT

The contents of the EIA report are arranged as follows:

Chapter 1: The chapter gives an overview of the need for the project, objectives and need for EIA study etc. The methodology adopted for conducting the EIA study for the proposed dredge the existing navigation channel is also described in this chapter.

Chapter 2: A brief write-up on various project appurtenances, infrastructure available at the port, etc. has been covered in this chapter.

Chapter 3: Baseline environmental conditions including physical, biological and socio-economic parameters, resource base and infrastructure have been described in this Chapter. The baseline study involved both field work and review of existing documents, which is necessary for identification of data which may already have been collected for other purposes.

Chapter 4: Prediction is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur as a result of the proposed activity.

Chapter 5: Environmental Management Plan (EMP) outlines measures for amelioration of anticipated adverse impacts likely to occur as a result of proposed activities is presented in this chapter.

Chapter 6: Details the Risk Analysis and Disaster Management Plan.

Chapter 7: Environmental Monitoring Programme for implementation during Construction of cargo.

Chapter 8: cost required for implementation of Environmental Management Plan and Environmental Monitoring Programme are summarized in this Chapter

Chapter 9: Delineates the Disclosure of Consultants.

CHAPTER-2
PROJECT DESCRIPTION

CHAPTER-2

PROJECT DESCRIPTION

2.1 GENERAL

The port of Mormugao, one of the oldest ports of India was commissioned in 1885 and is among the twelve Major Ports of the country. The Mormugao Port is a leading Major Port on the West Coast of India, located at the entrance of Zuari estuary on the west coast of India (State of Goa). Once known as the premier iron- ore exporting Port of India, today the port is set to diversify into other commodities as well as containers. Coal/Coke is a major commodity handled at the port. During the year 2013-14, more than 7.5 million tons of coal was handled at Mormugao Port. There are two dedicated coal terminals (berth 6 & 7) which are being operated by private operators. The demand for coal imports through Mormugao Port remains very strong. Mormugao Port has an excellent natural harbor and over the years, the Port has developed a deep draft channel (-) 14.4 m CD. It has good rail and road connectivity. Along with the demand for coal, the general cargo traffic has also witnessed a growth during the past two years at Mormugao Port.

The iron ore handling at the port are being carried out at Berth No.9, Mooring Dolphins West of Breakwater by deploying Trans shippers and directly from barge to ship. Handling operations at West of Breakwater are not carried out during bad weather conditions. At Mooring Dolphins and berth 9, Iron ore is handled round the year, except for the period when the plant is shut down for maintenance. During the year 2014-15, more than 9.0 million tons of coal was handled at Mormugao Port. There are two dedicated coal terminals (berth 6 & 7) which are being operated by private operators. The demand for coal imports through Mormugao Port remains very strong (Additional 20 million tonnes in the next 8 to 10 years). Similarly the demand for General cargo is also very strong. On the back of the strong demand for

coal imports and general cargo import/export, during the year 2014 - 15 the port witnessed a growth of 25% over the previous year. For the

year 2015-16 too, the growth recorded is of the order of 27% over the previous year.

2.2 EXISTING PORT FACILITIES

The total cargo handling capacity of MoPT is 43.8 MTPA. Berth wise details of the capacity of operational berths and type of cargo are shown in Table-2.1.

Table 2.1 Berth Wise Capacity of MoPT

S.No.	Berth No.	Capacity (in MTPA)	Cargo
1	Berth No. 8	1.5	Liquid Bulk
2	Berth No. 9	11.5	IronOre
3	MooringDolphins	10.0	IronOre/Coal
4	Transshipper	6.0	IronOre
5	Berth No. 5 &6	7.5	Coal, Coke, General Cargo
6	Berth No. 7	4.61	Coal/Coke
7	Berth No. 10& 11	2.65	General Cargo
	Total	**43.8**	

MPT handled 50 MTPA of cargo during the year 2011, which reduced to 14.7 MTPA during the year 2015. Iron ore was the main export commodity from MoPT up to 2011. The share of MoPT traffic in All India traffic was around 8.6% in 1995 and it dropped to 5.6% in 2011-12. Since the ban on Iron ore mining & its export, the cargo handling at MoPT has declined sharply and the share of traffic has gone down to about 1.4 % in 2015 The huge drop was primarily due to drop in export of Iron Ore, attributable to the Govt. policy of ”No export & no mining of Iron ore in Goa as well as Karnataka State”. Commodity-wise traffic handled at MoPT during 2001 to 2015 is given in Table 2.2.

Table-2-2- Traffic at MoPT by commodities in MTPA

	2001	2005	2010	2011	2012	2013	2014	2015
POL	1.089	1.010	0.964	0.938	0.923	0.823	0.527	0.571
Phosphoric Acid	0.112	0.362	0.485	0.394	0.334	0.158	0.236	0.359
Liquid Ammonia	0.026	0.085	0.125	0.107	0.083	0.031	0.062	0.087
Caustic Soda	0.075	0.000	0.025	0.028	0.021	0.016	0.040	0.046
Edible Oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
LIQUIDCARGO	1.302	1.457	1.619	1.470	1.392	1.038	0.865	1.066
Iron Ore	15.663	24.717	40.574	40.625	29.370	7.421	0.044	0.759
Thermal Coal	0.420	0.283	0.957	1.633	1.163	0.768	0.000	1.937

	2001	2005	2010	2011	2012	2013	2014	2015
Coking Coal	0.892	2.732	3.784	4.933	5.669	6.606	7.517	6.631
Other coal	0.615	0.000	0.000	0.000	0.000	0.000	0.000	0.711
FRM	0.124	0.172	0.125	0.242	0.093	0.078	0.179	0.227
DRYBULK	17.714	27.904	45.440	47.433	36.295	14.873	7.740	10.264
Foodgrains	0.000	0.000	0.000	0.066	0.000	0.060	0.044	0.011
Iron & Steel	0.057	0.036	0.310	0.000	0.122	0.013	0.060	1.953
Sugar	0.000	0.000	0.126	0.000	0.000	0.000	0.000	0.000
Bauxite	0.105	0.025	0.000	0.070	0.153	0.267	0.000	0.000
Other Misc	0.406	1.120	1.050	0.771	0.808	1.159	2.644	1.104
Break Bulk	0.568	1.181	1.596	0.937	1.083	1.569	2.898	3.069
Containers	0.044	0.117	0.192	0.182	0.231	0.213	0.236	0.312
TEU		10	17	18	22	20	19	25
Total	**19.63**	**30.66**	**48.85**	**50.02**	**39.00**	**17.69**	**11.74**	**14.71**
LIQUIDCARGO	6.63	4.75	3.31	2.94	3.57	5.87	7.37	7.25
DRYBULK	90.25	91.01	93.03	94.82	93.06	84.06	65.93	69.77
Break Bulk	2.89	3.85	3.27	1.87	2.78	8.87	24.69	20.86
Containers	0.22	0.38	0.39	0.36	0.59	1.20	2.01	2.12
	100	100	100	100	100	100	100	100

Traffic Forecast for various commodities at Mormugao Port from 2016 to 2030 are given in Table 2.3.

Table-2.3 Commodity Wise Traffic Forecast at Mormugao Port (MTPA)

Description	2016	2017	2018	2019	2020	2025	2030
POL	0.40	0.40	0.41	0.42	0.42	0.46	0.50
LPG	0.05	0.05	0.05	0.05	0.05	0.06	0.06
Phosphoric Acid	0.16	0.17	0.17	0.18	0.19	0.27	0.33
Liquid Ammonia	0.30	0.32	0.34	0.36	0.38	0.53	0.66
Sub Total	**0.91**	**0.94**	**0.97**	**1.01**	**1.04**	**1.32**	**1.55**
Iron Ore Export	3.50	3.70	4.00	4.30	4.50	6.50	8.50
Iron Ore Import	2.00	2.10	2.30	2.40	2.60	3.40	4.60
Thermal Coal	1.94	4.46	7.21	8.5	8.89	11.33	14.37
Coking Coal	10.8	12.1	13.2	14.5	15.8	24.3	36.7
Fertilizer	0.32	0.33	0.35	0.36	0.37	0.43	0.74
Sub Total	**18.56**	**22.69**	**27.06**	**30.06**	**32.16**	**45.96**	**64.91**
Break Bulk	4.75	5.14	5.55	5.98	6.43	9.12	12.38
Containers	0.36	0.41	0.46	2.14	2.28	3.09	4.23

2.3 CONVERSION OF BERTH 8, 9 & BARGE BERTHS

The port has total 5 numbers of barge berths where 8 numbers of coal unloaders and 1 continuous barge unloader are equipped for unloading of

iron ore brought to the port for export from Berth 9 which is a dedicated iron ore export terminal operated by Port.

Before the iron ore ban in FY 2011, the port had handled 50.02 MT of traffic, whereas in FY 2014, it handled just 11.74 MT of traffic. However, with depressed iron ore prices in the international market and several restrictions by the Supreme Court on mining, Mormugao Port is now focusing on other cargo as it tries to position itself as a multi- commodity port. Hence the Port now intends to reclaim the Barge Berth area for redevelopment. The reclamation berth in the barge berth area can be named as Berth 9A.

Based on the traffic projection, the cargo basket will be decided for these berths. Details of the proposed cargo to be handled at Berth 8, 9 and 9A are shown in Table 2.4.

Table-2.4: Proposed Cargo for Berth 8, 9 & 9A

Berth No.	Present Cargo	Proposed Cargo
Berth 8	Liquid	Coal
Berth 9	Iron Ore	General Cargo and Containers
Berth 9A (Proposed Barge Berth Reclamation)	Iron Ore	Iron Ore

2.4 NEED FOR THE CONVERSION OF BERTH 8, 9 & BARGE BERTHS

Due to fall in iron ore prices in the international market and several restrictions by the Supreme Court on Iron ore mining, Mormugao Port is now focusing on other cargo as it tries to position itself as a multi-commodity port. The demand for handling facilities for coal and general cargo traffic has also made capacity addition a priority. Berth No.8 is a Liquid cargo handling berth, however the berth utilization is low. Thus the port plans to shift this operation to Berth No.10/Berth no.11. Berth No.9, which is a dedicated iron ore export berth and the barge berths along with the barge berths and the Mechanical Ore Handling Plant (MOHP) are also practically underutilized on account of recession in the iron ore export market.

The port therefore intends to put all these underutilized facilities to alternate use capable of handling Capesize Vessel. Hence, as a part of its endeavour to serve the Trade and the Nation, it has been decided to undertake the 'Redevelopment of Berths 8, 9, Barge Berths and Mechanical Ore Handling Plant at the Port of Mormugao' (the "Project") on Develop, Build, Finance, Operate and Transfer (the "DBFOT") basis, and also to carry out the bidding process for selection of the bidder to whom the Project will be awarded. The Port now intends to reclaim the Barge Berth area and convert the entire area for handling of containers and general cargo. The reclamation of entire barge berth area will facilitate additional storage area and quay length in line to the existing Berth 9 which can be utilized for handling and storage of containers and GC. The reclamation berth in the barge berth area can be named as Berth 9A.

Based on the traffic projection, the cargo basket will be decided for these berths. The requirement of open storage area and covered storage area will be carried out. Accordingly a plan showing all these facilities will be drawn along with other utilities such as road, rail, drains etc. The level of mechanization and various equipment requirements with their capacities will also be listed. Based on these inputs, the total capacity of the berth will be assessed. Barge berths at Mormugao Port are shown in Figure 2.1.

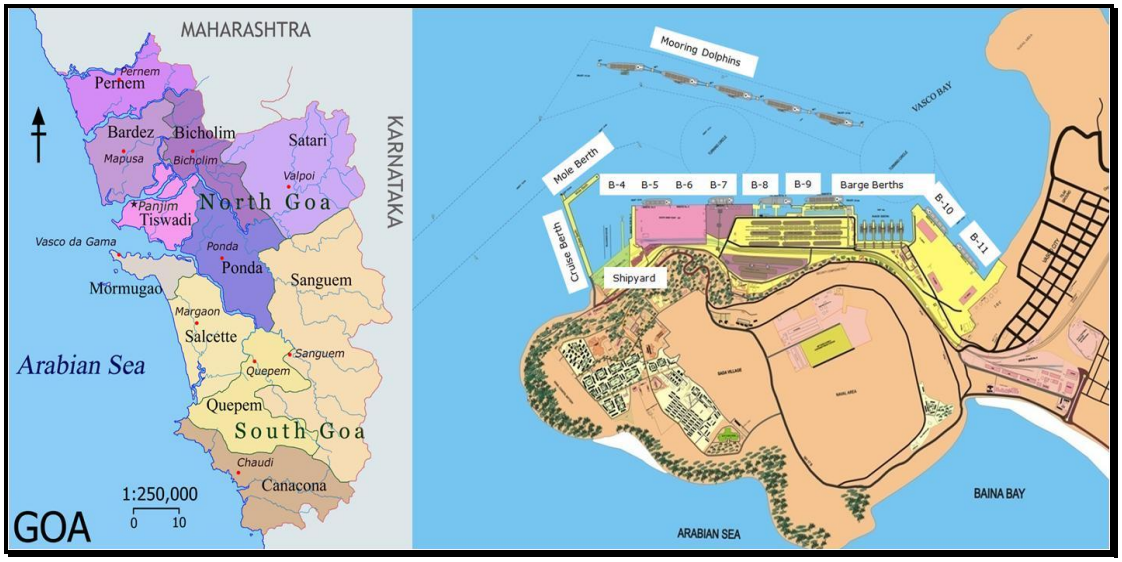


Figure-2.1 Location and Layout map of Mormugao Port

2.5 EXISTING INFRASTRUCTURE AT BERTH 8, 9 & BARGE BERTHS

2.5.1 Infrastructure facilities and cargo handling at Berth No. 8

Berth No. 8 is a dedicated berth for handling liquid cargo. Separate equipment and pipelines are installed at berth-8 for handling of liquid cargo and transportation up to the storage location/tanks. The details of the liquid cargo handled at Berth-8 during 2013-14 and 2014-15 are shown in Table 2.5.

Table 2.5- Liquid cargo handled at Berth-8 during 2013-14 and 2014-15 (Unit: 000 TPA)

Import Cargo	**2013-14**	**2014-15**
POL	428.95	371.59
Caustic Soda	39.37	45.63
Liquid Ammonia	62.20	87.35
Total Import Liquid Cargo	**530.52**	508.07
Export Cargo		
POL	4.62	
Total Import + Export	**535.14**	**508.07**
Percentage (%)	62 %	48 %

It can be observed that Berth 8, a dedicated liquid cargo berth has handled 62% and 48%of total liquid cargo handled at MoPT in the year 2013-14 and 2014-15 respectively. The details of the existing pipelines and storage facilities for liquid cargo handled at berth 8 are given in Table-2.6.

Table-2.6 Existing Pipelines and storage tanks at Mormugao Port

Pipeline No	Destination	Product	Pipeline Dia (")	Pipeline Area (Sqm)	Booster Station	Tankage Area (sqm)	Approx. Pipeline Length (m)
Pipeline - 1	JRF Tanks	Petroleum	12	561.74	No Booster Station	1176.3	990
Pipeline - 2	Indian Molasses	Petroleum	12	423.72	No Booster Station	701.3	939
Pipeline - 3	Tanks		12	36.45	No Booster Station		
Pipeline - 4	Ganesh Benzoplast Tankage	Liquid Handling	12	575.00 + 1086	Ganesh Benzoplast Booster Station (140.41sqm)	20000	1645
Pipeline - 5	ROB Baina	Petroleum	20	120.96 + 1131.2	Zuari Indian Oil Tank Booster Station (2500 sqm)	-	2597
Pipeline - 6	Zuari Agro Chemical Tank	Amonia	14	464.82	No Booster Station	6600	904
Pipeline - 7	Indian Oil Tank	Petroleum	16	-	No Booster Station	9981	1194

2.5.2 Existing Infrastructure and cargo handling at Berth 9

Berth 9 is a dedicated iron ore export terminal operated by Port. The terminal is well equipped with Mechanical Ore Handling Plant (MOHP). The area behind Berth 9 is utilized for stacking of iron ore. Present capacity of Berth 9 is 11.5 MTPA. . However, with depressed iron ore prices in the international market and several restrictions by the Supreme Court on mining, Mormugao Port is now focusing on other cargo as it tries to position itself as a multi-commodity port. Hence, Mormugao Port now intends to reclaim the Barge Berth area and convert the entire area for handling of containers and general cargo. The reclamation of entire barge berth area will facilitate additional storage area and quay length in line to the existing Berth 9 which can be utilized for handling and storage of containers and general cargo. The reclamation berth in the barge berth area can be named as Berth 9A.

2.5.3 Existing Infrastructure at Barge Berth

The Mormugao Port has a total of 5 barge berths, where 8 numbers of coal unloaders and 1 continuous barge unloader are equipped for unloading of iron ore brought to the port for export from Berth 9 which is a dedicated iron ore export terminal operated by Port. The area behind

Berth No. 9 is utilized for stacking of iron ore. The terminal is well equipped with Mechanical Ore Handling Plant (MOHP).

Presently the port handles general cargo and containers at Berth no 10 and 11 and the capacity of the berths are 2.65 MTPA. As the Liquid cargo is recommended to be handled at Berth 10 instead of Mooring Dolphins, the Potential traffic for Berth10 will also be available for proposed general cargo and Container terminal – Berth 9 and 9A.

2.6 PROPOSED FACILITIES AT BERTH NO. 8

The total Berth front now available after shifting of liquid handling from berth 8 and dismantling Iron Ore handling from berth 9 and Barge berth area is 950 m. It is proposed to shift the berth face up to 50 m from the existing face. Proposed project envisages the reclamation in an area of 11.40 ha including berth face and barge berth area. Hence, the total backup area after reclamation of entire barge berth area will be around 27.00 ha. It is proposed to use the backup area for handling and storage of coal, general cargo and containers as a part of the redevelopment. The total area proposed for coal stack yard is 7.97 ha. The future potential for coal and general cargo for Mormugao Port is found to be in increasing trend in the traffic projection study. The Google image of berth 8, 9 and barge berth is shown in Figure 2.2. Layout of the proposed redevelopment of Berth 8,9 and 9A are shown in Figure 2.3. Topography and contours of Mormugao port are depicted in Figure 2.4.

It is proposed that berth no 8 will be converted in to a bulk berth for handling of coal with all required mechanization facilities and stackyard. It is envisaged to handle capsize vessel at berth 8 for handling of coal. MoPT proposes to dredge the outer channel up to (-) 19.8 m CD and the maneuvering area up to (-) 19.5 m CD. The optimal capacity of the terminal is found to be 6.99 MTPA. The mechanical coal handling equipment as envisaged for the proposed coal berth 8 is given in Table-2.7.

Figure - 2.2 Google image of berth 8,9 and barge berth

Table-2.7: Mechanical Handling Equipments at Berth No.8 and Stockyard

Major equipment/system	Qty	Rated Capacity / Features
Grab Type bucket crane (each)	2	2000 TPH
Stacker cum Reclaimer	2	4000 TPH
Pay Loaders and Dozers	4	10 Ton
Rapid loading system	1	4000TPH
Dust suppression/Dry fog dust suppression	Lot	-
Potable Water system	Lot	-
AC, Ventilation etc.	Lot	-

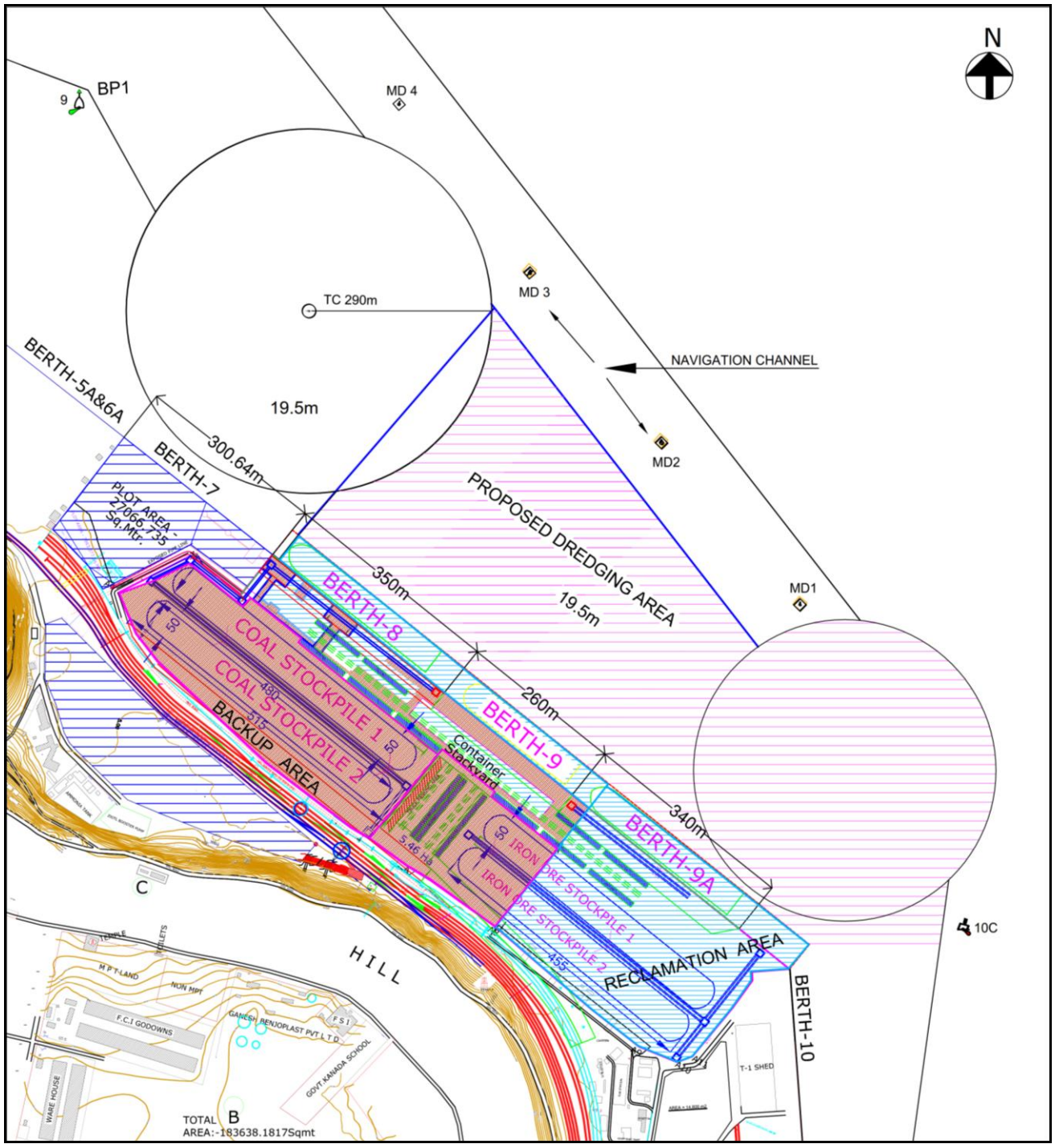


Figure-2.3 Layout of the redevelopment of Berth 8,9 and 9A

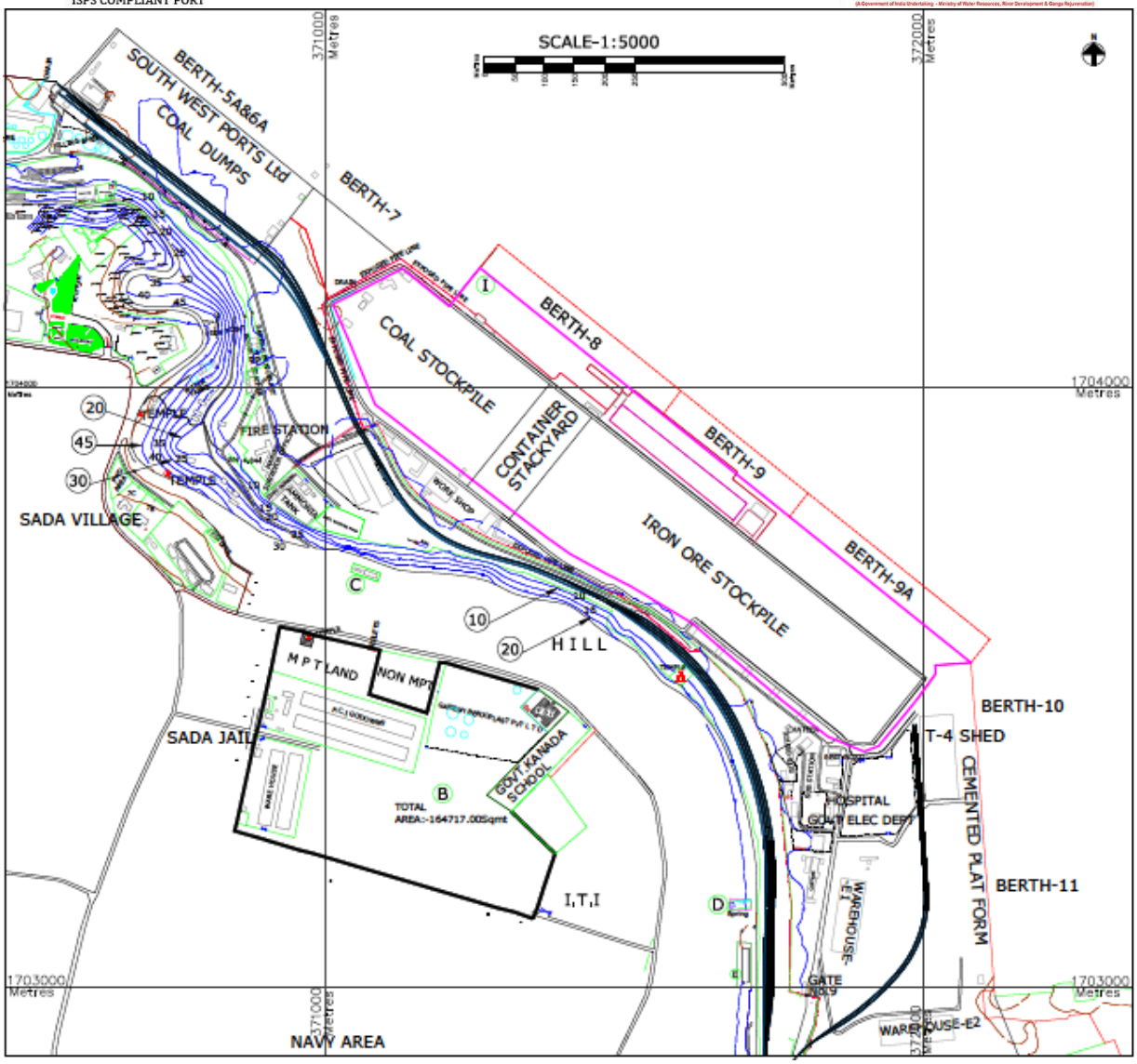


Figure 2.4: Topography and contours Map of Mormugao Port

2.6.1 Determination of length of coal berth proposed at existing 8th berth

It is proposed to handle capsize vessels at proposed berth 8 for handling of coal. The berth structure is proposed to be designed for 175000 DWT vessel. The length of 175,000 DWT vessel is 320 m. Hence, as per Harbour Approach Channel Design Guidelines -2014 the length of berth required has been calculated as 350 m and the remaining berth length of 600 m can be utilized as Container vessels berth and iron ore berth. The layout of dredging in the manoeuvring area in front of Berth 8, 9 & 9A and proposed reclamation area is shown in Figure - 2.5.

2.6.2 Turning Circle

The port has two turning circles in the inner channel. The turning circle in front of berth 7 will be utilized for turning of vessels called for existing berth 5, 6, 7 and proposed berth 8, 9. The turning circle will have to be designed for turning of capsize vessels as envisaged for berth 8 and 9. The turning circle in front of proposed reclamation berth 9A will be utilized for turning of vessels called for berth 10, 11 and proposed reclamation berth 9A. The radius of the turning circle will be 240 m and will require relocation.

The existing radius of both the turning circles is 240 m. As the turning circle in front of berth 7 will be utilized for turning of capsize vessels, the diameter of the turning circle will have to be increased. It is envisaged to handle capsize vessels at berth no 8 and 9. As discussed earlier in the report, the LOA of capesize vessels with 175000 DWT is around 300 - 320 m. Hence diameter of turning circle required is calculated to be 580 m.

2.6.3 Utilities

The terminal will be provided with various buildings, control room, substations etc. The facilities for the water supply pump house and overhead storage tank facilities has to be provided by the BOT operator inside the terminal. Water demand shall include raw water for greenery and landscape, dust suppression and Potable water for terminal users, port users and canteen and ship supply.

Hence water supply system, storm water drainage, fire fighting system, dusts suppression system, effluent treatment plant shall be provided. The total construction period is envisaged to be 36 months excluding preconstruction activities.

2.6.4 Cargo Handling Facilities

Grab Unloaders

A fully mechanized coal unloading system has been planned for handling of coal at berth 8. The berth will have 2 numbers of mechanical rail mounted grab type ship unloaders connected with conveyor system of required capacity for stacking and subsequent evacuation by rail or road.

The unloading rate for discharge of Cape size, Panamax size & Handy and Handy Max size dry bulk vessels has been considered at 50000 TPD and 35000 TPD respectively.

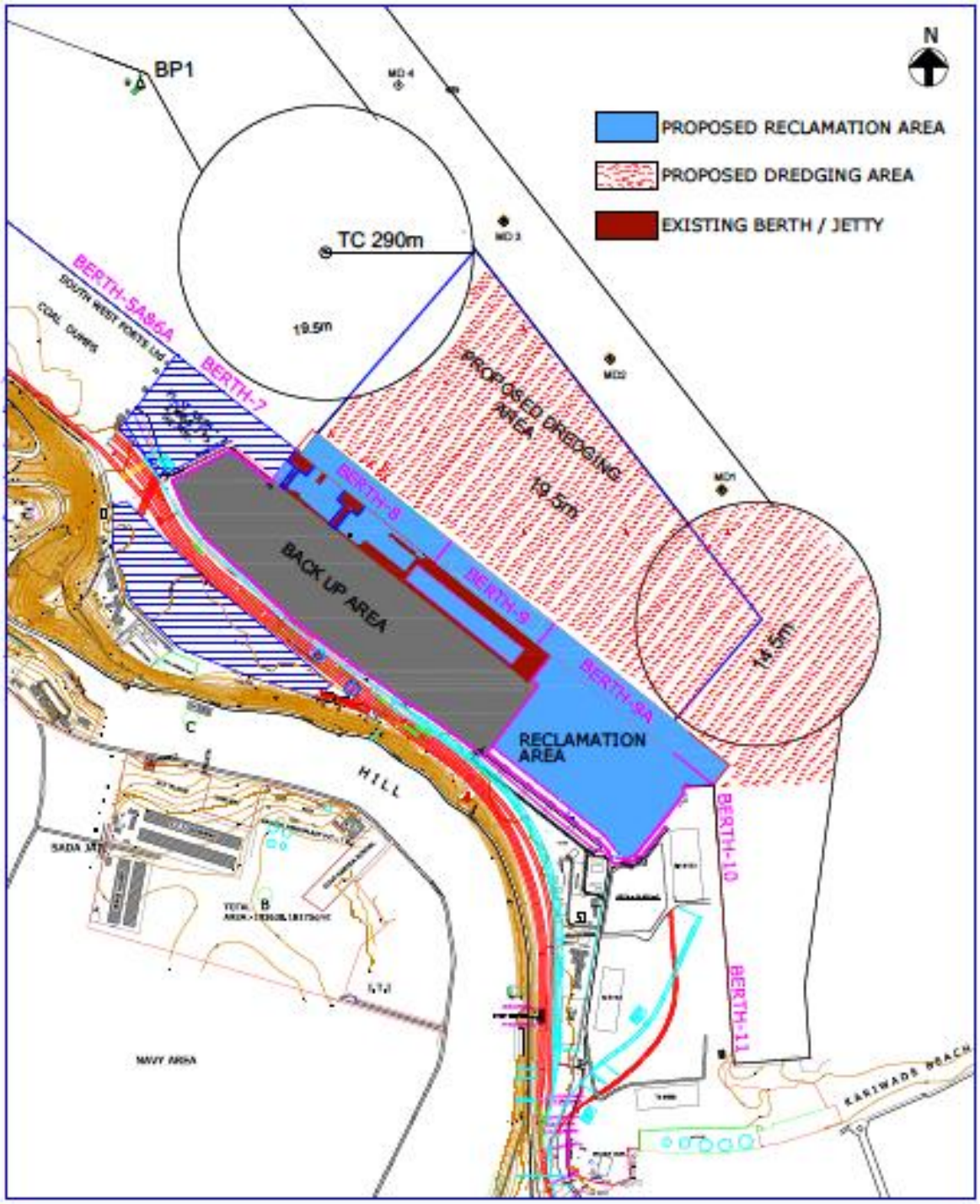


Figure-2.5 Dredging and Reclamation area map

Jetty Conveyor

A stream of jetty conveyor will be provided with rated capacity 4000 TPH running parallel on the full length of the jetty. The rated capacity of 4000 TPH will ensure that conveyor capacity will be sufficient to evacuate discharge vessels and evacuate coal from stockyard seamlessly.

Coal handling Equipments at Stackyard

The equipment required for stackyard operation are planned as per the unloading requirement of 50000 TPD. For stacking of coal at stockpile 1 and 2 and reclaiming of coal from stockpile, two stacker cum reclaimer with a rated capacity of 4000 TPH are provided. The stacker cum reclaimer should have adequate slew angle and luffing angle for the purpose of forming uniform stacks of 15 m height. Stackers will be rail mounted having rail gauge of around 8 m covering the entire length of the stockyard.

Cargo evacuation System

It is assumed that almost all the coal material will be evacuated through rail. For faster evacuation of coal, a Rapid rail loading system (RRLS) with capacity of 4000 TPH shall be installed. The RRLS shall be fed from the reclaimer through the connected conveyor. A full rake of 58 - 60 wagons, each 55 T capacity can evacuate 3300 T of coal.

2.6.5 Stockpile details

The area available for the coal storage is around 7.97 ha. The stockyard capacity has been found to be 6.99 MTPA considering 28 as turnaround ratio.

2.6.6 Covered Stackyard

Coal handling at Mormugao port has to be handled by planning and constructing a fully covered coal stackyard. The covered stackyard will be able to accommodate three stockpiles. The total area of covered coal stack yard will be 75400m^2. The dimension of the covered dome type storage yard will be 520 m X 145 m. The covered storage will require 550 m long shed housing 15 m high coal stack with mechanized facilities. The

shed is of 140 m span with 6 m high retaining walls supporting the roof structure. The shed will also be equipped with fire fighting and dust suppression system. With the above structure in place, Mormugao Port will be handling coal in a most environment friendly manner.

2.7 PROPOSED FACILITIES AT BERTH NO. 9

It is proposed to develop berth 9, as container and general cargo berth with a total length of 260 m. The total area proposed for the container stack yard is 5.46 ha. The indicative berth layout for the proposed General cargo and Container terminal is as shown in Figure-2.4. The traffic potential for the proposed general cargo and container terminal proposed to be developed at Berth 9 & barge berths is summarized in Table-2.8.

Table 2.8: Traffic Potential for Proposed GC & Container Berth 9 & 9A

Cargo	2019 (MTPA)	2020 (MTPA)	2025 (MTPA)	2030 (MTPA)
Fertilisers	0.36	0.37	0.43	0.74
Break Bulk Projection	5.98	6.44	9.12	12.39
Total GC and BB Cargo Potential	6.34	6.81	9.55	13.13
**Less, Capacity 10+11	2.65	2.65	2.65	2.65
Traffic Available for Berth 9 & 9A	3.69	4.16	6.90	10.48
Potential Container Traffic**, in TEU**	171	182	247	338

2.7.1 Cargo handling arrangements

The cargoes including iron and steel products, food grains (Bagged), Cement (Bagged), fertilizers etc. are expected to be handled at Berth-9.

The multipurpose berth will be equipped with two 100T Harbour Mobile Cranes (HMC) which can provide a maximum handing rate in the range of 10,000 – 12500 TPD. The proposed general cargo Berth 9 will be provided with two mobile harbour cranes with suitable grab attachments for handling of dry bulk/break bulk and General cargo. Cargo that are expected to be handled at proposed berth 9 are Container vessels, general cargo vessels and iron ore vessels etc.

Theoretical berth capacity of 4.18 MTPA has been considered for

equipment planning as well as for estimation of tariff for various cargo types. The design vessel considered for the container cum general cargo berth is 40,000 DWT vessels. However the structural design of berth can be carried out considering capsize vessels owing to future requirement. The layout of Proposed General Cargo and container terminal is as shown in Figure-2.4.

2.7.2 Cargo Handling Arrangements

The cargoes like steel and coil products, agro products (Bagged), Cement (Bagged), fertilizers etc. are expected to be handled at berth 9. The terminal will be equipped with 2 nos. 100T harbour mobile cranes with slings/grabs/Hook/Claw arrangements for loading unloading of containers and general cargo. Harbour Mobile Crane and Lifting arrangements are shown in Figure 2.6 and 2.7 respectively.

Figure-2.6 Harbour Mobile Crane and Sling Arrangements

Figure-2.7 Lifting arrangements – Grab/Claw/Hook

2.8 PROPOSED FACILITIES AT BERTH 9A

The proposed berth 9A will be dedicated for handling iron ore export. The length of the berth shall be 340 m. The reclaimed barge berth area will be utilised for berthing and handling of iron ore. Proposed project envisages the reclamation in an area of 11.40 ha including berth face and barge berth area. The area earmarked for container stack yard will be around 13 ha. Layout of Proposed General cargo and Container Terminal – Berth 9 and 9A is shown in Figure-2.4.

2.8.1 Turning Circle

The port has two turning circle in the inner channel. The turning circle in front of berth 7 will be utilized for turning of vessels called for existing berth 5, 6, 7 and proposed berth 8, 9. The turning circle will have to be designed for turning of capsize vessels as envisaged for berth 8 and 9. The turning circle in front of proposed reclamation berth 9A will be utilized for turning of vessels called for berth 10, 11 and proposed reclamation berth 9A. The diameter of the turning circle will be 240 m and will require relocation. The LOA of cape size vessels with 175,000 DWT is around 303 m. Hence diameter of turning circle required is calculated to be 580 m. The turning circle will have to be shifted by 125 m from the proposed berth line. The relocation and increasing the diameter of the turning circle from 480 m to 580 m, will interfere with Mooring Dolphin 3 and Mooring Dolphin 4. Hence the vessel berthing between MD 3 and MD 4 will have to be stopped.

Similarly, existing turning circle of 480 m diameter in front of the proposed berth 9A will have to be shifted by 125 m from the proposed reclamation berth 9A (Refer Figure 2.4).

2.8.2 Details of the dredging activities

The port has proposed a dredging depth of (-) 19.8 m CD in the outer channel and (-) 19.5 m CD in the inner channel and turning circle in front of berth 7. However the maneuvering area in front of berth 8, 9 and 9A will have to be deepened for the maneuvering of capsize vessels. It is envisaged to berth capsize vessels at berth 8 for handling of coal.

Hence, the berthing area in front of proposed berth 8, 9 and 9A will have to be deepened for the maneuvering of capsize vessel. The details of the quantity of the dredged material are given in table **Table-2.9.**

Table 2.9- Details of Quantity of dredged material

Description	Area (Sqm)	Existing Depth (-) m CD	Proposed Depth (-) m CD	Depth of dredging (m)	Tolerance (m)	Total Qty (Cum)
Inner channel area in front of berth 8, 9 and 9A	405082	14.1	19.5	5.4	0.3	2438213
Total Quantity of Soil						**2438213**

The dredging quantity has been estimated to be 2.44 million cum considering entire dredging to be carried out in soil. It assumed that the rock is not encountered up to (-) 19.8 m CD in the inner channel. However the rock level has to be confirmed based on seismic survey and geo technical investigation.

2.9 RECLAMATION

Reclamation of entire barge berth area is proposed to facilitate additional to rage area and quay length inline to the existing Berth 9 which can be utilized for handling and storage of containers and general cargo. The reclamation berth in the barge berth area can be named as Berth 9A. The total length of reclamation front is around 950 m and total area is around 11.40 ha.

The total quantity of the material required for the reclamation has been estimated as about 11.40 Mm^3. The material required for reclamation will be boulders and murrum. About 3 lakh m^3 excavated loose material is available in port operational area and balance quanitity of 8.40 lakh m3 will be transported from nearest quarry site located about 15 km from Mormugao Port at Verna and Cortalim. The reclaimed barge berth area will be utilized for berthing and handling of general cargo and container vessels. The total backup area after the reclamation of entire barge berth area and berth face will be around 27.00 ha. The area proposed to be

reclaimed for the redevelopment of berth 8,9 & 9A is shown in Figure 2.5.

2.10 SHORE PROTECTION WORK

RCC retaining wall will be constructed throughout the length of the berth including returns on landside. The wall will be founded above the maximum water level. The required SBC for the foundation on backfill will be achieved by providing geogrids/geotextiles and proper compaction. The transit structure / slab will rest on top of retaining wall at one end and on cantilever projection of berth on the other end. Since the dredging will be carried out up to the berthing line, it is assumed that a natural slope of 1:1.8 will be achieved and the shore protection will be provided to dissipate wave energy.

2.11 POWER SUPPLY

The total indicative Power requirement (maximum demand) for the mechanical coal handling system, iron ore handling, general cargo and container handling has been envisaged to be around 24.33 MW. The total power requirement has been carried out considering mechanical handling equipments for coal unloading terminal, iron ore loading and un loading terminal, stockyard, Belt conveyors, RRLS for Coal terminal, container terminal all utilities services, Conveyor gallery lightening, yard lightning, shed lightening, all Administration, staff Room & other emergency requirements.

2.12 WATER DEMAND

Water demand shall include raw water for greenery and landscape, dust suppression and Potable water for terminal users, port users and canteen and ship supply. The facilities for the water supply pump house and overhead storage tank facilities has to be provided by the BOT operator inside the terminal. Potable water requirement during construction has been estimated as 60 cum/day and water requirement during operation phase will be 40 cum/day. The source of potable water for the Port is Public Works Department, Goa.

2.13 WATER SUPPLY SYSTEM

The fresh water requirement of the port is 1600m^3 including the port colony and port hospital, horticulture, dust suppression etc. The fresh water is received through Goa Public Works Department (PWD). MPT has an underground water tank of 440m^3, two surface tank of 560m^3 and 550m^3 and one overhead tank of 324m^3 capacity at headland. Proposed facility is within Mormugao Port and drinking water is available near the proposed facility. However, facilities for the water supply, pump house and overhead storage tank required for proposed redevelopment has to be provided by the BOT operator inside the terminal.

2.14 STORM WATER DRAINAGE

The storm water drainage on jetty will be done by providing necessary drains. The sizing of drains will be based on the rainfall data available and return period not less than 10 years. It is required to provide an efficient storm runoff and disposal system in the terminal area. Proposed Storm water drainage and water supply line are depicted in Figure 2.8.

Storm water drainage shall be designed with the following basic consideration:

- The drainage system shall be separate system to carry only storm runoff of the stackyard and jetty area.
- Storm run-off from the stackyard will be collected in catch pits. Such catch
- pits will be connected with buried pipe conduit for conveyance and
- discharge into harbour basin through number of out-fall;
- The drainage of jetty area is limited to some drainage spouts discharging
- directly to the harbour
- Conveyance of flow will be through gravity only.
- System design will be based on the Manual on “Sewerage and
- Sewage Treatment” - Central Public Health and Environmental
- Engineering Organization (CPHEEO), Govt. of India and IRC: SP-50,

- Guidelines on Urban Drainage, 1999 published by Indian Roads Congress,
- A maximum and minimum velocity through the conduit shall be 2.50 m/sec and 0.6 m/sec respectively (as per CPHEEO manual)
- Minimum diameter of the conduit : 150mm (as per CPHEEO manual)

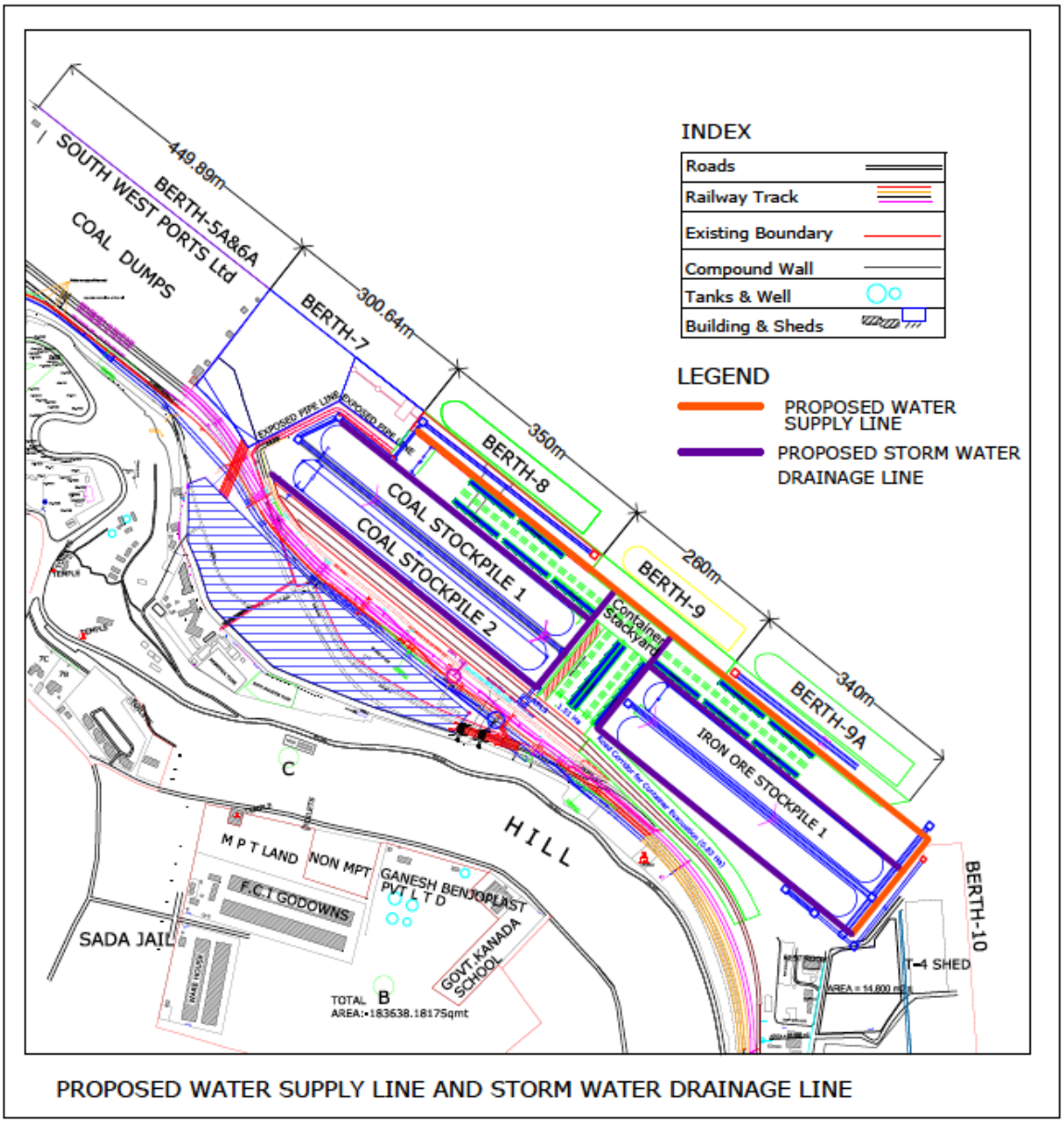


Figure: 2.8 Proposed Storm water drainage and water supply line

2.15 FIRE FIGHTING SYSTEM

The requirement of water for fire fighting will be catered by use of sea water, if possible. Otherwise Port Authorities will provide same. Any

separate storage required for this is not considered in this report. Fire protection in Ports shall consist of the following

- ► Fire Protection
- ► Fire Alarms
- ► Fire-Fighting Equipments
- ► Means of escape in case of fire

All sources of ignition should be highly controlled. Appropriate uses of Fire Fighting equipment's & agents like water, foam, carbon dioxide & powder are commonly used.

2.16 DUST SUPPRESSION SYSTEM

Jet type dust suppression system with plain water shall be provided for all the transfer points and feeders in jetty area and plain water type dust suppression system shall be provided for stackyard. The dust suppression system shall comprise the following:

- Dry Fog System installed at all transfer points
- Wheel washing facility for trucks
- Installed Medium Velocity Water (MVW) spray system designed to operate through linear heat detection system (Analogue)
- Wind shield of 15 Mtrs height along outer periphery of cargo stacks
- Nevis (Mist / Cannon) Systems – one truck mounted and other wheel mounted
- Sprinkling system for stack-yards
- Covering of cargo in all modes of transportation and stacking

2.17 HTL/LTL DEMARCATION

As per the clause No3 (i), (a) of the CRZ Notification of 6th January 2011, the proposed expansion and modernization activity at Mormugao Port is permissible activity. However, as per the Coastal Regulation Zone (CRZ) notification dated 6th January 2011, project specific HTL/LTL demarcation is required for the projects requiring CRZ clearance. CRZ mapping is required to be done indicating HTL and LTL and proposed project layout for the project by one of the authorised agencies approved by MoEF in a scale of 1:4000. Hence, CRZ mapping for the proposed site in Mormugao

Port has been done through Institute of Remote Sensing (IRS) Anna University, Chennai.

Methodology Adopted

In order to prepare the local level map on 1:4,000 scale, the site was visited by Experts from IRS, Anna University. The tide level observations for the last 19 years were studied from the Tide Tables. From the satellite imagery of the coastal zone, geomorphology has been studied. Based on the geomorphic units, high tide line has been identified in the field and traced by field survey.

As per the definition of High Tide Line, it is the line on the land up to which the highest water line reaches during the spring tide. At the mapping area, there is a clear boundary between the tidal portion and vegetation which is usually very much apparent. This boundary line coincides with the HTL line interpreted from the high resolution satellite imagery.

Field Survey

Dual Frequency GPS (Model: Trimble 5700) instruments were used for HTL demarcation and image control points observation. Field surveys were carried out to trace the tide levels in the project area in the month of June 2016. Four teams involved in the field survey. During field survey, two teams had taken control points for Satellite imagery and Village maps for the corresponding area and the other two teams had taken HTL/LTL points along the coast.

Data Processing

The following softwares were used for data processing.

- Trimble Geomatics Office for GPS data downloading and Processing
- ArcGIS 9.2 for Map rectification and Map making

The observed GPS data have been downloaded and processed in the Trimble Geomatics Office software. The processed GPS coordinates were

entered into ArcGIS 9.2 for Imagery Geo referencing. The processed HTL points were plotted using the same software on the Cadastral maps at the scale of 1:4,000.

Output

The cadastral maps of 1:4,000 scale have been used as the base maps. In these maps, High Tide Line(HTL), 100 m from HTL(for creek portions), 200m from HTL, 500m from HTL, Low Tide Line and the categories of CRZ areas inthe project site as per CRZ notification 2011 have been marked. The processed coordinates of HTL lines in WGS-84 co-ordinate systems are also given in the report prepared by IRS, Anna University, which is being submitted separately.

The CRZ mapping for the proposed project has been done by Institute of Remote Sensing (IRS) Anna University, Chennai, The CRZ mapping report includes the HTL/LTL map covering an area of 7 km radius from project site and superimposing project layout on a map of 1:4000 scale. The HTL /LTL Report prepared by Institute of Remote Sensing (IRS) Anna University, Chennai is being submitted separately.

Results

The observed baselines of GNSS receivers were processed using TBC software to derive the coordinates of HTL reference points, ground control points for geo-referencing of satellite imagery and cadastral maps. The ground control points were used to geo-reference the cadastral maps of project area. The HTL and LTL for sea/creek was superimposed on to geo-referenced cadastral map along with ecologically sensitive areas in the vicinity of project site. Both coast and river/creek are existing near the project site. Therefore 200 m & 500 m setback lines from HTL for coast and 100 m setback line from HTL for creek are generated and superimposed on to map. The CRZ map in 1:4000 scale showing HTL, LTL, setback lines, various coastal regulatory zones near the project site and project site layout are presented in CRZ map.

Conclusions

- High Tide Line, Low Tide Line and their set back lines as per CRZ notifications, 2011 for the proposed project site(covering 7 Km radius around it) for berth nos. 8 & 9 are marked in the CRZ maps(in 1:4000 scale) furnished in CRZ demarcation report
- No mangroves or any other eco-sensitive entity is present at or near the location of the proposed berth nos. 8 & 9. The aerial distance between the proposed berths location and the nearest mangroves is 6888.320 m.
- The proposed berth nos. 8 & 9 in Mormugao port lies in area falls in CRZ-II, the tidal influenced portion of Zuari river under CRZ-IV (B) classification as per CRZ notifications, 2011.

The HTL/LTL demarcation for the project site was conducted by Institute of Remote Sensing (IRS) Anna University, Chennai. The HTL /LTL Report prepared by Institute of Remote Sensing (IRS) Anna University, Chennai is being enclosed as Annexure-II.

2.18 COST ESTIMATES

The estimate of capital cost including various items of civil works, mechanical works, electrical works, utilities, etc is worked out to be Rs.1145.36 crores.

CHAPTER-3
ENVIRONMENTAL BASELINE STATUS

CHAPTER-3

ENVIRONMENTAL BASELINE STATUS

3.1 GENERAL

The assessment of baseline environmental setting is an essential component of any EIA study. As a part of the study, a Scoping Matrix was prepared, based on which, various parameters to be covered for assessment of baseline environmental setting were identified. The assessment of environmental impacts due to construction and commissioning of the proposed coal terminal requires a comprehensive and scientific consideration of various environmental aspects and their interaction with natural resources, namely, physico-chemical parameters i.e. meteorology, geology, soil, land use and water quality, biological parameters i.e. terrestrial flora and fauna, marine flora and fauna, fish species, etc. and socio-economic parameters i.e. demography, occupational profile, etc. As a part of the study, a large quantum of related data as available with various departments was collected. Various departments including Forest Department, Fisheries Department, and Directorate of Economics & Statistics was collected. Field studies for primary data generation on various aspects too were conducted as a part of the EIA study.

As a part of the EIA study, the Baseline Status has been ascertained for the following aspects:

- Meteorology
- Bathymetry
- Cyclones
- Sediment Transport
- Topography
- Tides
- Waves
- Currents
- Grownd Water Quality
- Soil Quality
- Landuse pattern
- Marine Water Quality
- Sediments
- Marine Ecology

- Fisheries
- Socio economic

3.2 STUDY AREA

The Study Area considered for EIA Study is the area within 10 km radius, keeping the project site at the centre. The Study Area Map is enclosed as Figure-3.1.

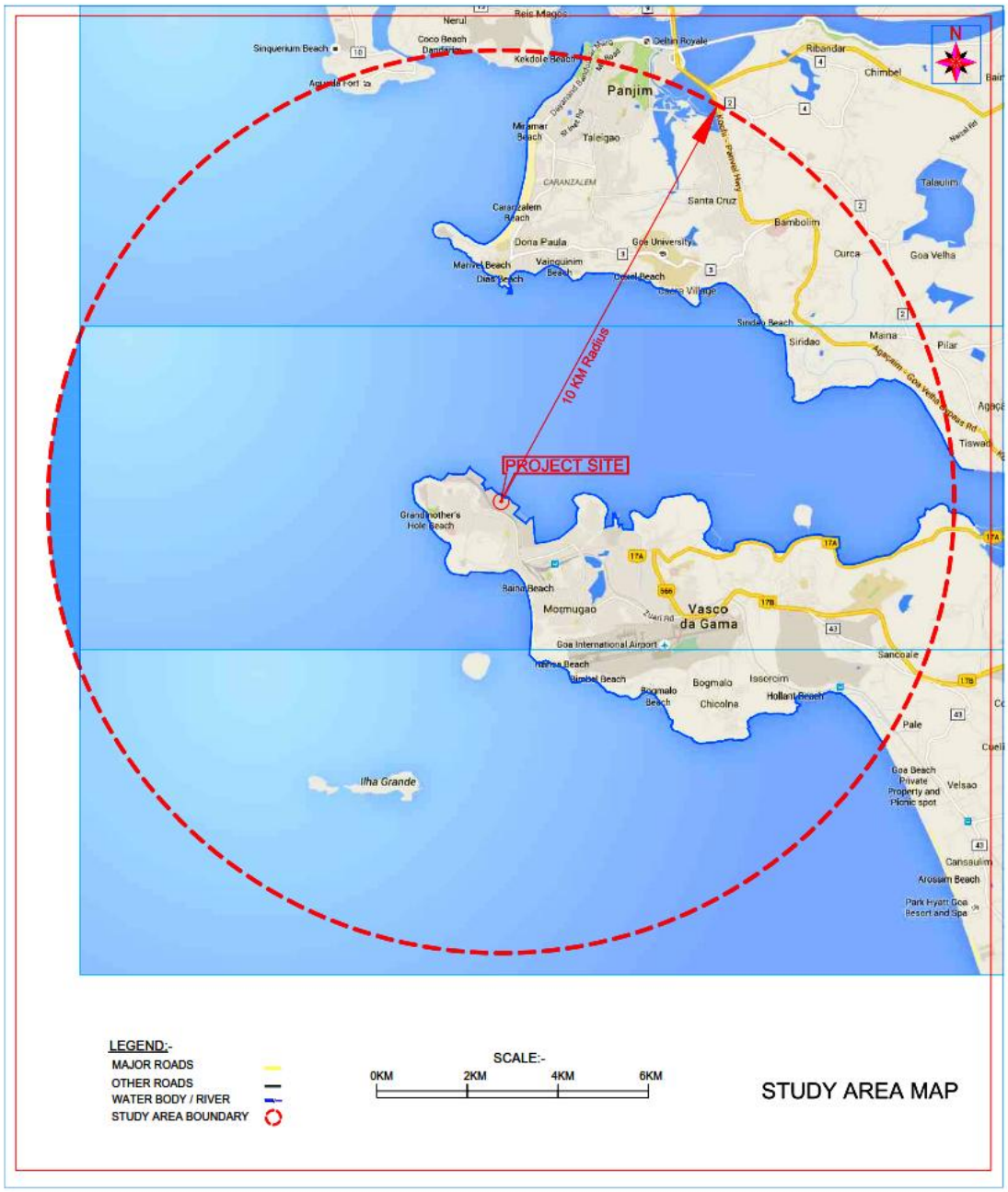


Figure-3.1: Study Area Map

3.3 METEOROLOGY

Goa experiences a tropical monsoon climate under the Köppen climate classification. Goa, being in the tropical zone and near the Arabian Sea, has a hot and humid climate for most of the year.

The calendar year in the project area can be divided into four main seasons. The winter season lasts from December to February followed by pre-monsoon season from March to May. The monsoon season begins in June and continues upto mid-October. The period from mid-October to November constitutes the post-monsoon season.

The average meteorological conditions of the Marmugao as per observation of IMD from 1981-2010 are summarized given in Table-3.1.

Table-3.1: Average meteorological conditions in the project area district

Month	Temperature (ºC)		Rainfall (mm)	Relative Humidity (%)		Mean Wind Speed (kmph)
	Maximum	Minimum		08.30 hrs.	17.30 hrs.	
January	31.8	21.9	0.4	72	64	7.1
February	31.3	22.3	0	75	67	8.4
March	31.9	24.2	0.2	78	71	9
April	32.8	26.2	3.7	76	71	9.4
May	33.2	27.1	90.6	76	73	9.9
June	30.7	25.2	831.5	87	84	13.4
July	29.2	24.5	824.5	89	86	14.9
August	28.9	24.2	550.2	90	87	11.7
September	29.9	24.3	256.3	88	83	7.4
October	31.6	24.6	136	82	78	6
November	33.1	23.8	19.7	70	67	5.4
December	32.7	22.5	5	67	63	5.9
Total			**2718.1**			
Average	**31.4**	**24.2**		**79**	**74**	**9.0**

Source: IMD, Mormugao

Temperature: Marginal variations in the daily maximum temperatures are observed throughout the year, as they ranges from 28.9^{0}C to 33.2^{0}C. The minimum temperatures, however show greater variations, range from 21.9^{0}C to 27.1^{0}C. Goa has a short winter season between mid-December and February. The monthwise temperature variations in the project area is shown in Figure-3.2.

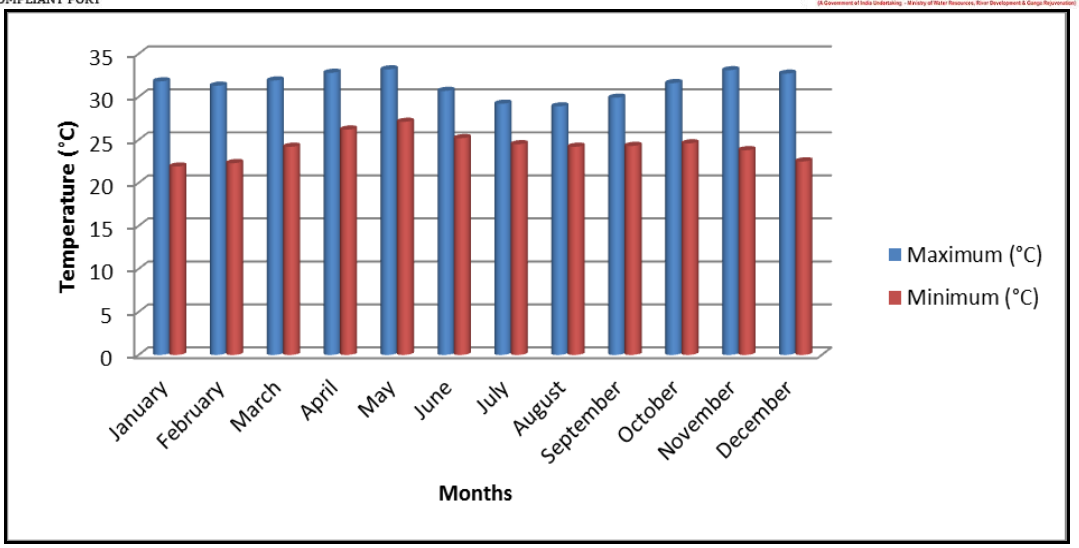


Figure 3.2: Temperature variations in the project area

Rainfall: The total annual rainfall in the project area district is 2718 mm. Majority of the rainfall is received in the months from June to September. Usually maximum average monthly rainfall of 831 mm occurs in June. There is practically no rainfall from December to April. The average rainy days in a year are about 94. The monthwise rainfall received in Mormagao is depicted in Figure- 3.3.

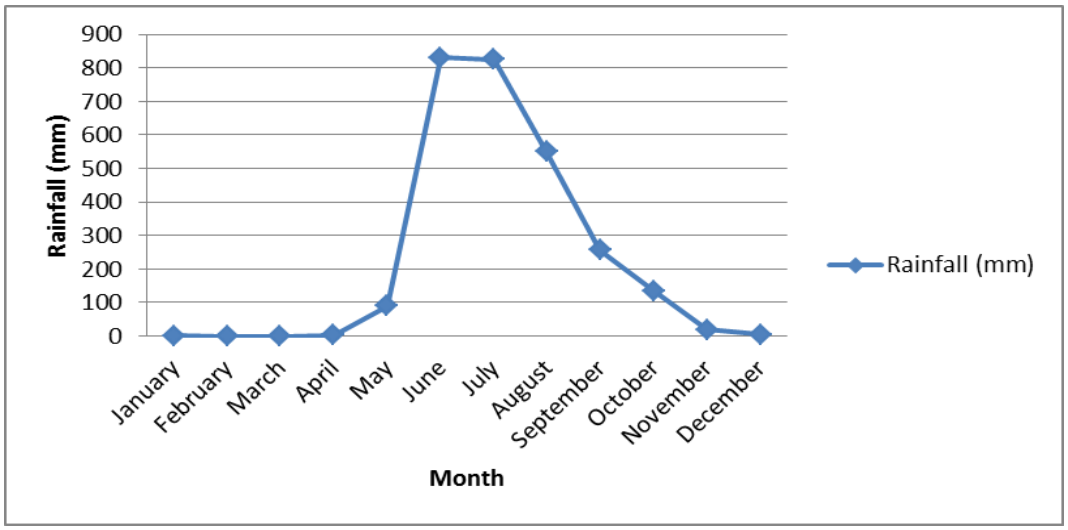


Figure 3.3: Rainfall variations in the project area

Winds: The mean sea wind varies from 2 on the Beaufort scale in November to 4 in July. The annual mean sea wind speed is of the order of 13.6 kmph. In an average year, there are 316 days with wind speed varying between 0 to 3 on the Beaufort scale and 48 days with winds varying between 4 to 7 on the Beaufort scale.

The predominant wind direction changes with the time of the year. During the period from June – September, wind blows from the west and south-west. During the remaining period, the wind direction is from NE, ESE during the evening. The highest speed of 105 km/hrwas recorded in June 1994. Winds of force more than 10 on the Beaufort scale are not expected. The wind speed ranged from 5.4 kmph to 14.9 kmph. The monthwise variations in mean wind speed in the project area are shown in Figure 3.4.

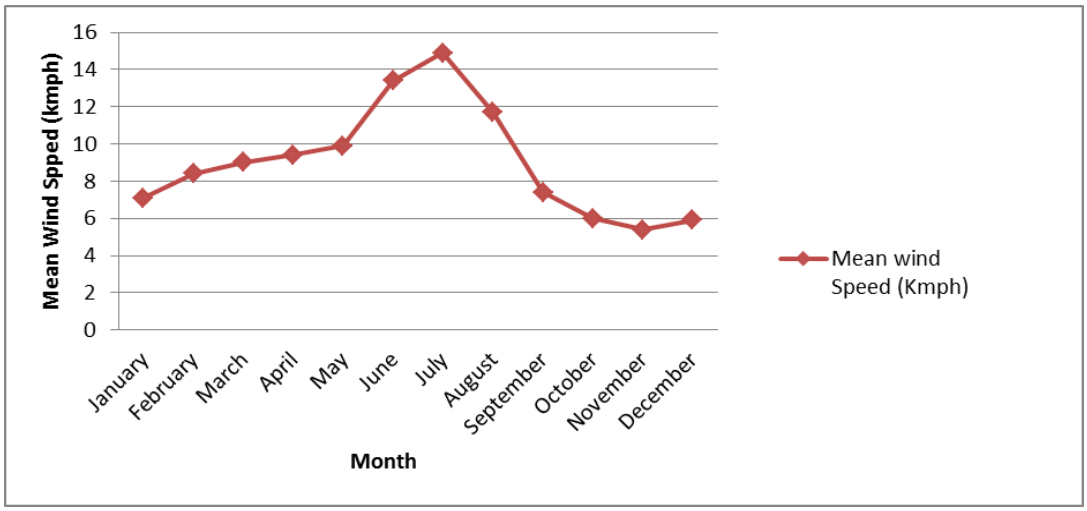


Figure 3.4: Mean wind speed variations in the project area

Relative Humidity

The mean yearly relative humidity at 0830 hours is 79% and 74% at 1730 hours. The monthly average humidity is lowest in December (63%) and highest in monsoon months from July to September (85%).

Visibility

Sometimes mist develops during sunrise on the west coast, above latitude 16° N, but disperses thereafter. Smog hangs over the land at Goa from November to March obscuring everything in view mostly after sunrise and occasionally in the evenings. However, smog lasts only for short durations. Visibility is generally good for most part of the year.

3.4 BATHYMETRY

The current bathymetry chart shows that in the outer channel the proposed dredge level of 19.8 m is available at a distance of 10 km away from the inner channel. Depth of the order of 14 m exists at the entrance

of the inner channel and towards the harbour basin and turning circle area the depth is reducing up to 13.1 m.

Seabed Features

The sea bed exhibits an even low to medium level of reflectivity, indicative of silty clays and sands, with a few patches of higher reflectivity indicating the presence of isolated highly weathered bed rock. In the outer channel, highly weathered bed rock patches are also seen above the dredging limit of 19.8m.

3.5 CYCLONES

In general the west coast of India is less prone to cyclonic storms compared to the east coast. From the information reported by India Meteorological Department (IMD), a total of 1034 disturbances occurred in the Bay of Bengal during the period from 1891 to 1970 of which 363 intensified to cyclonic storms, the rest being 'depressions'. On an average the number of cyclonic disturbances per year during this period was about 13. However, if the data is updated to 1990, the number of cyclonic events per annum works out to be 16, varying from a minimum of 8 to a maximum of 18.

The above cyclones may be divided into two broad categories. The first group consists of cyclones that originate in the Bay of Bengal and cross the East coast at certain locations. These storms pass over the Indian landmass and lose their strength before crossing the West coast. The second group consists of cyclones that cross over to the Arabian Sea at the southern tip of the Indian Peninsula and veer northwards towards Saurashtra. These cyclones are much stronger and more dangerous for the west coast and normally occur during the transition months of May and November.

3.6 SEDIMENT TRANSPORT

Unlike the East coast, West coast exhibits very low rates of "Littoral Drift". This is primarily due to the high tidal range, where the waves act on different parts of the flat offshore lower beach and the action on the beach above the high tide level are restricted to a very short time interval. Under

such circumstances, it is difficult to discern the direction of the net drift as this is likely to change with local shoreline configuration.

3.7 TOPOGRAPHY

The existing port stretches from the breakwater area to berth no. 11 close to the Vasco city. The proposed area to be developed is situated west of the existing breakwater. The only land available consists of the foreshore area. Immediately behind the foreshore area is the Headland slope. Towards the south is the approach channel. The land between the Headland slope and the approach channel has to be reclaimed to meet the necessary back up area requirement.

3.8 TIDES

The nature of tide prevailing at Mormugao is mainly semi-diurnal exhibiting two high and two low waters in a tidal day. The mean tidal variation is of the order of 1.6m at spring tide and around 0.7m at neap tides.

Based on Indian Naval Hydrographic Chart No. 2020, the tide levels with respect to chart datum at Mormugao Harbour are given in Table-3.2.

Table-3.2: Tide levels with respect to Chart Datum

Higher High water at Spring	+2.3 m
Mean Higher High Water (MHHW)	+1.9 m
Mean Lower High Water (MLHW)	+1.8 m
Mean Higher Low Water (MHLW)	+1 m
Mean Lower Low Water (MLLW)	+0.5 m
Mean Sea Level (MSL)	+1.3 m

3.9 WAVES

Mormugao harbour on the southern side where berths are located is protected by a breakwater and mole and generally it is the waves from directions between SW and NW that could affect the tranquillity in the harbour. The deep water waves from NW generally have a small probability of exceedence and do not affect harbour tranquillity significantly since their heights get reduced by the time they reach the harbour. Wave periods during the monsoons tend to be longer than during the rest of the year when NW winds prevail.

During the master plan study, HOWE India constructed the wave rose diagram from the visually observed wave heights during the period 1949 to

1962, from the area bounded by Latitude 10°N to 20°N and Longitude 70°E to 80°E. These wave analysis indicated that the yearly average probability of exceedence of the wave height of 2 m for the Westerly direction would be

Direction	Exc. Hs = 2 m
SW	4.7 %
W	4.5%
NW	0.4 %

The deep water wave climate is summarized in Table-3.3.

Table-3.3: Deep Water Wave Climate(Probability of exceedance in % of time)

HS =	1.0 m	2.0 m	3.0 m	4.0 m
SW	12.2	8.7	4.7	2.2
W	21.6	13.6	7.4	3.0
NW	8.4	2.0	0.6	0.2

Due to refraction, shoaling and breaking, the wave direction and wave height will change while travelling from deep water to the harbour entrance. Generally by refraction the waves from NW turn to WNW. Waves from W and NW reduce in height. All wave conditions higher than Hs = 4 m are reduced by wave breaking. The operational wave climate at the harbour entrance is presented in Table-3.4.

Table-3.4: Operational Wave Climate at Harbour (Probability of Exceedance in % of time)

HS =	1.0 m	2.0 m	3.0 m	4.0 m
SW	12.2	8.7	4.7	2.2
W	21.6	13.6	7.4	3.0
NW	8.4	2.0	0.6	0.2

The extreme wave climate at the harbour entrance is as follows:

Frequency of occurrence	**Hs**
4.7 m	10/year
5.0 m	1/year
5.4 m	1/10 years
5.8 m	1/100 years

Extreme wave conditions at harbour entrance will occur mainly during the monsoon period. The period of the extreme waves varies between T = 7 S and 13 S.

3.10 CURRENTS

The currents in the region outside the sheltered harbour have been found to be generally less than one knot, during fair season and are mainly caused by tidal ebb and flow. Within the sheltered harbour, indicated current strengths are of the order of 30 to 40 cm/sec. During heavy monsoon rains, current pattern is altered from that during the fair season but the current strength does not get appreciably altered.

As a part of the field observations in Vasco bay, current observations were earlier taken at two locations (CM1 – 15° 26' 00"N, 73° 48' 18" E , CM2 – 15º24' 21"N, 73° 48' 42" E). A summary of the current measurements is given in Table-3.5.

Table-3.5: Current Measurements

	CM1 (Water depth, 7 m)			CM2 (Water depth, 3.5 m)
	Near surface	**Mid depth**	**Near bottom**	**Near bottom**
Maximum Speed (cm/sec)	68	31	29	57
Minimum Speed (cm/sec)	0	0	0	0
Predominant Direction	ESE- WNW	ESE-WNW	ESE - WNW	ESE

Measurements at open location (CM1) indicate that the predominant flow is in the ESE - WNW direction, while at the location (CM2) close to the shore, the predominant direction is ESE. The flow of currents is predominantly due to the tidal currents. During flood water, flow is towards Zuari River while during the ebbing, the reversal of flow takes place. The maximum current velocity was observed as 68 cm /sec.

3.11 GROUND WATER QUALITY

Proposed project does not envisages the use of ground water and discharge of waste water. However ground water samples were collected from 5 Nos. locations in the study area, to understand the status of ground water quality in the study area. Sampling Locations are listed below:

- GW1- MPT Harbour Gate No.1
- GW2- MPT Harbour Gate No.2
- GW3- V3 SET Workshop Bina Goa
- GW4- Sasmolem Bina Goa
- GW5- Vasco Near Railway station

The results of the water quality analysis is given Tables- 3.6 and locations are shown in Figure-3.5.

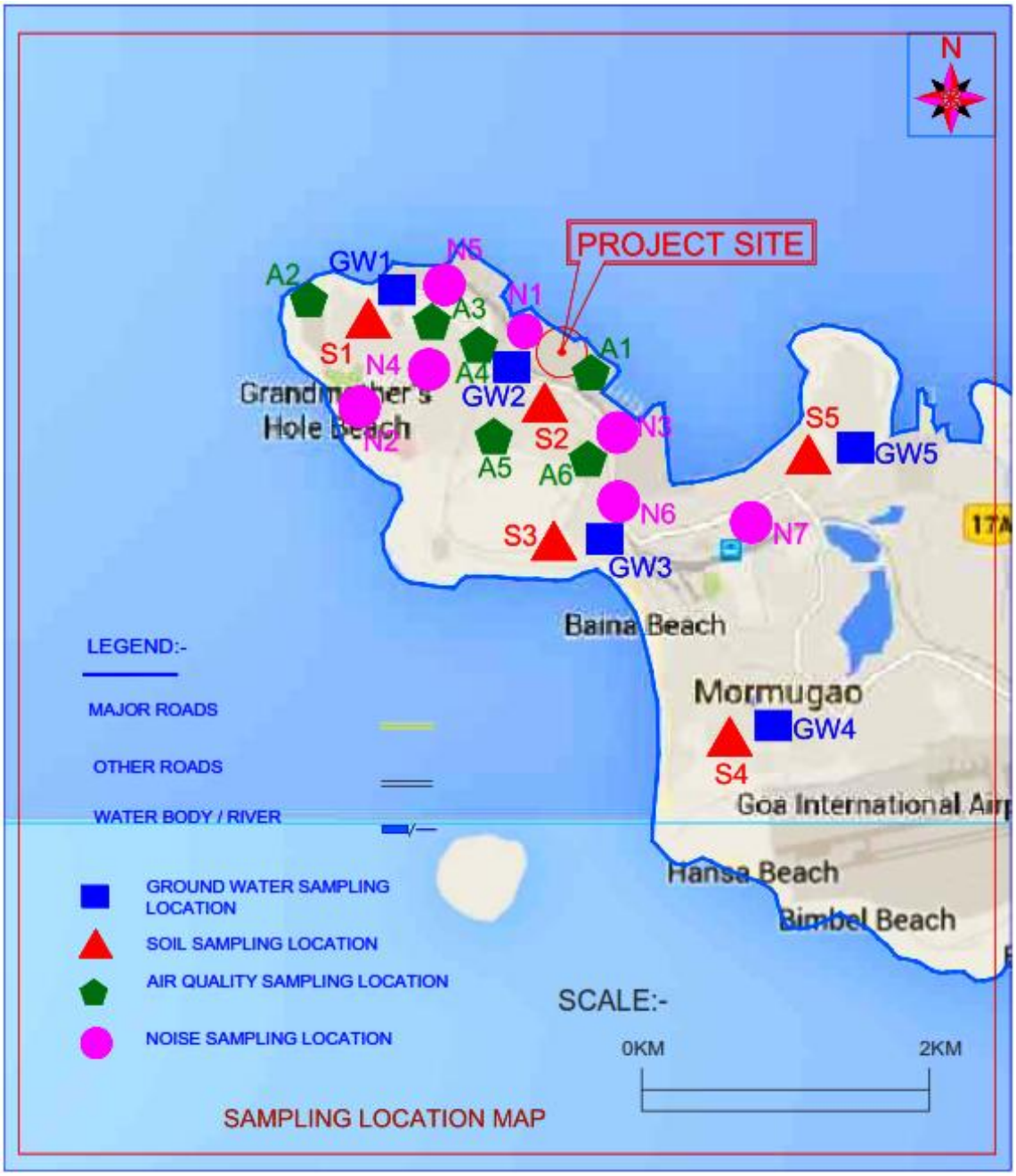


Figure-3.5: Sampling Location Map

Table-3.6: Ground water quality

Parameters	Stations				
	GW-1	GW-2	GW-3	GW-4	GW-5
pH value	6.21	6.5	6.60	7.05	5.5
Temperature, ^oC	33.4	33.4	33.4	33.4	33.4
Electrical Conductivity at 25°C, μmhos/cm	184	190	452	444.4	124
Total Alkalinity (as $CaCO_3$), mg/l	29.9	29.9	124	188.3	18.5
Chlorides (as Cl),mg/1	17.6	43.2	42.5	43.2	39.7
Total Hardness (as $CaCO_3$), mg/l	84.0	80.0	248	256	72
Calcium (as $CaCO_3$), mg/1	11.2	25.6	56.1	80.1	17.6
Magnesium (as $CaCO_3$),mg/1	13.6	13.8	19.4	33.6	6.8
Nitrate (as NO_3), mg/l	0.07	4.0	0.08	7.78	1.4
Sulphate (as SO_4), mg/l	13.8	13.1	4.3	14.4	5.4
Iron (as Fe), mg/1	0.4	0.4	0.3	0.02	0.2
Phosphate (as PO_4), mg/l	<0.04	<0.04	<0.04	<0.04	<0.04
Total Silica (as SiO_2), mg/l	19.2	3.5	4.2	8.3	2.9
BOD (3 days at 27°C), mg/l	0.5	<0.1	<0.1	<0.1	<0.1
COD, mg/l	1.41	<1.0	<1.0	<1.0	<1.0
Oil & Grease, mg/l	<2.0	<2.0	<2.0	<2.0	<2.0
Total Suspended Solids, mg/l	5.0	1.0	1.0	1.0	1.0
Sodium (as Na), mg/l	56.8	30.7	9.9	34.1	25.9
Potassium (as K) ,mg/1	25	5.5	1.4	8.3	4.4
Phenolic Compounds (as C_6H_5OH),mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (as As), mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Total Chromium (as Cr), mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury (as Hg), mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Copper (as Cu), mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (as Zn), mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium (as Cd), mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Lead (as Pb), mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Residual Sodium Carbonate, meq/l	Zero	Zero	Zero	Zero	Zero
Fluorides (as F), mg/l	<0.01	<0.01	0.11	0.21	0.11
Coliform Organisms/100 ml, (MPN)	10	Absent	Absent	12	Absent

The pH level in various groundwater samples in post monsoon season was observed to be within neutral range (6.5-7.6), which is within the permissible limit specified for meeting drinking water requirements. The total hardness in various water samples ranged from 80 to 256 mg/l. The total hardness level in some of the groundwater samples were higher than the permissible limit of 200 mg/l, specified for meeting drinking water requirement. However, the hardness level was well within the cause of Rejection Limit of 600 mg/l. The principal hardness causing cations are calcium, magnesium, strontium and ferrous and iron. The concentration of calcium and magnesium are mainly responsible for the hardness level in water.

Chlorides occur in all natural waters in widely varying concentrations, chlorides is available in natural water, mainly through solvent power of water, which dissolves chlorides from top soil and deeper formations. Sulphates ion is one of the major anions occurring in natural water. It is an important parameter because of its cathartic affect, when it is present in higher concentration. The chlorides and sulphates level was found to be below the permissible but below the cause of rejection limit specified for drinking water purposes in some of the ground water samples.

The concentration of various heavy metals was observed to be below detectable limit. This is expected in an area, where heavy metals loading is not from geogenic sources and there are no anthropogenic sources as well.

3.12 SOIL QUALITY

Proposed project is entirely located within the existing Mormugao Port operational area and does not envisage land acquisition and does not involved any discharge of waste water on the ground. However soil samples were collected from 5 locations in the study area, to understand the status of soil quality in the same. The results of soil quality analysis are shown in Table-3.7.

- S1- MPT Harbour Gate No.1
- S2- MPT Harbour Gate No.2
- S3- V3 SET Workshop Bina Goa
- S4- Sasmolem Bina Goa
- S5- Vasco Near Railway station

Table-3.7: Results of soil quality monitoring

S.No.	Parameters	Station				
		S1	S2	S3	S4	S5
1.	pH value	4.02	5.06	5.19	4.50	5.80
2.	Bulk Density, g/cm^3	1.33	1.30	1.45	1.42	1.36
3.	Total Kjeldahl Nitrogen , %w/w	0.19	0.06	0.03	0.08	0.11
4.	Available Phpsphorous (as P), mg/kg	60.86	64.62	72.31	104.9	127.27
5.	Phosphate (as P), mg/kg	64.15	66.28	77.92	110.73	130.42
6.	Organic Matter, %	2.92	1.53	0.81	2.05	1.80
7.	Sodium Absorption Ratio	0.62	0.55	0.60	0.76	0.76
8.	Sodium (as Na), mg/kg	181.20	185.03	188.11	257.86	212.75
9.	Available Potassium (as K), mg/kg	672.05	557.43	217.81	478.22	780.83
10.	Texture	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay	Sandy Clay Loam	Sandy Clay Loam
11.	Particle Size Distribution					
	• Very Coarse Sand (<2000-1000μ)	22.73	24.15	28.14	24.69	24.08
	• Coarse sand (<1000-500μ)	18.66	18.19	17.15	19.74	20.16
	• Medium Sand (<500-250μ)	24.42	23.98	20.06	22.17	22.84
	• Fine Sand (<250-100μ)	0.73	0.29	0.82	0.72	0.44
	• Very Fine Sand (<100-50μ)	7.95	7.33	8.49	7.68	8.11
	• Silt (<50 - 2μ)	14.78	15.91	16.06	14.54	14.61
	• Clay (<2μ)	10.73	10.15	9.28	10.46	9.76

The pH of soil at various sites lies within neutral range. The levels of NPK indicates moderate to high soil productivity.

3.13 LANDUSE PATTERN

The landuse pattern of the study area has also been assessed using satellite data. The Resources at-2 LISS-IV, Path 096, Row 062, sub-scene-A, dated 15.12.2014, digital satellite was procured from National Remote Sensing Agency (NRSA), Hyderabad for assessing the landuse pattern of the study area. The FCC of the study area is shown in Figure-3.6 and the classified imagery of the study area is enclosed as Figure-3.6. The landuse pattern is summarized in Table-3.7.

Table-3.8 : landuse pattern of Study Area

S. No.	Category	Area(ha)	Area (%)
1	Dense Vegetation	2056	4.92
2	Open Vegetation	2664	6.38
3	Open Land/Barren Land	3721	8.91
4	Sand/beach	259	0.62
5	Water Body	31434	75.24
6	Agricultural Land	1057	2.53
7	Builtup Area	589	1.41
	Total	**41780**	**100.00**

The major landuse category is water body accounting for about 75.24% of the total study area. The area under dense and open vegetation in the study area is 4.92% and 6.38 % respectively. The agricultural area accounts for about 2.53% of the Study Area, while built-up area accounts for 1.41% of the total Study Area.

3.14 AMBIENT AIR QUALITY

As a part of field studies, ambient air quality monitored at various locations in the study area by WAPCOS from 4th March 2016 to 28th May 2016. The ambient air quality monitoring was carried out with a frequency of two samples per week for twelve consecutive weeks at six locations in the study period. The parameters monitored as a part of the study are listed as below:

- Particulate Matter less than 2.5 microns ($PM_{2.5}$)
- Particulate Matter less than 10 microns (PM_{10})
- Sulphur dioxide (SO_2)
- Nitrogen dioxide (NO_2)
- Carbon Monoxide (as CO)
- Ozone (as O3)
- Lead (as Pb)
- Ammonia (as NH3)
- Benzene (as C6H6)
- Benzo (O) Pyrene (as BaP)
- Arsenic (as As)
- Nickel (as Ni)

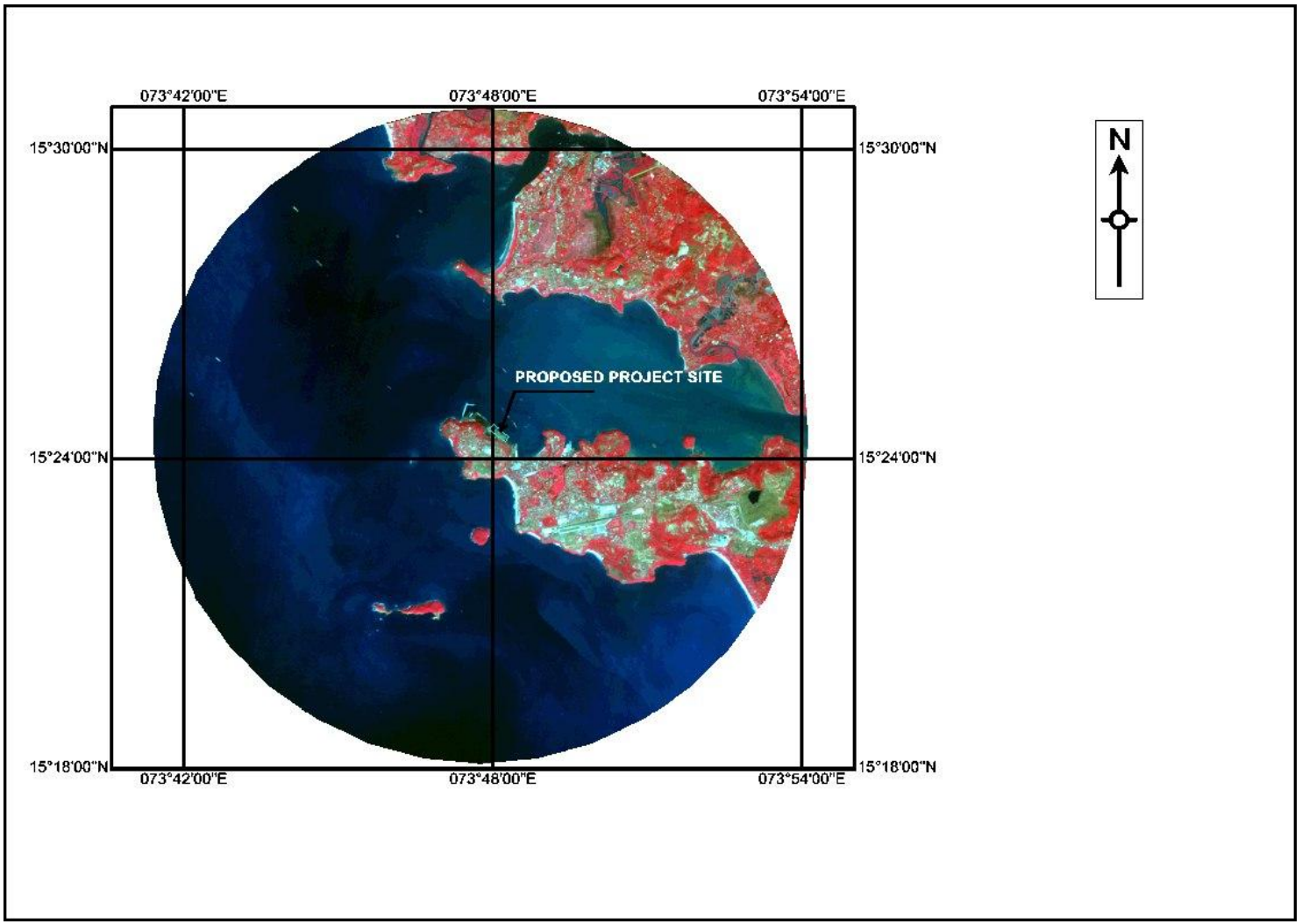


Figure-3.6: FCC of the study area

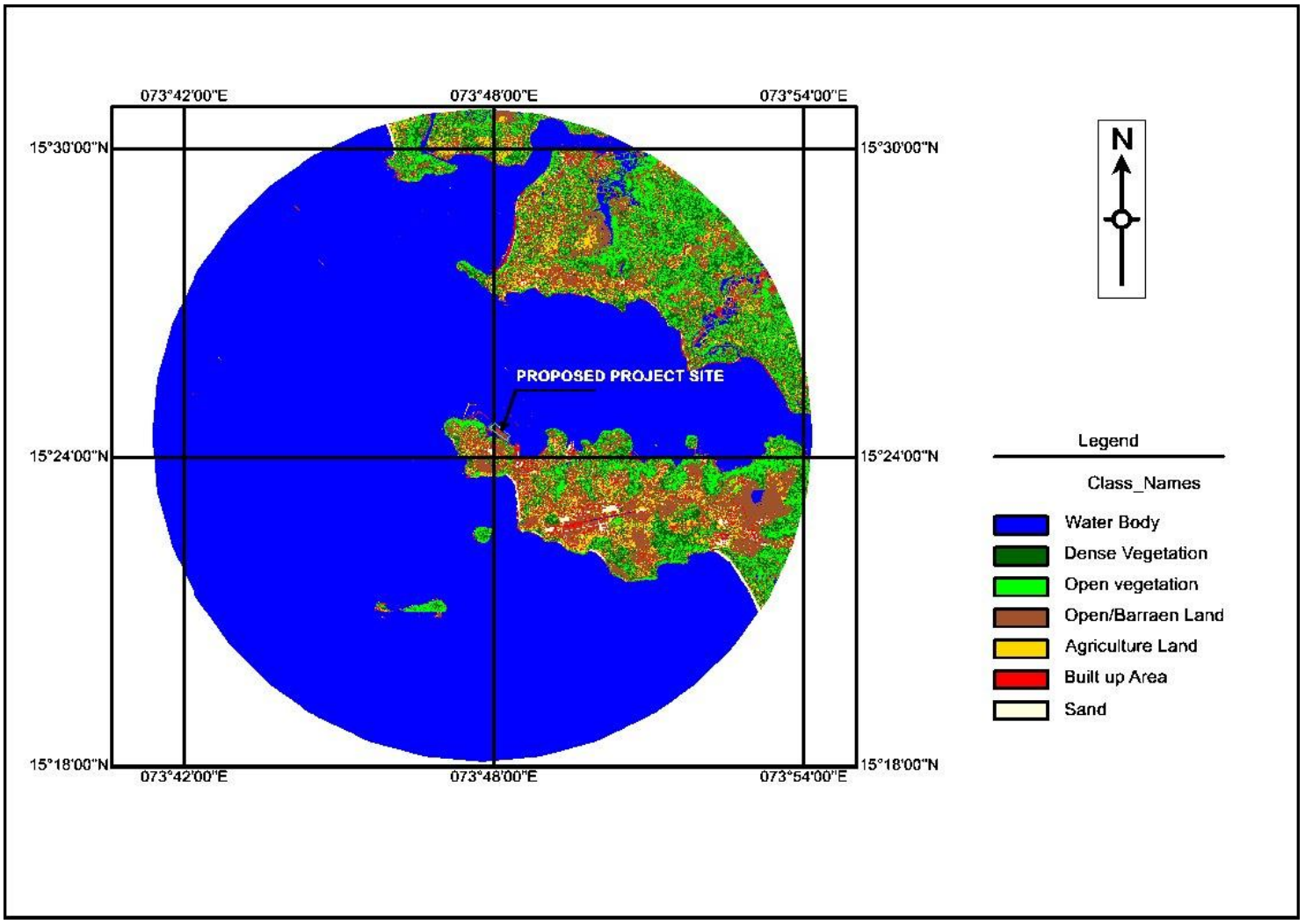


Figure-3.7: Land use pattern of the study area

The location of ambient air quality monitoring stations is given in Table-3.9. The results of ambient air quality survey conducted during the study period are given in Table-3.10. The summary of ambient air quality monitoring is given in Table-3.11. The ambient air quality standards specified by Central Pollution Control Board (CPCB) are enclosed as Annexure-III. Thje location of Air Quality Monitoring station were selected based on the prominent wind directions during the monitoring period. The ambient air quality stations were selected considering that the upwind, downwind, and cross wind direction with respect to proposed project site are covered. The location of ambient air quality monitoring stations is shown in Figure-3.5.

Table- 3.9: Location of Ambient Air Quality Monitoring Stations

S. No.	Station Code	Location	Latitude	Longitude
1	MPT-1	Project Site	$15^0$24’32”	$73^0$48’7.13”
2	MPT-2	MPT Colony	$15^0$24’43.76”	$73^0$47’12.35”
3	MPT-3	MPT Guest House	$15^0$24’39”	$73^0$48’26.10”
4	MPT-4	Near Sub Jail	$15^0$24’25.13”	$73^0$47’44.72”
5	MPT-5	Bagoda	$15^0$24’16.70”	$73^0$48’44.60”
6	MPT-6	Vasco	$15^0$24’5.3”	$73^0$48’11.70”

Table-3.10: Results of ambient air quality monitoring

S. No.	Date of Sampling	$PM_{2.5}$	PM_{10}	SO_2	NO_2	CO	O_3	Pb	NH_3	C_6H_6	BaP	As	Ni
		µg/m³	µg/m³	µg/m³	µg/m³	mg/m³	µg/m³	µg/m³	µg/m³	µg/m³	ng/m³	ng/m³	ng/m³
Sampling Location -1– MPT Site													
1	04-05/03/2016	36.2	79.5	23.5	38.4	0.5	57	ND	13	0.2	ND	ND	ND
2	07-08/03/2016	35.5	76.8	25.3	46.7	0.5	41.2	ND	11.5	0.7	ND	ND	ND
3	10-11/03/2016	37.5	82.2	24.8	54.5	0.7	46.2	ND	14.6	0.6	ND	ND	ND
4	14-15/03/2016	42	108	27.5	44.6	0.7	48.4	ND	13.6	0.8	ND	ND	ND
5	17-18/03/2016	47.5	115	26.8	46.5	0.8	45	ND	15.6	0.6	ND	ND	ND
6	21-22/03/2016	35.8	78	26.6	42.5	0.7	48.1	ND	14.5	0.4	ND	ND	ND
7	24-25/03/2016	36	78.5	22.6	55.7	0.7	54.6	ND	13	0.3	ND	ND	ND
8	28-29/03/2016	34.5	81.2	24.7	51.4	0.8	41.6	ND	15.3	0.5	ND	ND	ND
1	04-05/04/2016	47.5	128.8	23.5	38.7	0.6	57	ND	13	0.2	ND	ND	ND
2	07-08/04/2016	32.8	85.6	24.8	46.2	0.6	51	ND	15.7	0.4	ND	ND	ND
3	11-12/04/2016	45	92.2	28.8	51.3	0.6	51	ND	14.3	0.3	ND	ND	ND
4	15-16/04/2016	34.5	85.2	24.5	36.4	0.6	43	ND	14.1	0.3	ND	ND	ND
5	18-19/04/2016	34.7	82.5	27.4	49.9	0.6	43	ND	15.1	0.4	ND	ND	ND
6	22-23/04/2016	33	79.5	27	49.6	0.9	48	ND	14.4	0.3	ND	ND	ND
7	25-26/04/2016	44.3	98.5	26.9	56.7	0.8	56	ND	13	0.3	ND	ND	ND
8	29-30/04/2016	34.2	75	25.8	56.8	0.7	43	ND	15.1	0.2	ND	ND	ND
1	02-03/05/2016	40.2	85.2	27.4	45.7	0.5	53	ND	14.6	0.5	ND	ND	ND
2	06-07/05/2016	35.5	72	27.3	45.3	0.8	47	ND	14.3	0.6	ND	ND	ND
3	09-10/05/2016	34.5	80.2	25.6	46.5	0.7	56	ND	14.2	0.5	ND	ND	ND
4	13-14/05/2016	33.2	76.5	31.5	50.4	0.6	53	ND	14.5	0.5	ND	ND	ND
5	16-17/05/2016	30.5	69.5	29.5	49	0.6	50	ND	15.2	0.7	ND	ND	ND

S. No.	Date of Sampling	$PM_{2.5}$ µg/m³	PM_{10} µg/m³	SO_2 µg/m³	NO_2 µg/m³	CO mg/m³	O_3 µg/m³	Pb µg/m³	NH_3 µg/m³	C_6H_6 µg/m³	BaP ng/m³	As ng/m³	Ni ng/m³
6	20-21/05/2016	30.5	72.5	28.4	46	0.6	55	ND	11.7	0.4	ND	ND	ND
7	23-24/05/2016	32	72.2	29.8	44.3	0.6	56	ND	11.5	0.5	ND	ND	ND
8	27-28/05/2016	30.5	64.5	26.5	51	0.7	64	ND	11.7	0.6	ND	ND	ND
Sampling Location -2– MPT Colony													
1	04-05/03/2016	34.3	75.5	27.8	48.4	0.6	41	ND	12.4	0.3	ND	ND	ND
2	07-08/03/2016	32.6	69.6	25.8	44.6	0.5	31.7	ND	11.7	0.8	ND	ND	ND
3	10-11/03/2016	32.2	70.5	25.9	52.4	0.8	44.2	ND	14	0.3	ND	ND	ND
4	14-15/03/2016	31.3	65.2	26.3	43.8	0.8	47.1	ND	14.5	0.8	ND	ND	ND
5	17-18/03/2016	33.7	75.2	25.8	51	0.9	43	ND	13.8	0.4	ND	ND	ND
6	21-22/03/2016	35.5	75.4	26.3	57.2	0.8	39.8	ND	10.3	0.3	ND	ND	ND
7	24-25/03/2016	32.2	69.5	25.8	63.4	1	47.2	ND	10.2	0.6	ND	ND	ND
8	28-29/03/2016	32.5	80.2	29.4	50.2	0.8	44.2	ND	10.5	0.3	ND	ND	ND
1	04-05/04/2016	35.3	68	26.7	45.3	0.5	44	ND	11.9	0.4	ND	ND	ND
2	07-08/04/2016	34.8	85	26.5	49.6	0.7	42	ND	13.7	0.6	ND	ND	ND
3	11-12/04/2016	32.8	78	29.9	52.1	0.6	53	ND	11.6	0.2	ND	ND	ND
4	15-16/04/2016	36,8	72.9	28.3	33.2	0.5	45	ND	11.3	0.4	ND	ND	ND
5	18-19/04/2016	33.7	80.2	28.7	53.5	0.5	43	ND	11.7	0.5	ND	ND	ND
6	22-23/04/2016	34.8	74.4	26.3	53.2	0.5	46	ND	13.2	0.4	ND	ND	ND
7	25-26/04/2016	31.3	64.4	28.5	51.5	0.7	48	ND	13.6	0.4	ND	ND	ND
8	29-30/04/2016	31.5	70.2	24.8	51.2	0.5	43	ND	11.9	0.6	ND	ND	ND
1	02-03/05/2016	38.2	62	24.7	46.8	0.6	47	ND	12.5	0.5	ND	ND	ND
2	06-07/05/2016	36.2	72.6	26.5	52.1	0.8	45	ND	14.6	0.7	ND	ND	ND
3	09-10/05/2016	32.7	68	26.5	49.6	0.5	57	ND	12.5	0.4	ND	ND	ND

S. No.	Date of Sampling	$PM_{2.5}$ µg/m³	PM_{10} µg/m³	SO_2 µg/m³	NO_2 µg/m³	CO mg/m³	O_3 µg/m³	Pb µg/m³	NH_3 µg/m³	C_6H_6 µg/m³	BaP ng/m³	As ng/m³	Ni ng/m³
4	13-14/05/2016	32.5	79.5	26.3	44.2	0.7	55	ND	12.5	0.5	ND	ND	ND
5	16-17/05/2016	30	72.5	31.4	54	0.6	44	ND	13.3	0.6	ND	ND	ND
6	20-21/05/2016	34.5	72.5	27.8	54.5	0.7	48	ND	12.7	0.5	ND	ND	ND
7	23-24/05/2016	31	70.2	29.6	49.7	0.5	48	ND	12.8	0.5	ND	ND	ND
8	27-28/05/2016	31.5	72.5	21.8	55.3	0.5	54	ND	13.2	0.7	ND	ND	ND
Sampling Location-3 - MPT Guest House													
1	04-05/03/2016	33.2	72.5	26.4	39.6	0.8	62	ND	17.1	0.4	ND	ND	ND
2	07-08/03/2016	31.2	70.2	27.4	49.7	0.7	44.6	ND	17.3	0.9	ND	ND	ND
3	10-11/03/2016	27.4	68.5	27.3	56	0.9	53.7	ND	10.7	0.8	ND	ND	ND
4	14-15/03/2016	31.5	76.5	27.3	58.2	0.8	64.3	ND	9.6	0.4	ND	ND	ND
5	17-18/03/2016	31.2	65	27.2	56.3	0.8	37.9	ND	16.5	0.6	ND	ND	ND
6	21-22/03/2016	26.5	68.7	27.5	59.7	0.7	47.3	ND	14.5	0.4	ND	ND	ND
7	24-25/03/2016	33.5	75	26.2	51.7	0.9	45	ND	13.7	0.3	ND	ND	ND
8	28-29/03/2016	49.2	75.2	37.3	54	0.9	61	ND	16.7	0.6	ND	ND	ND
1	04-05/04/2016	34.3	82.5	27.8	41.4	0.6	41	ND	12.4	0.3	ND	ND	ND
2	07-08/04/2016	32.8	75	27.8	51	0.7	47	ND	12.4	0.1	ND	ND	ND
3	11-12/04/2016	32.3	69.8	30.2	49.7	0.7	45	ND	14.3	0.4	ND	ND	ND
4	15-16/04/2016	37.3	88	24.9	38	0.7	42	ND	13.7	0.5	ND	ND	ND
5	18-19/04/2016	33.7	75.2	26.3	49.8	0.7	40	ND	12	0.4	ND	ND	ND
6	22-23/04/2016	33	76.5	25.9	49.9	0.5	43	ND	11.8	0.5	ND	ND	ND
7	25-26/04/2016	30.6	65.4	27.5	53.2	0.7	49	ND	12.4	0.4	ND	ND	ND
8	29-30/04/2016	28.2	68.2	25.3	48.7	0.6	40	ND	13.5	0.3	ND	ND	ND
1	02-03/05/2016	31.2	66.5	28.3	44.5	0.7	51	ND	11.3	0.7	ND	ND	ND

S. No.	Date of Sampling	$PM_{2.5}$ µg/m³	PM_{10} µg/m³	SO_2 µg/m³	NO_2 µg/m³	CO mg/m³	O_3 µg/m³	Pb µg/m³	NH_3 µg/m³	C_6H_6 µg/m³	BaP ng/m³	As ng/m³	Ni ng/m³
2	06-07/05/2016	34.2	65	26.5	50.4	0.6	49	ND	13	0.5	ND	ND	ND
3	09-10/05/2016	32.5	72.2	28.3	51.5	0.7	49	ND	13.6	0.5	ND	ND	ND
4	13-14/05/2016	33.2	74.5	27.5	51.2	0.8	47	ND	14.5	0.6	ND	ND	ND
5	16-17/05/2016	31.5	64.5	29.7	55.2	0.8	46	ND	11.7	0.7	ND	ND	ND
6	20-21/05/2016	35.3	58	32.4	51.6	0.5	48	ND	12.5	0.7	ND	ND	ND
7	23-24/05/2016	34.8	70.2	30.4	51	0.6	49	ND	11.7	0.5	ND	ND	ND
8	27-28/05/2016	33.2	72.5	26.5	46	0.6	63	ND	11	0.5	ND	ND	ND
Sampling Location-4 – Near Sub Jail													
1	04-05/03/2016	33.3	76.5	26.9	46.7	0.8	53	ND	13	0.2	ND	ND	ND
2	07-08/03/2016	34.2	68.6	34	55.3	0.6	42.1	ND	10.2	0.7	ND	ND	ND
3	10-11/03/2016	35	63.5	31	58.3	0.9	58	ND	13.2	0.7	ND	ND	ND
4	14-15/03/2016	32.5	71.8	27.1	51.7	0.9	52	ND	10.3	0.6	ND	ND	ND
5	17-18/03/2016	34.7	74.2	31	49	0.7	44.1	ND	14.4	0.6	ND	ND	ND
6	21-22/03/2016	32.2	76.4	37.2	64.5	0.9	44.1	ND	17.2	0.2	ND	ND	ND
7	24-25/03/2016	33.5	69.5	29.7	58.2	0.9	51.7	ND	11	0.7	ND	ND	ND
8	28-29/03/2016	38.5	81.2	28.7	57.7	0.9	49.7	ND	18.2	0.2	ND	ND	ND
1	04-05/04/2016	39.3	96.5	29.3	56.2	0.8	43	ND	22.6	0.3	ND	ND	ND
2	07-08/04/2016	35.8	85.5	27.3	48.2	0.9	49	ND	18.2	0.2	ND	ND	ND
3	11-12/04/2016	42.9	100.2	34.2	50.3	0.7	49	ND	13.7	0.3	ND	ND	ND
4	15-16/04/2016	37.3	91.2	29.3	35.1	0.6	47	ND	14.5	0.5	ND	ND	ND
5	18-19/04/2016	34.7	82.2	29.2	51.2	0.6	51	ND	13.7	0.5	ND	ND	ND
6	22-23/04/2016	36.8	74.5	27.4	48.5	0.7	47	ND	13.5	0.5	ND	ND	ND
7	25-26/04/2016	32.3	98.5	29.5	57.4	0.6	51	ND	14.2	0.3	ND	ND	ND

S. No.	Date of Sampling	$PM_{2.5}$ µg/m³	PM_{10} µg/m³	SO_2 µg/m³	NO_2 µg/m³	CO mg/m³	O_3 µg/m³	Pb µg/m³	NH_3 µg/m³	C_6H_6 µg/m³	BaP ng/m³	As ng/m³	Ni ng/m³
8	29-30/04/2016	32.5	75.2	27.3	58.3	0.8	45	ND	14.2	0.4	ND	ND	ND
1	02-03/05/2016	36.2	112	22.3	52.1	0.7	49	ND	16.8	0.5	ND	ND	ND
2	06-07/05/2016	39.5	115	25.8	54.2	0.7	51	ND	15.4	0.6	ND	ND	ND
3	09-10/05/2016	36.5	86.2	31.3	48.5	0.4	53	ND	14.6	0.5	ND	ND	ND
4	13-14/05/2016	34.2	78.5	28.3	49.8	0.8	51	ND	13.1	0.7	ND	ND	ND
5	16-17/05/2016	31	74.58	26.3	49.7	0.5	50	ND	16.4	0.6	ND	ND	ND
6	20-21/05/2016	32.5	69.58	30.6	50.6	0.5	48	ND	14.7	0.6	ND	ND	ND
7	23-24/05/2016	32	72.25	33.7	52.5	0.7	51	ND	13.4	0.4	ND	ND	ND
8	27-28/05/2016	34.5	80	28.3	49.8	0.8	58	ND	10.8	0.7	ND	ND	ND
Sampling Location-5 – Bagoda													
1	04-05/03/2016	36.2	79.5	23.5	38.4	0.5	57	ND	13	0.2	ND	ND	ND
2	07-08/03/2016	35.5	76.8	25.3	46.7	0.5	41.2	ND	11.5	0.7	ND	ND	ND
3	10-11/03/2016	37.5	82.2	24.8	54.5	0.7	46.2	ND	14.6	0.6	ND	ND	ND
4	14-15/03/2016	34.5	72	27.5	44.6	0.7	48.4	ND	13.6	0.8	ND	ND	ND
5	17-18/03/2016	32.7	75.2	26.8	46.5	0.8	45	ND	15.6	0.6	ND	ND	ND
6	21-22/03/2016	35.8	78	26.6	42.5	0.7	48.1	ND	14.5	0.4	ND	ND	ND
7	24-25/03/2016	36	78.5	22.6	55.7	0.7	54.6	ND	13	0.3	ND	ND	ND
8	28-29/03/2016	34.5	81.2	24.7	51.4	0.8	41.6	ND	15.3	0.5	ND	ND	ND
1	04-05/04/2016	37.4	92.5	23.5	38.7	0.6	57	ND	13	0.2	ND	ND	ND
2	07-08/04/2016	32.8	85.6	24.8	46.2	0.6	51	ND	15.7	0.4	ND	ND	ND
3	11-12/04/2016	38.5	85	28.8	51.3	0.6	51	ND	14.3	0.3	ND	ND	ND
4	15-16/04/2016	32	70	24.5	36.4	0.6	43	ND	14.1	0.3	ND	ND	ND
5	18-19/04/2016	33.2	72.5	27.4	49.9	0.6	43	ND	15.1	0.4	ND	ND	ND

S. No.	Date of Sampling	$PM_{2.5}$ µg/m³	PM_{10} µg/m³	SO_2 µg/m³	NO_2 µg/m³	CO mg/m³	O_3 µg/m³	Pb µg/m³	NH_3 µg/m³	C_6H_6 µg/m³	BaP ng/m³	As ng/m³	Ni ng/m³
6	22-23/04/2016	33	79.5	27	49.6	0.9	48	ND	14.4	0.3	ND	ND	ND
7	25-26/04/2016	44.3	98.5	26.9	56.7	0.8	56	ND	13	0.3	ND	ND	ND
8	29-30/04/2016	34.2	75	25.8	56.8	0.7	46	ND	15.1	0.2	ND	ND	ND
1	02-03/05/2016	37.4	85.2	27.4	45.7	0.5	53	ND	14.6	0.5	ND	ND	ND
2	06-07/05/2016	35.5	72	27.3	45.3	0.8	47	ND	14.3	0.6	ND	ND	ND
3	09-10/05/2016	34.5	75.4	25.6	46.5	0.7	56	ND	14.2	0.5	ND	ND	ND
4	13-14/05/2016	33.2	76.5	31.5	50.4	0.6	53	ND	14.5	0.5	ND	ND	ND
5	16-17/05/2016	29.8	62.2	29.5	49	0.6	50	ND	15.2	0.7	ND	ND	ND
6	20-21/05/2016	30.5	71.3	28.4	46	0.6	55	ND	11.7	0.4	ND	ND	ND
7	23-24/05/2016	32	72.2	29.8	44.3	0.6	56	ND	11.5	0.5	ND	ND	ND
8	27-28/05/2016	30.5	69.7	26.5	51	0.7	54	ND	11.7	0.6	ND	ND	ND
Sampling Location -6–Vasco													
1	04-05/03/2016	32.3	82	23.7	39.2	0.8	58	ND	9.5	0.2	ND	ND	ND
2	07-08/03/2016	35.5	72.4	24.7	59.4	0.7	42.4	ND	16.6	0.6	ND	ND	ND
3	10-11/03/2016	30	71.2	25.6	57.2	0.8	56.6	ND	11.6	0.8	ND	ND	ND
4	14-15/03/2016	34.5	71.8	26.6	52.4	0.8	63.7	ND	12.4	0.8	ND	ND	ND
5	17-18/03/2016	38.5	95	28.5	44.6	0.9	47	ND	14.8	0.7	ND	ND	ND
6	21-22/03/2016	33.2	73	22.5	44.3	0.8	45.6	ND	15.7	0.6	ND	ND	ND
7	24-25/03/2016	31.2	72.5	27.5	53.6	0.9	55.4	ND	9.5	0.5	ND	ND	ND
8	28-29/03/2016	37.5	82	28.4	49.6	0.6	47.5	ND	16.5	0.4	ND	ND	ND
1	04-05/04/2016	40.5	102	23.7	39.5	0.8	58	ND	9.5	0.2	ND	ND	ND
2	07-08/04/2016	36.8	86.6	27.2	42.5	0.8	48	ND	19	0.4	ND	ND	ND
3	11-12/04/2016	46	102.2	31.4	48.5	0.5	48	ND	15	0.4	ND	ND	ND

S. No.	Date of Sampling	$PM_{2.5}$ $\mu g/m^3$	PM_{10} $\mu g/m^3$	SO_2 $\mu g/m^3$	NO_2 $\mu g/m^3$	CO mg/m^3	O_3 $\mu g/m^3$	Pb $\mu g/m^3$	NH_3 $\mu g/m^3$	C_6H_6 $\mu g/m^3$	BaP ng/m^3	As ng/m^3	Ni ng/m^3
4	15-16/04/2016	36.3	90.2	25.5	32.3	0.8	48	ND	16.3	0.4	ND	ND	ND
5	18-19/04/2016	38.5	82.5	27.2	48.5	0.6	45	ND	14.3	0.3	ND	ND	ND
6	22-23/04/2016	37	98	21.9	48.2	0.9	45	ND	15.3	0.3	ND	ND	ND
7	25-26/04/2016	41.5	99.5	26.6	59.5	0.8	58	ND	9.5	0.5	ND	ND	ND
8	29-30/04/2016	38	89.5	26.9	52.5	0.9	48	ND	16.3	0.2	ND	ND	ND
1	02-03/05/2016	39.4	93.2	26.1	45	0.9	57	ND	11.5	0.7	ND	ND	ND
2	06-07/05/2016	38.6	86.4	26.6	44.7	0.7	46	ND	16.8	0.6	ND	ND	ND
3	09-10/05/2016	37.5	83.2	26.7	47.2	0.6	51	ND	13.5	0.4	ND	ND	ND
4	13-14/05/2016	29.5	79.5	30.5	50.6	0.7	51	ND	15	0.3	ND	ND	ND
5	16-17/05/2016	31.5	74.5	28.2	48.9	0.7	49	ND	13.9	0.4	ND	ND	ND
6	20-21/05/2016	32.5	69.5	26.7	50	0.7	50	ND	13.8	0.4	ND	ND	ND
7	23-24/05/2016	33	72.2	27.3	49.3	0.9	58	ND	10.2	0.6	ND	ND	ND
8	27-28/05/2016	32.5	72	27.6	48.2	0.9	63	ND	12.5	0.6	ND	ND	ND

Table- 3.11: Summary of ambient air quality monitoring (Unit: µg/m^3)

Station	Maximum	Minimum	Average
Particulate Matter$_{2.5}$ ($PM_{2.5}$) (Unit: µg/m^3)			
MPT site	47.5	30.5	36.6
MPT Colony	38.2	30.0	33.3
MPT Guest House	49.2	26.5	33.0
Near Sub Jail,	42.9	31.0	35.0
Bagoda	44.3	29.8	34.6
Vasco	46.0	29.5	35.9
Particulate Matter$_{10}$ (PM_{10}) (Unit: µg/m^3)			
MPT site	128.8	64.5	84.1
MPT Colony	85.0	62.0	72.7
MPT Guest House	88.0	58.0	71.5
Near Sub Jail,	115.0	63.5	82.2
Bagoda	98.5	62.2	77.8
Vasco	102.2	69.5	83.4
Sulphur Dioxide (SO_2) (Unit: µg/m^3)			
MPT Site	31.5	22.6	26.5
MPT Colony	31.4	21.8	26.9
MPT Guest House	37.3	24.9	28.0
Near Sub Jail	37.2	22.3	29.4
Bagoda	31.5	22.6	26.5
Vasco	31.4	21.9	26.6
Nitrogen Dioxide (No_2) (Unit: µg/m^3)			
MPT Site	56.8	36.4	47.7
MPT Colony	63.4	33.2	50.3
MPT Guest House	59.7	38.0	50.3
Near Sub Jail,	64.5	35.1	52.2
Bagoda	56.8	36.7	47.7
Vasco	59.5	32.3	48.1
Carbon Monoxide (CO) (Unit: mg/m^3)			
MPT Site	0.9	0.5	0.7
MPT Colony	1.0	0.5	0.6
MPT Guest House	0.9	0.5	0.7
Near Sub Jail	0.9	0.4	0.7
Bagoda	0.9	0.5	0.6
Vasco	0.9	0.5	0.7
Ozone (O_3) (Unit: µg/m^3)			
MPT Site	64.0	41.2	50.3
MPT Colony	57.0	31.7	45.9
MPT Guest House	64.3	37.9	48.5
Near Sub Jail	58.0	42.1	49.4
Bagoda	57.0	41.2	50.0
Vasco	63.7	42.4	51.6
Ammonia (NH_3) (Unit: µg/m^3)			
MPT Site	15.7	11.5	13.9
MPT Colony	14.6	10.2	12.5

MPT Guest House	17.3	9.6	13.2
Near Sub Jail	22.6	10.2	14.5
Bagoda	15.7	11.5	13.9
Vasco	19.0	9.5	13.7
Benzene (C_6H_6) (Unit: µg/m^3)			
MPT Site	0.8	0.2	0.4
MPT Colony	0.8	0.2	0.5
MPT Guest House	0.9	0.1	0.5
Near Sub Jail	0.7	0.2	0.4
Bagoda	0.8	0.2	0.4
Vasco	0.8	0.2	0.4

O

Observations on $PM_{2.5}$ levels

The average concentration of $PM_{2.5}$ at various stations monitored ranged from 33.0 to 36.5 µg/m^3. The highest $PM_{2.5}$ value was recorded as 47.5 µg/m^3 near Project Siteand lowest values of 30.0 µg/m^3 were recorded near MPT colony. The $PM_{2.5}$ values monitored during the field survey were within the permissible limit of 60 µg/m^3 for industrial, residential, rural and other areas (Refer Annexure-III).

Observations on ambient PM_{10} levels

It is observed from Table-3.11 that average concentration of PM_{10} at various stations ranged from 71.5 to 84.1µg/m^3. The highest PM_{10} value was recorded as 128 µg/m^3 near project site and lowest values of 58.0µg/m^3 were recorded near MPT Guest House. The average PM_{10} values monitored during the field survey were generally with in the permissible of 100 µg/m^3, limits except at few occasions for industrial, residential, rural and other areas.

Observations on ambient SO_2 levels

The summary of ambient SO_2 level as monitored during field studies is given in Table-3.11. The average concentration of SO_2 at various stations in the study area was well below the prescribed limit of 80 µg/m^3 specified for industrial, residential, rural and other areas (Refer Annexure-III). The average concentration of SO_2 at various stations monitored ranged from

26.5 to 29.4µg/m^3. The highest SO_2 value was recorded as 37.3 µg/m^3 near MPT Guest House and is below detectable limit in all the locations.

Observations on ambient NO_2 levels

It can be seen from Table-3.11 that during the study period, average NO_2 concentration at various sampling stations ranged from 47.7 to 52.2µg/m^3. The highest NO_2value was recorded as 64.5 µg/m^3 near Sub Jail and lowest value of 32.3 µg/m^3 was recorded near Vasco. The average concentration of NO_2 at various stations in the study area was observed to be well below the prescribed limit of 80 µg/m^3 specified for industrial, residential, rural and other areas.

Observations on CO levels

The average concentration of CO at various stations monitored ranged from 0.6 to 0.7 mg/m^3. The highest CO value was recorded as 1 mg/m^3 near MPT colony and lowest values of 0.4 mg/m^3 were recorded near MPT Guest House. The CO values monitored during the field survey were below permissible limit of 2 mg/m^3 for industrial, residential, rural and other areas.

Observations on ambient Ozone (O_3) levels

It is observed from Table-3.11 that average concentration of Ozone (O_3) at various stations ranged from 45.9 to 51.6µg/m^3. The highest Ozone value was recorded as 64.3 µg/m^3 near MPT Guest house and lowest values of 31.7 µg/m^3 were recorded near MPT colony. The Ozonevalues monitored during the field survey were below the permissible limit of 100 µg/m^3 for industrial, residential, rural and other areas.

Observations on Ammonia (NH_3) levels

The average concentration of Ammonia (NH_3)at various stations monitored ranged from 12.5 to 14.4 µg/m^3. The highest NH_3value was recorded as 22.6 µg/m^3 near Sub Jail, Headland Sada and lowest values of 9.5 g/m^3were recorded near Vasco area. The NH_3 values monitored during the

field survey were below permissible limit of 400 μg/m^3 for industrial, residential, rural and other areas.

Observations on ambient Benzene (C_6H_6) levels

It is observed from Table-3.11 that average concentration of C_6H_6 at various stations ranged from 0.4to 0.5 μg/m^3. The highest C_6H_6value was recorded as 0.9 μg/m^3 near MPT Guest House and lowest values of 0.1 μg/m^3 were also recorded in the same station. The C_6H_6 values monitored during the field survey were below the permissible limit of 5 μg/m^3 for industrial, residential, rural and other areas.

Values of Lead, Benzo (O) Pyrene, Arsenic and Nickel were below detectable limits at all the stations.

3.15 AMBIENT NOISE LEVELS

Baseline noise data has been measured using a weighted sound pressure level meter. The survey was carried out in calm surroundings. Sound Pressure Level (SPL) measurement in the outside environment was made using sound pressure level meter. Hourly noise meter readings were taken at each site, and equivalent day time and night time noise levels were estimated. The ambient noise levels were recorded at 7 locations and details are listed Table- 3.12. The hourly ambient noise levels recorded at various locations are listed in Table-3.13. The day time and night time noise levels are presented in Table-3.14. The ambient noise standards are enclosed as Annexure-IV. The stations covered as a part of ambient air quality monitoring are shown in Figure-3.5.

Table-3.12: List of Noise monitoring stations

S.No.	Noise monitoring station
1	Near Project site
2	D- Type Quarters MPT colony
3	D Type Quarter Near Sub Jail MPT
4	MPT Guest House
5	JSW Office Port Complex Building
6	A Type Quarters, Bogda Bharat Line
7	Vasco- Hotel Westend

Table- 3.13: Ambient Noise Level in the study area [Unit: dB(A)]

Time	Stations						
	S1	S2	S3	S4	S5	S6	S7
6AM-7AM	42.3	47.1	46.4	45.7	49.8	51.7	46.9
7AM-8AM	44.3	50.2	47.9	46.9	52.7	48.2	49.9
8AM-9AM	45.6	51.5	51.4	47.8	53.9	54.9	52.2
9AM-10AM	47.5	49.2	51.2	48.8	54.9	55.2	50.9
10AM-11AM	47.6	51.4	49	50.9	51.2	49.1	50.1
11AM-12PM	48.5	51.2	51	52.8	49.2	49.2	48.4
12PM-1PM	50.3	52	51	52	59.8	48.3	50.9
1PM-2PM	51.6	51.2	49	52.8	49.1	55	47.9
2PM-3PM	51.6	50.1	51	49	49.5	58.4	52.1
3PM-4PM	52.6	52.1	51	52.9	51	48.2	53.1
4PM-5PM	50.2	51	49.2	49.2	49.2	49.8	51.4
5PM-6PM	51.1	50.1	51	53.2	49.5	51	49.7
6PM-7PM	51	52	52	52.7	51	49.2	52.2
7PM-8PM	53.2	51	51	51.8	52.1	56	48.2
8PM-9PM	50.2	47.1	53	49.8	51.8	49.2	49.9
9PM-10PM	47.6	43.2	50.4	47.2	47.7	52.2	45.2
10PM-11PM	45.6	41.1	46.2	45.1	46.2	50.2	41.7
11PM-12AM	43.2	40.1	43.2	41.9	43	46.7	40.1
12AM-1AM	40.2	39.5	41.2	39.8	40.1	43.3	37.8
1AM-2AM	37.2	37.2	40.2	38.2	38	40.1	34.2
2AM-3AM	36.1	38.2	39.5	38.8	38.7	38.5	37.4
3AM-4AM	38.2	40.5	41.6	41.2	40.2	42.5	39.8
4AM-5AM	39.2	42.1	43.5	42.2	41.1	45.4	31.4
5AM-6AM	41.6	43.5	45.7	45.1	44.2	47.4	42.9

Table- 3.14: Equivalent noise levels in the Study Area

S.No.	Noise monitoring station	Leq(day)	Leq(night)
1	Near Project site	50.40	40.39
2	D- Type Quarters MPT colony	50.70	38.83
3	D Type Quarter Near Sub Jail MPT	50.60	42.69
4	MPT Guest House	51.01	40.94
5	JSW Office Port Complex Building	52.88	41.12
6	A Type Quarters, Bogda Bharat Line	52.90	44.90
7	Vasco- Hotel Westend	50.60	38.36

It may be seen from the Table-3.14, that the day time equivalent noise level ranged from a minimum of 50.40 dB (A) to a maximum of 52.90 dB (A). The night time equivalent noise level ranged from a minimum of 38.36 dB (A) to a maximum of 44.90 dB (A). The day and night time equivalent noise level at various sites located close to residential areas and commercial area were compared with Ambient Noise Standards (Refer Annexure- IV) and were observed to be well below the permissible limit specified.

3.16 MARINE ECOLOGICAL SURVEY

The prime objective of the present ecological survey is to study the impact of expansion of second iron ore terminal on the existing quality of land, marine ecology and socio-economic environment during construction and operation phases of the proposed terminal. These impacts will be ascertained by superimposing the impacts due to the planned activities on the baseline environmental status. Mitigation measures in the form of an Environmental Management Plan (EMP) have also been outlined as a part of the EIA report. To accomplish this, experts from the Centre of Advanced Study (CAS) in Marine Biology of Annamalai University, Tamilnadu where given the task of sampling and analyzing marine biology parameters during 2nd week of May 2016. During the survey, water, sediment and biological samples (phytoplankton, zooplankton, macrobenthos, meio-benthos and microbial samples besides sea weeds, sea grasses, and fishery resources) were collected across two different depths (surface and subsurface). The anticipated impact area in the surrounding water was idendified considering the proposed project activities i.e. construction, dredging, reclamation, retaining wall etc. The water and sediment samples were collected from 10 locations and the geographical locations of the each sampling station are given Table-3.15 and are shown in Figure-3.8.

Table-3.15: Sampling Locations and its Geographical Coordinates

S. No.	St. Code	Latitude (N)	Longitude (E)	Depth (m)
1.	MPT-1	15°24'35.29"N	73°48'16.77"E	7.5
2.	MPT-2	15°24'46.24"N	73°49'2.96"E	4.5
3.	MPT-3	15°25'30.15"N	73°48'0.15"E	12.0
4.	MPT-4	15°26'5.02"N	73°48'6.09"E	14.0
5.	MPT-5	15°26'8.47"N	73°47'14.30"E	15.0
6.	MPT-6	15°25'22.69"N	73°46'22.49"E	12.5
7.	MPT-7	15°25'14.31"N	73°45'48.10"E	13.0
8.	MPT-8	15°24'46.15"N	73°46'53.04"E	10.0
9.	MPT-9	15°25'9.87"N	73°47'34.58"E	11.5
10.	MPT-10	15°24'54.20"N	73°47'50.96"E	15.5

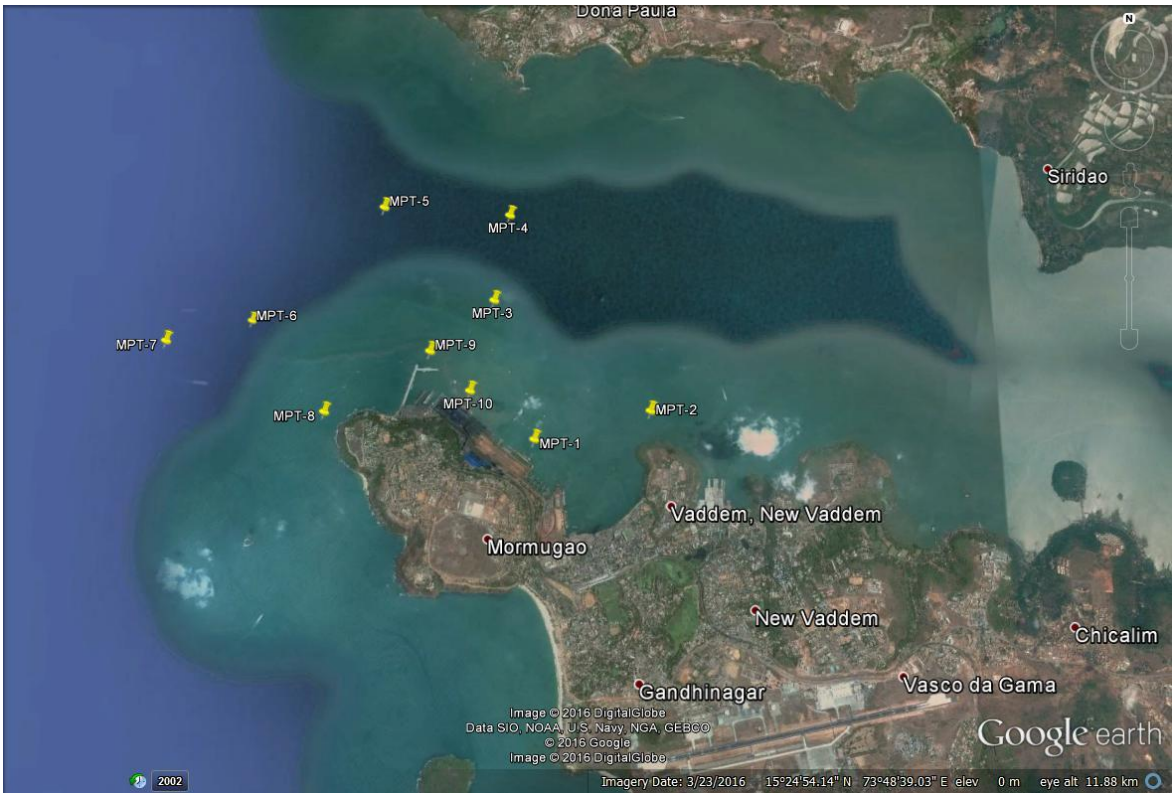


Figure-3.8: Map showing the marine sampling locations

METHODOLOGY ADOPTED FOR VARIOUS ANALYSES

Water and Sediment Sampling

Water samples were collected at the surface and sub-surface level using Universal water sampler and transferred to the pre-cleaned polypropylene and glass containers. Sediment samples were collected using Van veen grab transferred to clean polythene bags and transported to the shore. The samples were air-dried and the plant root and other debris were removed and stored for further analysis.

Temperature, Salinity and pH

The physical parameters such as temperature, salinity and pH were measured in-situ in the field. The sub-surface temperature was measured with a mercury thermometer (±0.02°C accuracy) and the pH was measured by a calibrated pH pen (pH ep-3 model). Salinity was estimated using a Hand Refractometer (Atago, Japan). Water samples collected for dissolved oxygen estimation were transferred carefully to BOD bottles. The DO was immediately fixed and brought to the shore for further analysis.

Preservation and Laboratory Analysis

After collection, the samples were immediately cooled to 4°C and then brought to the temporarily set up Field Lab, in an insulated thermocool box. On reaching, water samples were filtered through Whatman GF/C filter paper and analysed for organic matter and other nutrients. Unfiltered samples were used for the estimation of total nitrogen and total phosphorus. All the analyses were carried out by adopting Standard procedures for samples of aquatic origin. The methodology for each analysis is briefly given below:

Dissolved Oxygen

The modified Winkler's method as described by Strickland and Parsons (1972) was adopted for the estimation of dissolved oxygen. The values are expressed in mg/l.

Nitrate and Nitrite

The nitrate and nitrite content of samples were analysed by following the method described by Strickland and Parsons (1972). The nitrite was estimated from highly coloured azo dye formed by the addition of N (1-Napthyl) ethylene diaminedihydro-chloride and sulfanilamide into the solution was then measured at 543 nm in a spectrophotometer. The same procedure was followed for the estimation of nitrate. For this, nitrate was reduced to nitrite by passing the sample through copper coated cadmium column. The calculated values are expressed in μmol of Nitrogen/l

Inorganic Phosphate

The single solution mixed reagent procedure developed by Murphy and Riley (1962) was followed for the estimation of dissolved inorganic phosphate levels in water samples. This involves the conversion of phosphate into phosphomolybdic acid, which was then reduced to molybdenum blue color complexes and then the intensity of colour was measured at 882 nm in a spectrophotometer. The calculated values are expressed in µmol of Phosphate/L.

Total Phosphorus

The Total Phosphorus in water samples was estimated by adopting the method described by Menzel and Corwin (1964). This procedure involves the conversion of organically bound phosphate into inorganic phosphate by wet oxidation of samples with potassium persulphate in an autoclave for 30 min at 15 lbs pressure. The converted inorganic phosphate was then estimated by using the method described by Murphy and Riley (1962). The subtraction of original dissolved inorganic phosphate from total phosphate yielded the organic phosphate in the water sample. The calculated value is expressed in µmol of Phosphorus/L.

Reactive Silicate

The reactive silicate content of water was estimated by following the method of Strickland and Parsons (1972). In this method, the intensity of

blue color formed by silico-molybdate complex was measured at 810 nm in a spectrophotometer and the calculated values are expressed in µmol of Silica/l

Sediment Analysis

For the analysis of soil textural composition and pH, the air-dried sediment samples were used as such. For all other analyses, sediment samples were ground to fine powder and dried in an oven at 110°C to constant weight for an hour.

Total Organic Carbon

The estimation of total organic carbon in sediment was performed by adopting the method of El Wakeel and Riley (1956). The procedure involves chromic acid digestion and subsequent titration against Ferrous ammonium sulphate solution in the presence of 1-10 phenonthroline indicator. The values calculated are expressed in mg C/g of sediment.

Bacteriological Methods

Collection of samples

Surface water samples were collected in 30ml sterile screw capped bottles for bacteriological assessment. Enough air space was left in the bottles to allow thorough mixing. Precautionary measures were taken to avoid contamination through handling. For microbial assessment in sediment samples, a known quantity of samples was collected from the grab samples using sterilised spatula. The central portion of the collected sediment was aseptically transferred into sterile polyethylene bags. All the samples were brought to the laboratory in portable ice box soon after collection and bacteriological analyses were carried out with necessary dilution.

Enumeration of Total Viable Counts (TVC)

TVC was enumerated by adopting the spread plate method using Zobell's Marine Agar medium (EA123, Hi-Media, Mumbai). The samples (water and sediment) were diluted using the sterile sea water and 0.1 ml of the

diluted sample was pippeted into the petriplates containing Zobell's Marine Agar and it was spread using a 'L' shaped glass spreader. The plates after inoculation were incubated in an inverted position at a temperature of 28+2°C for 24 to 48 h. The colonies were counted and the population density expressed as Colony Forming Unit (CFU) per ml or g of the sample. The bacterial colonies were picked up from the pertidishes and re-streaked in appropriate nutrient agar plates thrice before a pure culture was established in agar slants.

Enumeration of Total Coliforms

Macconkey agar with 0.15% bile salt, crystal violet and NaCl has been recommended in accordance with USP/Nfxi (1) for the detection, isolation and enumeration of coliforms and intestinal pathogens in water, dairy products, pharmaceutical preparations, etc. The agar weighing 51.5 g in 1000 ml distilled water was heated up to the boiling point to dissolve the medium completely and sterilized by autoclaving at 15 lbs pressure (121°C) for 15 min. suitably diluted samples were inoculated in the petriplates containing medium and were incubated for 48 h. After incubation, the colonies of *E. coli* appeared with pink color.

M-FC agar was employed for detection and enumeration Faecal Coliforms by the membrane filter technique at higher temperature (44.5°C). The agar weighing 52 g was suspended in 1000 ml of distilled water and heated up to the boiling point to dissolve the medium completely, 10ml of Rosolic acid (dissolved in 0.2 N NaOH) was added, heated with frequent agitation and boiled for 1 min. Then the medium was cooled to 50°C. Finally, the medium was poured into small 60mm plates. Samples filtered by Millipore apparatus using 0.45µm Whatman filter papers were impregnated in the petriplates. After 48 h of incubation, the colonies of *E. coli* appeared with blue colour.

Chlorophyll `a'

The samples were filtered through Whatman GF/C filter papers and the chlorophyll was extracted into 90% acetone. The resulting colored acetone extract was measured in a spectrophotometer at different wave lengths and the same acetone extracts were acidified and measured for the phaeo-pigments. The detailed methodology as described in APHA manual (1989) was followed.

Phytoplanktons

Phytoplankton samples were collected from the surface waters of the study area by towing a plankton net (mouth diameter 0.35 m) made of bolting silk [No.30 mesh size 48 µm) for half an hour. These samples were preserved in 5% neutralized formalin and used for qualitative analysis. For the quantitative analysis of phytoplankton, the settling method as described by Sukhanovo (1978) was adopted. Numerical plankton analysis was carried out using Utermohl's inverted plankton microscope.

Phytoplankton species was identified using the standard works of Hustedt (1930-1966), Venkataraman (1939), Cupp (1943), Subramanian (1946), Prescott (1954), Desikachary (1959 and 1987), Hendey (1964), Steidinger and Williams (1970) and Taylor (1976) and Anand*et al.* (1986).

Zooplanktons

Zooplankton samples were collected from the surface waters of the study area by horizontal towing of plankton net with mouth diameter of 0.35 m, made of bolting silk (No. 70 mesh size 200 µm) for half an hour. After collection, the samples were preserved in 5% neutralized formalin and used for quantitative analysis. The zooplankton collected were identified to the species level using the classical works of Dakin and Colefax (1940), Davis (1955), Kasthurirangan (1963) and Wickstead (1965) and Damodara Naidu (1981). For the quantitative analysis of zooplankton, a known quantity of water (100 L) was filtered through a bag net (0.33 mm mesh size) and filtrate was made up to 1 litre in a wide mouthed bottle and

then enumerated using Utermohl's inverted plankton microscope. The plankton density is expressed as number of organisms/m^3.

Benthic Community

For studying the benthic organisms, sediment samples were collected using Van veen grab which covered an area of 0.1m^2. The wet sediment was sieved with varying mesh sizes (0.5mm -macrofauna and 0.062mm-meiofauna) for segregating the organisms. The organisms retained in the sieve were fixed in 5-7% formalin and stained further with Rose Bengal solution for easy spotting at the time of sorting. After a day or two, the organisms were sorted into various groups. The number of organisms in each grab sample was expressed as number per meter square. All the species were sorted, enumerated and identified to the advanced taxonomic level possible with the consultation of available literature. The works of Fauvel (1953), Day (1967) were referred for polychaetes; Barnes (1980) and Lyla *et al*. (1999) for crustaceans; Subba Rao *et al.* (1991) and Ramakrishna (2003) for molluscs.

3.16.1 WATER QUALITY ANALYSIS

The water quality parameters and nutrients analysed in the Mormugao coastal water is given in Tables-3.16 and 3.17 respectively. Water quality is determined by physical, chemical and microbiological properties of waters. These water quality characteristics throughout the world are characterized with wide variability. Therefore the quality of natural water sources used for different purposes should be established in terms of the specific water-quality parameters. There are "no set standards" for water quality values because it varies from one place to another place, therefore it can be compared only with the help of secondary data such as government reports, research articles, Ph.D., thesis and etc

The range of physico-chemical parameters was found to be within the permissible range. Similarly, the ecologically sensitive chemical parameters such as Dissolved Oxygen, BOD, nutrients were also at the

optimal concentration with a few exceptions which might be owing to the prevailing seasonal variation.

Table-3.16: Results of Water Quality Analysis

St. Code	Water Tem. (°C)	Salinity (psu)	EC (µS/cm)	pH	DO (mg/l)	BOD (mg/l)	TSS (ppm)	Turbidity (NTU)
MPT-1	29.3	37.2	71.04	8.7	4.8	1.8	16.5	4.7
MPT-1-SS	28.0	35.2	89.87	8.3	5.3	2.0	18.5	5.3
MPT-2	29.5	36.7	70.00	8.4	4.6	2.4	14.8	5.0
MPT-2-SS	28.4	35.0	58.97	8.0	5.1	2.7	18.6	5.6
MPT-3	29.8	35.0	69.23	8.1	4.0	1.6	13.9	5.9
MPT-3-SS	28.6	35.9	59.07	7.8	4.9	1.9	15.8	6.6
MPT-4	30.0	37.9	75.32	8.5	4.5	1.7	17.3	4.4
MPT-4-SS	29.2	36.5	66.19	8.2	5.1	2.1	19.5	4.8
MPT-5	31.3	37.0	73.98	8.6	3.7	2.8	14.7	6.3
MPT-5-SS	30.4	36.2	69.03	8.4	4.4	2.3	19.3	6.9
MPT-6	29.0	34.5	58.77	8.5	5.1	2.2	14.5	6.6
MPT-6-SS	27.1	33.5	49.07	8.3	5.6	2.4	19.1	7.3
MPT-7	31.9	33.0	59.65	8.7	4.3	2.0	19.3	6.9
MPT-7-SS	28.2	31.2	47.54	8.2	5.0	2.3	22.6	7.7
MPT-8	31.0	32.9	58.87	8.7	5.2	1.3	23.2	8.0
MPT-8-SS	29.6	31.7	49.01	8.3	5.9	1.5	28.5	8.9
MPT-9	29.1	32.8	57.52	8.5	6.4	1.8	24.8	7.8
MPT-9-SS	28.5	32.0	49.86	8.1	5.9	2.3	29.2	8.4
MPT-10	29.7	33.7	60.89	8.6	5.0	2.0	21.4	8.1
MPT-10-SS	28.3	32.5	55.12	8.2	5.4	2.3	26.5	8.6

Table-3.17: Nutrients in Water Samples

St. Code	NO_2	NO_3	NH_3-N	TN	TP	IP	SiO_4	PHC	POC
	(µmol/l)							(µg/l)	(µgC/l)
MPT-1	0.75	2.67	0.045	20.39	2.67	1.19	29.07	2.892	115.2
MPT-1-SS	0.89	2.93	0.060	15.16	2.95	1.48	30.78	2.671	110.2
MPT-2	0.78	2.51	0.057	19.42	2.78	0.55	26.90	2.780	119.9
MPT-2-SS	0.74	3.05	0.073	20.73	3.67	1.09	35.64	2.946	120.2
MPT-3	1.07	2.27	0.029	23.78	2.73	1.55	29.07	2.685	105.9
MPT-3-SS	1.26	3.68	0.048	26.04	3.24	1.23	33.75	2.462	111.6
MPT-4	0.98	3.00	0.053	21.68	3.00	1.67	21.37	1.976	120.6
MPT-4-SS	1.03	3.89	0.064	27.46	3.83	2.13	30.02	2.292	115.9
MPT-5	1.05	3.55	0.049	23.90	2.89	1.29	27.35	2.528	119.6
MPT-5-SS	0.98	4.08	0.067	28.55	3.75	1.56	34.81	2.722	121.3
MPT-6	1.35	3.59	0.063	24.00	3.50	1.37	30.00	2.580	126.7
MPT-6-SS	0.96	4.78	0.078	32.09	4.19	1.90	38.90	2.611	117.1
MPT-7	0.92	4.15	0.060	30.43	3.67	1.71	29.55	2.593	123.9
MPT-7-SS	1.45	4.63	0.084	35.73	4.07	2.09	32.34	2.642	118.6
MPT-8	0.94	3.11	0.069	33.68	3.89	2.17	30.45	2.826	124.4
MPT-8-SS	1.00	5.21	0.075	30.97	4.11	2.87	35.82	2.963	126.7
MPT-9	1.37	4.67	0.081	32.49	3.77	2.00	32.67	3.378	117.1
MPT-9-SS	1.65	5.00	0.091	37.89	4.01	2.64	39.10	3.773	127.7
MPT-10	1.05	3.36	0.077	32.31	3.37	1.89	36.78	3.236	120.9

St. Code	NO_2	NO_3	NH_3-N	TN	TP	IP	SiO_4	PHC	POC
	(µmol/l)							(µg/l)	(µgC/l)
MPT-10-SS	1.26	4.09	0.083	34.84	3.87	2.31	43.78	3.537	123.2

Depth

The depth in the study area varied between 4.5 and 15.5 m with maximum was recorded at MPT-10 and minimum at MPT-2 (Figure-3.9).

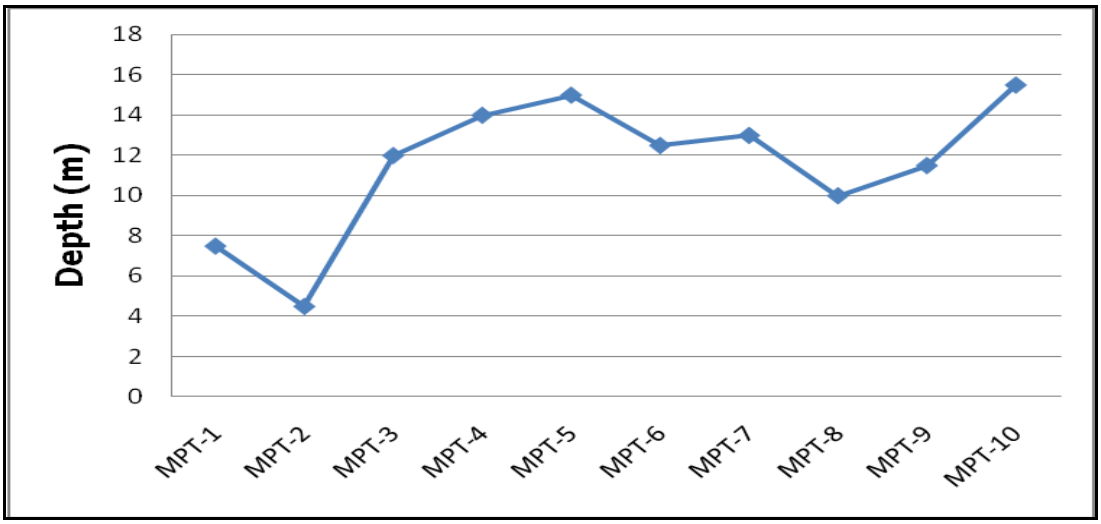


Figure-3.9: Depth level recorded at various stations

Water Temperature

Temperature affects the ability of water to hold the oxygen as well as the ability of organisms to resist to certain pollutants. The water temperature fluctuated from 27.1 to 31.9°C. The maximum value was at MPT-7-SS and minimum was recorded at MPT-6 (Figure-3.10).). However a maximum of 40°C is the thershold limit for tempreature in the near shore environment and 45°C in the offshore waters.

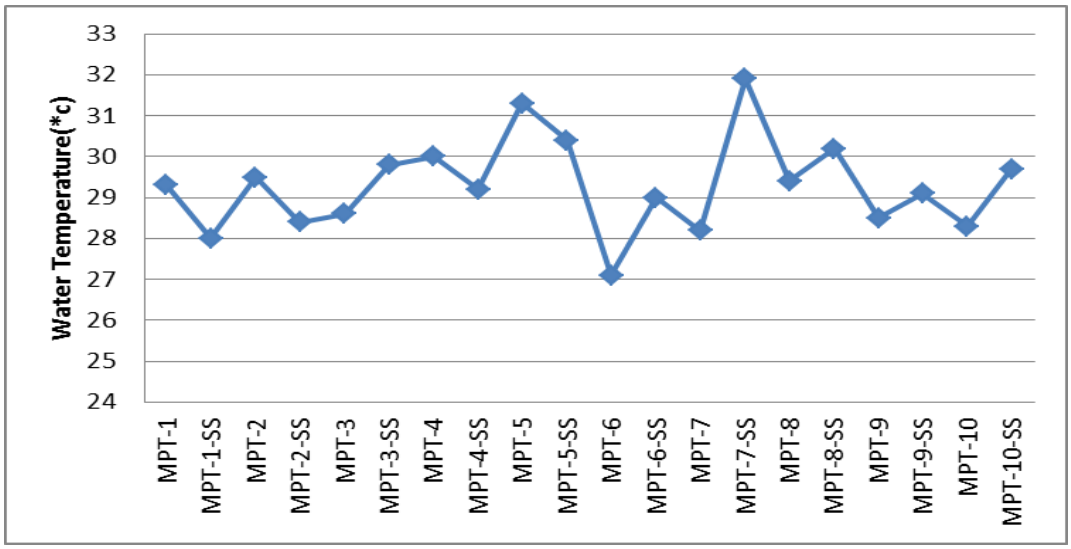


Figure-3.10: Water temperature recorded at various stations

Electrical Conductivity

The Electrical Conductivity varied from 47.54 to 89.87 (µS/cm). The lowest value was recorded at station MPT-7-ss and the highest value was recorded at station MPT-1-ss (Figure-3.11). The values recorded in this study is within the range (40- 250 µS/cm) as suggested by Environmental Protection Agency (EPA, 2012)

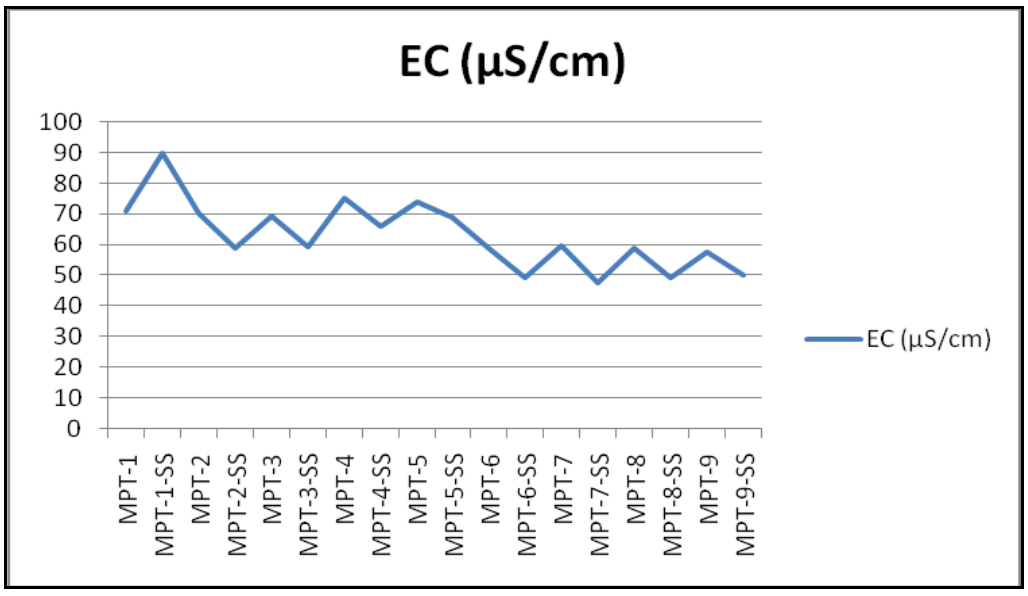


Figure-3.11: Electrical Conductivity recorded at various stations

Salinity

The water salinity varied from 31.2 to 39.8 PSU. The salinity was found to be lower at MPT-7-ss and higher at MPT-1-ss (Figure-3.12). Salinity levels indicates the mixing of creek water with the sea water. Salinity levels indicate the mixing of creek water with the sea water and the value recorded in this study is comparable (32-41 PSU) with the values reported earlier by Gujarat Ecology Commission (2013) at Mundra port.

pH

pH is an importatnt indicator of chemical change in water, it is affected by temperature, presuures, chemical contaminants, photosynthetic and microorganisms activities. Pollution can change the pH of water, which in turn can harm living organisms in water. Sea water pH values ranges from 6.5 to 9.0, as per the water quality criteria for class SW-IV waters (Haebour Waters). The marine water pH values in the samples collected from the study area varied between 7.8 and 8.7 with minimum was recorded at MPT-3-ss and maximum was recorded at MPT-1, 7& 8 (Figure-3.13). The Ph values were in the range of allowable limits of 6-9 for coastal nearshore in the study area.

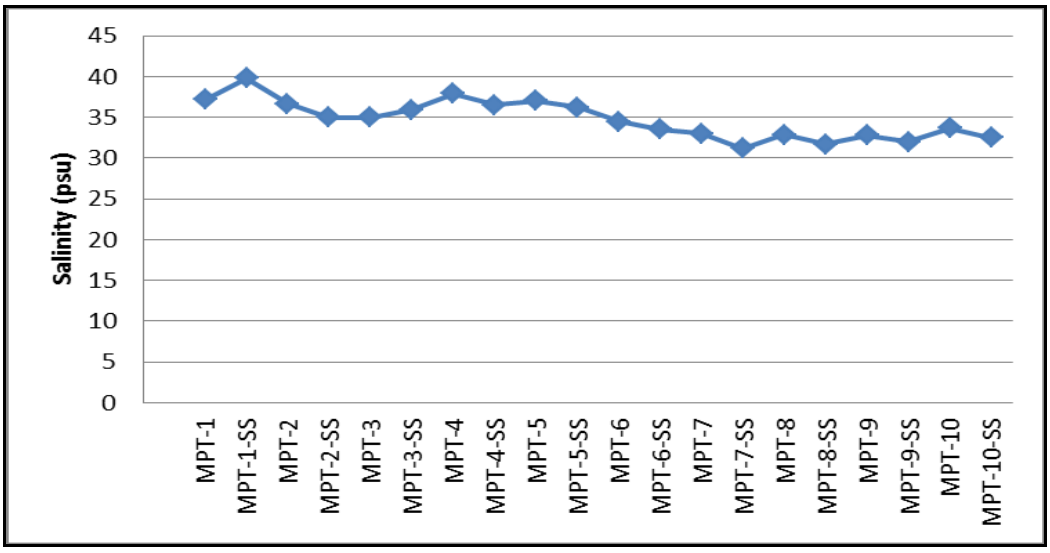


Figure-3.12: Salinity recorded at various stations

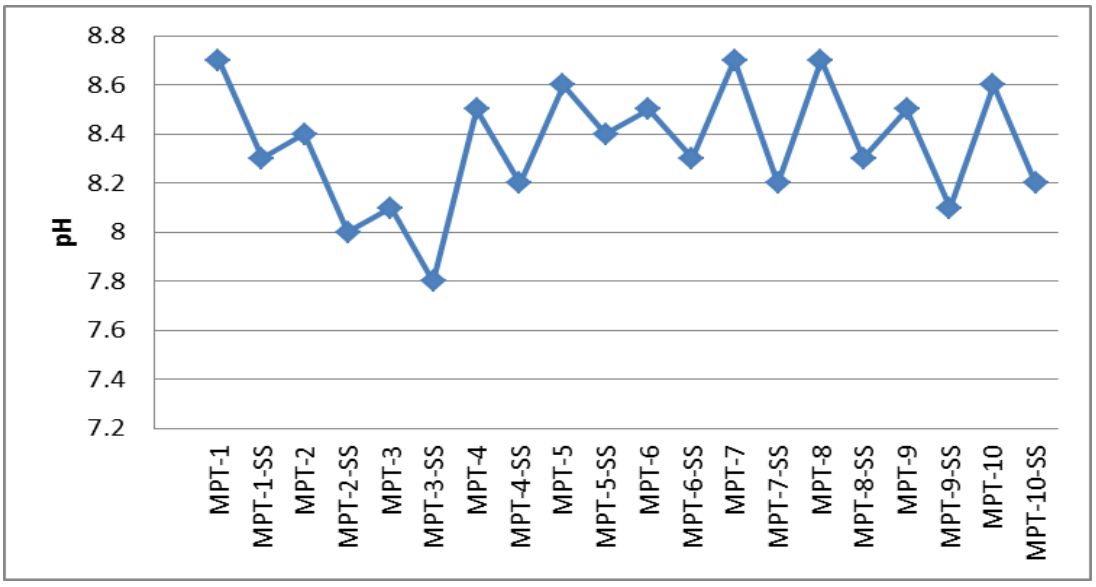


Figure-3.13: Water pH recorded at various stations

Total Suspended Solids (TSS)

The Total Suspended Solids values ranged between 13.9 and 29.2 ppm. The minimum value was recorded at MPT-3 and the maximum was recorded at MPT-9-ss (Figure-3.14). The permissible limits of TSS for nearshore coastal waters is 250. However swells in the near shore environment can rise the TSS levels as in the present study.

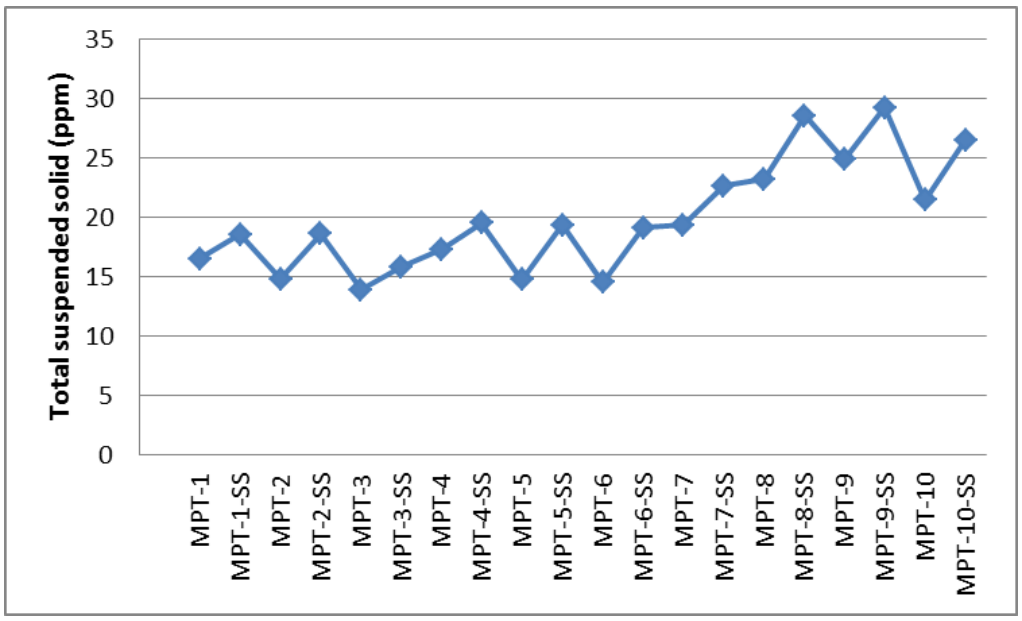


Figure-3.14: Total Suspended Solids recorded at various stations

Turbidity

The turbidity values were between 4.4 and 8.9 NTU. The minimum level was at MPT-4 and the maximum level was at MPT-8-SS (Figure-3.15). The turbidity values are parallel to the values (9.5-275) recorded by Shirodkar et al. (2012) at Mumbai Coast.

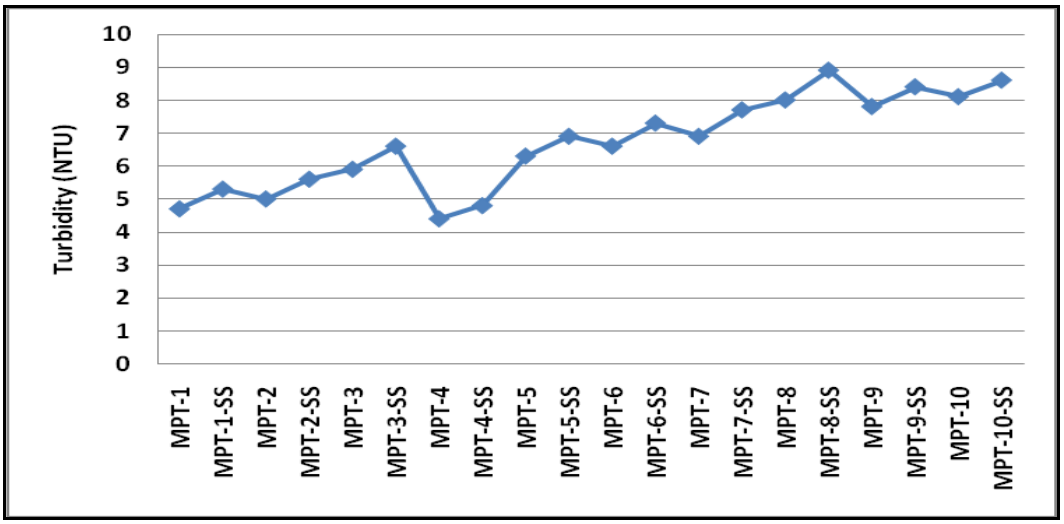


Figure-3.15: Turbidity recorded at various stations

Dissolved oxygen

The Dissolved Oxygen level as per the water quality criteria for class SW-IV waters (Harbour Waters) should be 3 mg/l or 40% saturation value, considering the biodegradation of oil and inhibition to oxygen production through photosynthesis. However DO level in the water samples varied between 3.7 and 6.4 mg/l, which indicates good quality of water in the study area. The lower value was at MPT-5 and the higher level was recorded at MPT-9 (Figure-3.16).

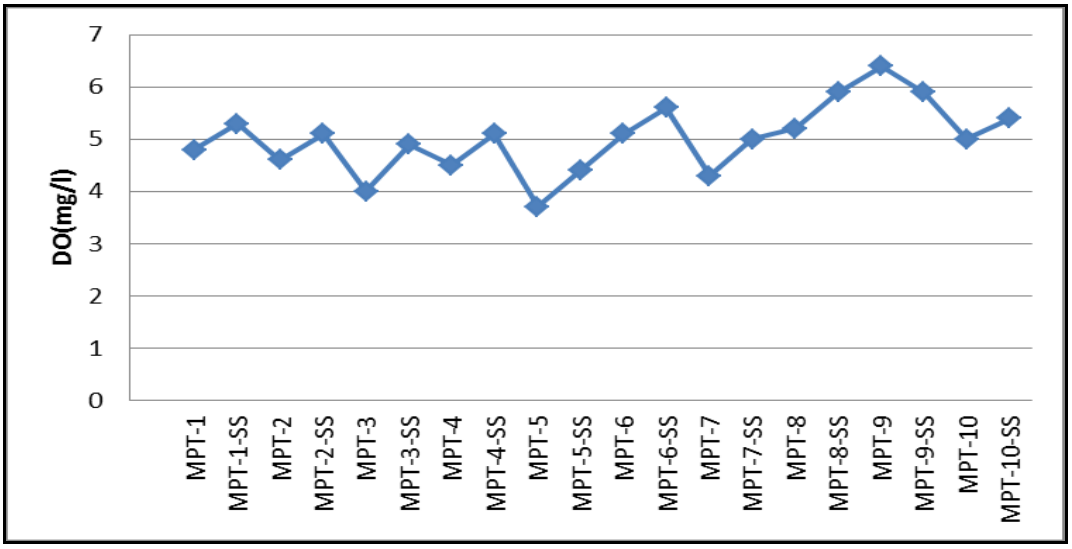


Figure-3.16: Dissolved oxygen recorded at various stations

Biological Oxygen Demand

BOD levels to maintain the water quality relatively free from pollution caused by swage amd other decomposable wastes ,as per the water quality criteria for class SW-IV waters (Haebour Waters) is 3 mg/l. However BOD values observed in the water samples collected from the study area varied between 1.3 and 2.8 mg/l with minimum at MPT-8 and the maximum value was recorded at MPT-5 (Figure-3.17). Hence, BOD in the Studya area is under the allowable levels only.

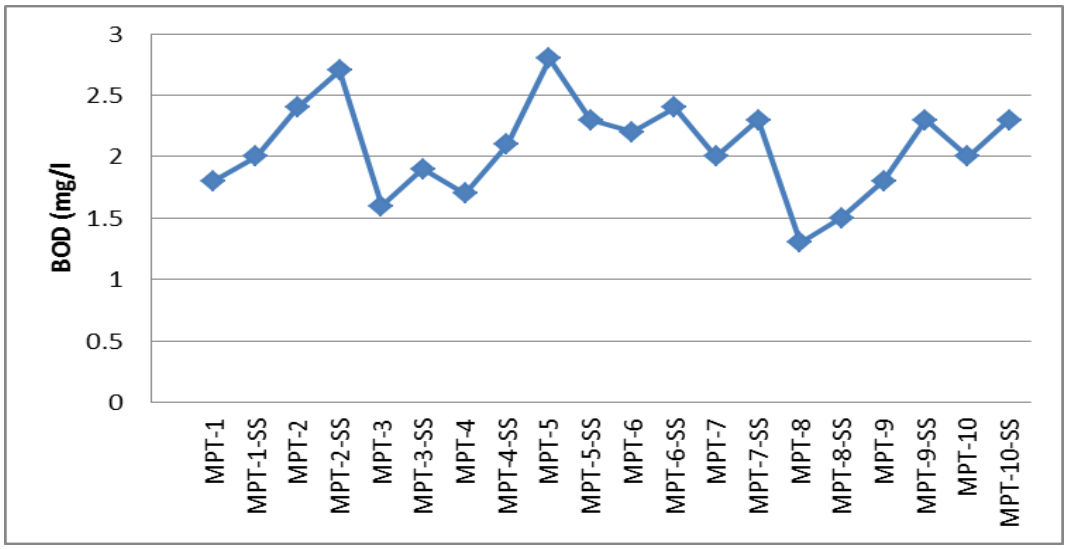


Figure-3.17: Biological oxygen demand recorded at various stations

Nutrients

The life supporting processes in the sea requires a range of inorganic substances, of which, the role of nitrogen, phosphorus and silicon are considered to be immense in marine ecosystem. Among the nitrogenous compounds, nitrite, nitrate and ammonia are the major constituents, which play a key role in the growth and proliferation of primary producers like phytoplankton, which in turn in the distribution of secondary and tertiary consumers. The results of various parameters recorded are given in the following paragraphs.

Nitrite

The nitrite level varied from 0.74 to 1.65µmol/l with maximum was recorded at MPT-9-ss and minimum was recorded at MPT-2-ss (Figure-3.18).

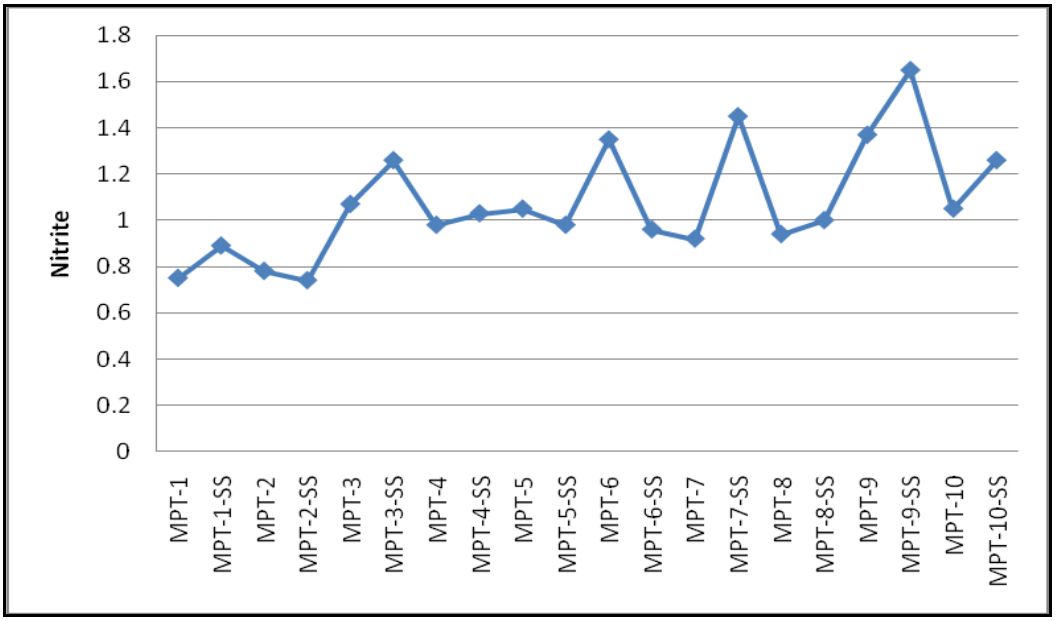


Figure-3.18: Nitrite recorded at various stations

Nitrate

Nitrate concentration ranged between 2.27 and 5.21µmol/l with minimum was at MPT-3 and the maximum value was recorded at MPT-8-ss (Figure-3.19). Lower values of nitrate in the coastal water suggests that the mixing of degradable wastes from the runoff from zuari creek.

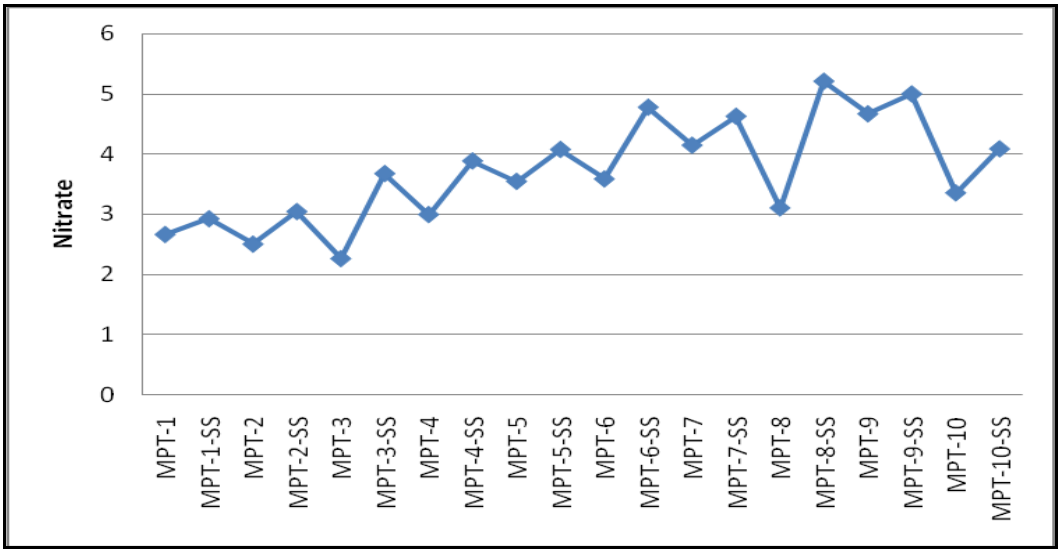


Figure-3.19: Nitrate recorded at various stations

Ammonical Nitrogen

The ammonia concentration varied from 0.029 to 0.091µmol/l. The maximum concentration (0.091µmol/l) was recorded at MPT-9-ss and minimum (0.029µmol/l) was at MPT-3 (Figure-3.20). The ammonia concentration recorded in this study was very less (1.7-2.3µmol/l) than the values recorded by Sukumaran et al., (2011) while they study the influence of anthropogenic factors on benthic polychaete distribution in the Ratnagiri Bay.

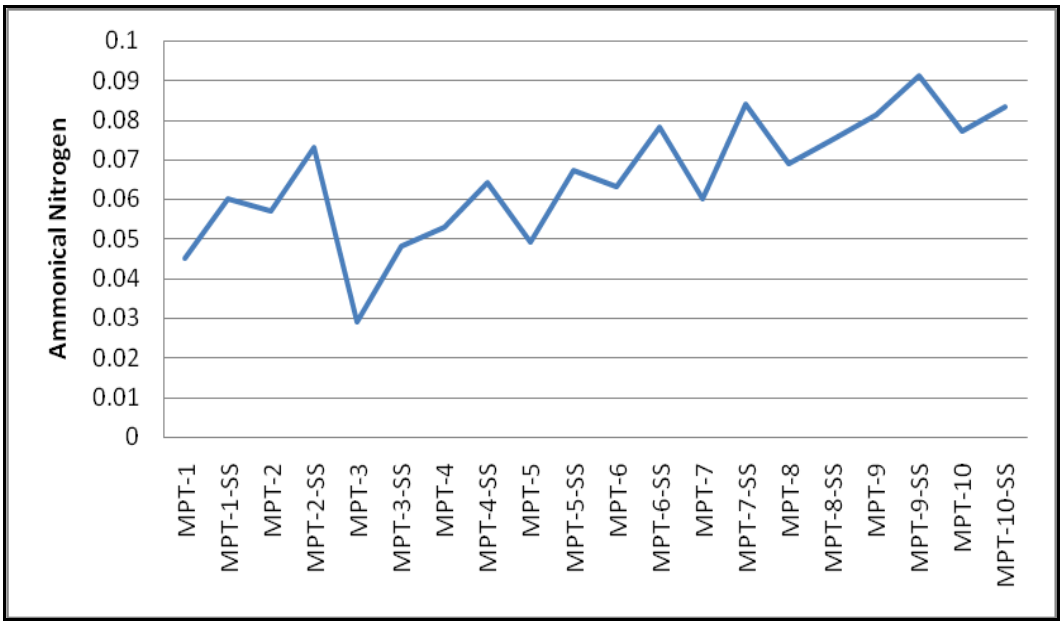


Figure-3.20: Ammonical nitrogen recorded at various stations

Total Nitrogen

Total nitrogen values ranged from 15.16 to 37.89µmol/l. The minimum value was at MPT-1-ss and the maximum value was recorded at MPT-9-ss (Figure-3.21). The National Institute of Ocean Technology (NIOT, 2004), Technical wing of Ministry of Earth Sceinces, Govt. of India, reported the total nitrogen value of Ennore Creek & north Chennai Coastal water as 56.8-294µmol/l, which is much more than the values recorded in this study.

Total Phosphorus

It ranged from 2.67 to 4.19 µmol/l with minimum value was recorded at MPT-1 and the maximum value was at MPT-6-ss (Figure-3.22). The higher values of total phosphorus in the deep waters is due to upwelling of the bottom waters

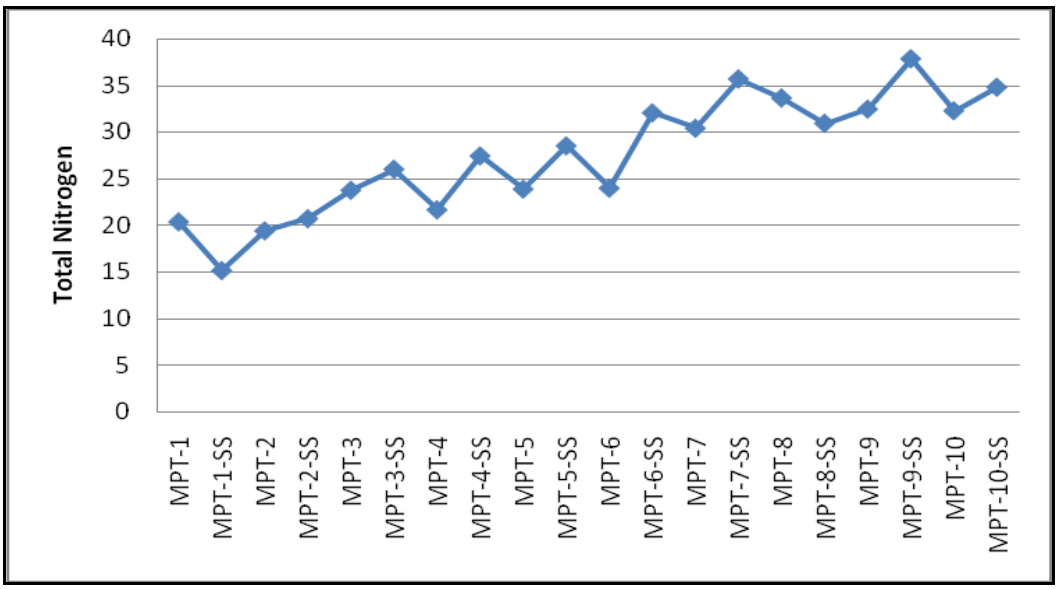


Figure-3.21: Total nitrogen recorded at various stations

.

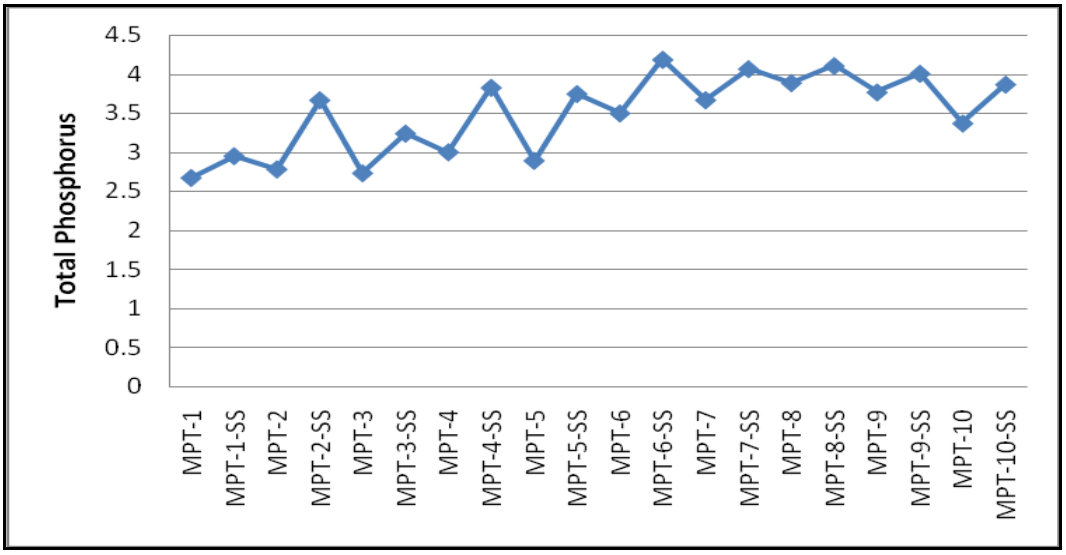


Figure-3.22: Total phosphorous recorded at various stations

Inorganic Phosphate

The inorganic phosphate values ranged between 0.55 and 2.87µmol/l with maximum value was recorded at MPT-8-ss and the minimum was at MPT-2 (Figure-3.23). Posphate levels were within the standards of 15 µmol/l specified for coastal water.

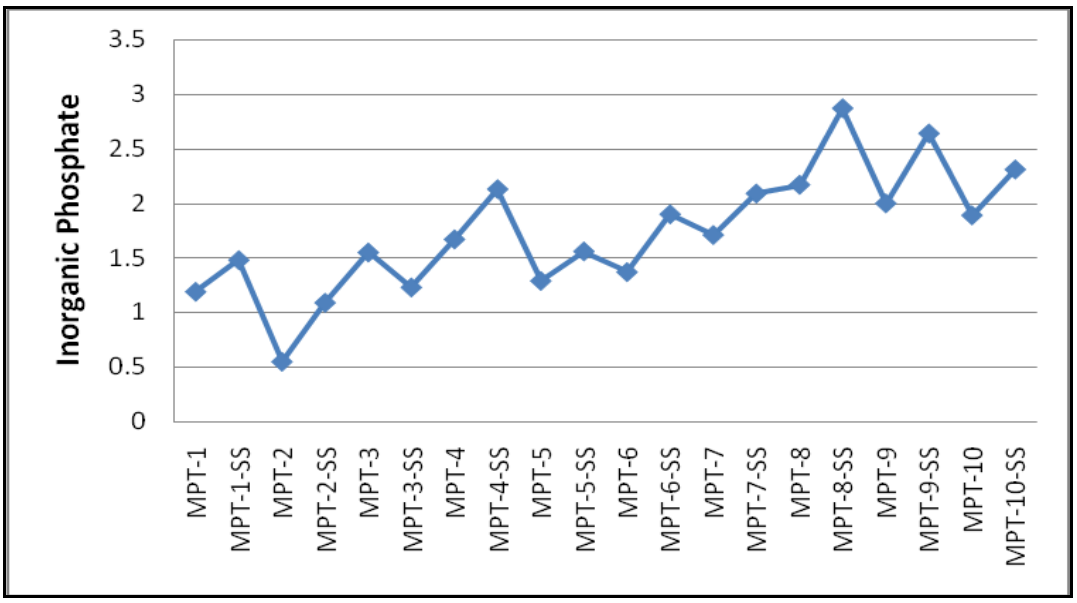


Figure-3.23: Inorganic phosphate recorded at various stations

Reactive Silicate

The silicate values ranged between 21.37 and 43.78µmol/l. The minimum (21.37 µmol/l) and the maximum (43.78µmol/l) values were recorded at MPT-4 and MPT-10-ss respectively (Figure-3.24).

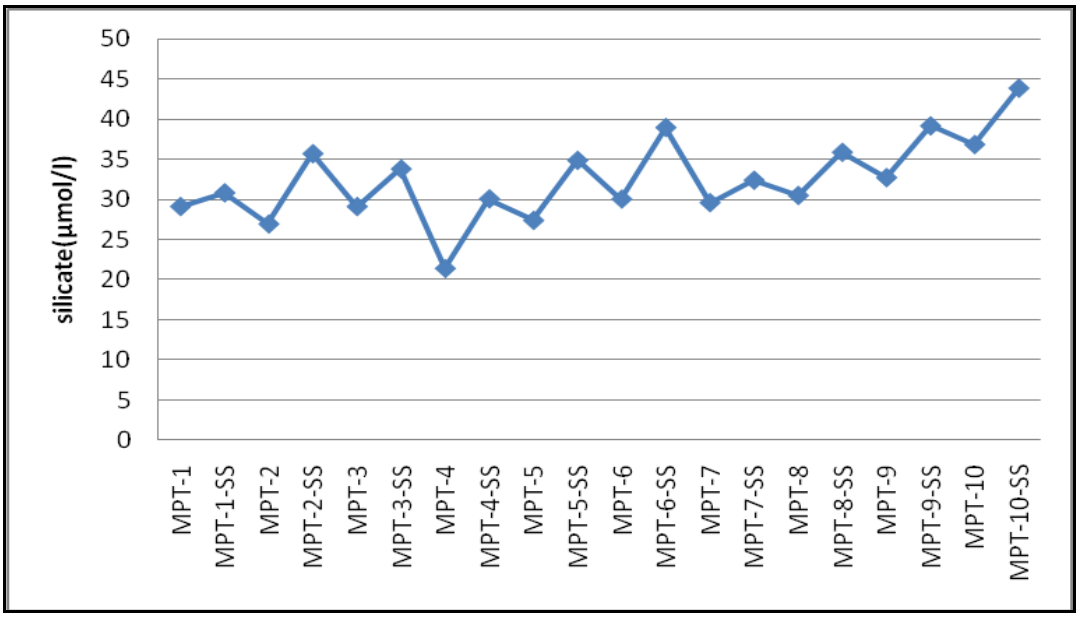


Figure-3.24: Reactive silicate levels recorded at various stations

Petroleum Hydrocarbons

PHC level in water fluctuated from 1.467 and 1.973µg/l. The maximum was recorded at MPT-9-ss and the minimum was recorded at MPT-3-ss (Figure-3.25). similar pattern was reported by National Institute of Oceanography (NIO, 2002) at Kandla Port area.

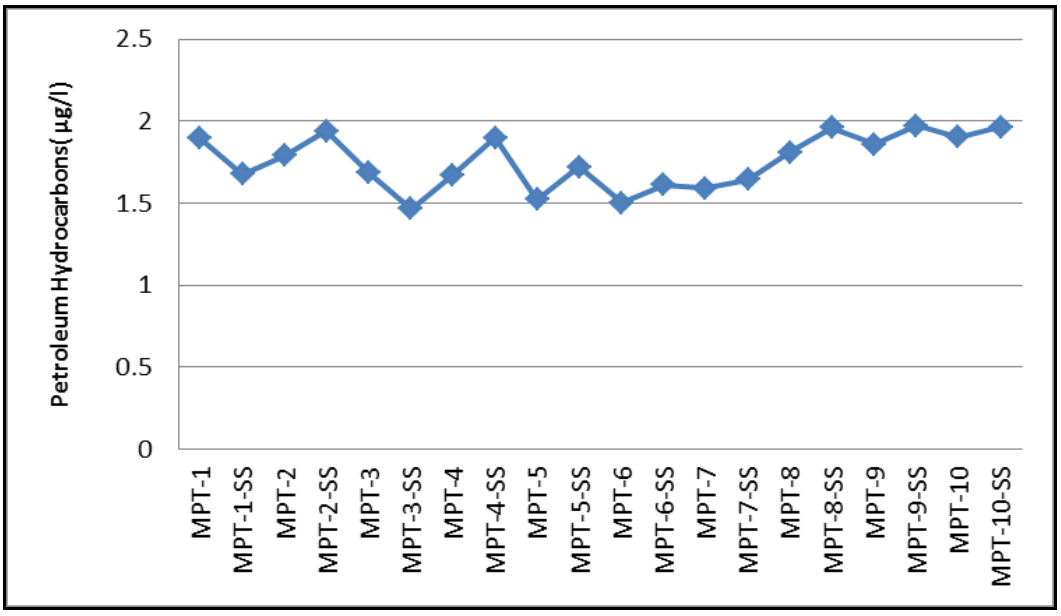


Figure-3.25: Petroleum hydrocarbons level recorded at various stations

Heavy Metals in water samples

The heavy metal present in the water sample is given in Table-3.18.

Table– 3.18: Heavy Metals Recorded in various Water Samples

ST.Code	Fe	Zn	Mn	Cd	Ni	Cr	Pb	Cu	Hg
	(µg/l)								
MPT-1	18.23	15.78	31.27	1.00	1.14	2.70	2.40	3.92	0.31
MPT-1-SS	20.31	18.89	29.47	0.97	1.01	2.45	2.63	4.75	0.39
MPT-2	15.71	16.31	23.89	1.09	1.13	2.63	2.89	3.39	0.33
MPT-2-SS	17.05	19.54	25.37	0.83	1.27	2.89	2.55	3.51	0.38
MPT-3	16.74	20.97	32.87	0.58	1.12	1.63	2.47	4.57	0.28
MPT-3-SS	23.89	22.89	33.69	0.64	1.17	1.90	2.20	4.82	0.32
MPT-4	19.78	19.08	27.83	0.89	0.32	1.73	2.78	5.82	0.36
MPT-4-SS	21.32	21.67	29.59	0.78	0.68	2.10	2.93	6.13	0.39
MPT-5	24.71	20.90	28.03	0.95	0.55	2.08	3.36	4.98	0.37
MPT-5-SS	20.01	23.87	31.93	1.20	0.89	2.38	3.09	3.91	0.41
MPT-6	20.88	18.34	30.93	0.81	0.71	2.21	2.79	4.19	0.40
MPT-6-SS	25.56	20.09	32.65	0.79	0.93	2.64	3.59	4.59	0.44
MPT-7	22.03	23.67	28.89	0.94	0.56	2.88	3.24	4.98	0.36
MPT-7-SS	21.61	19.81	30.30	0.88	0.79	3.03	3.89	4.75	0.38
MPT-8	22.83	21.56	30.67	1.09	0.99	3.10	3.65	5.04	0.39
MPT-8-SS	25.35	23.89	31.87	1.37	1.13	3.47	3.98	5.43	0.47
MPT-9	20.76	20.44	34.57	1.05	1.05	3.00	3.66	5.19	0.32
MPT-9-SS	24.53	22.36	36.72	1.23	1.35	3.27	4.78	6.86	0.37
MPT-10	19.25	19.93	30.78	0.98	1.03	2.58	3.00	4.58	0.34
MPT-10-SS	21.04	21.18	33.12	1.11	1.17	2.79	3.34	5.84	0.38

Iron

The iron level varied from 15.71 to 25.56µg/l (Figure-3.26). The maximum value was recorded at MPT-6-ss and the minimum value was recorded at MPT-2 during this survey. Mesquita and Kaisary (2002) recorded lower levels (3-15.7µg/l) of Iron in Zuari estuary.

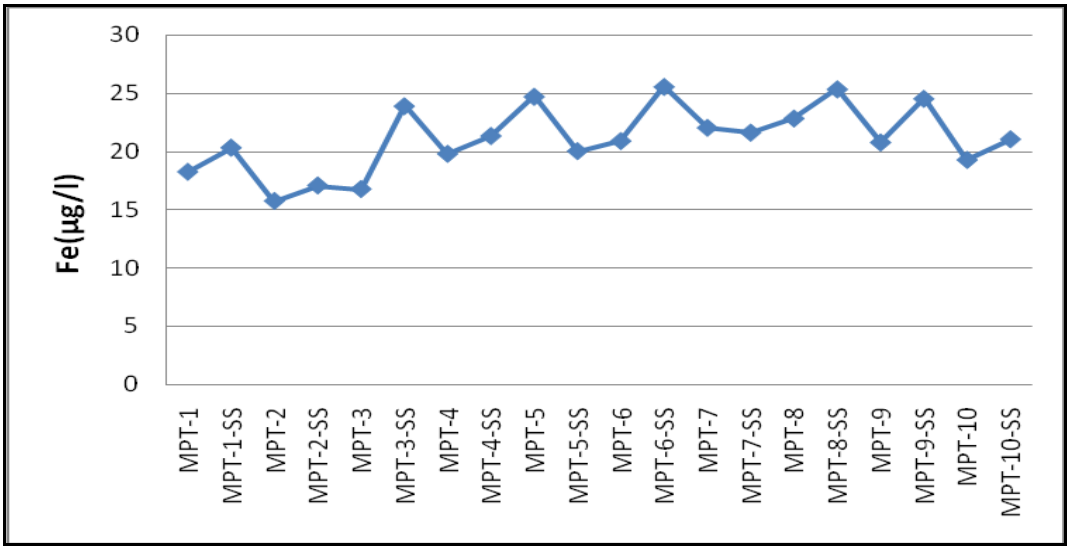


Figure-3.26: Iron level recorded at various stations

Zinc

The zinc level varied from 15.78 to 23.89 µg/l (Figure-3.27). The maximum was recorded at MPT-8-ss and the minimum was recorded at MPT-1 during this survey. Zinc is an essential trace element which is required in minimum quantity for the wellbeing of the aquatic animals.

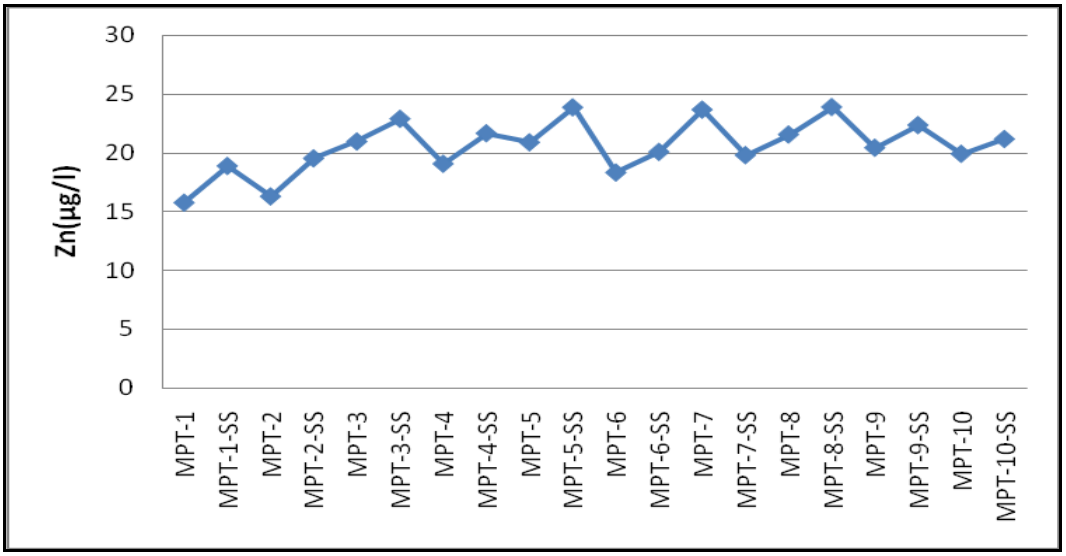


Figure-3.27: Zinc level recorded at various stations

Manganese

The Manganese level varied from 23.89 to 36.72µg/l (Figure-3.28). The maximum was recorded at MPT-9-ss and the minimum was recorded at

MPT-2 during this survey. As in Iron, Mesquita and Kaisary (2002) recorded lower (4-14µg/l) level of manganese in Zuari estuary.

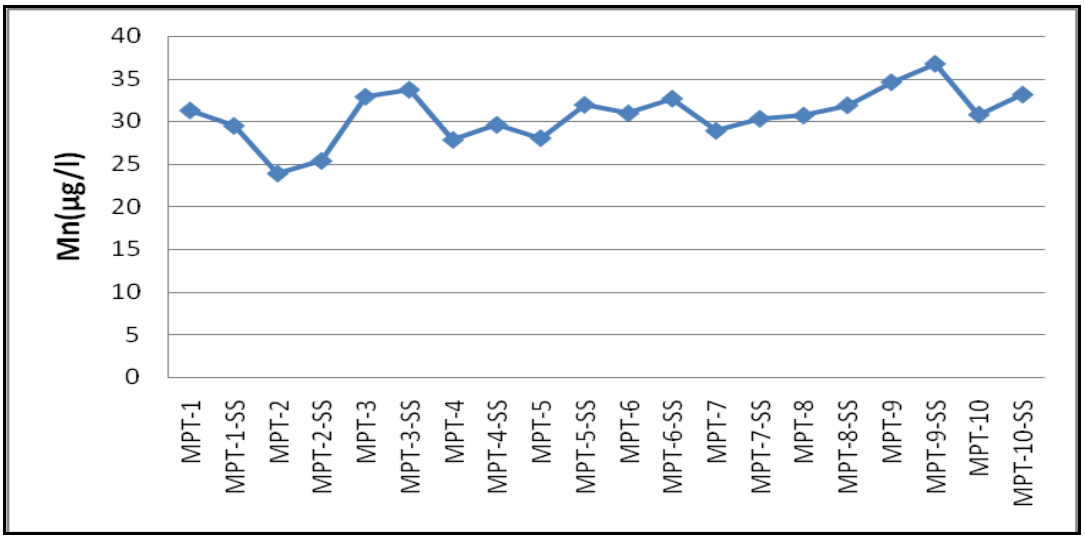


Figure-3.28: Manganese recorded at various stations

Cadmium

The Cadmium level varied from 0.58 to 1.37µg/l (Figure-3.29). The maximum was recorded at MPT-8-ss and the minimum was recorded at MPT-3 during this survey.

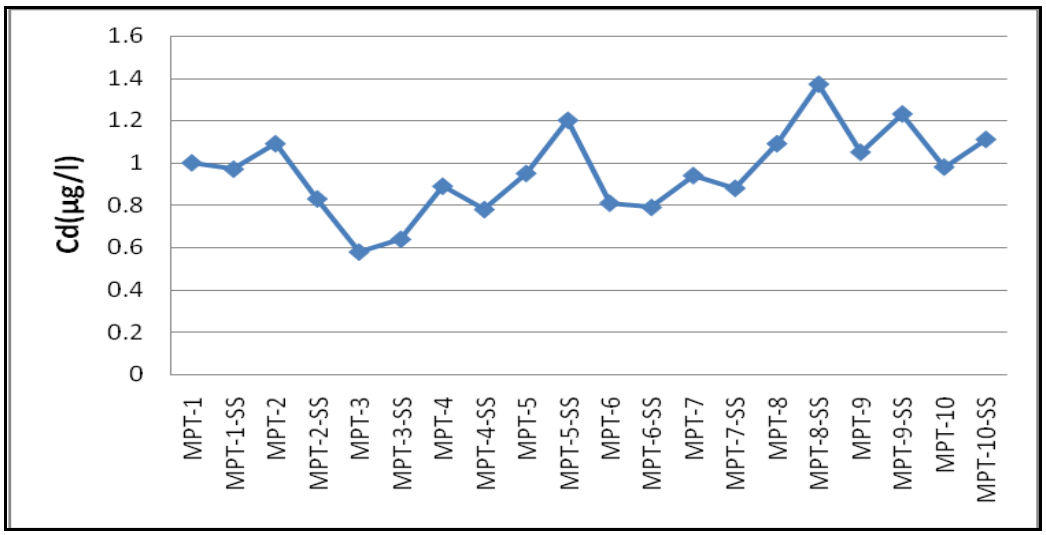


Figure-3.29: Cadmium level recorded at various stations

Nickel

The Nickel level varied from 0.32 to 1.35µg/l (Figure-3.30). The maximum level was recorded at MPT-9-ss and the minimum was recorded at MPT-4 during this survey.

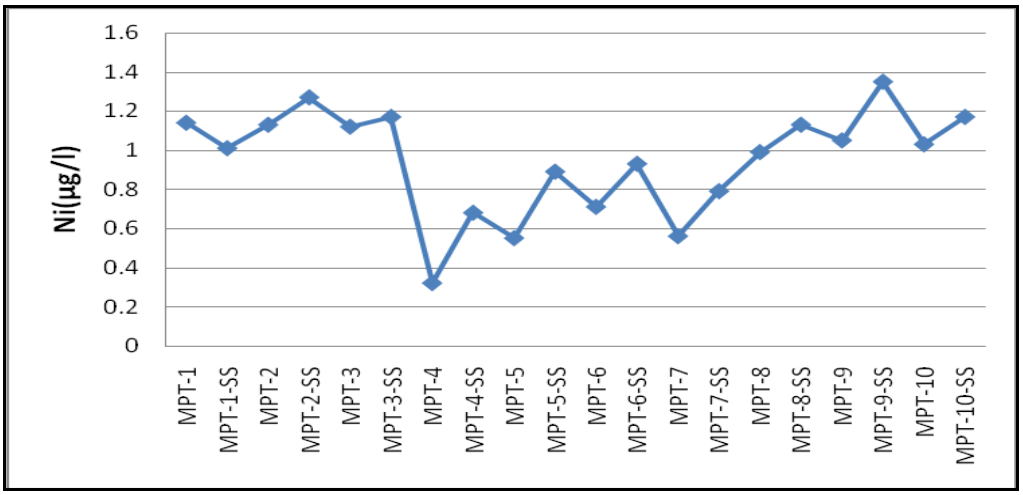


Figure-3.30: Nickel level recorded at various stations

Chromium

The chromium level varied from 1.63 to 3.47µg/l (Figure-3.31). The maximum value was recorded at MPT-8-ss and the minimum was recorded at MPT-3 during this survey.

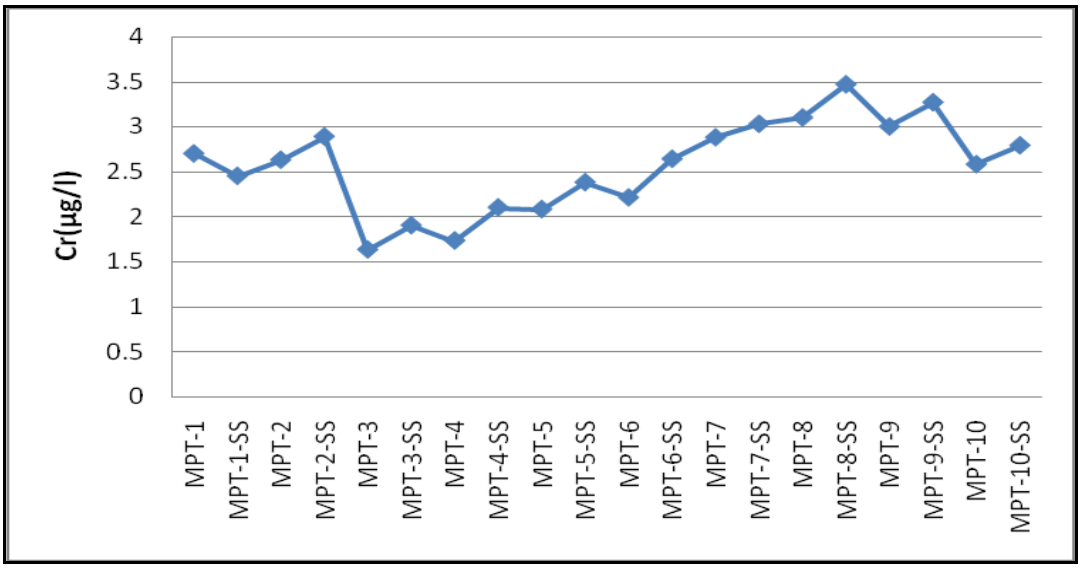


Figure-3.31: Chromium level recorded at various stations

Lead

The Lead level ranged from 2.20 to 4.78µg/l (Figure-3.32) with maximum value was recorded at MPT-9-ss and the minimum was recorded at MPT-3 during this survey.

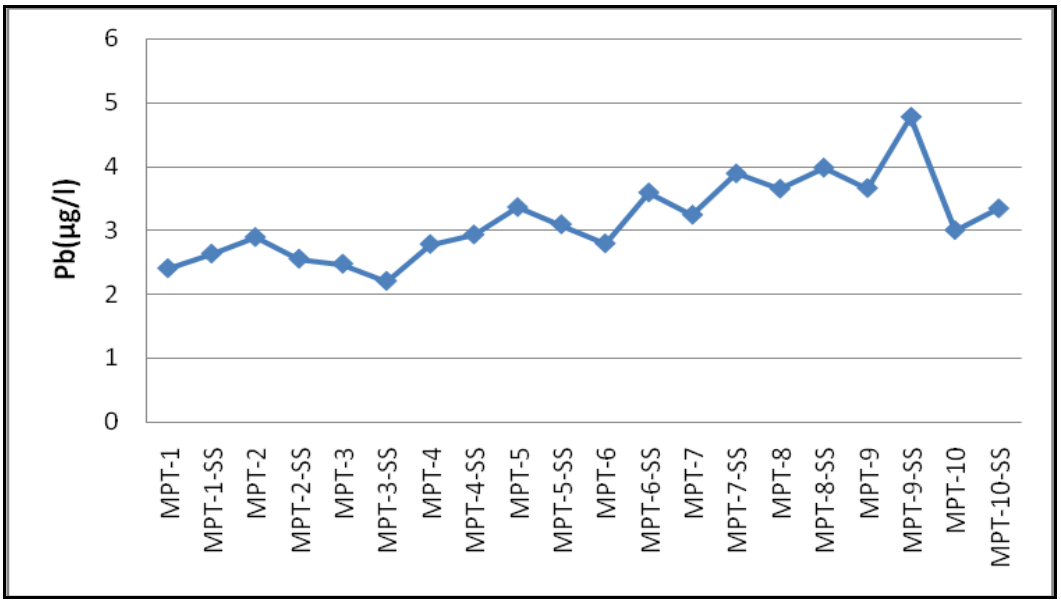


Figure-3.32. Lead level recorded at various stations

Copper

The copper level varied from 3.39 to 6.86µg/l (Figure-3.33). The maximum was recorded at MPT-9-ss and the minimum was recorded at MPT-2 during this survey.

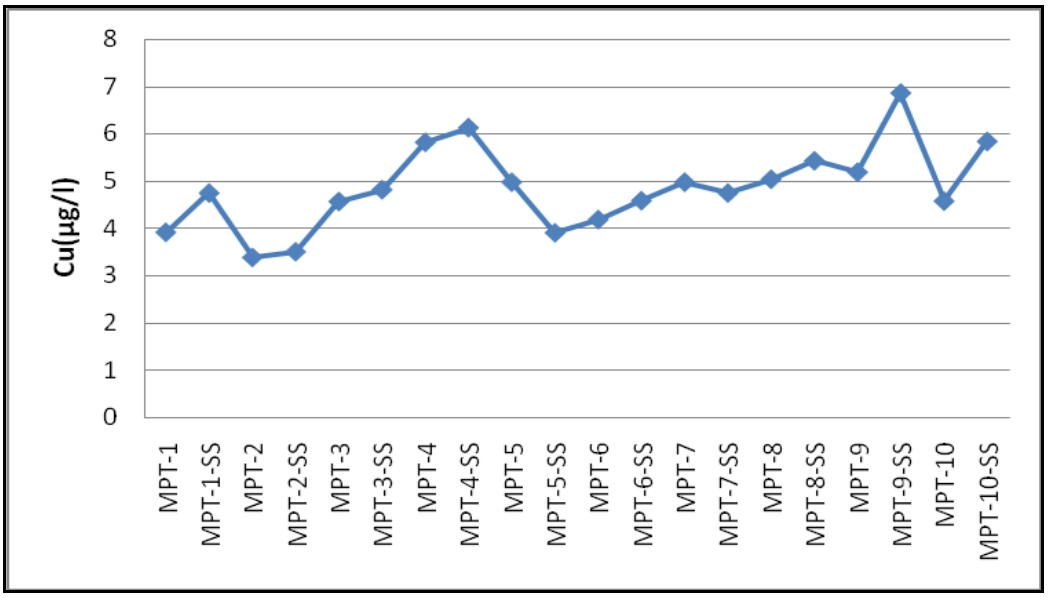


Figure-3.33: Copper level recorded at various stations

Mercury

The mercury level varied from 0.28 to 0.47µg/l (Figure-3.34). The maximum value was recorded at MPT-8-ss and the minimum was recorded at MPT-3 during this survey. However mercury is found to be toxic when it reaches a concentation of 1.8 µg/L (Shirodkar et al. 2010) and therefore the level is well within the safe range.

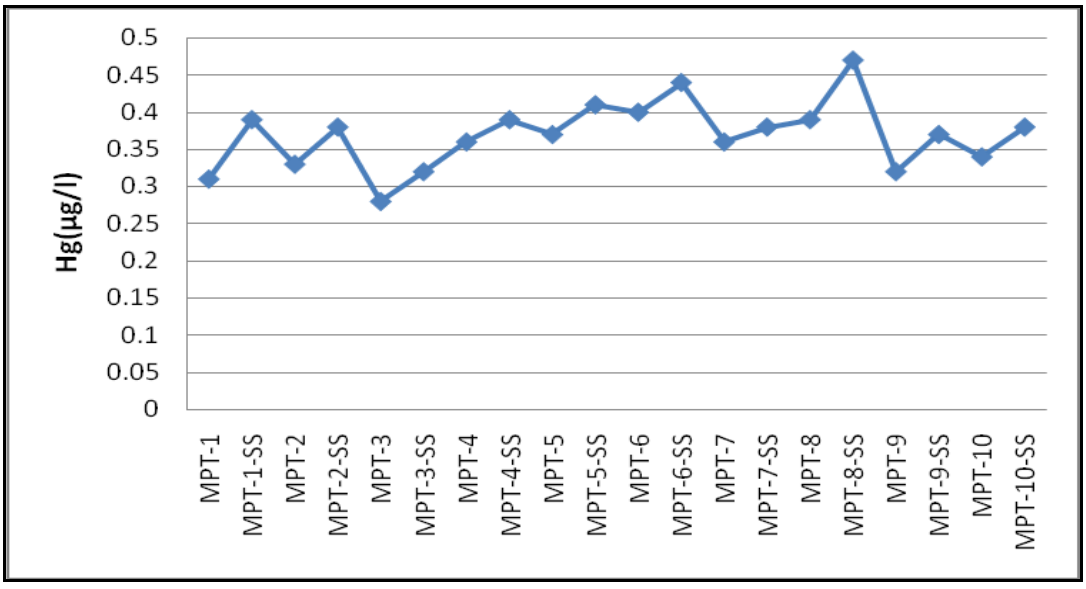


Figure-3.34: Mercury level recorded at various stations

3.16.2 SEDIMENT CHARACTERISTICS

As regards soil texture, the sand, silt and clay fraction at each station along with their textural classification indicated that the sand and silt composition was higher when compared to clay during this survey. The results of sediment analysis is given in Table-3.19.

Table–3.19: Sediment Sample analysed in Madhwad coastal waters

St. Code	Sediment pH	Sand (%)	Silt (%)	Clay (%)	TOC (mgC/g)	Sediment PHC (µg/g)
MPT-1	8.1	70.79	25.06	4.15	4.81	0.735
MPT-2	8.3	72.21	24.67	3.12	5.93	0.530
MPT-3	8.6	64.04	27.07	8.89	6.59	0.471
MPT-4	8.4	82.32	14.40	3.28	5.07	0.678
MPT-5	8.5	76.35	22.04	1.61	6.52	0.594
MPT-6	8.2	78.57	18.38	3.05	8.10	0.773
MPT-7	8.7	71.47	23.22	5.31	5.79	0.634
MPT-8	8.6	80.22	12.15	7.63	6.17	0.742
MPT-9	8.8	31.23	60.01	8.76	5.52	0.800
MPT-10	8.4	13.18	66.70	20.13	4.59	0.710

Sediment pH

The sediment pH varied from maximum of 8.8 at MPT-9 and minimum of 8.1 at station MPT-1 (Figure-3.35).

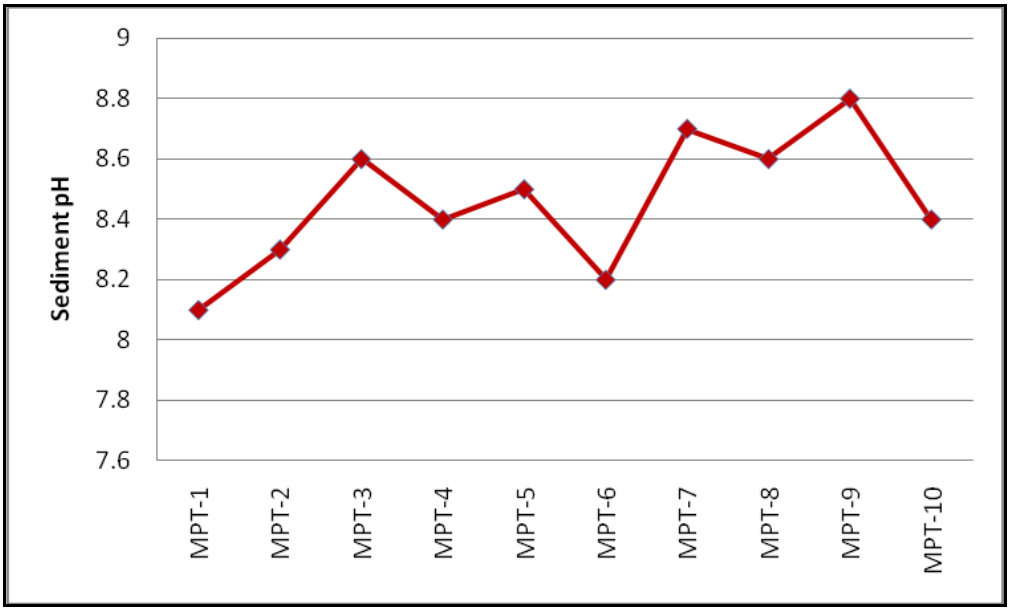


Figure-3.35: Sediment pH recorded at various stations

Texture

The sand content varied from 13.18 to 82.32 % with maximum value at MPT-4 and the minimum at MPT-10; maximum silt content (66.70%) was found to be at MPT-10 and minimum (12.15%) at MPT-8 and the maximum clay (20.13%) was found to be at MPT-10 and minimum (1.61%) at MPT-5 (Figure-3.36).

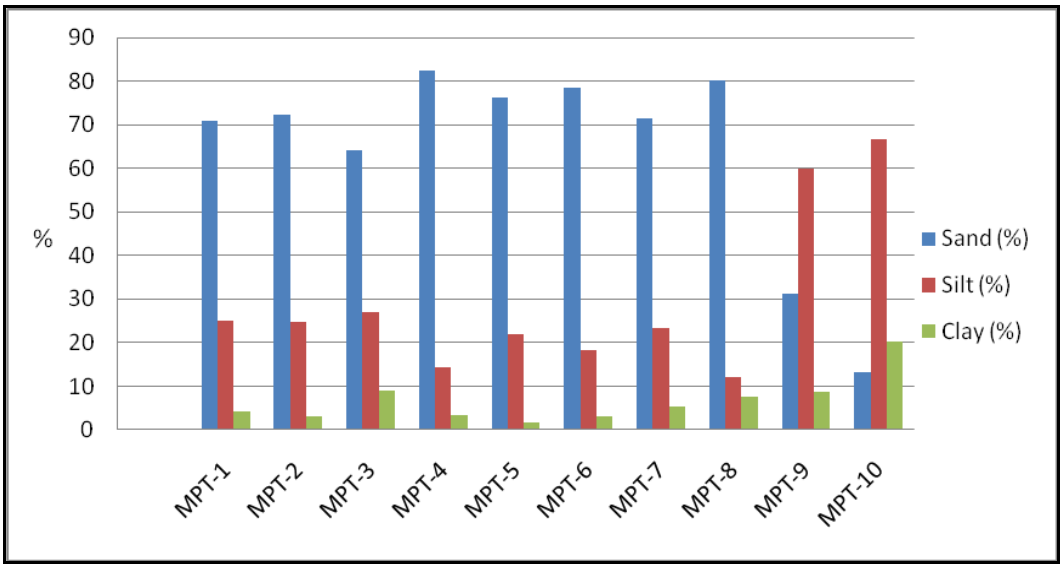


Figure-3.36: Variations in texture recorded in various stations

Total Organic Carbon

The Total Organic Carbon level ranged between 4.59 and 8.10 mgC/g. The maximum level (8.10 mgC/g) was found at MPT-6 and minimum (4.59 mgC/g) at MPT-10 (Figure-3.37).

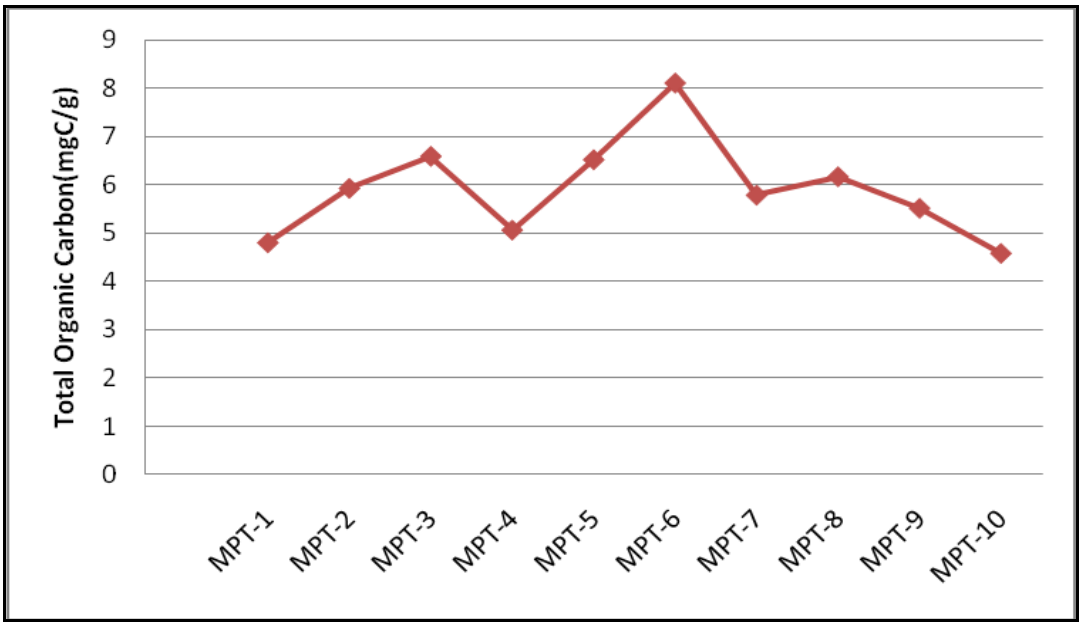


Figure-3.37: Total Organic Carbon recorded in various stations

Sediment PHC

The Sediment PHC level varied from 0.471 to 0.800 µg/g (Figure-3.38). The maximum was recorded at MPT-9 and the minimum was recorded at MPT-3 during this survey.

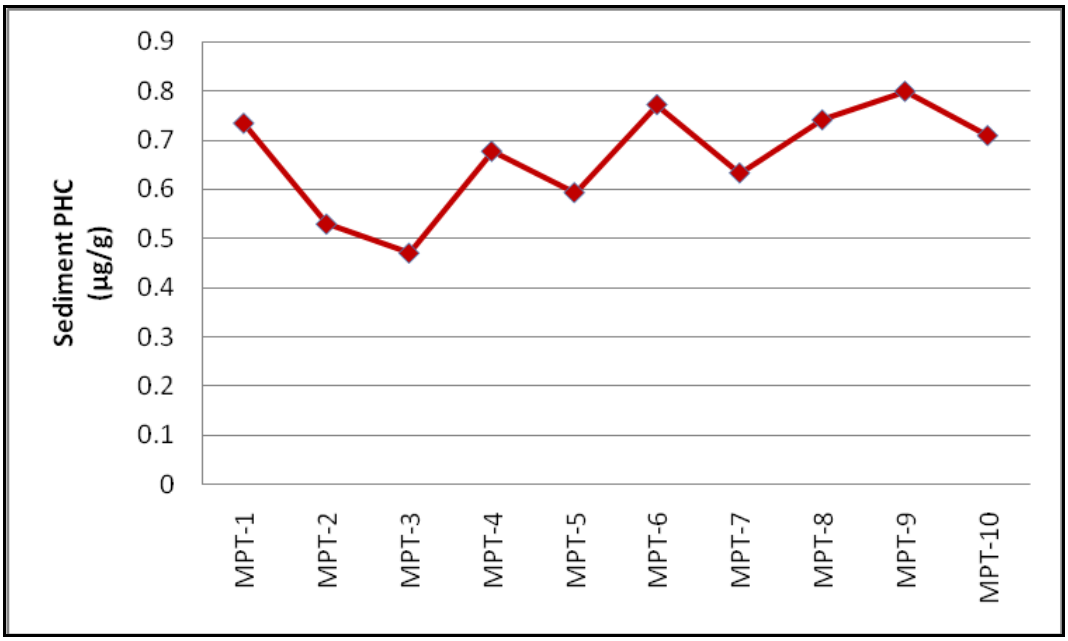


Figure-3.38: Sediment PHC level recorded at various stations

Heavy Metals in sediments

The concentration of heavy metals in sediment samples indicates that it is well within the ERM (Effective Range Median) which means there are no possibilities of Heavy metal contamination in the region. Similarly sediment samples showed more concentrations compared to water samples. The results of analysis of heavy metal in the sediments are given in Table-3.20.

Table–3.20: Heavy Metals Recorded in Sediment Samples

St. Code	Fe	Zn	Mn	Cd	Ni	Cr	Pb	Cu	Hg
	(µg/g)								
MPT-1	4230	25.90	24.89	4.93	15.71	6.41	4.90	16.93	0.49
MPT-2	5145	22.71	29.13	3.30	16.31	5.32	5.34	13.89	0.56
MPT-3	5532	14.57	25.82	5.93	14.96	4.30	6.47	17.65	0.20
MPT-4	6082	23.36	33.89	3.51	10.34	7.85	5.59	15.49	0.53
MPT-5	4390	18.31	37.37	2.50	17.69	8.00	4.34	20.83	0.35
MPT-6	5193	25.93	30.45	5.33	12.54	5.78	6.01	23.92	0.40
MPT-7	4872	20.72	39.88	4.03	15.02	6.67	6.73	21.74	0.58
MPT-8	5301	30.29	40.02	6.39	11.75	8.18	5.16	22.21	0.68
MPT-9	6784	23.88	36.23	5.38	19.83	6.05	8.37	28.31	0.49
MPT-10	5081	27.41	52.78	4.73	15.78	7.38	6.75	25.64	0.55

Iron

The Iron level varied from 4230 to 6784µg/g (Figure-3.39). The maximum was recorded at MPT-9 and the minimum was recorded at MPT-1 during this survey.

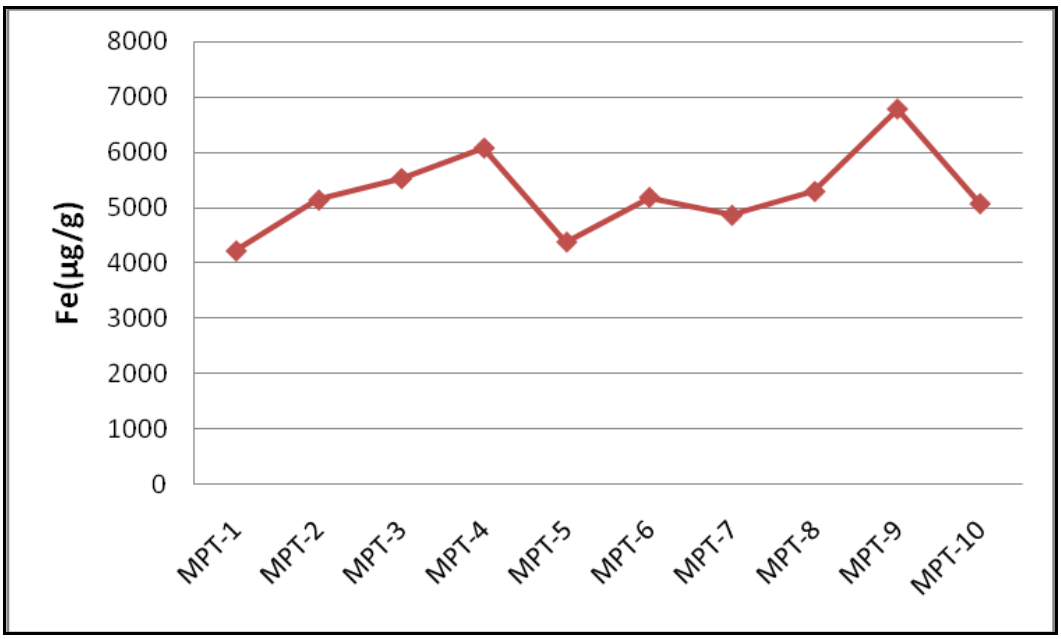


Figure-3.39: Iron level recorded at various stations.

Zinc

Zinc level varied from 14.57 to 30.29µg/g (Figure-3.40). The maximum was recorded at MPT-8 and the minimum was recorded at MPT-3 during this survey.

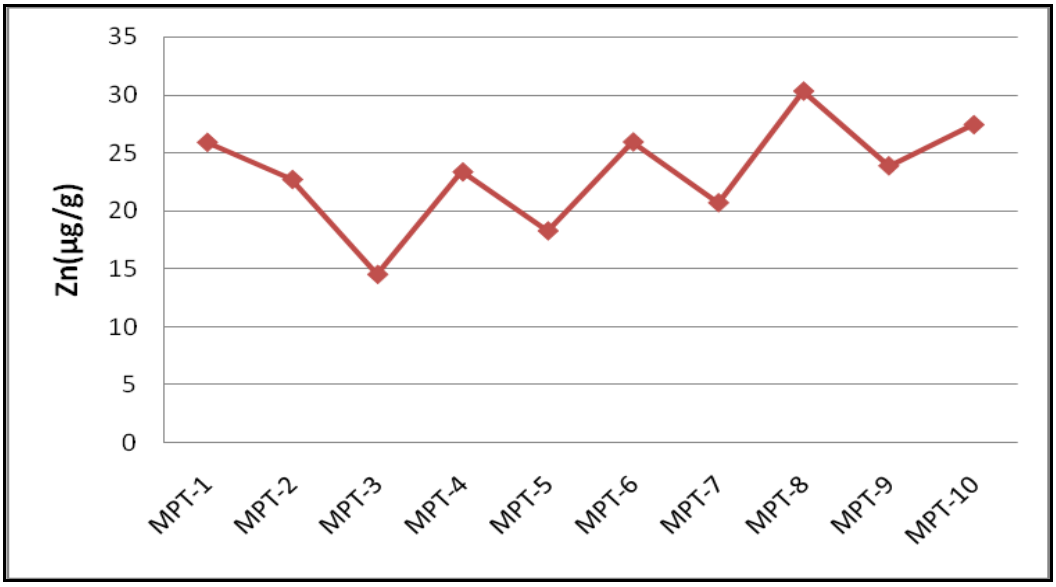


Figure-3.40: Zinc level recorded at various stations

Manganese

The Manganese level varied from 24.89 to 52.78µg/g (Figure-3.41). The maximum was recorded at MPT-10 and the minimum was recorded at MPT-1during this survey.

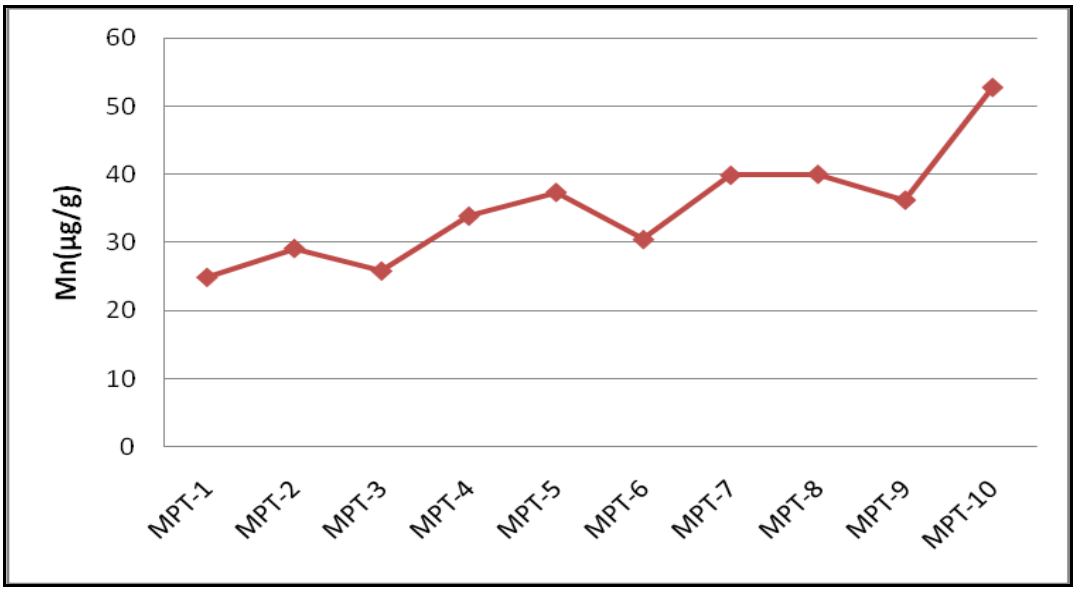


Figure-3.41: Manganese level recorded at various stations

Cadmium

The Cadmium level varied from 2.50 to 6.39µg/g (Figure-3.42). The maximum was recorded at MPT-8 and the minimum was recorded at MPT-5 during this survey.

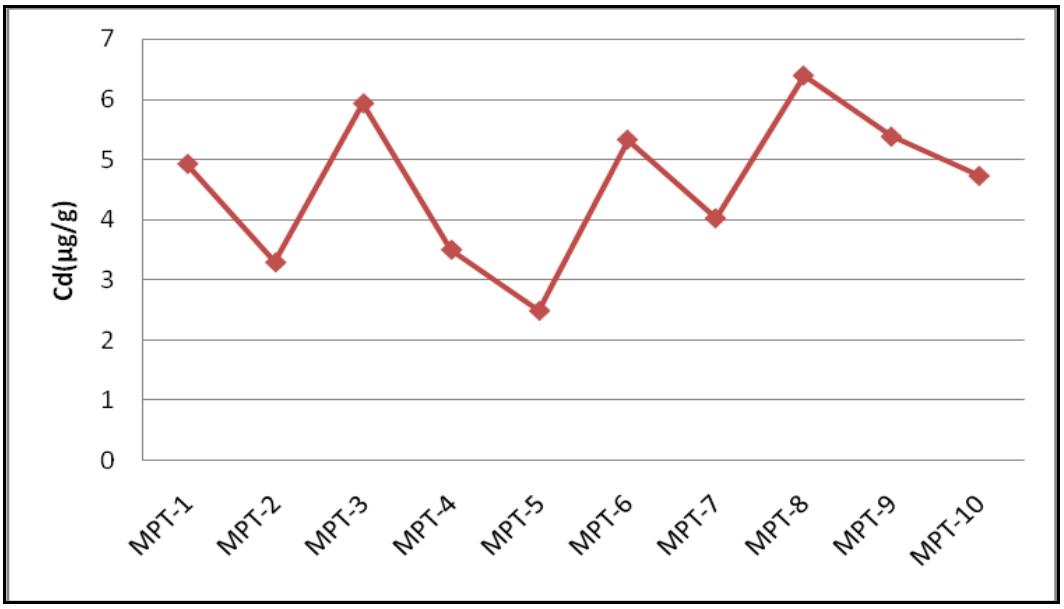


Figure-3.42: Cadmium level recorded at various stations

Nickel

The nickel level varied from 10.34 to 19.83µg/g (Figure-3.43). The maximum was recorded at MPT-9 and the minimum was recorded at MPT-4 during this survey.

Chromium

The Chromium level varied from 4.30 to 8.18µg/g (Figure-3.44). The maximum was recorded at MPT-8 and the minimum was recorded at MPT-3 during this survey.

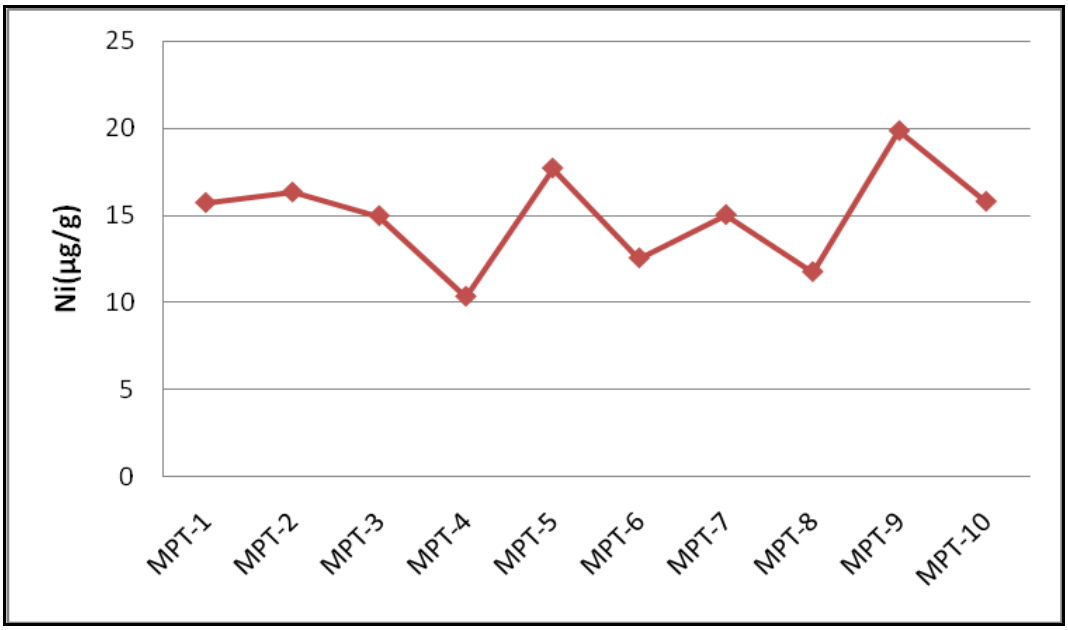


Figure-3.43: Nickel level recorded at various stations

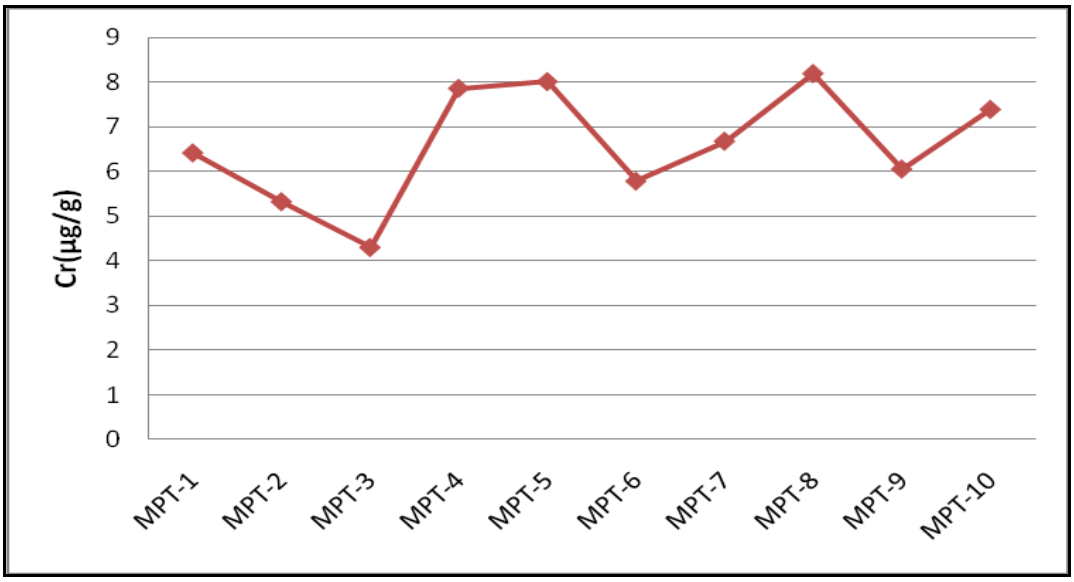


Figure-3.44: Chromium level recorded at various stations

Lead

The lead level varied from 4.34 to 8.37µg/g (Figure-3.45). The maximum was recorded at MPT-9 and the minimum was recorded at MPT-5 during this survey.

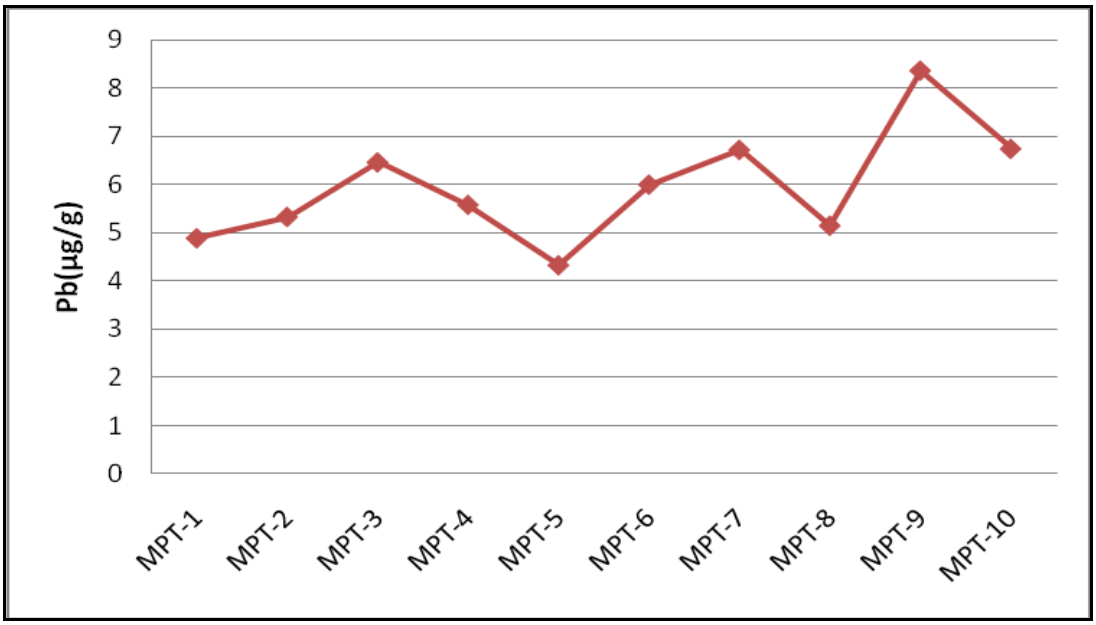


Figure-3.45: Lead level recorded at various stations

Copper

The copper level varied from 13.89 to 28.31µg/g (Figure-3.46). The maximum was recorded at MPT-9 and the minimum was recorded at MPT-2 during this survey.

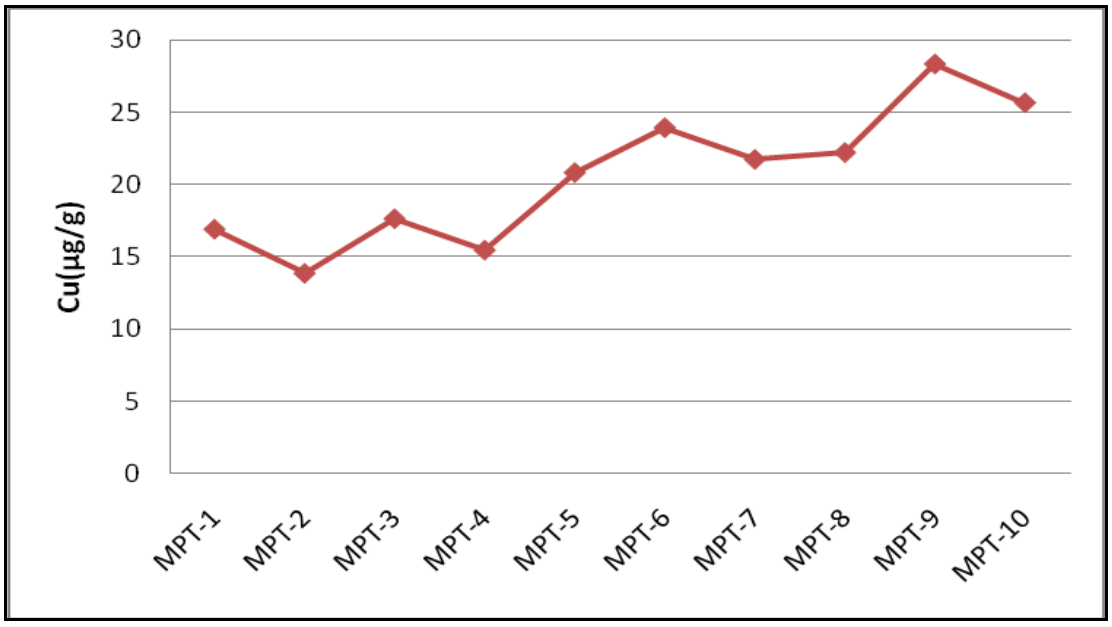


Figure-3.46: Copper level recorded at various stations

Mercury

The lead level varied from 0.20 to 0.68µg/g (Figure-3.47). The maximum was recorded at MPT-8 and the minimum was recorded at MPT-3 during this survey.

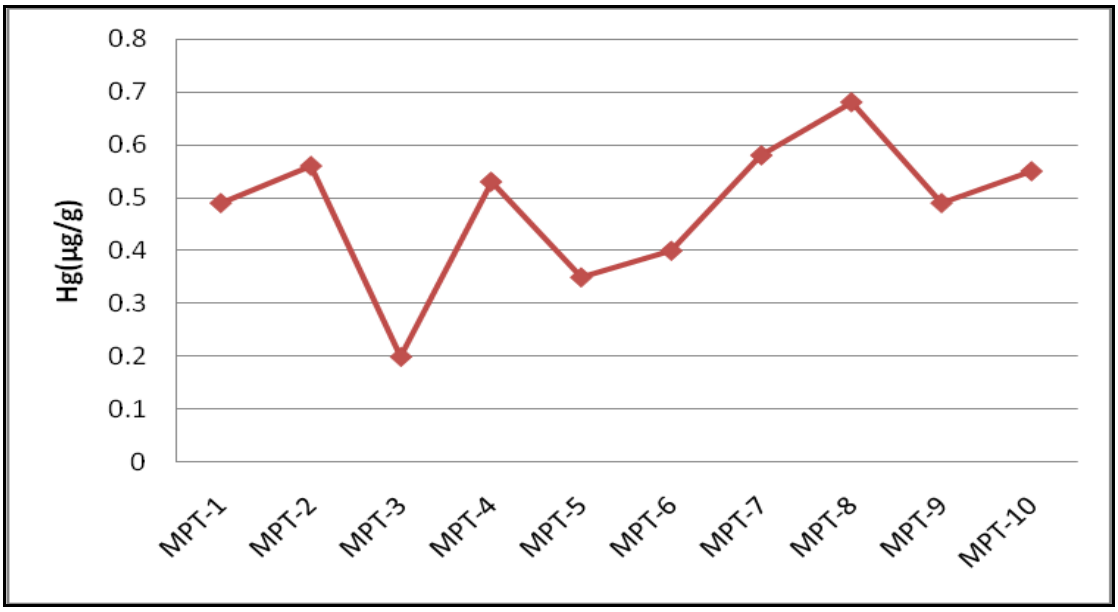


Figure-3.47: Mercury level recorded at various stations

3.16.3 MICROBIOLOGY

Water Samples

The total viable count in water samples ranged from $16x10^1$ to $36x10^2$CFU/ml. The maximum count was found at MPT-9 and the minimum count was found at MPT-4. The Total coliform count in the samples varied from 16 $x10^1$ to 30 $x10^2$ CFU/ml with the high colony count was observed at MPT-9 and the low count was observed at MPT-5. The *E. coli* count ranged from $06x10^1$ to $18x10^2$ CFU/ml with a maximum value was found at MPT-9 and the low values were found at MPT-4. The *Faecal coliform* was found to vary from $10x10^1$ to$26x10^2$ CFU/ml with high values was found at MPT-10 and the low value was found at MPT-4. The

Streptococcus faecalis count ranged from $08x10^1$ to $16x10^2$CFU/ml. The high values were recorded at MGL-8 and the low values were recorded at MGL-5. The *Shigella* count varied from $08x10^1$ to $20x10^2$ CFU/ml with a high value was found at MPT-10 and low value was found at MPT-2. The *Pseudomonas aeurginosa* count ranged from $08x10^1$ to $24x10^2$CFU/ml with high values was found at MPT-7 and the low values at MPT-2 & 4. The *Salmonella* colony count varied from $07x10^1$ to $23x10^2$ CFU/ml with the high values were found at MPT-8 and the low values at MPT-5. *Vibrio parahaemolyticus* colony count varied from $08x10^1$ to $24x10^2$ CFU/ml with the high values was found at MPT-7 and low values at MPT-5. The *Vibrio cholera* colony was found to have values from $17x10^1$ to $27x10^2$ CFU/ml. The high colony count was observed at MPT-9 and the low count was recorded at MPT-2 (Table-3.21). Shirodkar et al., 2012 studied the microbiology of both sediment and water samples of Mormugao harbour water and recorded similar range of bacterial population.

Sediment samples

With respect to sediment samples, the total viable count in sediment samples ranged from $27x10^3$ to $44x10^4$CFU/g. The maximum was found at MPT-9 and the minimum value was found at MPT-1&2. The Total coli form count in the samples varied from $17x10^3$ to $32x10^4$ CFU/g with the high colony count was observed at MPT-9 and the low count was observed at MPT-1. The *E. coli* count ranged from $15x10^2$ to $20x10^4$CFU/g with the high values was found at MPT-9 and the low value was found at MPT-1. The *Faecal coliform* count was found to vary from $15x10^2$ to $24x10^4$ CFU/g with the high value was found at MPT-10 and the low values was found at MPT-1. The *Streptococcus faecalis* count ranged from $13x10^2$ to $17x10^4$CFU/g. The high values were recorded at MPT-9 and the low values were recorded at MPT-1. The *Shigella* counts varied from $07x10^3$ to $21x10^4$CFU/g with the high values were found at MPT-10 and a low value was found at MPT-4. *Pseudomonas aeurginosa* counts ranged from

$11x10^2$ to $15x10^4$CFU/g with the high values were found at MPT-8 and the low values at MPT-2. Salmonella colony counts varied from $14x10^2$ to $24x10^4$CFU/g with the high values was found at MPT-8 and the low values at MPT-2. *Vibrio parahaemolyticus* colony count varied from $8x10^2$ to $23x10^4$ CFU/g with the high values was found at MPT-8 and low values at MPT-2. The other species *Vibrio cholerae* colony was found to have values from $11x10^2$ to $29x10^4$CFU/g with the high colony count was observed at MPT-9 and the low count was observed at MPT-2 (Table 3.22). Shirodkar et al., 2012 studied the microbiology of both sediment and water samples of Mormugao harbour water and recorded similar range of bacterial population.

Table-3.21: Bacterial population recorded in water samples recorded in various stations

Sl.No	Station Code	TC	VP	VC	SL	FC	EC	SH	PA	SF	TVC
1	MPT-1	$20x10^1$	$12 x10^1$	$22 x10^1$	$18 x10^1$	$19 x10^1$	$13x10^1$	$18x10^1$	$16 x10^1$	$11 x10^1$	$27 x10^1$
2	MPT-2	$18 x10^1$	$20 x10^1$	$17 x10^1$	$22 x10^1$	$18x10^1$	$10x10^1$	$13x10^1$	$08 x10^1$	$09 x10^1$	$20 x10^1$
3	MPT-3	$17 x10^1$	$21 x10^1$	$18 x10^1$	$10x10^1$	$20x10^1$	$17x10^1$	$09x10^1$	$10 x10^1$	$10 x10^1$	$25 x10^1$
4	MPT-4	$18x10^1$	$13 x10^1$	$20 x10^1$	$08 x10^1$	$10x10^1$	$06x10^1$	$12x10^1$	$08 x10^1$	$12x10^1$	$16 x10^1$
5	MPT-5	$16x10^1$	$08 x10^1$	$19 x10^1$	$07 x10^1$	$13 x10^1$	$12x10^1$	$13x10^1$	$12x10^1$	$08 x10^1$	$18 x10^1$
6	MPT-6	$22x10^2$	$10 x10^2$	$16 x10^2$	$12 x10^2$	$10 x10^2$	$08x10^2$	$09 x10^2$	$06 x10^2$	$10 x10^2$	$24 x10^2$
7	MPT-7	$25x10^2$	$24 x10^2$	$26 x10^2$	$13 x10^2$	$15x10^2$	$13x10^2$	$16x10^2$	$24 x10^2$	$10x10^2$	$24x10^2$
8	MPT-8	$24 x10^2$	$18 x10^2$	$22 x10^2$	$23 x10^2$	$16x10^2$	$13x10^2$	$17x10^2$	$11x10^2$	$16 x10^2$	$28 x10^2$
9	MPT-9	$30x10^2$	$15 x10^2$	$27 x10^2$	$20 x10^2$	$10 x10^2$	$18x10^2$	$11 x10^2$	$10 x10^2$	$15 x10^2$	$36 x10^2$
10	MPT-10	$28 x10^2$	$10 x10^2$	$15 x10^2$	$12 x10^2$	$26x10^2$	$08x10^2$	$20x10^2$	$13 x10^2$	$14 x10^2$	$31 x10^2$

Table-3.22: Bacterial population recorded in sediment samples collected in various stations

Sl. No	Station Code	TC	VP	VC	SL	FC	EC	SH	PA	SF	TVC
1	**MPT-1**	$17 x10^2$	$19 x10^2$	$20 x10^2$	$16 x10^2$	$15 x10^2$	$15x10^2$	$13 x10^2$	$13x10^2$	$13 x10^2$	$27 x10^2$
2	**MPT-2**	$18 x10^2$	$18 x10^2$	$11 x10^2$	$14x10^2$	$16x10^2$	$16x10^2$	$17x10^2$	$11x10^2$	$11 x10^2$	$27 x10^2$
3	**MPT-3**	$15 x10^3$	$16 x10^3$	$10 x10^3$	$18x10^3$	$19x10^3$	$15x10^3$	$11x10^3$	$10x10^3$	$09 x10^3$	$31 x10^3$
4	**MPT-4**	$13 x10^3$	$19 x10^3$	$24 x10^3$	$15 x10^3$	$16x10^3$	$13x10^3$	$07x10^3$	$08x10^3$	$14 x10^3$	$28 x10^3$
5	**MPT-5**	$11x10^3$	$16 x10^3$	$13 x10^3$	$11 x10^3$	$12 x10^3$	$13x10^3$	$19x10^3$	$09x10^3$	$09 x10^3$	$25 x10^3$
6	**MPT-6**	$20 x10^4$	$12 x10^4$	$16 x10^4$	$21x10^4$	$13x10^4$	$16x10^4$	$13x10^4$	$10x10^4$	$16x10^4$	$29 x10^4$
7	**MPT-7**	$28 x10^4$	$13 x10^4$	$20 x10^4$	$18 x10^4$	$22 x10^4$	$11x10^4$	$10 x10^4$	$12x10^4$	$13 x10^4$	$32 x10^4$
8	**MPT-8**	$29 x10^4$	$23x10^4$	$23 x10^4$	$24 x10^4$	$18 x10^4$	$17x10^4$	$18 x10^4$	$15 x10^4$	$15 x10^4$	$40 x10^4$
9	**MPT-9**	$32 x10^4$	$17 x10^4$	$29 x10^4$	$10 x10^4$	$21x10^4$	$20x10^4$	$12 x10^4$	$10 x10^4$	$17x10^4$	$44 x10^4$
10	**MPT-10**	$25 x10^4$	$15 x10^4$	$22 x10^4$	$13 x10^4$	$24 x10^4$	$19x10^4$	$21x10^4$	$09x10^4$	$11 x10^4$	$32 x10^4$

3.16.4 CHLOROPHYLL

Chlorophyll –a (mg/m^3), Phaeopigments (mg/m^3), and Total biomass

In the present study, the chlorophyll '*a*' in water sample varied from 0.425 to 2.546 mg/m^3 with maximum at MPT-7 and minimum at MPT-9. The Phaeopigments content varied from 0.332 to 1.718 mg/m^3 with maximum in MPT-6 and the minimum was observed in MPT-8 and the Total biomass values varied from 17.88 to 42.54 maximum at MPT-7 and minimum at MPT-9 (Table-3.23).. Gujarat Ecological Commission (1999) reported 0.7-0.9 µg/m3 of Chlorophyll-a from the Kandla port waters which is far lesser than our values.

Table-3.23: Chlorophyll *a*, Phaeopigments and total biomass

Stations	Chlorophyll (a) (mg/m^3)	Phaeopigments (mg/m^3)	Total biomass (ml/100m^3)
MPT-1	0.742	0.412	22.66
MPT-1-SS	0.821	0.405	20.42
MPT-2	0.853	0.342	21.37
MPT-2-SS	0.735	0.521	22.35
MPT-3	1.125	0.672	26.75
MPT-3-SS	0.98	0.742	25.87
MPT-4	1.465	0.843	28.18
MPT-4-SS	0.943	0.821	27.42
MPT-5	1.173	0.424	25.65
MPT-5-SS	0.88	0.583	27.56
MPT-6	1.946	1.718	37.65
MPT-6-SS	0.983	0.954	35.76
MPT-7	2.546	1.336	42.54
MPT-7-SS	1.545	0984	42.67
MPT-8	0.987	0.332	27.88
MPT-8-SS	0.923	0.467	25.45
MPT-9	0.425	0.428	17.88
MPT-9-SS	0.483	0.325	20.56
MPT-10	1.27	0.436	23.40
MPT-10-SS	0.983	0.542	22.45

3.16.5 PLANKTON

Phytoplankton

In the present study period, species belonging to three groups namely diatoms, dinoflagellates and blue greens were recorded. Of these, diatoms were found to be the dominant group with 40 species. Dinoflagellates formed next group with 5 species and blue greens came last in the order with 4 species in all the stations.

Among the diatoms, *Bellerochea malleus, Cerataulina orientalis, Coscinodiscus centralis, C. granii, Chaetoceros affinis, C. curvisetus, Leptocylindrus danicus, Skeletonema costatum, Diatoma anceps, Thalassionema nitzschioides, Triceratium favus*, *Cyclotella* sp. *Nitzschia* sp. *Planktonella sol, Odentella mobilensis, O. sinensis, Pleurosigma normani, Rhizosolenia alata, R. styliformis* and *Streptotheca* sp were found to be the commonly occurring species in the samples collected in various stations. Amongst dinoflagellates, *Ceratium furca, C. trichoceros, Prorocentrum micans* and *Protoperidinium oceanicum* and blue green *Anabeana* sp. and *Spirulina* sp. *Tricodesmium erythraeum* showed consistency in their occurrence in the samples collected in different stations of Marmugao port waters. Monitoring and Testing of Marine water & Sediment samples for Capital Dredging inside the Mormugao Port, Goa on 28/4/2016 by Dredging Corporation of India Ltd (DCI) accounted the similar range of population density, percentage composition and diversity indices of phytoplankton.

The abundance and density of Phytoplanktons at various sampling stations is given in Table-3.24.

Table-3.24: Abundance and density of Phytoplanktons at various sampling stations (Cells/lit)

Phytoplanktons	MPT-1	MPT-2	MPT-3	MPT-4	MPT-5	MPT-6	MPT-7	MPT-8	MPT-9	MPT-10
Blue greens										
Oscillatoria sp.	330	225	0	0	60	0	90	0	0	120
Lyngbya sp	330	10	0	225	0	105	85	180	135	0
Spirulina sp.	10	175	0	250	120	180	132	0	0	60
Tricodesmium erythraeum	330	570	135	750	255	60	180	0	90	30
Diatoms										
Bacteriastrum hyalinum	135	0	135	350	60	90	150	90	0	60
Bellerochea malleus	150	0	0	156	135	0	0	128	0	30
Cerataulina orientalis	315	90	315	0	0	240	0	90	90	0
Chaetoceros curvisetus	240	120	240	130	0	195	60	125	30	30
C. diversus	120	0	120	0	90	0	0	30	0	255
Coscinodiscus perferatus	15	120	15	145	0	125	60	150	120	0
C. centralis	90	75	90	150	210	240	125	90	75	0
C. gigas	0	225	185	0	0	0	120	0	75	90
C. granii	10	0	0	120	440	160	0	30	0	115
Coscinodiscus sp	250	40	60	0	15	0	60	30	0	0
Cyclotella sp.	125	0	0	60	105	60	30	75	90	125
Dinophysis sp	0	10	75	30	0	0	60	0	135	
Ditylum brightwelli	250	330	60	60	0	320	90	0	60	35
Diatoma anceps	0	200	452	90	125	0	120	105	0	0
Eucampia zoodicus	180	0	105	120	0	180	66	0	90	210
Fragilaria sp.	500	0	180	66	90	0	125	110	0	60
Grammatophora marina	50	330	90	0	0	30	120	45	0	30
Gyrosigma balticum	100	210	0	120	90	210	90	135	75	105
Leptocylindrus danicus	200	110	45	90	0	60	60	75	90	45
Lithodesmium undulatum	175	0	90	60	120	120	520	410	120	0
Navicula granulata	0	250	60	520	0	240	0	0	90	39

Phytoplanktons	MPT-1	MPT-2	MPT-3	MPT-4	MPT-5	MPT-6	MPT-7	MPT-8	MPT-9	MPT-10
Nitzschia closterium	175	0	360	0	135	0	60	60	0	90
N. longisima	155	120	30	120	60	0	75	0	0	45
Odontella aurita	0	0	0	75	0	135	450	125	145	30
O. mobiliensis	215	245	135	450	75	0	90	30	15	330
O. sinensis	150	450	0	90	0	255	450	30	90	220
Planktonella sol	165	0	0	450	0	90	90	0	125	220
Pleurosigma elongatum	105	135	375	90	0	105	180	185	*0	110
Pleurosigma normanii	0	85	0	180	165	0	150	90	45	0
Rhizosolenia alata	24	140	375	150	135	160	120	60	0	220
R. imbricate	145	0	135	120	0	0	30	0	0	133
R. styliformis	220	120	35	120	0	120	330	0	0	640
Skeletonema costatum	0	110	120	330	80	220	125	120	0	85
Stephanophysis palmeriana	90	140	0	125	0	330	0	0	120	135
Streptotheca sp	0	0	0	0	450	0	0	330	0	120
Thalassionema nitzschioides	0	120	120	0	220	0	330	330	60	45
Thalassiosira subtilis	200	0	0	330	0	120	120	0	0	0
Thalassiothrix frauenfeldii	45	35	120	120	0	155	120	0	55	120
Triceratium favus	150	0	0	120	65	120	330	330	0	45
T. reticulatum	150	80	0	110	410	135	0	220	210	210
Dinoflagellates										
Ceratium furca	50	120	120	240	65	80	220	220	120	0
C. tripos	455	1080	130	0	220	80	350	0	0	127
C. trichoceros	0	0	0	350	60	220	225	350	455	135
Prorocentrum micans	0	285	180	0	0	420	85	225	133	0
Protoperidinium oceanicum	105	120	0	350	0	150	225	0	0	510
Total	**6504**	**6475**	**4687**	**7412**	**4055**	**5510**	**6498**	**4603**	**2938**	**5009**

Population density

Density of phytoplankton varied from 2,938 to 7,412 Cells/l with maximum at MPT-4 and minimum at MPT -9 (Figure-3.48).

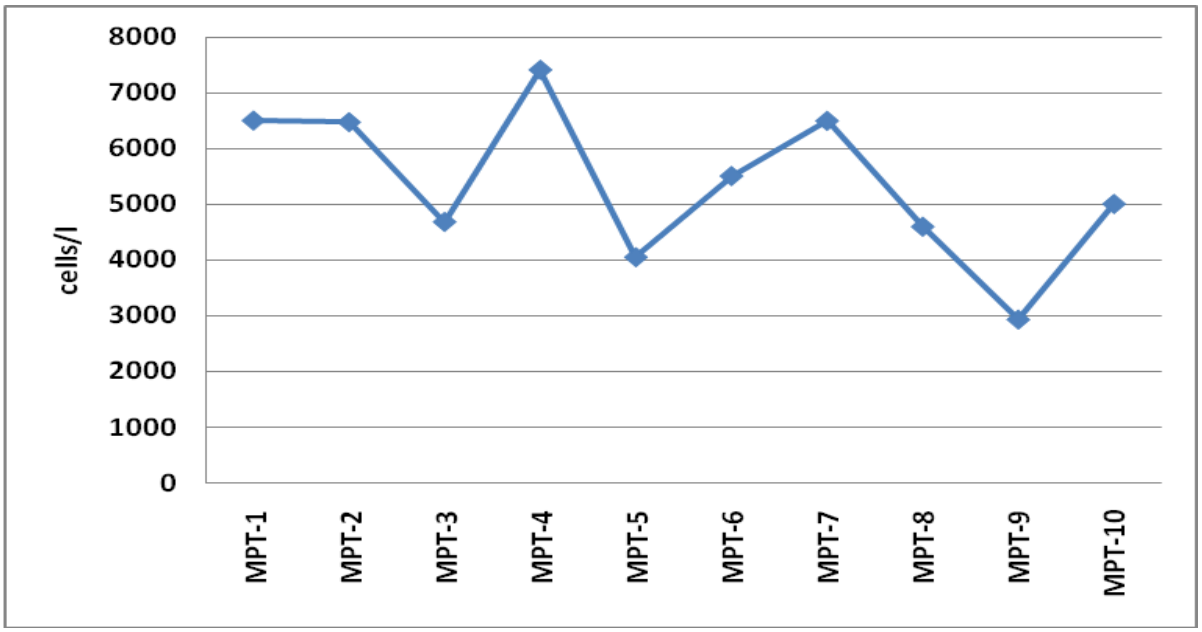


Figure-3.48: Population density of Phytoplankton recorded in various stations

Percentage composition

When the results of percentage composition of phytoplankton were viewed, diatoms constituted the maximum with 82% to the total followed by dinoflagellates with 10% and blue greens with 8% of the total (Figure-3.49).

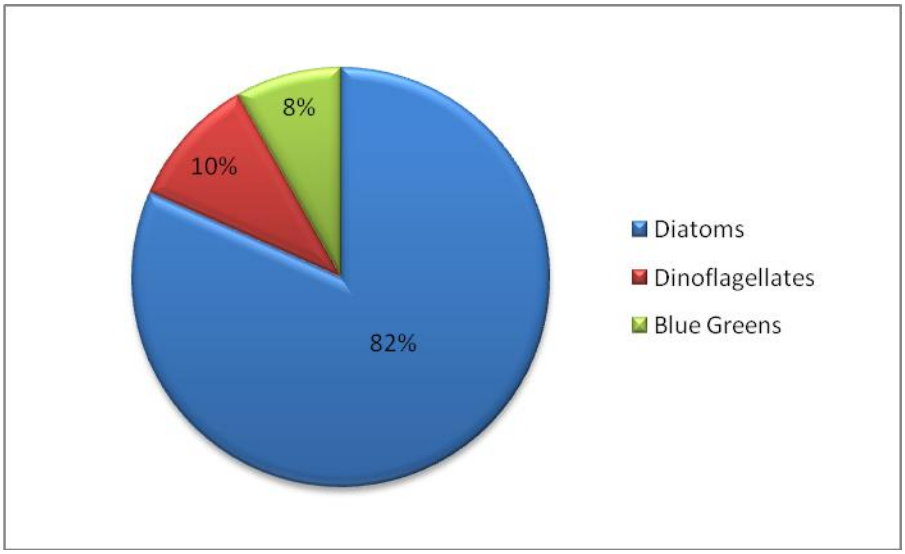


Figure-3.49: Percentage composition of Phytoplankton

Diversity Indices

In Mormugao port waters, the data collected on phytoplankton species were subjected to various diversity indices. The species diversity (H') varied from 3.540 to 5.075 with maximum in MPT-6 and minimum in MPT-8. The species richness (d) ranged between 3.151 and 4.751 with maximum in MPT-6 and minimum in MPT-2. The species evenness (J') varied from 0.814 to 0.943 with the maximum in MPT-10 and minimum in MPT-8 (Table-3.25).

Table-3.25: Diversity indices, *a*-Shannon diversity (H'); b-Margalef richness (d) and c-Pielou's evenness (J') calculated for Phytoplankton in Marmugao port waters

Stations	H' (diversity)	d (richness)	J' (evenness)
MPT-1	3.914	4.104	0.902
MPT-2	4.583	3.151	0.901
MPT-3	3.652	4.661	0.930
MPT-4	4.442	3.752	0.934
MPT-5	4.940	3.939	0.863
MPT-6	5.075	4.751	0.935
MPT-7	4.024	3.163	0.828
MPT-8	3.540	3.368	0.814

Stations	H' (diversity)	d (richness)	J' (evenness)
MPT-9	3.772	4.321	0.909
MPT-10	4.469	3.428	0.943

3.16.6 ZOOPLANKTONS

During the study period, three groups of macro zooplankton namely, calanoida, cyclopoida, and harpacticoida and 2 groups of micro zooplankton namely, spirotricha and larval forms and group “others” of zooplankton were recorded. Among these, calanoida were found to be the dominant group with 11 species. Larval forms came as next dominant group with 7 species. Cyclopoida and harpacticdoia came next in the order with 5 species each and spirotricha with 4 species. While group “Others” showed only meager contributions in the collection.

Among the calanoida, *Acartia danae, Acrocalanus gibber, A. gracilis, Labidocera sp. Nannocalanus minor, Paracalanus parvus, Temora discaudata* and cyclopoida, *Oithona rigida, O.brevicornis, O. similis, Corycaeus danae* and larval forms, gastropod veliger, bivalve veliger, barnacle nauplii and harpacticoida, *Macrosetella aculata, Microsetella norvegica* were found to be the frequenters in the collections. In the case of spirotricha *Tintinnopsis cylindrica, T. uruguayensis Sagitta* sp*. Oikopleura* parva showed consistency in their occurrence in the samples collected in various stations. The abundance and density of zooplanktons at various sampling stations is given in Table-3.26.

Table-3.26: Abundance and density of zooplankton at various sampling stations (Unit- Nos/m^3)

Zooplankton	MPT-1	MPT-2	MPT-3	MPT-4	MPT-5	MPT-6	MPT-7	MPT-8	MPT-9	MPT-10
Acartia danae	85	375	350	0	0	350	0	0	225	0
A. spinicauda	75	0	110	0	135	175	0	0	120	280
Acrocalanus giber	210	320	45	45	225	450	120	75	0	0
A. gracilis	0	110	0	85	0	450	125	450	120	350
Calanopia minor	85	0	120	45	0	0	0	0	130	0
Centropages furcatus	50	20	35	350	110	0	110	125	235	65
Labidocera pavo	0	10	0	0	0	125	210	120	0	46
Nannocalanus minor	220	0	120	96	125	410	315	650	0	150
Paracalanus parvus	450	320	0	320	145	0	20	0	85	0
Pontella sp.	50	0	120	90	0	650	0	410	350	40
Temora discaudata	110	0	375	0	350	0	175	0	250	25
Cyclopoida										
Oithona brevicornis	120	0	0	356	225	85	210	25	0	350
O. rigida	320	425	350	0	350	0	0	540	0	540
O. similis	375	0	155	350	110	120	840	40	80	0
Corycaeus danae	0	195	35	225	140	125	540	350	240	145
C. catus	235	0	0	250	0	40	350	20	90	95
Harpacticoida										
Macrosetella aculata	0	320	0	225	350	540	220	110	0	0
M. gracilis	0	425	350	224	0	210	0	450	230	120
Microsetella norvegica	145	0	225	485	160	540	350	0	0	0
M. rosea	0	120	0	650	350	0	0	120	115	0
Euterpina acutiforns	510	155	450	0	0	120	0	0	350	650
Spirotricha										
Favella brevis	120	0	0	0	350	450	60	350	0	45
Tintinnopsis cylindrical	185	320	300	225	350	0	120	250	125	0
T. uruguayensis	350	0	0	350	0	355	350	85	0	0

Zooplankton	MPT-1	MPT-2	MPT-3	MPT-4	MPT-5	MPT-6	MPT-7	MPT-8	MPT-9	MPT-10
Oikopleura parva	350	0	115	0	420	0	0	225	320	420
Larval forms										
Barnacle naupilii	375	0	45	0	705	0	50	30	125	325
Bivalve veliger	350	225	350	350	0	350	350	0	150	540
Copepod nauplius	225	85	0	0	325	225	0	225	225	100
Crustacean nauplius	0	641	865	612	0	350	350	120	0	350
Gastropod veliger	120	95	350	0	350	0	60	0	45	225
Mysis larva	350	160	0	0	515	110	0	850	85	0
Polychaete larva	0	0	385	190	0	175	745	0	195	0
Others										
Lucifer hanseni	0	263	165	612	0	300	0	125	0	350
Sagitta sp	282	525	120	0	465	357	120	20	120	20
Total	**5747**	**5109**	**5535**	**6135**	**6255**	**7062**	**5790**	**5765**	**4010**	**5231**

Population density

As found in phytoplankton, zooplankton density varied from 4,010 to 7,062 Nos/m^3 with maximum at MPT-6 and minimum at MPT-9 (Figure-3.50).

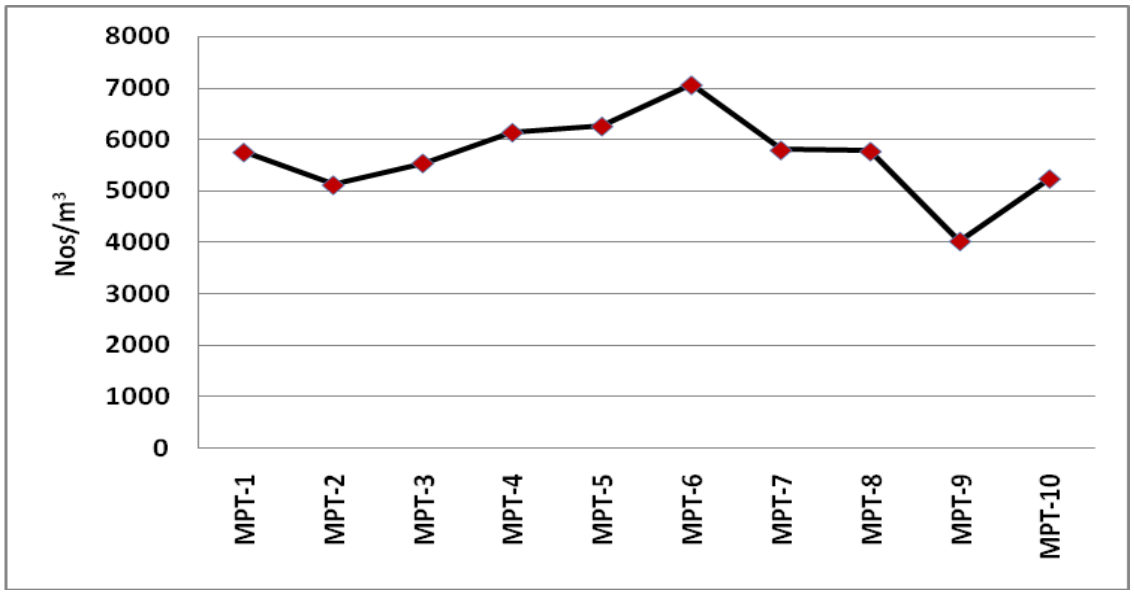


Figure-3.50: Population density of Zooplankton

Percentage composition

Likewise, in zooplankton, calanoida emerged as the dominant group by constituting 32%, followed by larval forms with 20%, cyclopoida and Harpacticoida with 15% each, spirotricha with 12% of the total percentage composition, and group “others” with 6% (Figure-3.51).

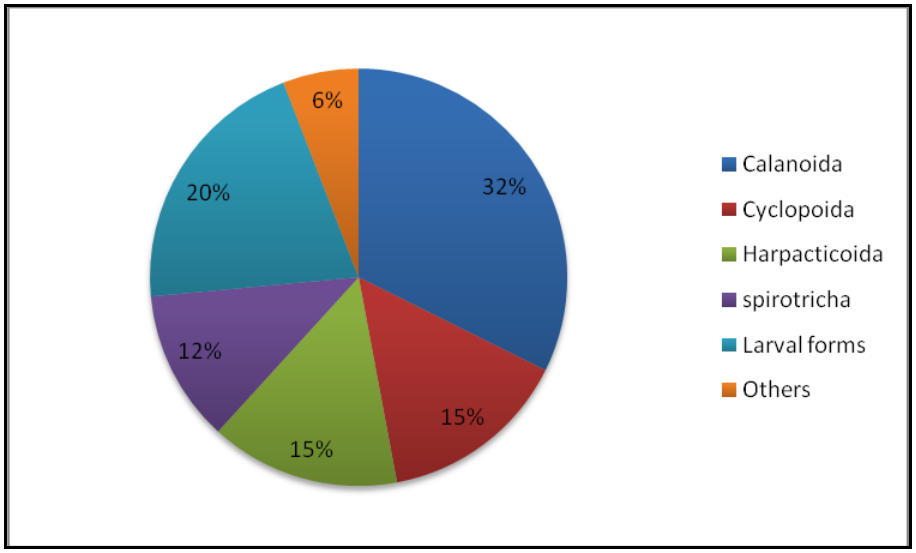


Figure-3.51: Percentage composition of Zooplankton recorded in various stations

Diversity indices

As done for phytoplankton, the zooplankton species diversity (H’) varied from 3.116 to 5.035 with maximum in MPT-7 and minimum in MPT-9. The species richness (d) ranged between 3.152 and 4.424 with maximum in MPT-7 and minimum in MPT-9. The species evenness (J’) varied from 0.812 to 0.948 with the maximum in MPT-6 and minimum in MPT-3 (Table-3.27).

Table-3.27: Diversity indices, *a*-Shannon diversity (H'); b-Margalef richness d) and c-Pielou's evenness (J') calculated for Zooplanktons in Marmugao port waters

Stations	H' (diversity)	d (richness)	J' (evenness)
MPT-1	3.451	3.882	0.847
MPT-2	4.048	3.338	0.922
MPT-3	4.127	3.553	0.812
MPT-4	4.196	4.393	0.941
MPT-5	4.255	3.399	0.854
MPT-6	4.346	3.595	0.948
MPT-7	5.035	4.424	0.905
MPT-8	4.052	3.770	0.872
MPT-9	3.116	3.152	0.851
MPT-10	4.089	3.357	0.904

3.16.7 BENTHOS

Macro-benthos

During the present investigation, four groups of benthic organisms namely polychaetes, crustaceans, bivalves and gastropods were recorded. Of these, polychaetes constituted the dominant group followed by crustaceans, gastropods and bivalves. Altogether 44 species of macro fauna were recorded. Of these, polychaetes topped the list with 25 species. Crustaceans were found to be the next dominant group in the order of abundance with 7 species. Bivalves and gastropods with 6 species each of the total benthic organisms collected. Among the polychaetes, *Armandia* sp., *Prionospio pinn*ata, *Eunice* sp., *Goniada emerita*, *Lumbrinereis* sp., *Notomastus aberrans*, *Nereis* sp., *Nephtys* sp., *Magelon*a *cincta*, were found to be the most commonly occurring species in the samples collected in Mormugao coastal waters. Coming to crustaceans *Angeliera* sp., *Ampithoe romondi*, *Gammarus* sp. and in bivalves, veligers of *Anadara*, *Donax* and gastropods *Cerithidea cingulata* and *Turris veligers* were found to be the common species in the collection.

The abundance and density of Macrobenthos at various sampling stations is given in Table-3.28. Benthos population density, percentage composition and diversity values of this study are found to be similar to the report submitted by Dredging Corporation of India Ltd (DCI) for Mormugao Port.

Population density

The population density varied from 700 to 1550 Nos. m^{-3} with maximum at MPT-5 and minimum at MPT-10 (Figure-3.52).

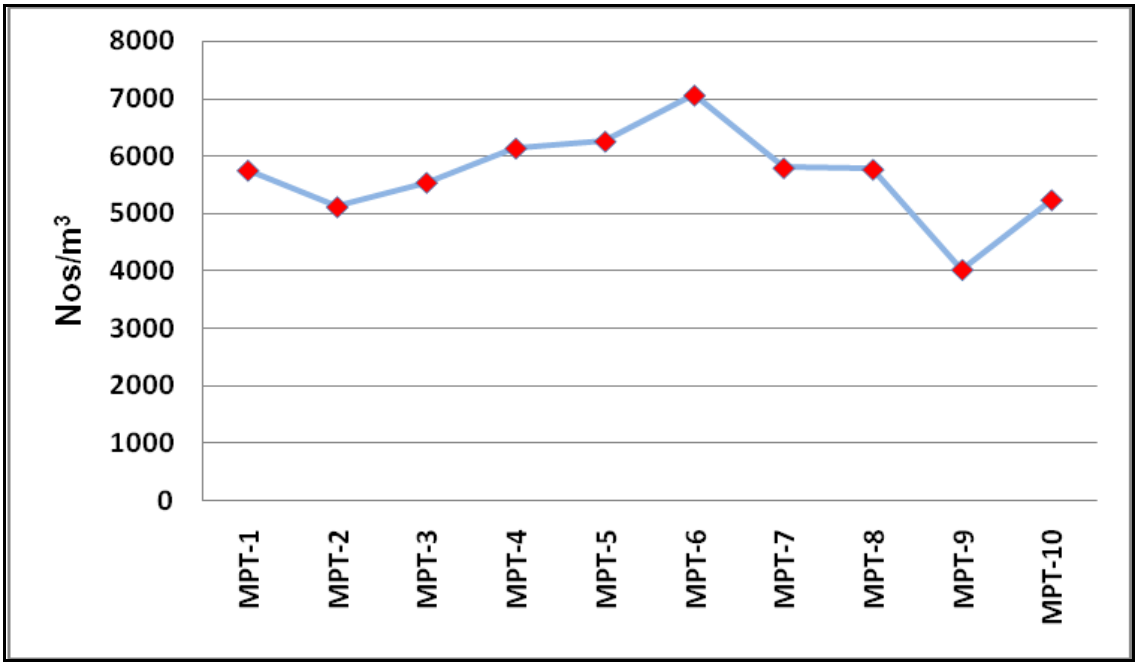


Figure-3.52: Population density of Macro benthos

Percentage composition

When the results of percentage composition of benthic fauna were viewed, polychaetes topped the list with 57% to the total benthic organisms. Crustaceans, bivalves and gastropods contributed with 16%, 13% and 14% respectively to the benthic samples collected (Figure-3.53)

Table 3.28: Abundance and density of Macrobenthos at various sampling stations (Unit- Nos/m^3)

Macrobenthos	MPT-1	MPT-2	MPT-3	MPT-4	MPT-5	MPT-6	MPT-7	MPT-8	MPT-9	MPT-10
Polychaetes										
Armandia sp.	50	50	0	25	75	0	50	25	0	0
Armandia longicaudata	50	0	75	50	0	0	25	0	0	0
Capitella capitata	0	0	50	0	50	25	0	0	50	0
Cossura coasta	50	0	0	25	0	0	0	0	0	25
Cirratulus concinnus	0	25	75	0	0	0	25	25	25	25
Eunice sp.	50	0	0	25	25	50	0	25	0	0
Goniada emerita	0	75	50	25	50	0	0	50	25	50
Exogone clavator	75	0	0	25	0	25	100	75	0	0
Lumbrineris sp.	0	0	25	0	0	25	0	0	0	0
Nephtys sp.	0	0	100	25	25	75	75	0	50	50
Nereis sp.	75	150	0	0	0	0	0	25	25	0
Notomastus aberans	0	0	0	0	50	25	50	100	0	25
Perinereis capensis	0	25	0	0	0	0	0	0	25	0
Platynereis sp.	0	50	75	0	100	25	0	50	25	50
Phylo capensis	0	0	0	0	0	0	25	0	25	25
Prionospio capensis	0	50	0	25	0	0	0	100	0	0
Prionospio cirrifera	0	0	100	25	0	50	0	0	0	25
Prionospio pinnata	100	0	75	0	0	50	75	0	0	0
Syllis sp.	0	75	0	0	100	0	0	50	100	100
Glycera longipinnis	50	0	50	100	0	50	50	0	0	25
Glycera alba	0	25	0	0	0	0	125	150	0	0
Pygospio elegans	50	0	0	0	100	100	50	0	0	0
Sabellides sp.	0	0	0	75	75	50	100	50	50	0
Magelona cincta	50	0	0	25	100	50	0	75	0	0
Serpula sp.	0	50	50	0	50	25	0	0	25	0
Crustaceans										

Macrobenthos	MPT-1	MPT-2	MPT-3	MPT-4	MPT-5	MPT-6	MPT-7	MPT-8	MPT-9	MPT-10
Ampithoe rubricate	25	0	100	25	25	0	25	0	150	0
Ampithoe romondi	0	25	0	0	50	75	0	0	50	25
Angeliera sp.	25	0	0	0	0	0	0	50	0	0
Campylaspis sp.	0	0	75	50	25	25	50	25	50	0
Gammarus sp.	125	75	0	75	0	100	0	0	0	0
Gynodiastylis sp.	175	0	75	100	150	0	75	0	0	50
Paragnathia formica	0	0	100	0	125	50	0	0	50	0
Bivalves										
Anadara veligers	0	25	50	50	50	0	0	0	0	0
Anadora granosa	0	25	0	25	50	0	0	25	0	0
Cardium veligers	25	25	25	0	0	50	50	50	75	50
Donax veligers	0	50	0	50	0	0	100	100	50	50
Meretrix veligers	0	0	75	0	125	50	0	0	0	0
Meretrix casta	125	100	50	100	50	0	0	0	0	0
Gastropods										
Bullia veligers	50	0	0	50	0	0	100	75	0	0
Cerithidea cingulate	50	0	0	0	0	0	0	0	50	50
Littorina veligers	0	0	25	75	25	25	100	0	0	0
Nassarius variegatus	50	25	0	25	50	0	25	50	50	25
Natica veligers	0	0	0	0	25	25	0	0	25	0
Turris veligers	0	50	50	0	0	50	50	50	0	50
Total	**1250**	**975**	**1350**	**1075**	**1550**	**1075**	**1325**	**1225**	**975**	**700**

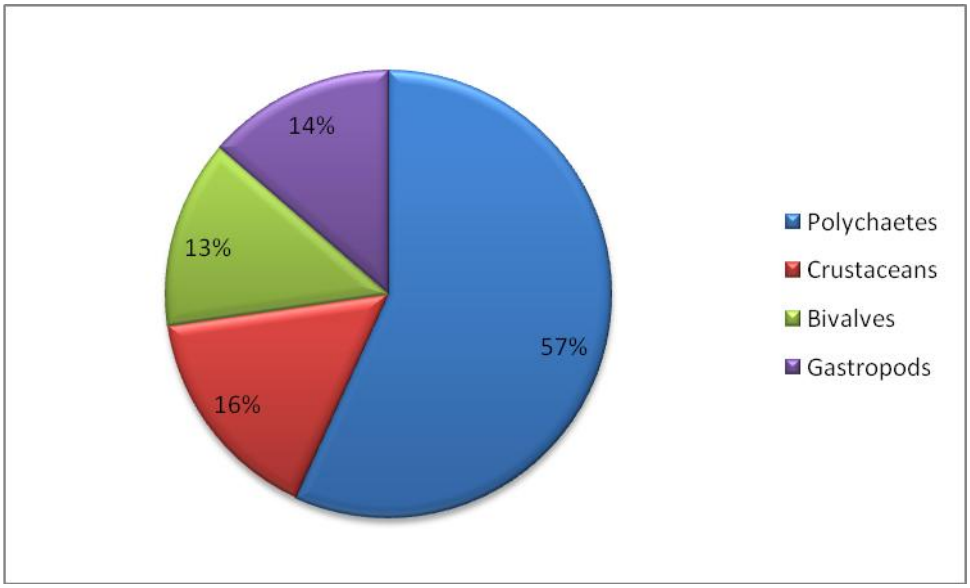


Figure-3.53: Percentage composition of macro benthos

Diversity Indices

The diversity values varied from 3.684 to 5.984 with maximum at MPT-5 and minimum at MPT-10. Species richness (d) fluctuated from 2.953 to 4.487 with maximum at MPT-4 and minimum at MPT-2; with respect to Pielou's evenness (J'), it varied from 0.8385 to 0.9734 with maximum at MPT- 3; and minimum at MPT- 2 (Table-3.29).

Table-3.29:Diversity indices *a*-Shannon diversity (H'); b-Margalef richness (d) and c-Pielou's evenness (J') calculated for macro benthos in Mormugao coastal waters

Stations	Shannon diversity (H')	Margalef richness (d)	Pielou's evenness (J')
MPT-1	3.983	3.044	0.9469
MPT-2	4.252	2.953	0.8385
MPT-3	3.703	3.015	0.9734
MPT-4	4.958	4.487	0.9483
MPT-5	5.984	3.374	0.8539
MPT-6	5.761	4.366	0.9607
MPT-7	5.845	3.037	0.8606

Stations	Shannon diversity (H')	Margalef richness (d)	Pielou's evenness (J')
MPT-8	4.384	3.145	0.9561
MPT-9	3.983	3.564	0.8561
MPT-10	3.684	4.051	0.9624

Meio-benthos

In the present study, as many as 32 species belonging to four groups of meio-benthic organisms namely foraminiferans, nematodes, harpacticoids and ostracodes were recorded. Of these, foraminiferans topped the list with 12 species. Nematodes were found to be the next dominant group in the order of abundance with 11 species. Harpacticoids and ostracodes came next with 6 and 3 species respectively.

Among the foraminiferans, *Ammonia beccari, Bolivina abbreviate,* and were commonly found in all the stations. With respect to nematodes, *Desmoscolex* sp., *Theristus sp., Astomonema* sp., *and Viscosia* sp*.,* were found to be the common species in the samples collected in various stations. Coming to ostracodes, *Basslerites liebaui, Diasterope schmitti,* and harpacticoids, *Diarthrodes* sp*.,* were found to be common species in the collection. The details are given in Table-3.30. Benthos population density, percentage composition and diversity values of this study are found to be similar to the report submitted by Dredging Corporation of India Ltd (DCI) for Mormugao Port

Table-3.30: Abundance and density of Meiobenthos at various sampling stations (Unit- Nos/10 cm^2)

Meiobenthos	MPT-1	MPT-2	MPT-3	MPT-4	MPT-5	MPT-6	MPT-7	MPT-8	MPT-9	MPT-10
Nematodes										
Astomonema sp.	4	12	6	5	5	5	5	0	19	14
Daptonema conicum	2	10	0	8	0	6	6	0	4	9
Desmoscolex sp.	13	9	12	5	7	8	10	5	17	22
Draconema sp.	9	3	5	0	0	0	6	8	0	0
Halalaimus filum	8	11	5	0	6	0	6	0	22	22
Microlaimus sp.	7	7	0	3	3	8	6	9	6	15
Neochromodora sp.	0	0	0	9	7	6	0	6	0	4
Odontophora sp.	7	9	7	9	3	0	6	3	7	0
Stephanolaimus sp.	3	7	5	9	4	8	7	6	5	6
Theristus sp.	4	2	8	8	6	6	0	0	5	2
Viscosia sp.	7	7	9	9	3	8	6	0	0	3
Foraminiferans										
Ammonia beccarii	3	4	8	0	6	6	4	11	4	8
Amphisorus sp.	0	11	9	6	9	9	13	0	7	9
Astrorotalia inflata	4	6	3	5	5	3	0	11	3	0
Bolivia abbreviata	0	4	0	12	3	3	5	5	4	0
Eponides repandus	4	3	3	5	6	5	6	4	7	5
Globigerina sp.	6	0	4	9	0	6	6	5	4	7
Quinqueloculina sp.	0	5	6	0	5	0	0	5	7	5
Rosalina bertheloti	5	6	0	2	0	6	3	0	8	6
Spirillina limbata	5	4	5	3	4	0	6	12	8	5
Spiroloculina sp.	6	0	6	3	0	7	5	0	3	6
Textularia agglutinans	3	6	5	5	5	5	6	4	5	6
Cornoboides advena	6	5	0	4	0	5	5	15	4	3

Meiobenthos	MPT-1	MPT-2	MPT-3	MPT-4	MPT-5	MPT-6	MPT-7	MPT-8	MPT-9	MPT-10
Harpacticoids										
Apodopsyllus vermiculiformis	1	3	0	2	5	3	4	2	3	1
Cervinia sp.	11	2	10	3	5	1	8	5	2	0
Cylindropsyllus sp.	0	3	1	3	1	2	2	3	1	2
Diarthrodes sp.	0	1	1	0	1	3	4	4	2	3
Laophonte thoracica	0	3	5	2	8	6	6	4	4	3
Laptastocus sp.	4	6	0	3	6	0	6	0	6	8
Ostrocodes										
Basslerites liebaui	3	3	4	3	4	6	3	5	3	0
Diasterope schmitti	3	2	0	0	0	4	2	5	3	4
Tanella kingmaii	2	4	1	6	0	4	5	1	0	2
Total	**130**	**158**	**128**	**141**	**117**	**139**	**157**	**138**	**173**	**180**

Population density

The population density of meiofauna varied from 117 to 180 nos.10cm^{-2} with maximum at MPT-10 and minimum at MPT-5 (Figure-3.54).

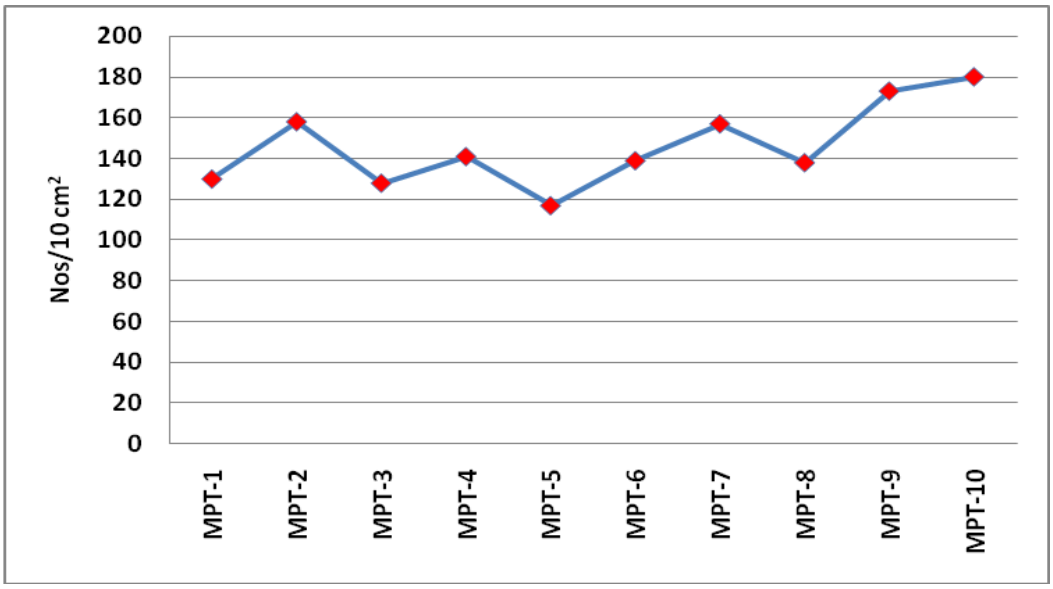


Figure-3.54: Population density of meio benthos recorded in various stations

Percentage composition

The results of percentage composition of meio-fauna revealed that foraminiferans constituted the maximum with 38% of the total meio-benthic organisms. Nematodes, Harpacticoids and Ostracodes contributed with 34%, 19%, and 9% respectively to the total meio-benthic samples collected (Figure-3.55).

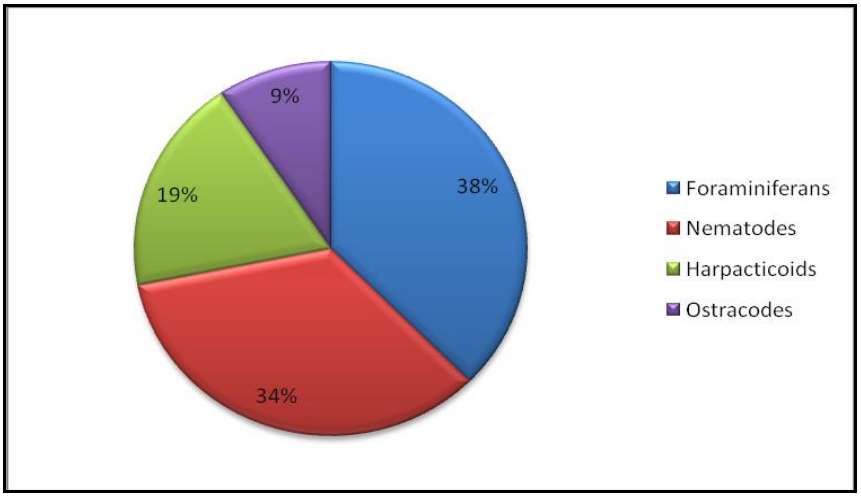


Figure-3.55: Percentage composition of meio - benthos

Diversity Indices

The diversity values varied from 3.213 to 6.782 with maximum at MPT-7 and minimum at MPT-9. Species richness (d) fluctuated from 4.772 to 5.678 with maximum at MPT-9 and minimum at MPT-5; with respect to Pielou's evenness (J'), it varied from 0.8496 to 0.9787 with maximum at MPT-6 and minimum at MPT- 9 (Table-3.31). Regarding diversity indices values of both benthos and plankton, the values recorded presently comparable with the values reported by Muthuvelu et al. (2013) who studied on the impact of anthropogenic activities on the benthic biodiversity in two different areas along the east coast of India.

Table-3.31: Diversity indices *a*-Shannon diversity (H'); b-Margalef richness (d) and c-Pielou's evenness (J') calculated for meio benthos in Marmagoa coastal waters

Stations	Shannon diversity (H')	Margalef richness (d)	Pielou's evenness (J')
MPT-1	3.721	5.467	0.9642
MPT-2	3.959	4.987	0.9592
MPT-3	4.619	4.988	0.9455
MPT-4	5.903	5.385	0.9560
MPT-5	6.422	4.772	0.9746
MPT-6	6.613	5.432	0.9787
MPT-7	6.782	5.363	0.9511
MPT-8	4.312	4.896	0.9567
MPT-9	3.213	5.678	0.8496
MPT-10	3.542	5.546	0.9451

BIOTA-ENVIRONMENT MATCHING

This gives us the Biota-Environment correlation matrices. That can help us in identifying the negative impacts due to the proposed project. A ρω value of >0.8 shows a strong correlation between the environmental factors and the biota.

In the present study, the large number of physical and chemical variables and biological variables were collected in the Mormogoa port waters. It is well known that most of the physic-chemical variables are known to influence the biotic variables like phytoplankton and zooplankton besides benthic fauna in one or other way. Therefore, the physico – chemical

variables were correlated with plankton and benthos data using BIO-ENV method through PRIMER ecological software. Since for ecological data, this software is widely used one for matching the biotic variables with abiotic entities. The results of best variable combinations are given Tables 3.32.

The results revealed that, among the variable matched, nine variables namely Temperature, salinity, Total organic carbon (TOC), Total phosphorous, dissolved oxygen, silt content, Total Nitrogen, pH and Clay content were featured as the major variables influencing the benthic faunal distribution. Of these, salinity, Clay content, TOC, TP and DO got manifested in the first level with a rho value of 0.924 in influencing the benthic fauna and followed by other parameters with less correlation values in the successive levels as given in the above Table-3.32.

Table-3.32: Harmonic rank correlations (ρω) between benthic abundance data and environmental similarity matrices for the samples collected in Mormugoa coastal waters

Sl. No.	No. of variables	Best variable combinations	Correlation (ρω)
1.	5	Salinity -Clay – TOC– TP-DO	0.924
2.	4	TOC –Silt – Temperature – TN	0.896
3.	3	Silt – Clay – TP	0.837
4.	3	Clay – Silt-pH	0.765

Similarly as done for benthic data, among the variables matched, 10 parameters such as Temperature, salinity, dissolved oxygen, reactive silicate, nitrate, TSS, pH, Nitrite, Turbidity and TP were featured as the key variables in influencing the distribution of planktonic organisms. Among these, temperature, salinity, DO, reactive silicate, nitrate and TSS got manifested in the first level of correlation with a value of 0.936 and followed by other parameters with less value in the successive levels in influencing the plankton abundance. The details are given in Table-3.33.

Table-3.33: Harmonic rank correlations (ρω) between Plankton abundance and environmental similarity matrices for the samples collected in Mormugoa coastal waters

S. No.	No. of variables	Best variable combinations	Correlation (ρω)
1.	6	Temp-Salinity -DO –reactive silicate-Nitrate - TSS	0.936
2.	4	pH –Nitrite – Turbidity – Phosphate	0.833
3.	4	Salinity – Silicate –temperature-pH	0.789
4.	2	Turbidity –Nitrate	0.756

Finfish distribution

With respect to finfish distribution, the following species namely *Pampus argentus, Ilisha striatula, Pampus chinenis, Hyporhamphus dussumieri, Scomberoides lysan, Lutjanus malabaricus, Harpadon nehereus, Cynoglossus linga, Rastrelliger kanagurta, Cynoglossus arel* and *Carangoides caeruleopinnatus* were predominantly recorded nearby in and around Khariwada fish landing center, which is located near Mormugoa port waters.

Sea weed and sea grass distribution

The studies carried out by NIO suggestes the presenece of large number of sea weed species in various parts of Goa. However, only patchy distribution of seaweeds namely *Ulva fasciata*, *Gracilaria corticata*, *Hypnea valentiae* and *Padina tetrastomatica* were recorded in the present study. Similarly, the sea grass species namely *Cymodocea serrulata* was reported during the present survey. Since, NIO has carried out the survey for about two years and covered larger area during the survey while present study is based on one time sampling carried out during 2nd week of may 2016. This might be the reason for the lesser occurance of sea grass species during the present survey.

Mangrove Distribution

The nearest identified patch of mangroves are observed in Sankval area of Zuari River (Southern Bank), at a distance of at least 5 km from the

proposed project site. The details of the mangrove species found in the study area:

- Avicennia officinalis
- Avicennia alba
- Acanthus illicifolius
- Aegiceras corniculatum and
- Excoecaria agallocha
- Rhizophora mucronata
- Rhizophora apiculata
- Bruguiera gymnorrhiza

Corals and other endangered species

The occurance of coral reefs in the Grade island has been documented by rsearchers recently (Shesdev Patro et al., 2015). The nearest habitat of corals from the proposed site is Grand island, located about 7 km from Mormugao Port and navigation channel. Proposed dumping site is located about 10 km from the Grand island. Shesdev Patro et al., 2015 reported the presence of *Carijoa riisei* from the Grand island at a site with ($73^0$46'46.605"E, $15^0$21'0.636"N) at a depth of 10-12 m. However, studies also concluded that the occurrence of the species in Grand Island as a new locational record and could not assess the impact on the reef due to lack of baseline data on the reef health.

Turtle Nesting Grounds

Goa with a small coastal length of 120 km, records one of the earliest community based initiatives in sea turtle conservation, next to Kerala. Sporadic nesting of olive ridley and leatherback turtles has been recorded all along the coast of Goa but recent nesting records are only of olive ridleys. Of the 120 km coastline, about 8 km in Goa have been identified as major nesting sites and are being protected by the Forest Department of the State Government of Goa. These sites are Morjim in north Goa, and Galgibaga and Agonda in south Goa. Nesting takes place between October and March each year. All the turtle nesting grounds are beyond the 10 km radius or outside the Study Area of the proposed project. The occurrence of other endangered species like Dugongs etc. was not found

during the survey.The location of the turtle nesting grounds are given in the Table-3.34.

Table-3.34: Location of Turtle Nesting Grounds in Goa

S.No	Nesting beach	Co-ordinates	
1.	Mandrem	15” 38’ 57.25’ N	73˚ 42’ 55.0.4’E
2.	Ashvem	15” 38’ 47.39’N	78˚ 43’ 00.17’E
3.	Morjim	15” 36’ 53.25’N	73” 44’ 09.34’E
4.	Agonda	15” 02’ 24.04 N	73” 59’ 16.66’E
5.	Galgibaga	14” 57’ 32.07 N	74” 02’ 56.64 E

3.17 FISHERIES

Goa has two Kinds of fisheries, namely Inland fisheries and Marine fisheries.

Inland Fisheries

Inland Fisheries of Goa are one of the richest source spread over 250 kms in length. Inland fisheries are divided into two types, that is, Brackish and Fresh water fisheries. Brackish water fisheries include extensive estuaries or river mouth, a large number of lagoons, back waters and brackish water lakes, etc. Inland fishery resources are an important aspect of fishery resources and their marketing in the study area. Inland water of Goa produces a variety of fresh water species, brackish water fish and skimps/prawns over the years.

Marine Fisheries

Marine fishery resources comprising of coastline of 104 kms. It is a broken coastline characterized by numerous bays and head lands. Groups of oceanic Islands with numerous creeks, mangroves and swamps. Goa has a large scope for fisheries production, particularly, through brackish water and marine production. Marine fishing is a seasonal industry for a period of nine months. The fishing season commences from the mid of August, when the fishing ban is lifted in the study area and lasts till the end of May. Marine fisheries are closed (practically closed) during monsoon, and fisherman utilize this period for mending their nets, maintenance of the fishing vessels and boats and also preparing new nets, etc.The list of fish species available in marine and inland Goa waters is given in Table 3.35.

Table 3.35: Fish species reported in Goa waters

Marine (Sea) Species	Inland (River/Creek)Species
Mackerels (Bangdo)	Prawns (Sungtam)
Oil Sardins (Tarle)	Lady fish (Muddoshi)
Other Sardins (Pedve)	Mullets (Shevto)
Prawns (Sungtam)	Gerres (Shetki)
Seer fish (Viswan)	Lutianus (Tamso)
Shark (Mori)	Cat fish (Sangot)
Skates (Fadke)	Anchovy (Motialli)
Rays (Vagolem)	Pearl spot (Kalunder)
KowalaCoval (Velli)	Betki (Channok)
Golden Anchovy (Kapsale)	Milk Fish (Gholsi)
Cat fish (Sangot)	Megalops (Keri)
Sciaenoids (Dodiaro)	Scatophagus (Mutre)
Butter fish (Saundale)	Ambasis (Burante)
Jew fish (Ghol)	Crabs (kurlio)
Indian Salmon (Rawao)	Black water Clams (kubye)
Silver belly (kampi)	False Clams (Tisrio)
Lobster (Shivod)	Oysters (Kalwam)
Soles (Lepo)	Mussel (Xinanee)
Silver Bars (karli)	Lepo
Pomfrets (Paplet)	Indian salmon
Lady fish (Muddoshi)	Balle Reddish
Mullets (Shevto)	Others (Pedve, Saundale)
Caranx (Tonki,Concoretc)	
Others Clupeids	
Bombay Duck (Bombil)	
Sepia (Manki)	
Perches (Gobro)	
Crabs (Kurlio)	
Ambasis (Burante)	
Ribbon fish (Balle)	
Thread fin (Dara Rane)	
Herrings	
Tunafish	
Horse Mackerals	
Leather Jacket (Diana)	
Indian Shad	

Source: Directorate of Fisheries, Government of Goa

Marine Fish Landing

In the study area of the proposed project; major, minor and medium marine fish landing centers are present. Inland fish landing centers are present only in the Tiswadi Taluaka of the study area. Most of the beach landing facilities are located all along the sandy beaches of Goa. The

following fish landing centers falls in the study area of the proposed project:

- Khariwada fish landing centre
- Baina beach landing facility
- Bogmalo beach landing facility

The fish catch at various fish landing centres in the study area is given in the Table 3.36 and 3.37.

Table 3.36: Fish Catch at different FLCs in the study area for the year 2015 (in tonnes)

S. No.	Species	Khariwada	Baina	Bogmalo
1.	Mackerals (Bangdo)	3711	186	16
2.	Sardines (Tarlo)	7325	116	9
3.	Other sardines	1463	78	7
4.	Prawns	0	0	
	Big	111	10	8
	Medium	1110	6	2
	Small	318	14	7
5.	Seer fish	114	23	2
6.	Shark	6	7	1
7.	Kowala Coval	13	0	0
8.	Golden Anchovy	26	0	0
9.	Catfish	67	28	0
10.	Sciaenoids	201	51	1
11.	Butter fish	158	51	1
12.	Silver belly	501	87	7
13.	Lobster	0	0	1
14.	Soles	357	74	14
15.	Silver bars	41	4	0
16.	Pomfrets	120	76	0
17.	Ladyfish	8	0	0
18.	Mullets	9	7	2
19.	Caranx	2	6	0
20.	Sepia/ cuttle fish	88	5	5
21.	Perches	0	2	0
22.	Crabs	145	75	14
23.	Ribbon fish	80	0	0
24.	Thread fin	17	0	0
25.	Tuna	469	0	0
26.	Miscellaneous	716	102	40
	Total	**17,176**	**1008**	**146**

Source: Directorate of Fisheries, Government of Goa

Table 3.37: Marine fish production of Goa for the Period from 2011 to 2014 (in tonnes)

Species	2010	2011	2012	2013	2014
Mackerals(Bangdo)	23831	22128	17860	12994	10308
Sardines(Tarlo)	23732	26391	34329	31629	80849
Cat Fish(Sangot)	1402	1545	364	383	598
Shark Fish(Mori)	3159	375	234	281	307
Seer Fish(Wiswan)	1229	1884	1616	2751	1621
Prawns(Sungtam)	9970	8008	8968	8380	9283
Pomprets(Paplet)	185	376	174	1342	643
Cuttle Fish(Manki)	1341	1012	1180	4422	2150
Tuna(Bokdo)	2524	3801	2621	3520	1368
Ribbon Fish(BAlle)	839	49	644	1107	376
Reef Cod(Gobro)	1303	5	495	1409	1262
KowalaKowal(velli)	279	438	562	1046	618
Golden Anchovy (Kapsale)	2	--	50	29	2
Silver Belly(Kampi)	1584	1012	1146	3328	1991
Soles(Lepo)	1606	3995	3683	2579	3982
Silver Bar(Karli)	219	62	98	54	121
Crabs(Kurlio)	763	1236	1160	830	1256
Sciaenoids(Dodiaro)	1376	1448	1629	1425	1802
Butter Fish(Soundale)	1116	978	656	594	676
Others	10002	11482	9159	9881	8894
Total	**87062**	**86185**	**86628**	**87984**	**128107**

Source: Directorate of Fisheries, Government of Goa

Fisherman Population

The study area has a total 1540 fishermen population. A total of 405 fishermen families are registered in the study area. Population of fisherman in the study area Taluka is given in Table 3.38.

Table 3.38: Fishermen population in the study area

S. No.	Name of Village	Fishermen Families	Traditional Fishermen Families	Fisherfolk population
	Taluk:Marmagoa			
1	Vasco	45	45	262
2	Baina	71	69	421
3	Bogmalo	23	15	109
4	Velsao	66	66	348

3.18 FLORA

The Forest Survey of India has mapped the forest types in using satellite data with reference to Champion and Seth Classification. As per this assessment in the State of Forest Report 2011, the state has 5 forest types which belong to five forest type groups as listed in Table-3.39.

Table-3.39: Forest Types reported in Goa

S. No	Forest type	% area
1.	Tropical Wet evergereen	24.97
2.	Tropical Semi evergreen	19.33
3.	Tropical Moist Deciduous	25.39
4.	Littoral and Swamp	0.45
5.	Tropical dry deciduous	0.01

The details of the floral species reported in the Study Area is given in Table-3.40.

Table-3.40: List of floral species recorded from the study area

Botanical Name	Local/Vernacular Name	Family	Habit
Sesuvium portulacastrum	-	Aizoaceae	Herb
Mangifera indica	Ambo	Anacardiaceae	Tree
Anacardium occidentale	Kaju	Anacardiaceae	Tree
Holigarnaarnottiana	Ranbibo	Anacardiaceae	Tree
Lannea coromandelica	Moi	Anacardiceae	Tree
Spondia mangifera	Ambado	Anacrdiaceae	Tree
Ananas comosus	Ananas	Annonaceae	Shrub
Thevetia peruviana	-	Apocynaceae	Shrub
Wrightia tinctoria	Kalakundo	Apocynaceae	Tree
Hollarhena antidysentric	Kudo	Apocynaceae	Tree
Alstonia scholarias	Saton	Apocynaceae	Tree
Calamus sp.	-	Arecaceae	Shrub
Phoenix loureiroi	-	Arecaceae	Shrub
Caryota urens	Billemad	Arecaceae	Tree
Cocos nucifera	Naal	Arecaceae	Tree
Borassus flabellifer	Toddy palm	Arecaceae	Tree
Calotropisgigantea	Rui,Dhavirui	Asclepidiaceae	Shrub
Ageratumconyzoides	-	Asteraceae	Herb
Elephantopus scaber	-	Asteraceae	Herb
Launaea sarmentosa	-	Asteraceae	Herb
Melanthera biflora	-	Asteraceae	Herb

Botanical Name	Local/Vernacular Name	Family	Habit
Tridax procumbens	-	Asteraceae	Herb
Bombaxceiba	Savar	Bombacaceae	Tree
Garunga pinnata	Kakad	Burseraceae	Tree
Ceasalpinia crista	-	Caesalpiniaceae	Tree
Cassia fistula	Bayo	Caesalpiniaceae	Tree
Calaphyllus inophyllum	Oondi	Calophyllaceae	Tree
Carica papaya	Papaya	Caricaceae	Tree
Casuarina equisetifolia	Phiramgisaro	Casuarinaceae	Tree
Arthrocnemum indicum	-	Chenopodiaceae	Herb
Cyanotis axillaris	-	Commelinaceae	Herb
Ipomea pes- caprae	Maryadvel	Convolvulaceae	Herb
Mukia maderaspatana	-	Cucurbitacea	Climber
Cyperus pangorei	-	Cyperaceae	Sedge
Cyperusarenarius	-	Cyperaceae	Sedge
Derris heterophylla	-	Fabaceae	Shrub
Tephrosia purpurea	-	Fabaceae	Shrub
Adenanthera pavonia	Gunj	Fabaceae	Tree
Abrus precatorius	Gunji	Fabaceae	Climber
Pongamia pinnata	Karanji	Fabaceae	Tree
Halophila beccarii	-	Hydrocharitaceae	Herb
Hyptis suaveolens	-	Lamiaceae	Herb
Leucas aspera	Tumbo	Lamiaceae	Herb
Careya arborea	Kumbiyo	Lecethidaceae	Tree
Justiciasimplex	-	Malvaceae	Herb
Sida acuta	Bala, /Chikna	Malvaceae	Herb
Hibiscus tiliaceus	Belipata	Malvaceae	Tree
Thespecia populinea	Bhendi	Malvaceae	Tree
Thespecia lampa	Ran Bhendi	Malvaceae	Shrub
Melia azedarach	Fernage Nimb	Meliaceae	Tree
Azadirachta indica	Nimb	Meliaceae	Tree
Mimosa pudica	-	Mimosaceae	Herb
Albizzia odoratissima	Kala Siras	Mimosaceae	Tree
Albizzia lebbek	Siras	Mimosaceae	Tree
Xylia xylocarpa	Zamba	Mimosaceae	Tree
Mollugo oppositifolia	-	Molluginaceae	Herb
Ficus religiosa	Pipal	Moracea	Tree
Ficus bengalensis	Vad	Moracea	Tree
Ficus arnotianna	Asti Payr	Moraceae	Tree
Artocarpus heterophyllus	Phanas	Moraceae	Tree
Ficus glomerata	Rumbad	Moraceae	Tree

Botanical Name	Local/Vernacular Name	Family	Habit
Musa paradisiaca	Keli	Musaceae	Tree
Syzgium caryophyllatum	Bhedas	Myrtaceae	Tree
Syzgium cumini	Jamun	Myrtaceae	Tree
Boerhavia diffusa L.	-	Nyctaginaceae	Herb
Nymphaea pubescens	KamalSalak	Nymphaeaceae	Herb
Nymphaea nouchali	KasturiSalak	Nymphaeaceae	Herb
Passiflora foetida	Running pop	Passifloraceae	Climber
Digitaria adscendens	-	Poaceae	Grass
Eragrostis uniloides	-	Poaceae	Grass
Saccharum spontaneum	-	Poaceae	Grass
Spinifex littoreus	Saramto	Poaceae	Grass
Eichhornia crassipes	-	Pontederiaceae	Herb
Portulaca quadrifida	Bhumygol	Portulacaceae	Herb
Acrostichum aureum	-	Pteridaceae	Fern
Zizuphus mauriliana	Boram	Rhamnaceae	Shrub
Hedyotis herbacea	-	Rubiaceae	Herb
Morinda citrifolia	-	Rubiaceae	Tree
Adina cordifolia	Hedu	Rubiaceae	Tree
Saraca indica	Asoka	Sapindaceae	Tree
Manilkara hexandra	Kirni	Sapotaceae	Tree
Mimusops elengi	Onwal	Sapotaceae	Tree
Datura innoxia	Datura	Solanaceae	Herb
Triumfetta rhomboidea	Tupkati	Tiliaceae	Herb
Holoptelia integrifolia	Vavalo	Ulmaceae	Tree
Phyla nudiflora	-	Verbenaceae	Herb
Vitex altissima	Bavalgi	Verbenaceae	Shrub
Vitex negundo	Limgud	Verbenaceae	Shrub
Gmelina arborea	Shivan	Verbenaceae	Tree
Clerodendron inermi	Siritmari	Verbenaceae	Shrub
Leea indica	Jino	Vitaceae	Shrub

3.19 FAUNA

Mammals

There are almost fifty species of mammals found in the State. Most of these are unfortunately hardly ever visible to the average visitor. Among the mammals found in the study area are common Jackal, Monkeys, Indian civet, wild dog, Indian hare, Gaur, Indian porcupine, Wild boar and the mongoose. Monkeys are found all across Goa. The most common

species is the pink-bottomed macaque followed by the Hanuman langur. Goa has four species of bats, the fruit bat, the Dormers bat, the rufous horse-shoe bat, and the Malay fox vampire. Flying foxes are also present in large numbers. Most of these are found in the rural interior areas. The Indian giant squirrel, the smaller three-striped squirrel and the five-striped palm squirrel are also found in most areas. No threatened, rare and endangered faunal species were present in the IUCN Red List of threatened animals.

The commonly reported mammal species from the study area are given in Table-3.41.

Table-3.41: List of mammals reported from the study area

Zoological Name	English Name	Local Name	IUCN status
Bandicota indica	Bandicoot rat	Kolindar	Least Concern
Bos gaurus	Gaur or Indian bison	Gavvo redo, Gavvo	Least Concern
Canis aureaus	Jackal	Kolo	Least Concern
Cuon alpinus	Wild dog	Kolsundo, Deucolo	Least Concern
Cynopterus brachyotis	Indian fulvous fruit bat	Pakho	Least Concern
Felis bengalensis	Leopard cat	Wagatti	Least Concern
Felis chaus	Jungle cat	Baul,	Least Concern
Funambulus palmarum	Three striped palm squirrel	Chani, Khar.	Least Concern
Herpestes edwardsii	Common grey mongoose	Mungoos, Munghas,	Least Concern
Hyaena hyaena	Striped hyaena	Yeul , Bhalu	Least Concern
Hysterix indica	Porcupine	Sal, Salinder	Least Concern
Lepus nigricollis	Black napped Hare	Soso	Least Concern
Lutra lutra	Common Otter	Udh,	Least Concern
Lutra perspicillata	Smooth coated Otter	Udh	Least Concern
Macaca radiata	Bonnet macaque	Khete, Makod.	Least Concern
Megaderma spasma	Indian false vampire bat	Vagul	Least Concern
Mus booduga	Indian field mouse	Undir	Least Concern
Otompos wronghtoni	Wronghton's freetailed bat	Vagul	Least Concern
Petaurista petarauista	Common flying squirrel	Ud pakho.	Least Concern
Pipistrellus dormeri	Dormers bat	Vagul	Least Concern
Presbytis entellus	Common Langur	Vanor	Least Concern
Pteropus giganteus	Flying Fox	Pakho	Least Concern
Rattus rattus	House Rat	Undir	Least Concern

Zoological Name	English Name	Local Name	IUCN status
Ratufa macroura	Malabar Giant Squirrel	Shekro,	Least Concern
Rhinolophus luctus	Horse shoe bat	Vagul	Least Concern
Suncus murinus	House shrew	Chuchunderi	Least Concern
Sus scrofa	Wild Boar	Ran dukar.	Least Concern
Viverricula indica	Small Indian civet cat	Javade,	Least Concern

Avi-fauna

Goa has an abundant birdlife. There are some very colourful species found in the State and among these are the three common species of kingfisher: the stork-billed kingfisher is the largest and most distinctive, the breasted kingfisher and and the common kingfisher are the others. Other common and brightly coloured species include the grass-green, blue and yellow bee-eaters, the golden oriole, and the Indian roller, Hoopes, purple sunbirds, and several kinds of bulbuls, babblers and drongos. The exotic paradise flycatcher is fairly widespread in Goa and among the region's most exquisite birds.

The snowy white cattle egret, the large egret and the little egret and herons are most common in the paddy fields along with cows and buffaloes. The beautiful whitebellied fish eagle, the brahminy kite and the pariah kite are birds of prey found around towns and fishing villages. House crows, jackdaws, king vultures and the white-backed vulture are also seen in most areas. In the state's forests are found the grey hornbill, the Indian pied hornbill and the magnificent great pied hornbill, several species of woodpecker including the lesser goldenback woodpecker and the Indian great black woodpecker, the red junglefowl, the grey or Sonnerat's jungle fowl. The commonly reported avi-faunal species in Goa are given in Table-3.42

Table-3.42: - List of avi-faunal species reported in Goa

Scientific name	Common name
Acridotheres fuscus	Jungle Myna
Acrocephalus aedon	Thick billed Warbler
Acrocephalus agricola	Paddyfield Warbler
Aegithina tiphia	Common Iora

Scientific name	Common name
Alcedo atthis	Common Kingfisher
Amaurornis phoenicurus	White-breasted Waterhen
Anas acuta	Northern Pintail
Anas crecca	Common Teal
Anas poecilorhyncha	Spot-billed
Anas querquedula	Garganey
Anastomus oscitans	Asian Openbill
Anthus richardi	Richards Pipit
Aquila pomarina	Lesser Spotted Eagle
Ardea cinerea	Grey Heron
Ardea purpurea	Purple Heron
Ardeola grayii	Indian Pond-Heron
Bubulcus ibis	Cattle Egret
Cacomantis passerinus	Grey-bellied Cuckoo
Calandrella brachydactyla	Greater Short-toed Lark
Calidris temminckii	Temminck's Stint
Celeus brachyyurus	Rufous woodpecker
Ceryle rudis	Pied Kingfisher
Charadrius alexandrinus	Kentish plover
Charadrius dubius	Little ringed plover
Chloropsis aurifrons	Gold fronted chloropsis
Circaetus gallicus	Short-toed Snake-Eagle
Columba livia	Rock Pigeon
Copsychus saularis	Magpie robin
Coracina mealnoptera	Black headed cuckoo shrike
Corvus macrorhynchos	Jungle crow
Corvus splendens	House Crow
Cuculus varius	Common Hawk-Cuckoo
Cyornis tickelliae	Tickell's blue flycatcher
Cypsirus Parvus	Palm Swift
Dendrocitta vagabunda	Indian tree pie
Dendrocopos mahrattensis	Yellow-crowned Woodpecker
Dendrocopus mahrattensis	Yellow fronted pied woodpecker
Dendrocygna javanica	Lesser Whistling teal
Dicaeum agile	Thick billed Flowerpecker
Dicrurus aeneus	Bronzed Drongo
Dicrurus caerulescens	White bellied Drongo
Dicrurus macrocercus	Black Drongo
Dinopium benghalense	Lesser golden back woodpecker
Dumetia hyperythra	White throated Babbler
Egretta gularis	Western Reef-Egret
Elanus caeruleus	Black-winged Kite
Eremopterix grisea	Ashy-crowned Sparrow-Lark
Eumyias thalassina	Verditer flycatcher

Scientific name	Common name
Fulica atra	Common Coot
Gallicrex cinerea	Watercock
Gallinula chloropus	Common Moorhen
Gallus sonneratii	Grey Junglefowl
Glareola lactea	Small Pratincole
Halcyon pileata	Black-capped Kingfisher
Halcyon smyrnensis	White-throated Kingfisher
Haliaeetus leucogaster	White-bellied Fish-Eagle
Haliastur indus	Brahminy Kite
Himantopus himantopus	Black-winged Stilt
Hirundo concolor	Dusky Crag Martin
Hirundo daurica	Red rumped Swallow
Iole indica	Yellow-browed Bulbul
Lanius schach	Rufous back Shrike
Lonchura malacca	Black headed Munia
Lonchura striata	White backed Munia
Megalaima viridis	Small Green Barbet
Merops orientalis	Little Green Bee-eater
Mesophoyx intermedia	Intermediate Egret
Milvus migrans	Black Kite
Motacilla madaraspatensis	Large Pied wagtail
Nectarinia asiatica	Purple Sunbird
Nectarinia zeylonica	Purple rumped Sunbird
Oriolus xanthornus	Black headed oriole
Passer domesticus	House Sparrow
Pavo cristatus	Indian Peafowl
Pelargopsis capensis	Stork-billed Kingfisher
Pellorneum ruficeps	Spotted Babbler
Pericrocotus cinnamomeus	Small Minivet
Picumnus innominatus	Speckled Piculet
Ploceus philippinus	Indian Baya
Pomatorhinus horsfieldii	Indian Scimitar-Babbler
Porzana fusca	Ruddy-breasted Crake
Prinia inornata	Plain Prinia
Prinia socialis	Ashy Prinia
Psittacula kyanocephala	Blossom headed parakeet
Pycnonotus cafer	Red vented Bulbul
Pycnonotus jocosus	Red whiskered Bulbul
Rhipidura albicollis	White throated fantail flycatcher
Saxicoloides fulicata	Indian Robin
Sitta frontalis	Velvet-fronted Nuthatch
Spizaetus cirrhatus	Changeable Hawk-Eagle
Sterna aurantia	River Tern
Streptopelia chinensis	Spotted Dove

Scientific name	Common name
Sturnus pagodarum	Brahminy Myna
Sturnus roseus	Rosy Starling
Terpsihone paradisi	Paradise flycatcher
Tringa cinerea	Terek Sandpiper
Tringa hypoleucos	Common Sandpiper
Tringa nebularia	Common Greenshank
Turdoides striatus	Jungle Babbler
Upupa epops	Hoopoe
Vanellus indicus	Red-wattled Lapwing

Reptiles

The State has a large reptilian/amphibian population. This includes the ubiquitous common house gecko, a variety of frogs and the common skink, monitor lizard, Garden Lizard. Twenty-three species of snakes are found in Goa. The nonpoisonous variety of snakes include the common blind snake, the Russell sand boa, the Indian python, the Indian wart snake, trinket snake, Indian rat snake, golden tree snake, common wolf snake, ,chequered keelback, striped keelback, Indian gamma and common green whip snake. Commonly observed reptilian fauna in the study area are given in Table-3.43.

Table-3.43: Important reptiles found in the Study Area

S. No.	Scientific name	Common name	Local Name
Snakes			
1.	*Ahaetulla nasutus*	Vine Snake	Harvel, Haryali
2.	*Amphiesma stolatum*	Buff striped keel back	Yevale.
3.	*Boiga forsteni*	Forsten's Cat Snake.	
4.	*Boiga trigonata*	Common Indian Cat Snake.	
5.	*Bungarus caeruleus*	Common Indian Krait	Kaner.
6.	*Calliophis nigrescens*		Coral Snake
7.	*Cerberus rhynchops*	Dogfaced water Snake	Pan ghonas
8.	*Chrysopelea ornata*	Golden back tree Snake	
9.	*Coelognathus helena*	Trinket Snake	
10.	*Dendrelaphis tristis*	Bronzeback tree Snake	Naneti, Nanado.
11.	*Echis carinatus*	Saw scaled Viper	Phoorshe
12.	*Enhydrina schistosa*	Hook-nosed Sea	

S. No.	Scientific name	Common name	Local Name
		Snake	
13.	*Eryx johnii*	Johns sand boa	Malun
14.	*Gongylophis conicus*	Common Sand Boa	Malun
15	*Grypotyphlops acutus*	Beaked worm snake	Sulo
16	*Lycodon aulicus*	Common Wolf snake	Pasko
17.	*Macropisthodon plumbicolor*	Green keelback.	Yevale
18.	*Naja naja*	Indian Spectacled Cobra	Nag, Parro
19	*Oligodon arnensis*	Common Kukri snake	
20	*Oligodon taeniolatus*	Variegated Kukri Snake	
21.	*Ophiophagus hannah*	King Cobra	Nagin, Dom.
22.	*Ptyas mucosa*	Indian Rat Snake	Dhaman.
23.	*Python molurus*	Indian Rock Python	Har, Mayndol
24.	*Ramphotyphlops braminus*	Brahminy worm snake	Telyo
25	*Trimeresurus malabaricus*	Malabar Pit Viper	Chapade
26	*Trimeresurus gramineus*	Bamboo Pit Viper	Chapade
27	*Uropeltis macrolepis macrolepis*	Bombay shield tail	
28.	*Vipera russelii*	Russels Viper	Ghonas,
29.	*Xenochropis piscator*	Checkered keelback	Yevale
Lizards, Skinks			
1	*Calotes rouxii*	Rouxii lizard	Sheddo
2	*Calotes versicolor*	Indian garden lizard	Sheddo
3	*Chamaeleo zeylanicus*	Indian chameleon	
4	*Draco dussumieri*	Flying lizard	Pavto
5	*Mabuya macularia*	Bronze skink	Shirli
Amphibians			
1.	*Duttaphrynus melanostictus*	Indian toad	Manaki
2.	*Hoplobatrachus tigerinus*	Indian bull frog	Bebo
3.	*Euphlyctis cyanophlyctis*	Indian skipper frog	Bebki
4.	*Sphaerotheca breviceps*	Indian burrowing frog	Bebki
5.	*Rhacophorus malabaricus*	Malabar gliding frog	
6.	*Rana malabarica*	Fungoid frog	Bebki

3.20 SOCIO-ECONOMIC ASPECTS

The aim of the socio-economic study is to assess the overall impact on various facets of socio-economic environment due to establishment of the project in the Study Area Villages. The present chapter outlines baseline socio-economic scenario of the study area villages. The study area (10 km radius around the proposed project area) is spread over in District South Goa subdistrict Mormugao and District North Goa subdistrict Tiswadi. The information presented in this chapter has been mainly extracted from Primary Census Abstract 2011 The following sections outline the socio-economic profile of the Study Area Villages.

3.21 DEMOGRAPHIC PROFILE

Population

As mentioned the proposed project is located in the District North and South Goa. The study area or the Project Influence Area comprises of about 19 villages in sub-district Mangrol. The total population in the study area villages is of the order of 267477 persons as per Census of India 2011. The distribution of population and demographic profile in the study area villages is outlined in Table-3.44 and depicted in Figure-3.56.

Table-3.44: Demographic profile in the study area villages

S. No	Village Name	Total Households	Total Population	Total Male	Total Female	Population<6 years	Average Family Size	Sex Ratio
	District South Goa							
	Subdistrict Mormugao							
1	Dabolim	1433	6027	3142	2885	699	4	918
2	Cuelim	430	1777	839	938	173	4	1118
3	Pale	473	1990	1010	980	202	4	970
4	Chicolna	669	2680	1350	1330	274	4	985
5	Mormugao (M Cl)	21524	94393	49633	44760	10025	4	902
6	Sancoale (CT)	5035	21923	11657	10266	2693	4	881
	Subtotal(A)	**29564**	**128790**	**67631**	**61159**	**14066**	**4**	**904**
	Subdistrict Tiswadi							
7	Batim	356	1489	739	750	132	4	1015

S. No	Village Name	Total Households	Total Population	Total Male	Total Female	Population<6 years	Average Family Size	Sex Ratio
8	Curca	560	2518	1232	1286	256	4	1044
9	Siridao	578	2417	1179	1238	218	4	1050
10	Panaji (M Corp. + OG)	17807	70991	35988	35003	6180	4	973
11	Renovadi (OG) WARD NO.-0033 (Rural MDDS CODE:626738)	125	500	259	241	42	4	931
12	Morambi-O-Pequeno (Merces) (OG) WARD NO.-0034 (Rural MDDS CODE:626739)	209	931	444	487	78	4	1097
13	Cujira (OG) WARD NO.-0035 (Rural MDDS CODE:626740)	296	1229	601	628	122	4	1045
14	Taleigao (OG) (Part) WARD NO.-0036 (Rural MDDS CODE:645598)	6003	24201	12402	11799	2356	4	951
15	Durgawadi (OG) (Part) WARD NO.-0037 (Rural MDDS CODE:645599)	388	1610	830	780	180	4	940
16	Murda (CT)	1803	7517	3699	3818	782	4	1032
17	Calapor (CT)	3514	14077	7118	6959	1443	4	978
18	Bambolim (CT)	1165	6885	4812	2073	525	6	431
19	Goa Velha (CT)	1055	4322	2129	2193	427	4	1030
	Subtotal(B)	**33859**	**138687**	**71432**	**67255**	**12741**	**4**	**942**
	Total(A+B)	**63423**	**267477**	**139063**	**128414**	**26807**	**4**	**923**

Source: Primary Census Abstract, 2011

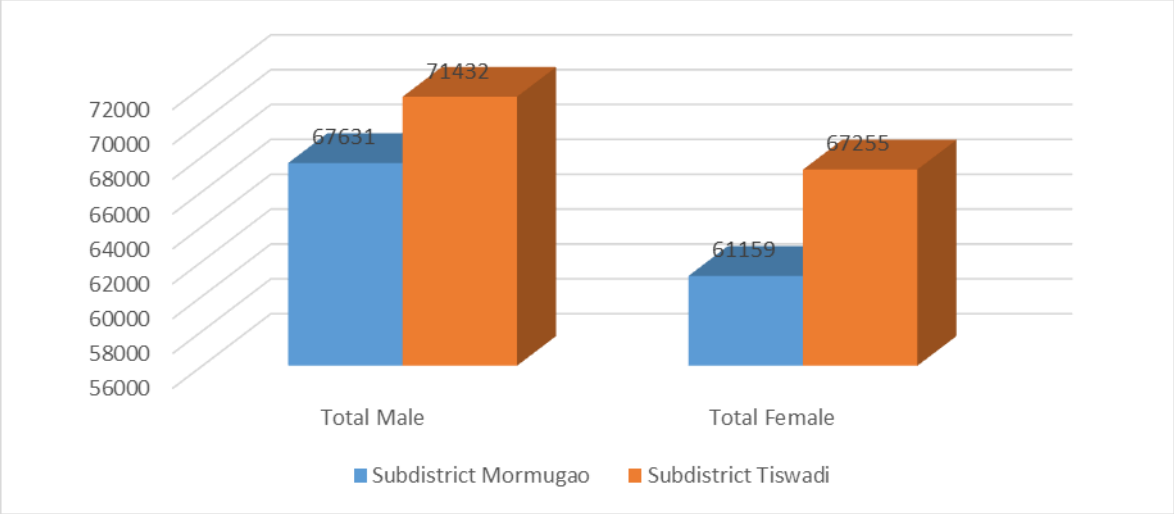


Figure-3.56: Demographic profile in the study area villages

The male and female population in study area villages comprises about 52.0.% and 48.0% respectively of the total population. The population comprising of children below the age of 6 years account for about 10.0% of the total population in the study area villages. The no. of females per 1000 males and average family size in the study area villages is 923 and 4 persons per family respectively.

Caste Profile

The distribution of population in study area villages on the basis of caste is summarized in Table-3.45 and Figure-3.57. The General Caste is the dominant caste in the study area accounting for about 92.38% of the total population followed by Schedule Tribe (5.39.%). Schedule Castes accounts for about 2.23% of the total population in the study area villages.

Table-3.45: Caste profile in the study area villages

S.No	Village Name	Total Population	Schedule Caste	Schedule Tribe	General Caste
	District South Goa				
	Subdistrict Mormugao				
1	Dabolim	6027	65	307	5655
2	Cuelim	1777	2	841	934
3	Pale	1990	6	76	1908
4	Chicolna	2680	45	376	2259
5	Mormugao (M Cl)	94393	2161	480	91752
6	Sancoale (CT)	21923	114	597	21212
	Subtotal(A)	**128790**	**2393**	**2677**	**123720**
	Subdistrict Tiswadi				
7	Batim	1489	12	21	1456
8	Curca	2518	11	497	2010
9	Siridao	2417	0	1265	1152
10	Panaji (M Corp. + OG)	70991	1707	4586	64698
11	Renovadi (OG) WARD NO.-0033 (Rural MDDS CODE:626738)	500	1	2	497
12	Morambi-O-Pequeno (Merces) (OG) WARD NO.-0034 (Rural MDDS CODE:626739)	931	8	4	919
13	Cujira (OG) WARD NO.-	1229	4	1	1224

S.No	Village Name	Total Population	Schedule Caste	Schedule Tribe	General Caste
	0035 (Rural MDDS CODE:626740)				
14	Taleigao (OG) (Part) WARD NO.-0036 (Rural MDDS CODE:645598)	24201	1097	2869	20235
15	Durgawadi (OG) (Part) WARD NO.-0037 (Rural MDDS CODE:645599)	1610	29	25	1556
16	Murda (CT)	7517	81	314	7122
17	Calapor (CT)	14077	427	1211	12439
18	Bambolim (CT)	6885	172	839	5874
19	Goa Velha (CT)	4322	20	116	4186
	Subtotal(B)	**138687**	**3569**	**11750**	**123368**
	Total(A+B)	**267477**	**5962**	**14427**	**247088**

Source: Primary Census Abstract, 2011

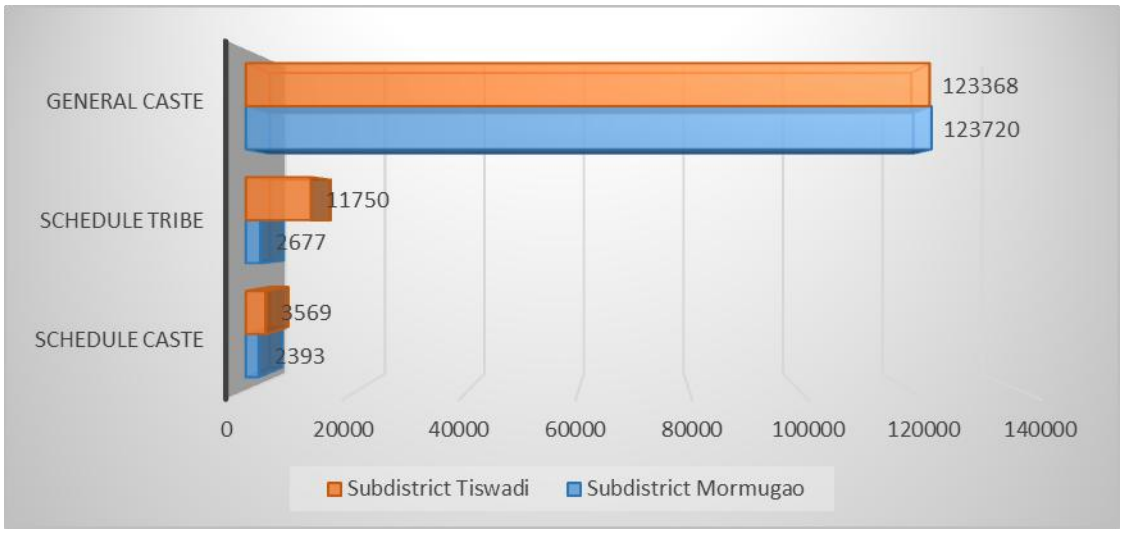


Figure-3.57: Caste profile in the study area villages

Literacy Level

The details of literate and illiterate population amongst the total population of study area villages are shown in Table-3.46. It is observed that about 81.49% of the total population in the study area villages is literate, while about 18.51% are illiterate (Refer Figure-3.58). The literacy rate among male and female population is 84.38% and 78.36% respectively.

Table-3.46: Distribution of literate and illiterate population in study area villages

S. No	Village Name	Total Population	Population Literate	Male Literate	Female Literate	Population Illiterate	Male Illiterate	Female Illiterate
	District South Goa							
	Subdistrict Mormugao							
1	Dabolim	6027	4739	2550	2189	1288	592	696
2	Cuelim	1777	1307	667	640	470	172	298
3	Pale	1990	1537	834	703	453	176	277
4	Chicolna	2680	2117	1127	990	563	223	340
5	Mormugao (M Cl)	94393	76068	41548	34520	18325	8085	10240
6	Sancoale (CT)	21923	16656	9429	7227	5267	2228	3039
	Subtotal(A)	**128790**	**102424**	**56155**	**46269**	**26366**	**11476**	**14890**
	Subdistrict Tiswadi							
7	Batim	1489	1218	633	585	271	106	165
8	Curca	2518	1952	1014	938	566	218	348
9	Siridao	2417	1786	929	857	631	250	381
10	Panaji (M Corp. + OG)	70991	60071	31090	28981	10920	4898	6022
11	Renovadi	500	418	221	197	82	38	44
12	Morambi-O-Pequeno	931	767	378	389	164	66	98
13	Cujira	1229	1033	516	517	196	85	111
14	Taleigao	24201	19755	10441	9314	4446	1961	2485
15	Durgawadi	1610	1345	710	635	265	120	145
16	Murda (CT)	7517	6117	3066	3051	1400	633	767
17	Calapor (CT)	14077	11628	6043	5585	2449	1075	1374
18	Bambolim (CT)	6885	5971	4362	1609	914	450	464
19	Goa Velha (CT)	4322	3473	1779	1694	849	350	499
	Subtotal(B)	**138687**	**115534**	**61182**	**54352**	**23153**	**10250**	**12903**
	Total(A+B)	**267477**	**217958**	**117337**	**100621**	**49519**	**21726**	**27793**

Source: Primary Census Abstract-2011

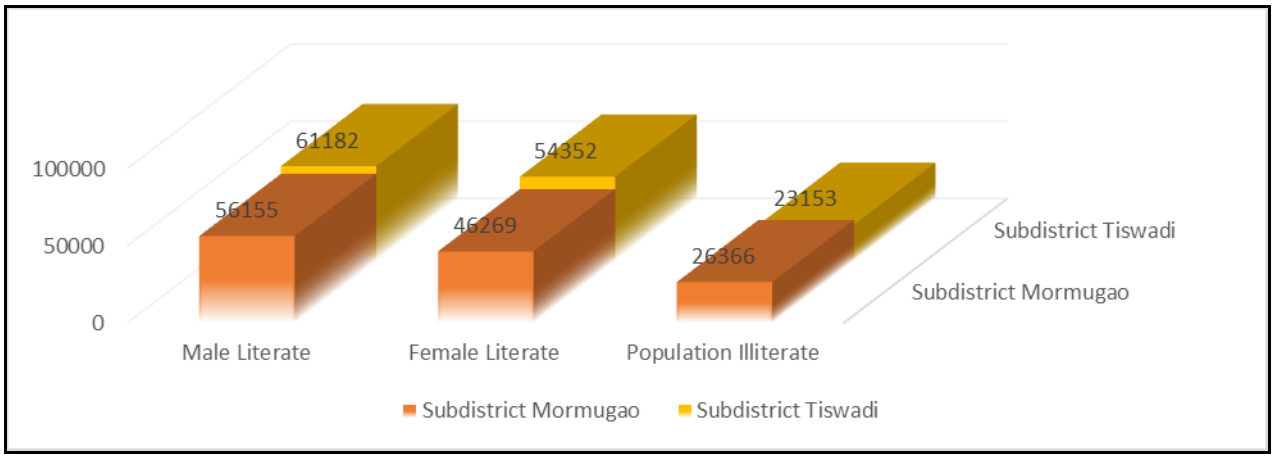


Figure-3.58: Literacy profile in the study area villages

Occupational profile

The details on occupational profile in the study area villages are given in Table-3.47 and Figure-3.59. It is observed that 41.40% of the total population is engaged in some form of economically productive activity or vocational activity, and have been designated as Total Working population. On the other hand, Non-workers or persons who are dependent on the population, which is engaged in economically productive work accounts for about 58.60% of the total population. Among the population that is working about 36.98% has been designated as Main workers while the remaining 4.42% has been designated as Marginal workers.

Table-3.47: Occupational profile in the study area villages

S.No	Village Name	Total Population	Total Workers	Main Workers	Marginal Workers	Non Workers
	District South Goa					
	Subdistrict Mormugao					
1	Dabolim	6027	2563	2434	129	3464
2	Cuelim	1777	673	613	60	1104
3	Pale	1990	701	585	116	1289
4	Chicolna	2680	1032	937	95	1648
5	Mormugao (M Cl)	94393	36929	32208	4721	57464
6	Sancoale (CT)	21923	9310	7795	1515	12613
	Subtotal(A)	**128790**	**51208**	**44572**	**6636**	**77582**
	Subdistrict Tiswadi					

S.No	Village Name	Total Population	Total Workers	Main Workers	Marginal Workers	Non Workers
7	Batim	1489	422	347	75	1067
8	Curca	2518	925	877	48	1593
9	Siridao	2417	867	676	191	1550
10	Panaji (M Corp. + OG)	70991	30220	27709	2511	40771
11	Renovadi (OG)	500	186	168	18	314
12	Morambi-O-Pequeno	931	376	345	31	555
13	Cujira	1229	481	409	72	748
14	Taleigao)	24201	10437	9582	855	13764
15	Durgawadi (	1610	645	597	48	965
16	Murda (CT)	7517	3015	2626	389	4502
17	Calapor (CT)	14077	5743	5239	504	8334
18	Bambolim (CT)	6885	4429	4252	177	2456
19	Goa Velha (CT)	4322	1771	1506	265	2551
	Subtotal(B)	**138687**	**59517**	**54333**	**5184**	**79170**
	Total(A+B)	**267477**	**110725**	**98905**	**11820**	**156752**

Source: Primary Census Abstract 2011

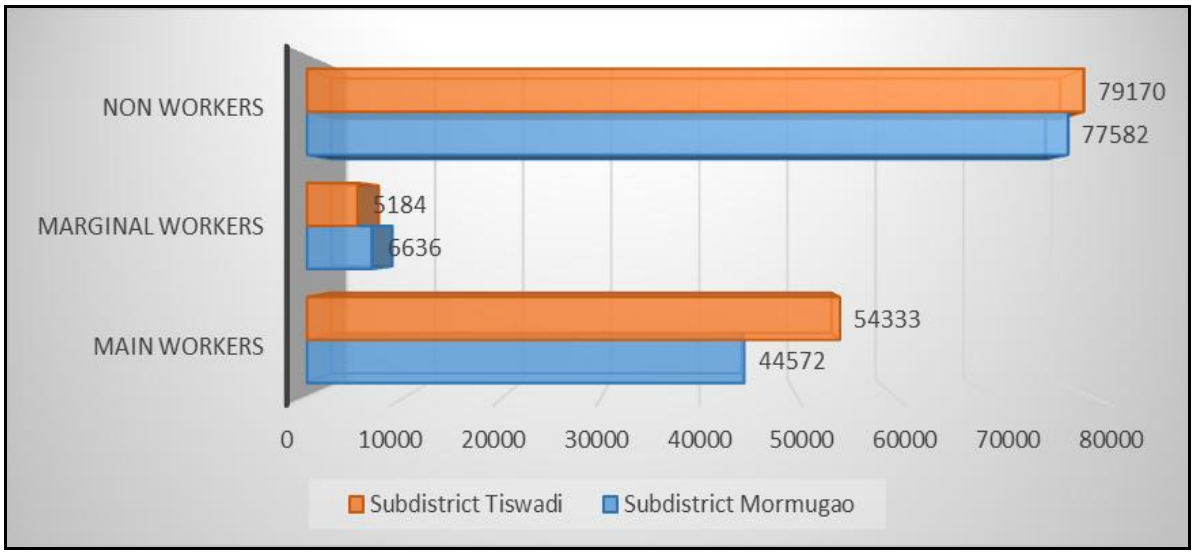


Figure-3.59: Occupational profile in the study area villages

CHAPTER-4
PREDICTION OF IMPACTS

CHAPTER-4

PREDICTION OF IMPACTS

4.1 INTRODUCTION

The proposed project envisages the Redevelopment of existing Berths 8, 9 and Barge Berths at the Mormugoa Port Trust, Goa. Entire facility will come within existing Port area. The existing structures will be dismantled for the proposed development. Scope of work broadly cover development of 3 nos. berths by construction of 25 m wide berthing structure, and anciliary structures for handling cargo. Works include Designing, Engineering, Financing, Construction, Operation, Maintenance and Marketing and providing the Project facilities. The proposed project involves covered storage for coal cargo and open storage for general cargo, construction of Bund and extension of Berth face. The total length of reclamation front is around 950 m and total area is around 11.40 ha. Total quantity of capital dredging has been estimated to be 2.44 Mm^3 for deepening the area near the Berth face from 14.40 up to -19.80m. The Cargo to be handled at the proposed facility will include coal / coke / gypsum / limestone / dolomite / iron ore / and container etc. Existing capacity of Berth No. 8 and 9 is 13 MMTPA which will increase to 19 MMTPA, with one coal berth, one iron ore berth and one multipurpose cargo berth.

Based on the project details and the baseline environmental status, potential impacts likely to accrue as a result of the proposed project have been identified. The assessment for quite a few disciplines is subjective in nature and cannot be quantified. Wherever possible, the impacts have been quantified. However, for non-tangible impacts, qualitative assessment has been done so as to formulate appropriate management measures for them as well.

4.2 IMPACTS DURING CONSTRUCTION PHASE

4.2.1 LAND ENVIRONMENT

a) Impacts due to pre-construction activities

Pre-construction activities generally involve the construction of access roads, clearing of the project site, siting of labour camps construction of storage sheds, etc. However, the proposed project envisages the of Redevelopment of Berth No. 8 and 9 at the Mormugao Port, which are well connected by rail and road. There is no need of the construction of new roads and land acquisition for the proposed development. However, preparatory activities like the use of existing access road, construction of storage sheds, etc. may have some impact on surrounding environment. This disturbance will be limited to the construction area alone and is not expected to have impact beyond the construction area.

b) Impacts on land use pattern of the area

The proposed project site is located within Mormugao Port area and envisages the construction of Bund and extension of Berth face up to 50 m. The total area of reclamation in the project will be around 11.40 ha. The total backup area after the reclamation of entire barge berth area and berth face will be around 27 ha. Railway lines, land for cargo stacking, conveyor system, offices, roads, railway and other allied facilities shall also be developed as a part of the project. However, all the activities are within the Mormugao Port limits and hence, no major impact is anticipated on land use pattern except reclamation as a result of the proposed modernisation of Berths 8, 9 and Barge Berths.

c) Impacts due to quarrying operation

The proposed project envisages reclamation of an area of 11.40 ha and increasing the area to about 27 ha. Apart from the reclamation work 1.0 lakh m^3 of crushed aggregate and 60,000 m^3 of sand will be required for the construction activity. No dedicated quarry is proposed for the extraction of filling material for the redevelopment works. Required reclamation material will be obtained from nearest approved quarries located at about 15 km

from the Mormugao Port, at Verna and Cortalim. Crushed granite metal will be brought from Quepm Taluka located at about 60 km from the site and sand will be sourced from the river in Karwar and Pernem, which are located about 70 and 100 km, from the proposed site respectively. Since, no dedicated quarry is required for the extraction of filling and construction material for the proposed redevelopment works, adverse impacts due to quarrying operations are not anticipated. However, transportation of material may lead to rise in the fugitive dust and gaseous emissions during filling operations. This will be restricted to the construction area and will manifest only during the ongoing works.

d) Impacts due to generation of garbage at port

No labour camps are required for the project, therefore quantity of domestic solid waste will be very limited. The garbage generated during construction phase will be compressed of packaging material, used tyres, plastic, metal items, etc. Such items shall be collected and sold to scrap dealers. Hence, no major impacts are anticipated on this account.

4.2.2 WATER ENVIRONMENT

a) Impacts due to effluents from labour camps

The average labour strength likely to be deployed for the execution of the proposed modernization will be about 100. The small labour force will be coming from nearby area and no labour camps are needed at the project site. As such only the existing sanitation facilities of Mormugao Port will suffice. The total water requirement for domestic purposes during construction phase has been estimated as 4500 litre/day (@ 45 lpcd X 100 persons) and the quantity of domestic sewage likely to be generated during construction phase will be about 3600 litre/day. The used domestic water normally contains high BOD, which needs proper treatment and disposal, otherwise, it can have an adverse impact on the DO levels of the receiving body. There are existing sewage handling facilities in operation at Mormugao Port, which can handle the additional inputs due to the proposed redevelopment activities in the Port.

Apart from the domestic water requirements, fresh water will be required for

construction purpose also. The total fresh water requirement during construction phase has been estimated as 60 m^3 and will be met from existing sources of Mormugao port. Fresh water requirement for operation phase has been estimated at 40 cum/day. The water will be obtained from public Works Department (PWD), Goa.

b) Impacts on marine water quality

Redox potential (eH) and pH are two variables that control the characteristics of chemicals and heavy metals in water and sediment. As long as the pH remains around 8 and eH< 150 mV, most of the chemicals and metals will remain bound to the solid phase without being released into the surrounding water. Only anoxic conditions reduce the eH below this level and hence if dissolved oxygen level is normal no leaching of chemicals and heavy metals will occur.

In the present survey site pH varied between 7.8 and 8.7 and dissolved oxygen was 3.7 to 6.4 mg/l which is ideal for a marine ecosystem. Dissolved oxygen levels are not reduced to anoxic conditions. Under these circumstances, there is no possibility of any of the chemicals or metals being leached into the water. Moreover, sediment samples collected from all the sites were uncontaminated. As such no adverse impact due to dredging or dumping on the chemical characteristics of water or sediment is expected.

4.2.3 IMPACTS ON TERRESTRIAL ECOLOGY

The direct impact of construction activity for any project is generally limited in the vicinity of the construction sites only. The proposed project envisages redevelopment of Berths 8 and 9 at the Mormugao Port. The entire facility will come within existing Port area. There is no need of construction of new roads and of additional land acquisition for the proposed development. Hence, no significant impact is anticipated due to the proposed project. The site of the proposed redevelopment is an existing Port activity area without any flora and fauna. It is only the being redeveloped. Thus no impact whatsoever on terrestrial ecology is involved.

4.2.4 IMPACTS ON MARINE ENVIRONMENT

a) Impacts due to capital dredging and disposal of dredged material

The process of sedimentation and the environmental quality of the overlying waters typically decides heterogeneous distribution of contaminants within the sediments. It has been variously reported that sediments are sinks for heavy metals and their disturbance through dredging could cause the remobilization of metals. The sediment metal concentrations at the proposed project site are no high and are in fact far lower than in other nearby locations of the Coast.

The existing depth of the channel, in front of Berths 8, 9 and Barge Berths is (-) 14.1 m below the CD. Mormugao Port proposes to allow capesize vessels after the redevelopment of Berth 8 and 9. The required depths to cater to capesize vessels in the inner channel is (-) 19.8m below CD. Hence, capital dredging has to be carried out alongside of the proposed Berths in the shipping channel. The quantity of dredging has been estimated at 2.44 Mm^3 and the details are given in Table 4.1.

Table-4.1- Details of Quantity of dredged material

Description	Area (Sqm)	Existing Depth (-) m CD	Proposed Depth (-) m CD	Depth of dredging (m)	Tolerance (m)	Total Qty (Cum)
Inner channel area in front of berth 8, 9 and	405082	14.1	19.5	5.4	0.3	2438213
Total Quantity of dredged material						2438213

The Dredger proposed to be employed to carryout dredging is Trailer Suction Hoper Dredger (TSHD) with a capacity of dredging upto 250m^3/hour. Two TSHD's are proposed to be deployed with daily output of about 50,000 m^3 per day. The excavation of bottom sediments can cause a variety of environmental impacts such as increase in turbidity, increase in chemical pollutant concentrations, depletion of oxygen and loss of benthic population. Problems arise in particular where sediments have been contaminated by chemicals / metals. But, present study reveals that the

sediments in and around the proposed project area do not have any significant pollutant (metal) concentrations.

The dredged materials will be dumped in the designated dumping site identified by the CWPRS. The proposed dumping area identified for capital dredging has a depth of 27m below CD at 356000E and 1705000N and that for maintenance dredging will be at 358500E and 1706500N with a depth of -23m contour. These have been identified by CWPRS using MIKE 21 HD modelling. The dumping sites have been continuously monitored for changes in parameter levels and these have been found to be minimal. The dumping site location map is enclosed as **Figure-4.1.**

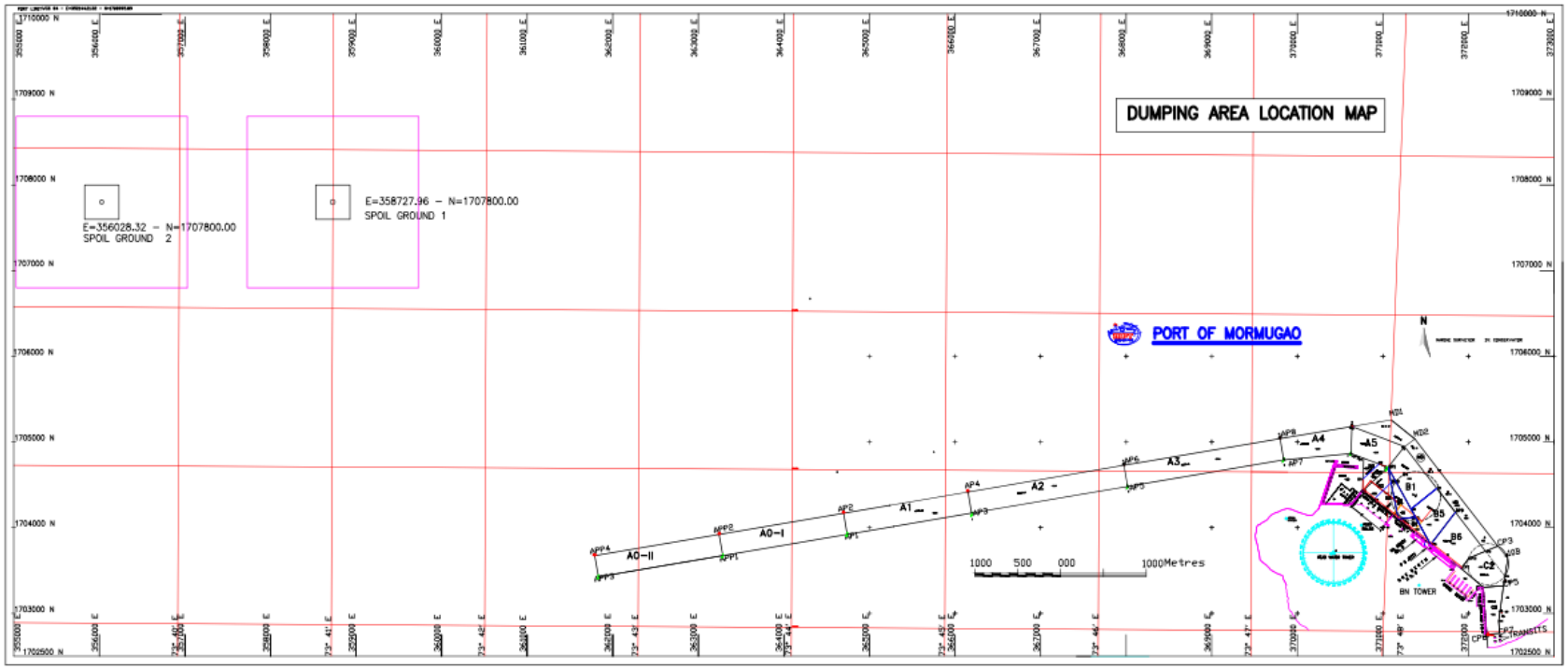


Figure-4.1: Dumping site location map

b) Impacts on marine ecology

The project area has moderate productivity. It is entirely located within the most active Port area of MPT, which as seen shipping activity for more than five decades. The area is also under periodical maintenance dredging during the said period. There are no sites of ecological significance in and around the project area. Likewise, no spawning ground was observed. The proposed dredging will be conducted in the same area to increase the width and depth of the navigation channel. As a result of dredging, significant impacts on marine ecology is anticipated. In the areas to be dredged, the existing marine life would be adversely affected. The area to be dredged would, however, recolonize in short duration after the cessation of dredging activities. However, these areas would have regular ship traffic, which leads to significant disturbance as compared to the pre-project status. This means that though the dredged stretches are likely to get recolonized, the ecology is not expected to develop up to the pre-project levels.

- Dredging work in the berths number 8, 9 and Barge Berths is to be carried out to increase the levels from 14.4 to 19.5 m. The total quantity of dredged sediment is about 2.44 Mm^3. The equipment to be employed to carryout dredging is Cutter Suction Dredger having a capacity of dredging 250 m^3/hour, which will run on diesel.
- Disruption of bottom sediments can cause a variety of environmental impacts like increase in turbidity, increase in chemical pollutant concentrations, depletion of oxygen and loss of benthic population.
- Problems arise in particular where sediments have been contaminated by chemicals / metals. But, the present study reveals that the sediments in and around the proposed project area are not contaminated.
- Excavation of soft bottom by dredging also removes the habitat (Benthic communities) of those forms living in the bottom sediments are subject to direct mortality or burial, however, these organisms

usually recover from disturbances in a relatively short time. Initially invertebrate species diversity may increase in dredged channels, as opportunistic species rapidly colonise the excavated area.

- Digging or disturbing the substratum will also increase the turbidity of waters. This turbidity will reduce the transparency of water followed by reduction in the penetration of light, which in turn result in low level of primary production. However, this impact is likely to be temporary in nature, likely to last during dredging activities or few days after that.
- Organics in the suspended material can deplete available dissolved oxygen from the surrounding waters and temporarily create stressed conditions for many aquatic animals.
- The severity and extent of dredging related impacts depends on the type of dredging equipment used and the susceptibility of nearby habitat types and aquatic biota. The choice of TSHD optimizes the dredging production, thus reducing the dredging time and minimizes the effects of turbidity more over than the conventional dredging methods.

c) Impacts on benthic organisms

During dredging operations, the removal of material from the sea bed also removes the animals living on and in the sediments (benthic animals). With the exception of some deep burrowing animals or mobile surface animals that may survive a dredging event through avoidance, dredging may initially result in the complete removal of animals from the excavation site.

The dredging sites tend to recover on completion of dredging activities. The recovery of disturbed habitats following dredging ultimately depends upon the nature of the new sediment at the dredge site, sources and types of re-colonising animals, and the extent of the disturbance. In soft sediment environments recovery of animal communities generally occurs relatively quickly and a more rapid recovery of communities has been observed in areas exposed to periodic disturbances, such as maintained channels.

Thus, in area under maintenance dredging in subsequent years, the recovery of benthic organisms is not expected to be significant.

Dredging works in coastal areas world-wide showed that the rates of recovery of benthic communities following dredging in various habitats varied greatly. Recovery rates were most rapid in highly disturbed sediments in estuaries that are dominated by opportunistic species. In general, recovery times increase in stable gravel and sand habitats dominated by long-lived components with complex biological interactions controlling community structure. Thus, in the dredging site of the proposed project, where the texture of the sediments is mainly sandy, the recovery time is expected to be relatively slow.

The severity and extent of dredging related impacts depends on the type of dredging equipment used and the susceptibility of nearby habitat types and aquatic biota. The choice of TSHD optimizes the dredging production, thus reducing the dredging time and minimizes the effects of turbidity more over than the conventional dredging methods.

d) Impacts on benthic organisms and fish fauna due to entrainment

Entrainment occurs when organisms are trapped during the uptake of sediments and water by dredging machinery. Benthic fauna are particularly vulnerable to being entrained by dredging uptake, but mobile epibenthic and demersal organisms such as burrowing shrimp, crabs and fish may also be susceptible to entrainment under some conditions. Since dredging is proposed to be carried out using cutter suction dredger there is a possibility of benthic organisms being trapped and displaced along with the dredged materials.

Fishes have the ability to avoid plumes and dredge activity areas. Whereas the behavioral nature of fish present and the options available to them in order to avoid the dredge areas are dependent on the local factors such as availability of undisturbed areas etc. Hence the availability of environmental windows will help to avoid entrainment and limit risk is also suggested.

e) Impacts on Suspended sediments and turbidity

Another possible impact is the release of toxic elements from the sediment, if the same is contaminated. In the case of contaminated sediment, acute toxicity, chronic toxicity and bioaccumulation are the possible effects. However the base line sediment data collected in this study has shown that the concentration of the hazardous trace elements is very low. As such no significant release of such elements is expected during dredging. Moreover any such adverse impact are short term, and no serious effects have been reported from any earlier instances or experimental studies.

During the construction phase dredging and disposal of dredge materials will increase the turbidity levels, which may affect the marine water quality. This is mainly because the dredged material gets released during one or all the operations mentioned below:

- Excavation of material during dredging operations
- Loss of material during transport to dumping ground
- Overflow from the dredger while loading
- Loss of material from the dredger during transportation.
- Dumping of dredge materials during disposal in the sea.

The cumulative impact of all the above operations is increase in turbidity levels. Good dredging practices can however, minimize turbidity.

It has also been observed that slope collapse is the major factor responsible for increase in the turbidity levels. If the depth of cut is too high, there is possibility of slope collapse, which releases a sediment cloud. This will further move outside the suction radius of dredged head. In order to avoid this typical situation, the depth of cut be restricted to:

$$\gamma H/C < 5.5$$

where,

γ - unit weight of the soil

H - depth of soil

C - Cohesive strength of soil

The dredging and disposal of dredged material may affect the survival and propagation of benthic and free-swimming organisms. The macro-benthic life, which remains, attached to the stones, boulders etc. gets dislodged and is carried away downstream by turbulent flow. The benthic fauna gets affected during the construction and dredging operations. However, in due course of time the area gets recolonized, with fresh benthic fauna. The density and diversity of benthic fauna, will however, be less as compared with the pre-dredging levels.

When dredging and disposing of non-contaminated sediments, the key impacts are the increase in suspended sediments and turbidity levels. Any dredging method releases suspended sediments into the water column, during excavation itself and during the flow of sediments from hoppers and barges. In many cases, locally increased suspended sediments and turbidity associated with dredging and disposal is obvious from the turbidity 'plumes' which may be seen trailing behind dredgers or disposal sites.

Increase in suspended sediments and turbidity levels from dredging and disposal operations may under certain conditions have adverse effects on marine animals and plants by reducing light penetration into the water column and by physical disturbance.

Increased suspended sediments can affect fishes, if suspended sediments become trapped in their gills increased fatalities of young fish have been observed in highly turbid water. Adult fish are likely to move away from or avoid areas of high-suspended solids, such as dredging sites, unless food supplies are increased as a result of increases in organic material. The increase in turbidity could marginally affect the fisheries in the area.

The increase in turbidity results in a decrease in the depth that light is able to penetrate the water column, which may affect submerged plants, by temporarily reducing productivity and growth rates. However, the project is proposed within the Mormugaon Port, and benthic fauna is not well developed in these areas, hence impacts on this account is not expected to

be significant. The degree of re-suspension of sediments and turbidity during dredging and disposal depends on:

- Sediments being dredged (size, density and quality of the material)
- Method of dredging (and disposal)
- Hydrodynamic regime in the dredging and disposal area (current direction and speed, mixing rate, tidal state) and
- Existing water quality and characteristics (background suspended sediment and turbidity levels).

In most cases, sediment re-suspension is only likely to present a potential problem if it is moved out of the immediate dredging location by tidal processes. In general, the effects of suspended sediments and turbidity are generally short term (<1 week after activity) and near-field (<1km from activity). These are of concern only, if sensitive species are located in the vicinity of the maintained channel. Since, no sensitive species are observed in the areas to be dredged, hence, no adverse impacts are anticipated. Dredged material is proposed to be disposed off at designated site in deep sea.

In various sampling locations covered as a part of the study, sediment samples analyzed did not show the presence of any appreciable levels of contamination and hence may not pose any such problems.

f) Impacts due to settlement of suspended sediments

Sediments dispersed during maintenance dredging and disposal may resettle over the seabed and the animals and plants that live on and within it. This blanketing or smothering of benthic animals and plants may cause stress, reduced rates of growth or reproduction and in the worse cases the effects may be fatal. Generally sediments settle within the vicinity of the dredged area, where they are likely to have little effect on the recently disturbed communities, particularly in areas where dredging is a well-established activity. Hence, impacts on this account are not expected to be

significant in areas to be covered under maintenance dredging. However, in other areas to be dredged, too, settlement of suspended sediments will be just after they have been freshly disturbed hence, adverse impacts on this account are not anticipated.

It has been generally found that, if sediments are not toxic in-situ, they do not become so even after the disposal. The dredged material is not used for backfilling hence, adverse impacts on marine water quality and ground water quality are not anticipated.

g) Impacts on fisheries

The most important impact on fishes may be suspended solid load or changes in the food chain. The high turbidity due to heavy suspended solid load during dredging or disposal of dredged materials results in clogging of gills of fishes thereby causing asphyxiation. But since fishes are free swimming they very well avoid such areas and move to safer areas. Once the turbidity disperses due to current and wave disturbances, they come back to the area. Due to this capability of the fishes there is virtually no impact on fishes and fisheries by dredging and disposal. The study also did not show the existence of breeding grounds for fisheries. Further, as stated earlier the area under the proposed dredging activity is located well within the active shipping zone of the Port where no fishing activity takes place.

h) Impacts on phytoplankton and primary productivity

Biomass of phytoplankton depends mainly on the availability of light in nutrient rich waters. Dredging and disposal may lead to increased turbidity and consequent reduction of light penetration for short periods. This may affect primary productivity and plankton biomass. However, turbidity due to dredging and dumping will be observed only in a localised area and only for a very short duration. Hence these impacts are not expected to be significant in nature.

Based on the marine ecological status of the project area, it may be concluded that the site supports only limited biodiversity with very low

densities of biological organisms. Most of the environmental variables are recorded within the optimal levels, recorded in other parts of the west coast. The dissolved oxygen is fairly good, largely due to the high water exchanges. Due to high water exchanges, heavy metal concentration in water and sediment samples are low. The site supports low benthic population. There are no records or sighting of rare / endangered / threatened organisms in the area. In general, the biodiversity profile of the proposed dredging area is low.

i) Impacts on Corals

The occurrence of coral reefs in the Grade island has been documented by researchers recently (Shesdev Patro et al., 2015). The nearest habitat of corals from the proposed site is Grand island located about 5 km. Sediment texture in the study area was primarily silty which means the sediment will take time to settle down and having more chances to be carried to the Island.

j) Impacts due to reclamation

About 11.40 ha of area are to be reclaimed by filling with dredged material. The chemical impacts due to the backfilling are dependent on the redox potential and pH. Normally, if pH remains around 8, heavy metals like zinc, copper and mercury will remain bound to the solid phase. In the post-project phase, after the reclamation of land, pH and redox potential in the adjacent water is not expected to change. In the post-project phase, since no change is anticipated in the pH and redox potential, heavy metals are likely to remain bound to the sediments. The backfilling material will be obtained from already existing loose materials available in the Port area from due to various activities. However if the present available quantities does not suffice the needs for backfilling then the available materials within a 30km radius will be used. Care will be taken that no hill cutting will be permitted for backfilling activities. Since the material used for backfilling is not having any contaminants, no impact on the marine water quality or change in

ground water quality is anticipated due to dumping of murrum for reclamation. It has been generally found that, if sediments are not toxic in-situ, they do not become so even after the backfilling. Hence, adverse impacts on marine water quality are not anticipated.

Dredging and disposal of dredged spoils are key elements of the present project. The dredging proposals are mainly carried out to provide navigable water depths for shipping at ports and harbours. Once material is excavated from the seabed by a dredger, it can be handled in various ways. Often dredged material is loaded into a hopper (part of the dredger itself or on a separate vessel) and transported to a disposal site where the contents of the hopper are emptied directly in the open ocean (i.e. sea dumping) or via a pipeline that allows the dredge material to be pumped to location where it is used for engineering purposes. The impacts have been categorised for construction as well as operation phases.

4.2.5 AIR ENVIRONMENT

a) IMPACTS DUE TO FUGITIVE EMISSIONS

Propose project envisages the redevelopment of Berths 8th, 9th and barge berth at the Port of Mormugao, Goa. Entire facility will come within existing Port area. Existing structures will be dismantled for the proposed development. Propose project involves the covered storage for coal cargo and open storage for general cargo, construction of Bund, extension of Berth face, reclamation in an area of 11.40 ha and capital dredging of 2.44 Mm^3.

The total quantity of the material required for the reclamation has been estimated as about 11.40 lakh m^3. Apart from the reclamation work 1.0 lakh m^3 of crushed aggregate and 60,000 m^3 of sand will be required for the construction activity.

The material required for reclamation will be boulders and murrum. About 3 lakh m^3 excavated loose material is available in port operational area and balance quanitity of 8.40 lakh m^3 will be transported from nearest quarry site located about 15 km from Mormugao Port at Verna and Cortalim. Crushed granite metal will be brought from Quepm Taluka located at about 60 km from the site and sand will be sourced from the river in Karwar and Pernem, which is located about 70 to 100 km from the proposed site. Hence, the increase in the number of trucks will be of the order of 110 Nos. of trips per day, considering the construction period of 36 months. Transportation of reclamation and construction material will lead to rise in the traffic during construction phase. Hence, transportation activity will increase fugitive dust and gaseous emissions in the area.

The major pollutant in the construction phase is SPM being air-borne due to various construction activities. The vehicular movement generates pollutants such as NOx, CO and HC. But, the vehicular pollution is not expected to lead to any major impacts. The soils in the project area are sandy in texture, and are likely to generate dust as a result of vehicular movement. However, the fugitive emissions generated due to vehicular movement are not expected to travel beyond a distance of 200 to 300 m. The impact on air environment during construction phase is not expected to be significant, since, there are habitation in the vicinity of the site.

b) Impacts due to construction equipment

The combustion of diesel in various construction equipment could be one of the possible sources of incremental air pollution during the construction phase. The fuel utilization rates of various equipments expected to be in operation during construction phase is given in Table-4.2. Under the worst case scenario, it has been considered that equipment used for construction of berth and earthwork at each site, are operating at a common point.

Table-4.2: Fuel combustion during construction phase

S. No	Equipment	Fuel consumption rate (lph)	No. of units	Total fuel consumption (l)
1.	Dumpers	30	4	120
2.	Generators	30	2	60
3.	Batching plant	40	1	40
4.	Dumpers	20	4	80
5.	Loaders and unloaders	25	3	75
6.	Excavators	25	2	50
7.	Water tanker	8	5	40
	Total			**465**

The major pollutant likely to be emitted due to construction of diesel in various construction equipment shall be SO_2. The short-term increase in SO_2 concentration has been predicted using Gaussian plume dispersion model. The results are summarized in Table-4.3.

Table-4.3: Short-term (24 hr) increase in concentration of SO_2 ($\mu g/m^3$)

Wind Speed (m/s)	Distance (km)			
	0.1	0.2	0.3	0.4
0.2	$2.14x10^{-08}$	$1.01x10^{-08}$	$2.18x10^{-09}$	$8.22x10^{-10}$
0.85	$5.03x10^{-09}$	$2.38x^{-09}$	$5.14x10^{-10}$	$1.93x10^{-10}$
1.53	$2.8x10^{-09}$	$1.32x10^{-09}$	$2.85x10^{-10}$	$1.07x10^{-10}$
2.78	$1.54x10^{-09}$	$7.28x10^{-10}$	$1.57x10^{-10}$	$5.91x10^{-11}$
4.30	$9.95x10^{-10}$	$4.71x10^{-10}$	$1.02x10^{-10}$	$3.82x10^{-11}$
5.98	$7.21x10^{-10}$	$3.42x10^{-10}$	$7.36x10^{-11}$	$2.77x10^{-11}$
7.00	$6.11x10^{-10}$	$2.89x10^{-10}$	$6.24x10^{-11}$	$2.35x10^{-11}$

It is evident from Table 4.3 that the maximum short-term increase in SO_2 is observed as 0.0214 $\mu g/m^3$, which is at a distance of 100 m from the emission source. The incremental concentration is quite low and does not require any specific control measure. Thus, the operation of construction equipment is not expected to have any major impact on the ambient air quality as a result of the project.

4.2.6 NOISE ENVIRONMENT

a) Noise due to operation of construction equipments

The major sources of noise during construction phase are due to operation of various construction equipments. The noise levels generated by various construction equipments are given in Table-4.4.

Table-4.4: Average noise levels generated by the operation of construction equipment

Equipment	Noise level (dB(A))
Floating pontoon with crane	70
Winch machine	80
Transit mixer	75
Dumpers	75
Dredger	85
Booster pumps	85

Under the worst-case scenario, considered for prediction of noise levels during construction phase, it has been assumed that equipment required during construction phase is operating at a common point. Likewise, to predict the worst-case scenario, attenuation due to various factors too has not been considered during noise modelling. Modeling studies were conducted to assess the increase in noise level due to operation of various construction equipments, and the results of this exercise are given in Table-4.5.

Table-4.5: Predicted noise levels due to the operation of various construction equipment

Distance (m)	Ambient noise level (dB(A))	Increase in noise level due to construction activities (dB(A))	Noise level due to construction activities (dB(A))	Increase in ambient noise level due to construction activities (dB(A))
30	50	69	82	32
50	50	65	79	29
100	50	59	75	25
200	50	53	72	22
500	50	45	70	20

Distance (m)	Ambient noise level (dB(A))	Increase in noise level due to construction activities (dB(A))	Noise level due to construction activities (dB(A))	Increase in ambient noise level due to construction activities (dB(A))
1000	50	39	70	20
1500	50	35	70	20
2000	50	33	70	20

It is clear from Table 4.5, that at a distance of 1 km from the construction site, the increase in noise levels will be only 20 dB(A). The nearest residential areas are at a distance of more than 0.5 km from the proposed project site. Hence, no major adverse impacts are anticipated on ambient noise levels during construction phase of the proposed project.

However care would be taken to reduce the noise levels from propagating out of the construction sites by appropriate noise abating methods. Installation of screens also helps in dust suppression and prevents the propagation of noise.

It would be worthwhile to mention that all the equipment have been assumed to operate at a common point and hence generation of noise shall be restricted to the construction area only. This assumption leads to over-estimation of the increase in noise levels. Also, it is a known fact that there is a reduction in noise level as the sound wave passes through a barrier.

Walls of various houses or other structure will attenuate at least 30 dB(A) of noise. In addition there is noise attenuation due to the following factors.

- Air absorption
- Rain
- Atmospheric in-homogeneities
- Vegetal cover

Thus, no increases in noise levels are anticipated as a result of various activities, during the project construction phase due to the following:

- Assumption that all equipment are operating from a common point leads to over-estimation of increase in noise level

- Attenuation of 30 dB(A) of noise by wall of any structure
- Noise attenuation due to various factors.

b) Noise due to increased vehicular movement

During construction phase, there will be significant increase in vehicular movement for transportation of construction material. At present, there is no vehicular movement near the barrage site. During construction phase, the increase in vehicular movement is expected to increase up to a maximum of 110 trucks per day. The increase in number of trucks is too small to cause any adverse impact on ambient noise level.

c) Impacts of noise on labour

The effect of high noise levels on the operating personnel has to be considered as this may be particularly harmful. It is known that continuous exposures to high noise levels above 90 dB(A) affects the hearing acuity of the workers/operators and hence, should be avoided. To prevent these effects, it has been recommended by Occupational Safety and Health Administration (OSHA) that the exposure period of affected persons be limited as in Table-4.6.

Table-4.6: Maximum Exposure Periods specified by OSHA

Maximum equivalent continuous Noise level dB(A)	Unprotected exposure period per day for 8 hrs/day and 5 days/week
90	8
95	4
100	2
105	1
110	½
115	¼
120	No exposure permitted at or above this level

4.3 IMPACTS DURING PROJECT OPERATION PHASE

4.3.1 WATER ENVIRONMENT

No staff colony is proposed as a part of the project. Total water requirement for domestic purposes during operations phase has been estimated as 40 m^3/day and the quantity of domestic sewage likely to be generated during construction phase will be about 32 m^3/day. The total manpower required during the construction phase would be of the order of 100 nos. Hence, the no separate canteen, toilets and drinking water facilities are envisaged and the construction staff will use the existing sanitation and canteen facilities of Mormugaon Port. Fresh water requirement during operation phase will be met with the water received from Public Works Department (PWD), Goa.

4.3.2 AIR ENVIRONMENT

Generation of dust during cargo handling

Proposed project envisages the handling of Coal at berth No. 8, berth No.9 will be used for container and general cargo, while berth 9A will cater to the requirements for Iron ore. Handling of coal, limestone and Iron ore will lead to increased level of dust in the port area. Dust consists of tiny particles carried by air currents, which are caused by a wide range of construction activities. Controlling dust emissions helps to:

- Reduce contamination of property, environment, and human health
- Reduce impacts on aquatic life, vegetation, and water quality due to turbidity and sedimentation
- Reduce vehicle and equipment damage and abrasion due to mechanical wear, road impact, and particle consumptions in the operating equipment
- Reduce accidents and injuries due to poor visibility.

Operations requiring dust prevention:

- Dumping of coal and iron ore
- Transportation

- Transfer points
- Stockpiling/reclaiming

In these operations, moisture can be applied to the material when it is stationary or moving or both. Operations requiring airborne dust suppression:

- Conveyer system
- Transfer points
- Loading/unloading

Nozzles produce drops to collide with dust particles that are already airborne. The moisture weighs the particles down so they are returned to the material source or ground.

Generation of Garbage at Port

The other problem envisaged during operation phase could be the disposal of garbage. This could comprise floating materials, packaging, polythene or plastic materials. Garbage accumulated on the deck is also problematic and shall be suitably disposed.

However, the proposed project is very small in nature, the peak labour requirement has been estimates as 100. Considering the size and location of the project labour colony is not proposed for construction and operation of the project. Labour population shall use the existing canteen and sanitation facilities of Mormugao port. Hence, garbage generation is not anticipated in the project.

4.3.3 ENVIRONMENTAL IMPACT FROM SHIP TRAFFIC

During the operational phase with additional facilities there will be increased activities of ship movement in the region. All these activities may have impacts on marine lives. Possible sources of such impacts on marine environment would be from;

- Accidental Oil Spill from the calling ships
- Ballast water
- Illegal tank washing

- Ship grounding, physical damage of bottom community
- Anchoring
- Discharges of sewage from vessels
- Discharge of solid waste
- Ship traffic poses a risk of oil pollution from the following sources
- Small spills caused by the accidental or intentional release of oil-contaminated bilge water from freights
- Minor spills caused by release of bunker oil during terminal operations
- Major spills caused by the rupture of a bunker oil tank in a bulk/cargo vessel collision, shipwreck of a bulk/cargo vessel.
- Marine environmental implications during routine operations at the jetty could be due to the following cases..
- Escapement of cargo during loading/unloading operations
- Release of wastes generated from the ships including garbage, solid waste, oily ballast and bilge water as well as sewage
- Wastes generated at the port terminal such as domestic wastewater, effluent from the grit/oil separator and garbage.

4.3.4 IMPACTS DUE TO NOISE

During project operation phase also, the major source of noise could be due to operation of various equipment. Fitting of exhaust mufflers and intake mufflers could reduce the noise from air unloading equipments. It is very useful for reducing the low frequency noise levels. Chassis and engine structural vibration noise can be dealt with by isolating the engine from the chassis and by the fitting of covers over various sections of engines. It is recommended that workers operating various equipments during project construction and operation phases are provided with ear plugs.

4.3.5 SPILLAGE OF SOLID CARGO

The impact of accidental release of solid cargo, particularly during rough weather, can take place. However, it would have limited impact on the environment. However, the port operations may be hampered if the ship is damaged or the cargo goes overboard that could risk navigation. The escapement of bulks such as iron ore, bulk cargo and container cargo during unloading is not expected to cause any serious impact, as they are non-toxic. Thus, no major impact on marine ecology is anticipated on account of spillage of solid cargo.

Ships generated wastes

The four basic categories of wastes generated by ships are as follows:

- Oily waste which usually consists of some oil mixed with larger quantities of sea water, but also fuel residues and sludges.
- Sewage generated by crew.
- Garbage originating from the crew, the maintenance of the ship, cargo etc.

The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) prohibit all ships from discharging wastes at sea which could result in pollution of the marine environment. MARPOL 73/78 applies to oil tankers, cruise ships, general cargo and container vessels, tugs, ferries, yachts and small pleasure craft.

MARPOL 73/78 requires that ships retain all the wastes on board until reaching port. However, certain wastes can be discharged under certain conditions such as the distance from shore, the type of waste and the condition of the waste (e.g., ground foodstuffs).

4.3.6 IMPACTS ON SOCIO-ECONOMIC ENVIRONMENT

In the construction stage the peak labour force, skilled and unskilled labourers, is estimated at about 100 labour population are likely to come

from nearby sites. Since the laborers will be coming from nearby areas, no labour camps are proposed in the project.

The proposed project lies with existing forest area, hence no additional land acquisition. The issues pertaining to resettlement and rehabilitation are not expanded in this project.

4.4 SHORELINE CHANGE STATUS

West coast exhibits very low rates of littoral drift, primarily due to the high tidal range, where the waves act on different parts of the flat offshore lower beach and the action on the beach above the high tide level are restricted to a very short time interval. As it is difficult to distinguish the direction of the net drift, its effect on the local shoreline remains unchanged.

Apart from this, the operating berths are erosion protected with under deck pitching, so no shoreline change corresponding to the waterfront is likely to happen. Therefore, the existing shoreline along the Mormugao Port Trust is quite stable without any significant changes in the shoreline along its coast. This can be substantiated from the study report on “Use of Satellite data for detection of violation of land use along the Coastal Regulation Zone and Impact of Port structures on Shoreline Changes” by Ministry of Earth Sciences (MoES), prepared for the Ministry of Environment and Forests (MoEF&CC), New Delhi.

4.5 RECOMMENDATIONS

To decrease the impact due to direct behavioral and long-term impact on the ecosystem, the following recommendations are suggested

- More extensive use of multi-season pre and post-dredging biological surveys to assess animal community impacts;
- Incorporation of cumulative effects analysis into all dredging project plans;
- Increased use of landscape-scale planning concepts to plan for beneficial use projects most suitable to the area's landscape

ecology and biotic community and food web relationships, like planting of trees and estuary associated species;

- Identification of turbidity and noise thresholds to assess fish injury risks
- The site-specific selection of dredging equipment and methods and operational procedures, can mitigate some of the negative direct effects of dredging. For example: use of a closed or sealed bucket clamshell dredge can be used to minimize the effects of increased turbidity and contain contaminated materials.

CHAPTER-5
ENVIRONMENTAL MANAGEMENT PLAN

CHAPTER–5

ENVIRONMENTAL MANAGEMENT PLAN

5.1 GENERAL

The aim of the Environmental Management Plan (EMP) is to ensure that the stress/load on the ecosystem is within its carrying capacity. The most reliable way to achieve the above objective is to incorporate the management plan into the overall planning and implementation of the project. The Environmental Management Plan (EMP) for the proposed expansion project is classified into the following categories:

- EMP during project construction phase
- EMP during project operation phase

5.2 EMP DURING CONSTRUCTION PHASE

During construction phase the impacts will be felt both in the marine and land environment. The impacts are discussed under separate heads in marine and land environments in this chapter.

5.2.1 Land Environment

The major impacts on land environment are expected during construction phase only. Considering the size of the project, no labour camps is envisaged at proposed site. It is proposed to use the existing licensed quarries located in Verna and Cortalim villages, which are within a distance of approx. 2Km. Other construction material such as Reinforcing/structural steel, bulk handling equipment spares, etc. will be procured from the market of Vasco and Margao. Hence, no impacts are anticipated on account of quarrying. It shall be made mandatory for the contractor to remove all temporary haul roads, storage areas, structures, and restore the site etc. on completion of construction activities. These aspects will be made mandatory in the Agreement to be signed with the Project contractor involved in construction activities.

The entire project will be constructed within Mormugao Port area, which is well connected by road and rail network. Hence, there is no need for constructing new roads. However, adequate provisions shall be made for

the timely repairs of roads. On completion of construction activities, the roads should be resurfaced completely.

5.2.2 Solid Waste Management

During construction phase, about 100 Nos. of labour are likely to congregate during the daytime. No labour camp is envisaged and all the workers will come from nearby places within Goa. Construction workers will use the existing canteen facility. In Mormugao Port Trust, solid waste generated are collected and handed over to the Mormugao Municipal Council at their dumping yard. The same facility is proposed to be used for the solid waste generated in the Berths. A provision of Rs. 10 lakh has been earmarked for the purchase of one covered tempo for conveyance of solid waste to the landfill site.

5.2.3 Environmental Management Plan for water Environment

Drinking Water for Labour population

During construction phase, about 100 workers per shift are likely to be engaged. Since the total number of work force proposed to be deployed during construction phase is very small, the said labour force will be allowed to use the existing drinking water, canteen and toilet facilities of Mormugao Port.

Sanitation Facilities

As mentioned earlier, the total increase in population during construction phase, would be of the order of 100. The total water requirement for domestic purposes during construction phase has been estimated as 4Cum/day and the quantity of domestic sewage likely to be generated during construction phase will be about 60 litre/day. Since the total number of work force project existing toilet facilities will be utilized.An amount of Rs. 12.5 lakh has been earmarked for maintenance of toilets and other facilities used by the project workerd. The details are given in Table 5.1.

Table-5.1: Cost estimates for development of sanitation facilities

S. No.	Item	Rate (Rs./unit)	Number	Total cost (Rs. lakh)
1.	Existing toilets maintenace	50,000	5	2.5
2.	Sewage collection and transportation from Existing toilets to MPT STP at	Lump sum	1	10.0

S. No.	Item	Rate (Rs./unit)	Number	Total cost (Rs. lakh)
	Headland Sada.			
	Total			**12.5**

Effluent from workshops, oil storage etc.

The effluent from workshops, oil storage, etc. will contain oil and grease particles which shall be treated in an oil skimmer and suitably disposed after treatment or will be sold to registered recyclers approved by the GSPCB. An amount of Rs.10 lakh has been earmarked for this purpose.

5.2.4 Environmental Management Plan for dredging operation

Proposed project envisages the deepening of turning circle and berth face from -14.4 m up to -19.50 m. The total quantity of dredged material has been estimated as 2.44 Mm^3. The impacts on coastal environment during dredging phase would be mainly on marine water quality and ecology. An important factor in minimizing adverse impacts would be optimizing the dredging period and avoidance of activities beyond the specified area of implementation. The main impact area would be the turning circle and berth face and dumping area of about 2km X 2km.

Base line analysis of Marine water did not indicate the presence of any appreciable source of pollution in the proposed dredging and dumping area. Sediments comprise of sand and silt and are free from pollutants and hence do not pose any risk to marine ecology. However, adverse impacts are anticipated due to increase in turbidity, decrease in light penetration, reduction in primary productivity and removal of benthic organisms during the dredging.

The total quantity of dredging material likely to be generated from capital dredging has been estimated as 2.44 Mm^3. However, considering the impacts on marine ecology due to dredging operations, it is proposed to dredge the channel using Trailing Suction Hopper Dredger. This methods is considered environmentally safe methods as leakage of dredged material and dispersal of sediments in this methods is minimal. No blasting is involved in the process.

The entire dredging work will be undertaken with TSHD, as stated above and hence there is no need of any blasting operation. The dredged material will be dumped in the designated dumping ground suggested by CWPRS. The layout of the area to be dredged is shown in Figure-5.1.

The key measures recommended to control marine pollution from dredging and dredging equipment are listed as below:

- Spillage of fuel/engine oil and lubricants from the dredging equipment are a likely source of organic pollution which impacts marine life, particularly benthic organisms. This shall be prevented by proper maintenance of the dredgers and by providing necessary arrangement to trap the spillage.
- Net enclosures using silt screens to be placed around the dredging area, wherever necessary in order to control the spread of the turbid plume.
- The proposed dredging activities will be carried out under confined conditions which will minimise the spread of sediments into the neighbouring water column and cause minimum disturbance to the marine ecology of the area.
- Vessels operating during dredging phase such as dredger shall be equipped with spill response kits.
- Dredging shall not be undertaken during fish breeding season and other special weather situations.

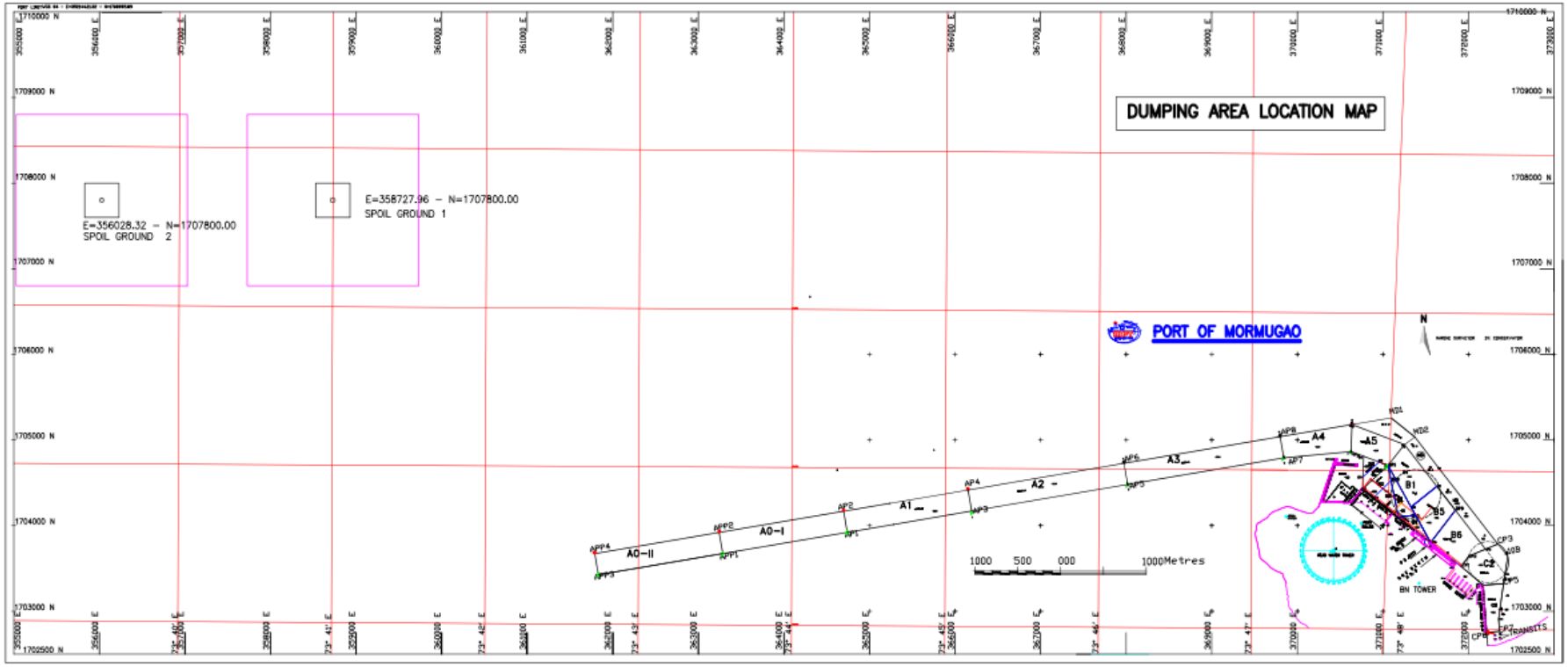


Figure-5.1 Dumping ground location map

5.2.5 Hydrodynamics and Siltation Studies

The present project envisages to deepen the existing approach to Berth 8, 9 and 9A, alongside of Berth and turning circle pertaining to Berth 8, 9 and 9A to be deepened from (-) 14.1 m to (-) 19.5 m covering a total plan area of about 0.40 km^2.

This will have an impact on the marine environment in two ways

- **Permanent Impacts:** induced by the foot prints of the proposed structures /reclamation area on currents, water levels, waves, sediment transport, water quality, shoreline evolution in the vicinity. However the listed secondary impacts in case of the present Project will be confined only to the active Port area which is well protected against erosion.
- **Temporary Impacts:** Occur during dredging works. The extent and potential impacts of sediment plumes generated during the dredging works are determined by the type of dredger, dredging methodology, type of sediments and flow conditions during dredging works. These impacts are usually limited to the duration of the dredging works and expected to recover within a short period of 3-4months.

Environmental feedback monitoring and management of dredging works

Ensuring that no or minimal adverse impacts are caused by dredging works requires a careful assessment of the dredging works and stresses induced on the sensitive receptors to guide the works.

Historically, dredging works have been managed in a static manner based monitoring works and compliance to single trigger values, with threshold values defined as the values not to be exceeded. This approach is quite common where developers appreciate a need to place environmental constraints. This approach has many limitations due to the limited available spatial and temporal information.

To address the limitations of static monitoring, adaptive management strategies have been developed specifically aimed at addressing the problems of a static monitoring approach to environmental management. It consists of following four elements,

- Implementation of the project and collection of baseline information,

- Monitoring including measurements and modelling works,
- Evaluation of data and results
- Adaptation which not only includes re-assessment of the implemented dredging strategy, but also the evaluation of the objective target values that are usually quite uncertain.

In this way it is possible to adapt the works to the conditions at the site minimizing impacts on sensitive receptors while optimizing the dredging works.

Simulation of Sediment Movement

Detailed studies for the Hydro dynamics and Siltation patterns and for identifying the suitable disposal grounds using 2-D Mathematical model MIKE21, for the Deepening proposal at Mormugao port were carried out by CWPRS. In order to simulate sedimentation in the approach channel and harbour area, the sediment transport model studies were carried out using MIKE 21 MT model. The Mud transport model was coupled with the hydrodynamic model.

Identification of Disposal Grounds

Mike-21AD (Advection and Dispersion) model was used to study the sediment behaviour after dumping the dredged material. Model was simulated for a period of one month considering 2500 cum of slurry being dumped at an interval of one hour at- 27m depth contour (356000 E and 1705000 N) north of the approach channel. It was observed from the model that sediment plume moves towards north and it spreads in 4 km wide span. Plume crosses the north boundary of model and it could be seen from the sediment plume pattern that it may move further 5 km towards north before it dies. The dredging takes place during month of August-September when the flow is northward. In order to optimize the disposal ground location, disposal at other shallower contour depths viz .(-) 25 m and (-)26 m were also tried but the plumes were observed to intersect the port areas, hence were not recommended. Thus location (356000 E and 1705000 N) is recommended to dump the dredged material at -27 m depth contour in 2 km by 2 km area.

The following recommendations are made which require to be adopted for amelioration of adverse impacts on marine ecology:

- Dredger operators should follow proper safety procedures to avoid accidents and spills.
- Authorities should ensure that all the ships moving in proximity to the area to be dredged or disposal sites do not affect such activities or vice-versa.
- To reduce the potential for error on the part of the Contractor, endeavour should be made to regularly monitor the activities during dredging and disposal activities.
- The timing of dredging and disposal activities could be planned, where practical, to avoid and reduce any adverse impacts on sensitive marine flora and fauna.

5.2.6 Environmental Management Plan for Spoil Disposal (Dumping) Grounds

This section deals with management techniques to minimise the physical effects of disposal of dredged material. The key to management lies in selection of dumping site for the disposal of dredged material very crucial to minimize the impact on marine ecology. In addition, appropriate methods of dredging and of disposal should be chosen in order to minimise the environmental effects. The total quantity of dredging material likely to be generated has been estimated as 2.44 Mm^3, which needs to be suitable disposed of. Dredged material mainly comprises of sand and silt. Following management measures are recommended for dumping of dredged material:

- CWPRS has carried out hydrodynamic studies and dispersion studies for finding out a suitable offshore location to dispose of the dredged material. As per CWPRS recommendations a disposal area of 2 X 2 km, is located at a distance of 1 km north from the intersection of the center line of the outer approach channel with the -20 m contour at a depth of about -27 m CD. Location of dumping ground is shown in Figure-5.1.The proposed dumping ground as per CWPRS studies is located about 14 km away from the breakwater head at 27 m depth contour on 1 km north from the offshore end of the approach channel.
- To avoid excessive degradation of the seabed as a whole, the number of

dumping locations shall be limited as far as possible and each site shall be used to the extent that will not interfere with navigation.

- Disposal vessels should be equipped with accurate positioning systems, e.g. with Automatic Identification System (AIS), which shall be switched on during disposal operations. Disposal vessels and operations shall be inspected regularly to ensure that the conditions of the disposal permit are being complied with and that the crew are aware of their responsibilities under the permit.
- Dredgers and barges shall be fitted with automatic recording device for dumping locations and should be inspected to ensure that disposal is taking place at the specified disposal site.
- Spillage of fuel / engine oil and lubricants from the dredging equipments are a likely source of organic pollution which impacts marine life, particularly benthos. This shall be prevented by suitable precautions and also by providing necessary mechanisms to trap the spillage.
- Vessels operating during disposal of dredged material shall be equipped with spill response kits.
- Dumping activities to be scheduled and planned to minimise impacts on marine ecology.
- Dumping shall not be undertaken during fish breeding season and other special weather situations.
- Dredging activities to be scheduled and planned to minimise impacts on fishermen and marine ecology.
- Disposal of sewage from the dredgers and barges, shall be prevented with suitable wastewater treatment measures

Since, sediments comprises of sand and silt, Hence, dredged material is likely to get dispersed in surrounding water and will not have long term adverse impacts. Hence, adverse impacts are not anticipated due to burial of benthic fauna at dumping sites. However, short term impacts are anticipated due to increase in turbidity.

A feedback monitoring programme needs to be implemented to minimize impacts during dredging work with following environmental management objectives:

- No reversible impacts to primary benthic producer habitats or other environmental receptors e.g. no mortalities to corals and destruction of coral reefs
- Minimize impacts during dredging works
- Minimize risks of real or perceived impacts that could lead to stoppages of dredging

5.2.7 Air Environment

A) Control of Emissions

Minor air quality impacts will be caused by emissions from construction vehicles, equipment and DG sets, and emissions from transportation traffic. Frequent truck trips will be required during the construction period for transportation of construction material and delivery of other equipment and materials. The following measures are recommended for control of air pollution:

- The contractor will be responsible for maintaining properly functioning construction equipment to minimize exhaust.
- Construction equipment and vehicles will be turned off when not used for extended periods of time.
- Unnecessary idling of construction vehicles to be prohibited.
- Effective traffic management to be undertaken to avoid significant delays in and around the project area.
- Road damage caused by sub-project activities will be promptly attended to with proper road repair and maintenance work.

B) Air Pollution control due to DG sets

The Central Pollution Control Board (CPCB) has issued emission limits for generators up to 800 KW. The same are outlined in Table-5.2, and are recommended to be followed.

Table-5.2 :Emission limits for DG sets prescribed by CPCB

Parameter	Emission limits (gm/kwhr)
NOx	9.2
HC	1.3
CO	2.5
PM	0.3
Smoke limit*	0.7

Note :* Light absorption coefficient at full load (m^{-1})

The above standards need to follow by the contractor operating the DG sets. The other measures are recommended as below:

- Location of DG sets and other emission generating equipment should be decided keeping in view the predominant wind direction so that emissions do not effect nearby residential areas.
- Stack height of DG sets to be kept in accordance with CPCB norms, which prescribes the minimum height of stack to be provided with each generator set to be calculated using the following formula:
  - H = h+0.2x √KVA
  - H = Total height of stack in metre
  - h = Height of the building in metres where the generator set is installed
  - KVA = Total generator capacity of the set in KVA

C) Dust Control measures

To minimize issues related to the generation of dust during the construction phase of the project, the following measures have been identified:

- Identification of construction limits (minimal area required for construction activities). In the present case the construction area is limited to the space occupied by the existing Berths 8, 9 and Barge Berths. Any dust generated in this confined area can seldom pollute places beyond the boundary of the MPT complex.
- Contractor will be required to cover stockpiled fine aggregate and trucks hauling, sand, and other loose materials. The trucks will also maintain appropriate height of freeboard.
- Contractor shall ensure that there is effective traffic management at site. This will include appropriate controls over the speed directions and number of trucks/vehicles which will move at various construction points.
- Construction area and vicinity (access roads, and working areas) shall be swept with water sweepers on a daily basis to ensure there is no visible dust.

Most dust control methods are inexpensive, easy to install, and simple to maintain. There are many categories of dust sources. In the cargo handling

areas of the Berth 8, 9 and 9A both dust prevention and dust suppression are required. The type of system will depend on the dust source and the operation in progress. The dust suppression system proposed in the present Project redevelopment of Berth 8, 9 & 9A will include the following:

- Dry Fog System installed at all transfer points
- Wheel washing facility for trucks
- Installed Medium Velocity Water (MVW) spray system designed to operate through linear heat detection system (Analogue)
- Wind shield of 15 Mtrs height along outer periphery of cargo stacks
- Nevis (Mist / Cannon) Systems – one truck mounted and other wheel mounted
- Sprinkling system for stack-yards
- Covering of cargo in all modes of transportation and stacking

Jet type dust suppression system with plain water shall be provided for all the transfer points and feeders in jetty area and plain water type dust suppression system shall be provided for stackyard. The dust suppression system shall comprise of all the accessories like tanks, pumps etc. Water reservoir with a capacity of 450m^3 is proposed with the available head of 80m. The pumping capacity shall be 75m^3/hr. A provision of Rs.3.5 crores for providing the dust suppression system has been earmarked in the project cost.

5.2.8 Noise Control Measures

The contractors will be required to maintain properly functioning equipment and comply with occupational safety and health standards. The construction equipment will be required to use available noise suppression devices and properly maintained mufflers.

- Vehicles to be equipped with mufflers recommended by the vehicle manufacturer.
- Deployment of construction equipment and unnecessary idling of equipment within noise sensitive areas to be avoided whenever possible.

Monitoring of noise levels will be conducted during the construction phase of the project. In case of exceeding of pre-determined acceptable noise levels by the machinery will require the contractor(s) to stop work and remedy the situation prior to continuing construction. It is known that continuous exposure to noise levels above 90 dB (A) affects the hearing of the workers/operators

and hence has to be avoided. Other physiological and psychological effects have also been reported in literature, but the effect on hearing acuity has been specially stressed. To prevent these effects, it has been recommended by international specialist organizations that the exposure period of affected persons be limited as specified in Table-5.3.

Table-5.3: Maximum Exposure Periods specified by OSHA

Maximum equivalent continuous Noise level dB(A)	Unprotected exposure period per day for 8 hrs/day and 5 days/week
90	8
95	4
100	2
105	1
110	½
115	¼
120	No exposure permitted at or above this level

5.2.9 Control of Pollution due to increased vehicles

The movement of vehicles is likely to increase during construction phase and later in the operation phase of the project. Thus, as a control measure, vehicles emitting pollutants above the prescribed standards will not be allowed to ply either in the project construction or in the operation phases. Vehicles and construction equipment will be fitted with internal devices i.e. catalytic converters to reduce CO and HC emissions.

All the roads in the vicinity of the project site are Asphalted/Concrete roads. Therefore increase in fugitive emissions from to the movement of trucks during construction phase is not anticipated.

5.3 EMP DURING OPERATION PHASE

Effluent Treatment Plant

A settling tank shall be provided to suitably treat the coal pile run-off water before discharge. The treatment plant will be of recycling type where the treated water will be again used for dust suppression. The detention time and storage capacity are given in Table 5.4.

Table-5.4: Details of detention time and storage capacity of ETP

S.No.	Capacity/time	Unit
1	ETP capacity	450m^3
2	Detention time	24hours
3	Clearwater tank capacity	450 cum
4	Pump capacity	75 m^3/hr
5	Head	80m

Various management measures needs to be implemented for Control of air pollution in the Tender Document for the Contractor involved in construction activities. The same shall be monitored on a regular basis by the project proponents. A provision of Rs. 5 lakh has been earmarked for commissioning of settling tank.

5.3.2 Control of Water Pollution from Oil Spill

The other major source of water pollution is oil spills which may occur during bunkering operations. To combat oil pollution near the jetty, portable oil skimmers should be available at the berth. A clean sweep oil recovery unit consisting of a power pack and the recovery unit mounted on a system can be utilized for this purpose. The recovery unit generally consists of a recovery drum, collecting trough, screw conveyor, discharge housing and wiper assembly. In addition, the berths should have chemical dispersants with spray pumps, catamarans for collection of debris and recovery of oil and tanker carriers of 5 kl capacity for recovering sludge/bilge water. Mormugao Port is already has an operation as Oil Response System. Since the barge jetty is proposed within Mormugao Port the same system can also be utilised for the proposed project.

The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the protocol of 1978 (MARPOL, 73/78), has issued guidelines for prevention of Marine Pollution. These are listed in subsequent paragraphs and should be strictly adhered to for prevention of marine pollution.

- Ships are prohibited to discharge oil or oily water such as oily bilge water containing more than 15 ppm of oil within 19 km (12 miles) of land;
- Chemicals are evaluated for environmental hazard which may cause environmental hazards if discharged into the sea (categories A, B, C and D). Discharge into the sea of the most harmful chemicals (category A) is

prohibited. Tank washings and other residues of less harmful substances (categories B, C and D) may only be discharged keeping in mind certain conditions e.g. total quantity of discharge, distance from the shore, depth of water prescribed depending on the hazards. There are no restrictions on substances such as water, wine, acetone, etc;

- Harmful substances in the packaged form should not be disposed into the sea;
- Sewage generated at the ship should not be disposed off into the sea, unless it is treated or it is disposed off at a certain distance from land;
- Garbage produced on ship must be kept on board and discharged either ashore or into the sea under certain conditions, such as distance from the land; discharge of all plastics is prohibited.

5.3.3 Oil Spill Response Plan

The Response plan should describe the recommended procedures for responding to an oil spill with essential information. The format of the operational plan should be as follows:

Reporting oil spill incidence

Immediately upon notice of an oil spill, incidence reporting will be done in the prescribed format to: the Internal within organization, Indian Coast Guard, Oil Industry Safety Directorate, Directorate General of Hydrocarbon (DGH), Concerned Port Authorities and Mutual Aid Partners.

Details of Notification information

- Date and time of observation (24 hour clock).
- Position (preferably Lat. /Long., and/or description using recognized names).
- Source and cause of spill.
- Estimate of amount spilled and continued spillage rate.
- Description of the slick size.
- Type of oil spilled and characteristics
- Tide, weather and sea conditions.
- Owners of oil and carrier.
- Clean-up organization in place/responsible – name and contact details of on-Scene Commander.

- Action, both taken and intended, to combat pollution and prevent further spillage.
- Statutory local environmental bodies and contact details.
- Name, occupation and contact details of initial observers.

Surveillance and tracking of oil at sea

Immediately after the spill, carry out the surveillance for assessing the quantity of spilled oil:

- Identification of sensitive areas
- Identify the sensitive areas and inform the parties.
- Protect the sensitive areas as per the priorities.

Development of site specific response plan

- On-scene co-ordinator will identify the facilities required and sources from where the resources are mobilized.
- Operations planning and mobilization procedures
- Mobilization procedures are required only in case the spill is likely to affect the coastline and damage the marine sensitive areas.

Control of operations

- Establish a management team with experts and advisors
  - Update information (sea/wind/weather forecast, aerial surveillance, beach report)
- Review and plan operations accordingly
- Obtain additional equipment, supplies and man power if required
- Prepare daily incident log and management reports
- Prepare operations accounting and financing reports
- Prepare releases for public and press conferences
- Brief local and government officials including Coast Guard

Termination of operations

- Standing-down equipment for cleaning, maintaining and replacing
- Prepare formal detail report

Management of Oil Spills

Majority of spills at terminals result from routine operations such as valve leakages, improper couplings, pipeline leaks etc. These operational spills are

generally small with over 90 % involving quantities of a few litres to a few tonnes. Rare but large accidental spills can occur when a ship gets involved in an accident such as collision or grounding. Hence, response at several levels is necessary for combating oil spills of such variable quantity.

The National Oil Spill Disaster Contingency Plan (NOS-DCP) describes the responsibilities of ports handling petroleum and its products. Indian Coast Guard is the Central Coordinating Agency for marine response. NOS-DCP considers response at 3 Tiers for combating oil spills. The Plan makes port authorities responsible to respond to accidents within the port limits (Tier-1 response) though they can seek additional assistance through the Regional Communication / Operational Centre of the Coast Guard.

5.3.4 Oil Spill Contingency Plan (OSCP)

To successfully combat an oil spill, the manpower needs to be thoroughly trained since quick and efficient response is the primary factor deciding the efficiency of the operation. It is also vital that all equipment is routinely inspected and regular mocks are held. The following issues will be earnestly addressed:

In view of handling of increased volume of petroleum products when the port is expanded the OSCP will be re-examined and modified if required in consultation with the Indian Coast Guard.

SOPs will be developed for every facet of operational OSCP that will include notification; strategy for combating depending on oil type, quantity involved and area of spill impact; deployment of booms to contain and to protect sensitive habitats, mainly mangroves; deployment of skimmers; on board and shore storage of recovered oil; strategy for shoreline cleaning and storage of oil contaminated sediment; use of dispersants; final disposal of recovered oil and contaminated sediment; closure of operation; dissemination of information to public and media etc.

The oil spill combating equipment will be stored in the vicinity of the oil berth and a suitable vessel will be always kept stand by for quick response during loading / unloading operations of petroleum and while providing bunker.

Mock drills involving deployment of critical oil spill containment and recovery equipment will be held at least once in 3 months.

Manpower responsible for responding to oil spills will be thoroughly trained in all facets of oil spill response.

The oil spill combating equipment will be inspected regularly as recommended by the manufacturers and records of inspection will be maintained. Prompt action will be taken to attend to deficiencies, if identified during inspection.

5.3.5 Control of Water Pollution from Marine Transportation

The other major source of water pollution is oil spills which may occur during bunkering operations. To combat oil pollution near the port, portable oil skimmers should be available at the berth. A clean sweep oil recovery unit consisting of a power pack and the recovery unit mounted on a system can be utilized for this purpose. The recovery unit generally consists of a recovery drum, collecting trough, screw conveyor, discharge housing and wiper assembly. In addition, the berths should have chemical dispersants with spray pumps, catamarans for collection of debris and recovery of oil and tanker carriers of 5 kl capacity for recovering sludge/bilge water.

The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the protocol of 1978 (MARPOL, 73/78), has issued guidelines for prevention of Marine Pollution. These are listed in subsequent paragraphs and should be strictly adhered to for prevention of marine pollution.

- Ships are prohibited to discharge oil or oily water such as oily bilge water containing more than 15 ppm of oil within 19 km (12 miles) of land;
- Chemicals are evaluated for environmental hazard which may cause environmental hazards if discharged into the sea (categories A, B, C and D). Discharge into the sea of the most harmful chemicals (category A) is prohibited. Tank washings and other residues of less harmful substances (categories B, C and D) may only be discharged keeping in mind certain conditions e.g. total quantity of discharge, distance from the shore, depth of water prescribed depending on the hazards. There are no restrictions on substances such as water, wine, acetone, etc;
- Harmful substances in the packaged form should not be disposed into the sea;
- Sewage generated at the ship should not be disposed off into the sea, unless it is treated or it is disposed off at a certain distance from land;

- Garbage produced on ship must be kept on board and discharged either ashore or into the sea under certain conditions, such as distance from the land; discharge of all plastics is prohibited.

5.3.7 Intertidal Sand and Mud Flats

Intermittent beaches are present along the intertidal zone in the of the 10km radius of the Port area. Polychaete worms, crustaceans, molluscs and echinoderms can be found on, and in, these inter-tidal mud and sandbanks. Crabs, teleosts, amphipods and gastropods are also present. Gastropod molluscs and crabs may be present on the upper banks adjacent to mangroves. These animals are particularly important as prey items for many of the species that are exploited commercially (e.g. prawns, bottom-feeding fish). However these areas will not be under stress due to the developments in the proposed Berth number 8, 9 and 9A.

5.3.8 Wastes Generated on the Berths:

The wastes generated at Berths normally include domestic effluent, garbage/ solid waste (debris, leftover plastic items, boxes, other packaging materials, empty barrels etc.). A dedicated site for collection/ storage and segregation the said waste material will be established in the vicinity of the Berths. The collected waste will be segregated into different categories (bio degradable, recyclable, reusable and land filled type). Part of the bio degradable waste will be composted and balance disposed off as municipal sewage. Recyclable waste will be disposed through Authorised contractors. Hazardous waste if any, will be handed over to approved agency accredited by GSPCB.

5.3.9 Air Environment

Control of Emissions

Impacts due to coal handling

The annual coal handling at proposed berth 8 will be about 12 MMTPA. Mormugoa Port trust has been handling cargo using dust suppression methodologies to keep the dust under control. Similarly it is proposed to handle the coal and other cargo in the proposed facility in most environment friendly manner. Hence, covered stackyard is proposed for the storage of coal to minimize the dust emissions from coal handling. The total storage capacity

of the stack yard will be about 7 MMTPA and the area of covered coal stack yard will be 75400m^2. The dimension of the covered dome type storage yard will be 520 m X 145 m. The covered storage will require 550 m long shed housing 15 m high coal stack with mechanized facilities. The shed will be equipped with firefighting and dust suppression system, which shall Prevent fine coal particles from flying away due to wind, thereby reducing the probable pollution in nearby surroundings. Covered Coal stack yard will be have mechanized coal handling facility such Stacker cum reclaimer, conveyor belts etc, and the coal will be reclaimed and feed to the rail loading system.

Dust suppression system will be provided at berth 9 and 9A also to prevent the entrainment of fugitive emissions. Hence, up gradation of the berth number 8, 9 and the Barge Berth will further lead to reduction in the fugitive dust emission due to the advanced handling methods and dust suppression.

5.4 GREENBELT DEVELOPMENT

Mormugaon Port has developed the green belt in an area of 36 acre. However it is proposed to develop greenbelt around various project appurtenances of the proposed project, which will go a long way to achieve environmental protection and mitigation of pollution levels in the area.

Depending upon the topo-climatological conditions and regional ecological status, selection of the appropriate plant species has been made. The various criteria adopted for selecting the species for greenbelt development are:

- Plants should be fast growing
- Preferably perennial and evergreen
- Indigenous
- Resistant to SPM pollution
- Should maintain the ecological and hydrological balance of the region.

The general considerations involved while developing the greenbelt are:

- Trees growing up to 10 m or above in height with perennial foliage should be planted around the perimeter of the proposed project area and on both sites of the conveyor belt.
- Planting of trees should be undertaken in appropriate encircling rows around the project site.
- Trees should also be planted along the roadside.

- Generally fast growing trees should be planted.
- Since, the tree trunk area is normally devoid of foliage upto a height of 3 m, it may be useful to have shrubbery in front of the trees so as to give coverage to this portion.

Taking into consideration the above parameters, the greenbelt development plan has been evolved for the proposed on the periphery of the backup area to reduce the pollution levels to the maximum possible extent. The plantation will be at a spacing of 2.5 x 2.5 m. The width of the greenbelt will be 15 m. The project proponents will also do the maintenance of the plantation area. The cost of plantation per hectare is estimated at Rs.100,000/ha. About 2 ha of land is proposed to be afforested as a part of Greenbelt Development Plan on the periphery of the backup area. The total cost of afforestation works out to Rs.2 lakh. The species for greenbelt development are listed in Table-5.5. Location of existing and proposed green belt are depicted in Figure 5.2.

Table-5.5: List of tree species recommended for greenbelt development

S.No.	Location	Botanical Name	Local Name	Characteristics
1	Outer Boundary	*Casuarina equisetifolia*	Whistling pine	• Long leaves • Wind breaking • Capture higher amount of dust
2		*Polyalthealongifolia*	Ashoka	
3		*Alistonia scholaris*	Saptaparni	
4	Middle fringe	*Azadirachta indica*	Neem	• Morphological feature of plant leaves aids for dust capture efficiency • Capacity to withstand vibrations, thus combats noise pollution
5		*Albizzia lebbeck*	Shirish	
6		*Cassia fistula*	Amaltash	
7		*Ficus virens*	Pilkhan	
8	Inner area	*Delonix regia*	Gulmohur	• Have dust filtering capacity • Absorbs noise radiations • Flowers and fruits add to
9		*Moringa olifera*	Drumstick	
10		*Caesalpinnia spp*	Patamg/ kadukaranj	
11		*Michelia champaca*	Champa	

S.No.	Location	Botanical Name	Local Name	Characteristics
12		*Cassia siamea*	Kassod	the aesthetics
13		*Lagerstroemia parviflora*		
14	Other shrubs	*Calotropis gigentia*	Madar	• Fills the gaps between the large trees to form a thick barrier • Aesthetic value
15		*Tabernaemontana divaricata*	Chandani	
17		*Lantana camera*	Raimuniya	
18		*Thvetia peruviana*	PilaKaner	
19		*Nerium indicum*	LalKaner	

5.5 ENVIRONMENT MANAGEMENT CELL

Mormugao Port has constituted Environmental Management Cell (EMC) headed by Executive Engineer along with a team. Environmental Management Cell (EMC) will be responsible for management of the environment in all environment retreated activities. The team constitute environmental engineer, chemists and horticulture supervisors. The Head (Environment) will be responsible for Environmental Management Activities in the proposed project. Basically, this department will supervise the monitoring of environmental pollution levels viz. source emission monitoring, ambient air quality, water and effluent quality, noise level either departmentally or by appointing external agencies wherever necessary. In case the monitored results of environmental monitoring are found to exceed the allowable limits, the Environmental Management Cell will suggest remedial action and get these suggestions implemented through the operation group.

The EMC will also coordinate all the related activities such as collection of statistics of health of workers and population of the region, afforestation and greenbelt development. This will be supported by a fully equipped laboratory to carry out the analysis.

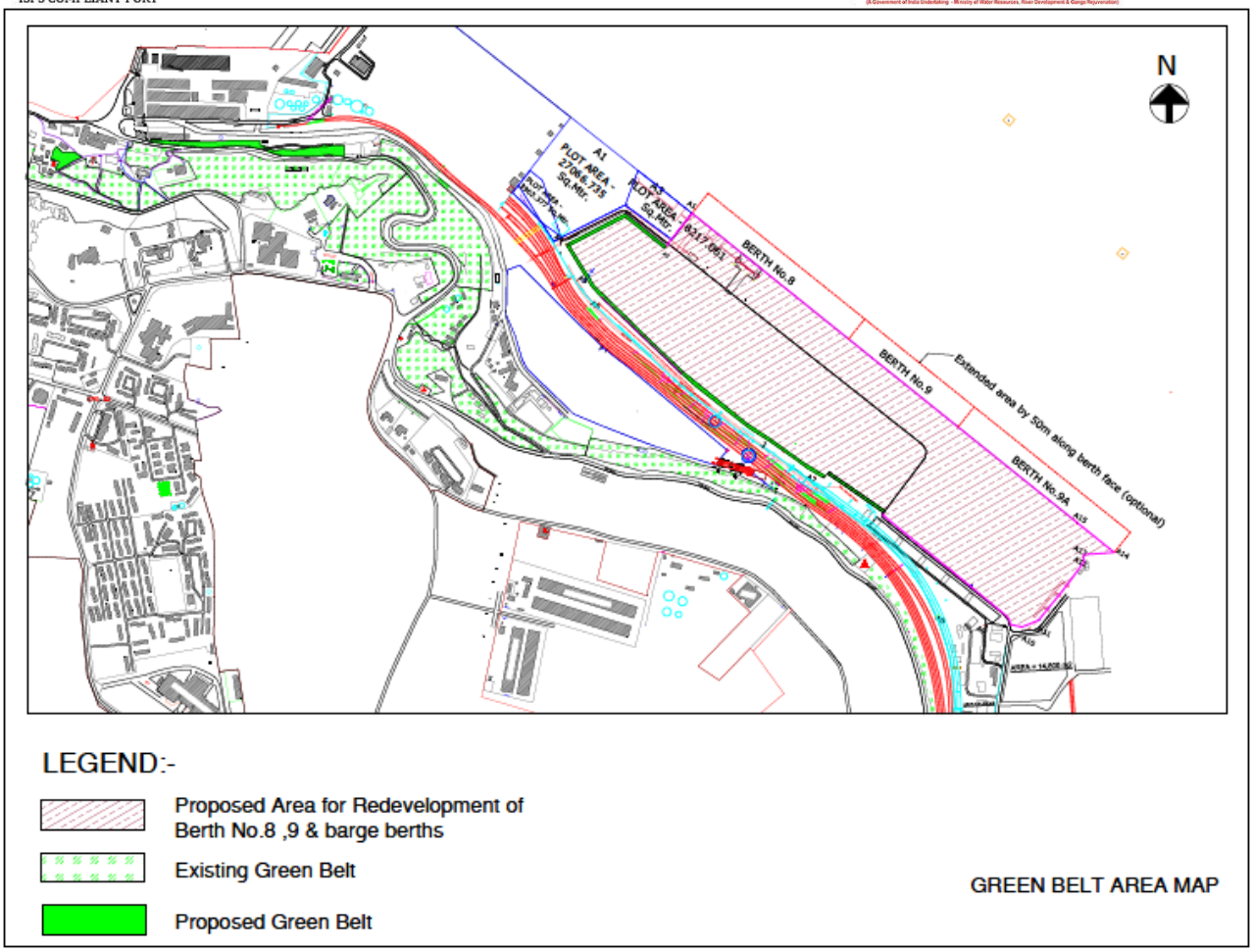


Figure-5.2: Location of Greenbelt

CHAPTER-6
DISASTER MANAGEMENT PLAN

CHAPTER- 6

RISK ASSESSMENT & DISASTER MANAGEMENT PLAN

6.1 INTRODUCTION

Risk Assessment & Disaster Management planning is an integral and essential part of loss prevention strategy. The term, `hazard' refers to sources of potential risks considering frequency and severity of damage from hazards. Hazard denotes a property or a situation that in particular circumstances could lead to harm. Risk on other hand, is a function of the probability of a hazard occurring and the magnitude of the consequences. Risk therefore, represents the likelihood of a potential hazard being realized. Risk Estimation involves identifying the probability of harm occurring from an intended action or accidental event. Risk Evaluation determines the significance of estimated risks, including risk perception. The Risk Analysis study is a combination of risk estimation and risk evaluation.

The cargo proposed to be handled at proposed facility includes Coal and General Cargo. However, there is still possibility that disaster may occur. In order to minimize damages in case of accident or emergency, a risk analysis study has been carried out to quantify zone of influence of various failure cases and a disaster management plan has been prepared to control the spread of incident effectively. Effective action is possible due to existence of pre-planned and practiced procedures for dealing with emergencies. The present chapter outlines the hazard identification, risk assessment and Disaster Management Plan to control the spread of incident effectively.

6.2 HAZARD AND RISK ASSESSMENT OF MORMUGAO PORT

The proposed project envisages the redevelopment of Berths 8th and 9th at the Port of Mormugao, Goa. Entire facility will come within existing Port area. Existing structures will be dismantled for the proposed development. The proposed project involves covered storage for coal cargo and open storage for general cargo are proposed, construction of bund, extension of

Berth face, reclamation in an area of 6.6 ha capital dredging of 3.71 Mm^3 for deepening of turning circle from 14.40 up to -19.50 m near the Berth face up to 50 m distance. Cargo composition for the proposed facility will include coal / coke / gypsum / limestone / dolomite / iron ore / container, etc. The existing capacity of berth 8^{th} and 9^{th} is 13 MMTPA which will increase to 18 MMTPA, with the redevelopment of one coal berth, one iron ore berth and one multicargo berth.

The total quay length of the proposed 3 nos. berths will be 950 m, to facilitate handling of cape size vessels, and additional provision of 90 m. for providing barge unloader jetties. It is envisaged to provide new berth no. 8 of length 360 m of capacity 5.5 MMTPA, dedicated for handling import / export cargoes such as coal, coke, gypsum, dolomite, limestone, etc cargo. Second berth of length 240 m. is exclusively for handling general cargo including containers having capacity to handle 4.00 MMTPA and third berth of length 350 m is exclusively for handling import /export cargo such as iron ore / bauxite or any other minerals of capacity 8.5 MMTPA. The details of the proposed redevelopment are given as below:

- ✓ Capital Dredging of approx. 3.71 Mm^3 will be involved for deepening from 14.40 up to -19.50 m near the Berth face up to 50 m distance.
- ✓ Back-up area is about 65 acres. Capacity is about 18.0 MMTPA, with one coal berth, one iron ore berth and one multi cargo berth
- ✓ The proposal is redeveloping the existing dedicated iron ore berths and one liquid berth to one dedicated coal berth and one iron ore berth and one multipurpose cargo berth capable of handling cape size vessels.
- ✓ Entire facility will come within existing Port area and dismantling of existing structures will be taken up.
- ✓ Construction of Bund, extension of Berth face, railway lines, land for cargo stacking, conveyor system and other offices and structures, roads, railway and other facilities.
- ✓ Old Iron ore handling equipments like conveyor system, ship loaders, stackers, reclaimers etc will be demolished

- ✓ Temporary sites used for construction works or housing of construction workers will be provided by the Port in its land
- ✓ Above ground buildings, structures or earthworks including linear structures, cut and fill or excavations
- ✓ Approx. 6.6 ha of land cover under reclamation work
- ✓ Depth 14.40 up to -19.50 m near the Berth face up to 50 m distance.
- ✓ Dredged material can be utilised for reclamations
- ✓ Road construction for balance stretch, for linking Port to the Highway for a distance of approx. 2 km is undertaken by NHAI.
- ✓ Existing railway facility will be augmented for evacuation of additional rail borne cargo

6.3 HAZARDS ASSOCIATED WITH THE PROJECT

6.3.1 Traffic Risk

Impact of Existing / Upcoming Port on Traffic Forecast

TCE has considered the impact of neighbouring existing / upcoming ports and their augmentation plans while carrying out the traffic projection for Mormugao Port. Further, sensitivity analysis has been carried out varying the traffic projection for Mormugao Port by (±) 20% and the impact on Project IRR and Equity IRR has been assessed. The traffic sensitivity analysis has been discussed in the financial analysis chapter.

Impact of Govt. Policy

The government's ban on the export of iron ore has had an adverse effect on the MPT's efficiency. Further, the present government is inclined against export of iron ore fines and is encouraging consumption of iron ore in domestic steel industry. In view of these, the forecast for export of iron ore fines has been capped at the present iron ore handling capacity of the port.

Impact of Connecting Infrastructure Project

The planning of the proposed coal berth 8 and GC/container berth 9 and 9A has been carried out considering significant evacuation by Rail. The terminal will require a Rail Container Depot (RCD) for loading of container in to wagons for onward evacuation. The coal berth will require a

dedicated rail siding for loading of coal in to wagons for onward evacuation. The total number of rail sidings required at the back of the stackyard is 3 including 1 escape line. The length of area available behind the stackyard is insufficient for facilitating RCD. The alignment of the rail line is also required to be studied.

6.3.2 Technical Risks

Subsoil Strata

TCE has evaluated past geo-technical investigation in the Mormugao Port region to evaluate the sub soil strata. It is not envisaged to encounter any rock up to (-) 19. 5 m CD in front of berth 8, 9 and 9A. However it is proposed to carry out geo technical investigation, and to incorporate the results in the design stage.

Slope Stability Analysis

The dredge level in front of the berth is proposed to be (-) 19.5 M CD. However, the berth pocket depth at berth 10 and 11 will be maintained at (-) 13.1 m CD. A slope stability analysis will be required to ascertain a stable slope.

Dredging Quantity

The project involves capital dredging in front of the proposed berth 8, 9 and 9A. The quantity of dredging has been estimated considering soil dredging up to (-) 19.5 m CD. However the dredging quantity needs to be updated after carrying out fresh Geo technical investigation and seismic survey in the manoeuvring area of berth 8, 9 and 9A.

Adequacy of Existing Navigational Facilities

The presence of Mooring Dolphins may cause hindrance to the vessel manoeuvring in front of berth 8, 9 and 9A. Because of the increased diameter of the turning circle for capsize vessels; the turning circle is interfering with the existing MD 1 and 3. Hence to avoid the risk of vessel collision at the manoeuvring area and turning circle with the Mooring Dolphins, it is proposed to provide sufficient navigational aids and to provide controlled manoeuvring with tug assistance.

6.3.3 Operational Risks

Equipment Breakdown

The coal berth 8 will be equipped with 2 numbers of gantry grab crane. The GC/container berth 9 and 9A will be equipped with four numbers of Harbour Mobile Cranes. Hence adequate redundancy has been provided at berth in terms of quay cranes to eliminate the down time expected due to equipments breakdown that could affect the cargo handling operation.

System Failure

Adequate redundancy has been provided at the proposed berths to maintain a continuous cargo handling operation and flow and to avoid performance decline of the system due to any unforeseen system break down. All the critical components of the system have been provided with increased capacity / additional stand by machines with an intention of increasing reliability of the system, in the form of a backup or fail-safe.

Adequacy of Berth and Yard

The length of berth and yard area has been estimated to be sufficient enough to handle the projected coal, General cargo and container traffic at MPT. The area available for the stackyard behind the berth is 20.02 Ha. The stackyard is found adequate for berth 8, 9 and 9A with capacities as discussed in above chapters. The length available behind the berth for Rail Container Depot, RRLS and road access area is adequate. Any further increment in cargo demand can be met through increasing the plot turnaround time only up to a certain extent. No additional land is available for expansion.

6.3.4 Hazards associated with coal handling

All the Three Berths will be used for handling variety of general cargo such as coal, coke, gypsum, dolomite, limestone, containers, iron ore / bauxite or any other minerals. The present project modification shall be handling and storing of Coal in the Tune of 18 MTPA. Hence there will be lot of activities/ enhancement starting from entry of cargo vessel, unloading from ship, transfer the same to the coal berth/Coal yard for storage, Supply the same by Wagon etc.

Coal, being flammable, basically poses following hazards:

1. Coal fire hazard in coal storage
2. Coal dust explosion hazard in handling of coal in confined spaces

6.3.4.1 Nature of Hazard

The schedule in Appendix 1 of the Code refers to the BCSN "COAL (bituminous and anthracite)". As material hazardous in bulk (MHB) it is placed in Group B (and A).

Group B cargoes possess a chemical hazard; coal may create flammable atmosphere, heat up spontaneously, deplete oxygen concentration and may corrode metal structures. When cargo oxidises (generating heat) it releases the toxic gas carbon monoxide. It is recommended that extreme care should be taken at all times, if crew members are required to inspect the cargo while at sea.

Group A cargoes are defined as those which may liquify if shipped at moisture contents in excess of their transportable moisture limit (TML). This can in extreme cases cause a ship to capsize with very little advance warning.

6.3.4.2 Vulnerability situation of the Site with respect to Hazardous Material handling

A common user Port needs to create capability, both in terms of protective hardware as well as systems to handle emergencies arising out of hazardous consequences related to handling of hazardous cargoes. The hazard responses will be specific to the nature of cargo, mode of handling and storage and likely modes in which there could be loss of containments and hazardous consequences. Cargoes which may cause damage due to inappropriate handling have been studied for their damage potential; suggested Standard Operating Procedures (SOP) have been suggested for their handling and storage in various existing form.

Hazards due to storage and handling of combustible or mildly toxic material in solid form are bulk cargoes such as coal and limestone are not hazardous per definition of the term in the MSIHC Rules, 1996 (listing in the Schedule 1, Part I and/or II of the Rules).

Coal is not categorized as 'hazardous substance material' per Manufacture Storage, Import of Hazardous Chemical Rules, 1989.

a) Coal Fire

Coal is classified according to their carbon content. Common coal types handled on Ports may be Anthracite (80-96% carbon), Bituminous (35-80% carbon), Lignite (25-35% carbon) and Peat (less than 25% carbon). International or coastal shipping of low grades of coal such as lignite or peat is rarely done.

Fire in bulk stored coal stockpile is a very common occurrence. The risk of fire exists, wherever significant amount of coal is stored or used. Coal, being combustible, is susceptible to a variety of causes of ignition. However, most common reason for fire in a coal stockpile is spontaneous combustion, i.e. combustion without contact by any external ignition source.

Spontaneous combustion depends on many complex and different factors such as:

1. Type of coal
2. Age of coal
3. Composition of coal
4. Method of storage
5. Moisture content
6. Final use

Such fires can be very difficult to extinguish because of the amount of coal involved and the difficulty of reaching to the root of the problem. Moreover, coal in either the smouldering or flaming stage may produce copious amounts of methane and carbon monoxide gases. In addition to their toxicity, these gases are highly explosive in certain concentrations, and can further complicate efforts to fight this type of coal fire.

The fire fighting efforts need to be concentrated on extinguishing the fire rather than on wetting the whole of coal stockpile. It is advisable that water be applied from a safe distance. The coal fire spreads at a very slow rate

that allows sufficient time to mount an adequate fire-fighting strategy depending on the type and the quantity of coal on fire.

Hazards commonly associated with coal fire are burn injuries to the workers and fire fighters. These can be avoided with proper fire fighting techniques and personal protective equipment.

b) Coal Dust Explosion

Coal dust when dispersed in air and ignited has a tendency to explode. Crusher Houses and conveyor systems are most susceptible to this hazard. For explosion to occur, the dust mixture should have:

- Particles dispersed in the air with minimum size
- Dust concentration must be reasonably uniform
- Minimum explosive concentration for coal dust (33% volatile) is 50 g/m^3

Failure of dust extraction and suppression systems may lead to abnormal conditions and increasing the concentration of coal dust to the explosive limits. Sources of ignition present are incandescent bulbs with the glasses of bulkhead fittings missing, electric equipment and cables, friction, spontaneous combustion in accumulated dust. Dust explosions may occur without any warnings with maximum explosion pressure up to 6.4 bar. Another, dangerous characteristic of dust explosions is that it sets off secondary explosions after the occurrence of the initial explosion. Many a time, the secondary explosions are more damaging than primary ones. The dust explosions are powerful enough to destroy structures, kill or injure people and set dangerous fires likely to damage a large portion of the Coal Handling Plant including collapse of its steel structure, which may cripple the lifeline of the power plant. Stockpile areas shall be provided with automatic garden type sprinklers for dust suppression.

Control of Coal Dust Fire

Automated extinguishment systems that are activated in the early stages of fire development can reduce the potential for flame spread. For optimum results, these piped installations will be combined with the dust control misting/sprinkler systems (hybrid system).

These systems will shift from dust control / housekeeping mode to a fire suppression mode automatically or manually when activated by workers and thus activated to deliver an extinguishing agent in the event of fire. The distribution of the sprinklers and the distance between them will be such that full and efficient coverage will be obtained. Switches for manual operation of the fire suppression system will be strategically distributed at the plant, and they will be conspicuous (properly identified and marked).

Fire Extinguishing Agents, e.g., Water alone are not recommended to suppress a coal fire because the surface tension of water does not allow it to penetrate deep below the coal surface and reach the fire unless large quantities are injected. They extinguish by cooling. (Used for dust control)

A three-step approach to suppress coal fires is recommended

1. Development of an action plan: This step ellaborates initial investigation of the suspected fire, performance of a thermo graphic survey, mapping the fire within the bunker or silo, and suspending coal-feeding operations to the affected area.

2. Preparation of the area: After the action plan has been developed, the next step is to prepare the area for firefighting operations by neutralizing dusting in the immediate area, ventilating the area, and staging equipment and personnel to prepare to attack the fire.

3. Extinguish the fire: After all preparations have been made, firefighting can begin. Monitoring the fire at this stage is key to the effort's success.

Recommended Methods for Extinguishing Coal Fires Using a fire hose to stream water through the top of a bunker or silo is not recommended. Nor is using a stream to "drill" into the coal in an attempt to reach the fire. This technique most likely will stir up the coal and dust and result in a flash explosion.

A secondary explosion can also occur as the heat ignites float dust in the air. An industry accepted, and most preferred method of extinguishing a fire is to get the agent directly to the origin of the fire. To do this, the location of the fire within the pile must be known (a thermal image will make this spot easier to find).

The main tool used to deliver an agent directly to a hot spot is a piercing rod. These are designed to pierce the surface of the coal and be manually maneuvered to the hot spot. The benefit of piercing rods is that they can be used to render inert the inside of the stockpile atmosphere by spraying the sides and surface of the coal with agent prior to storing it.

It must be considered that the longer the rod, the harder it is to maneuver it inside the enclosure. Rods are generally made of stainless steel and come in several diameters (0.75 inches, 1.25 inches, and 1.5 inches). The tip of the rod is perforated and cone shaped, which allows it to be easily inserted deep into the coal and used at any angle. The rod can be inserted through the top or the sides of the enclosure if access ports have been pre-installed.

6.3.5 Security Risk

It is proposed to provide state of the art security system and container scanning area at the gate complex to avoid theft, smuggling, illegal trade, vandalism, illegal immigration, Blockade etc

6.3.6 Activities involving Hazard and Risk

Construction Stage involves following Activities

- Dredging
- Preparation of Area
- Piling
- Civil Structure
- Back filling of Reclaimed area of 75 Acres for infrastructure like storage, parking area, Road etc
- Partition wall of 875 m for brake wave.

Dredging is the removal of sediments and debris from the bottom of lakes, rivers, harbours, and other water bodies. It is a routine necessity in waterways around the world because sedimentation—the natural process of sand and silt washing downstream—gradually fills channels and harbours. It is an excavation activity or operation usually carried out at least partly underwater, in shallow seas or fresh water areas with the purpose of gathering up bottom sediments and disposing them at a

different location. This technique is often used to keep waterways navigable.

A dredger is a type of offshore vessel used for the purpose of excavating the sediment. Dredgers are often employed to clear out waterways so that they can remain navigable. These waterways are most often harbours, ports, and canals. The dredger is made distinct by its long crane, although there are many different types with varying appearances. These cranes do not have to be located in water, but rather can be positioned on the shore or on a platform. Among the many types of dredging vessels are the suction dredgers.

Rather than using a shovel-type attachment for excavating, a long vacuum is used to move material. There are also bucket dredgers. These are mechanical, rather than suction, and appear as a series of buckets along a conveyor belt. Dredgers are often used for fishing and clamming. These dredgers use buckets and arms to scoop up clams from the sediment in shallow waters. Water injection dredgers are another form that works by way of injecting low pressure water into the sediment in order to bring things to the surface.

6.3.6.1 Hazards Associated with Dredging

The cranes of dredgers are extremely dangerous. Workers are prone to fall accidents as well. Another concern with dredging is offshore pollution. If a dredge sinks, oil can seep out into the water that they are operating in.

A dredging process hazard analysis (PHA) is a systematic identification of the potential hazardous scenarios within a dredging operation. Many federal agencies are now requiring firms to perform PHAs during their mobilization phase. For example, Occupational Safety and Health Administration (OSHA) and the U.S. Environmental Protection Agency (EPA) require that PHAs are performed before a contract becomes operational, and are mandatory for all new processes or when modifications are made to the original PHA. The U.S. Army Corps of Engineers requires that Accident Prevention Plans address the risk associated with each task when preparing a PHA. PHAs shall define the

activities being performed and identify the work sequences, the specific anticipated hazards, site conditions, equipment, materials, and the control measures to be implemented to eliminate or reduce each hazard to an acceptable level of risk (USACE 2008).

A generic risk matrix is shown in Figure-6.1. The risk assessment team establishes for each identified risk “item” its level of severity (the impact upon the project, or outcome/degree of the incident, near miss or accident) and its corresponding probability of occurrence (how many times that risk event can occur, or likelihood of the hazard to cause an incident, near miss, or accident). The result is that each item is assessed a level of risk (ranging from very high to very low). Once the level of risk is determined for the severity (x-axis of chart) and probability (y-axis of chart), a Risk Assessment Code (RAC) is selected for each hazard. This assessment and selection is then continued for each identified hazard in the PHA.

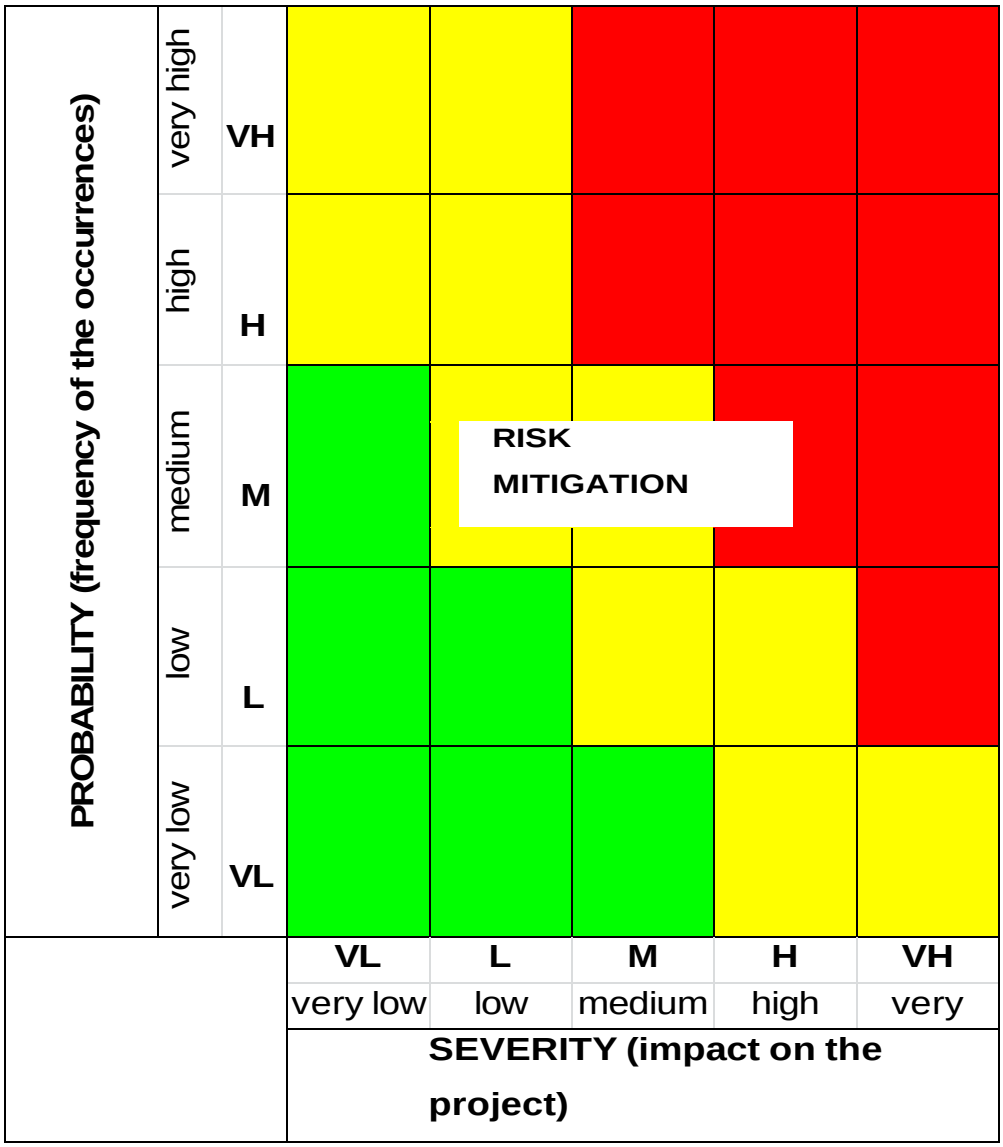


Figure-6.1: Generic Risk Matrix

Dredger Monitoring Software

Dredgers are often equipped with dredge monitoring software to help the dredging operator position the dredger and monitor the current dredge level. The monitoring software often uses Real Time Kinematic satellite navigation to accurately record where the machine has been operating and to what depth the machine has dredged.

6.3.6.2 Hazards Associated with Piling

In specifying the use of piles the designer should be aware of, and assess the risks from, the following principal hazards. It is important that, where

these risks cannot be eliminated or reduced during the design process and they are perceived as 'significant risks'. The prospective principal contractors must outline the control measures proposed in respect of these 'significant hazards' in the Construction Phase Plan. When a tender is accepted and the project reaches the construction phase the principal contractor must control the hazards and risks as outlined in his construction phase plan.

Possible hazards and risks

- Health hazards such as contact with contaminated risings and contact with hazardous materials or dusts.
- Noise & vibration
- Contact with plant or machinery during lifting, slewing and pitching of piling elements, movement of piling rigs, etc.
- Plant instability caused by gradients, variable ground conditions, and/or inadequate bearing capacity
- Hazards of buried or overhead services
- Collapse of excavations, nearby structures etc.

Following measures are recommended:

- All pile driving equipment are of good design and sound construction, taking into account the ergonomic principles and are properly maintained.
- Pile driver is firmly supported on a heavy timber sill, concrete bed or other secured foundation.
- If a pile driver is required to be erected in proximity to an electrical conductor all necessary precautions are taken to ensure safety.
- Hoses of steam and air hammer are securely lashed to such hammer so as to prevent them from whipping in case of connection or break.
- Adequate precaution is taken to prevent the pile driver from overturning.
- All necessary precautions are taken to prevent hammer from missing the pile.

- A responsible person for inspecting pile driving equipment inspects such equipment before taking it into use and takes all appropriate measures as required for the safety of building workers before commencing piling work by such equipment.

Operation of Pile Driving Equipment

The following measures are recommended:

- Only experienced and trained worker operates pile-driving so as to avoid any probable danger from such operation;
- Every worker employed in pile driving operation or in the vicinity of such pile driving operation wears ear protection and safety helmet or hard hat and safety shoes;
- Piles are prepared at a distance, at least equal to twice the length of the longest pile, from the place of pile-driving operations;
- When a pile driver is not in use, the hammer of such pile driver is blocked at the bottom of the heads of such pile driver.

Pile Testing

The employer shall ensure at a construction site of a building or other construction work that:

- Testing of pile is conducted under the supervision of a responsible person for such testing.
- Practicable measures like displaying of warning notices, barricading the area and other similar measures are taken to protect the area where the pile testing is carried out.
- Entry to a pile testing area is prohibited to general public to ensure safety.

6.4 SAFETY PRACTICES DURING CONSTRUCTION

A health and Safety Plan comprising of the following shall be prepared:

- General Description of the Work
- Details of timing within the project
- Details of Risks to workers at the pre-tender stage
- Information required by potential principal contractor to demonstrate

competence or adequacy of resources

- Information for preparing a health and safety plan for the construction phase and information for welfare provision and to be further developed before the construction work begins.

In addition, the planning supervisor shall keep a health and safety file which shall be updated as the construction project progresses. This file shall contain information on the risks that will have to be managed during its maintenance, repair or renovation. It shall be given to the client when the Project is completed to show to construction firms who carry out any future design, construction or maintenance work.

Working at height

Although workers are at risk from numerous hazards on construction site, the most common involves workers falling from height. The most common cause for fall from height is due to inadequate access to and from the work place as the work place is not safe enough.

To ensure safety when planning for work at height contractor must consider whether the existing structure can be access safely and provide a safe place of work. If this is not a case then extra working platform like scaffold or a cradle may be needed.

Construction Vehicles

Majority of the accident involving construction vehicle occur because transport activities are inadequately planned and controlled. Some examples are as follows:

- Vehicle loads can strike when reversing and driver may not be properly trained
- To avoid such accident risk assessment of all transport activities on a construction site to be carried out
- Provision of one way traffic routes to ensure that corner have clear sight lines
- Separation of pedestrians and vehicles by establish pedestrian-only area from which vehicles are completely excluded
- Establishment of Vehicle-only areas, specially where space is limited

or traffic is heavy

- Ensure Vehicle –only routes have speed control measures, are clearly signposted and are free from obstruction.

6.5 TYPES OF EMERGENCIES

The type of emergency primarily considered here is the major emergency which may be defined as one which has the potential to cause serious danger to persons and/or damage to property and which tends to cause disruption inside and/or outside the site and may require the co-operation of outside agencies.

Emergency is a general term implying hazardous situation both inside and outside the premises. Thus the emergencies termed “on-site” when it confines itself within the installation even though it may require external help and ‘offsite” when emergency extends beyond its premises. It is to be understood here, that if an emergency occurs inside the project area and could not be controlled properly and timely, it may lead to an “off-site” emergency.

An emergency in the premises can arise due to certain undesired incidents resulting in fire, explosion or oil spill.

6.6 PRIORITY IN EMERGENCY HANDLING

The general order of priority for involving measures during the course of emergency would be as follows:

- Safeguard life
- Safeguard environment
- Safeguard property

6.7 OBJECTIVES OF THE DISASTER MANAGEMENT PLAN

The main objectives of the Disaster Management Plan would be:

- Ensure that loss of life and injuries to persons are minimized
- Damage to environment is minimized, property loss is minimized
- Relief and rehabilitation measures are effective and prompt
- Minimize the outage duration of the facilities.

The above objectives are sought to be achieved through some of the following measures:

- Providing information to all concerned on the estimated consequences of the events that are likely to develop as a result of the emergency.
- Mobilizing on-site resources.
- Calling up assistance from outside agencies.
- Initiating and organizing evacuation of affected workmen.
- Providing necessary first-aid and other medical services that may be required.
- Collecting data on the latest developments, other information and requirements.

6.8 HAZARD IDENTIFICATION

Hazards in the proposed facility can happen during the construction phase, operation phase or due to natural calamities like earthquake/cyclones/Tsunami etc. some potential hazards that can happen are identified as given below:-

- Berthing accident, impact on jetty, mooring failure etc.
- Grounding of vessel, oil spillage, wreckage and impact on marine environment
- Breaking of coal conveyor which can cause breathing problems.
- Accident caused by cyclones, rough sea, earth quake
- Fire breakout

Hazards that can arise during construction phase are as listed below:-

- Hazards due to moving of machinery, heavy construction equipment, falling of tools from a height, etc
- Hazards can also be happen during transportation through road and sea like collision of vehicle, barges etc.
- The noise generated during construction may affect workers health.
- Material used during construction phase e.g. fuels, lubricant, paints,

and other flammable materials can cause fire and explosion risk. It has to be ensured that there are no live wires causing short circuits to ignite these materials.

Hazards that can arise during coal handling plant operation phase are as listed below:-

- The mechanization of coal handling operation planned can be classified as non hazardous with respect to operation of the plant. As the coal unloading and conveying is done through mechanized grab unloaders and connecting conveyor, there will be no spillage of coal.
- The possible hazards that can happen during ship movements at the offshore jetty are collision, grounding, etc. During barge unloading operations, the possible hazard may arise due to collision between vessels.
- Transfer of coal from unloaders to the jetty (belt) conveyor will not cause any spillage during this operation as there is very minimal possibility of mal-operation/ non-synchronization.
- The main hazards related to belt conveyors are mechanical. Other hazards are produced by non-compliance with ergonomic principles when workers operate near the conveyor (operation station, control of the process, loading and unloading), failure or malfunction or safety-related control systems, electrical hazards, and thermal phenomena (such as heat, fire or explosion). The mechanical hazards are mostly related to Mechanical power transmission components, moving components (idlers, pulleys, belt), Pinching zones (feeder, skirt-board, skirt-board seal) that can cause damage by shearing and crushing, moving loads that can cause damage by shearing and crushing between the load and a fixed component, moving sub-assemblies (ejectors, switches, transfer mechanism) that can cause damage by shearing and crushing.

Hazards that can arise due to natural calamities are:-

- As per the seismic zoning map of India, Goa region falls in zone III which is a moderate intensity zone with regards to seismic activity due to the presence of 23 fault lines in its vicinity. The design of the facilities should incorporate this factor which would give the required structural integrity.
- Necessary mitigation steps shall be taken during cyclone effect as per Disaster Management Rules.

6.9 IDENTIFICATION OF POTENTIAL ACCIDENTS

The possible accidents from the proposed port development at Mormugao are envisaged from the spontaneous ignition of coal dust at the stackyard of proposed coal berth 8. Coal dust when dispersed in air and ignited would explode. Conveyor systems are most susceptible to this hazard. Failure of dust extraction and suppression systems in stockyard area may lead to abnormal conditions and increasing the concentration of coal dust to the explosive limits. Sources of ignition present are incandescent bulbs with the glasses of bulkhead fittings missing, electric equipment and cables, friction, spontaneous combustion in accumulated dust. Dust explosions may occur without any warnings with maximum explosion pressure up to 6.4 bars.

CONVEYOR SYSTEM SAFETY

Belt conveyor is safe system. The operation and maintenance of this system in the project are also safe.

SAFETY FEATURES

Dust suppression system is proposed at stockyard. The stackyard will be fully covered with dome type shed. Fire hydrant system is proposed to be installed at berths, conveyor gallery, stockyard, RRLS, etc.

6.10 RISK MITIGATION MEASURES

The following measures can be taken to avoid the above said risks:-

- Preparation of Standard Operating Procedures (SOP's) and compliance to the guideline and procedure enlisted.

- Monitoring System for process parameters including manual checking should be established.
- Leak Detection and Spill Control System should be detailed for all the materials.
- Automation of the preliminary firefighting/system cooling initiation based on HC, temperature and smoke detectors should be ensured to prevent a small incident from escalating. This would also give adequate time for effective personnel response and intervention.
- All sources of ignition should be removed from the handling and transferring areas.
- Removal of spark generating electronic equipment such as cellular phones should be strictly followed
- Procedures for ensuring use of relevant Personal Protective Equipments (PPE) should be delineated and strictly enforced to prevent exposure to personnel
- Periodic Inspection / Corrosion Monitoring should be carried out
- Periodic Training to Personnel

Above all, consistent and total quality assurance for engineering design, hardware selection, through construction to commissioning and subsequent operation and maintenance has to be adopted.

6.11 DISASTER MANAGEMENT PLAN

6.11.1 General

The purpose of a Disaster Management Plan (DMP) is to identify the future incidents and to manage the effects of that efficiently to reduce the damage level. DMP helps in minimizing the impact of any incident and helps n suppressing the effects.

In case of a major emergency, which can cause serious injury or loss of life, can be manage efficiently if a proper DMP is in Place. Such emergencies can be caused by several factors e.g. Failure of the System, Human Error, Natural Disaster (Earthquakes, cyclones, etc), Vessel collision or sabotage, Explosion and fire, Material spillage at the proposed

facility. A Disaster Management Plan enumerates the mitigation measures, precaution to be taken and procedures to mitigate a major Disaster, e.g.

- Procedure for Controlling accidental events (Including natural disaster) with minimum damage to men, material and machine (MMM)
- Reduce the damage level to the facility without any harm to the humans
- Rescuing victims and treating them suitably
- Identifying the persons affected and Informing relatives of the casualties
- Providing authentic information to news media and others
- Maintaining records of the disaster event and its cause, damage level, and equipment needed as evidence in any subsequent enquiry.
- Rehabilitating the facility, plant, and area.
- Coordination between people while carrying out rescue operation

Control of any hazards at the site and the management of such disasters/accidents can be prevented. Several factors causing disasters other than natural causes are:-

- Poor design of the structures, plants and machineries
- Poor manpower and increased human errors
- Poor operational skill and lack of training
- Negligence toward timely maintenance and inspection

Performing these activities can reduce the risk of accidents, but it may not be possible to fully eliminate them. Since absolute safety is not achievable, an essential part of a major hazard control must also include minimizing the effects of a major accident.

An important element of mitigation is emergency planning are:-

- Recognizing potential accidents identifying the types of accidents which may occur,

- Assessing the consequences of such accidents and deciding on the emergency
- procedures that would need to be implemented in the event of the specific type of emergency

6.11.2 Objectives of Disaster Management Plan

The prime objectives of the Disaster Management Plan are:-

- To have advance planning for each possible emergency scenario and to combat them and to minimize the adverse effect to Man, Material and Machine.
- To identify the advance warnings, evacuation of surrounding personnel to be evacuated
- To rescue, provide relief and assist affected people, environment and settlements.
- To localize the emergency caused and, if possible, eliminate it; and
- To minimize the overall and long term effects of the accident on people, environment and property

Elimination of hazards will require prompt action by operators and emergency staff operating:-

- Various kind of firefighting equipments including Water sprays
- Emergency and synchronized Shut Down of the entire mechanical handling systems, etc

Also minimizing the effects of the disaster will include, Rescue of the affected people, Providing First aid and required medication, Evacuation of the affected people and Rehabilitation and giving information promptly to people living nearby.

6.11.3 Disaster and its Causes

Identification of causes for disaster is very important for emergency planning and requires systematic identification of potential emergencies at the proposed facilities. Experience has shown that for every occasion that the full potential of an accident is realized, there are many occasions when some less severe event occurs or when a developing incident is mitigated before reaching full potential. Most major accidents

envisaged at the proposed facilities fall within one of the following categories:

- Ship collision and grounding
- Failure of Shore Unloaders
- Failure at the Junction Houses
- Failure in the trough/pipe belt conveyor system
- Fire or explosion due to the presence of coal dust
- Spill during loading and discharge operation (LDO) and subsequent fire
- Mechanical / electrical failures

6.11.4 Categorization of Emergency Plan

Any emergency situation has to be first categorized as an onsite emergency or an offsite emergency, the difference being that the effects of the onsite emergency are confined within the premises while those of an offsite emergency spill over beyond the jetty/operational area premises or even beyond the project site premises. Thus, the onsite and offsite emergency plans are detailed below:

6.11.4.1 Onsite Emergency Plan

The onsite Emergency plan would contain the following components:

- Formulation of Disaster Management Plan and Emergency Services
- Organization Structure, Roles and Responsibilities of Emergency Teams
- Effective Communication
- Emergency Control Centre
- Alarm Systems & Assembly Points
- Mutual Aid Scheme
- Onsite Emergency Plan and Rehearsals
- Terminal and Vessel Emergency Plan
- Spillage & Contingency Plan
- Formulation of Disaster Management Plan for Cyclones and Earthquakes

6.11.4.2 Offsite Emergency Plan

The components of an offsite emergency plan would include:

- Identification of locations of hazardous or dangerous substances, personnel and emergency control rooms.
- Technical information such as chemical and physical properties, dangers etc
- Background information, past accidents, control techniques and effects of hazardous materials of relevance
- Identification of facilities and transport routes for toxic materials if any
- Contact for further advice such as meteorological information, transport, temporary food and accommodation, first aid and hospital services, water etc.
- Establishing communication links including firefighting materials, damage control and repair items
- Detailing emergency response procedures
- Notification to public at large
- Evacuation arrangements
- Press / media handling
- Addressing longer term environmental cleanup.

6.12 ONSITE ENERGENCY PLAN

Formulation of Disaster Management Plan and Emergency Services

Proper assessment of the risks and hazards at the time of construction/installation results in additional safeguards or better procedures.

The Disaster Management Plan must be related to the above said final assessment and it is the responsibility of the owner (MPT) management to formulate the disaster management plan. The Disaster Management Plan would enumerate the followings:-

- Assessment of the magnitude and nature of the events foreseen and the probability of their occurrence
- Formulation of the plan and liaison with outside authorities e.g. various public administration authorities, authorities dealing with

disaster managements, including the emergency services

- Procedures for raising the alarm and communication both within and outside the project area (jetty, stockyard etc)
- Appointment of key personnel and their duties and responsibilities (organizational structure)
- Emergency Control Centre
- Action on site and Action off site

6.13 ORGANIZATION STRUCTURE

The early minutes just after the incident / accident / disasters, are the most critical period in prevention of escalation of the disaster and to stop further propagation so that damage to the human, and properties can be minimized or avoided. Therefore, the personnel available at or near the incident site (and often responsible for or carrying out that particular activity) and on a round the clock basis play a vital role in an emergency.

In each hazardous location it is necessary to nominate a functionary as the "Incident Controller" who is invariably a shift-in-charge of the facility. The Incident Controller tackling the emergency in real terms requires support from various other services e.g. fire & safety, medical services, security, engineering, administration, technical services covering communication, transport and personnel functions, etc. Responsible key person for each one of these services, therefore, should be nominated to be part of the organization for disaster management.

The "Site Main Controller" (SMC) will be the Unit In-charge. The various controllers for the above said emergency services will have to co-ordinate with the SMC through the functional Key Persons at the incident site. The Key Person will generally be located at the site of incident and the Controllers will report of the incident to the Emergency Control Centre. The duties and responsibilities of various Key Persons and Controllers will be written down ensuring no grey areas or overlapping responsibilities. Various Controllers from the various service provider organizations nominated to become a part of the disaster management organization will be informed of their role and responsibility. The members can be from:-

- Operation/Maintenance Controller
- Fire and Safety Controller
- Communication Controller
- Environment Controller

6.14 ROLES AND RESPONSIBILITIES OF EMERGENCY TEAM

The role and responsibility of various responsible persons in the emergency team is briefed below:-

6.14.1 Site Main Controller (Site In-charge)

Site main Controller is the site in-charge and his roles and responsibility is to access the extent and magnitude of the damage caused and by maintaining continuous communication with the Site Incident Controller (SIC). Some other responsibilities of Site Main Controller are as given below:-

- To determine the extent of emergency and required planning to mitigate
- Monitoring and controlling the emergencies and engaging the workforce without overlapping of disaster management team
- To take decisions on operation of the plant or any shut down of any process decide whether any section / process / area to be shut down / isolated in the event of any accident
- To finalize the means of evaluation and explore the possibilities of taking help from offsite sources
- Review, monitor the rescue operation and firefighting operations in consultation with Safety Coordinator
- Co-ordination with the safety officer regarding evacuation and shelter rehabilitation aspects
- Arrange for restoration and normalcy in consultation with Incident Controller
- Announcement of conclusion of emergency
- Issuance of authorized statements and ensures that all evidences of the incident are preserved.

6.14.2 Site Incident Controller (Shift in-charge)

The roles and responsibilities of a site incident Controller (Shift In-Charge) is as enumerated below:-

- To Establish Emergency Control Centre and inform Site Main Controller (SMC).
- To Ensure availability of Controllers/Team member
- To Priority decisions for strategy for development of resources for incident control
- Periodic assessment of actual disaster zone and resource deployment (own / external)
- Periodic status report of SMC
- Seek help for Fire Fighting, Medical Aid, Rescue, Transport, Traffic Arrangement, Law and Order
- Inform the following authorities about the incident through zonal/sector authorities
    a) District Collector/ District Magistrate
    b) Superintendent of Police
    c) Environmental Authority (State/Central)
    d) Health Officer
    e) Inspector of Factories
    f) Neighboring Installations
- Establish contacts with the following, through controllers:
    a. Superintendents of nearby hospitals
    b. Chief Fire Officer of nearby fire services
    c. Insurance Company
    d. Establish First Aid Centre through Safety Coordinator
- Establish Information Centers

6.14.3 Emergency Coordinators

Logistics Coordinator

The duties and responsibilities in the event of any emergency include:

a. Report at the affected area to the SMC & SIC
b. Arrange to attend all maintenance jobs as instructed by SIC

c. Ensure that all essential services like power, water etc. are maintained without interruption
d. Ensure adequate manpower availability at the affected area
e. Reporting all the incidents to SIC
f. Arrange for all the tools, materials at the site of emergency

Communication Coordinator:

The Responsibilities of a communication coordinator include:

- Report to SMC & SIC
- Removal of non-essential personnel from the emergency area in consultation with SIC
- Contact with SIC and arrange for necessary facilities
- Control over entry and maintain law & order and arrange for police help in consultation with SMC
- Liaison with external agencies in consultation with SMC
- Co-ordination of transportation requirements for moving personnel for first aid, evacuation, rehabilitation etc.
- Maintenance of inventory systems in the Emergency Control Centre

Safety Coordinator:

The Responsibilities of a safety coordinator include:

- Immediate Reporting to SIC
- Co-ordination with Security officer and security personnel
- Ensure availability of all safety equipments at site
- Co-ordination of all rescue operations
- Co-ordination of availability of first aid to all injured personnel
- Advice to SIC on firefighting operations
- Ensure availability of necessary antidotes/ medicines in case of toxic release

6.15 COMMUNICATION

An essential component of any emergency preparedness programme is the communication links for gathering information needed for overall co-ordination e.g. emergency control centre with in-house as

well as outside emergency services. Too much reliance on the telephone system Fixed lines/ Mobile phones is risky as it can soon be overloaded in an emergency situation. A computer with internet and printer facility and photocopying machine, wireless networks, fax, intercom units are recommended for higher reliability.

Help line numbers will be setup for emergency related queries. The description of the tasks and responsibilities, reporting place, etc. for each key functionary will be, as far as possible, so drafted as to reduce the communication needs between the interacting groups and permit good mutual understanding and well co-ordinate independent actions to tackle emergency situations.

6.16 EMERGENCY CONTROL CENTRE

The emergency control centre should be established separately for proposed coal berth 8, container and GC berth 9 and 9A at Mormugao Port and should be equipped with the following:

- An adequate number of external telephones. If possible, one should accept outgoing calls only, in order to bypass jammed switchboards during an emergency.
- An adequate number of internal telephones, Radio equipment/pager system.
- A layout plan of the facility
- Location of possible spillage/fire points
- Sources of safety equipment and other fire-fighting system elements
- Escape Routes
- A nominal roll of employees at the facility
- A list of Key Personnel with addresses, telephone numbers, etc
- An adequate number of personnel protective/safety equipment available on site /back up in warehouse or with other member groups of mutual aid programme
- Locations of various firefighting arrangements at the facility.

6.17 ALARM SYSTEMS

The emergency (due to fires or spillages) should be initiated by the first person noticing it by activating the fire alarm from the nearest call-point or by contacting the fire control room immediately on the internal telephone in case of any emergency. If in the opinion of the shift in-charge in consultation with the fire safety officer, the severity of the emergency is such that it can primarily be coped with by MPT's own resources (aided by fire fighting appliances from the fire brigade, if required) the siren code for ONSITE CRISIS will be sounded through the hooter. The siren codes for distinguishing between an ONSITE & OFFSITE CRISIS will be clearly established. The onsite/ offsite siren codes should be informed to the neighboring population of the facility.

6.18 PLANS FOR EMERGENCY

6.18.1 Mutual Aid Scheme

Assistance in terms of equipment and manpower will be taken from the neighboring installations under a Mutual Aid Scheme / Zonal Disaster Management Plan.

6.18.2 Assembly Points

Shifting or evacuating facility personnel during an onsite crisis will be done to a predetermined assembly point in a safe part of the facility. The assembly point will be identified at safe locations.

6.18.3 Onsite Emergency Plan and Rehearsals

Once the emergency programme is finalized, it should be made known to all personnel so that each one knows his or her role in the event of an emergency. The plan will be regularly tested through the rehearsals, at a regular frequency and updated accordingly.

6.18.4 Terminal Emergency Plan

This plan will be drawn up in consultation with Fire Brigade, Coast Guard etc. The plan will include:

- Stopping of unloading operation immediately at the terminal
- Specific initial action to be taken by those at the location of emergency (to notify time, position, source and cause of spill) to control room and

to Department of Ports, Coast Guard, Indian Navy, etc

- Immediate action to combat pollution
- Evaluation of situation by on-scene controller regarding threat posed by spill and identify threatened resources
- Co-ordinated arrangement for quick and safe release of tanker in case of an emergency
- Details of communication system available and siren code
- An inventory, including location details of emergency equipment
- Sound alarm-terminal fire-fighting staff to fight fire
- Un-berth vessel to depart
- Electric power to switch off and emergency lighting to switch on.

The ships calling at the terminal will be advised of the terminal's emergency plan particularly the alarm signals and procedures to summon assistance in the event of an emergency on board.

6.18.5 Vessel Emergency Plan

Planning and preparations are essential if personnel are to deal effectively with emergencies on board a vessel. Though various types of emergencies can occur on the ship, only fire on the vessel at the terminal is of major concern in the present context. The immediate action to be taken by the master of the vessel will include:

- Raise the alarm (also sound the terminal fire alarm to support ship's efforts to control fire) and commence shutting down any discharging, bunkering or de- ballasting operations which may be taking place
- Fight the fire from Tug with fire-fighting equipment
- Locate and assess the incident and assess possible dangers
- Organize manpower and equipment for quick control of the incident
- Co-ordinate arrangements for quick and safe release of the vessel
- Mobilize port tugs and launches and keep pilots and mooring staff and standby to remove vessel from the terminal, if required.

6.18.6 Rough Weather Plan

The major hazard therefore is likely to be due to high waves during the monsoon. The recommended tranquility conditions of 1.2 - 1.5 m may not

occur for about 20 percent of the time during the monsoon season. Hence the jetty operator as well as emergency coordinator should obtain regular updates from IMD about the weather status to ensure that no ship operations are carried out under unfavorable conditions. During such conditions the following emergency situations may occur and need to be monitored and attended to:-

- **Carrier collision / grounding:** Especially during rough weather, carrier collision with jetty / grounding of carrier is possible mainly because of uneven distribution of cargo in the carrier. If such events take place, immediate alert and action especially for saving crew as well as jetty personnel must be given out. A life boat must be kept moored with all first aid facilities near the work site both construction and operation phases. Since the facilities on land will be about 7-10 km away, this is essential. Life buoys must be kept available at all times.
- **Fuel/ oil spills:** Because of carrier collisions / grounding or even during route operations, spilling or leak of fuel/ Oils from carriers as well as from storage facilities (if any) on the jetty are possible. The oil spill contingency plan as described in the next section need to activate during such an event. As this is a barge terminal, Grounding may not cause any tilting to the barges and spillage may not occur. However at anchorages while unloading the coal from the OGV, grounding may occur in case of bigger vessel with deeper draft during low tide period.
- **Inundation:** During periods of heavy rain and rough weather, wave heights can be high enough to cause various degree of flooding of the jetty. During the pre-monsoon period (august- September), the emergency coordinator will liaise with maintenance division to ensure that all storm water drained and other areas where flooding may occur are kept clear to ensure free drainage of water. During the monsoon, the emergency coordinator will ensure a system for regular updating of weather information especially rainfall forecasts from the IMD and will

monitor wave heights so that decisions can be taken regarding berthing of carriers and unloading/ loading cargo. In addition, during periods of heavy rain/ swells, who ever notice water in places where there should be any water or water above the danger marks if so marked. They should take immediate action and also follow the line of action to communicate to the emergency coordinator for additional action.

6.18.7 Spillage and Contingency Plan

The purpose of this plan is to identify, prevent and control all probable spillages in proposed Coal and GC berths for safe and healthy working of personnel and machinery.

Probable materials for spillage:

- Electrical equipment area (Transformer oil and cable filling compounds)
- Liquid and solid wastes
- Coal

Spillages in the proposed coal berth 8 can lead to loss of property, Interfaces with safe moving of personnel, Damage to equipment when left unattended, Health hazard, Fire hazard, etc.

Prevention of spillage:

Routine checks of the system have to be made to ensure that no leak or spill starts. Any minor leakage has to be reported to the concerned person (Shift In-charge, Operation & Maintenance team member). Leakage has to be arrested in the shortest possible time. Necessary arrangements have to be made to collect the leakage and to store in proper place.

In case of spillage the following measures would be adopted:-

- Oil spill on the land should be properly cleaned using absorbents, cotton waste, sand, saw dust etc.
- The collected oil is disposed to SPCB/CPCB authorized agency
- Oil spill on the proposed berths should be properly cleaned using absorbents, cotton waste, and sand, saw dust etc., and the materials used for cleaning should be incinerated.

- Major oil spills can be taken to oil separator and the same to be reused depending on the quality.

Oil Spill Contingency Plan

The proposed berths will be equipped with necessary modern equipment to contain and recover oil spills. In addition, MPT shall develop a customized Oil Spill Contingency Plan to cope with any accidental oil spill. The contingency plan will be prepared by MPT in consultation with the Maritime Board/Department of Ports/Ministry of Shipping.

In case of an oil spill, immediate steps would be taken to contain and control the spill. An Oil Spill Contingency Plan will outline the steps to be taken before, during and after a spill. In the present case, an Oil Spill Contingency Plan covering Hazard Identification, Vulnerability Analysis, Risk Assessment and Response Actions will be prepared.

Hazard Identification:

All conditions which can lead to an oil spill will be identified and necessary information to react to a spill under different conditions will be studied.

Vulnerability Analysis:

Vulnerability analysis will help to identify the resources and communities which could be affected due a spill and accordingly they can be informed or quick measures can be taken so that it results in minimum damage. Information on the following will be collected as a part of vulnerability analysis:

- Public safety officials
- Schools, nursing homes, hospitals and prisons in the area
- Recreational areas
- Special events such as festivals and when they occur
- Ecologically sensitive areas specially areas susceptible to oil or water pollution

Risk Assessment:

Based on hazard identification and vulnerability analysis, the extent of risks involved will be assessed.

Response Actions:

Response actions will provide information on all the immediate actions that will be taken in the event of a spill. It will have information on the following:

- Measures to prevent further flow of oil
- Measures to prevent ignition
- Agencies responsible for clean-up effort
- Information on the extent of spill
- Measures to contain spill to a limited area
- Measures to remove oil
- Measures to dispose the spilled oil

Mock drills will be carried out to test the effectiveness of the contingency plan.

6.18.8 Contingency Plan for Coal

In the proposed coal terminal area, unloading, conveying, handling, transfer and storage is envisaged. During coal handling and transfer activities there may be fugitive dust emission which might cause occupational health hazards. Hence, dust suppression will be provided. Dust control equipment system consisting of suitable pump, storage tank for water and sprinklers & nozzles for dust suppression at discharge/feeding points of belt conveyors are proposed at each transfer tower for efficient dust control. In addition to the above, suitable spray system shall also be provided at Shore Unloader & coal stockyard.

The water sprinkling system at high-pressure swiveling type nozzles shall be installed to cover the entire handling and transfer areas at the jetty.

Emergency Committee

The Emergency Committee is to be set up for major off-site emergencies and along with Coal unloading jetty. This committee would comprise of the following members:-

- Collector/ District Magistrate – Chairman
- Officer In-Charge Proposed Container/GC/Coal Berth - Member
- Port Officer, MPT – Member
- Govt. representative from Environmental board – Member

- Police (Law and Order): Dy. Suptd. Of Police – Member
- Police (Traffic): Police Inspector – Member
- Fire & Rescue Services: Local Station Officer – Member
- Inspector of Factories, Mormugao – Member
- Representative officer from Central Railway: - Member
- Health Officer Goa: - Member
- Representative Officer from Transport - Member
- Representative from Fisheries; Local Fishermen's body – Member
- BSNL, Area Manager; other telecom service providers – Member
- Registrar, Local land registration office - Member

6.19 DISASTER MANAGEMENT PLAN FOR CYCLONES

6.19.1 General

Concessionaire/MPT will develop a customized Disaster Management Plan (DMP) to cope during disasters from natural calamities such as rough weather conditions, cyclones, Tsunami and floods, etc. Proper planning can reduce the potential damage from disasters in terms of losses to human lives, proposed coal terminal, and environmental damage and rehabilitation costs. The DMP for Cyclones and Tsunami will be prepared by concessionaire/MPT in consultation with the Maritime Board, Local administration body, and SPCB/CPCB. The rough weather operations will be controlled in three stages:

- Green Status – The operations of coal unloading will be carried out as planned.
- Yellow Status – This is an alert stage indicating possibility of rough weather. Still operations can be continued with all emergency precautions
- Red Status – Emergency situations or rough weather; operation will be suspended.

Activities controlled by in-charge of emergency operations. The vessels are to be moved to safe anchorage or will be advised to proceed to sea. The main components of the DMP for cyclones will include the following:

- Pre-Disaster (or Pre-Cyclone) Plan
- On (or During Cyclone) Disaster Plan
- Post (or After Cyclone) Disaster Plan

6.19.2 Pre-Cyclone Plan

Pre-Cyclone Measures:

Proposed Coal berth 8, GC and Container Berth 9 and 9A will maintain and exchange information continuously with the local IMD authorities for continuous updates of meteorological conditions in general and emerging / predicted weather phenomenon such as cyclones in particular. Upon issue of a cyclone warning by the IMD, the management would immediately initiate the Pre-Cyclone Measures. The Goa Collectorate/ Port Department / MPT and other authorities would be informed of the imminent cyclone. All coal terminal officials dealing with operations and disaster management will be informed.

Pre-Cyclone Exercise:

On signaling of a cyclone alert, the Control Room will be manned 24 hours a day for disaster management. The 'Weather Signals' depending on the data available about the cyclone and it's threat perception will be informed to all personnel. The marine side operations will be regulated as per the rough-weather classification and will be continued with all emergency precautions. The different personnel of proposed Coal, GC and Container berths would assume their roles and responsibilities as previously identified for disaster management. The standby arrangement for power supply will be checked. Pre- identified Rescue Centre will be kept in readiness. A pre-alert will be issued regarding suspension of all operations in case of emergency and to await instructions regarding the same. All the Crafts and Ships will be fully secured inside the harbour area. Communication system including standby arrangement will be tested for working condition. Vehicles involved in rescue operations will be checked for working condition. Coal Terminal crafts to be engaged in rescue will be kept in readiness. The safety in the project area will be ensured. During Cyclone Plan: The emergency alarm siren will be raised as per the 'Alarm

System'. All personnel will be evacuated except essential operational personnel and personnel dealing with disaster management. The cargo handling operations will be suspended. The vessel/Barges will be moved to safe anchorage or will be advised to proceed to sea. Power supply will be disconnected and alternative power supply will be restored in essential operational areas. Terminal Crafts and Tugs will continue to be in readiness for rescue.

This would be the rescue and rehabilitation stage after passing of the cyclone. The damages would be assessed and rehabilitation work initiated to restore operations at the earliest. The records of the events during the cyclone will be maintained and reviewed for possible enhancements to the DMP.

6.20 RECOMMENDATIONS - IMPLEMENTATION OF OFFSITE EMERGENCY PLAN

- Emergency control centre will be the focal point to co-ordinate emergency activities
- Emergency control centre would be equipped with adequate number of equipment mentioned under heading "Emergency Control Centre"
- Succession or second-line controllers would be named for assuming responsibilities in case disaster occurs in absence of principal coordinators
- Hot line would be provided between proposed Coal berth 8, container and GC berth
- 9 and 9A and Fire Brigade at Goa region.
- Concessionaire would make arrangement for coded siren system or through some other suitable means to alert people in surrounding areas in case of off-site crisis.

A summarized version of action procedures detailing the "Role of Essential Staff in Major Emergency" should be issued in a flip chart like booklet form to all concerned persons (officers and supervisors) at work places and also to senior officers of the civic administration.

CHAPTER-7
ENVIRONMENTAL MONITORING PROGRAMME

CHAPTER-7

ENVIRONMENTAL MONITORING PROGRAMME

7.1 THE NEED

Monitoring is an essential component for sustainability of any developmental project. It is an integral part of any environmental assessment process. Any development project introduces complex inter-relationships in the project area between people, various natural resources, biota and the many developing forces. Thus, a new environment is created. It is very difficult to predict with complete certainty the exact post-project environmental scenario. Hence, monitoring of critical parameters is essential during project construction and operation phases.

Monitoring of environmental indicators signal potential problems and facilitate timely prompt implementation of effective remedial measures. It will also allow for validation of the assumptions and assessments made in the present study.

Monitoring becomes essential to ensure that the mitigation measures planned for environmental protection function effectively during the entire period of project operation. The data so generated also serves as a data bank for prediction of scenarios during construction and operation phases in similar projects.

7.2 AREAS OF CONCERN

From the monitoring point of view, the important parameters are marine water quality, ambient air quality, noise, etc. An attempt is made to establish early warning system which indicate the stress on the environment. Suggested monitoring parameters and programmes are described in the subsequent sections.

7.3 MARINE WATER & SEDIMENT QUALITY

7.3.1 Construction phase

The marine water quality shall be monitored for three seasons during project construction phase, close to the major construction sites. Both

surface and bottom waters shall be sampled and analysed. The parameters to be monitored are as follows:

Marine Water

Physico-chemical parameters

- pH
- Salinity
- Conductivity
- TDS
- Turbidity
- D.O.
- BOD
- Phosphates
- Nitrates
- Sulphates
- Chlorides

Biological parameters

- Light penetration
- Chlorophyll
- Primary Productivity
- Phytoplankton (No. of species and their density)
- Zooplankton (No. of species and their density)

Sediments

Physio-chemical parameters

- Texture
- pH
- Total Kjeldahl Nitrogen
- COD
- Sodium
- Potassium
- Phosphates
- Chlorides
- Sulphates

Biological Parameters

- Benthic Meio-fauna
- Benthic Macro-fauna

The marine water and sediment sampling and analysis be conducted by an external agency. A provision of Rs.20 lakh/year has been earmarked for this purpose. As the construction will be for 3 years, and considering an

escalation of 10% every year, an amount of Rs. 80 lakh has been earmarked.

7.3.2 Operation Phase

The marine water quality shall be monitored for three seasons in a yearduring project operation phase. Both surface and bottom waters shall be sampled and analysed. The parameters to be monitored are as follows:

Marine Water

Physico-chemical parameters

- pH
- Salinity
- Conductivity
- TDS
- Turbidity
- D.O.
- BOD
- Phosphates
- Nitrates
- Sulphates
- Chlorides

Biological parameters

- Light penetration
- Chlorophyll
- Primary Productivity
- Phytoplanktons (No. of species and their density)
- Zooplanktons (No. of species and their density)

Sediments

Physio-chemical parameters

- Texture
- pH
- Total Kjeldahl Nitrogen
- COD
- Sodium
- Potassium
- Phosphates
- Chlorides
- Sulphates

Biological Parameters

- Benthic Meio-fauna
- Benthic Macro-fauna

The marine water and sediment sampling and analysis be conducted by an external agency. A provision of Rs.20 lakh/year has been earmarked for this purpose.

7.4 AMBIENT AIR QUALITY

7.4.1 Construction Phase

Ambient air quality monitoring shall be monitored at three stations close to the construction sites. The monitoring can be conducted for three seasons. For each season, monitoring can be conducted twice a week for 4 consecutive weeks. The parameters to be monitored are PM_{10}, $PM_{2.5}$, SO_2 and NO_2. An amount of Rs. 5 lakh/year would be required. Considering, construction phase of 3 years and an escalation of 10% every year, an amount of Rs. 16.55 lakh has been earmarked for this purpose. The ambient air quality monitoring shall be conducted by an agency approved by Goa State Pollution Control Board.

7.4.2 Operation Phase

The ambient air quality monitoring shall be conducted at three locations. Air quality could be monitored for three seasons in a year. High volume samplers can be used for this purpose. The frequency of monitoring shall be twice a week for 24 hours for four consecutive weeks. The parameters to be monitored are PM_{10}, $PM_{2.5}$, SO_2 and NO_2. The ambient air quality monitoring during project operation phase shall be conducted by an agency approved by Goa Pollution Control Board. An amount of Rs. 6 lakh/year can be earmarked for this purpose.

7.5 NOISE

Personnel involved in work areas, where high noise levels are likely to be observed during project construction and operation phases. For such in-plant personnel, audiometric examination should be arranged at least once a year.

The noise level monitoring during construction and operation phases will be carried out by the project staff and a noise meter can be purchased

Neighbourhood (up to radius of 1 km)

It is recommended that during project operation phase, monitoring of sensitive areas like schools and Medicare centres be conducted within a distance of 1 km radius of the harbour to ascertain noise levels at receptors, taking note of any excessive build-up in any particular direction.

7.6 GREENBELT DEVELOPMENT

Sites of greenbelt development should be monitored once in every month during project operation phase to study the growth of various species and to identify the needs if any, such as for irrigation, fertilizer dosing, pesticides, etc. The monitoring can be conducted by project staff.

7.7 SUMMARY OF ENVIRONMENTAL MONITORING PROGRAMME

The summary of Environmental Monitoring Programme for implementation during project construction and operation phases is given in Tables-7.1 and 7.2 respectively.

Table-7.1 Summary of Environmental Monitoring Programme for Project Construction Phase

S. No.	Entity	Parameters to be monitored	Frequency of monitoring	Location* in Numbers
1.	**Marine water**			
	Physico-chemical parameters	pH, Salinity, EC, TDS, Turbidity, Phosphates, Nitrates, Sulphates, Chlorides.	Once in three months	3 Nos. closest to the activity
	Biological parameters	Light penetration, Chlorophyll, Primary Productivity, Phyto-planktons, Zooplanktons	Once in three months	3 Nos. closest to the activity
2.	**Sediments**			
	Physico-chemical parameters	Texture, pH, Sodium, Potassium, Phosphate, Chlorides, Sulphates	Once in three months	3 Nos. closest to the activity.
	Biological parameters	Benthic Meio-fauna, Benthic Macro-fauna	Once in three months	3 Nos.
3.	Ambient air quality	PM_{10}, $PM_{2.5}$, SO_2 & NO_2	- Summer, Post-monsoon and Winter seasons. - Twice a week for four	2 Nos.

S. No.	Entity	Parameters to be monitored	Frequency of monitoring	Location* in Numbers
			consecutive weeks per season.	
4.	Noise	Equivalent Noise Level	During peak construction activities	2 Nos.

Table-7.2: Summary of Environmental Monitoring Programme for Project Operation Phase

S. No.	Aspects	Parameters to be monitored	Frequency of monitoring	Location*
1.	**Marine water**			
	Physico-chemical parameters	pH, Salinity, EC, TDS, Turbidity, Phosphates, Nitrates, Sulphates, Chlorides.	Once in three months	3 Nos.
	Biological parameters	Light penetration, Chlorophyll, Primary Productivity, Phyto-plankton, Zooplankton	Once in three months	3 Nos.
2.	**Sediments**			
	Physico-chemical parameters	Texture, pH, Sodium, Potassium, Phosphate, Chlorides, Sulphates	Once in three months	3 Nos.
	Biological parameters	Benthic Meio-fauna, Benthic Macro-fauna	Once in three months	3 Nos.
3.	Ambient air quality	PM_{10}, $PM_{2.5}$, SO_2 & NO_2	- Summer, Post-monsoon & Winter seasons. - Twice a week for four consecutive weeks per season.	3 Nos.
5.	Noise	Equivalent Noise Level	Once per month	3 Nos. 50m, 100m and 500m away from operational area.
6.	Greenbelt Development	Rate of survival and growth of various species	Once per month	Various plantation sites.

* Amongst the locations selected for baseline studies of this EIA.

7.8 ENVIRONMENTAL MANAGEMENT CELL

Mormugao Port is an operational Port and has a Pollution control co-ordination cell. Environmental parameters are being monitored on monthly/seasonal bases by engaging the approved Consultants/ Laboratory. The Environmental Management Cell of Mormugao Port shall coordinate the implementation of various measures outlined in the Environmental Management Plan. The Environmental Management Cell shall integrate the Environmental Monitoring Programme specified for the proposed project will be integrated with the existing Monitoring Programme and coordinate its implementation.

CHAPTER-8
COST ESTIMATE

CHAPTER-8

COST ESTIMATES

8.1 ENVIRONMENTAL MANAGEMENT PLAN

The cost estimates for implementing Environmental Management Plan shall be **Rs.327.25 Lakh**. The details are given in Table-8.1.

Table-8.1: Summary of cost estimate for implementing Environmental Management Plan (EMP)

S. No.	Parameter	Cost (Rs. lakh)
1	Solid waste management	10.0
2	Community toilets and Sewage network from community toilets to existing STP	12.5
3	settling tank	5.0
4	Effluent collection and disposal from workshops	10.0
5	Dust suppression, water supply and fire fighting equipment	200.0
6	Construction of effluent treatment plant	5.0
7	Green belt development	2.0
8	Implementation of Environmental Monitoring Programme during dredging phase (Refer Table-8.2)	82.75
	Total	**327.25**

8.2 ENVIRONMENTAL MONITORING PROGRAMME

The cost estimate for implementation of Environmental Monitoring Programme during dredging phase is given in Table-8.2.

Table-8.2: Cost estimate for implementation of Environmental Monitoring Programme during construction phase

S.No.	Item	Cost (Rs. lakh)
1	Marine water and sediment quality	66.20
2	Ambient Air Quality	16.55
	Total	**82.75**

8.3 ENVIRONMENTAL MONITORING DURING OPERATION PHASE

The marine water quality, sediment quality, noise, air quality also needs to be monitored in the project area during operation phase. The same shall be integrated with the existing Environmental Monitoring Programme of the Mormugao Port Trust. The details are given in Table-8.3.

Table-8.3: Cost estimate for implementation of Environmental Monitoring Programme during operation phase

S.No.	Item	Cost (Rs. lakh)
1	Marine water and sediment quality	25.0
2	Ambient Air Quality	6.0
	Total	**31.0**

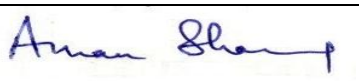
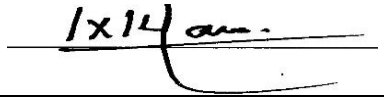
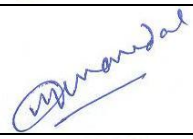
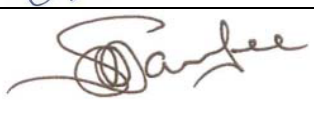
CHAPTER-9
DISCLOSURE OF CONSULTANTS INVOLVED IN THE EIA STUDY

CHAPTER – 9

DISCLOSURE OF CONSULTANTS INVOLVED IN THE EIA STUDY

The EIA study has been conducted by WAPCOS Ltd., a government of India Undertaking under Ministry of Water Resources, River Development and Ganga Rejuvenation. WAPCOS Ltd., has a full-fledged Centre for Environment who has conducted the EIA study. The list of the Experts involved in the EIA study is given in Table-9.1.

Table-9.1: List of Experts involved in the EIA study

S. No.	Name	Expertise	Signature
1.	Dr. Aman Sharma	EIA Coordinator	
2.	Mr. A. S. Leo	Air Pollution	
3.	Dr. S.K. Tyagi	Ecology and Bio-diversity Expert	
4.	Mr. R.V. Ramana	Noise Expert	
5.	Dr. K.K. Gaur	Social Expert	
6.	Mr. S.M. Dixit	Air Quality Expert	
7.	Mrs. Moumita Mondal Ghosh	Landuse Expert	
8.	Swapan Kumar Bandopadhyay	Risk and DMP Expert	

ANNEXURES

ANNEXURE- I

F.No.10-33/2015-IA.III
Government of India
Ministry of Environment, Forest & Climate Change
(IA.III Section)

Indira Paryavaran Bhawan,
Jor Bagh Road,
New Delhi - 3

Dated: 16th February, 2016

To

The Chairman,
M/s Mormugao Port Trust,
Administrative Office,
Headland, Sada
Goa– 403804

Sub: Redevelopment of Berths 8, 9 and Barge Berths at the Port of Mormugao, Goa by M/s Mormugao Port Trust –Terms of Reference (ToR) reg.

Ref.: Your online proposal no. IA/GA/MIS/33482/2015 dated 01.12.2015.

Sir,

Kindly refer your online proposal no. IA/GA/MIS/33482/2015 dated 01.12.2015 alongwith project documents including Form-I, Pre-feasibility Report and draft 'Terms of Reference' as per the EIA Notification, 2006. It is noted that Mormugao Port Trust has proposed for redevelopment of Berths 8, 9 and Barge Berths at the Port of Mormugao, Goa. Following are the details of proposed facilities :

(i). Construction of bund, extension of berth face, railway line conveyor system and office structure.
(ii). Covered storage for coal cargo and open storage for general cargo.
(iii). Construction of one coal berth.
(iv). Construction of one Iron Ore Berth and
(v). Construction of one multipurpose cargo berth.
(vi). Reclamation of 640000 m^2.
(vii). Capital dredging – 24 lakh m^3.
(viii). Capacity of proposed capacity will be 19 MMTPA
(ix). Proposed length of berth – 950 m.
(x). Proposed length of unloading jetty – 90 m.
(xi). Backup area is 65 acres.
(xii). Reclamation -16 acre.

2. Draft Terms of Reference (TOR) have been discussed and finalized by the 1st Expert Appraisal Committee (Infrastructure -2) held during 21st – 22ndDecember, 2015 for preparation of EIA/EMP report. The Committee prescribed the following TOR in addition to Standard TOR provided at Annexure-1 for preparation of EIA-EMP report :

i. A separate chapter on status of compliance of Environmental Conditions granted by State/Centre to be provided. As per circular dated 30th May, 2012 issued by MoEF, a certified report by Regional Office, MoEF&CC on status of compliance of conditions on existing unit to be provided in EIA-EMP report.
ii. Copy of consent to establish and consent to operate for the existing facilities.

iii. Submit a copy of layout superimposed on the HTL/LTL map demarcated by an authorized agency on 1:4000 scale.
iv. Details of existing and proposed port facilities
v. Layout plan of existing and proposed Greenbelt.
vi. Action plan for drainage system to be included.
vii. Details of air pollution control measures to be taken as well as cost to be incurred.
viii. Total Water consumption and its source. Wastewater management plan.
ix. The impact of dredging and dumping on marine biodiversity shall be evaluated through the National Institute of Oceanography, Dona Paula and a Biodiversity Management plan as advised by them implemented. A copy of the biodiversity Management plan shall be incorporated in the EIA –EMP report."
x. Details of Environmental Monitoring Plan.
xi. Disaster Management Plan for the above terminal.
xii. Status of court case pending against the project.
xiii. Recommendation of the SCZMA.
xiv. A tabular chart with index for point wise compliance of above TORs.
xv. Public hearing to be conducted and issues raised and commitments made by the project proponent on the same should be included in EIA/EMP Report in the form of tabular chart with financial budget for complying with the commitments made.

3. These 'TORs' should be considered for the preparation of EIA / EMP report for Redevelopment of Berths 8, 9 and Barge Berths at the Port of Mormugao, Goa by M/s Mormugao Port Trust in addition to all the relevant information as per the 'General Structure of EIA' given in Appendix III and IIIA in the EIA Notification, 2006. The EIA/EMP as per TORs should be submitted to the **Chairman, Goa Pollution Control Board, (GPCB)** for public consultation. The SPCB shall conduct the public hearing/public consultation as per the provisions of EIA notification, 2006.

4.0 You are requested to kindly submit the final EIA/EMP prepared as per TORs and incorporating all the issues raised during Public Hearing / Public Consultation to the Ministry for considering the proposal for environmental clearance ***within 3 years as per the MoEF O.M. No. J-11013/41/2006-IA.II (I) dated 8th October, 2014.***

5.0 The consultants involved in the preparation of EIA/EMP report after accreditation with Quality Council of India / National Accreditation Board of Education and Training (QCI/NABET) would need to include a certificate in this regard in the EIA/EMP reports prepared by them and data provided by other Organization(s)/Laboratories including their status of approvals etc.

(A.N. Singh)
Scientist 'D'

Copy to:

1) The Chairman, Goa State Pollution Control Board, Dempo Towers, I[st] Floor, EDC Plaza, Patto, Panaji, Goa - 403001.

2) Additional Principal Chief Conservator of Forests (C), Ministry of Environment, Forest and Climate Change, Regional Office (SZ), Kendriya Sadan, 4th Floor, E&F Wings, 17th Main Road, Koramangala II Block, Bangalore – 560034

Annexure-I

STANDARD TERMS OF REFERENCE FOR CONDUCTING ENVIRONMENT IMPACT ASSESSMENT STUDY FOR PORT, HARBOURS INFORMATION TO BE INCLUDED IN EIA/EMP REPORT

i. Reasons for selecting the site with details of alternate sites examined/rejected/selected on merit with comparative statement and reason/basis for selection. The examination should justify site suitability in terms of environmental angle, resources sustainability associated with selected site as compared to rejected sites. The analysis should include parameters considered along with weightage criteria for short-listing selected site.

ii. Details of the land use break-up for the proposed project. Details of land use around 10 km radius of the project site. Examine and submit detail of land use around 10 km radius of the project site and map of the project area and 10 km area from boundary of the proposed/existing project area, delineating project areas notified under the wild life (Protection) Act, 1972/critically polluted areas as identified by the CPCB from time to time/notified eco-sensitive areas/interstate boundaries and international boundaries. Analysis should be made based on latest satellite imagery for land use with raw images.

iii. Submit the present land use and permission required for any conversion such as forest, agriculture etc. land acquisition status, rehabilitation of communities/ villages and present status of such activities.

iv. Examine and submit the water bodies including the seasonal ones within the corridor of impacts along with their status, volumetric capacity, quality likely impacts on them due to the project.

v. Submit a copy of the contour plan with slopes, drainage pattern of the site and surrounding area

vi. Submit the details of terrain, level with respect to MSL, filling required, source of filling materials and transportation details etc.

vii. Examine road/rail connectivity to the project site and impact on the existing traffic network due to the proposed project/activities. A detailed traffic and transportation study should be made for existing and projected passenger and cargo traffic.

viii. Submit details regarding R&R involved in the project

ix. Submit a copy of layout superimposed on the HTL/LTL map demarcated by an authorized agency on 1:4000 scale along with the recommendation of the SCZMA.

x. Submit the status of shore line change at the project site

xi. Details of the layout plan including details of channel, breakwaters, dredging, disposal and reclamation.

xii. Details of handling of each cargo, storage, transport along with spillage control, dust preventive measures.

xiii. Submit the details of fishing activity and likely impacts on the fishing activity due to the project.

xiv. Details of oil spill contingency plan.

xv. Details of bathymetry study.

xvi. Details of ship tranquillity study.

xvii. Examine the details of water requirement, impact on competitive user, treatment details, use of treated waste water. Prepare a water balance chart.

xviii. Details of rainwater harvesting and utilization of rain water.

xix. Examine details of Solid waste generation treatment and its disposal.

xx. Details of desalination plant and the study for outfall and intake.

xxi. Examine baseline environmental quality along with projected incremental load due to the proposed project/activities.

xxii. The air quality monitoring should be carried out according to the notification issued on 16th November, 2009.

xxiii. Examine separately the details for construction and operation phases both for Environmental Management Plan and Environmental Monitoring Plan with cost and parameters.

xxiv. Submit details of a comprehensive Risk Assessment and Disaster Management Plan including emergency evacuation during natural and man-made disasters

xxv. Submit details of the trees to be cut including their species and whether it also involves any protected or endangered species. Measures taken to reduce the number of the trees to be removed should be explained in detail. Submit the details of compensatory plantation. Explore the possibilities of relocating the existing trees.

xxvi. Examine the details of afforestation measures indicating land and financial outlay. Landscape plan, green belts and open spaces may be described. A thick green belt should be planned all around the nearest settlement to mitigate noise and vibrations. The identification of species/ plants should be made based on the botanical studies.

xxvii. A detailed draft EIA/EMP report should be prepared in accordance with the above additional TOR and should be submitted to the Ministry in accordance with the Notification.

xxviii. Any further clarification on carrying out the above studies including anticipated impacts due to the project and mitigative measure, project proponent can refer to the model ToR available on Ministry website "http://moef.nic.in/Manual/Port and harbour".

*****

ANNEXURE -III

National Ambient Air Quality Standards (Unit: μg/m^3)

S. No.	***Pollutants***	***Time Weighted Average***	***Concentration in the Ambient Air***	
			Industrial, Residential, Rural and other area	***Ecologically sensitive area (Notified by Central Government)***
1	*Sulphur Dioxide(SO_2)*	*Annual**	*50*	*20*
		*24 hours***	*80*	*80*
2	*Nitrogen Dioxide (NO_2)*	*Annual**	*40*	*30*
		*24 hours***	*80*	*80*
3	*Particulate Matter (Size less than 10μm), PM_{10}*	*Annual**	*60*	*60*
		*24 hours***	*100*	*100*
4	*Particulate Matter (Size less than 2.5μm), $PM_{2.5}$*	*Annual**	*40*	*40*
		*24 hours***	*60*	*60*
5	*Lead (Pb)*	*Annual**	*0.5*	*0.5*
		*24 hours***	*1.0*	*1.0*
6	*Carbon Monoxide (CO)*	*8 hours***	*2.0*	*2.0*
		*1 hour***	*4.0*	*4.0*
7	*Ozone (O_3)*	*8 hours***	*100*	*100*
		*1 hours***	*180*	*180*
8	*Ammonia (NH_3)*	*Annual**	*100*	*100*
		*24 hours***	*400*	*400*
9	*Benzene (C_6H_6)*	*Annual**	*5.0*	*5.0*
10	*Benzo(a) pyrene (Bap)*	*Annual**	*1.0* ng/m^3	*1.0* ng/m^3
11	*Arsenic (As)*	*Annual**	*6.0* ng/m^3	*6.0* ng/m^3
12	*Nickel (Ni)*	*Annual**	*20* ng/m^3	*20* ng/m^3

Note:

* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at a uniform interval.

** 24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

ANNEXURE- IV

Ambiant Noise Standards

Area Code	*Category of Area*	*Limits in dB(A)Leq*	
		Day time	*Night time*
A.	*Industrial Area*	*75*	*70*
B.	*Commercial Area*	*65*	*55*
C.	*Residential Area*	*55*	*45*
D.	*Silence Zone*	*50*	*40*

Note: 1. Day time 6 A.M. and 9 P.M.

2. Night time is 9 P.M. and 6 A.M.

3. Silence zone is defined as areas upto 100 meters around such premises as hospitals, educational institutions and courts. The silence zones are to be declared by competent authority. Use of vehicular horns, loudspeakers and bursting of crackers shall be banned in these zones.

4. Environment (Protection) Third Amendment Rules, 2000 Gazette notification, Government of India, date 14.2.2000.