EIA STUDY FOR THE DEVELOPMENT OF THE EXISTING PUDUCHERRY MINOR PORT BY CARRYING OUT CAPITAL DREDGING AND CONSTRUCTION OF A PILE SUPPORTED BRIDGE BETWEEN DRAINAGE CHANNEL AND NAVIGATIONAL CHANNEL UNDER "SAGARMALA" SCHEME IN UPPALAM, PUDUCHERRY

PROJECT CODE: 653021819

FOR
PORT DEPARTMENT
GOVERNMENT OF PUDUCHERRY

Thro'
INDIAN INSTITUTE OF TECHNOLOGY
MADRAS

JUNE 2019

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Client	Indian Institute of Technology, Madras.
Project Title	EIA study for the development of the existing Puducherry Minor Port by carrying out capital dredging and construction of a pile supported bridge between drainage channel and navigational channel under "Sagarmala" scheme in Uppalam, Puducherry.
Project Code	653021819

Abstract

The Port Department of Government of Puducherry has proposed to re-commence operation in the Minor Port at Uppalam in Puducherry. The port is one of the well-known minor ports in India. It had successfully handled different types of cargoes like Fertilizers, Iron Scrap, Carbon black feed oil, Wheat, Molasses, Fluorspar, Cement, Sugar, Palm olein, Timber log etc. during the years from 1993 to 2006.

After 2006, the port and its navigational channel could not be properly maintained due to financial constraints. The navigational channel then got silted up heavily. Now the Port Department is planning to re-establish the past status of the Puducherry Port by improving and developing the existing port. The Port Department with funds under *Sagarmala* from Government of India aims for a complete up-gradation of the existing Minor Port as all-weather Port.

The proposed activities are: *i) capital dredging in the port basin and in navigational channel, ii) disposal of dredged sediments having sand fractions on the northern side of the shoreline for beach stabilization and clay type sediments at offshore in open sea and iii) construction of a pile supported bridge cum walkway across the drainage channel to prevent solid waste disposal into the port waters.*

The objective of this report is to prepare an Environmental Impact Assessment (EIA) for the proposed project in order to seek for Statutory Clearances. This report presents the details of the EIA and EMP studies including impact assessment, mitigation measures, EMP and post project monitoring.

The proposed activities are classified as Category 'A' project as per EIA notification 2006. This necessitates environment clearance from MoEFCC.

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				Figures	17

Declaration by Experts contributing to the EIA

I, here by, certify that I was a part of the EIA team in the following capacity that developed the above EIA.

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Declaration by the Head of the Accredited Consultant Organization/authorized person

I, Dr. P. Chandramohan, hereby, confirm that the above mentioned experts were involved in preparation of this EIA report entitled *"EIA study for the development of the existing Puducherry Minor Port by carrying out capital dredging and construction of a pile supported bridge between drainage channel and navigational channel under "Sagarmala" scheme in Uppalam, Puducherry"*. I also confirm that the EC has gone through the report and the consultant organization shall be fully accountable for any misleading information mentioned in this statement.

It is certified that NO ethical plagiarism have been carried out and external data/ text has not been used without proper acknowledgement, while preparing this EIA report.

Signature	:	
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NABET Certificate No. & Issue Date	:	NABET/EIA/1720/RA 0082 & 05.01.18 Sectors: 27 & 33

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1. INTRODUCTION

The Port Department of Government of Puducherry is planning to re-commence operation in the Puducherry Minor Port situated in Uppalam at Puducherry. The port has not been in operation since 2006 due to lack of suitable draft and adequate width in the harbour basin and navigational channel due to continuous siltation.

Puducherry New Port is a Minor Port with general cargo handling facilities which was constructed between 1986 and 1993. Potential of siltation at Ariyankuppam River mouth was identified at the port planning stage itself. In order to stabilize the river mouth to facilitate the safe navigational depth, one north breakwater; one south breakwater connected with trestle and a sand trap with submarine tunnel between south and north breakwaters were constructed. Maintenance dredging was also recommended to keep the port operational. The Old Port was in operation from 1962 and the New Port from 1993 to 2006 handling different types of cargoes like Fertilizers, Iron Scrap, Carbon black feed oil, Wheat, Molasses, Fluorspar, Cement, Sugar, Palm olein, Timber log etc.

Continuous deposition of sand/ silt and non-maintenance of navigational channel at entrance together made the port non-operational. For the past 9 years, the existing port facilities are idling without generating revenue. On the otherhand, the dredging required to keep safe navigational depth for Thengaithittu fishing vessels is being continuously done by Port Department.

The Port Department aims to utilise the funds sanctioned under Sagarmala from the Union Government of India for a complete up-gradation of the existing Minor Port as all-weather Port. As part of its first Phase, Port Department of Puducherry has appointed IITM to explore the possibilities of sustainable re-commencement of Minor Port by considering difficulties such as siltation, shoreline changes, wave dynamics, dredging and dredge disposal. Accordingly, IITM has prepared the Detailed Project Report on 'Development of Minor Port at Pondicherry' with various modelling studies and recommendations.

IIT has proposed the following: i) capital dredging in the port basin and navigational channel, ii) disposal of dredged sediments having sand fractions on the northern side of the shoreline for beach stabilization and clay type sediments at offshore in open sea and iii) construction of a pile supported bridge cum walkway across the drainage channel to prevent solid waste disposal into the port waters.

The proposed re-commencement of port by carrying out dredging attracts both EIA Notification, 2006 and CRZ Notification, 2011. Therefore, the proposed project requires both Environmental Clearance from Ministry of Environment, Forest and Climate Change (MoEFCC) and CRZ clearance from Puducherry Coastal Zone Management Authority (PCZMA) and MoEFCC.

The project falls under activity 7(e) 'Ports & Harbors' and categorized as category B (handling capacity <5 MTPA) as per schedule of EIA Notification, 2006. However as per EIA Notification, 2006 according to the General Conditions, the project falls under the inter-state boundaries (Tamil Nadu and Puducherry) will be treated as category A. Based on the online EC application and presentation made before the Expert Appraisal Committee (EAC), the ToR has been received from MoEFCC on 19th February 2019.

In order to meet this statutory requirement, Environmental Impact Assessment Study on Development of Minor Port by carrying out dredging under Sagarmala Scheme has been carried out by Indomer Coastal Hydraulics (P) Ltd., Chennai which is an ISO 9001:2015 organization and NABET - QCI accredited organization vide NABET/EIA/1720/RA 0082 & 05.01.18 for the Sector 27: Oil & Gas Transportation pipeline (crude and refinery/ petrochemical products), passing through national parks/ sanctuaries/ coral reefs/ ecologically sensitive areas including LNG Terminal and Sector 33: Ports, harbours, jetties, marine terminals, breakwaters and dredging and NABL accredited organization. The copy of the accreditation is presented in Chapter 10.

Field studies were undertaken in March 2019. This report presents the details of EIA and EMP studies carried out for the proposed development of Minor Port for the Port Department, Government of Puducherry.

1.1. Purpose of the report

Re-commencement of operation in existing minor port attracts both EIA Notification 2006 and Coastal Regulation Zone Notification 2011.

In accordance with CRZ Notification 2011, Section 1 (i) & (ii) and its subsequent amendments, setting up/expansion of any industry, operations or processes and manufacture or handling within 500 m on the landward side along the sea front from the High Tide Line (HTL) and land area between HTL to 100 m or width of the creek whichever is less on the landward side along the tidal influenced water bodies that are connected to the sea and the distance up to which salinity concentration of 5 parts per thousand (ppt) measured during the driest period of the year requires prior CRZ clearance before commencing onsite activities.

The proposed development falls in CRZ I A, CRZ I B, CRZ II, CRZ IV A, CRZ IV B and are permissible activities as per CRZ Notification 2011.

As per Environment Impact Assessment Notification dated 14th September 2006, new projects or activities, or the expansion or modernization of existing projects proposed in any part of India shall obtain prior environmental clearance from Ministry of Environment Forests and Climate Change (MoEFCC)/State Environment Impact Assessment Authority (SEIAA).

EIA studies and report preparation have been done following the provisions of EIA Notification September 2006 as amended and CRZ Notification, 2011 as amended.

The scope of the EIA study broadly includes following:

i) Environmental baseline data collection: Primary baseline data collection through field surveys and monitoring with respect to terrestrial (air, noise, water, soil) and marine environment (seawater, seabed sediment, sub tidal and intertidal benthos, ecology and biodiversity) attributes and socioeconomics in the study area. In addition, collection of secondary baseline information from government agencies.

ii) Prediction and Identification of environmental impacts of the proposed project followed by evaluation of significance of the predicted impacts and their mitigation measures;

iii) Risk assessment and Disaster Management Plan; and Corporate Environment Responsibility (CER)

iv) Formulation of Environment Management Plan (EMP) and suggest environment monitoring requirements for effective implementation of EMP.

All calendar dates are referred in Indian style as dd.mm.yy. (eg. 27.04.19 for 27th April 2019) and the time is referred to Indian Standard Time in 24 hour clock, eg. 3 p.m. is written as 1500 hrs. The WGS 84 spheroid in Zone 44 is followed for surveys and for the presentation in this report. SI units are followed for fundamental and derived units. The depths are referred with respect to Chart Datum (CD). This report has been organized as per the standard norms outlined by MoEFCC Notification issued on 14th September 2006.

1.2. Identification of Project and Project Proponent

Identification of Project and Proposed Activities

Puducherry Old Port was constructed in 1962 and the Puducherry New Port was developed between 1986 and 1993 with cargo handling capacity of 0.4 MTPA. The port was in operation for 13 years since its construction from 1993 to 2006. Afterwards, due to litigations and regular maintenance of the port by carrying out recommended maintenance dredging was not done and the Ariyankuppam River mouth got silted up. The port is non - operational (from 2006 to 2018) for the last 12 years without generating any income.

Now, Port Department, Government of Puducherry proposes to revive the existing minor port under Sagarmala Scheme by carrying out capital dredging. Project in brief includes the following four activities:

- Capital dredging of 0.73 million m^3 and maintenance dredging of 0.15 million m^3 per year,
- Stabilization of shoreline by disposal of sediments of sand fractions of the dredge spoil in the northern shoreline of Ariyankuppam River (i.e.) north of northern breakwater,
- Disposal of clay type fine sediments of dredged material at identified spot at offshore in open sea, and
- Construction of piled bridge cum walkway to prevent solid waste draining into the port channel.

Project Proponent

Puducherry Port is one of the minor ports of India situated in Uppalam at Puducherry District. The port was once a centre of international trade of commerce and lost it prominence at the end of French era.

Port Department, Government of Puducherry aims to re-commence the past status of the Puducherry Port by improving and developing the existing port .

1.3. Brief description of project

Project Location: Puducherry Minor Port is located at Latitude: 11° 55' 1.47" N and Longitude: 79° 49' 28.12" E in Re-Survey No. 402, Uppalam village, Puducherry about 2 Km upstream from the Ariyankuppam River mouth. Location map of project site is shown in Fig. 1.1.

Nature of Project: Re-commencement of existing minor port by carrying out capital and maintenance dredging and construction of piled bridge between drainage channel and navigational channel.

Size of Project: Proposed capital dredging of 0.73 million m^3 and maintenance dredging of 0.15 million m^3 per year and the total handling capacity of the port will be 0.4 MTPA.

1.4. Terms of Reference (ToR)

Proposed re-commencement of minor port falls under project 7(e) "Ports & Harbours", and categorized as category B (handling capacity <5 MTPA) as per schedule of EIA Notification, 2006. However, as per EIA Notification, 2006 according to the General Conditions, the project falls under the inter-state boundaries (Tamil Nadu and Puducherry) will be treated as category A.

Port Department, Government of Puducherry has to obtain Environmental Clearance (EC) and Coastal Regulation Zone (CRZ) from MoEFCC and PCZMA. Accordingly, Port Department, Government of Puducherry has presented the details of project to the Expert Appraisal Committee of Infrastructure Development and Miscellaneous Projects for the grant of ToR in its 38th meeting held on 06 - 08 February 2019.

As per the recommendation of the EAC, Ministry of Environment Forest and Climate Change has issued the ToR vide letter No. F. No. 10-8/2019-1A-III dated 19th February 2019 for the preparation of the Environmental Impact Assessment (EIA) report and Environmental Management Plan (EMP). The ToR and the compliance conditions therein are tabulated below:

ToR No	ToR	Reference
1	Importance and benefits of the project.	The details regarding benefits of the project are presented in Chapter 7, Page 7.1.
2	Submit a copy of layout superimposed on the HTL/LTL map demarcated by an authorized agency on 1:4000 scale.	The layout superimposed on the HTL/LTL map demarcated by IRS, Anna University, Chennai is given separately. The extract of the copy of the map is shown in Fig. 1.2. of this report.
3	Recommendation of the SCZMA.	The application for SCZMA is being made.

ToR No	ToR	Reference
4	Submit superimposing of latest CZMP as per CRZ (2011) on the CRZ map.	The layout superimposed on the HTL/LTL map demarcated by IRS, Anna University, Chennai is given separately. The extract of the copy of the map is shown in Fig. 1.2. of this report.
5	Submit a complete set of documents required as per para 4.2 (i) of CRZ Notification, 2011.	Presented in Annexure II.
6	Hydrodynamics study on impact of jetty/dredging on flow characteristics.	Detailed Modelling studies on Hydrodynamic study was made by IIT separately. The report is presented in Annexure III.
7	Flooding and related impact on creek and control area during the cyclonic storm should be studied.	The impact due to flooding and cyclone are presented in Chapter 6, Section 6.2, Page 6.1 to 6.7.
8	Ship navigational studies for the entrance channel should be carried out.	Ship navigational study was prepared by IIT. The report is presented in Annexure IV.
9	The project proponents shall satisfactorily address to all the complaints/suggestions that have been received against the project till the date of submission of proposals for Appraisal.	All the complaints/ suggestion will be incorporated in the final EIA report.
10	Various Dock and shipbuilding facilities with capacities for existing and proposed project.	No dock and shipbuilding facilities are proposed. The proposed activities are presented in Chapter 2, Section 2.4, Page 2.3 to 2.5.
11	The EIA would give a detailed analysis of the Impacts of storage and handling and the management plan of each cargo type along with the proposed compliance to the Hazardous Chemicals Storage rules.	The details are presented in Chapter 4, Section 4.2.1, Page 4.1 to 4.5.
12	Study the impact of dredging on the shoreline and protection of northern coast by beach nourishment.	The details are presented in Chapter 4, Section 4.2.2, Page 4.10.

ToR No	ToR	Reference
13	Study the impact of dredging and dumping on marine ecology and draw up a management plan through the NIO or any other institute specializing in marine ecology.	The impact of dredging and dumping on marine ecology and Management plan are presented in Chapter 4, Section 4.2.2., Page 4.7 to 4.10 and Chapter 8, Section 8.2.2, Page 8.8.
14	A detailed analysis of the physico-chemical and biotic components in the highly turbid waters round the project site (as exhibited in the Google map shown during the presentation), compare it with the physico-chemical and biotic components in the adjacent clearer (blue) waters both in terms of baseline and impact assessment and draw up a management plan.	Sampling programme was planned in such a way to understand the turbid waters at nearshore and the blue water at offshore. Comparative analysis is presented in Chapter 3, section 3.2.2.1, Page 3.21.
15	Details of Emission, effluents, solid waste and hazardous waste generation and their management in the existing and proposed facilities.	The details are presented in Chapter 4, section 4.2.1, Page 4.1 to 4.5.
16	Requirement of water, power, with source of supply, status of approval, water balance diagram, man-power requirement (regular and contract).	The details are presented in Chapter 2, Section 2.7, Page 2.6. Water balance diagram is presented in Chapter 4, Section 4.2.1, Page 4.3.
17	Permission from CGWA in case of groundwater use being proposed for the project.	No groundwater will be drawn during construction and operational phase.
18	Wastewater Management Plan.	The details are presented in Chapter 8, Section 8.2, Page 8.6 and 8.7.
19	Details of Environmental Monitoring Plan.	The Environment Monitoring Plan is presented in Chapter 5, Page 5.1.
20	To prepare a detailed biodiversity impact assessment report and management plan through the NIO or any other institute of repute on marine, brackish water and freshwater ecology and biodiversity. The report shall study the impact on the rivers, estuary and the sea and -include the intertidal biotopes, corals and coral communities, molluscs, sea	The marine, brackish water and fresh water ecology and biodiversity and impact on the rivers, estuary and the sea and

ToR No	ToR	Reference
	grasses, sea weeds, subtidal habitats, fishes, other marine and aquatic micro, macro and mega flora and fauna including benthos, plankton, turtles, birds etc. as also the productivity. The data collection and impact assessment shall be as per standard survey methods.	including the intertidal biotopes, corals and coral communities, molluscs, sea grasses, sea weeds, subtidal habitats, fishes, other marine and aquatic micro, macro and mega flora and fauna including benthos, plankton, turtles, birds, productivity etc. are studied by the reputed marine biologist of retired scientists from NIO by Indomer, the organization by the scientists on CSIR-NIO Technology promotion scheme. The details are presented in Chapter 3, Section 3.2.4, Page 3.21 to 3.33. The impacts on the marine organisms are given in Chapter 4, Section 4.2.2, Page 4.6 to 4.14.
21	A certificate from the competent authority for discharging treated effluent/ untreated effluents into the Public sewer/ disposal/drainage systems along with the final disposal point.	Certificate is presented in Annexure V.
22	A certificate from the local body supplying water, specifying the total annual water availability with the local authority, the quantity of water already committed, the quantity of water allotted to the project under consideration and the balance water available. This should be specified separately for - ground water and surface water sources, ensuring that there is no impact on other users.	Certificate is presented in Annexure VI.
23	A certificate of adequacy of available power from the agency supplying power to the project along with the load allowed for the project.	Certificate is presented in Annexure VII.
24	A certificate from the competent authority handling municipal solid wastes, indicating the existing civic capacities of handling and their adequacy to cater to the M.S.W. generated from project.	Certificate is presented in Annexure VIII.
25	The Air Quality Index shall be calculated for base level air quality	AQI has found to be in satisfactory level. It is

ToR No	ToR	Reference
		presented in Chapter 3, Section 3.1, Page 3.5.
26	The EIA would study the impact of dewatering and draw up an action plan for disposal of the excess water	No dewatering activity is proposed.
27	The EIA would study the impact of Demolition and conformance to the Construction and Demolition Rules under the E.P. Act 1986.	No demolition work is envisaged.
28	An assessment of the cumulative impact of all development and increased inhabitation being carried out or proposed to be carried out by the project or other agencies in the core area, shall be made for traffic densities and parking capabilities in a 05 kms radius from the site. A detailed traffic management and a traffic decongestion plan drawn up through an organization of repute and specializing in Transport Planning shall be submitted with the EIA. The Plan to be implemented to the satisfaction of the State Urban Development and Transport Departments shall also include the consent of all the concerned implementing agencies.	Traffic Management Plan is presented in Chapter 8, Section 8.2, Page 8.8.
29	Disaster Management Plan for the above terminal.	Disaster Management Plan is presented in Chapter, Section 6.2, Page 6.1 to 6.7.
30	Layout plan of existing and proposed Greenbelt.	Layout of proposed greenbelt development is shown in Fig. 8.1.
31	Status of court case pending against the project.	No court case against this project.
32	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.	Application for public hearing is being made.
33	Plan for Corporate Environment Responsibility (CER) as specified under Ministry's Office Memorandum vide F.No. 22-65/2017-IA.III dated 1st May 2018 shall be prepared and submitted along with EIA Report.	Details about CER is presented in Chapter 7, Section 7.2, Page 7.1 to 7.2.
34	A tabular chart with index for point wise compliance of above ToRs.	referred and complied

1.5. CRZ classification

The demarcation of High Tide Line (HTL), Low Tide Line (LTL) and Coastal Regulation Zone (CRZ) for the proposed activities was awarded to Institute of Remote Sensing (IRS), Anna University, Chennai which is an approved agency/institution by MoEFCC. The CRZ report *'Demarcation of High Tide Line (HTL), Low Tide Line (LTL) and CRZ map for the project site at Thengaithittu village, Ariyankuppam Commune, Puducherry'* has been submitted separately. The extract copy of demarcation of High Tide Line (HTL), Low Tide Line (LTL) and Coastal Regulation Zone (CRZ) for

the proposed activities are shown in Fig. 1.2. According to the CRZ map the proposed development falls under:

i) CRZ I A – Ecologically Sensitive Areas.
ii) CRZ I B – Between HTL and LTL.
iii) CRZ II – Developed Areas.
iv) CRZ IV A – Between LTL and 12 Nautical Miles into sea.
v) CRZ IV B - Water area of the tidal influenced water body from the mouth of the water body at the sea upto the influence of tide which is measured as five parts per thousand during the driest season of the year.

2. PROJECT DESCRIPTION

2.1. Type of project

Port Department, Government of Puducherry proposes to re-commence the minor port at Ariyankuppam River by carrying out i) capital dredging in the port basin and in navigational channel, ii) disposal of dredged sediments having sand fractions on the northern side of the shoreline for beach stabilization and clay type sediments in open sea and iii) construction of a pile supported bridge cum walkway across the drainage channel to prevent solid waste disposal into the port waters.

2.2. Need of the project

Puducherry Port is one of the minor ports in India, it was in operation from 1993 to 2006 and also during the French Era. The minor port has shore connected north breakwater of length 150 m and south breakwater of length 250 m which is not shore connected and has trestle of dimensions 250 m x 7 m.

Since 2006 over the years the sand accretion worsened on the south of the south breakwater. It may also be noted that the south breakwater is not shore connected and there is a piled structure constructed to allow sand to settle in the sand trap inside the basin. Since there was no dredging and pumping operation, the sand overflowed the sand trap and started filling up the harbour basin north of the south breakwater. Subsequently the accretion of the sand on the south of the south breakwater started bypassing the structure and entering the approach channel and gradually sand started entering the harbour basin also. The port was not in operation due to the loss of draft to meagre 1-2 m and any navigational activities requires a minimum depth of 3-4 m and also because of the regular maintenance dredging was not carried out and the mouth got silted up. There is no income generation from the minor port for the past 12 years.

Chennai Port one of the major ports in India, is located around 140 km north of Puducherry, now Chennai Port is attaining its full handling capacity. Cargoes manufacturing firms moving their products between Chennai and Puducherry are expected to shift the transportation from road to sea. Therefore, Puducherry is expected to emerge as a satellite port to Chennai, it will ease congestion on roads caused by containers originating from the Chennai Port.

The cargoes generated from Puducherry hinterland will be transported through sea to Chennai Port for shipping to overseas destinations through mainline and feeder vessels and similarly, the import cargo destined for Puducherry hinterland will be unloaded at Chennai Port and will be moved in small coastal vessels to the Puducherry Port, thus reducing logistic costs, besides easing road congestion.

Due to the activities planned to handle cargoes sufficient depth has to be maintained for the draft. Dredging will be required in order to provide a suitable depth of water both in the approach channel and the area within the breakwaters. The proposed re-commencement of all-weather Puducherry Minor Port will bring the direct and indirect employment opportunities to the local peoples and also helps to improve the economic growth of the Puducherry government. There will be an increasing requirement from the existing and new customers associated with importing and exporting activities. This necessitated to tap the business in the region. Further,

since both the commercial port and fishing harbour share a common entrance to the sea, fishermen community would also benefit due to round the clock navigation facility.

Beach nourishment on the northern side of the north breakwater will attract the tourist which will also generate employment opportunities. The construction of piled bridge cum walkway is used to access the other end of the port area and also stops the discharge of sewage into the port waters, this will helps to improve the ecological and biological environment in the port waters.

2.3. Project Location

The proposed re-commencement of minor port in Re-survey no. 402, Uppalam at Puducherry is located 2 km upstream of backwaters of Ariyankuppam. The minor port is situated along the east coast of India between two major ports i.e., Chennai Port and Tuticorin V.O.C Port. It was suitable for Lighterage operations during fair weather (February to September). The satellite imagery of the project region is shown in Fig. 2.1.

Puducherry is a historical seaport city located along the Coromandel Coast. It was the capital of former *French India* colony, though it was also held at times by the Dutch and British. After the independence of India in 1947, France relinquished Puducherry in 1954, and it then came under the central administration of the Republic of India. In 1962 Puducherry had become part of the *Union Territory of Puducherry*. The waterfront of the port lies north of Ariyankuppam natural drainage channel and south of the old port jetty. The Ariyankuppam channel serves as the common entrance to the fishing harbour located at Ariyankuppam village.

The proposed project location is well connected by road and rail. The National Highway NH45A is passing in southwest at a distance of approximately 1.5 km from project location. The nearest railway station is Puducherry, which is at a distance of 1 km north and the nearest international airport is Chennai located at 125 km northeast from the project site. Nainar Mandapam and Vambakeerapalayam are the nearest habitations located at a distance of less than 3 km from the proposed project site. The location of an existing port is shown in Fig. 2.2.

Puducherry fishing harbour is located straight ahead of the entrance from the river mouth and at a distance of 700 m. The fishing harbour has its own berth and its associated infrastructure facilities. The existing channel to fishing harbour is periodically maintained to have suitable draft.

The proposed project location is located in a typical morphological setup with Ariyankuppam River mouth on the southern side and eroding shoreline on the northern side. The Ariyankuppam River mouth serves as an entrance to the fishing harbour and also drains large amount of fresh water during the rainy season in northeast monsoon. Due to human interference, the coastline on the northern side abutting the Puducherry town, undergoing continuous erosion. The seawall has been built along 7 km long stretch from the northern bank of Ariyankuppam River. Several important Government buildings and historical monuments exist along this eroding stretch of this coastline. The coastline on the southern side of the Ariyankuppam River remains nearly stable, but some small accretions were reported over a stretch of 2 km.

This coastal region is composed of fine sand and silt brought by the rivers over the geological years. The coastal region is drained by Malattar River, Kuduvalyar River and Ariyankuppam River at south. The brackish water lakes like Kaliveli tank and Marakkanam reservoir are present at north. The legendary Buckingham Canal of east coast starts its course from Puducherry at south.

The typical form of southern part of east coast comprises with rocky shores with high waves at Gulf of Mannar, low alluvial coastline with calm sea and offshore islands at Palk Bay, which is protected by Srilankan Island and then the open coastline exposed to direct waves from the Bay of Bengal. This open coastline exposed directly to Bay of Bengal starts at Puducherry and continues till Sundarbans. The continental shelf off Puducherry is very narrow less than 15 km and takes a steep turn from north-south to northeast-southwest. Therefore, the wave activity which remains relatively low at 50 km south becomes active from Puducherry. The inland remains relatively elevated with defined foreshore and backshore. The inland rises more than 5 m above HTL at 1 km distance and are mostly fertile used for agriculture. Due to manmade encroachment the shorefront along the Puducherry town is exposed to erosion and the sea walls built along the coast migrates the place of erosion further north. The volume of littoral drift is relatively less compared to Chennai at north, but remains large compared to Nagapattinam at south.

The project region is influenced by 3 climatic conditions, viz., fair weather period from February to May, southwest monsoon from June to September, northeast monsoon from October to January. This part of the coast is more influenced during northeast monsoon compared to southwest monsoon.

The proposed project falls under Seismic Zone II as per NDMA earthquake zone map. No ecologically sensitive areas viz., marine national parks, marine sanctuaries, wetlands, sensitive flora and fauna falls under the study area of 10 km from the project site.

Details of connectivity and salient features of the project site and surrounding area are presented below.

Particulars	Details
Approx. Geographic location boundaries	Latitude: 11° 56' 1.47" N Longitude: 79° 50' 28.12" E
Administrative location	Re-Survey No. 402, Uppalam, Puducherry District, Puducherry
Current land use	Project site - Vacant land with small build up area, surrounding area – Built up area
Nearest Town	Puducherry ~ 3 km NW of project site
Rivers/Streams/Creek	Ariyankuppam River adjacent to port Chunnambar River ~ 4.3 km S
Nearest Highway	National Highway (NH) 45A ~ 1.5 km (SW)
Nearest Railway station	Puducherry~ 1 km (N)
Nearest International Airport	Chennai Airport ~ 125 km (NE)
Protected areas (National parks/ sanctuaries)	Oussudu wildlife sanctuary ~ 9.6 km (NW)
Sites of Historical/ Archaeological importance	Arikamedu ~ 1.9 km (S)
Seismic Zone	Zone II (IS 1893: 2002)

**all distances are measured as aerial distance*

2.4. Project Description

The proposed facility is a barge loading/ unloading including utilization of existing cargo berth by dredging of the harbour basin and navigational channel to the required depth of (-) 5.0 m, except at the submarine tunnel where the depth shall be (-) 4.0 m. The existing cargo berth will

handle about 0.4 MTPA of general/ liquid cargo. The mother vessel will be 60000 DWT for mid sea operations and 3000 DWT barges for loading/ unloading. The offshore anchorage will be at (-) 15.00 m depth at the distance of 3175 m from the shoreline. The proposed activities of the project region are shown in Fig. 2.3.

Vessel specification

Vessel type	LOA (m)	Draft (m)
Mother ship (60,000 DWT)	245	12
Barge (3000 DWT)	70	3.5

Utility services for existing berth

The details about the utility services are explained in DPR prepared by IITM. Container handling can be described as a system that links two external processes

- Quayside process: water based transport
- Landside process hinterland transport (including inland waterways)

The traffic functions required at both interfaces are as follows:

- Loading and unloading of containers to and from vessels,
- Storage for containers,
- Verification of container information,
- Checking or recording of container damage,
- Verification of container content, and
- Providing supporting services

Container handling infrastructure

A number of infrastructures are essential to a container handling are:

i. Quay wall,
ii. Apron,
iii. Storage area,
iv. Landside traffic system and
v. Buildings

Container handling equipment

i. Mobile Harbour Crane (MHC)
ii. Reach stacker

Cargo handling

Loading/unloading of cargo will be done as per standard operating procedures, and in compliance with the international regulations as specified in International Safety Guide. The cumulative cargo handling capacity of the port will be about 0.4 MTPA. The cargo handling details of the proposed berth is as below:

Proposed cargo handling facilities

Sl. No.	Products	Cargo Handling (TPA)
1	Dry bulk cargo like sand, food grains, pulses, fertilizer, etc.	1,28,000
2	Liquid bulk cargo like molasses, edible and non-edible oil, etc.	90,000
3	General Cargo (break bulk cargo) like cement, sugar, timber, etc.	50,000
4	Container cargo	1,32,000
	Total	4,00,000

Drainage barrier cum walkway

The solid waste from drainage are getting deposited in the navigational channel and directly affecting the draft of the navigational channel. In order to maintain the draft, drainage barrier will be constructed to block the solid waste draining into the channel. The drainage barrier will be constructed such a way to act as walkway for the access the other end.

2.5. Resource Requirements

Power requirement: During operation phase the electricity requirement will meet out through power supply by Puducherry Electricity Board. The power required at the port for the following activities:

- Operation of berths,
- Lighting of the port area,
- Offices and transit sheds,
- Utility buildings, and
- Miscellaneous

The power requirement for the proposed activities is around 300 kVA. Besides, the port has one Transformer of 315 kVA with HT power supply to meet with emergency needs.

Water Requirement: Good water facilities should be provided in the terminal. The policy of the government of Puducherry is to promote less water intensive industries. Total water demand is broadly classified in the following categories:

- Potable water for consumption of port personnel,
- Potable water for vessels calling at this port,
- Water for dust suppression,
- Water for firefighting, and
- Other uses like gardening etc.

The water required for the proposed activity is 15 KLD which will be met from the PWD/ water suppliers. Desalination and recycling techniques of wastewater will be encouraged for future needs.

Manpower Requirement: The total manpower for the proposed activities is about 200 personnel. About 100 people will be temporarily engaged during construction phase; local people will be preferred based on the skill set requirement. During the operation phase about 100 personnel will be employed.

Dredge disposal: The estimated quantity for capital dredging will be 0.73 million m^3 and maintenance will be 0.15 million m^3 per year. The dredged sediments having sand fractions will be deposited on the northern side of the shoreline for shore stabilization and the clay type sediments will be disposed offshore in open sea at a designated dredge disposal location as shown in Fig. 2.3. The depth of about 20 m CD is selected for the disposal location to ensure the proper spread of dredge spoil. TSHD/ cutter section/ any other suitable dredging methodology will be utilized to carry out the dredge disposal work.

Waste Disposal: The hazardous waste generation consists of used or spent oil, discarded containers etc. Generally, oily waste is stored in closed containers and given to approved recyclers. The practice of solid and hazardous waste management as per Solid Waste Management Rules, 2016 and Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 will be followed in the proposed activities.

2.6. Project Cost and Implementation schedule

The estimated cost of the project is Rs. 44 Crore. The project implementation schedule has been prepared for the port development. The schedule is prepared taking into account all the items of the project, the various activity and duration of each activity involved. However, the complete port development is expected to take about 12 months as per the DPR prepared by IITM:

Implementation schedule

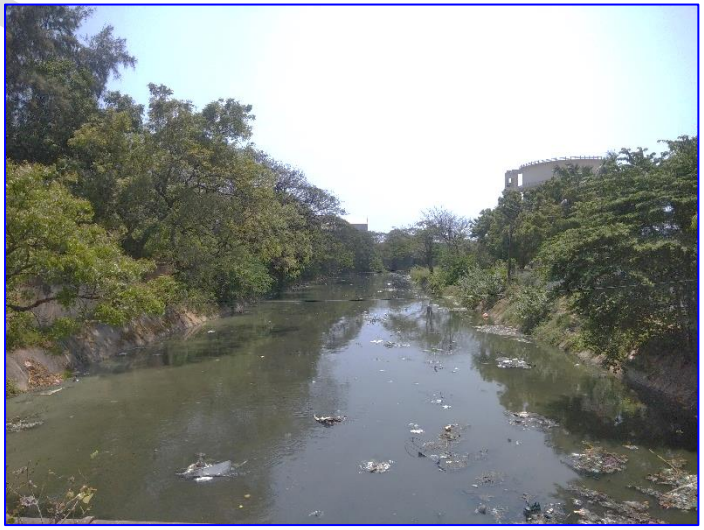
Construction sequence	1	2	3	4	5	6	7	8	9	10	11	12
All activities	12 months											
Construction of drainage barrier												
Capital dredging												

Gallery

Existing port berth facilities

Existing storage area

Mangroves on the opposite side of Port



Drainage channel entering into port waters

Ariyankuppam River mouth

Puducherry fishing harbour

Seawalls near the project region

Southern breakwater

3. DESCRIPTION OF ENVIRONMENT

This chapter covers the description of baseline environmental status of the study area with respect to prominent environment attributes. The study area covers 10 km radius from the proposed project. The baseline data collection for Terrestrial and Marine environment parameters has been collected during fair weather (March 2019).

3.1. Terrestrial environment

The baseline data collection has been done for assessing ambient air quality, ambient noise level, surface water quality, ground water quality, soil quality, ecology, and socio-economic status in terrestrial environment. The parameters were analyzed by Indomer in-house laboratory, Chennai, which is accredited by National Accreditation Board for Testing and Calibration Laboratories (NABL).

3.1.1. Air environment

3.1.1.1. Selection of monitoring stations

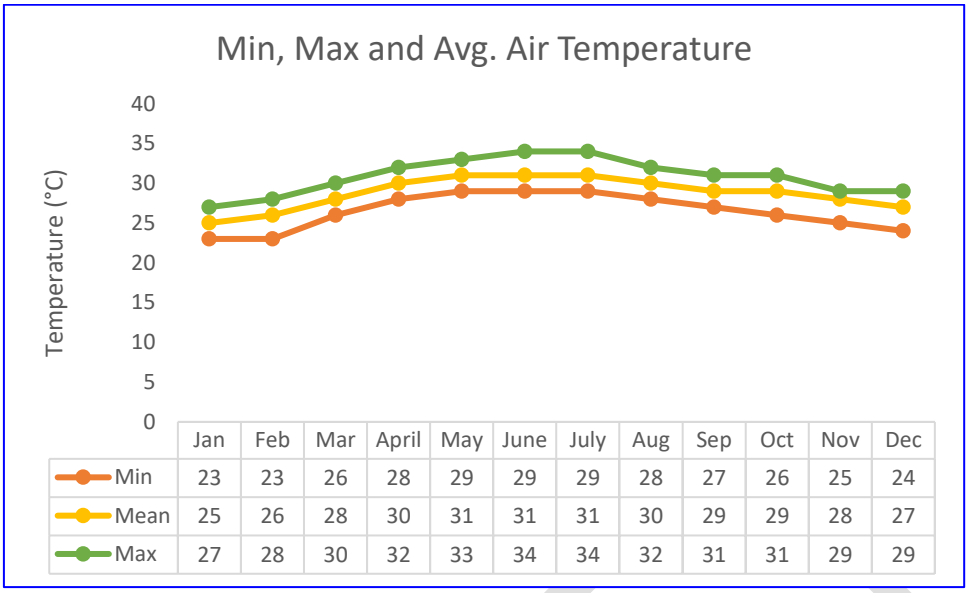
The baseline status of the ambient air quality has been assessed through a scientifically designed monitoring network based on following considerations on:

i) Meteorological conditions on synoptic basis covering the upwind and downwind directions in monitoring seasons,
ii) Topography of the study area,
iii) Human settlements,
iv) Representatives of regional background air quality for obtaining baseline status,
v) Representatives of likely impact areas covering 10 km radius from the project site, and
vi) Micro-meteorology of the site.
vii) Availability of the power connection and roof top of appropriate house.

Accordingly, two monitoring location are selected in the downwind direction and two in upwind direction. The sampling points are well distributed around the project site and appropriate parameters are monitored. The AAQ monitoring stations are given in Table 3.1 and station locations are shown in Fig. 3.1.

Micro meteorology

Air Temperature: Based on the secondary data available in the world weather online, the Variation in maximum temperature are observed throughout the year in 2018, as it ranges from 23°C to 34°C. The minimum temperatures varied from 23°C to 29°C. April to June is the hottest period of the year, with a mean maximum temperature of about 31°C recorded. January is the coldest month, with minimum temperature of about 23°C.

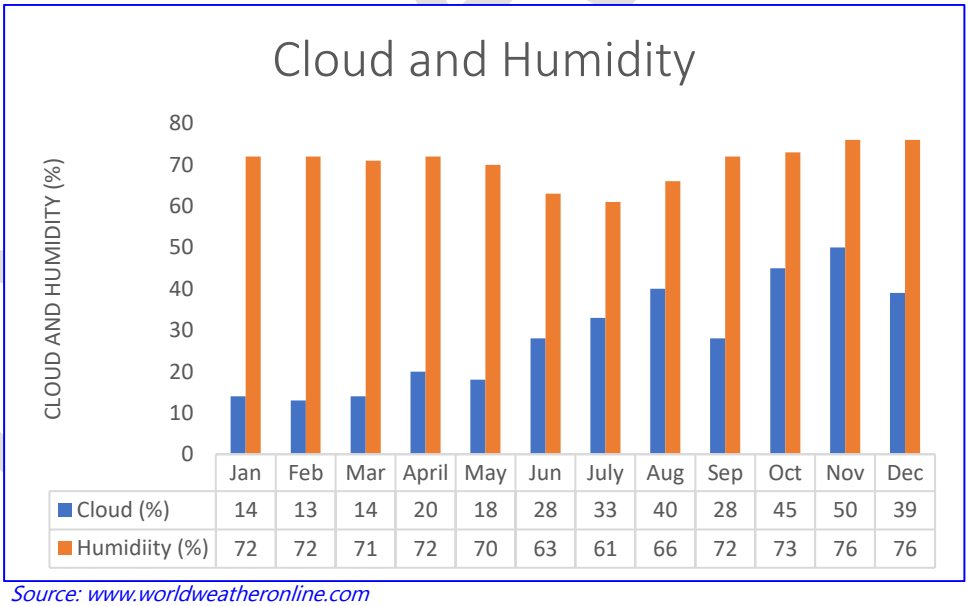


	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Min	23	23	26	28	29	29	29	28	27	26	25	24
Mean	25	26	28	30	31	31	31	30	29	29	28	27
Max	27	28	30	32	33	34	34	32	31	31	29	29

Source: www.worldweatheronline.com

Maximum, Minimum and Average temperature of Puducherry during 2018

Cloud cover and Humidity: Based on the secondary data available in the world weather online, the monthly variations of average cloud cover and humidity are shown below. During the northeast monsoon, substantially high cloud formation is seen. During the months of October, November and December cloud of greater than 39% was seen in the year 2018. Clear sky is seen from January to June and September. The average humidity is in the range 60 to 80% throughout the year. Humidity is more during NE monsoon compared to other seasons.



	Jan	Feb	Mar	April	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Cloud (%)	14	13	14	20	18	28	33	40	28	45	50	39
Humidiity (%)	72	72	71	72	70	63	61	66	72	73	76	76

Source: www.worldweatheronline.com

Average cloud cover and humidity of Puducherry during 2018

Rainfall: Based on the secondary data available in IMD, the total annual average rainfall in the Puducherry for the last five years is 1338 mm. Compared to the rainfall received in the year of 2015 (2138 mm), the amount of rainfall has reduced in 2016. Majority of the rainfall is received during southwest and Northeast monsoon in the month of June - December. Rainfall is practically nil in the month of February to April.

The rainfall details of Puducherry for the last five years are given below,

Month	Year (mm)				
	2013	2014	2015	2016	2017
January	0.0	0.5	19.1	0.6	105.9
February	3.5	27.5	0.2	0.0	0.0
March	16.2	0.0	0.0	0.0	8.3
April	1.1	0.0	103.0	0.0	0.0
May	1.5	150.8	152.0	106.4	1.6
June	85.1	138.9	15.0	49.7	59.8
July	45.1	48.4	52.2	20.1	135.3
August	378.7	105.3	162.9	188.2	193.4
September	144.1	183.4	77.4	130.0	84.8
October	64.0	383.8	71.0	35.3	262.4
November	237.8	219.3	807.6	9.1	437.0
December	141.8	63.6	678.0	118.2	163.2
Total	1119	1322	2138	658	1452

Source: www.imd.gov.in

Wind: Based on the data available with Indomer, the wind speed exists around 6-8 m/s with the predominant direction of 20-70°N during the months of January, February, November and December. From March to May, the wind speed exists around 4-6 m/s with the predominant direction of 90-250°N. The wind speed of 2-6 exists in the months of September and October with the direction of wind predominantly prevailed in 220-270°N. Seasonal wise wind rose is shown in Fig. 3.2.

Month wise distribution of wind speed and direction

Month	Speed (m/s)	Predominant Direction (°N)
January	6 - 8	40 - 60
February	6 - 8	50 – 70
March	4 – 6	90 – 120
April	4 – 6	120 – 160
May	4 - 6	180 – 250
June	6 – 8	220 – 270
July	4 - 8	230 – 280
August	4 - 8	240 – 280
September	2 – 6	220 – 270
October	2 – 4	250 – 270
November	6 - 8	20 – 70
December	6 - 8	20 - 70

Source: Indomer

3.1.1.2. Duration of sampling

The gaseous and particulate air samples were collected at 4 locations using high and low volume air samplers. The AAQ monitoring stations are given in Table 3.1 and station locations are shown in Fig. 3.1. The monitoring was carried out with a frequency of two days continuous per week during fair weather period.

In compliance to the National Ambient Air Quality Standards (NAAQS), 2009 issued by MoEFCC vide G.S.R. No. 826 (E) dated 16th November 2009, the following parameters were monitored: Particulate Matter (PM_{10}), Particulate Matter ($PM_{2.5}$), Sulphur Dioxide (SO_2), Oxides of Nitrogen (NO_x), Ammonia (NH_3), Carbon Monoxide (CO), Lead (Pb), Arsenic (As), Nickel (Ni).

National Ambient Air Quality Standard are given in Table 3.2. The monitored ambient air quality results are given in Table 3.3.

3.1.1.3. Ambient air quality monitoring results

Particulate Matter 10 (PM_{10})

The PM_{10} concentration varied between 35.3 µg/m^3 at Port office (AQ1) and 52.8 µg/m^3 near Reddiyarpalayam (AQ3). The values are well within the prescribed limit.

Particulate Matter 2.5 ($PM_{2.5}$)

The $PM_{2.5}$ concentration varies between 10.2 µg/m^3 at Ariyankuppam (AQ2) and 20.6 µg/m^3 at Reddiyarpalayam (AQ3). The values are well within the prescribed limit.

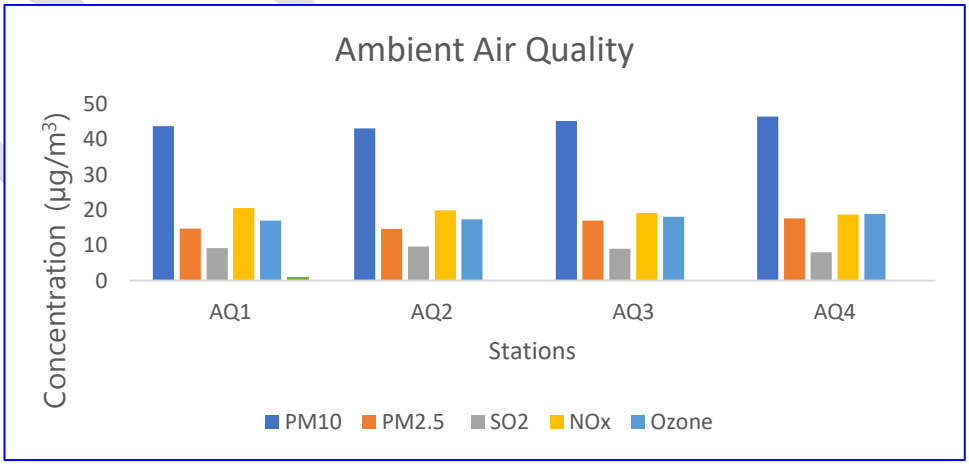
Gaseous pollutants

SO_2: The concentration of SO_2 varied between 6.0 µg/m^3 at Port Office (AQ1) and 12.8 µg/m^3 at Ariyankuppam (AQ2). The values are well within the prescribed limit.

NO_x: In the study area, NO_x concentration varied between 15.2 µg/m^3 at Kumaran Nagar (AQ4) and 23.1 µg/m^3 at Port Office (AQ1). The values are well within the prescribed limit.

Ozone: The concentration of Ozone varied from 14.0 µg/m^3 at Port Office (AQ1) and 21.0 µg/m^3 at Reddiyarpalayam (AQ4). The values are well within the prescribed limit.

The concentrations of **CO, Lead, Ammonia, Arsenic, Nickel** are found below the detection limit.



Air quality monitoring results shows that, pollutants are within NAAQ standards. Monitored values recorded within study can be attributed to movement of vehicles, boats, workshops etc. Air Quality Index (AQI) for the project region found to be in the satisfactory level (51 – 100) based on the AAQM results.


Air quality sample collection

3.1.2. Water environment

The representative ground water and surface water locations were monitored to understand the following:

- To assess the ground water and surface water quality characteristics covering the 10 km radius around the project site,
- To study the physical and chemical parameters,
- To analyze the impacts on agricultural productivity, surface drainage during normal and rainy conditions including flooding, habitat conditions, recreational resources and aesthetics in the vicinity and predict impact of the project on water quality.

3.1.2.2. Selection of water sampling stations

Sampling locations were identified based on reconnaissance, type of water body, relative importance as resource and proximity to industry. The nearby villages in the study area are using bore-well, open well, supply from industry and pond for various activities like drinking, washing, agricultural and other domestic uses etc. Therefore, open-well and bore well samples have been considered for ground water sampling.

Water samples were collected from three stations for surface water (SW1 to SW3) and at four stations for groundwater (GW1 to GW4). The details of the locations are given in Table 3.4. The sampling locations are shown in Fig. 3.3.

3.1.2.3. Ground water quality monitoring results

To assess the existing quality of ground water, impact of urbanization and/ industrialization, samples were collected and analyzed for their physico chemical and bacteriological

characteristics. The results were compared with drinking water quality standards (IS: 10500 – 2012).
Ground water was collected at four station (GW1 – GW4). Turbidity was found to vary between 0.8 (GW2) and 5.5 (GW1) NTU. Total Hardness varied in the range from 152 (GW3) to 400 (GW4) mg/l. pH was in the range between 6.11 (GW2) and 6.87 (GW1). TDS concentration varied between 298 (GW3) and 662 mg/l (GW4). The results of the ground water quality results during the study period is given in Table 3.5

Ground water quality results show that the water quality in the study area is within permissible limit specified for drinking water standards IS 10500:2012.

3.1.2.4. Surface water quality monitoring results

Surface water quality analysis is important because they help to protect and restore the quality of the surface waters. The detailed surface water quality are presented in Table 3.6. The results obtained were compared with the class of water based on designated best use specified by CPCB.

Surface water was collected at three station (SW1 – SW3). Turbidity varied between 5.3 (SW1) and 23.6 (SW2) NTU. TSS concentration was in the range from 8 (SW1) to 28 (SW2) mg/l. The pH was in the range 6.85 (SW3) - 7.22 (SW1). TDS concentration varied between 362 (SW2) and 750 (SW3) mg/l. Total Hardness was in the range from 112 (SW2) to 292 (SW3) mg/l. BOD value vary from <2 (SW1) to 12 mg/l (SW3). DO varied between 5.2 (SW3) and 6.1 (SW1) mg/l.

The surface water quality suggests that the surface water bodies within study area are satisfying various designated uses as per CPCB criteria such as Drinking water with and without conventional treatment, irrigation, outdoor bathing and industrial cooling. Overall surface water quality is good.

Collection of surface water samples

3.1.3. Land environment

3.1.3.1. Land use/Land cover

In the study area, dominant land use categories are sea, crop lands, built up area, plantation, scrub land, river/creek/canal, industry, lake/ pond/ tanks, barren land.

The land use/ land cover of the project area covering 10 km radius map is given as Fig. 3.4. Based on output, area statistics is calculated for different land use classes and given in Table 3.7.
Total area considered for the land use study is 31399.29 Ha., of this (50.37 %) includes sea. Study also suggest that a total of 16.5 % and 15.76 % of the area is occupied by built up area and crop lands and the area of 0.33 % is occupied with different industries, and creek/river/canal in the region is about 2.24%. The rest is distributed among port area, mangroves, groynes and breakwater, fishing harbour, barren land etc.

3.1.3.2. Topography

The region is flat country of average elevation of about 15 meters above sea level, intersected by the deltaic channels of River Gingee and Pennaiyar and other streams forming the two main drainage basins, interspersed with lakes and tanks. To the North-West of Puducherry town, a girdle of low hills is noticed to extend in an east north east – west south west direction. This high ground suddenly emerges from the low alluvial plain country. River Gingee crosses the region diagonally from north-west to south-east. Pennaiyar forms the southern border. Actually, the alluvial delta of Pennaiyar is almost on dead level ground, only a few meters above the sea. To the north-west of these hills is a section of fossiliferous limestone formations of the Cretaceous age. *(Source: District Disaster Management Plan, Puducherry).*

3.1.3.3. Soil

It is essential to determine the quality of soil in the area and identify the impacts of urbanization and industrialization on soil quality and predict impacts, which may arise due to the project activities.

The soil sampling locations have been identified with the following objectives: i) To determine the soil characteristics of the study area covering 10 km radius, ii) To determine the impact of industrialization on soil characteristics; and iii) To assess soil quality from agricultural point of view.

3.1.3.4. Selection of soil sampling stations

Soil samples were collected from four stations (SQ1 to SQ4) covering 10 km radius from project site. These samples were taken as scoop samples and were analyzed for various parameters. The soil sampling stations are listed in Table 3.8. The locations of soil sampling are shown in Fig. 3.3. The soil quality results are given in Table 3.9.

3.1.3.5. Soil quality

The soil analysis results shows that water holding capacity varied from 27 to 32 % and porosity ranged from 29 to 35 %, which indicates that soils are having loamy sand texture predominantly. The soil pH was acidic to neutral and ranged from 4.61 to 7.05, while EC (electrical conductivity) varied from 0.130 to 0.212 dS/m and ESP ranged from 2.02 to 2.18, which indicate that soils are neither saline (EC<0.80 dS/m) nor sodic (ESP<15) . Among basic cations predominance of calcium (0.13 to 0.32 meq/100g) was seen followed by sodium (0.03 to 0.39 meq/100g) and magnesium (0.02 to 0.06 meq/100g). The soil fertility measured by status of organic carbon (0.24 to 0.36 %), total phosphorus (9.8 to 18.4 mg/kg) and exchangeable potassium (0.03 to 0.04 meq/100g)

indicated that soils are low (<0.5 % OC)) in nitrogen, phosphorus (<28 kg/ha) and potassium (0.03 to 0.04 meq/100g) status.

The soil quality results show that the soil in the project area is free from any contamination. The results of soil analysis indicate that the soil in the study area is loamy soil. The soils are acidic to neutral in reaction and are low in nutrients status. The acidic soils require application of either lime or dolomite to improve the status of basic cations.

Soil sample collection during monitoring period

3.1.4. Noise environment

Impact of noise sources on environment depend upon the sources which are generating the noise and their respective characteristics. The environmental impact of the noise level can have several effects varying from annoyance to hearing loss depending on loudness of noise levels. The locations of Noise measurements covering 10 km radius from the project site are shown in Fig. 3.1.

3.1.4.1. Selection of measurement stations

The main objective of noise measurements in 10 km radius of the study area is to establish the baseline noise levels and assess the impact of the noise expected to be generated by proposed project activities. Noise level monitoring network stations were identified for assessment of existing ambient noise level status keeping in view noise source, major activity carried out at the locations, land use pattern etc.

The day noise levels have been monitored during 6 am to 10 pm and the night levels during 10 pm to 6 am. Four monitoring stations (NQ1 to NQ4) were selected as per the noise source identified based on field survey. The main noise generating activities in the study area is traffic movement, market, residential and movement of fishing boats. The noise levels were monitored using digital Sound level meter in the study area at on an hourly basis for 24 hours.

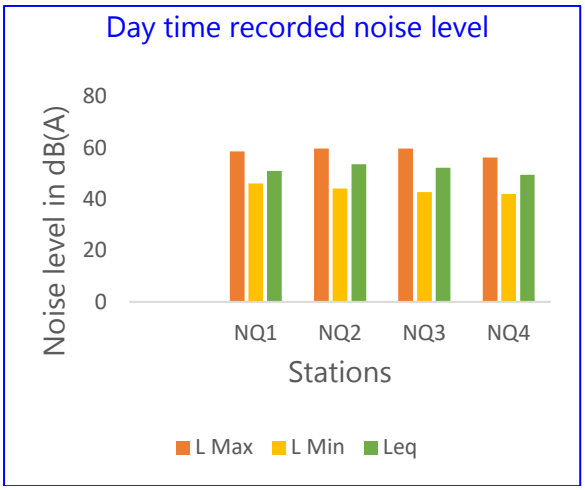
The details of monitoring stations are given in Table 3.10. The Ambient Noise Quality Standards as per CPCB are given in Table 3.11.

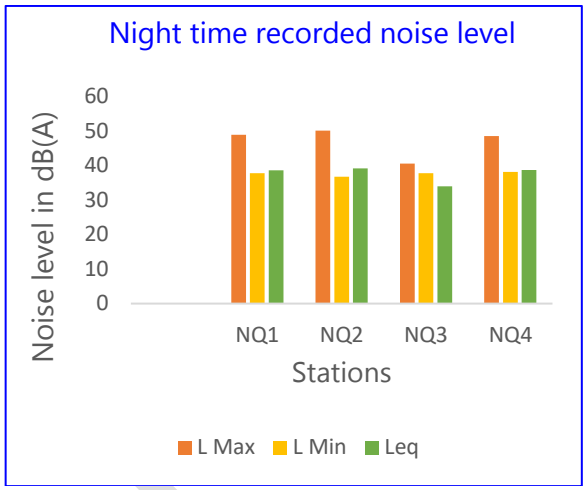
3.1.4.2. Recorded noise levels

The daytime and nighttime equivalent noise levels are given in Table 3.12.

3.1.4.3. Noise measurement results

The equivalent noise level in residential area during the day time varied between 42.1 dB(A) and 59.8 dB(A) whereas during the night time Leq value varied between 36.8 dB(A) and 50.1 dB(A). At all the monitoring stations, the noise levels comply with the CPCB standards as per their defined categories.





The measured noise levels were within the ambient noise standards prescribed under Noise Pollution (Regulation and control) Rules, 2000. The major sources of noise in the project area are influenced by vehicle movement and sea breeze.

3.1.5. Socio-economic environment

Socio-economic components of the environment comprise various features viz., demographic structure, availability of basic amenities such as housing, education, medical facilities, drinking water facilities, postal, and telephone facilities, communication facilities, recreational, cultural facilities and approach to villages etc. The study of these parameters helps in identifying, predicting and evaluating the likely impacts due to the proposed project activity in the project region. The socio-economic profile of the study area is significant for a proposed project as it may cause both positive and negative impacts.

Site area is around 3.5 km SE of Puducherry. Puducherry fishing harbour is also located on the Ariyankuppam River which is at a distance of 700 m from the river mouth. The proposed project region falls under the limit of Puducherry municipality.
Methodology: Methodology applied for the study is as per the standard norms of socio-economic EIA studies. The sources of data collection are:

i. Secondary data collection through Panchayat office, Taluk office,
ii. Available data through Government web sites (District Census Hand book, 2011).

3.1.5.1. Demography and Literacy

Puducherry District spreads over an area of about 239 sq.km and it lies on the Coromandel Coast. As per Census 2011, the total population of Puducherry District is 9,50,289 out of which 4,68,258 are male and 4,82,031 are female. The sex ratio is 1029 females for 1000 males. The total literate

population of the district is 7,26,649 out of which 3,80,946 are males and 3,45,703 are females. The administrative division of Puducherry has 4 Taluks, 3 Statutory Towns and 62 revenue Villages. The total population of Puducherry District 69.2 per cent was enumerated from urban areas and the rest 30.8 per cent was counted from rural areas. The proposed project location is also falls under urban areas. The details of literates and illiterates of Puducherry Taluk is given Table 3.13.

The habitations and distance from proposed project site are presented in Table 3.14. From the survey, it is found that a total of 7 villages/ habitations including census towns are situated in 10 km radius. Only two habitations are located in the core zone of 5 km radius.

The summary of the demographic profile of villages in and around the proposed project site is given in Table 3.15. There are seven villages/ habitations existing within 10 km radius of the project site. The total number of households are 18484. The total population of these seven villages/ habitations is 75470 out of which 37033 are males and 38440 are females (Source: Census, 2011).

The details of literates and illiterates in the villages in the study area are given in Table 3.16. The literacy rate of the villages is relatively less compared to the Union Territory literacy rate. In the study area out of the total population, 73 % are literate. The male literates are more than the female literates.

3.1.5.2. Educational Facilities

The available educational facilities village-wise are presented in Table 3.17. Educational facilities with Primary Schools are available in the villages around the project and also in Anganwadi centers. Higher secondary and ITI facilities are available in all the villages. Higher education facilities like engineering/science/arts colleges are available in Puducherry which is the district headquarters. Secondary education is available in Puducherry, Ariyankuppam, Manavely, Thavalakuppam within 10 km from project site. Despite high overall enrolment rate, the standard of education is yet to be improved.

3.1.5.3. Housing pattern

Almost all the villagers have better housings and more than 75% of the households are concrete roofs and the rest are tiled or asbestos roofs. Most of the villagers have their own land. Most of the houses have 2 to 3 rooms.

3.1.5.4. Infrastructure facilities

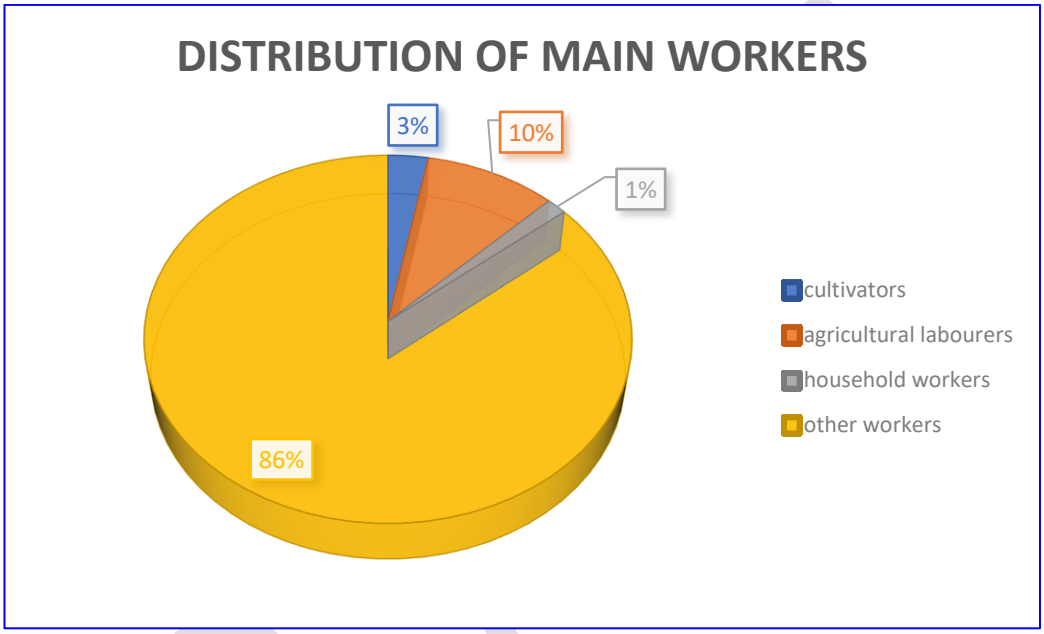
Availability of different infrastructural facilities in study area villages is given in Table 3.18. Infrastructural facilities are essential for the village development programmes. Electricity and road facilities are available in all the villages. The Government has taken effort to provide sufficient drinking water through pipeline.

3.1.5.5. Occupation Pattern

The details of total number of workers and industrial category wise workers in the neighbouring villages are presented in Tables 3.19 and 3.20. While some people are working in agriculture,

fishing activities, household work, others are engaged in industrial technical/admin/floor level labours, small/medium business, shops, auto/taxis, car renting etc. Some of the households rear domestic animals.

Below figure represents that around 86% of the total population are worked in the other industries like service in Government and private companies, fishing, small/medium business, shops, auto/taxis etc., and followed by agricultural workers (10%), cultivators (3%), house hold workers (1%).



3.1.5.6. Health and sanitation status

General health of the people is observed to be normal. Some of the habitations have proper water supply system through common pipelines supplying drinking water. Most of the houses in the project region has proper drainage facility.

3.1.5.7. Socio-economic status with reference to Quality of Life

Most of the people are dependent on jobs/business and fishing as their main source of living. More than 100 boats are operated from the fishing harbour and tourism is also popular in this project region. Therefore, most of the people are dependent on these activities for their livelihood either directly or indirectly. It is noticed that almost all the houses possess modern living amenities like TV with dishes, Fridge, Washing Machines, Mobiles and Motorcycles. Some of the residents own cars.

3.1.6. Terrestrial ecology and biodiversity

3.1.6.1. Flora

To assess the terrestrial vegetation, various places within 10 km radius of project region were visited and the occurrence of various trees, shrubs, etc., was noted. The terrestrial environment is characterized by a mix of urban, suburban and rural setup. Few lakes also occur within the study area. It is noteworthy that one such lake, Oussudu lake, is declared as a sanctuary for birds. The climate in this study area alongwith the occurrence of lakes, make it a potential place for growth of variety of trees, shrubs, water plants, etc. Thus, the enhanced floral biodiversity also increases the distribution of fauna, especially of birds. Surrounding the lakes old trees, such as Banyan, tamarind, etc., were noticed. Trees such as Teak, *Pongamia* sp., agricultural crops such as coconuts, palms, banana, etc., wild trees/plants such as *Prosopis juliflora*, *Calotropis* sp., etc., were also observed.

Banyan tree - *Ficus benghalensis*

Tamarind tree – *Tamarindus indica*

Teak tree – *Tectona grandis*

Palm trees – *Borassus flabellifer*

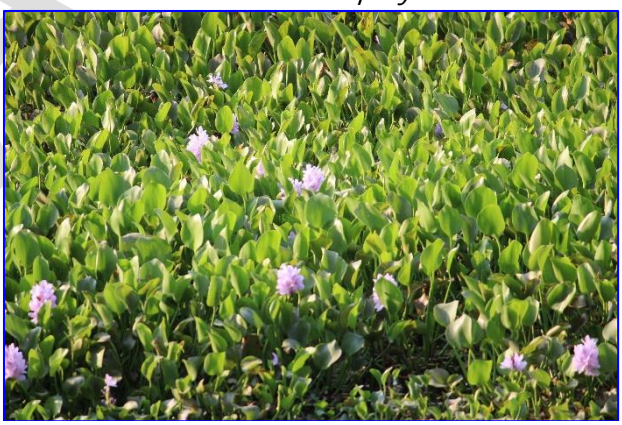
Coconut trees – *Cocos nucifera*

Banana – *Musa paradisiaca*

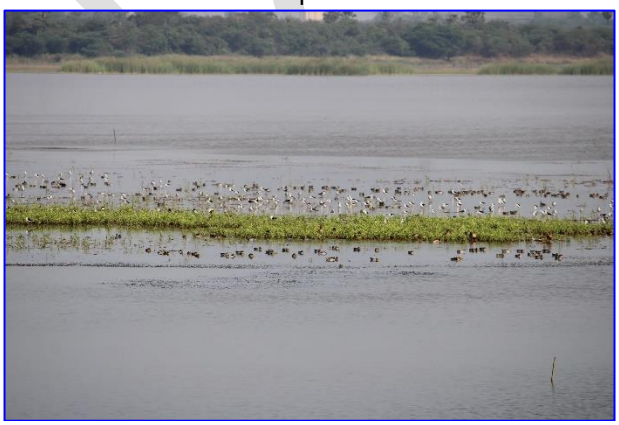
Pongamia pinnata

Thorn tree – *Prosopis juliflora*

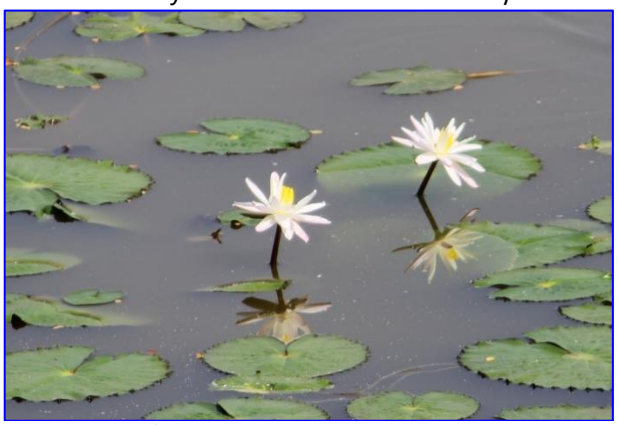
Velrampet Lake



Water hyacinth – *Eicchornia crassipes*



Oussudu Lake – Bird sanctuary



Lily flower plant – *Nymphaea* sp.

3.1.6.2. Fauna

Oussudu lake is a rich biodiversity spot. During October to February, plenty of migratory birds can be seen in this lake as well as other lakes, localities, in Pondicherry. Over 160 species of birds, both aquatic and terrestrial, have been observed in the area, including Painted Stork, Darter, Black-headed Ibis, Spot-billed Pelican and Eurasian Spoon Bill.

Over 60 species of butterflies have been spotted in the Sanctuary, including endemic species such as the Common-banded Peacock and the Crimson Rose. Various species of frogs, turtles, lizards, snakes and mammals are also found here, while at least 25 species of fish have been recorded in the lake's waters.

3.2. Marine Environment

The seawater samples, seabed sediment samples and biological parameters were collected covering 10 km radius at 7 stations (SS1 to SS7). Stns. SS1 to SS3 and Stn. SS7 are at Ariyankuppam River and the remaining samples Stn. SS4 to Stn. SS6 were collected at open sea. The details of the sampling stations are presented in Table 3.21 and also shown in Fig. 3.5. The water samples were collected at three water depths across the vertical i.e., surface, mid depth and bottom.

The seawater quality parameters were analyzed by inhouse laboratory accredited by National Accreditation Board for Laboratory (NABL). The method of collection and analysis protocols are given in Annexure I.

Seawater quality parameters: Temperature, pH, Salinity, Total Dissolved Solids, Turbidity, Total suspended solids, Dissolved Oxygen, Bio-Chemical Oxygen Demand, Chemical Oxygen Demand Ammonia-N, Nitrite-N, Nitrate-N, Phosphorous, Total Nitrogen, Total hardness, Chloride, Calcium, Magnesium.

Sediment quality parameters: Sediment structure, Total Nitrogen, Total Phosphorous, Total organic carbon, Calcium carbonate, Cadmium, Total Chromium, Lead, Mercury and Total Petroleum Hydrocarbon.

Ecology and Biodiversity: Planktons, Benthos and Molluscs, Microbiology, Coastal vegetation, Seaweeds and Sea grasses, Mangroves, Coral reefs, Marine National Parks and Marine Sanctuary, Turtles, Endangered species and Fisheries.

3.2.1. Physical parameters

3.2.1.1. Waves: Based on the available data at Indomer, the measured directional wave data for the period from July to June for the range of significant wave height are given below. It showed that the significant wave height vary around 0.75 m from February to May and July to September and 1.0 m from October to January and June. The predominant zero crossing wave periods remain around 6 s over the whole year. The predominant wave direction prevails around 115° during March and October, 120° to 150° in April to September, and 95° to 100° from November to February. The occurrence of storms and depressions during northeast monsoon often increases the wave activity in this region.

The wave climate prevailing in the post project conditions does not affect the tranquility. The dredging results in more draft and most of the time the basin is having good tranquility condition.

Waves near the project region

Month	Mean Wave height (m)	Wave period (s)	Wave direction (deg. N)
January	1.00	6	100
February	0.75	6	100
March	0.75	6	115
April	0.75	6	135
May	0.75	6	150
June	1.00	6	150
July	0.75	6	120
August	0.75	6	120
September	0.75	6	135
October	1.00	6	115
November	1.00	6	95
December	1.00	6	100

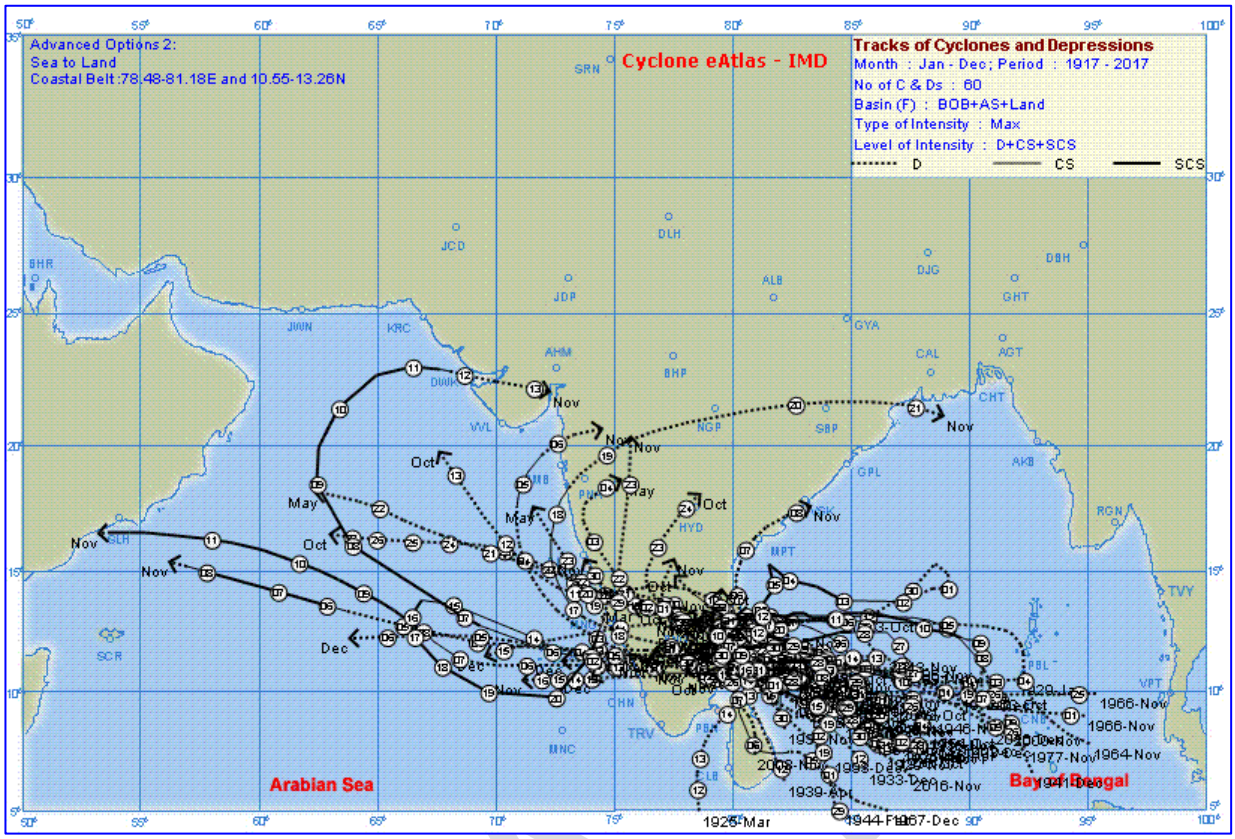
Source: Inhouse data

3.2.1.2. Cyclones: Based on Tracks of Cyclones in the cyclone e-Atlas provided by Indian Meteorological Department (IMD), Chennai. The tracks of cyclones which have crossed the coast near Puducherry (within 150 km and 75 on either side) during 1917 to 2017 are presented in Table below. It showed that totally 60 cyclones had passed within 300 km of the project region whereas only 34 had passed within 75 km. The occurrence of storms in this region was more frequent in November (30) followed by October (12) and December (9).

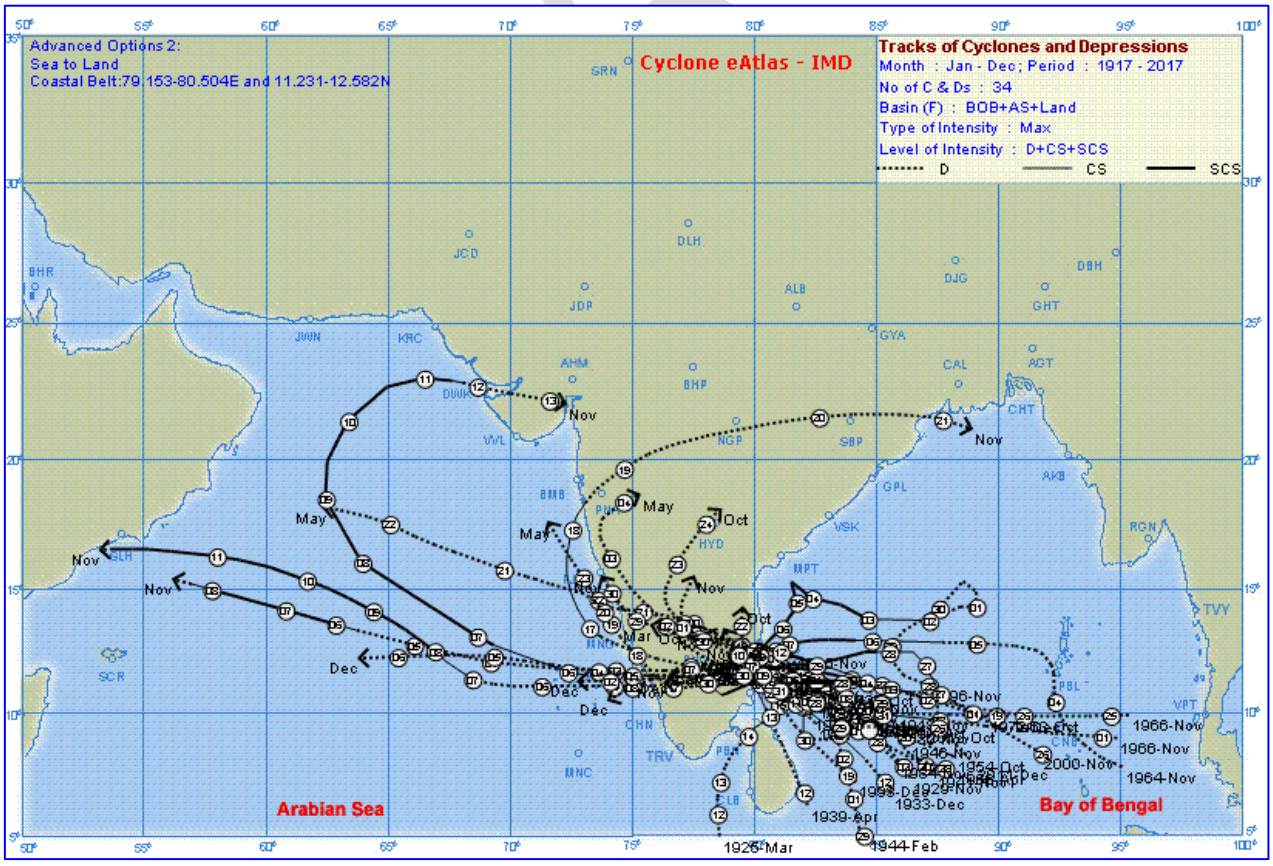
Tracks of cyclones passed Puducherry region - 1917 to 2017

Month	Occurred/ Crossed in the 150 km radius	Occurred/ Crossed in the 75 km radius
January	1	0
February	1	0
March	1	1
April	2	1
May	4	2
June	0	0
July	0	0
August	0	0
September	0	0
October	12	6
November	30	16
December	9	4
TOTAL	**60**	**34**

Source: IMD, Chennai



Tracks of Cyclones and Depressions crossed within 150 km (1917 - 2017)



Tracks of Cyclones and Depressions crossed within 75 km (1917 - 2017)

3.2.1.3. Tides: Based on the measured tide data available, the variation of tide were compiled for the project region. The design tide levels with respect to Chart Datum for Puducherry region as presented in Naval Hydrographic Chart (No. 3003) are given below.

Mean High Water Spring	(+) 1.3 m
Mean High Water Neap	(+) 1.0 m
Mean Sea Level	*(+) 0.9 m*
Mean Low Water Neap	(+) 0.7 m
Mean Low Water Spring	(+) 0.5 m

Based on the secondary data, the tides in this region are semi-diurnal with an average spring tidal range of 1.0 m and a neap tidal range of 0.3 m.

3.2.1.4. Currents: Based on available data with Indomer, the variation in current speed and direction is shown in Fig. 3.6. The current speed varied mostly between 0.02 m/s and 0.14 m/s. The current directions varied between 0° N and 30° N.

3.2.1.5. Bathymetry: The bathymetry chart prepared by IITM is shown in Fig. 3.7. The bathymetry chart indicates that the water depth contours runs nearly parallel to the coastline up to (-) 15 m water depth. The water depth of 2 m, 4 m, 6 m, 8 m, 10 m, 12 m and 15 m occur at distances of 121 m, 248 m, 444 m, 720 m, 1193 m, 1693 m, and 3175 m respectively.

3.2.1.6. Littoral Drift: Based on the data given in DPR prepared by IITM, the estimation of and direction of littoral drift along the coast of Puducherry was estimated. The net transport is about 0.35×10^6 m^3. It is directed towards north. The sediment transport rate was high in June (109.8×10^3 m^3/month) followed by August (85.8×10^3 m^3/month). During the month of April and May the sediment transport is nearly same (45×10^3 m^3/month) followed by July (42.95×10^3 m^3/month) and September (39.9×10^3 m^3/month). November and December have the sediment transport rate of 12.5×10^3 m^3/month and 23.3×10^3 m^3/month respectively. It was negligibly small ($<7 \times 10^3$ m^3/month) in January, February, March. The transport was towards north during March to October and south during November to February. The monthly volume of longshore sediment transport rate near project region is given in Table below.

Month wise distribution of Longshore sediment transport

Month	Quantity (m^3/month)
January	6964.71
February	1855.17
March	-5176.31
April	-45983.65
May	-45538.02
June	-109801.72
July	-42957.30
August	-85850.53
September	-39894.63
October	-17047.71
November	12542.83
December	23250.77

(-) Transport towards north
(+) Transport towards south

Source: IITM

3.2.1.7. Tsunami: Occurrence of Tsunami is an extremely rare phenomenon along the Indian coast. The past history shows that the periodicity of occurrence may range from 300 to 500 years. No reliable historical records of occurrence of Tsunami events and their impacts along the Indian coast are available because of its exceedingly rare nature. However, Tsunami occurred on 26.12.04 with an epicenter near Indonesia in the Bay of Bengal and had a dreadful devastation effect along the entire Tamilnadu coast. The magnitude of impact was very severe along the coastal stretch between Nagapattinam and Cuddalore. During this Tsunami, the water level rise (Tsunami run up) along the stretch of port was around 2.5 m – 3.5 m.

In case of a repetition of such a rare event along the coast, we can expect a run up of 2.5 m due to Tsunami. The proposed port is located 2 km inside the river mouth and the breakwaters can partly protect from the scale of destruction from Tsunami.

3.2.2. Seawater quality

The seawater quality parameters such as, Temperature, pH, Salinity, Total dissolved solids, Turbidity, Total suspended solids, Dissolved Oxygen, Bio-Chemical Oxygen Demand, Chemical Oxygen Demand, Calcium, Chloride, Magnesium, Total hardness Ammonia-N, Nitrite-N, Nitrate-N, Phosphorus, and Total Nitrogen are given in Table 3.22. Results for Cadmium, Chromium, Lead, Arsenic and Mercury, are presented in Table 3.23.

Temperature: Steep gradients of seawater temperature with depths bear direct impact on the productivity and animal communities of the region. The temperature varied from 25.4°C to 26.7°C at Stns. SS1 to SS7. There was no significant variation in temperature.

Salinity: Generally, the variation in salinity occurs because of differences in evaporation, precipitation, freezing and freshwater runoff at nearshore and due to upwelling/sinking in deeper water. Seawater salinity also varies with water depth at deeper water because of density and pressure variation with depth. The measured salinity of the collected water samples ranged between 12.5 and 34.2 PSU at Stns. SS1 to SS7.

Dissolved Oxygen (DO): Of all the dissolved gases in water, oxygen is the most important one for the survival of aquatic biota. The amount of oxygen dissolved in the water column at a given time is the balance between consumption and replenishment. In an ideal ecosystem, these two processes should be at equilibrium to keep the water column saturated with DO.

Dissolved oxygen content varied from 0.8 to 6.1 mg/l with the minimum at Stn. SS1 and Stn. SS7 and the maximum at Stn. SS5. Review of literature indicates that the DO levels below 2 mg/l are only known to cause respiratory impacts on marine fauna.

pH: Variations in pH due to chemical and other industrial discharges render a water column unsuitable for the rearing of fish and other aquatic life. pH is a very sensitive and most important parameter of an environmental study. Primary production, respiration and mineralization are able to alter the redox and pH of aqueous system due to the changes in oxygen and carbonate concentration. Identifying pH for acidic or alkaline disturbances enables one to locate zones of pollution and other quality conditions for the use of seawater. During the present study, pH did not show much variation and varied from 7.15 to 8.08 at all stations. The results show that the pH values lie within the range of normal seawater.

Turbidity: Turbidity is another measure to understand the suspended particulate matter which controls the transparency and photosynthesis in the water column. The turbidity varied between 11 and 28.4 NTU in the study area. While, the minimum was recorded at Stn. SS6 and the maximum was recorded at Stn. SS3 Bottom.

Total Suspended Solids (TSS): TSS in seawater originate either from autochthonous (biological life) or allochthonous (derived from terrestrial matter) sources. TSS varied in a range of 16 to 36 mg/l in the study area.

Chloride: The values ranges between 6812 and 18638 mg/l at Stns. SS1 to SS7.

Calcium: The calcium concentration varied from 220 to 421 mg/l at Stns. SS1 to SS7. **Magnesium:** The Magnesium values ranged between 456 and 1283 mg/l at Stns. SS1 to SS7. **Total Hardness:** The concentration varied from 2425 to 6300 mg/l at all the stations.

BOD: The concentration of BOD found to be vary from 1.4 to 42 mg/l. **COD:** The value found to range between 14.2 and 104 mg/l.

Nutrients: Nutrients determine the potential fertility of an ecosystem and hence it is important to know their distribution and behavior in different geographical locations and seasons. The fishery potential of an area is in turn, dependent on the availability of primary nutrients like nitrogen and phosphorus. Enrichment of these nutrients by anthropogenic inputs in the coastal waters having limited ventilation may result in water becoming eutrophicated.

The major inorganic species of nitrogen in water are ammonia, nitrite and nitrate of which nitrite is very unstable and ammonia is bio-chemically oxidized to nitrate. Hence, the concentrations of nitrite and ammonia are often very low in natural waters. The utilization of nutrients such as nitrates and phosphates can be taken as a measure of the productivity of the area.

Inorganic phosphate and nitrogen compounds in the sea play a decisive role in the biological production. Normally they occur in low concentrations. Their distribution in the coastal waters is mostly influenced by land run off. Since nutrients form an important index to the primary productivity of an ecosystem, the study of its distribution is important from the point of view of its role in the biological productivity and also as an indicator of pollutant. Values of various nutrient parameters analyzed at different stations are presented in Table 3.22.

Ammonia-Nitrogen (NH_3-N): Unpolluted waters are generally devoid of ammonia and nitrite. However, coastal input by sewage and other nitrogenous organic matter and fertilizers can increase these nutrients to higher levels. In addition, ammonia in seawater can also come from various organisms as an excretory product due to the metabolic activity and the decomposition of organic matter by micro-organisms. The concentration of Ammonia varied from 0.04 to 8.7 mg/l at Stns. SS1 to SS7. **Nitrite-Nitrogen (NO_2-N):** Nitrite is an essential element, which occurs in seawater as an intermediate compound in the microbial reduction of nitrate or in the oxidation of ammonia. In addition, nitrite is excreted by phytoplankton especially, during plankton bloom. In the present study, Nitrite concentration ranged from 0.01 to 0.6 mg/l at Stns. SS1 to SS7. **Nitrate-Nitrogen (NO_3-N):** Nitrate values are in general higher as compared to nitrite values. Nitrate is the final oxidation product of nitrogen compounds in seawater and is considered to be the only thermodynamically stable oxidation level of nitrogen in seawater. Nitrate is considered to be the micronutrient, which controls primary production in the euphotic surface layer. The

concentration of nitrate is governed by several factors of which microbial oxidation of NH_3 and uptake by primary producers may be important. In the present study, Nitrate concentration varied from 0.46 to 8.24 mg/l at Stns. SS1 to SS7. **Total Nitrogen:** The total nitrogen concentration varied from 1.08 to 17.8 mg/l at Stns. SS1 to SS7.

Phosphate-Phosphorus (PO_4-P): Phosphate concentration varied from 0.04 to 8.7 µmol/l at Stn. SS1 and Stn. SS10.

Trace metal concentration: Concentrations of trace metals in water are often close to the background level due to their efficient removal from the water column through hydrolysis and adsorption by suspended particulate matter as sediments serve as an ultimate sink for several trace metals and their analyses can serve as a useful indicator of metal pollution. Knowledge of the trace metal concentration in seawater is very important from the point of view of their possible adverse effects on marine biota. Oysters by their ability to concentrate some trace metals from the environment are considered to be useful indicators of metal pollution. Many of the trace metals are adsorbed to the particulate matter and are ultimately deposited at the bottom. Bottom sediments are considered to provide a reliable estimate of metal pollution status. The relationship between gross concentration of heavy metal in solution and its ability to cause toxic effects in an organism is a complex one and is mostly decided by the speciation of metal and the condition of the organism. Whether or not a trace metal can interact with the biota depends on its "bio-availability" in the medium. Presence of other toxicants or metals can reduce or increase the additive toxicity of each element. In addition to these factors, temperature, pH, salinity, turbidity and dissolved oxygen concentration also significantly affect metal-organism interactions.

The nominal presences of trace metals, which occur in seawater, are found to be necessary to promote growth of marine organisms. The concentration levels of Cadmium, Lead, Mercury and measured at all 7 locations are presented in Table 3.23.

Cadmium (Cd): The cadmium concentration varied between 0.78 and 5.73 µg/l at all stations in the study region. **Chromium (Cr):** The chromium concentration varied between 3.86 and 4.79 µg/l at all stations in the study region. **Lead:** The concentration of lead in the study region was found to be <0.01 µg/l at Stns. SS1 to SS7. **Arsenic:** The concentration of arsenic in the study region was found varied from 14.9 to 36.4 µg/l at Stns. SS1 to SS7. **Mercury (Hg):** During this study, the concentration of the study region was below detectable level of 0.01 µg/l at Stns. SS1 to SS7.

Seawater quality results shows that pH, Turbidity and other parameters are generally pertain to be in the range of normal seawater influenced by land drainage. The values of DO, salinity, chloride, nutrients and phosphorous though generally in the range expected for inshore and coastal areas, the stations at SS1 to SS3 and SS7 indicate the influence of organic pollution – possibly sewage, shows the discharge of drainage in the Ariyankuppam River but the values lie in the range of normal wastewater level. By Construction of the drainage barrier is likely will help to reduce the concentration level of nutrients in the port waters. The coastal waters at Stns. SS4 to SS6 are free from contamination and the results are within the normal seawater quality.


Collection of Seawater sample

3.2.2.1. Comparison of Physico – Chemical properties of clear water and turbid water

The details of comparison between nearshore and offshore waters is presented in Table 3.24. It shows that the creek water quality at Stns. SS1 – SS3 and SS7 appears to be highly deteriorated due to lower DO, higher BOD, higher nutrients namely NH_3, PO_4; higher turbidity indicating drainage of sewage from the upstream. The lower salinities reveal restricted tidal intrusion in the segment adversely affecting the flushing of the pollutants from the segment. The impact is also clearly noticed in the mouth region also. However, the nearshore water quality at 2 km and 5 km was very lowly polluted and that normally observed for the region. It possesses comparatively higher pH, higher salinity and DO, lower nutrients than those recorded for the creek segment. The offshore water quality at Stn. SS6 possesses the unpolluted status free from any negative impact due to the influxes of sewage through the creek.

3.2.3. Seabed sediment quality

Seabed sediment samples were collected at 7 locations (Stns. SB1 - SB7), the results are given in Table 3.25.

Sediment size distribution: The sediment at the sampling stations was predominantly comprised of fine sand and medium sand.

The seabed sediment results are given in the Table 3.26. **Total Organic Carbon:** Total organic carbon content concentration varied from 0.6 to 7.2 %. **Total Nitrogen:** Total nitrogen concentration varied from 96 to 446 µg/g in Stns. SB1 to SB7. **Phosphorus:** Total phosphorus concentration varied from 11.3 to 54 µg/g in Stns. SB1 to SB7. **Calcium Carbonate:** The calcium carbonate ranged between 3.5 and 20.2 %.

The concentration of heavy metals, phenol and total petroleum hydrocarbons in seabed sediment samples are given in Table 3.27.

Cadmium (Cd): The concentration of cadmium is <0.1 µg/g at all stations. **Total Chromium (Cr):** The concentrations of chromium ranged from 31 to 195 µg/g at Stns. SB1 to SB7. **Lead (Pb):** The concentrations of lead varied between 1.79 and 15.5 µg/g. **Mercury (Hg):** The concentrations of mercury was below detectable limit (i.e., <0.1 µg/g).

The heavy metal concentration in the sediment samples showed relatively low values in the study area. Total Nitrogen and Phosphorus values are high due to discharge of sewage in the port water.

Collection of Seabed Sediments

3.2.4. Marine Ecology and Biodiversity

Biological status of an area is an essential prerequisite for environmental impact assessment and can be evolved by selecting a few reliable parameters from a complex ecosystem. Whenever we consider assessment of the implications of environmental pollution, we must be aware of the fact that despite many changes, that may occur in the physico-chemical properties of water body and seabed sediment, the ultimate consequences are inevitably of biological nature.

The biological parameters considered in the present study are primary production, phytoplankton biomass, diversity and population, zooplankton biomass, diversity and population, seabed and inter-tidal / sub-tidal macro benthic diversity and population, bacterial population in coastal waters and seabed sediments and fishery of the region. Phytoplankton and zooplankton reflect the productivity of a water column at primary and secondary levels. Benthic organisms being sedentary animals associated with the seabed, provide information regarding the integrated effects of stress due to disturbances, if any, and hence are good indicators of early warning of potential damage.

3.2.4.1. Plankton

Phytoplankton and primary productivity: Phytoplankton are the primary source of food in the marine environment. The concentration and numerical abundance of phytoplankton indicate the fertility of a region. The plankton population depends primarily upon the nutrients present in the sea water and the sunlight for photosynthesis. This primary production is an important source of food for the higher organisms in the marine food chain.

The measured primary production results are given in Table 3.28. The primary productivity values varied between 264 and 456 mgC/m^3/day (average value is 357 mgC/m^3/day).

Phytoplankton species composition: Various phytoplankton groups observed in the samples and their species compositions are given in Table 3.29.

The floral diversity fluctuated from 19 to 37 species. Totally, 43 species of phytoplankton (net samples) represented by 3 diverse groups namely, Bacillariophyceae, (31 species, consisting of 20 centrales and 11 pennales), Dinophyceae (10) and Cyanophyceae (2) were enumerated.

Numerical abundance and percentage of phytoplankton: The numerical abundance of phytoplankton population varied between 7200 and 20400 nos./l from all stations. Bacillariophyceae (Diatoms) consisting of Centrales (52.7%) and Pennales (23.1%), formed the

major group followed by Dinoflagellates (16.7%) and Cyanophyceae (7.6%). *Rhizosolenia alata* (9.8%) was most dominant species followed by *Coscinodiscus centralis* (6.4%), *Trichodesmium erythraeum* (5.5%), *Odontella mobiliensis* (4.8%) and *Coscinodiscus marginatus* (3.8%). The numerical abundance of phytoplankton is given in Table 3.30.

Diversity indices of phytoplankton: Based on the PRIMER software, the Shannon-Wiener (H') diversity clearly showed the diverse nature of project area (4.13-4.90).

Diversity indices of phytoplankton

Station	S	N	d	J'	H'(log2)	1-Lambda'
SS1	19	7200	2.03	0.97	4.13	0.94
SS2	20	8400	2.10	0.97	4.20	0.94
SS3	28	9200	2.96	0.97	4.66	0.95
SS4	25	14100	2.51	0.98	4.56	0.95
SS5	28	20400	2.72	0.98	4.72	0.96
SS6	32	19200	3.14	0.98	4.90	0.96
SS7	19	7400	2.02	0.99	4.22	0.95

S= Total species; N= total individuals; d= species richness; J'=evenness;

The similarity in species composition and abundance among stations varied from 47.43 to 81.78% with an average similarity percentage of 63.47%.

Zooplankton: Various zooplankton groups and their percentage composition observed at various stations are given in Table 3.31.

Species composition and biomass of zooplankton

The zooplankton diversity varied from 16 to 30 species. Zooplankton population analysis at various stations showed that their numerical abundance varied from 62415 to 160920 nos./100 m^3. The zooplankton biomass at various stations varied from 26.3 to 73.9 ml/100 m^3.

Percentage composition zooplankton

Zooplankton population mostly consists *of Acartia danae* (6.9%), *Acrocalanus* sp. (6.3%), *Acartia erythraea* (5.0%), *Centropages furcatus* (4.5%) and *Paracalanus parvus* (3.5%).

Diversity indices of zooplankton

The Shannon-Wiener (H') diversity clearly showed the rich diversity of the project area (3.94-4.83).

Diversity indices of zooplankton

Station	S	N	d	J'	H'(log2)	1-Lambda'
SS1	16	65193	1.35	0.99	3.94	0.93
SS2	19	62419	1.63	0.97	4.14	0.94
SS3	23	76697	1.96	0.97	4.37	0.95
SS4	28	114552	2.32	0.96	4.62	0.95
SS5	28	122127	2.31	0.98	4.70	0.96
SS6	30	160916	2.42	0.98	4.83	0.96
SS7	20	63072	1.72	0.99	4.27	0.95

S= Total species; N= total individuals; d= species richness; J'=evenness;

The similarity in species composition and abundance among stations varied from 32.14 to 76.79% with an average similarity percentage of 61.04%.

3.2.4.2. Benthos and Molluscs

Benthic faunal population in an environment depends on the nature of the substratum and its organic matter content.

Abundance of subtidal and intertidal benthic organisms: Numerical abundance of macro benthic organisms are given in Table 3.32.

The sediment characteristics analysis showed that the study area essentially contained fine sand. The subtidal benthic fauna population ranged from 520 to 880 nos./m^2 at all station. The faunal population mainly consists of polychaete worms, molluscs and crustaceans. The intertidal benthic fauna population ranged from 240 to 345 nos./m^2. The faunal population mainly consists of polychaete worms, crustaceans and molluscs.

Diversity indices of Benthos: The Shannon-Wiener (H') diversity clearly showed the rich diversity of the project area (2.28-3.48).

Diversity indices of Benthos

Station	S	N	d	J'	H'(log2)	1-Lambda'
SS1	8	640	1.08	0.98	2.95	0.87
SS2	8	560	1.11	0.97	2.90	0.86
SS3	8	680	1.07	0.99	2.98	0.87
SS4	12	880	1.62	0.97	3.48	0.91
SS5	11	760	1.51	0.97	3.37	0.90
SS6	11	840	1.49	0.98	3.40	0.90
SS7	8	520	1.12	0.96	2.87	0.85
IB1	7	330	1.04	0.98	2.74	0.85
IB2	5	240	0.73	0.98	2.28	0.79
IB3	8	345	1.20	0.98	2.95	0.87

S= Total species; N= total individuals; d= species richness; J'=evenness;

The similarity in species composition and abundance among stations varied from 11.92 to 93.02% with an average similarity percentage of 47.82%.

Benthos from the fishery bycatch comprised largely of molluscs. Out of molluscs, gastropods dominated the composition followed by bivalves. Crabs like *Calappa lophos* were also observed among benthos.

About 76 species of macroinvertebrates, including 37 molluscs (21 gastropods and 16 bivalves), 22 crustaceans, 7 amphipods, 6 polychaetes, 3 barnacles and 1 oligochaete, were reported from the mangrove forests of Puducherry.

Gastropod - *Rapana* sp.

Gastropod - *Turritella acutangula*

Gastropod - *Phalium glaucum*

Bivalve - *Meretrix casta*

Bivalve - *Anadara rhombea*

Crab - *Calappa lophos*

3.2.4.3. Microbiology

Microorganism distribution in the marine and brackish environment plays an important role in the decomposition of organic matter and mineralization. Since the last two decades, water quality analysis was given more importance in marine pollution monitoring programmes. These pathogenic bacteria invade into marine environment through human and animal excreta, river runoff, land runoff, sewage with organic and inorganic contents, agricultural waste and industrial waste. Hence, the spatial and temporal distribution of the Total faecal coliforms as well as pathogenic bacteria in water and sediment is essential to assess the sanitary conditions. The regular monitoring in the coastal environment is an integral and essential part in predicting the microbial population of coastal waters.

Microbial count in surface water and sediment: Bacterial counts in the surface water and seabed sediment were analysed and are given in Tables 3.33 and 3.34. In the water samples, population density varied from 0.01 to 6.66 nos.×10^3 CFU/ml at Stns. SS1 to SS7. The sediment sample population density varied from 0.01 to 6.78 nos.×10^4 CFU/g at Stns. SB1 to SB7.

The pathogenic organism such as (TVC) *Escherichia coli, Vibrio* like organisms, *Shigella, Vibrio cholerae, Vibrio parahaemolyticus,* Total coliforms have been recorded in the study area. The counts indicated lesser population which shows that the environment is fairly healthy and free from any major pollution.

In general, the coastal waters are influenced by *Escherichia coli, Salmonella* sp., *Klebsiella* sp., *Enterobacter* sp., *Bacillus* sp., and *Staphylococcus* sp., and *Vibrio* like organisms. Estuaries and creeks are influenced by *E.coli*, *Shigella* sp., *Vibrio cholerae, Vibrio parahaemolyticus, Pseudomonas* sp., and other pathogens like Total Coliforms.

Collection of intertidal benthos

Collection of plankton

3.2.4.4. Coastal vegetation

The group of plants which are influenced by the coastal biosphere is known as coastal vegetation. It comprises of marine algal vegetation of littoral and sub littoral region, phanerogamic and algal vegetation of salt and brackish marshes, vegetation of intertidal and supra tidal regions, vegetation of beaches/ cliffs, mangroves etc. Each of these types of vegetation grows under specific environmental condition which subsequently leads to a distinct vegetation zonation in coastal or estuarine areas.

The intertidal, foreshore and backshore areas are sandy in nature with firm soil at the backshore and almost dry. Coastal vegetation is dominated by the thorn trees, *Prosopis juliflora,* in almost all around the vast expanse in nearshore and further in inland area. Coastal vegetation also comprises of trees like *Casuarina* sp., palm trees, etc., and creepers like *Spinifex littoreus, Ipomoea pes-caprae* and other plants. Areas near the fishing harbor / fish landing centre are dominated by thorn trees and mangroves.

Backshore with *Casuarina* sp.

Foreshore with *Prosopis* sp.

Foreshore with *Spinifex littoreus*

Backshore with *Ipomea pes-caprae*

3.2.4.5. Seaweeds and Sea grasses

Seaweeds: Seaweeds are marine macro algae and primitive type of plants, growing abundantly in the shallow waters of sea, estuaries and backwaters. They flourish wherever rocky, coral or suitable substrata are available for their attachment. They belong to three groups namely green, brown and red based on their pigmentation, morphological and anatomical characters.

One green seaweed species was seen attached to the boulders, that were kept for protecting the shoreline from erosion and to minimize the wave action at the entrance of the fishing harbour. Earlier few species of seaweeds were reported from the study site, viz., two species of green algae, *Ulva fasciata & Chaetomorpha* sp., and two species of red algae, *Halymenia doresii & Grateloupia lithophila*.

Green Alga on boulders

Sea grasses: No sea grasses were noticed in the project region.

3.2.4.6. Mangroves

Mangroves protect the shoreline against erosion caused by wind and water currents and mitigate the impact of natural calamities such as cyclones and tsunamis. Mangroves also support rich fishery resources. Hence, it is very important to have a well-developed and healthy mangrove cover for the socio- economic security of coastal areas.

Mangroves were seen on the Fishing harbour side, fish landing centre and other nearby sheltered coastal areas. Species like *Avicennia marina, Rhizophora* sp. and *Bruguiera* sp. were observed in the study site. *Avicennia marina* was the dominant species. Earlier studies have recorded 7 species of true mangroves and 16 species of mangrove associates. The 7 true mangroves were *Avicennia marina, Bruguiera cylindrica, Bruguiera gymnorrhiza, Rhizophora apiculata, Rhizophora mucronata, Acanthus ebracteatus* and *Acanthus ilicifolius.* Mangroves around the project region is shown in Fig. 3.8.

Rhizophora sp.

Rhizophora sp.

Avicennia marina

Avicennia marina

Mangrove associate - *Sesuvium* sp.

Mangroves being a nursery ground for a variety of finfishes and shellfishes, serve as a potential feeding and nesting site for a variety of resident and migratory birds. 14 species of avifauna have been reported earlier, including egrets, night herons, little cormorants, black-winged stilts, sandpipers, etc.

Egret - *Egretta garzetta*

Black-crowned night heron, *Nycticorax nycticorax*

Little cormorant - *Phalocrocorax* sp.

Black-winged Stilts - *Himantopus himantopus*

Sandpipers - *Tringa* sp.

Mangroves are found along both the banks of the navigational channel. However, the proposed navigational route will not disturb any mangroves but falls within the buffer zone of the mangrove area. Suitable mangrove plantation measures will be taken to preserve and improve the mangrove habitat near the project region.

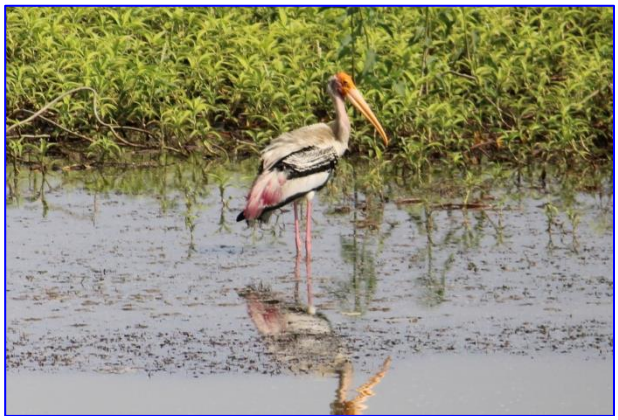
3.2.4.7. Coral reefs

Corals are not present in the project region.

3.2.4.8. Marine National Park and Marine Sanctuaries

No marine national parks and marine sanctuaries exist near the project site. A freshwater bird sanctuary namely, Oussudu Wildlife Sanctuary exists within Puducherry limits and it is located inland around 9.6 km from the project region. It also has extended into areas of Tamilnadu. The 800-acre Oussudu lake spreads equally in Puducherry and Tamil Nadu territories. Apart from being a nesting site for few species like common coot, flocks of a few thousand flamingos have been noticed in the past few years during the migratory season. It has been designated as one of the important wetlands of Asia by the International Union for Conservation of Nature (IUCN).

Birds at Oussudu lake


Oussudu lake - Painted stork


Oussudu lake – Flamingos

At Velrampet lake also, varieties of birds, such as egrets, cormorants, storks, etc., were noticed.


Velrampet lake – Painted storks


Velrampet lake – Egret


Velrampet lake – Black cormorant

3.2.4.9. Turtles

There is no turtle nesting within the project site. Turtles need calm and ideal location with good sandy beaches for nesting. But the project region is protected by seawalls on the northern side of the project region which is not ideal an location for turtle nesting. Nesting of Olive Ridley turtles to the south of the project region near the coast of Chinnaveerampattinam is reported, which is located away from the project site. However, there is no activity is proposed in the southern part of the project region.

3.2.4.10. Endangered species

Many of the major wildlife supported in the Oussudu Wildlife sanctuaries and other nearby wetlands, especially the resident and migrant birds are protected under Indian Wildlife (Protection) Act, 1972. Birds such as coots, cormorants, cranes, egrets, flamingos, storks, etc., are included in Schedule IV. Olive Ridley turtles, a Schedule I specie presence in several places along the coast of Pondicherry to the south of project region has been reported earlier.

3.2.4.11. Fisheries

Fisheries statistics comprising fishermen villages, population, fishing crafts, etc., for Puducherry UT, for the year 2016-17 are given in Table 3.35. 314 species of marine fishes have been reported for the Pondicherry and Karaikal coasts *(Source: Mishra and Krishnan, 2003)*. Species wise fish landing in Puducherry for the year 2018 is given in Table 3.36. It is observed that sardines, mackerels, perches, etc., dominate the marine fishery catch followed by carangids, silver bellies, seer fishes, perches, prawns, etc.

Scomberomorus sp.

Selaroides leptolepis

Nemipterus japonicus

Gerres filamentosus

Cynoglossus sp.

Alutera monoceros

Portunus sanguinolentus

Lutjanus russelli

Loligo sp.

Table 3.1. Ambient Air Quality monitoring stations

Station	Locations	WGS Spheroid 84		UTM Coordinates (Zone 44)		Distance from project region (m)
		Latitude, N	Longitude, E	X (m)	Y (m)	
AQ1	Port Office	11°55'08"	79°49'31"	372082	1317870	698
AQ2	Ariyankuppam	11°53'39"	79°48'26"	370114	1315144	3666
AQ3	Reddiyarpalayam	11°55'47"	79°48'21"	369985	1319064	3093
AQ4	Kumaran Nagar	11°57'27"	79°47'22"	370013	1322158	5245

Table 3.2. National Ambient Air Quality Standard

Pollutant	Time	Industrial, Residential, Rural & other areas	Ecologically Sensitive area (Notified by Central Govt.)
PM_{10} (µg/m^3)	Annual Avg.	60	60
	24 hours	100	100
$PM_{2.5}$ (µg/m^3)	Annual Avg.	40	40
	24 hours	60	60
Sulphur Dioxide (µg/m^3)	Annual Avg.*	50	20
	24 hours**	80	80
Oxides of Nitrogen (µg/m^3)	Annual Avg.	40	30
	24 hours	80	80
Carbon monoxide (mg/m^3)	8 hours	2	2
	1 hour	4	4
Ozone (µg/m^3)	8 hours	100	100
	1 hour	180	180
Ammonia (µg/m^3)	Annual	100	100
	24 Hours	400	400
Lead (µg/m^3)	Annual	0.5	0.5
	24 Hours	1.0	1.0
Arsenic (ng/m^3)	Annual	06	06
Nickel (ng/m^3)	Annual	20	20
Benzene (C_6H_6) (µg/m^3)	Annual	05	05
Benzo (a) Pyrene (ng/m^3)	Annual	01	01

Source: Gazette of India Notification, dated 16th Nov, 2009

** Annual Arithmetic Mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals*

*** 24 hourly or 8 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*

Table 3.3. Measured Air Quality

Station	PM_{10} (µg/m³)				$PM_{2.5}$ (µg/m³)			
	Min	Max	Mean	98 percentile	Min	Max	Mean	98 percentile
AQ1	35.3	51.0	43.7	50.9	10.6	18.6	14.7	18.5
AQ2	36.2	49.8	43.1	49.7	10.2	19.4	14.6	19.2
AQ3	35.9	52.8	45.1	52.5	13.2	20.6	17.0	20.5
AQ4	40.6	50.8	46.4	50.6	15.4	19.3	17.6	19.2

Contd…

Station	SO_2 (µg/m³)				NO_X (µg/m³)			
	Min	Max	Mean	98 percentile	Min	Max	Mean	98 percentile
AQ1	6.0	11.4	9.2	11.2	15.8	23.1	20.5	23.1
AQ2	6.2	12.8	9.6	12.6	16.4	22.9	19.9	22.9
AQ3	6.5	11.5	9.0	11.4	16.8	20.8	19.1	20.8
AQ4	6.8	8.8	8.0	8.8	15.2	21.6	18.7	21.6

Contd…

Station	Ozone (µg/m³)				CO (mg/m³)	Ammonia (µg/m³)	Lead (µg/m³)	Arsenic (ng/m³)	Nickel (ng/m³)
	Min	Max	Mean	98 percentile					
AQ1	14.0	20.0	17.0	19.9	BDL (DL:0.1)	BDL (DL:5.0)	BDL (DL:0.001)	BDL (DL:1.0)	BDL (DL:3.0)
AQ2	14.6	20.0	17.3	19.9	BDL (DL:0.1)	BDL (DL:5.0)	BDL (DL:0.001)	BDL (DL:1.0)	BDL (DL:3.0)
AQ3	15.0	20.6	18.1	20.6	BDL (DL:0.1)	BDL (DL:5.0)	BDL (DL:0.001)	BDL (DL:1.0)	BDL (DL:3.0)
AQ4	16.8	21.0	18.9	20.9	BDL (DL:0.1)	BDL (DL:5.0)	BDL (DL:0.001)	BDL (DL:1.0)	BDL (DL:3.0)

Table. 3.4. Ground water and surface water sampling locations

Station	Location	WGS Spheroid 84		UTM Coordinates (Zone 44)		Source	Distance from project region (m)
		Latitude, N	Longitude, E	X (m)	Y (m)		
Ground water							
GW1	Mudalali Society	11°55'12"	79°48'56"	371024	1318001	Bore Well	1760
GW2	Subbaiah Nagar	11°56'47"	79°49'13"	369736	1320907	Bore Well	4415
GW3	Ariyankuppam	11°56'47"	79°49'00"	369613	1315376	Bore Well	3900
GW4	Kombakkam	11°54'50"	79°47'01"	367532	1317347	Bore Well	5233
Surface Water							
SW1	Velrampet	11°54'51"	79°48'02"	369406	1317352	Lake	3365
SW2	Oussudu Lake	11°56'30"	79°44'48"	363537	1320422	Lake	9615
SW3	Kanagan Lake	11°56'07"	79°47'55"	369195	1319681	Lake	4081

Table 3.5. Measured Ground water quality

Sl. No.	Parameter	Unit	GW1	GW2	GW3	GW4	IS 10500:2012 Standard
1	Colour	Hazen	<5.0	<5.0	<5.0	<5.0	5-15
2	pH	-	6.87	6.11	6.56	6.53	6.5 – 8.5
3	Turbidity	NTU	5.5	0.8	1.1	2.7	1-5
4	TDS	mg/l	596	374	298	662	500-2000
5	Total Alkalinity	mg/l	146	130	166	320	200-600
6	Total Hardness	mg/l	272	208	152	400	200-600
7	Calcium as Ca	mg/l	61	63	42	87	75-200
8	Magnesium as Mg	mg/l	29	13	12	45	30-100
9	Chloride	mg/l	303	124	64	219	250-1000
10	Sulphate	mg/l	48.6	29.7	29	19.1	200-400
11	Phosphate	mg/l	0.09	0.1	0.16	0.71	-
12	Sulphide	mg/l	<0.02	<0.02	<0.02	<0.02	<0.05
13	Residual Chlorine	mg/l	<0.1	<0.1	<0.1	<0.1	0.2-1.0
14	Fluoride	mg/l	0.35	0.29	0.36	0.94	1.0-1.5
15	Oil & Grease	mg/l	<0.1	<0.1	<0.1	<0.1	*

Table 3.6. Measured Surface water quality

Sl. No.	Parameter	Unit	SW1	SW2	SW3	CPCB Standards
1	Colour	Hazen	<5.0	<5.0	<5.0	Class A
2	pH	-	7.22	7.05	6.85	Class A, B, C, D & E
3	Turbidity	NTU	5.3	23.6	6.5	*
4	Total Suspended Solids	mg/l	8	28	9.4	*
5	TDS	mg/l	436	362	750	Class A, C
6	Dissolved Oxygen	mg/l	6.1	5.6	5.2	Class A, B, C & D
7	Biochemical Oxygen Demand	mg/l	<2	2	2.2	Class A, B, C
8	Chemical Oxygen Demand	mg/l	4	8	28	*
9	Ammoniacal Nitrogen	mg/l	0.15	0.18	0.64	Class D
10	Nitrite Nitrogen	mg/l	0.03	0.04	0.18	*
11	Total Alkalinity	mg/l	178	112	266	*
12	Total Hardness	mg/l	152	112	292	Class A
13	Calcium	mg/l	27	19	69	Class A
14	Magnesium	mg/l	20	16	29	Class A
15	Chloride	mg/l	140	124	240	Class A
16	Sulphate	mg/l	5.3	14.2	35.9	Class A, C, E
17	Phosphate	mg/l	0.12	0.38	0.63	*
18	Sulphide	mg/l	<0.02	<0.02	<0.02	*
19	Residual Chlorine	mg/l	<0.1	<0.1	<0.1	*
20	Fluoride	mg/l	0.65	1.14	0.52	Class A, B, C
21	Oil & Grease	mg/l	<0.1	<0.1	<0.1	Class C & D

Note: *Not Specified: Class A – Drinking water source without conventional treatment but after disinfection limit; Class B – Outdoor Bathing limit; Class C – Drinking water source with conventional treatment followed by disinfection limit; Class D – Fish culture and wild life propagation limit; Class E – Irrigation, Industrial cooling or controlled waste disposal limit.

Table 3.7. Land use classification

Sl. No.	LU/LC Classes	Area (Ha.)	%
1	Urban Built up	4005.76	12.757
2	Rural Built up	1203.3	3.832
3	Industrial area	103.91	0.331
4	Airport	73.66	0.235
5	Beach	16.72	0.053
6	Crop land	4950.74	15.767
7	Plantation	1880.31	5.988
8	Barren land	347.96	1.108
9	Mangroves	81.89	0.261
10	Scrub land	1460.74	4.652
11	Wetland	20.23	0.064
12	Saltpan	41.74	0.133
13	Sandy Area	134.41	0.428
14	Lake / Ponds / Tanks	507.07	1.615
15	River / Stream / Canals / Creek	704.38	2.243
16	Old Port	5.17	0.016
17	New Port	4.7	0.015
18	Port Region	20.98	0.067
19	Fishing Harbour	7.87	0.025
20	Groyne	0.98	0.003
21	Jetty	0.26	0.001
22	North Breakwater	0.38	0.001
23	South Breakwater	0.68	0.002
24	Sea Wall	9.65	0.031
25	Sea	15815.82	50.370
Total		31399.29	100

Table 3.8. Soil sampling stations

Station	Location	WGS Spheroid 84		UTM Coordinates (Zone 44)		Source	Distance from project region (m)
		Latitude, N	Longitude, E	X (m)	Y (m)		
SQ1	Port Office	11°55'01"	79°49'39"	372324	1317664	Barren land	431
SQ2	Subbaiah Nagar	11°56'47"	79°48'13"	369735	1320912	Agriculture land	4414
SQ3	Edayarpalayam	11°52'36"	79°47'31"	368447	1313217	Agriculture land	6207
SQ4	Kamaraj Nagar	11°57'41"	79°47'28"	368371	1322574	Agriculture land	6566

Table 3.9. Measured Soil Quality

Sl. No.	Parameter	Unit	SQ1	SQ2	SQ3	SQ4
1	Porosity	%	35	31	33	29
2	Water Holding Capacity	%	27	30	29	32
3	Soil Separates					
A	Sand	%	82	84	83	88
B	Silt		14.0	12.0	12.0	10.0
C	Clay		4.0	2.0	5.0	2.0
4	Soil texture	-	Loamy Sand	Loamy Sand	Loamy Sand	Sandy Loam
5	Cation Exchange Capacity	meq of Na/100 g	0.27	0.48	0.67	0.25
6	pH	-	5.77	7.05	4.61	5.47
7	Electrical Conductivity	dS/m	0.196	0.149	0.212	0.130
8	Sodium Adsorption Ratio	-	0.09	0.19	1.10	0.22
9	Organic Carbon	%	0.34	0.24	0.28	0.36
10	Total Phosphorous	kg/ha	412.2	237.4	219.5	362.9
11	Exchangeable Calcium	meq of Ca/100 g	0.15	0.32	0.23	0.13
12	Exchangeable Magnesium	meq of Mg/100 g	0.06	0.04	0.02	0.02
13	Exchangeable Sodium	meq of Na/100 g	0.03	0.08	0.39	0.06
14	Exchangeable Potassium	meq of K/100 g	0.03	0.04	0.03	0.04

Table 3.10. Noise measurement stations

Station	Location	Category	WGS Spheroid 84		UTM Coordinates (Zone 44)		Distance from the project region
			Latitude, N	Longitude, E	X (m)	Y (m)	
NQ1	Port Office	Industrial	11°55'07"	79°49'32"	372117	1317830	698
NQ2	Ariyankuppam	Residential	11°53'43"	79°48'25"	370095	1315258	3666
NQ3	Reddiyarpalayam	Residential	11°55'48"	79°48'20"	369944	1319113	3093
NQ4	Kumaran Nagar	Residential	11°57'27"	79°48'22"	370013	1322158	5245

Table 3.11. Ambient Noise Quality Standard as per CPCB

Type of Area	Limits in dB(A) Leq*	
	Day Time	Night Time
Industrial Area	75	70
Commercial Area	65	55
Residential Area	55	45
Silence Zone	50	40

**-dB (A) Leq denotes the time weighted average of the sound level in decibels on scale A which is relatable to human hearing*
Source: Pollution Control Acts, Rule and Notifications issued there under, by Pollution Control Law Series: PCLS/02/2006(Fifth Edition) of Central Pollution Control Board, January 2006, pp 926
Day and Night time shall mean from 6:00 a.m. to 10:00 p.m. and 10:00 p.m. to 6:00 a.m. respectively.

Table 3.12. Measured Noise quality in dB(A) Leq

Station	Day			Night		
	L Max	L Min	Leq	L Max	L Min	Leq
NQ1	58.6	46.2	51.0	48.9	37.8	38.6
NQ2	59.8	44.2	53.6	50.1	36.8	39.2
NQ3	59.8	42.8	52.3	40.6	37.8	34.0
NQ4	56.2	42.1	49.5	48.6	38.2	38.7

Table 3.13. Literates and illiterates in Puducherry Taluk

Total/ Rural/Urban	Number of literates and illiterates			Literacy rate			Literacy rate (%)			Gap in Male-Female Literacy Rate Person
	Person	Males	Females	Person	Males	Females	Person	Males	Females	
Total	9,50,289	4,68,258	4,82,031	7,26,649	3,80,946	3,45,703	76.47	81.35	71.72	9.63
Rural	2,93,080	1,44,769	1,48,311	2,03,781	1,10,274	93,507	69.53	76.17	63.05	13.12
Urban	6,57,209	3,23,489	3,33,720	5,22,868	2,70,672	2,52,196	79.56	83.67	75.57	8.1

Source: District Census Handbook 2011

Table 3.14. Habitations /villages and their distance from study area

Sl. No	Name of the habitations	Distance from project area (Km)
1	Ariyankuppam	3.1
2	Manavely	3.7
3	Purnankuppam	5.1
4	Thavalakuppam	7.1
5	Abishegapakkam	7.6
6	Thimmanaickenpalayam	9.5
7	Korkadu	9.8

Table 3.15. Population and households of villages/ habitations in the 10 km radius of project site

Sl. No	Village/ habitation	Total Population			Total number of households
		Male	Female	Total	
1	Ariyankuppam	14565	15243	29808	7350
2	Manavely	7777	7889	15666	3878
3	Purnankuppam	3370	3396	6766	1742
4	Thavalakuppam	4472	4740	9212	2252
5	Abishegapakkam	3516	3608	7124	1616
6	Thimmanaickenpalayam	1653	1826	3476	808
7	Korkadu	1680	1738	3418	838
	Total	37033	38440	75470	18484
	%	49.07	50.93	-	-

Source: District Census Handbook 2011

Table 3.16. Literates and illiterates within 10 km radius of study area

Village	Literates			Illiterates		
	Person	Males	Females	Person	Males	Females
Ariyankuppam	22326	11738	10588	7482	2827	4655
Manavely	11606	6269	5537	4060	1508	2552
Purnankuppam	4645	2605	2040	2121	765	1356
Thavalakuppam	6805	3546	3259	2407	926	1481
Abishegapakkam	5317	2827	2490	1807	689	1118
Thimmanaickenpalayam	2199	1173	1026	1280	480	800
Korkadu	2271	1256	1015	1147	424	723
Total	55169	29414	25955	20304	7619	12685
%	73.1			26.9		

Source: District Census Handbook 2011

Table 3.17. Educational facilities in the project region

Village	Primary School		Middle school		Higher secondary School		College	Technical College
	Govt.	Private	Govt.	Private	Govt.	Private		
Ariyankuppam	6	8	4	4	2	3	-	-
Manavely	6	4	2	4	2	1	1	-
Purnankuppam	3	1	2	1	-	-	-	-
Thavalakuppam	5	3	2	2	1	-	1	-
Abishegapakkam	2	1	1	1	-	-	1	1
Thimmanaickenpalayam	1	-	1	-	-	-	-	-
Korkadu	2	1	1	1	1	-	-	-
Total	25	18	13	13	6	4	3	1

Source: District Census handbook, 2011

Table 3.18. Availability of different facilities

Sl. No	Village Name	Telephone / Mobile phone	Village Approach Road	Roads Facilities in village	Civil Supplies	Temple/Church/ masjid
1	Ariyankuppam	✓	✓	✓	✓	✓
2	Manavely	✓	✓	✓	✓	✓
3	Purnankuppam	✓	✓	✓	✓	✓
4	Thavalakuppam	✓	✓	✓	✓	✓
5	Abishegapakkam	✓	✓	✓	✓	✓
6	Thimmanaickenpalayam	✓	✓	✓	✓	✓
7	Korkadu	✓	✓	✓	✓	✓

Source: District Census handbook, 2011

Table 3.19. Details of total number of workers in villages

Sl. No.	Village	Total workers		Main Workers		Marginal workers	
		Males	Females	Males	Females	Males	Females
1	Ariyankuppam	7985	2196	7703	2028	282	168
2	Manavely	4224	1166	4041	1006	183	160
3	Purnankuppam	18885	796	1790	650	95	146
4	Thavalakuppam	2478	607	2261	525	217	82

Sl. No.	Village	Total workers		Main Workers		Marginal workers	
		Males	Females	Males	Females	Males	Females
5	Abishegapakkam	1744	688	1447	442	297	246
6	Thimmanaickenpalayam	882	560	687	378	195	182
7	Korkadu	871	443	696	224	175	219
Total		37069	6456	18625	5253	1444	1203
%		85.17	14.83	78.00	22.00	54.55	45.45

Source: District census handbook, 2011

Table 3.20. Details of category – wise workers

Sl. No	Village	Industrial category of main workers							
		Cultivators		Agricultural labourers		Household workers		Other workers	
		Males	Females	Males	Females	Males	Females	Males	Females
1	Ariyankuppam	67	8	159	40	93	80	7384	1900
2	Manavely	130	21	216	101	42	43	3653	841
3	Purnankuppam	158	50	185	164	5	4	1442	432
4	Thavalakuppam	81	11	157	64	23	26	2000	424
5	Abishegapakkam	71	8	205	102	10	6	1161	326
6	Thimmanaickenpalayam	23	11	291	267	1	4	372	96
7	Korkadu	50	11	218	124	10	6	418	83
Total		580	120	1431	862	184	169	16430	4102
%		82.86	17.14	62.41	37.59	52.12	47.88	80.02	19.98

Source: District census handbook, 2011

Table 3.21. Seawater, Seabed sediment and Biological sampling stations

Station	Geographical Coordinates (WGS 84)		UTM Coordinates (Zone 44)		Measurement depth from surface to vertical (m)
	Latitude, N	Longitude, E	Easting (mX)	Northing (mY)	
Seawater, seabed sediment*, and biological sampling stations					
SS1 & SB1	11°55'00"	79°49'24"	371880	1317630	S
SS2 & SB2	11°54'25"	79°49'12"	371515	1316548	S & B
SS3 & SB3	11°54'23"	79°49'48"	372597	1316489	S & B
SS4 & SB4	11°54'59"	79°50'59"	374757	1317575	S, M & B
SS5 & SB5	11°54'54"	79°52'38"	377749	1317411	S, M & B
SS6 & SB6	11°54'46"	79°55'23"	382745	1317135	S, M & B
SS7 & SB7	11°54'46"	79°49'41"	372380	1317194	S
Intertidal benthos sampling stations					
IB1	11°55'23"	79°49'06"	371721	1312792	-
IB2	11°55'29"	79°50'05"	373128	1318514	-
IB3	11°57'41"	79°50'30"	373898	1322575	-

S = Surface, M = Mid depth, B = Bottom

**Seabed sediments were collected at bottom*

Table 3.22. Seawater quality in Puducherry coastal waters in March 2019

Station	Water Depth	Temp. (°C)	Salinity (PSU)	pH	DO (mg/l)	NO_2-N (mg/l)	NO_3-N (mg/l)	PO_4-P (mg/l)	NH_3-N (mg/l)	Total Nitrogen as N (mg/l)
SS1	S	26.6	12.8	7.24	0.8	0.3	8.24	4.85	5.5	14.6
SS2	S	26.6	20.0	7.26	1.0	0.2	8.12	2.7	3.4	12.4
SS3	S	26.7	25.6	7.20	4.0	0.3	7.86	3.59	5.8	14.5
	B	25.9	26.2	7.16	4.0	0.6	7.92	1.93	1.95	11.0
SS4	S	26.5	33.5	8.04	5.9	0.02	0.98	0.07	0.18	1.68
	M	26.1	33.8	8.01	6.0	0.01	1.1	0.08	0.11	1.72
	B	25.4	34.2	7.96	6.1	0.01	1.14	0.06	0.04	1.69
SS5	S	26.6	33.4	8.08	6.1	0.01	0.54	0.05	0.1	1.15
	M	25.8	33.7	8.04	6.1	0.02	0.62	0.06	0.08	1.22
	B	25.4	33.9	7.98	5.9	0.02	0.68	0.07	0.09	1.29
SS6	S	26.5	33.3	8.07	6.2	0.02	0.46	0.04	0.1	1.08
	M	26.1	33.6	8.04	6.1	0.02	0.5	0.07	0.08	1.10
	B	25.6	34.0	7.99	5.9	0.02	0.56	0.07	0.05	1.13
SS7	S	26.6	12.5	7.15	0.8	0.2	7.42	8.7	9.7	17.8

Contd…

Station	Water Depth	Total suspended solid (mg/l)	Turbidity (NTU)	BOD (mg/l)	COD (mg/l)	Chloride as Cl (mg/l)	Calcium as Ca (mg/l)	Magnesium as Mg (mg/l)	Total Hardness as $CaCO_3$ (mg/l)
SS1	S	24.0	17.8	32	85.2	6975	220	456	2425
SS2	S	30.8	22.6	34	92.9	10899	230	456	2450
SS3	S	34.8	24.2	24	62.0	13951	240	462	2500
	B	36.6	28.4	26	66.0	14278	230	468	2500
SS4	S	24.0	17.6	2.6	16.6	18256	391	1277	6225
	M	24.0	17.8	2.5	16.2	18420	411	1271	6250
	B	25.2	18.8	2.3	15.8	18638	421	1271	6275
SS5	S	16.4	11.8	1.4	14.4	18202	401	1265	6200
	M	17.8	12.2	1.6	16.0	18365	411	1283	6300
	B	18.2	12.5	1.8	18.2	18474	411	1283	6300
SS6	S	16.0	11.0	1.6	14.2	18147	411	1283	6300
	M	16.4	11.5	1.8	16.4	18311	421	1277	6300
	B	17.6	11.8	2.0	18.2	18529	421	1277	6300
SS7	S	31.8	23.4	42	104	6812	250	468	2550

Table 3.23. Concentration of heavy metals in Puducherry coastal waters in March 2019

Station	Water Depth	Cadmium as Cd (µg/l)	Chromium as Cr (µg/l)	Lead as Pb (µg/l)	Arsenic as As (µg/l)	Mercury as Hg (µg/l)
SS1	S	5.73	4.79	<0.1	21.7	<0.1
SS2	S	5.06	4.66	<0.1	17.1	<0.1
SS3	S	1.98	4.72	<0.1	15.1	<0.1
	B	1.86	4.64	<0.1	14.9	<0.1
SS4	S	3.12	3.95	<0.1	36.4	<0.1
	M	3.08	3.89	<0.1	36.1	<0.1
	B	3.05	3.86	<0.1	36.3	<0.1
SS5	S	1.16	4.32	<0.1	35.9	<0.1
	M	1.12	4.24	<0.1	35.4	<0.1
	B	1.08	3.98	<0.1	35.8	<0.1
SS6	S	0.81	3.86	<0.1	35.5	<0.1
	M	0.78	3.98	<0.1	35.1	<0.1
	B	0.80	4.05	<0.1	35.7	<0.1
SS7	S	0.96	4.03	<0.1	15.0	<0.1

Table 3.24. Comparison of physico-chemical properties of clear water and turbid water

Parameters	Turbid water (SS1 to SS3 & SS7)	Clear water (SS4 to SS6)
Temperature (°C)	25.9 – 26.7	25.4 – 26.6
pH	7.15 – 7.26	7.96 – 8.08
Salinity (PSU)	12.5 – 26.2	33.3 – 34.2
Turbidity (NTU)	17.8 – 28.4	11.0 – 18.8
TSS (mg/l)	24 – 36.6	16 – 25.2
DO (mg/l)	0.8 – 4.0	5.9 – 6.2
Calcium as Ca (mg/l)	220 - 250	391 – 421
Magnesium as Mg (mg/l)	456 - 468	1265 – 1283
Total Hardness as $CaCO_3$ (mg/l)	2425 - 2550	6200 – 6300
Chloride as Cl^- (mg/l)	6812 – 14278	18147 - 18638
Ammoniacal Nitrogen as NH_3 (mg/l)	1.95 – 9.7	0.04 – 0.18
Nitrite as NO_2 (mg/l)	0.2 – 0.6	0.01 – 0.02
Nitrate as NO_3 (mg/l)	7.42 – 8.24	0.46 – 1.14
Total Nitrogen as N (mg/l)	11.0 – 17.8	1.08 – 1.72
Phosphorus as PO_4 (mg/l)	1.93 – 8.7	0.04 – 0.08
Arsenic as As (µg/l)	14.9 – 21.7	35.1 – 36.4
Cadmium as Cd (µg/l)	0.96 – 5.73	0.78 – 3.12
Chromium as Cr (µg/l)	4.03 – 4.79	3.86 – 4.32
Lead as Pb (µg/l)	<0.1	<0.1
Mercury as Hg (µg/l	<0.1	<0.1

Table 3.25. Seabed Sediment size distribution in Puducherry coastal waters in March 2019

Station	Classification of Sediment	D_{50} mm	Coarse sand %	Medium sand %	Fine sand %	Slit & Clay %
SS1	Fine sand	0.20	12.6	13.2	70.7	3.5
SS2	Fine Sand with Medium sand	0.23	13.0	26.1	56.5	4.4
SS3	Fine sand	0.17	0.3	1.1	98.0	0.6
SS4	Medium sand with fine sand	0.32	25.2	27.6	46.8	0.5
SS5	Medium sand with very fine sand	0.26	6.4	26.5	66.3	0.8
SS6	Fine sand	0.17	10.5	10.0	76.0	3.4
SS7	Fine sand	0.13	3.4	3.1	86.8	6.7

Table 3.26. Seabed sediment quality parameters in Puducherry coastal waters in March 2019

Station	Total Organic Carbon (%)	Total Nitrogen (µg/g)	Total Phosphorus (µg/g)	Calcium Carbonate (%)
SS1	6.1	384	54.0	7.7
SS2	6.5	420	53.1	6.7
SS3	0.6	96	41.0	3.5
SS4	0.6	102	13.7	13.7
SS5	0.7	112	11.3	14.2
SS6	0.7	98	17.1	20.2
SS7	7.2	446	52.6	7.2

Table 3.27. Concentration of heavy metals in seabed sediments in Puducherry coastal waters in March 2019

Station	Heavy metals (µg/g)			
	Cadmium as Cd	Mercury as Hg	Lead as Pb	Chromium as Cr
SS1	<0.1	<0.1	15.5	195
SS2	<0.1	<0.1	12.9	104
SS3	<0.1	<0.1	2.25	59
SS4	<0.1	<0.1	2.35	33
SS5	<0.1	<0.1	2.62	41
SS6	<0.1	<0.1	2.62	37
SS7	<0.1	<0.1	1.79	31

Table 3.28. Primary productivity in Puducherry coastal waters in March 2019

Station	Gross primary productivity	Net primary productivity	Primary production (mgC/m^3/day)
SS1	1.1	0.7	264
SS2	1.2	0.8	288
SS3	1.4	0.8	336
SS4	1.6	1.0	384
SS5	1.9	1.1	456
SS6	1.8	1.0	432
SS7	1.4	0.9	336
Average			357

Table 3.29. Phytoplankton species composition (nos.) in Puducherry coastal waters in March 2019

Sl. No.	Species	Stations						
		SS1	SS2	SS3	SS4	SS5	SS6	SS7
Phylum: Heterokontophyta								
Class: Bacillariophyceae (Diatoms)								
Order: Centrales								
1	*Bacteriastrum hyalinum*	-	-	+	-	+	+	-
2	*Bellerochea malleus*	+	-	+	-	+	+	-
3	*Chaetoceros* sp.	-	+	-	+	+	-	-
4	*Chaetoceros affinis*	+	-	+	+	-	+	+
5	*Chaetoceros diversum*	-	+	-	+	+	+	-
6	*Coscinodiscus centralis*	+	+	+	+	+	+	+
7	*Coscinodiscus marginatus*	-	+	+	+	+	+	-
8	*Coscinodiscus radiatus*	-	-	+	+	+	+	-
9	*Ditylum brightwellii*	+	-	+	+	+	-	+
10	*Hemidiscus hardmannianus*	-	-	+	-	+	-	-
11	*Leptocylindrus* sp.	+	+	-	+	+	+	+
12	*Odontella mobiliensis*	+	+	+	+	+	+	+
13	*Odontella sinensis*	-	+	-	+	+	+	-
14	*Planktoniella sol*	-	-	+	-	+	-	+
15	*Rhizosolenia* sp.	+	-	+	+	-	+	+
16	*Rhizosolenia alata*	+	+	+	+	+	-	+
17	*Rhizosolenia robusta*	-	+	-	+	+	+	+
18	*Skeletonema costatum*	-	+	+	-	+	+	+
19	*Thalassiosira subtilis*	+	-	+	-	+	+	-
20	*Triceratium* sp.	-	-	-	+	-	+	-
	Sub total	9	10	14	14	17	15	10
Order: Pennales								
21	*Asterionella glacialis*	-	+	+	-	+	-	+
22	*Bacillaria* sp.	+	-	+	+	-	+	-
23	*Gyrosigma* sp.	-	-	-	+	+	+	-
24	*Navicula* sp.	+	+	-	+	+	+	+
25	*Nitzschia* sp.	-	-	+	-	+	+	-
26	*Nitzschia longissima*	+	+	+	+	+	-	+
27	*Pleurosigma* sp.	-	-	+	-	+	+	-
28	*Pleurosigma directum*	-	+	-	+	-	+	+
29	*Pleurosigma elongatum*	+	+	+	-	+	-	-
30	*Thalassionema nitzschioides*	+	-	+	+	+	+	+
31	*Thalassiothrix frauenfeldii*	-	+	+	+	+	+	-
	Sub total	5	6	8	7	9	8	5
Class: Dinophyceae (Dinoflagellates)								
32	*Ceratium furca*	+	-	+	-	+	+	+
33	*Ceratium fusus*	-	+	+	+	+	+	+
34	*Ceratium macroceros*	+	-	+	-	+	-	-
35	*Ceratium tripos*	+	+	+	+	+	-	-
36	*Dinophysis* sp.	-	-	+	+	+	+	-
37	*Dinophysis caudata*	-	+	-	+	+	+	+
38	*Dinophysis schuttii*	-	-	+	-	+	+	-
39	*Prorocentrum micans*	+	-	-	+	-	+	-
40	*Protoperidinium divergens*	-	+	+	-	+	+	+
41	*Peridinium oceanicum*	-	+	-	+	+	+	-
	Sub total	4	5	7	6	9	8	4
Class: Cyanophyceae								
42	*Chlorella marina*	-	-	-	+	+	+	-
43	*Trichodesmium erythraeum*	+	+	+	+	+	+	+
	Sub total	1	1	1	2	2	2	1
	Total	**19**	**22**	**30**	**29**	**37**	**33**	**20**

Table 3.30. Numerical abundance of Phytoplankton (nos./l) in Puducherry coastal waters in March 2019

Sl. No.	Genus/ species	Stations							Total	%
		SS1	SS2	SS3	SS4	SS5	SS6	SS7		
Phylum: Heterokontophyta										
Class: Bacillariophyceae (Diatoms)										
Order: Centrales										
1	*Bellerochea malleus*	300	-	400	-	600	600	-	1900	2.2
2	*Chaetoceros* sp.	-	300	-	600	1000	-	-	1900	2.2
3	*Chaetoceros affinis*	200	-	400	500	-	500	300	1900	2.2
4	*Coscinodiscus centralis*	400	600	500	800	1600	1200	400	5500	6.4
5	*Coscinodiscus marginatus*	-	300	400	600	1000	1000	-	3300	3.8
6	*Coscinodiscus radiatus*	-	-	300	500	800	800	-	2400	2.8
7	*Ditylum brightwellii*	200	-	200	400	-	400	300	1500	1.7
8	*Hemidiscus hardmannianus*	-	-	200	-	600	-	-	800	0.9
9	*Leptocylindrus* sp.	300	300	-	500	500	600	300	2500	2.9
10	*Odontella mobiliensis*	500	400	500	800	1000	500	400	4100	4.8
11	*Odontella sinensis*	-	300	-	400	600	600	-	1900	2.2
12	*Planktoniella sol*	-	-	300	-	600	-	300	1200	1.4
13	*Rhizosolenia* sp.	300	-	300	500	-	500	400	2000	2.3
14	*Rhizosolenia alata*	1000	1200	1100	1500	1400	1600	600	8400	9.8
15	*Rhizosolenia robusta*	-	300	-	600	-	600	400	1900	2.2
16	*Skeletonema costatum*	-	400	300	-	500	500	300	2000	2.3
17	*Thalassiosira subtilis*	300	-	200	-	400	400	-	1300	1.5
18	*Triceratium* sp.	-	-	-	500	-	300	-	800	0.9
	Subtotal	3500	4100	5100	8200	10600	10100	3700	45300	52.7
Order: Pennales										
19	*Asterionella glacialis*	-	400	300	-	600	-	400	1700	2.0
20	*Bacillaria* sp.	300	-	200	500	-	500	-	1500	1.7
21	*Navicula* sp.	400	500	-	400	800	600	400	3100	3.6
22	*Nitzschia* sp.	-	-	300	-	700	500	-	1500	1.7
23	*Nitzschia longissima*	300	400	200	600	-	400	400	2300	2.7
24	*Pleurosigma* sp.	-	-	300	-	600	600	-	1500	1.7
25	*Pleurosigma directum*	-	300	-	400	-	500	400	1600	1.9
26	*Pleurosigma elongatum*	300	400	200	-	600	-	-	1500	1.7
27	*Thalassionema nitzschioides*	400	-	300	500	600	600	400	2800	3.3
28	*Thalassiothrix frauenfeldii*	-	300	400	400	700	500	-	2300	2.7
	Subtotal	1700	2300	2200	2800	4600	4200	2000	19800	23.1
Class: Dinophyceae (Dinoflagellates)										
29	*Ceratium furca*	400	-	300	-	600	600	400	2300	2.7
30	*Ceratium fusus*	-	400	200	500	600	500	400	2600	3.0
31	*Ceratium macroceros*	300	-	200	-	500	-	-	1000	1.2
32	*Ceratium tripos*	400	300	300	500	-	400	-	1900	2.2
33	*Dinophysis caudata*	-	300	-	400	600	600	300	2200	2.6
34	*Dinophysis schuttii*	-	-	300	-	500	500	-	1300	1.5
35	*Prorocentrum micans*	300	-	-	500	-	400	-	1200	1.4
36	*Protoperidinium divergens*	-	400	200	-	700	500	-	1800	2.1
	Subtotal	1400	1400	1500	1900	3500	3500	1100	14300	16.6
Class: Cyanophyceae										
37	*Chlorella marina*	-	-	-	500	700	600	-	1800	2.1
38	*Trichodesmium erythraeum*	600	600	400	700	1000	800	600	4700	5.5
	Total	**600**	**600**	**400**	**1200**	**1700**	**1400**	**600**	**6500**	**7.6**
	No. of species	**7200**	**8400**	**9200**	**14100**	**20400**	**19200**	**7400**	**85900**	**100.0**

Table 3.31. Abundance of Zooplankton (nos./100 m^3) in Puducherry coastal waters in March 2019

Sl. No.	Genus/Species	Stations							Total	%
		SS1	SS2	SS3	SS4	SS5	SS6	SS7		
Phylum: Protozoa										
Order: Tintinnids (Ciliate groups)										
1	*Dictyocysta* sp.	4815	2714	-	4644	2874	4926	2628	22601	3.4
2	*Favella* sp.	-	4071	4511	3096	4310	6568	-	22556	3.4
3	*Tintinnopsis* sp.	5031	-	3008	-	-	1642	-	9681	1.5
Phylum: Chaetognatha										
4	*Sagitta* sp.	-	-	3008	4644	5747	4926	-	18325	2.8
Phylum: Polychaeta										
5	Polychaete larvae	-	-	-	1548	-	3284	-	4832	0.7
Phylum: Mollusca										
6	Bivalve veliger larvae	2516	1357	-	4644	2874	4926	1314	17630	2.7
7	Gastropods veliger larvae	-	-	3008	3096	-	-	-	6103	0.9
Phylum: Athropoda										
Class: Crustacea										
Order: Copepoda										
Sub-order: Calanoida										
8	*Acartia danae*	-	5427	7519	12384	8621	8210	3942	46103	6.9
9	*Acartia erythraea*	6289	-	4511	7740	5747	6568	2628	33484	5.0
10	*Acartia spinicauda*	-	5427	6015	-	7184	9852	-	28479	4.3
11	*Acrocalanus* sp.	5031	4071	6015	7740	5747	8210	5256	42071	6.3
12	*Calanopia minor*	-	5427	-	4644	-	4926	-	14997	2.3
13	*Centropages furcatus*	5031	-	4511	4644	7184	4926	3942	30239	4.5
14	*Eucalanus elongatus*	-	2714	-	3096	5747	-	2628	14185	2.1
15	*Labidocera* sp.	-	-	3008	-	4310	6568	2628	16514	2.5
16	*Labidocera acuta*	-	4071	-	4644	5747	4926	-	19388	2.9
17	*Paracalanus parvus*	3774	-	3008	6192	-	6568	3942	23483	3.5
18	*Pontella* sp.	-	-	1504	-	2874	4926	2628	11932	1.8
19	*Temora discaudata*	3774	2714	-	3096	4310	-	3942	17836	2.7
20	*Temora tubinata*	-	4071	3008	4644	5747	4926	-	22395	3.4
21	Copepod nauplii	2516	-	1504	3096	4310	6568	2628	20622	3.1
Sub-order: Cyclopoida										
22	*Corycaeus danae*	3774	2714	-	3096	4310	4926	2628	21448	3.2
23	*Corycaeus catus*	-	2714	3008	-	2874	6568	3942	19105	2.9
24	*Oithona* sp.	5031	-	-	4644	-	4926	-	14602	2.2
25	*Oithona brevicornis*	-	4071	4511	3096	4310	8210	-	24198	3.6
26	*Oithona similis*	3774	-	3008	-	4310	-	2628	13720	2.1
27	*Oncaea venusta*	-	-	-	1548	2874	4926	-	9348	1.4
Sub-order: Harpacticoida										
28	*Macrosetella* sp.	3774	-	3008	1548	2874	-	-	11203	1.7
29	*Microsetella* sp.	-	1357	-	-	1437	3284	2628	8706	1.3
30	*Euterpina* sp.	5031	2714	1504	4644	-	4926	3942	22761	3.4
Other Crustaceans										
31	Brachyuran zoea	-	2714	1504	3096	1437	3284	2628	14662	2.2
32	Crustacean nauplii	2516	-	-	-	2874	4926	3942	14258	2.1
33	Shrimp larvae	-	1357	3008	1548	-	4926	-	10838	1.6
34	*Lucifer* sp.	-	-	1504	3096	4310	3284	-	12194	1.8
Phylum: Chordata										
35	Fish larvae	-	2714	-	3096	4310	-	2628	12748	1.9
36	*Oikopleura* sp.	2516	-	1504	1548	2874	3284	-	11725	1.8
Total		**65193**	**62415**	**76692**	**114551**	**122126**	**160920**	**63075**	**664972**	**100.0**
No. of species		**16**	**19**	**23**	**28**	**28**	**30**	**20**	-	-
Biomass (ml/100m^3)		**36.9**	**31.2**	**42.1**	**51.1**	**57.5**	**73.9**	**26.3**	-	-

Table 3.32. Subtidal and Intertidal benthic population (nos./m^2) in Puducherry coastal waters in March 2019

Sl. No.	Groups	Subtidal benthos (nos./m^2)							Intertidal benthos (nos./m^2)		
		SB1	SB2	SB3	SB4	SB5	SB6	SB7	IB1	IB2	IB3
Phylum: Annelida											
Class: Polychaeta											
1	Family: Pilargidae *Ancistrosyllis* sp.	-	-	80	120	40	80	-	-	-	-
2	Family: Cossuridae *Cossura* sp.	80	-	-	80	40	-	-	-	-	-
3	Family: Dorvilleidae *Dorvillea* sp.	-	80	-	-	80	80	-	-	-	-
4	Family: Glyceridae *Glycera* sp.	-	-	-	-	-	120	-	-	-	-
5	Family: Nereididae *Perinereis* sp.	-	-	80	-	80	80	-	-	-	-
6	Family: Spionidae *Prionospio* sp.	80	120	-	80	-	-	80	45	30	45
7	Family: Nephtyidae *Nephtys* sp.	-	-	-	40	80	80	-	-	-	-
8	Family : Capitellidae *Capitella capitata*	-	-	80	-	-	-	40	45	60	45
9	Family : Pisionidae *Pisione indica*	120	80	-	-	-	-	120	75	45	60
10	Unidentified polychaetes	80	40	120	80	80	80	80	-	-	-
Phylum: Arthropoda											
Class: Crustacea											
11	Amphipods	80	80	80	80	120	80	40	45	60	45
12	Isopods	-	40	-	40	40	40	-	30	-	30
13	*Emerita asiatica*	-	-	-	-	-	-	-	60	45	60
Phylum: Mollusca											
Class: Gastropoda											
14	*Oliva oliva*	-	-	-	80	-	-	-	-	-	-
15	Unidentified gastropods	80	40	80	40	80	40	40	-	-	30
Class: Bivalvia											
16	*Anadara rhombea*	-	-	-	80	40	80	-	-	-	-
17	*Cardita* sp.	-	-	-	-	80	-	-	-	-	-
18	*Donax* sp.	-	-	80	40	-	-	-	30	-	30
19	*Meretrix casta*	80	-	80	-	-	-	80	-	-	-
20	*Meretrix meretrix*	40	80	-	-	-	-	40	-	-	-
21	*Scapharca* sp.	-	-	-	120	-	80	-	-	-	-
	Total	**640**	**560**	**680**	**880**	**760**	**840**	**520**	**330**	**240**	**345**

Table 3.33. Bacterial population in seawater (x10^3 CFU/ml) in Puducherry coastal waters in March 2019

Media	Type of Bacteria	Stations						
		SS1	SS2	SS3	SS4	SS5	SS6	SS7
Nut Agar	TVC	6.23	6.56	6.36	6.34	6.21	6.11	6.66
Mac Agar	TC	0.83	0.86	0.74	0.72	0.67	0.62	0.81
Mac Agar	ECLO	0.19	0.20	0.17	0.16	0.17	0.16	0.18
XLD Agar	SHLO	0.11	0.09	0.08	0.06	0.07	0.06	0.09
XLD Agar	PKLO	0.18	0.16	0.14	0.15	0.13	0.12	0.17
TCBS Agar	VLO	0.41	0.43	0.37	0.35	0.30	0.33	0.40
TCBS Agar	VPLO	0.15	0.13	0.11	0.12	0.11	0.10	0.16
TCBS Agar	VCLO	0.08	0.09	0.08	0.07	0.06	0.06	0.08
CET Agar	PALO	0.02	0.03	0.02	0.02	0.01	0.01	0.04

TVC-Total Viable Counts; TC-Total Coliforms; ECLO-Escherichia coli like organisms; SHLO-Shigella like organisms; PKLO-Proteus klebsiella like organisms; VLO-Vibrio like organisms; VPLO- Vibrio parahaemolyticus like organisms; VCLO-Vibrio cholerae like organisms; PALO- Pseudomonas aeruginosa like organisms.

Table 3.34. Bacterial population in seabed sediments (x10^4 CFU/g) in Puducherry coastal waters in March 2019

Media	Type of Bacteria	Stations						
		SB1	SB2	SB3	SB4	SB5	SB6	SB7
Nut Agar	TVC	6.46	6.78	6.66	6.41	6.32	6.25	6.54
Mac Agar	TC	0.86	0.84	0.76	0.74	0.70	0.64	0.83
Mac Agar	ECLO	0.21	0.23	0.19	0.17	0.18	0.17	0.20
XLD Agar	SHLO	0.12	0.10	0.09	0.07	0.07	0.05	0.10
XLD Agar	PKLO	0.19	0.15	0.16	0.16	0.14	0.13	0.18
TCBS Agar	VLO	0.42	0.44	0.38	0.37	0.32	0.34	0.41
TCBS Agar	VPLO	0.16	0.14	0.12	0.13	0.10	0.11	0.17
TCBS Agar	VCLO	0.09	0.08	0.09	0.08	0.07	0.07	0.09
CET Agar	PALO	0.03	0.02	0.03	0.02	0.02	0.01	0.05

TVC-Total Viable Counts; TC-Total Coliforms; ECLO-*Escherichia coli* like organisms; SHLO-*Shigella* like organisms; PKLO-*Proteus klebsiella* like organisms; VLO-*Vibrio* like organisms; VPLO- *Vibrio parahaemolyticus* like organisms; VCLO-*Vibrio cholerae* like organisms; PALO- *Pseudomonas aeruginosa* like organisms.

Table 3.35. Fisheries statistics of Puducherry (2016 – 17)

Sl. No.	Details	Puducherry UT
1	Coastal Length (km)	45
2	Fishing Villages	
	(a) Marine	39
	(b) Inland	11
	(c) Total	50
3	Population	94058
	Male (56%)	52672
	Female (44%)	41386
4	Fishermen Families	21601
5	Fishing Crafts	
	(a) Wooden Mechanised Boats	334
	(b) Steel Mechanised Boats	285
	(c) FRP Mechanised Boats	368
	(d) FRP Cattamaram motorized	1467
	(e) Wooden Cattamaram with OBM	113
	(f) Wooden Cattamaram without OBM	1068
	(g)Total	3645
6	Fishermen Co-operative Societies	
	(a) Apex	1
	(b) Central	1
	(c) Primary Fishermen Societies	43
	(d) Primary Fisherwomen Societies	21
	(e)Total	66
7	Members Enrolled in FCS	59745
8	Minor Fishing Harbour	3

Table 3.36. Species-wise marine fish landing at Puducherry for the year 2018

Sl. No.	Species	Quantity (tonnes)
1	Pompano	78
2	*Hilsa ilisha* (Tenualosa)	82
3	Flatfish (Soles)	217
4	Sea catfishes	384
5	Lizard fishes	529
6	*Muraenosox* spp. (Eels)	7
7	*Lactarius* sp. (Parava)	162
8	*Leiognathus* sp. (Silver bellies)	967
9	Sciaenidae (Croackers)	209
10	*Upeneus* spp. (Goat fish)	70
11	*Lates* sp. *Lutjanus* (Perches)	1381
12	*Hemirhampus* sp. (Half beaks)	38
13	*Exocoetus* (Flying fish)	244
14	*Sphyraena* spp. (Barracudas)	423
15	Mugilidae (Mullets)	470
16	Polynemidae (Indian salmon)	30
17	*Caranx* spp. (Kala bangada)	944
18	Carangidae (Bangada)	88

Sl. No.	Species	Quantity (tonnes)
19	Stromatidae (Butter fish) Pomfrets)	363
20	*Sardinella longiceps* (Indian oil sardine)	1493
21	Engraulidae (Anchovies)	329
22	Other Clupeids	586
23	*Chirocentrus* spp.	8
24	Sardine	1224
25	Ribbonfish	463
26	Seer fish (*Scomberomorus* spp.)	816
27	*Auxis thazard,* etc (Frigate & Bullet Tuna)	130
28	*Euthynnus affinis* (Kawakawa)	178
29	*Katsuwonus pelamis* (Skipjack Tuna)	192
30	*Thunnus tonggol* (Long tail Tuna)	62
31	*Rastrelliger kanagurta* (Indian mackerel)	1093
32	Elasmobranchs (Sharks, Rays, Skates)	892
33	Other species (if any)	
a	Thrisoles	340
b	*Chorinemus*	42
c	Elagotis	15
d	Grouper	79
e	Perch like fish	552
f	Red mullets (*Synagris* sp.)	332
34	Other Marine fishes	
a	*Penaeus indicus*	655
b	*Penaeus monodon*	35
35	Non-penaeid prawns	
a	*Metapenaeus dobsoni*	134
36	Cephalopods (a) Squid & Cuttle fish	513
37	*Thunnus albacares* (Yellowfin tuna)	55
38	*Thunnus obesus* (Bigeye Tuna)	45
39	Crustacea (Marine Crustaceans)	578
40	Unspecified (Miscellaneous)	591
Total		18118

4. IMPACTS ASSESSMENT AND MITIGATION MEASURES

The proposed project comprises various activities each of which may have an impact on surrounding environment. The anticipated impacts and mitigation measures due to the project activities during dredging and operation phases are discussed. The impacts have been assessed for the proposed activities assuming that the pollution due to existing activities and nearby sources has already been covered under baseline environment monitoring. The magnitude of adverse impact will be minimum, if appropriate mitigation measures are implemented. Overall, no negative impacts on historic/ cultural heritage are expected. Nevertheless, the proposed project would bring positive impact on land use, people, their living and the economic development of the Puducherry.

4.1. Prediction of impacts

Identification of the impacts associated with proposed activities provides the status of anticipated impact on the environment, the prediction of impact will give the extent to which these conditions can alter the baseline environment conditions. Based on such predictions, appropriate site specific mitigation measures have to be drawn up in order to minimize the negative impact on the environment. Referring to the description of the proposed development and the measured baseline data, the different impacts are analyzed and presented below.

Terrestrial environment	Marine environment
Impact on air quality	Impact due to construction of piles
Impact on water quality	Impact due to dredging
Impact on land and soil quality	Impact due to disposal
Impact due to noise quality	Impact on shoreline changes
Impact on socio economic aspects	Impact on seabed
	Impact on mangroves
	Impact on fisheries and fishermen
	Impact due to storm surge and Tsunami
	Impact due to accidental oil spill

4.2. Impacts and Mitigation

4.2.1. Terrestrial environment

i) Air quality

Prediction of Impact

Construction phase: Activities like movements of construction equipment, earthwork, foundation work etc., will contribute towards dust emission. Significant dust emission are not expected due to construction of barrier. However, site clearance, leveling and grading may be required for the cargo storage. Exhaust emissions from vehicles and construction equipment, barges and dredgers deployed will cause temporary localized increase in levels of gaseous pollutants and suspended particulate matter in the ambient air. These emissions will be for short term and the emissions will cease once the construction phase is completed.

Operation phase: The anticipated impacts on air quality due to port operations are expected from emissions from activities like handling and transportation of cargoes and loading/unloading activities; barge berthing.

Mitigation measures

- Water sprinkling has to be carried out to suppress fugitive dust during earthworks and along unpaved sections of access roads.
- Engines and exhaust systems of all vehicles have to be maintained to keep the exhaust emission under statutory limits.
- Vehicles carrying loose construction material, debris, bulk cargo etc., will be properly covered with tarpaulin sheet to minimize windblown dust during transport.
- All labourers working in dust areas have to be provided with Personnel Protective Equipment as per the industry norms.
- Proper Standard Operating Procedure (SOP) will be in place for efficient port operations Berthing plan should be strictly followed to optimize the berthing hours.
- Vehicles coming for loading/unloading activities shall be screened for valid PUC.
- Mechanized loading/unloading should be provided.
- Periodic monitoring of air quality should be carried out and prompt remedial action will be taken in case deviations from NAAQS are recorded.

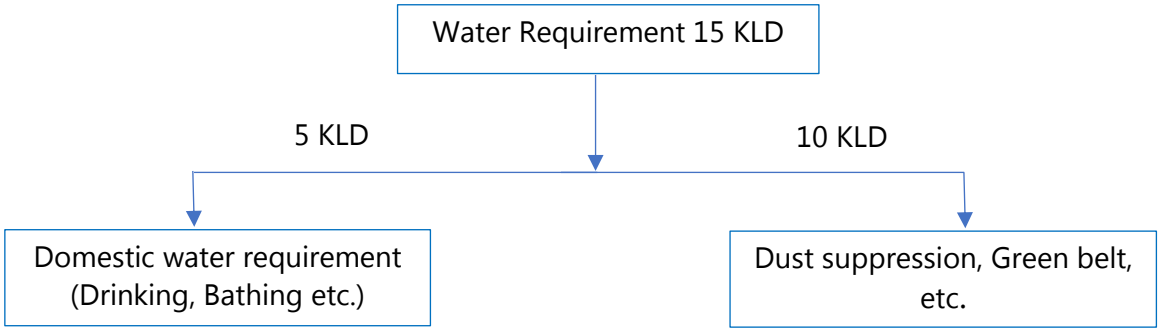
If the above mitigations are implemented, the impacts on air quality due to the construction and operational activities will be minimum.

ii) Water quality

Prediction of Impacts

Construction phase: The water requirement during the construction phase will be around 15 KLD. This water will be sourced from the PWD, if there is a shortfall, it will met with water from water tankers and water suppliers. Water has to be stored in an impervious sump. No ground water will be tapped for the construction work. The runoff from the site containing construction materials, debris, and construction waste and excavated earthen materials may have adverse impacts. Proper sanitation facilities like toilets and bathrooms will be provided for workers. Sewage generated will be treated through septic tanks - soak pit system.

Operation phase: The anticipated impacts on water environment during the operation phase are expected from water consumption and wastewater generation. For domestic purpose water requirement for the proposed project will be 15 KLD.



Water Balance Diagram

Mitigation

- Water wastage during construction phase can be prevented by promoting awareness among workers,
- Use of bio-toilets or portable/temporary STP may be considered if septic tank and soak pit system is found to be not feasible, or existing underground drainage system can be used.
- Adequate number of the dustbins/ garbage box will be provided during the construction phase,
- Usage of non-reusable plastics will be discouraged with in the port area,
- Site drainage should be planned in such a way to prevent any water logging during the construction phase,
- No discharge of untreated wastewater into water body or land should be permitted,
- Wastewater from barges will be handled as per MARPOL 73/78 Convention. Oily waste such as bilge, spent oil etc., will not be released to the sea. There will be provision of a tank on board to store this waste which will be periodically evacuated at the berth, stored in covered containers and given to recyclers. Likewise, MSW will be stored in bins on board and unloaded at berth for further disposal.
- Proper SOP will be devised for cargo handling at berth including the weather window within which the operations can be safely performed.

iii) Land and soil quality

Prediction of Impact

Construction phase: Some impacts on land / soil quality due to construction activities are anticipated from site preparation and solid and hazardous waste handling and spillages. The site preparation activity involves clearing of land from all hindrances and leveling the ground.

There may be soil erosion by the runoff of water due to various project activities. The disposal of sandy dredged material may affect soil quality at the beach nourishment sites if the sand is contaminated. The spillage of construction materials and non-reusable plastics bags, packing material, left-over construction debris etc., can significantly affect the soil quality in the absence of proper mitigation.

Operation phase: Anticipated impacts on land environment associated with operations are mainly associated with spillage of fuel oil and lubricants, spillage during cargo handling, storage, waste management and disposal activities.

The other source of land pollution can be the solid waste generated from the port such as MSW which if not properly collected and disposed would cause environmental degradation. The garbage shall be disposed to the Municipal solid waste disposal site. Spillage of fuel oil and lubricants will be collected in the trench and will be stored along with the waste oils.

Mitigation

- The construction waste may pose impacts on land environment by contamination of soil and hence the possibility of using these wastes for PCC works, road construction etc., will be explored. Left-over material will be sent to the authorized dump site.

- Fuels, paints and lubricants shall be stored at designated covered place with containment and concrete floor to prevent ground contamination and restrict spill within the enclosure.

- MSW from labour camp and garbage will be collected in designated bins which will be periodically evacuated and handed-over to Puducherry Municipality for disposal.

- Waste from barges will be collected and properly disposed as per MARPOL convention,

- The ground will be levelled and compacted and strengthened with green belt development as proposed to restrict soil erosion and improve overall greenery in the port premises.

- Usage of non-reusable plastics will be discouraged in the port area,

- Hazardous wastes will be collected and stored in closed containers at identified areas at site with containment and on concrete floor. Disposal of hazardous waste will be done as per the Hazardous Waste Management Rule,2016,

- There will be a need for disposal of solid waste from the labour camp if set up for construction activities. Construction waste shall be disposed as per Construction and Demolition Waste Management Rules, 2016.

iv) Noise quality

Prediction of Impact

Construction phase: The anticipated impacts on ambient noise quality due to construction phase are expected from construction equipment, vehicle movement, running machinery etc. The impacts can be minimized by selecting proper equipment, proper maintenance of vehicles and lubrication of equipment and machineries. The construction activities such as transportation of raw materials for civil works, construction machinery, are likely to cause increase in the ambient noise levels marginally and locally. As the construction activity will be confined to existing port area the noise outside the port is unlikely to increase. The impact will be localized, short term and reversible in nature. It will be ensured that the workers deployed in high noise areas are provided personal protective equipment such as ear plugs.

Operation phase: The anticipated impacts on the noise environment are expected due to proposed project activities like operation of barges, vehicular movement, loading/unloading cargoes.

Mitigation

- Appropriate equipment and machineries will be selected to maintain the noise levels below the levels stipulated by Central Pollution Control Board (CPCB),
- Persons exposed to high noise levels will be provided with Personnel Protective Equipment (PPE) and deployment on shifts basis will be adopted,
- Proper lubrication, muffling and modernization of equipment shall be done to reduce the noise;
- Ambient noise level monitoring will be periodically carried out in the port area,
- As there are no major noise generating sources the anticipated impacts on noise environment are found to be insignificant. Moreover, proposed Green belt will be effective in noise attenuation.

v) Socio economic aspects

Prediction of Impacts

Construction phase: No R&R is required for the project since there is no land acquisition and displacement of persons. The anticipated impacts on socio economic aspect are expected from Influx of workers, road traffic etc. Temporary influx of worker is expected during construction phase.

Operational phase: The proposed project activities will provide an opportunity for direct and indirect employment generation due to increase in business/ industrial activities. Impact on employment generation is seen as positive. Separate Budget allocation for CER activities will also improve the socio economics condition of surrounding villages.

Beach nourishment on the northern side of the north breakwater will helps to increase the tourism in the project region which will directly increase the employment opportunity.

Mitigation

- The workers will be sourced locally based on the skill set requirement,
- Need of labour camps if any should be provided with proper sanitation and medical facilities,
- Training and awareness sessions will be conducted by site personnel and contractor to ensure safety during construction,
- Indirect employment opportunities for other professions like drivers, vehicle owners and shopkeepers and
- Employment opportunity for unskilled and semi-skilled workers are anticipated.

4.2.2. Marine environment

The anticipated impact due to piling for drainage barrier cum walkway, dredging required for draft and disposal of dredged material will have an impact on water quality, shoreline, flora and fauna. The major construction work comprises of piling to provide support for walkway and dredging to create adequate depth at berth location for ensuring safe berthing. Impacts during the operational phase would be limited to cargo spillage; unintentional release of solid / liquid wastes to the sea, maintenance dredging and accidental spillage of fuel in the event of accidents such as collision and grounding of vessels.

i) Construction of pile for drainage barrier cum walkway

Impact: Pile driving, deposition of rubble, dredging, sand compaction and other construction work in water cause re-suspension of sediments leading to turbid waters. Re-suspension of sediments in water leads to an increase in the level of suspended solids and in the concentration of organic matter and contaminants such as heavy metals, organics etc., if the sediment being dredged is polluted. Increase in turbidity reduces sunlight penetration which can depress primary productivity.

Construction work disturbs bottom sediments and induces re-suspension, dispersal and eventual settlement of such sediments. In addition, the benthic organisms face considerable stress with their permanent loss at the pile-foot print. However, considering the size of the construction, this loss would be low. Moreover, piles, concrete surfaces, and other similar structures in water would provide substratum for organisms to settle to form new habitats though the species may differ.

One of the major impacts of pile driving is generation of noise and vibration on the marine organisms especially on fishes due to underwater sound pressure waves generated during hammering of the piles. Studies conducted elsewhere (even though limited) clearly indicate that pile driving causes a condition known as "barotraumas" (pathologies associated with exposure to drastic changes in pressure) in fish and mammals in the sea. These include hemorrhage and rupture of internal organs, including the swim bladder and kidneys in fish. Death can be instantaneous, occur within minutes after exposure or occur several days later. Bubble expansion

in blood vessels can cause hemorrhage. The various factors which are known to influence the impact on fish are: (i) Size and force of hammer strike; (ii) Distance from the pile; (iii) Depth of the water around the pile; (iv) Depth of the fish in the water column; (v) Amount of air in the water; (vi)The texture of the surface of the water (size and number of waves on the water surface); (vii) Bottom substrate composition and texture; (viii) Size of the fish; (ix) Species of the fish; (x) Presence of swim bladder; (xi) Physical condition of the fish and (xii) Effectiveness of sound/pressure attenuation technology used to minimize the impacts.

Mitigation: Relatively clean, efficient and safe construction techniques will be adopted for the construction of pile supported bridge. While designing these facilities and constructions the following points will be considered:

i) The technique adopted minimizes stirring up of the bed material in the water body while driving the piles.

ii) The scrap and construction waste materials will not be discarded at the site but collected and transported to the shore for further appropriate disposal. One of the most practical solutions to control the effects of pile driving operations is the use of 'air bubble curtain (ABC)'. Using an ABC will inhibit sound transmission through water due to the reflection and absorption of the sound waves by the small bubbles. The rising curtain of tightly spaced bubbles acts as a damper and can absorb the shock waves. The bubble curtain deployed for the duration of piling activity showed that its use resulted in noise reductions of 50% - 70%. There are other methods such as strobe light fish deterrent systems, rubber or foam bladders wrapped around the pile and large-coverage bubble mats installed on the seafloor which also proved useful to lower the acoustic waves. However, bubble curtain emerged as the most effective one in both performance and cost effectiveness.

In order to limit the damage at initial stage, the disturbance to the bed will be localized to the construction site. Explosives will not be used. The construction materials will be placed one above another by using proper hoisting machineries. There will not be any sudden increase in flow velocity close to the shore, which may otherwise pose hazard for the human beings and fishing boats. The construction of piled bridge will helps to improve the water quality by preventing the discharge of the solid waste into the port waters. The impact due to flooding in the wastewater canal will be minimal and storm water flow will not be affected by constructing the piled bridge.

ii) Dredging

The development includes dredging of the navigational channel and berthing area. Capital dredging will be 0.73 million m^3 and maintenance dredging will be about 0.15 million m^3 per year. It is proposed to use the sandy portion of the dredged material for shoreline management to the north of northern breakwater and the remaining dredged material will be disposed in the designated dumping location at offshore.

Dredging: The seabed around the berthing area and the navigational channel primarily consists of sand and silt and minor segment inside the estuary is clayey. The environmental effects of dredging include: (i) entrainment and removal of benthic organisms, (ii) increased turbidity at the dredging site, (iii) organic matter enrichment, (iv) fish injury associated with

exposure to suspended sediments, (v) decreased dissolved oxygen and (vi) fish behavioral effects due to noise.

Increased turbidity can affect the filter feeding organisms, such as shellfish, through clogging and damaging feeding and breathing organs (gills). Similarly, young fish can be damaged if suspended sediments become trapped in their gills and increased fatalities of young fish have been observed in heavily turbid water. Adult fishes 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. Increases in turbidity results in a decrease in the depth that light is able to penetrate the water column which may affect submerged seaweeds, sea grasses and phytoplankton, the major primary producer in the coastal waters.

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-colonizing animals and the extent of disturbance. In soft sediment environment recovery of animal communities generally occurs relatively quickly and a more rapid recovery of communities has been observed in areas exposed to periodic disturbances. A cursory examination of the literature indicates that the rates of recovery of benthic communities following dredging in various habitats varied greatly (from few weeks to several years). Recovery rates are generally more rapid in highly disturbed sediments that are dominated by opportunistic species compared to stable sand habitats that are dominated by long-lived components with complex biological interactions controlling community structure. In general, the studies conducted elsewhere indicate that the dredging impacts are relatively short term in areas of high sediment mobility. If any heavy metals are present in the seafloor sediment, then they may get released during dredging and increase in the concentration level in the water column. The disposal of dredged material at improper locations may lead to pollution and undesired accumulation of pollutants, if any, in the biota.

When the dredged materials, are disposed at sea they will have a blanketing and smothering effect on the benthic organisms in the immediate disposal site. This blanketing or smothering of benthic animals and plants, may cause stress, reduced rates of growth or reproduction and in the worst case the effects may be fatal. The sensitivity of marine animals and plants to siltation varies greatly.

In important spawning or nursery areas for fish and other animals, dredging can result in smothering eggs and larvae.

The continued disposal of maintenance dredging at disposal sites may prevent the development of stable benthic communities and the partial or complete loss of benthic production is an adverse effect which has to be accepted within regularly used disposal sites.

With the exception of the initial smothering of benthic, communities at the disposal site, which is inevitable, the potential for other effects to possibly occur as a result from disposal operations will be site specific, depending on the characteristics of the dredged material and the hydrodynamic conditions at the disposal site. The finer the material and the greater the energy at the disposal site, the greater the possibility of increased suspended sediments and of far-field effects. However, these far-field effects of turbidity smothering are generally only of high concern in areas of low background levels of suspended solids, but the project site has high background level of suspended solids.

Turbidity: Increase in turbidity results in decrease of light penetration in water column which may eventually affect the mass of phytoplankton which are the major primary producers in the coastal waters.

Removal of Benthic organism: During all dredging operations, the extraction of bottom sediments simultaneously leads to the removal of benthic organism living on the seabed and in the sediments. 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 organism from the excavation site.

The recovery of disturbed habitats following the dredging activity ultimately depends upon the nature of the new sediments reach the dredged site, sources and types of recolonizing animals and the extent of disturbance. In soft sediment environment, the recovery of animal communities generally occurs relatively quick.

Quantification: Average subtidal macrobenthos population density was 697 nos./m^2. Subtidal benthos comprised of about 21 groups. Based on the population density near the project location, the estimated loss of subtidal benthos will be about 697 nos./m^2, due to dredging. Polychaetes and Molluscs are the dominant groups. However, over the period of 6 months to one year, the benthic population will be recolonized.

From the rates of recovery of the benthic fauna following dredging in various habitats in coastal areas, it is reported that recolonization of benthic fauna was observed within 4 weeks to 18 months in mud substratum, while it took 1 to >2 years in sandy/gravel substratum. (*Newell et al., 1998).

Organic matter and nutrients: The release of organic rich sediments during dredging can result in the localized removal of oxygen from the surrounding water. Depending on the location and timing of the dredging, this may lead to the suffocation of marine animals and plants within the localized area or may deter migratory fish or mammals from passing through. However, it is important to stress that the removal of oxygen from water is only temporary, as tidal exchange would quickly replenish the oxygen supply. Therefore, in most cases where dredging is taking place in open coastal waters this localized removal of oxygen has little, if any, effect on marine life. Moreover, the bed sediment at the project site is not unduly enriched in organic carbon. Hence, its suspension in the water column during dredging is unlikely to deplete dissolved oxygen.

General statement about the impact of dredging on the hydrodynamics and geomorphology of a site cannot be made as the effects are site specific. Although all dredging activities can cause some change to the hydrodynamic flow, the magnitude and type of effect will be related to the overall size of excavation compared to the overall size of the system.

Mitigation

- In order to minimize destruction on sub-tidal benthic community while dredging, the dredging will be carried out in controlled manner confined to only navigational channel.

- The turbidity induced during the dredging will be minimized using controlled dredging techniques deploying appropriate dredgers.

- The net enclosures with booms will be placed around the dredging area in order to control the spread of the turbid plume, if required.

- Monitoring of the turbidity and sediment concentration will be carried out periodically.

iii) Disposal

In most cases, sediment re-suspension is likely to cause problem only if it is carried out of the dredging location by currents. Various studies show that, in general, the effects of suspended sediments and turbidity are confined to short term for less than a week on completion of dredging and limited to a region of less than a kilometer from the dredging location. The disposal of dredged sediments may affect the benthic organisms in the offshore. Increase in turbidity results in decrease of light penetration in water column which may eventually affect the mass of phytoplankton which are the major primary producers in the coastal waters.

Mitigation

- It is proposed to use the dredge material for shoreline management, the activity is already in place for protecting the shore from erosion. There will not be major impact due to the shoreline management and after the suitable level obtained the dredge waste will be disposed at designated offshore location.

- When dredged materials are disposed at offshore locations, the dumping will be carried out in sequence over the designated areas at different grids after allowing sufficient time between two dumps. This will help the sediments from the first dump to settle before the second dump commences. This way, the suspended load can be maintained at low level.

- Further to minimize the impacts of dredging and disposal, proper timings will be selected i.e. (i) selection of most favourable points in the tidal cycle to limit the extent of effects. and (ii) avoiding sensitive periods /breeding season for fishes and marine animals.

iv) Shoreline changes

Modelling study was conducted by IITM to assess the changes in shoreline due to the proposed project. The port is located 2 km upstream of the river mouth which will not affect the free flow of water and the seabed sediment movement. The net transport of sediment is about 0.35×10^6 m^3. It is directed towards north. The shoreline evolution conducted for the breakwater construction indicates a trend of erosion on the northern side and accretion on the southern side of the port entrance. The shoreline studies for five years indicated erosion of 250 m and accretion of about 265 m. However, the dredging on the sea floor for deepening the channel will have very minimum impact on the existing characteristics of the shoreline stability.

Mitigation

It is proposed to use the dredge material for nourishment at the intertidal area to the north of northern breakwater. The dumping will be uniformly done and not exceeding the height of 4 m. Hence the proposed beach nourishment will further stabilize the coast.

v) Tidal flat

The project region is devoid of any tidal flats.

vi) Seabed

Due to dredging along the river mouth from the port area, there will be a change in the seabed bathymetry which may alter the nearshore morphology. The modelling study suggests that the dredging has resulted in non-overflow over banks and hence the project location is safe.

Mitigation

- Periodic bathymetry survey will be carried out at nearshore to study the influence of dredging and availability of navigable depth. If the changes in the depth is noted then dredging has to be carried out to maintain the adequate depth for navigational channel.

- Monitoring of shoreline change - 2 km on either side, will be carried out six monthly and protective measures will be taken based on the findings, if required.

vii) Impact on seaweeds and sea grass

The survey indicates that seaweeds are seen on the boulders along the shore, the proposed dredging activity will be confined to only in the navigational channel. Hence, seaweeds will not be disturbed and the existing seaweed community would retain its integrity.

The project region is devoid of sea grass. Hence impact on seagrass does not arise.

viii) Impact on mangroves

Mangroves are seen along the both the banks of the river. The proposed navigational channel has the width of 40 m, the navigational channel route falls within the buffer zone of mangroves. The proposed dredging and construction activity will not cause any damage to the mangrove as there is no construction activity near the mangrove patches and dredging will also be carried out only in the navigational channel.

Considering the worst case scenario, the mangrove may get disturbed due to dredging activity. The total navigational area in the buffer zone is 12,722 m^2. The likelihood of disturbance of mangrove will be 4240 nos. As a measure towards the maintenance of the integrity of the mangrove habitat mangrove afforestation of 3 times amounting 12,740 nos. at suitable sites along the banks of the river or some other places will be undertaken in consultation with Forest Department – Puducherry and Institutes like Puducherry University or Annamalai University.

ix) Impact on corals

There are no corals in the study area. Hence, impact on corals does not arise.

x) Impact on turtles

There is no turtle nesting reported/ occurred within the project site. The shoreline of the project region is protected by seawalls on the northern side, which is not an ideal location for turtle nesting. They do not select the place like rocks on the shore. Turtle nesting was reported within 10 km radius of the project region. Earlier studies have reported the sporadic occurrence of turtle nesting to the southern side of the project region near the coast of Chinnaveerampattinam. This region is well outside the proposed project area. Hence there would be no impact on turtles.

xi) Impact on fisheries

Fishing harbour is located 700 m upstream from the river mouth and it has its own berth and associated infra structure. There is an existing practice of maintenance dredging near the river mouth to maintain the draft. The proposed dredging activity near river mouth is also the existing one in practice and that will not have any impact on fishes and fish catches. Once the channel is deepen, the project will helps to improve the economic growth of the fishermen. Round the clock, the fishermen community can use the navigational channel. Hence, economic loss to the fishermen is not envisaged. Therefore, there will not be any significant impact on fisheries due to the proposed project.

xii) Impact due to storm surge and Tsunami

Storm: Occurrence of storms are frequent in this region mostly during NE monsoon which originate from the Bay of Bengal. It is considered that a storm surge of around 3 m height along the project region for the cyclonic wind speed greater than 150 km/hr is possible.

Tsunami: Occurrence of Tsunami is an extremely rare phenomenon along the Indian coast. The past history shows that the periodicity of occurrence may range from 300 to 500 years. No reliable historical records of occurrence of Tsunami events and their impact along the Indian coast are available because of its exceedingly rare nature. The details are discussed in section 3.2.1.7 in Chapter 3.

Mitigation: Although the impact of Tsunami and storm can be disastrous, the impact can be minimized by adopting the key components of mitigation measures. It is suggested to raise the level of land and shelter belt plantation around the project boundary to prevent any impact from natural hazards. The nature gives the scientific understanding of preparing the energy dissipating obstruction on the shore that can greatly protect the people and property against Tsunami. For manmade emergencies, port should have a Disaster Management Plan which includes Emergency Response Action Plan to tackle any type of contingency such as grounding or collision of vessels, storm surge, fire incidents etc. where in procedures and action plan have been elaborated.

xiii) Accidental oil spill from barge

During towing and berthing of the barge, owing to natural calamity or piloting errors, there can be remote possibility of mishap of one to one barge collusion or barge hitting against the port or ship getting grounded. During such events, the barge may sink/break and lead to oil spill inside the port basin or in the vicinity.

It is difficult to assess the effect of oil in the marine environment because of the large variation in sources, quantities, and nature of the oil, and also the physical, chemical and biological conditions of the environments involved. The majority of research relating to the effects of the oil on the marine environment relates to major oil spill events, usually from shipping accidents and groundings, the environmental effects of which are well documented; particularly on birds and mammals. However, very little literature describes the effects of chronic discharges from run off or numerous small discharges of oil which are common in port and harbour areas.

Some of the potential effects of oil pollution are as follows:

- Marine animals and plants tend to be tolerant of low level concentrations of oil in sediments from chronic or small discharges, however this is not always the case.
- Prolonged exposure to major or minor oil spills can lead to mass mortality of benthic communities, fish, mammals and birds.
- Contamination of sediments with oil may modify chemical, physical and biological processes. Contaminants can be trapped in the sediments and later released as a result of disturbance such as erosion or dredging.
- In sediments oil is broken down relatively quickly by microorganisms which may result in the localized removal of oxygen from sediments and surrounding water with possible effects on marine life.
- The persistent toxic constituents of oil, such as heavy metals, can become stored in the sediments, and taken up into the food chain. Therefore, following large oil spills, even where animals recover in diversity and density, they may continue to suffer physiological and behavioural disorders which can result in reduction in growth and reproduction and in the worst cases, death.
- The breakdown of oil tends to be slowest in intertidal areas, which leads to the highest concentration and long residence times.

Mitigation: Oil Spill Contingency Plan as mandated by the National Oil Spill Disaster Contingency Plan, 2014, (NOS-DCP) will be in place to handle accidental spill. Accordingly, oil spill contingency equipment like boom, skimmer, and dispersant chemicals will be stored. Oil Contingency Team headed by a trained expert will be established and all arrangements will form as an integral part of the specialized team. They will establish coordination with the Indian Coast Guard – the designated national authority for oil spill response in Indian waters.

Reporting of oil spill will be according to the format and structure given in the NOS-DCP. The primary aims of an oil spill response are to protect human health and safety, minimize environmental impacts and to restore the environment as closer as possible to pre-spill conditions.

The environmental impact of an oil spill can be minimized by good management and planning, and by the response actions put into effect by the responsible agency. Such actions will largely depend on several factors viz., the type of oil(s) involved, the size of the spill, the location of the spill, the prevailing sea and weather conditions at the spill site; and the environmental sensitivity of the coastline impacted.

Oil Spill Response Technique has to be planned according to type of accident. Generally, it is done into three phases: (i) Mechanical recovery (normally effective within 6 hrs of the spill), (ii) Application of Dispersants (as per Guidelines of the Indian Coast Guard) and (iii) *In-situ* burning (seldom used because of safety to other infrastructure in the area of incident). The action plan changes according to the quantity of oil spilled as the requirement of handling equipment and vessels may vary. For this purpose, the action plan is divided into two Tiers, i.e. Tier-I where the spill is < 700 ton oil and Tier – II where the spill exceeds 700 ton. In Tier-I the local ports and organizations will normally take the responsibility of controlling spill and recovery of spilled oil. In Tier-II, the responsibility will be with Coast Guard who are equipped with trained manpower and equipment including vessels. The Government of India has established three national oil spill response (OSR) centres at Port Blair, Mumbai and Chennai under the overall control of the Director General, Indian Coast Guard. However, each OSR is under the control of a Regional Commander.

As these action plans are location specific, contingency plans for a particular site are to be developed by Port Authorities and vetted by the Indian Coast Guard. Accordingly, the Port should have necessary handling equipment like booms (Recovery booms, Inshore boom and Offshore booms), recovery skimmers, heavy oil recovery equipment, transfer pumps, dispersant application sets and storages for recovered oil. More importantly trained personnel needed to implement the contingency plan are to be recruited in the company who knows to follow up the procedure/ guidelines set forth by Indian Coast Guard.

- Awareness, training on oil spill and its impacts, contingency plan will be provided to the site personnel,
- Proper maintenance of oil spill equipment will be done, and regular mock drills will be carried out,
- The control room at the proposed berth will have provision and communication system required for Vessel Tracking and Port Management System (VTPMS) to avoid vessel collisions,
- The waste management from vessels will be done as per MARPOL 73/78 as amended, and strict supervision and checks will be kept on vessels for its compliance,

4.3. Summary of observations

The proposed project will have moderate and marginal impacts on both marine and terrestrial environment. The magnitude of adverse impact will be minimum, if appropriate mitigation

measures are implemented. Overall, there are no significant negative impacts on land use, air quality, marine flora and fauna, shoreline, seabed etc. The construction impacts with respect to air, noise, soil and water quality will be temporary in nature and reversible except the loss of benthos at pile footprints and dredging area where it will recolonize within short period of time after completion of dredging operation. There are no R&R issues due to the project. The impacts on social economical aspects are nearly absent. Nevertheless, the proposed project would provide opportunity for increase in business in the surrounding area and employment opportunities.

5. POST PROJECT MONITORING

The post project monitoring is an equally important aspect in Environmental Management Plan. In order to verify the outcome on the implemented mitigation measures and also to assess the effectiveness of proposed mitigation measures, the post project monitoring becomes inevitable. For the proposed expansion project, the existing system in place shall be strengthened.

A continuous review of post project monitoring program will be conducted by the Environment Management Cell (EMP) to identify the effectiveness of mitigation measures suggested.

5.1. Post Project Monitoring Program

Monitoring program is suggested to identify the variation in both terrestrial and marine environment due to operation of port. Monitoring program will be undertaken during the operational phases of the project and it should be repeated at periodic intervals after the commencement of operation. The monitoring will be organized with qualified and experienced environmental team. Standard procedures will be followed in sample collection and analysis. Half yearly monitoring of air quality, noise measurements, surface water quality, seawater quality, seabed sediment and marine ecology is recommended.

Post project monitoring program

Purpose	Parameter	Number of sampling stations	Frequency
Air			
To monitor impacts on Air	PM_{10}, $PM_{2.5}$, SO_x, NO_x, CO and other parameters specified in CTO	3	Twice in a year
Noise			
To monitor impacts on Noise	Leq daytime and night time	3	Twice in a year
Water			
To monitor impacts on Surface and Ground water	Total Alkalinity, Total Hardness, DO, BOD, Total Coliforms, TSS Chloride, Sulphate, pH, Colour, Turbidity, Total dissolved solids, Sulphide, Residual Chlorine and Fluoride.	3	Twice in a year
Soil			
To monitor impacts Soil quality	Measurement of soil pH, EC, salinity and CEC.	3	Twice in a year
Seawater & Sediment quality			
To monitor impacts on seawater and sediment quality.	Seawater: Measurements of levels of pH, Turbidity, Salinity, chloride, DO, BOD, total coliform and fecal coliform residual chloride, Nitrate, Nitrite and Ammonia. Seabed sediments: Total organic carbon, Total Phosphorus, Total	3	Twice in a year

Purpose	Parameter	Number of sampling stations	Frequency
	Nitrogen, Cadmium, Mercury, Lead, Chromium and Phenols		
Plankton			
To determine whether the community structure, habitat has been altered	Population and diversity of Phytoplankton, Population and diversity of zooplankton and Population and diversity of benthic fauna.	3	Twice in a year
Benthos			
To determine whether the community structure, habitat has been altered	Benthic faunal composition and diversity	3	Twice in a year
Shoreline monitoring			
To determine any shoreline, change on either side of the break water	Shoreline monitoring for 2 km on either side of the breakwater	-	Twice in a year

5.2. Review and Reporting

The results of monitoring will be reported to the statutory authorities Puducherry Pollution Control Committee (PPCC) and Regional Office of MoEFCC. Half yearly report should include condition of Environmental clearance and status of compliance. It shall also cover different statutory returns/ compliance reports to be submitted such as:

- Submission of half yearly compliance report in respect of the stipulated prior environmental clearance terms and conditions in soft copy to PPCC and Regional Office of MoEFCC at Chennai on 1st June and 1st December of each calendar year.

- If there is any aberrations is noted, then proper mitigation measures have to implemented as described in Chapter 4.

5.3. Summary of monitoring, review and reporting

The results of monitoring should be evaluated to identify changes if any, beyond the trend identified through baseline studies. The suggested monitoring locations for air quality, seawater and seabed sediments are shown in Figs. 5.1 to 5.3.

6. ADDITIONAL STUDIES

6.1. Risk assessment

Risk is the probability that injury to life or damage to property and the environment will occur. The extent to which risk is either increased or diminished is the result of the interaction of a multitude of causation chains of events. The man-made disasters like fire and accidents also can occur during construction as well as operation phases which would cause the burns, injuries and even loss of human life and property, disrupt services like overhead power and communication lines. Potential impacts due to accidents include injuries and burns which demand surgical interventions, poisoning or exposure to toxic material, trauma and even loss of human life, property damage includes damage/loss of fishing vessels/crafts and other surface vehicles, mechanical devices and equipment used during construction and operational phases. Vessel collision, sinking of boats due to unattended leaks and damages are potential risks. Probability of any hazardous incident and the consequent damage also depend on:

- Wind speed,
- Wind direction, and
- Atmospheric stability, Source of ignition

A hazard represents an event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural losses, damage to the environment, interruption of business, or other types of harm or loss. Earthquakes, floods and wildfire hazards represent the pervasive and primary events that result in disaster losses. Secondary hazards include dam failure, landslide and Tsunami's.

6.2. Disaster Management Plan

Cyclone, Tsunami and Storm surge are the most destructive force among the natural devastations. It causes instant disaster and burial of lives and destruction to entire coastal properties. Puducherry is classified under Seismic Zone II and hence, occurrence of earthquake is not of consequence The damage and loss can be minimized if appropriate preparedness plan is formulated. The following statutory guidelines are recommended by National Disaster Management Authority (NDMA) to minimize the impact due to Cyclone, Tsunami and storm.

- Developing sand dunes along the coast with shrubs or Casuarina trees for stabilization of the sand dunes (Tsunami Mound).

- Raising the ground level (above the design water level) with natural beach sand so as to rehabilitate the coastal region.

- Development of coastal forest (green belt) by planting Casuarina and coconut trees or other native species along the coastline.

- Adopting natural beach nourishment to create steep beach face.

- Creation of sandy ramps at close intervals along the coast.

In addition to the guidelines by NDMA, it is also necessary to adopt various preventive actions in the coastal region of the project site.

6.2.1. Flooding

IITM has prepared separate report on impact due to storm surge and flooding. The report is entitled 'Dredging in the harbour basin and navigational channel PMC for phase I development of Pondicherry Port – studies on flooding and related impact on creek and control area during cyclonic storm' is presented in Annexure IX. The studies concluded that the project area are not overflowing and the dredging would resulted in more depth. The report concludes that the impact due to occurrence of the flooding is low and the location is safe.

6.2.2. Disaster Control/ Response Plan

Disaster may arrive without any warning, unexpectedly in spite of all precautions & preventive measures taken. However, an efficient control/response plan can minimize the losses in terms of property, human lives and damage to the environment can be the minimum. The disasters that can occur in the coastal area are storms, storm surges, tsunami and earthquakes.

The plan should be developed to make best possible use of the resources at the command of the Port as well as outside resources available like Fire Services, Police, Civil Defence, Hospitals, Civil Administration, neighbouring institution and industries.

The objectives of Disaster Management Plan are:

- To contain and control the incident.
- To rescue the victim and treat them suitably in quickest possible time.
- To safeguard other personnel and evacuate them to safer places.
- To identify personnel affected/dead.
- To give immediate warning signal to the people in the surrounding areas in case such situation arising.
- To inform relatives of the casualties.
- To provide authoritative information to news media and others.
- To safeguard important records & information about the organization.
- To preserve damaged records & equipment needed as evidence for any subsequent enquiry.
- To rehabilitate the affected areas.
- To restore the facilities to normal working condition at the earliest.

6.2.3. Preparedness Plan

The preparedness plan shall contain details about: i) warning that should be given ii) Protective measures to contain the effect of surging water level and iii) Other precautionary measures to be taken. The following measures are the key aspects with reference to the project region.

i) Coordination with International and National Agencies,
ii) Vigilant online monitoring, and
iii) Emergency Evacuation.

Coordination with National Agencies

Tsunami waves do not induce high surface elevation in deep ocean and hence their presence is not felt in deep ocean until they reach the shallow water close to coast. If any, potentially significant sea level change is noted following a seismic activity, the data are transmitted acoustically to the surface buoys and relayed by satellites to the warning stations. Computer modelling converts the data into a prediction of potential damages for the use of the members of the network.

National: After the 2004 Tsunami affected the Indian sub-continent, the following organizations are involved on watch and cautioning the government and public in the event of possibility of occurrence of Tsunami. As a part of Tsunami hazard mitigation, warning systems have been established in India by the coordination of the following organizations.

i) National Disaster Management Authority (NDMA), New Delhi.
ii) Indian National Centre for Ocean Information Services (INCOIS), Hyderabad.
iii) Indian Meteorological Department (IMD), New Delhi.

The contact details of International and National agencies are given below:

Organization	Address	Email ID	Contact Number
NDMA	NDMA Bhavan, A-1 Safdarjang Enclave, New Delhi, DL - 110029.	www.ndma.gov.in	+91 - 11 - 26701700
INCOIS	Ocean Valley, Pragathi Nagar (BO), Nizampet (SO), Hyderabad - 500090	www.incois.gov.in	+91 - 40 - 23895002
IMD	Mausam Bhavan, Lodi road, New Delhi, DL - 110033.	www.imd.gov.in	+91- 11 - 24699216
IMD	Regional Meteorological Centre, 50 (New 6) College Road, Chennai - 600 006.	acwctp@gmail.com	044-28271951
District Collector	District Collector Vazhudavoor Road, Pettaiyanchathiram, Puducherry – 605009.	Dcrev.pon@nic.in	0413 2299500 0413-2299502

INCOIS in collaboration with NIOT has deployed DART buoys at 3 locations in the deep ocean along the fault plane of Andaman plate and Indonesian plate.

The online monitoring is capable of raising alarm in case of instantaneous change in surface elevation exceeding centimeter which can be caused by the generation of Tsunami. IMD interacts with the above institutions and takes the responsibility of broadcasting the disaster through various Media. In case of a Tsunami, the warning is usually broadcast based on the earthquake occurred in the nearby ocean. Irrespective of definite occurrence of Tsunami, the possibility to occur is also considered as equally vulnerable and accordingly the warning news is instantly flashed through Radios and TVs. The notification is followed by orders from the local Government Authorities on reinforcing evacuation, prohibition to enter the demarcated risky zone and mobilizing facilities for easier evacuation and augmenting medical facilities.

There are a variety of evacuation notification systems in case of Cyclone, Tsunami and Storm surge. They include sirens, weather radio, Emergency Alert System, Telephones, Emergency Weather Information Network etc. In each system, it should be noted that the application and message is consistent as well as continuous with repetition of messages with periodicity at short time interval. It should be ensured that the warning reaches immediately to all people prone to the devastation.

6.2.4. Vigilant online monitoring

The time at which the cyclone, storm surge or Tsunami may reach the coast can be predicted with sufficient lead time. The destruction can be minimized if the coastal populations are warned and evacuated to elevated place and inland in time. Therefore, keeping vigil on the warning is the very important aspect in protecting the lives. Live contact should be kept with the organizations indicated above transmitting the instant warning on occurrence of cyclone, Tsunami and storm surge. A vigilant team must be created and they should be trained to understand the method of monitoring and the kind of emergency preparedness. The vigilant team must monitor the warning systems around the clock. The training should be given periodically to update the system and methods of warning. The team should take the responsibility of giving immediate warning to the people in and around the port in case of disaster warning and they have to undertake the Emergency Preparedness Action. Safety drills should be conducted periodically. Operational and emergency preparedness procedures should be planned meticulously in order to act on the warning and to disseminate it rapidly and effectively to the public.

6.2.5. Emergency Evacuation

Evacuation of people from risk areas is the first priority when early warning is received or the natural warning sign indicates the immediate arrival of cyclone, Tsunami wave or rise of storm surge.

Evacuation plan describes the time span available before and during the Tsunami or storm surge event. When facing local threat, evacuation procedures most possibly will have the character of a ‘runaway effort’ and people should not expect to receive much institutional support. The primary objective should be bringing as many people as possible out of the reach of the wave’s impact to safe or ‘relatively safe’ areas. Therefore, necessary steps have to be taken in advance to enable and support the community at risk to protect themselves at any time.

6.2.6. Escape routes

The availability of safety zones that can be used as evacuation sites within walking distance must be inspected. People can be evacuated to higher grounds over ten meters in elevation or the deep inland (>1 km) away from coastal inundation area. Good elevated roads should be laid along the escape route to safe places which can be waded even during flooding.

6.2.7. Emergency alarm

An emergency alarm /siren should be in place at the port. In case of emergency when warning is given, the alarm at the port can be instantly activated and the vigilant team including the emergency response team can immediately start the evacuation and rescue operation. All the workers also should be advised to vacate and move to the designated safe places.

6.2.8. Fire-fighting facilities

The Port's fire service will be well equipped to handle all fire emergencies on the shore and on board the vessels. The office of the dock safety inspectorate, which is the regulatory authority to enforce safety, health and welfare of the dock workers, should function at this Port. Fire service at terminal should be functioning throughout the year. One fixed firefighting system needs to be installed at the main berth.

It is proposed to install fire hydrant system, which shall be designed to give adequate fire protection. Fire hydrant system is proposed at the following areas, which are classified as ordinary hazard areas.

a) General/Liquid cargo Jetty area,
b) Container yard area.

Further details about the fire-fighting facilities are given in DPR prepared by IITM

6.2.9. First aid facilities

First aid posts will be provided at the construction site to attend the workers on immediate basis in case of an injury or accident. This first-aid post will have the following facilities:

- First aid box with essential medicines including ORS packets.
- First aid appliances-splints and dressing materials.
- Stretcher, wheel chair, etc.

The first aid box must contain the following:

- 15 small sterilized dressings.
- 8 medium size sterilized dressings.

- 8 large size sterilized dressings.
- 8 large size sterilized burn dressings.
- 8 (15 g) packets sterilized cotton wool.
- 2 (60 ml.) bottle containing a two per cent alcohol solution of iodine.
- 2 (60 ml.) bottle containing sal volatile having the dose and mode of administration indicated on the label.
- 2 rolls of adhesive plaster, a snake-bite lancet.
- 2 (30 g) bottle of potassium permanganate crystals.
- 2 pair scissors.
- 2 copies of the first-aid leaflet issued by the Director General, Factory.
- Advice Service and Labour Institutes, Government of India.
- 2-3 bottles containing 100 tablets (each of 5 grains) of aspirin.
- Ointment for burns.
- 2-3 bottles of a suitable surgical anti-septic solution

6.2.10. Mitigation measures against Tsunami and Storm surge

Bio Shield

It is a general belief that natural formations such as coral reefs, grass beds, coastal vegetation such as mangroves, estuaries and deltas of river mouths and flood plains play an important role in dissipating the forces of Tsunami waves.

A bio-shield formed by planting a vegetation belt along coastlines would protect the region against coastal storms, cyclones and Tsunamis. The plantations could absorb the force of severe storms and Tsunamis, and it could act as a 'carbon sink' by absorbing emissions of the greenhouse gas.

The Coastal front comprises beaches, sand dunes, head lands, creeks/river and rocky cliffs. The coastal vegetation also has a very important role in stabilizing and trapping marine sediments and forming a protective buffer between the land and the sea.

Mangroves: Mangroves are often recognized as the best defenses against wind, waves and erosion by deflecting and absorbing much of the energy of winds hence, Forest department

encourages afforestation of Mangroves. Because of planting suitable species of mangroves along the coastline, during 2004 Tsunami, the fishing hamlets located on the leeward side of the Pitchavaram were totally safe without any traces of Tsunami. Therefore, Port Department may explore the suitability of their location to plant mangroves in consultation with Forest department.

Planting of Casuarinas: *Casuarina equisetifolia* is the most popular farm forestry tree in the coastal lands of Mainland India. The Casuarinas planted along the east-coast protected the region from Cyclone in November, 1999. Planting Casuarinas along the coastal front would provide substantial protection to the project region from the impacts of storm surges and Tsunami. Hence the water level rise during a Tsunami or storm will not have any major impact in this region.

Transplanting vegetation will not prevent the natural process of erosion, but it will accelerate natural recovery after damage. Additional works are often necessary to increase the potential for success. Thatching and beach recycling will assist in the accretion of sand, and will provide minor protection from Tsunami waves and will reduce damage due to trampling. Once grasses are well established, they may well become self-sustaining, although any storm erosion damage will need to be rapidly made good.

6.3. Oil spill contingency plan

India is a party to the United Nations Convention on the Law of the Sea (UNCLOS) and has an obligation to protect and preserve the marine environment. The Forty-second amendment to the Constitution of India obliges the State to endeavour to protect and improve the environment. This plan is a measure of fulfilment of the obligation on the State under the Law of the Sea Convention and the Constitution of India.

Oil spills may occur from ships either accidentally or due to illegal operational discharges. Accidental discharges may involve the escape of bunker fuel or oil cargo resulting from a marine incident. Oil spills may also be caused by accidental discharges from petroleum terminals and facilities and the offshore petroleum exploration and production industry. The threat is largely a function of the types of oil and bunkers and operational issues such as the degree of navigational hazards, the weather and shipping density.

The coast of Tamil Nadu and Puducherry now faces increased threat from oil spill from oil tankers, other cargo ships, port activities, petroleum exploration and exploitation activities, oil refineries etc., on the Puducherry coast and contiguous places. The contingency plan is provided to assist the Port Authority in dealing with an accidental discharge of oil. Its primary purpose is to set in motion the necessary actions to stop or minimize the discharge and to mitigate its effects. Effective planning ensures that the necessary actions are taken in a structured, logical and timely manner. This plan envisages the mutual assistance to respond to the oil spill with movement of equipment and personnel from neighboring ports /terminals.

6.3.1. Response Policy

The primary aim of an oil spill response is to:

- protect human health and safety;

- minimise environmental impacts; and
- restore the environment, as near as is practicable, to pre-spill conditions.

The environmental impact of an oil spill can be minimised by good management and planning, and by the response actions put into effect by the Combat Agency. Such actions will largely depend on several factors:

- the type of oil(s) involved;
- the size of the spill;
- the location of the spill;
- the prevailing sea and weather conditions at the spill site; and
- the environmental sensitivity of the coastline/site impacted.

Levels of Response

Under the NOSDCP, oil pollution preparedness and response requirements are categorized into three 'tiers'. The tiered approach to oil contingency planning identifies resources for responding to spills of increasing magnitude and complexity by extending the geographic area over which the response is coordinated. It provides a convenient categorization of response levels and a practical basis for planning. The NOSDCP recognizes three levels of tiered response.

TIER 1: Tier 1 is concerned with preparedness and immediate response to a small spill within the capabilities of facility operator or port authority. Seven hundred tons will be the upper limit of tier 1; however, the risk assessment of oil pollution and the surrounding environment will determine the required level of response preparedness and reflected in the standard of inventory for ports, oil agencies and Coastal States.

The agencies should have capability to provide first response to oil spill in their areas. The capability includes trained manpower and equipment. In cases where additional resources are required, these will generally be available from the local port authority, or from adjacent industry operators under mutual aid arrangements or locally from the Indian Coast Guard.

TIER 2: Tier 2 is concerned with preparedness and response to a spill that requires the co-ordination of more than one source of equipment and personnel. 'Tier 2' describes a wide range of spill sizes and potential scenarios response assistance for which can come from entities within a port area or from national sources outside the immediate geographic area.

The resources of the Combat Agency will need to be supplemented by other local, regional, and national resources.

TIER 3: Tier 3 is concerned with a major spill requiring the mobilization of all available national resources and depending upon the circumstances, will likely involve mobilization of regional and international systems. It is this tier of response where positive advance customs arrangements are critical to facilitate a successful effort.

The Combat Agency will require local, regional, national and possibly international assistance. International resources will be facilitated by the Statutory Agency through the Ministry of External Affairs.

6.3.2. Statutory and Combat Responsibilities

Responsibilities for responding to oil spills in Indian waters are shared between the Indian Coast Guard, State Governments, Port Authorities and Corporations, and the oil industry. Liability for clean-up of both, oil and Hazardous and Noxious Substances (HNS) spills remains with the polluter.

Statutory Agencies

The Statutory Agency is responsible for the institution of prosecutions and the recovery of cleanup costs on behalf of all participating agencies. The Statutory Agencies for oil spills are given the Table below:

Statutory Agencies for oil spills

Source / Location	Statutory Agency
From ships	The relevant Designated Authority under the Merchant Shipping Act, 1958
From offshore installations and upstream pipelines	The relevant Designated Authority under the Petroleum Act, 1934
From shore terminals, refineries and downstream pipelines	The relevant Designated Authority under the Petroleum and Natural Gas Regulatory Board Act, 2006
In major ports	The relevant Port Authority under the Major Ports Act
In non-major ports	The relevant Designated Authority in the Coastal State, or Union Territory

Combat Agencies for Oil spills

Combat Agencies have the operational responsibility to take action in order to respond to an oil spill in the marine environment in accordance with the relevant contingency plan. The Combat Agency responsible for responding to marine oil spills in various locations is given the following Table.
Combat Agencies for oil spills.

Source / Location	Combat Agency
At oil terminals	The relevant oil company or terminal operator using industry mutual-aid arrangements as required. Should a situation develop where the necessary response is beyond the oil company or terminal resources, or mutual-aid arrangements, responsibility for control will transfer to the Statutory Agency, with response assistance from other National Plan stakeholders as required
In ports	The port operator or responsible State Government authority, with response assistance from other National Plan stakeholders as required
Within shoreline and in intertidal zones	The responsible State Government authority with response assistance from other National Plan stakeholders as required
Beyond baseline	The Ministry of Defense via Indian Coast Guard, with response assistance from other National Plan stakeholders as required. In incidents close to shore when oil is likely to impact the shoreline, the State Government via the Statutory Agency will be the Combat Agency for protecting the coastline, whilst DG Shipping assumes responsibility for ship operational matters, for example, containing the oil within the ship, organizing salvage, etc.

The responsibility for overseeing response action for oil spills, other than those from offshore petroleum operations, is as follows:

- Within shoreline and intertidal zones - the State designated Statutory Agency.
- Beyond baseline - Indian Coast Guard, as the Statutory Agency.

The Combat Agency shall, as soon as possible, undertake preventive and cleanup action or may request another agency to act on its behalf. Regardless of which agency has lead responsibility, other agencies shall assist as far as is practical, in accordance with requests from the Combat Agency. In circumstances where the incident has exceeded, or is likely to exceed, the effective response capacity of the Combat Agency, or the response is not being conducted effectively, the Statutory Agency may assume control of the response.

A response by a Combat Agency and/ or Statutory Agency does not in any way indicate an admission of liability for the source of the spill or for acceptance of the costs of a spill or for cleanup which remains with the polluter. Liability for a spill is to be determined by due legal proceedings. Any response by a Combat Agency and/or Statutory Agency in good faith and any consequences thereof, direct or indirect, shall be immune from proceedings in any court of law in any State.

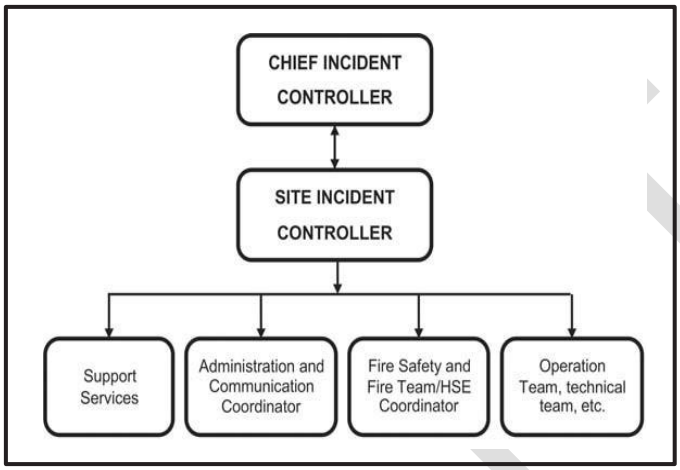
Incident Management Team

The facility oil spill contingency plan (OSCP) shall identify the safe transition from normal operation to emergency operations and systematic shut down, if any, and the delegation of authority from operations personnel to emergency response personnel. For this purpose, persons in charge of sea ports and oil installations shall identify in the facility OSCP an emergency response organization with appropriate individuals to perform designated responsibilities through specified lines of authority with succession planning and actuating the response management in accordance with relevant contingency plan requirements. Responsibilities for decision making shall be clearly shown in an emergency organization chart. The plan shall identify each responder's position, mission, duties and reporting relationship.

Overall objectives of the facility oil spill emergency control organization shall be:

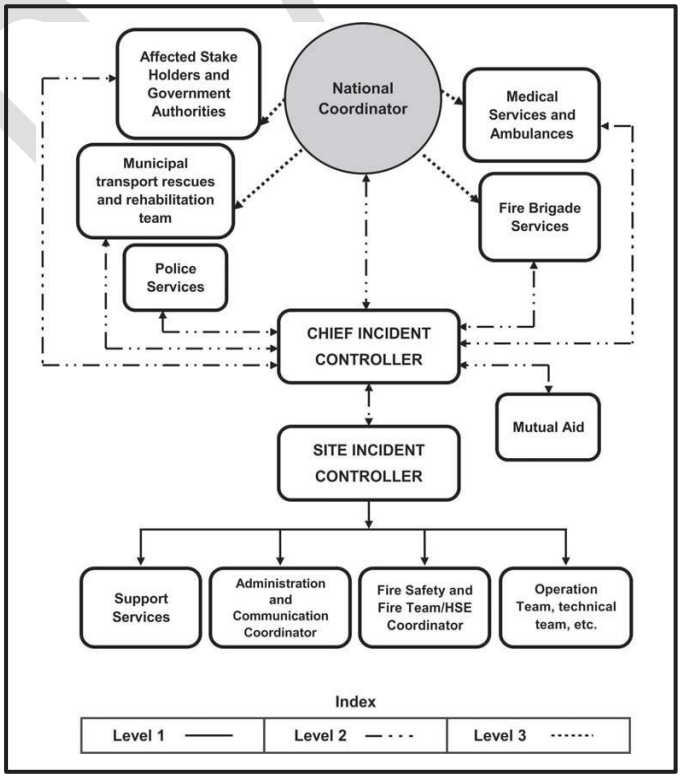
- To promptly control oil pollution problems as they develop at the scene;
- To prevent or limit the impact of oil pollution on other areas and off-site;
- To provide emergency personnel, selected for duties compatible with their normal work functions wherever feasible, with duties and functions assigned making full use of existing organizations and service groups such as fire, safety, occupational health, medical, transportation, personnel, maintenance, and security;
- To provide for employees who must assume additional responsibilities as per laid down procedure of the facility OSCP in the event of oil spill contingency;
- To provide for round-the-clock coverage, with shift personnel being prepared to take charge of the emergency control functions or emergency shutdown of system, if need be, until responsible personnel arrive at the site of emergency; and
- To provide for an alternate arrangement for each function.

The emergency organization shall be based on an incident command system to provide a standardized organisational structure that is flexible yet provides compatibility between agencies and events, whilst ensuring accountability and standardised records. The system clearly defines roles and responsibilities and provides interoperability between resource agencies. The structure also allows for the ability to escalate or downsize the response as required. A typical facility level Incident Management Team (IMT) for control of an oil spill emergency is shown the figure given below.



Typical facility level IMT for control of an oil spill

An entity can merge the functions as per their other statutory requirements and based on level of risk and range of operations. The organisation shall have to address all services and support system required and available to it. Basic oil spill emergency organogram is given below:



Basic oil spill emergency organogram

Support Services include Communication Services, Engineering/ Maintenance Services, Medical and Occupational Health, Human Resource and Welfare Service, Security, Media/ Public Relations, Transport and Logistics, Finance, Contract and Procurement and Environmental Services.

The number of staff required to fill positions in the IMT of the emergency organisation can be varied according to the size and complexity of the incident and the number of staff available. In a major incident all positions may be filled, but in a lesser incident one person may fill a number of positions. In a very small incident, the Site Incident Controller (SIC) will be able to carry out all management functions.

Persons in charge of sea ports and oil installations ensure that persons with appropriate experience and skills are identified so that they can be appointed to the various positions in the emergency organisation in the event of a marine pollution incident. If agency input into a response is required, the Coast Guard may place its liaison officer/s within the IMT, so as not to burden personnel that will be fully engaged in response activities.

The concerned Coast Guard Commander takes overall responsibility for management of the response in the event of a tier 2 or tier 3 oil spill and assumes charge of senior government, industry and media liaison.

Chief Incident Controller

Persons in charge of sea ports and oil installations shall identify appropriate individuals to act as a Chief Incident Controller (CIC). The CIC is responsible for the management and coordination of response operations at the scene of a pollution incident to achieve the most cost effective and least environmentally damaging resolution to the problem. During a major incident, the CIC is responsible to the relevant Coast Guard Commander for the operational aspects of the response.

The Chief Incident Controller (CIC) shall have overall responsibility to protect personnel, site facilities, and the public before, during, and after an emergency or disaster. The CIC shall be present at the ECC for counsel and overall guidance. Responsibilities of the Chief Incident Controller shall include the following:

- preparation, review and updation of the OSCP;
- assessment of situation and declaration of an oil spill emergency;
- mobilisation of main coordinators and key personnel;
- activation of Emergency Control Centers (ECC);
- taking decision on seeking assistance from mutual aid members and external agencies;
- continuously reviewing situation and deciding on appropriate response strategy;
- taking stock of casualties and ensuring timely medical attention;
- ensuring correct accounting and position of personnel after the emergency;

- ordering evacuation of personnel as and when necessary;
- taking decision in consultation with local Coast Guard and District Authorities, when a tier 2 or tier 3 spill is to be declared.

Site Incident Controller

The Site Incident Controller (SIC) shall be identified by the Chief Incident Controller and will report directly to him. SIC should be nominated by the entity in each shift of 24 hours. During lesser incidents, the SIC shall have overall responsibility for managing the response. Persons in charge of sea ports and oil installations should ensure that the SIC is assisted by a response team with appropriate planning, operational, technical, scientific, chemical, environmental, logistical, administrative, financial, and media liaison skills.

Responsibilities of the Site Incident Controller shall include the following:

- to maintain a workable oil spill emergency control plan, establish ECC, organize and equip the organization with OSCP and train the personnel;
- to make quick decisions and take full charge;
- to communicate to the ECC where it can coordinate activities among groups;
- to be responsible for ensuring that appropriate local and national government authorities are notified, preparation of media statements, obtaining approval from the CIC and releasing such statements once approval received;
- to ensure that the response to the oil pollution emergencies is in line with entity procedures, and to coordinate business continuity or recovery plan from the incident;
- to co-ordinate any specialist support required for the above purpose; and
- to decide on seeking assistance of mutual aid members and external agencies;
- Administration and Communication Coordinator;
- Responsibilities of the administration and communication coordinator shall include the following:
  - ❖ to coordinate with mutual aid members and other external agencies;
  - ❖ to direct them on arrival of external agencies to respective coordinators at desired locations;
  - ❖ to mobilize oil spill responders and resources for facilitating the response measures;
  - ❖ to monitor mobilization and demobilization of personnel and resources;

- ❖ to provide administrative and logistics assistance to various teams;
- ❖ to be responsible for all financial, legal, procurement, clerical, accounting and recording activities including the contracting of personnel, equipment and support resources;
- ❖ to be responsible for the management of the ECC.

Support Services

The following additional coordinators will be nominated at the sea ports and oil installations and delegated the specific responsibilities falling under the basic functions of SIC and/ or CIC:

- Human Resources Services coordinator
- Logistics Services Coordinator

In any response there is a vital need to ensure that response personnel are provided with adequate resources to enable an effective response to be mounted. The Logistics Services Coordinator shall ensure that all resources are made available as required. This includes the procurement and provision of personnel, equipment and support services for operations in the field and for the management of resource staging areas.

Media and Public Relations Coordinator: The Media and Public Relations Coordinator shall ensure adequate liaison between the incident management team and the media. All queries received from the media should be directed to this person. Before releasing any information, the Media and Public Relations Coordinators action should have the approval of either the relevant Coast Guard Commander or CIC, depending on the size of the spill.

Operations and Technical Coordinator: The Operations and Technical Coordinator is responsible for the provision of scientific and environmental information, maintenance of incident information services, and the development of Strategic and Incident Action Plans. He/She shall ensure the distribution of all information to the IMT and to all response personnel generally. He/She is responsible to the CIC for all response operational activities. This includes ensuring that the requirements of Incident Action Plans (IAP) are passed on to operational personnel in the field, and for ensuring that the plans are implemented effectively.

Environmental and Scientific Coordinator: The State Government shall pre-appoint the Environmental and Scientific Coordinator (ESC), either on a State, regional or local area basis. During a spill response, the ESC will normally form part of the Operations team. In this role the Operations Team is to provide the CIC with an up-to-date and balanced assessment of the likely environmental effects of an oil spill. The planning section will advise on environmental priorities and preferred response options, taking into account the significance, sensitivity and possible recovery of the resources likely to be affected. In major incidents, the ESC may directly advise the relevant Coast Guard Commander.

Harbour Response Powers of Port Authorities

For an incident occurring inside the port authority's jurisdiction, the harbour master (or equivalent person) is in control of the incident response from the outset. Harbour masters have powers to direct the time and manner of a ship's entry into, departure from, or movement within

a port. This gives a harbour master the power to regulate day to day movements within the port. However, it does not permit the harbour master to prohibit or insist upon entry.

Some port authorities have powers to issue general directions but, unlike the harbour master's powers, these powers are not ship and movement specific. Neither do they enable the port authority to prohibit or insist upon ship's entry into, departure from, or movement within a port.

Roles of the Port Authority and the Coast Guard: It is envisaged that many incidents will be handled entirely adequately by implementation the local contingency plan and through the combined efforts of the port authority, salvors, ship owners and crew, and Coast Guard staff from the region. In such cases the Coast Guard may not need to issue any directions. But the Coast Guard will be monitoring the decision and actions being taken and ensuring that they are being taken in the light of full knowledge of the relevant environment sensitivities and an understanding of the effects that might ensure.

Command and Control Centre: The SMCU is located either at the port's own ECC or at the nearest Coast Guard MRCC. Some ports can cope with large salvage operations. In these ports, it may be advantageous to exercise control using port facilities. The harbour master is a member of the SMCU and it may be beneficial to maintain their presence at the port so that they can keep control of to the activities within the port. The decision whether to use the port or Coast Guard facilities for the SMCU would be predetermined in the local plan taking account of many factors, including:

- the availability and range of communications equipment (radio link with the casualty, salvors, and emergency units on scene, spare telephone lines, e-mail facilities, faxes etc.);
- the need for ancillary equipment such as radar equipment for the control of port traffic;
- the availability of local knowledge such as environmentally sensitive areas, bathymetry, port resources to supplement rescue, salvage and counter pollution efforts;
- size of building and number of rooms available (large rooms for press briefings and communication, quiet rooms for decision making by the SMCU)
- the availability of support staff; and
- location (ease of access, availability parking).

Division of Responsibility for Clean up

The responsibility for cleanup of pollution on the water and at jetties wharves/ structure within jurisdiction, and at beach/shoreline owned by the port authority, whatever the source of the pollution, lies with the port authority. Cleanup of shoreline (including land exposed by falling tide) beyond port jurisdiction vests with the local administration.

Shoreline and On-Shore Response

In the early stages of an incident, the local administration establishes a response as per its own contingency plan. When the threat of pollution of the shoreline exceeds the capability of the most

affected local administration, the Coast Guard initiates a national plan response, and that local administration (or authorities) sets up a Shoreline Response Centre (SRC).

Each local authority's own contingency plan details the mechanism for escalating the response in accordance with the tiered response concept and specifies how to set up the SRC in the light of its own practices and organisation. These plans also contain the necessary authorisation to each local authority to enable the designated officer directing the SRC to take decision on behalf of the other local authorities concerned.

An SRC needs to contain representative of all the local authority services that may need to participate in the clean-up operation, and representative of all local and port authorities that may become involved. In addition, it contains an Environment Liaison Officer (ELO) nominated by the Chair of the Environment Group.

Disposal of Recovered Oil

Disposal of recovered oil is a difficult process. The recovered oil is to be stored in temporary storage devices or pits lined with plastic sheet until transferred to reception facilities. The Guidelines for disposal of recovered oil and the current list of approved recyclers is are given in NOS -DCP.

6.3.3. Scope of oil spill contingency plan

An oil spill contingency plan may appear complicated because it provides many details about the numerous steps required to prepare for and respond to spills. It also covers many different spill scenarios and addresses many different situations that may arise during or after a spill. Despite its complexity, a well-designed plan is easy to follow. The contingency plans always have four major aspects in common,

- Hazard identification,
- Vulnerability analysis,
- Risk assessment,
- Response actions.

Planners use hazard identification and vulnerability analysis for developing risk assessment and then it is used as a basis for planning specific response action.

Notification

- Spill of any nature shall be notified to the port through signal station. The responsibility of raising the alarm shall be with the master of the ship while the vessel in port limits.

- Preliminary oil spill notification report shall be given to the signal station.

Signal Station

- On receiving and recording the alarm, will communicate the same to the General Manager (MS)/Chief Manager (MS).

- Make an announcement on VHF about the situation.

- Inform the Agents of the vessel.
- Inform harbour crafts to be ready and should report to response team for further instructions.
- Activate response team.
- Update Port main office all the reports received from response team.
- As per instructions from main office center inform all other parties.
- Initial crisis notification/ oil spill notification sheet to be filled up and faxed to main office.
- Maintain record of events and communication log.
- Make an announcement on VHF Ch 16/74 about the latest situation.

Reporting of oil spill should be according to the format and structure given in NOSDCP. The primary aims of an oil spill response are to protect human health and safety, minimize environmental impacts and to restore the environment as closer as possible to pre-spill conditions.

The environmental impact of an oil spill can be minimized by good management and planning, and by the response actions put into effect by the responsible agency. Such actions will largely depend on several factors viz., the type of oil(s) involved, the size of the spill, the location of the spill, the prevailing sea and weather conditions at the spill site; and the environmental sensitivity of the coastline impacted.

Oil spill response techniques has to be planned according to type of accident. Generally, it is done into three means: (i) Mechanical Recovery (normally done within 6 hrs of the spill), (ii) Application of Dispersants (as per Guidelines of Coast Guard) and (iii) *In-situ* burning (seldom used because of safety to other infrastructure in the area of incident).

The action plan changes according to the quantity of oil spilled as the requirement of handling equipment and vessels may vary. For this purpose, the action plan is divided into two Tiers, i.e. Tier-I where the spill is < 700 ton oil and Tier – II where the spill exceeds 700 ton. In Tier-I the local ports and organizations will normally take the responsibility of controlling spill and recovery of spilled oil. In Tier-II, the responsibility will be with Coast Guard who is well equipped with trained man power and equipment including vessels.

The Government of India has established three national oil spill response (OSR) centres at Port Blair, Chennai and Mumbai under the overall control of Director General, Indian Coast Guard. However, each OSR is under the control of Regional Commander.

As these action plans are location specific, specific contingency plans are to be developed by Port Authorities and vetted by the Indian Coast Guard. Accordingly, the Port should have necessary handling equipment like booms (Recovery booms, Inshore boom and Offshore booms), Recovery skimmers, Heavy oil recovery equipment, Transfer pumps and Dispersant Application sets. More importantly trained personnel needed to implement the contingency plan should be recruited in

the company who knows to follow up the procedure/ guidelines set forth by Indian Coast Guard. The Indian Coast Guard conducts regular training programmes (twice in a year at local level, once in a year at Regional level and once in three years at National level) for equipment operators and response personnel at their Mumbai office which meets the requirements of the International Maritime Organization (IMO) modules.

Mobilizing Immediate Response

- Dispatch the oil spill combating equipment and activate the response
- Dispatch a vessel to collect a reel of boom, power pack, towing bridles, etc., a skimming unit and to take a slop barge alongside. Assisted by one of the line boats, the vessel will maintain 'J' configuration or take instruction from SCO.
- Once in position with the boom deployed, the vessel will deploy the recovery unit into the oil and commence recovery into flexi barge.
- In high sea states or currents a second vessel may need to assist.
- If oil traveled past the fixed boom, the vessels should proceed to the leading edge of the slick, deploy the boom, retaining one end, and passing the other end to other available vessel. The vessel should then take up station such that the boat forms 'J' configurations. The vessel on the short leg of the boom with the slop barge alongside will deploy the skimmer unit and recover oil into the slop barge.
- In the event of a large or continuing spillage a second boom should be deployed with two vessels, one of which will have storage capacity and a recovery unit onboard. This second containment system will take up station astern of the first boom array. Any oil escaping from the first system will then be contained by the second boom.

Use of Dispersants

- If oil is not contained, or is unlikely to be contained, SCO recommend who will seek approval from ICG for use of dispersants.
- While permission is being sought one or two vessels proceed to the leading edge of slick, deploying dispersant spraying equipment during transit.
- Once on station after firm instruction of on receipt of permission, vessel shall commence applying dispersant.

Post Cleaning Operations

- The collected oil samples will be sent to the Laboratory for analysis.
- The waste materials will be brought ashore and disposed through CPCB approved recyclers.

6.3.4. Oil spill response procedures

i) Detection and Reporting of Spillage of Oil

- Any person seeing the spill shall report the same by telephone to the Port Control Station.
- The person In-charge of the shift at the wharf/ jetty where the ship is berthed, involved in Pollution during cargo/bunker operations will also be responsible for raising the alarm and shall inform the Port Control Station.
- The Port Control Station on hearing the alarm/receipt of the information will pass the message to the Harbour Master and all other members of Incident Management Team. Description of oil spill is given below:

Description of oil spill

Sl. No.	Description Appearance	Layer Thickness Interval (µm)	Liters /km^2	Description of Appearance
1	Sheen (Silvery / Grey)	0.04 – 0.30	40 - 300	Light reflecting from very thin oil films
2	Rainbow	0.30 – 5.0	300 – 5000	Range of colours
3	Metallic	5.0 – 50	5000 – 50000	Homogeneous colour i.e. brown, blue or purple
4	Discontinuous True oil colour	50 – 200	50000 – 200000	Broken nature of colour
5	Continuous True oil colour	200 to more than 200	More than 200000	Diffuse in overcast condition

ii) Assessment and Containment

It is essential to do rapid assessment of the oil spill. Harbor Master will be the authority to assess the oil spill. If an oil spill has occurred, first collect the weather information and 77 hydrographic data to find out the movement of the spill and then finalize the action plan to clean up the spillage. Containment Booms may be used to restrict the movement of oils from spreading farther distances

6.3.5. Response Inventory

Tier 1 equipment for pollution response up to 700 tons is required to be held by port facilities. A list of response equipment to be kept with the port is given below:

Equipment	Quantity
Boat with trained crew	One
Skimmer	Two
Boom	500 m
Dispersant	1000 L

In addition to the tier 1 equipment, the Indian Coast Guard maintains stockpiles of equipment at its pollution response teams at Mumbai, Chennai, Port Blair and at Vadinar. The Indian Coast

Guard also operates two dedicated pollution response vessels. Stocks of oil spill dispersant are additionally held at each Coast Guard Station/ Air Station.

6.3.6. Mutual Aid

Since combating major emergencies might be beyond the capability of individual unit, it is essential to have mutual aid arrangements with neighbouring industries. Consideration shall be given to the following while preparing mutual aid arrangements:

a) Written mutual aid arrangements are to be worked out to facilitate additional help in the event of tier 2 emergencies by way of rendering manpower, medical aid or firefighting equipment, etc. a copy of which shall be forwarded to DGICG, the concerned Coast Guard Regional Commander, and other concerned authorities.

b) The mutual aid arrangement shall be such that the incident controller of the affected installation shall be supported by neighbouring industries on call basis for the support services materials and equipment already agreed. Further, all such services deputed by member industry shall work under the command of the site incident controller of the affected installation.

c) Mutual aid associations shall conduct regular meetings, develop written plans and test the effectiveness of their plans by holding drills. Drills are essential to establish a pattern for co-operation, detect weaknesses in communications, transportation and training. Periodic drills also help develop experience in handling problems and build confidence in the organization.

d) To make the emergency plan a success, the following exchange of information amongst the member organizations of mutual aid association is considered essential:

- The types of hazards in each installation and pollution response measures.
- The type of equipment, that would be deployed and procedure for replenishment.
- Written procedures which spell out the communication system for help and response. This is also required to get acquainted with operation of different pollution response equipment available at mutual aid members and compatibility for connecting at users place.
- Familiarization area of operations and drills for access and exit details carried out by mutual aid members.

6.3.7. Training and Exercises

The Indian Coast Guard conducts regular training programs and exercises for personnel likely to be involved in a response to an oil spill in the marine environment. These training programs and exercises are designed to enable India to have sufficient numbers of trained personnel to mount a credible and effective response to an oil spill incident. Joint exercise and training programmes may also be conducted with neighbouring countries to fulfil the requirement of regional oil spill contingency plan.

Training programs are regularly conducted at two levels, which recognise the overall technical complexity of managing an oil spill response and that the associated knowledge required by personnel varies depending on their level of responsibilities.

The two levels of training conducted are:

- Level 1 for operator level personnel, i.e., those undertaking on-site clean-up operations. In a major incident this would also include supervisors appointed as site managers.

- Level 2 for middle management personnel responsible for managing the operational response, e.g., incident controllers, their deputies and environment and scientific coordinators, and Fire Brigade (Hazardous Materials) specialists.

A certificate of level 1 course is deemed to be valid for a period of five years from the date of its issue. It is imperative that personnel designated for oil spill response operations undergo periodic training to maintain currency of certification.

The persons qualified in level 2 course will be designated for carrying out duties as Chief Incident Controller and Incident Controller.

Mock drills and exercises will be conducted by every port facility ad oil installation at such periodicity and at such scales as required by the Central Coordinating Authority. However, such mock drills and exercises shall in any case be conducted at least once every three months and a record shall be maintained of its conduct including the personnel participated, resources mobilized, etc. Area or regional level exercises will be conducted at least once every six months. National level pollution response exercises will be conducted at least once a year and involve mobilization of stakeholder resources.

In addition, communication mock drills will be conducted by the Coast Guard at the national and area or regional level as required.

6.3.8. Financial Arrangements

Detailed financial records, including all supporting information, are required, and are of particular importance when submitting claims to the Protection and Indemnity (P&I) insurers, as all claims will be assessed to ensure that the costs are reasonable, and are supported by satisfactory documentation.

Agencies should have in place appropriate systems to ensure that these requirements are met and that these are adequately outlined in contingency plans.

In general, costs will be considered 'reasonable' if they result from actions:

- undertaken on the basis of a technical appraisal of the incident;
- sought to enhance the natural processes of recovery; and recovery; and
- not undertaken purely for public relations reasons.

Capitation costs for deployment of government ships and aircraft shall be as promulgated by the Government of India, Government of any coastal State of India, or any other department or agency of the central or state government.

6.3.9. Record Keeping and Preparation of Claims

In order that claims may be processed with minimum delay, it is essential that accurate records are maintained to support claims. It should be noted that claims should be based on expenses actually incurred, that these are made as a direct result of an incident, and that the expenses incurred are reasonable. In the case of economic loss, documentation supporting the claims should demonstrate how the claim has been calculated. The following aspects are to be considered during response operations, and preparation of claims:

- delineation of the area affected describing the extent of pollution and identifying areas most heavily contaminated. This may be best presented as a map or chart accompanied by photographs;
- summary of events including a description of the work carried out in different areas and of the working methods chosen in relation to the circumstantial evidence linking an oil pollution with the ship involved in the incident (e.g. chemical analysis);
- labour costs (numbers and categories of laborer, rates of pay, hours worked, total costs etc.);
- dates on which work was carried out (weekly or daily costs); and
- material costs (consumable materials, fuel utilized, food, shelter, etc.).

Preparation of claims shall be guided by the manuals, guidelines etc. published from time to time by the International Oil Pollution Compensation Funds (IOPC Funds) such as the claims manual and guidelines for claims in the fisheries and tourism sector.

6.3.10. Port Responsibility

- To be in charge of the overall co-ordination of oil pollution response actions in jurisdiction.
- To identify suitable tugs, vessels and crafts when required for the operations.
- To identify surface crafts, on which dispersant spraying equipment can be mounted, and which can be used for rigging the boom.
- To ensure that for the purpose of part XIII of the Merchant Shipping Act, 1958, actions are taken by the various authorities under the overall legal responsibility of the receiver of wrecks.
- To ensure that at least the minimum equipment is kept available locally at all times.
- To arrange for training of personnel expected to be engaged in above operations.
- To arrange for periodical mock drills and exercises so as to keep equipment and personnel on continuous readiness for oil spill response operations.
- To consult the ICG, DG Shipping, OISD or other authority, when further advice/ assistance is required.

- To keep the ICG apprised of actions being taken.

The following people have to be informed immediately in case of any oil spill incident without delay:

i) Indian Coast Guard giving the details of the quantity and type of oil, exact location with coordinate,
ii) Dept. of Environment and Forests, Puducherry,
iii) Other ports located near to Puducherry,
iv) The Collectorate of Puducherry Administration,
v) Puducherry Pollution Control Committee,
vi) Department of Fisheries in Puducherry,
vii) Department of Tourism,
viii) Puducherry CZMA Committee,
ix) Puducherry Maritime Development Committee,
x) National Institute of Oceanography, Goa
xi) National Institute of Ocean Technology, Chennai
xii) Indian Institute of Technology – Madras,
xiii) Local Fishing Hamlets.

The following table gives the details of procedure of reporting and their role in case of oil spill for the Port region.

Oil Spill management plan

Action	Agency	Address/Phone nos.*	E-mail*
Firsthand information to and entire planning of Oil combating exercise	Indian Coast Guard, New Delhi	Coast Guard Headquarters, National Stadium Complex, New Delhi Pin Code: 110 001 Tel:0091-891-2568875 FAX:0091-891-2568879	dhq6@md4.vsnl.net.in
Advise	Puducherry Pollution Control Committee	III floor, PHB building, anna nagar, puducherry-5. Phone: 0413-2201256 Fax: 0413-2203494 E-mail: ppcc.pon@nic.in	-
Port facility for berthing vessels as per advise of ICG	Port Department, Puducherry	In house facility	-
In situ measurements of oil concentrations and finger printing	National Institute of oceanography, Goa or other institution as per ICG's advise.	NIO, Dona Paula-Goa, India. Tel: +91(0)832-2450450 Fax: +91(0)832-2450602	ocean@nio.org
Contingent action on spill control and spraying of dispersants	***Inhouse team at Port as per instructions of ICG for Tier-I***		

** these information have to be updated continuously*

6.4. Modelling studies

Various modelling studies for dredging and shore protection measures are carried out by Indian Institute of Technology Madras (IITM). The report is entitled as "Dredging in the harbour basin and navigational channel PMC for phase I development of Pondicherry Port" which is enclosed

herewith as Annexures III - XI (except annexures V - VIII) to , directed by the Port Department, Govt. of Puducherry. The modelling studies are carried out IITM are as follows;

- Dredging model – Dredging in the harbour basin and navigational channel PMC for phase I development of Pondicherry port – numerical 2 dimensional modelling.

- Wave model - Dredging in the harbour basin and navigational channel PMC for phase I development of Pondicherry port – analysis of offshore wave climate from the available sources in view of the capital dredging with the present breakwaters.

- Storm surge model - Dredging in the harbour basin and navigational channel PMC for phase I development of Pondicherry port – studies on flooding and related impact on creek and control area during cyclonic storm.

- Ship navigational study - Dredging in the harbour basin and navigational channel PMC for phase I development of Pondicherry port – ship navigational study.

- Shoreline model - Dredging in the harbour basin and navigational channel PMC for phase I development of Pondicherry port –shoreline evolution.

7. PROJECT BENEFITS

7.1. Introduction

The purpose of re-commencement of minor port is to improve the economic growth of Puducherry. The minor port will act as satellite port and there is an increasing requirement from the existing and new customers for importing, exporting of cargoes in the region.

The facility is an integral part of the business activities in the region and act as a service provider for the nearby industries for their import and export requirements. The port terminal is in operation between 1993 and 2006 and has been instrumental in with respect to developing physical infrastructure, providing employment, contribution to society etc. This chapter represents the expected benefits from the proposed project.

The following benefits are expected from the proposed project:

- The proponent has planned to recruit numbers of skilled, semi-skilled and unskilled man power.
- During the construction phase direct and indirect employment through contracts for civil construction, mechanical erection, electrification, piping works and associated amenities. The indirect employment potential of the projects would be significantly beneficial for the area.
- The proposed project is employing many people of various skills which would mean income to their families.
- This proposal would generate funds for the Govt. of Puducherry in terms of lease rent
- Lead to productive use of space.
- Additional activities which would be supportive in nature to the port project will also be developed in the nearby areas which will generate indirect employment opportunities.
- Improved business prospects to the boat operators and drivers.
- Improved business prospects to the local businesses around the project location – commercial establishments (like hotels and restaurants, etc.).
- Better facilities to the tourists and the local population that use the boating facility.
- Improved safety and better quality of services to the boat users.
- Better traffic management will improve the congestion in the area and reduce air and noise pollution.
- Vendors can have organized facility to operate their businesses in the project area due to defined shopping settlements.
- Beach nourishment on the northern side of the northern breakwater will improve the tourism which will generate employment opportunities.
- The deepening of the navigational channel will improve the economic status of the fisherfolks.
- The construction of piled bridge will prevent the entry of solid waste into port water

7.2. Corporate Environment Responsibility (CER)

As an approach of sustainable development, any project proponent should also contribute a stock of their capital investment for the development of the neighbouring environment. In view

of this aspect, the project proponent should allot 1% of the capital cost to monitor the surrounding environment periodically through corporate environment responsibility. The CER fund allocation should be utilized to develop infrastructure facilities like drinking water supply, sanitation and health, access roads, cross drainage, electrification through solar panel installation, rain water harvesting and solid waste management. Meanwhile, the ecological and biological status of the surrounding environment shall be monitored regularly by the proponent.

The proponent should also confirm that the aspects followed in the corporate environment responsibility are being implemented and periodically monitored. The same can be compiled and a compliance report can be forwarded to the concerned Pollution Control Board / MoEFCC regional office and to the District Magistrate for review.

CER activities for the proposed project site for a period of four years was given in Table below.

CER Activities	2020-21 in Lakh	2021-22 in Lakh	2022-23 in Lakh	2023-24 in Lakh	Total in Lakh	Estimation – Total CER Budget in Lakh
Infra development for Drinking Water supply, Sanitation, Health, Housing for BPL families, Skill development	2	2	2	2	8	44
School infra, facilities and support (e.g. library, science lab etc.)	4	4	4	4	16	
Contribution to various Govt schemes (Swach Bharat, Skill development etc.)	3	3	3	3	12	
Plantation in community areas	2	2	2	2	8	
Total (in Lakh)	11	11	11	11	44	

8. ENVIRONMENTAL MANAGEMENT PLAN

The proposed project involves construction of drainage barrier cum walkway, dredged material and disposal of dredge spoil. The impacts due to construction and operation of these facilities and activities related were described in Chapter 4. To address the anticipated impacts and to implement the mitigation measures Environment Management Plan (EMP) needs to be formulated. EMP identifies the approach, procedures and methods that will be used to control and minimize the environmental and social impacts of all construction and operational activities associated with project development. It is intended to reduce the negative impact of proposed project and to enhance the positive benefits from the project. As part of project, proponent shall commit to excel in environmental and social performance by ensuring the following:

- Comply with all environmental and social conditions associated with project approvals.
- Promote environmental awareness and understanding among employees and contractors through training, identification of roles and responsibilities towards environmental and social management.
- Monitor environmental performance throughout the project and implement an adaptive approach for continuous improvement.

The EMP provides an outline for environmental management measures developed for construction and operations phase to ensure environmental safeguards are in place to minimize and mitigate the identified impacts to the surrounding environment.

8.1. Summary of proposed impacts and mitigation measures

The details of the impacts due to the proposed project activities during construction and operation and its respective mitigation measures are explained in detail in Chapter 4. Based on these mitigation measures EMP has been prepared. Summary of impacts and suggested mitigation measures for construction and operation phases are briefly listed in below Table.

Impacts and mitigation measures of the proposed projects

Sl. No.	Impacts		Mitigation Measures
	Parameter	Cause	
Construction phase			
1	Air	Fugitive dust emission and dust generation from material transport concrete mixing, cement handling, welding and operations of machinery.	Water sprinkling in the construction site and on unpaved roads and provide covered transport for excavated material.
		Generation of dust from handling and transportation of fine & coarse gravel in uncovered trucks.	Truck will be allowed with loads limits, wetted to prevent material from being spilled / scattered or wind blown over roads and covered with tarpaulin sheets.

Sl. No.	Impacts		Mitigation Measures
	Parameter	Cause	
		Emission of air pollutants from vehicles, heavy machineries.	Vehicle should screened for valid PUC, Regular maintenance activities will be carried out to keep the vehicle in good condition.
2	Land	Utilisation of dredged material for shoreline management, construction debris and other wastes from construction activities.	Suitable dredged material will be utilized for shoreline management. Post construction clean up should be through contractor and all the debris generated should be properly stored and disposed off in a safe manner or recycled or reused wherever possible.
3	Water (Terrestrial and Marine)	Construction work in water would cause re-suspension of sediment due to piling and dredging.	Piling and dredging should be confined to proposed area only. Use of latest construction equipment for installation of the piles.
		Disposal of dredged spoil	The characteristics of dredged material shall be analyzed before dumping and proper disposal methods should be followed.
		Exploitation of water resources for domestic usage	No ground water will be extracted during the construction phase.
		Disposal of untreated waste water	Sanitation facilities to be provided at the construction site for the proper collection and disposal of sewage.
		Dredging: Minimum destruction on sub tidal benthic community	Use of appropriate dredging equipment consistent with soil conditions and quantity to be deployed. Controlled dredging confined to the area identified; Use of net enclosures with booms to prevent movement of turbid plume; Monitoring of the turbidity in the water column for a few days after dredging is completed. Use the dredge spoil level raising.
4	Noise	The major noise generating sources will be crusher excavators, crane, concrete mixer / dredgers etc.	Regular servicing and maintenance of construction machineries, equipment and vehicles to control noise.
			Personnel exposed to noise levels beyond threshold limits will be provided with protective gear like earplugs, muffs, etc. especially construction personnel involved in pile driving operations. Rotation of personnel should also be adopted.
5	Socio economics	No negative impact	No rehabilitation and resettlement involved in the project.

Sl. No.	Impacts		Mitigation Measures
	Parameter	Cause	
			Preference should be given to local labours while selecting labours during construction phase which will have a positive impact.
6	Biological environment	Construction activities may cause temporary displacement/drift of marine biota.	Controlled method of dredging using appropriate dredgers will be carried out confined to only port area in order to minimize destruction on sub-tidal benthic community. Booms (silt curtains) will be placed around the dredging area in order to control the spread of the turbid plume. Regular monitoring of the turbidity and sediment concentration in water will be conducted.
Operation Phase			
7	Air	Increased vehicular emission due to cargo handling.	Only the vehicles that have valid Pollution under Control (PUC) certificates should be used. Speed limits within the port should strictly followed and vehicle engine idling should be avoided.
8	Land	Generation of additional domestic and hazardous waste	Additional solid waste generated should be properly collected and disposed off safely. The hazardous waste authorization shall be obtained for additional hazardous waste generation. The hazardous waste will be disposed off as per the disposal practice specified in authorization.
		Green belt and green cover	Green belt should be developed inside the port area
9	Water (terrestrial & Marine)	Discharges from barge such as bilge water, ballast water, oily wastes, sewage, garbage and other residues.	No waste from the visiting vessel will be allowed to discharge in marine environment.
		Maintenance Dredging (Minimum destruction on sub tidal benthic community)	Monitoring of the turbidity in the water column for a few days after dredging is completed.
		Accidental Oil Spill	Proper contingency plan; Readily available oil handling equipment like booms, skimmer and chemicals for dispersion; Mock drills and awareness should be practices regularly. Updation of OSCP should be done to include the proposed facilities.
10	Socio economics	Employment opportunity.	The port development will provide direct or indirect employment opportunities .
11	Biological	Water pollution and bottom	Periodic monitoring of marine water quality

Sl. No.	Impacts		Mitigation Measures
	Parameter	Cause	
	Environment	contamination due to port operations.	and sediments will be undertaken.
12	Mangroves	Mangroves might get disturbed due to proposed dredging activity.	Mangrove plantations in suitable sites will be undertaken in consultation with the Forest Department.
13	Sea grass, Corals and Endangered species	Project area is devoid of Seaweeds, Sea grass, Corals and Endangered species. Hence, there will not be any impact.	

8.2. Environmental Management Plan

Environmental management plan for terrestrial marine environment are proposed based on impacts and mitigation measures identified. The major environment management measures are given below:

- Environment Management Cell (EMC)
- Institutional Mechanism
- Construction phase EMP
- Operation Phase EMP
- EMP monitoring and Review

8.2.1. EMP during construction phase

Labour management plan

The total number of workers to be engaged during construction phase will be about 100 nos. Preference will be to source the labours from nearby villages. Prior to commencement of groundwork, HSE management plan should be worked out with contractor to ensure the environment conditions at site does not deteriorate.

Workers should be provided with proper sanitation facilities, drinking water, training and awareness, medical checkup, good housekeeping etc. The company already practices pre and periodical medical checkups. The construction time schedule should be strictly followed so that the impacts from the construction activities are not prolonged.

Solid and hazardous waste management

Construction waste consisting of bricks, stones, cement, material, plastics, wires, etc. will be generated during the construction phase. Use of ready mix concrete will limit the reduction in material storage and wastages as compared to site mix concrete job. The construction contractor will ensure regular collection and proper disposal of construction waste debris, concrete, metal cutting wastes, waste/used oil etc. The construction waste shall be disposed as per the requirement of Construction & Demolition Waste. Scrap material such as waste pieces of wires, paints, discarded drums, etc., shall be reused or sold to approved scrap dealers.

Solid waste generated at construction site should be properly collected, segregated and disposed as per the present solid waste management practice at site. Solid waste generated from the barges and dredgers shall be collected at periodic intervals and disposed off properly. Used oil and discarded drums will be stored and sold to approved recyclers. Contaminated soil, if any shall be treated in accordance with hazardous Waste (Management and Transboundary Movement) Rules, 2016.

The provision of dedicated fabrication yard away from CRZ area, separate construction material storage facility will minimize the impacts due to waste and help in efficient waste collection. Such provision will also allow to maintain good housekeeping facilities at construction site.

Used oil/lubricants/solvents/paint containers to be kept on concrete floor to prevent ground contamination in case of leakage and should be provide with containment. Spill control kits such as spill trays etc., to contain and clean small spills and leaks. Workers will be made aware on waste prevention and the proper handling and storage of materials.

Air quality management

Good maintenance practices, efficient machineries, better housekeeping, planning of material transport routes, covered storage areas for construction materials, designated fabrication yard etc., will help in managing and mitigating the impacts on air environment expected due to construction phase. To reduce the impact from windblown dust, vehicular emissions following practices should be adopted:

Construction material – fugitive dust emissions

- Covered storage for construction material wherever loose material is placed in bulk
- Sprinkling of water in dust prone areas
- Covered transportation of loose construction material
- Barricading all open construction areas
- Provision of PPE like dust mask to the workers in dust prone areas

Vehicular emission and construction machinery

- All vehicles used to have a valid PUC.
- Regular servicing and maintenance of machineries like cranes, excavators, rollers etc., as well as vehicles to control fugitive air pollutant emission.
- Speed restrictions for all vehicles entering the port and avoidance of idle running of machines, equipment and vehicles.

Noise environment

The effective noise control measures should be implemented during construction phase to address the high noise generation from operation of construction equipment and machinery, vehicular transport, operation of pumps, compressors and diesel generator.

Periodic maintenance of construction machinery and transportation vehicles should be undertaken to reduce the noise impact. Silencers on engines and better greasing of rolling parts

can reduce the noise level. Regular servicing of construction equipment, machineries and vehicles. Ensure use of PPE like ear plugs/muff in high noise generating areas.

Water environment

The water requirement during the construction phase will be met from PWD/ external agencies. The expected daily water requirement for the construction phase is estimated to be about 15 KLD. The sewage generated will be disposed off through septic tank and soak pit system or upgrading existing underground drainage system. The fabrication yard and material storage area shall be provided with proper drainage system. Proper care should be taken so that run off from construction site should not contain construction material and choke the storm water drains.

Socio economics aspects

The socio economics quality of the people in the region can be improved by:

- Local people will be employed based on skill set during the construction phase to meet the man power requirement.
- Local population will get opportunities in related services activities like small contractors and sub-contractors for supply of construction materials, vehicles, construction equipment etc.
- Awareness sessions will be carried out for drivers on safe and defensive driving.
- Provision of drinking water, proper sanitation and medical facilities for workers etc., will be made.

Marine water environment

During concrete work care should be taken to prevent mortar or cementing material falling in the surrounding water. Dredgers used during dredging shall not be allowed to discharge any waste in the surrounding water. The construction schedule should be strictly followed to avoid, and time overrun which may in turn increase the impact period. Awareness will be held for contractors and workers regarding prevention of discharge of any waste / garbage in the marine environment.

Accidental collision of ships and Oil Spill

The movement of barges/ dredgers, service boats will be well planned and port control will optimize the tidal window for their movement in order to avoid any collision and grounding.

Existing Oil Spill Contingency Plan will be evaluated and modified if required to handle accidental oil spill if occurs during the construction phase. Oil spill contingency equipment like boom, skimmer and dispersant chemicals will be stored at existing jetty for faster response. Oil Spill Contingency Team established at the port may be strengthened, if required.

Seabed

Periodic bathymetry survey will be carried out at nearshore to study the influence of dredging and to maintain navigational safety.

8.2.2. EMP during operation phase

Air environment

- Regular monitoring of pollutant should be carried out and records to be maintained
- Ambient air quality monitoring for the parameters mentioned in Consent granted by pollution control committee should be done properly.
- Workplace area monitoring shall be carried out

Noise environment

- Vehicle with low horn noise should be used and transport vehicles equipped with silencers should be used.
- Periodical maintenance of transport vehicles should be done.
- Speed restriction should be followed for all vehicles entering the port area.
- Preference shall be given to low noise generating devices, equipment and machineries during procurement.

Water environment

- Metering facility shall be provided to keep account of water consumption and waste water generation.
- Sewage generate shall be disposed off through septic and soak pit system or upgrading the existing underground drainage system.
- Consent from Pollution Control Board should be obtained.

Rainwater harvesting

Rainwater collection is now an important component of wise resource use and environmental management. During operation phase rainwater from the roofs of buildings and storm water drains adjoining roads will be collected in a rainwater collection tank. During Pre-monsoon/ fair weather cleaning of collection tanks will be done. Rainwater collection tanks will be constructed in between the storage yard. 2 nos. of tank will provided with suitable dimension.

Solid and hazardous waste management

- The solid waste should be properly collected, segregated and disposed as per the existing practice through authorized agency. The recyclable and reusable material shall be sold to the authorized vendors.
- Hazardous waste authorization shall be obtained from Pollution control Board for additional hazardous waste quantity generated form the proposed project.
- The disposal method as prescribed in the authorization shall be strictly followed.
- The records of hazardous waste shall be maintained as per Form 3 and annual returns shall be filed as per Form 4 as prescribed in Hazardous and Other wastes (Management and Transboundary Movement) rules, 2016.
- Centralized hazardous waste storage facility at site with impervious bottom has been provided. The additional hazardous waste should also be stored within the same centralized facility.

The wastes carried by vessels are not allowed to be disposed in port waters. The vessels visiting the port will be required to comply to provision of MARPOL 73/78 and the port personnel will inspect tie vessel to check through methods like waste declaration and ship shore checklist.

Socio economics

- The operation of port terminal will generate direct and in direct employment opportunities and overall help in upliftment of socio economic activities.
- CER activities shall be taken up in the adjoining village in collaboration with the local bodies.

Maintenance dredging

The dredged sediments having sand fractions will be used for beach nourishment on the northern side of the shoreline and clay type sediments in open sea at the designated disposal site. The dumping of the dredged soil should be maintained uniform. Maintenance dredging should be confined to the requirement and surrounding area should not be impacted. The nourishment has to be done on the north of the northern breakwater in the intertidal area, the level has to be maintained properly and should not exceed 4 m. It is suggested that the dredged spoil barges may dispose the sediments at different locations in the disposal area in a sequential order as shown in Fig. 2.3.

Mangrove management

The proposed navigational channel will not affect the existing mangroves but falls within the buffer zone. The total navigational area in the buffer zone is 12,722 m^2. The likelihood of disturbance of mangrove will be 4240 nos., in the worst case scenario. To support health of the mangrove habitat, mangrove afforestation of 3 times amounting 12,720 nos. of plants along the banks of river will be undertaken. The mangrove plantation will be done in consultation with the Forest Department - Puducherry, Puducherry University or Annamalai University.

Green belt development

Green belt and green cover will be developed within the port premises. Layout of green belt is shown in Fig. 8.1. Roadside plantation plays a very important role for greening the area, increasing the shady area, increasing aesthetic value and for eco-development of the area. The approach roads to project site, etc., can be planted with flowering trees. Trees can be planted to increase aesthetic value as well as shady area along the roads. The choice of plants for green belt should include shrubs and trees. The intermixing of trees and shrubs should be such that the foliage area density in vertical is almost uniform.

Traffic management plan

The Puducherry Minor Port is well connected by road to its hinterland through important National Highways viz NH 45A and ECR for movement of container cargo , general cargo, bulk cargo, break bulk cargo and liquid cargo, from and to the port. No dirty cargo is proposed to be handled at this port. Further, cargo from and to the port shall be transported between 10:00 PM and 06:00 AM without any hindrance to the public.

An exclusive area has been earmarked in the new port for parking transport vehicles and therefore their movement to and from the Port shall be regulated without creating traffic snarls.

As far as Container cargo is concerned, part load as well as full load cargos are expected to be handled at this port. Further, in part load cargos, the cargo is to be received or dispatched to various users and therefore involves stuffing and de-stuffing operations.

As an additional measure, it would be impressed upon the port operators to concentrate on dispatching goods from and to the port through smaller trucks to the extent possible so as to reduce noise pollution as well as traffic congestion.

The Puducherry Minor Port is situated just 1 km from the Puducherry Railway station, which is connected to the railway grid by BG sidings. As such, cargo can also be moved out of the port through railway wagons if the need arises.

8.3. Environment Management Cell (EMC)

An Environment Management Cell (EMC) will be formed, which will be responsible for monitoring the environment status during construction and operation phases of the project. EMC will also organize the implementation of the aforesaid Environment Management Plan (EMP) / Post Project Monitoring (PPM). Role and responsibilities of EMC is listed below.

- Ensure effective communication and explanation of the content and requirements of the EMP to contractors and subcontractors.
- Provide appropriate and adequate resources allocated to allow for the effective implementation and maintenance of the EMP.
- Review of EMP performance and implementation of corrective actions, or stop work procedures, in the event of breaches of EMP conditions, that may lead to serious impacts on local communities, or affect the reputation of the project.
- Report any major environmental incidents that may have a significant impact on the surrounding environment.
- Preparation and implementation of environmental supervision plan during construction.
- Ensuring adequate training and education to all staff involved in environmental supervision.
- Evaluating the efficacy of the EIA, mitigation measures as stipulated in the EMP.
- Coordination with MoEFCC and other Central/State/ UT pollution control boards/ Committee for prevention and control of environmental pollution.
- Carryout half yearly monitoring program and preparation of compliance report.
- To implement Environmental Clearance condition stipulated by MoEFCC.
- Maintain environment monitoring records.

8.4. Training, Communication and Reporting

Training

Port personnel shall be trained for identification of various hazards, methods to combat and responsiveness to emergency preparedness etc.

Communication

Information with respect to any untoward incidences during the construction and operation of the project shall be communicated to local Gram Panchayat, local village workers, employees and other project-related individuals. Significant Environmental issues will be communicated to the concerned Govt. agencies such as Regional office - MoEFCC, Puducherry Pollution Control Committee (PCCC), Forest and Environment Department, District Collector etc.

Reporting

The EMC will be responsible for conducting environment monitoring, compilation and review of monitoring data, filling up the statutory forms/returns, maintenance of records regarding hazardous waste, environment awareness activities, submission of compliances six months EC compliance to PCCC and MoEFCC.

8.5. Institutional Mechanism

Institutional mechanism includes initial implementation of mitigation measures suggested in the EIA report along with EC conditions and implementation of CTO conditions. Continual improvement program includes adherence to stipulated EC condition, CTO condition by implementing latest equipment, technologies and labour force to monitor the environment.

8.6. Implementation of EMP

Overall implementation of EMP will be the responsibility of EMC. Various implementation items, description and appropriate time to implement EMP is listed below.

Implementation item	Description	When to implement
Formation of an Environment Management Cell (EMC)	An Environmental Management Cell shall be formed to implement proposed EMP	Prior to the commencement of construction work.
Contractor	The Construction Contractor should ensure that the intent of EMP is spread among construction workers. Make sure that all environmental safeguards and precautions are in place. Ensure that all equipment used is properly serviced and that all precautions are in place to prevent the likelihood of an environmental impact.	Before commencing construction work.

Implementation item	Description	When to implement
	The contractor shall be responsible for construction and worker management plan and safety of workers.	
Workers	Should be aware of the contents of EMP, and the reason for implementing its elements. Report all environmental incidents to the contractor /manager as soon as practicable, but within 24 hours of them occurring.	

8.7. EMP Monitoring and Review

The EMC shall continually review the EMP and mitigation measures described in Chapter 4 to find the effectiveness of proposed measures. The management shall conduct review to find effectiveness of EMP as follows:

- Annual review of EMP
- Review of EMP after reported accident/ significant non-compliance
- Post project monitoring results & evaluation
- Feedback from workers/stake holders

8.8. Environment management budget

The environment budget allocation is necessary to make resource available for effective implementation of Environment Management Plan. The budget allocated for marine environment management for proposed project is about Rs. 100 Lakh.

Environment Management Plan Budget

Sl. No	Construction Phase	Cost per Annum (Rs. in Lakh)	Operation Phase	Cost per Annum (Rs. in Lakh)
1	Environment Management Cell	10	Environment Management Cell	10
2	Environmental Monitoring	10	Environmental Monitoring	10
3	Waste Management	5	Shoreline monitoring	25
			Miscellaneous	30
	Total	25	Total	75

9. SUMMARY AND CONCLUSION

9.1. Introduction

The Port Department, Government of Puducherry proposes to re-commence the existing minor port in Uppalam at Puducherry District. The port was constructed between 1986 and 1993 and was in full-fledged operation from 1993 to 2006. Since 2006 the port was not in operation due to litigations against the port and improper maintenance of navigational channel which results in heavy siltation in Ariyankuppam River mouth to port.

Potential siltation at Ariyankuppam River mouth was identified at the port planning stage itself. In order to stabilize the river mouth to facilitate safe navigational depth, north breakwater, south breakwater were connected with trestle and a sand trap with submarine tunnel between south and north breakwater were constructed. The sand trap also got choked up due to siltation and improper maintenance.

Now the Government of Puducherry aims to utilise the funds sanctioned under Sagarmala from the Union Government of India. It is proposed to utilise the same structure and deepen the navigational channel and to prevent the entry of solid waste from the adjacent drainage channel (nearby the port). The Port Department, Government of Puducherry has appointed IITM as their technical consultants. Accordingly, IITM, has prepared Detailed Project Report and also conducted various Modelling studies.

The proposed project attracts both EIA Notification 2006 and CRZ Notification 2011. Hence it requires both Environmental and CRZ clearance from MoEFCC and recommendations from PCZMA respectively. The project falls under activity 7(e) 'Ports & Harbors' and categorized as category B (handling capacity <5 MTPA) as per schedule of EIA Notification, 2006. However as per EIA Notification, 2006 according to the General Conditions, the project falls under the inter-state boundaries (Tamil Nadu and Puducherry) will be treated as category A. ToR for the proposed project was issued by MoEFCC on 19th February 2019. Field studies were undertaken during March 2019.

9.2. Project Description

Puducherry Port is located 2 km upstream of Ariyankuppam River mouth. Based on the recommendations from IIT, the project would involve: i) capital dredging in the port basin and in navigational channel, ii) disposal of dredged sediments having sand fractions on the northern side of the shoreline for beach nourishment and clay type sediments in open sea and iii) construction of a pile supported bridge cum walkway across the drainage channel to prevent solid waste disposal into the port waters. The estimated quantity for capital and maintenance dredging are 0.73 million m^3 and 0.15 million m^3 per year respectively. The dredged material will be disposed at a distance of around 6 km and depth of (-) 20 m CD. The dredging of the harbour basin and navigational channel to the required depth of (-) 5 m, except at the submarine tunnel where the depth shall be (-) 4 m will be maintained. Suitable dredging methodology will be utilized to carry out the dredging and dredge disposal work.

Power requirement of 300 kVA will be met from Puducherry Electricity Board. Water requirement of 15 KLD will be met from PWD/ external agencies. The cost of the proposed project will be Rs. 44 Crore.

9.3. Description of Environment

The baseline data collection on both terrestrial and marine environment was collected during fair weather period (March 2019). The collected data were analysed by Indomer Inhouse Laboratory which is accredited by NABL.

Ambient air quality: Air quality monitoring results shows that, pollutants are within NAAQ Standard. Monitored values recorded within study can be attributed to movement of vehicles, boats, workshops etc. AQI is found to be in satisfactory level.

Ground water quality: The results of ground water quality shows that the most of parameters complies with IS 10500 – 2012.

Surface water quality: The surface water bodies within study area have good water quality and satisfy various designated uses as per CPCB criteria such as Drinking water with and without conventional treatment, irrigation, outdoor bathing and industrial cooling.

Soil quality: The soil quality results show that the soil in the project area is free from any contamination. The results of soil analysis indicate that the soil in the study area is loamy soil. The soils are acidic to neutral in reaction and are low in nutrients status. The acidic soils require application of either lime or dolomite to improve the status of basic cations.

Noise measurements: The measured noise levels were found to be within the Ambient Noise Standard prescribed under Noise Pollution (Regulation and control) Rules, 2000. The major sources of noise in the project area are vehicle movement and sea breeze.

Socio-economic environment: Most of the people are dependent on jobs/business and fishing activities as their main source of living. More than 100 numbers of boats are operated from the fishing harbour and tourism is also popular in this project region. Therefore, most of the people are dependent on these activities for their livelihood either directly or indirectly. It is noticed that almost all the houses possess modern living amenities like TV with dishes, Fridge, Washing Machines, Mobiles and Motorcycles.

Seawater quality: Seawater quality show that pH, Turbidity and other parameters are in the range of normal seawater /brackish water, except for marked local deviations. Thus, the values of DO, nutrients and phosphorous at Stns. SS1 to SS3 and Stn. SS7 clearly shows the influence of sewage discharged in the Ariyankuppam River. Constructing the proposed drainage barrier is expected to reduce the concentration level of nutrients in the port waters. The coastal waters at Stn. SS4 to Stn. SS6 are free from contamination.

Seabed sediment quality: The heavy metal concentration in the sediment samples indicated the absence of increase in their burden due to anthropogenic influence. Total Nitrogen and Total Phosphorus values are high due to discharge of sewage in the port water. In order to control concentrations of Total Nitrogen and Phosphorous in the port sediments it is necessary to release the treated sewage through a pipeline at a location in the sea after proper studies to identify the release site.

Marine ecology and biodiversity: Biological parameters considered in the present study are primary production, phytoplankton biomass, diversity and population, zooplankton biomass,

diversity and population, seabed and inter-tidal / sub-tidal macro benthic diversity and population, bacterial population in coastal waters and seabed sediments and fishery.

Phytoplankton: The numerical abundance of phytoplankton population varied between 7200 and 20400 nos./l from all stations.

Zooplankton: Zooplankton population analysis at various stations showed that their numerical abundance varied from 62415 to 160920 nos./100 m^3.

Benthos: The numerical abundance of the benthic fauna varied between 520 and 880 nos./m^2.

Microbiology*:* In the water samples, population density of microorganisms varied from 0.01 to 6.66 nos.×10^3 CFU/ml at Stns. SS1 to SS7. In the sediment samples, population density of microorganisms varied from 0.01 to 6.78 nos.×10^4 CFU/g at Stns. SB1 to SB7.

Coastal vegetation: Coastal vegetation also comprises of trees like *Casuarina* sp., palm trees, etc., and creepers like *Spinifex littoreus*, *Ipomoea pes-caprae* and *Prosopis juliflora* are almost present nearshore area.

Sea weeds: Only one green seaweed species was seen along the boulders near breakwater.

Mangroves: *Avicennia marina, Rhizophora* sp. and *Bruguiera* sp. were observed in the study site. *Avicennia marina* was the dominant species.

9.4. Anticipated Environment Impacts

9.4.1. Terrestrial Environment

Air Quality

Construction Phase: The proposed project is a redevelopment project and anticipated impacts will be lower than that of a green field project. The major activities are operation of construction equipment, transport of construction material etc. These activities would cause a temporary increase in air pollutants. The impacts will be temporary in nature and will cease once the construction are completed.

Operation Phase: The anticipated impacts on air quality are expected from fugitive emissions from activities like loading/unloading activities, vehicular emission and emissions from vessels during berthing hours.

Mitigation measures:

- Water sprinkling will be practiced at unpaved roads and dust-prone areas.
- Engines and exhaust systems of all vehicles and machinery and equipment will be regularly maintained to keep the emission under statutory limits.
- Vehicles with valid PUC only will be allowed to operate inside the port.

Water Quality

Construction Phase: The water requirement of about 15 KLD for the construction phase will be provided by the PWD/ external agencies. No ground water will be tapped for the construction work. Hence, no impact on local or village water resources is expected.

Operation phase: The anticipated impacts on water environment are expected from water consumption and wastewater generation. The water requirement for the proposed project will be supplied by the PWD/ external agencies. No ground water will be tapped. As there will not be any additional water requirement impacts on the water supply of the surrounding area are not expected.

As there in no manufacturing activity within the port, no process related wastewater generation is envisaged. The sewage from the proposed project shall be sent to the septic tanks within the port.

Wastewater: Wastewater would mainly comprised of site run off and sewage.

Proper sanitation facilities like toilets and bathrooms will be provided for workers. Sewage generated will be treated through septic tanks - soak pit system or by upgrading existing underground drainage system.

Mitigation measures:

- Wastage of water during construction phase will be prevented by promoting awareness.
- Site drainage plan to prevent any water logging during the construction and operational phases will be executed. Site run off during the rainy season will be channeled through storm water drains. The runoff will be directed to the rainwater collection tank.

Noise Quality

Construction phase: The anticipated impacts on ambient noise quality are expected from construction equipment, vehicle movement etc. The impact will be localized, short term and reversible in nature.

Operation phase: The anticipated impacts on the noise environment are expected due to activities like vehicular movement and loading/unloading of cargoes. As there are no major noise generating sources the anticipated impacts on noise environment would be insignificant.

Mitigation measures:

- Proper lubrication, muffling and modernization of equipment will be done to reduce noise.
- Periodic ambient noise level monitoring will be carried out.

Land and Soil quality

Construction Phase: Anticipated impacts are from site preparation, solid waste generation, spillages etc. On completion of civil work, materials like wooden scrap, steel scrap cement, gravel

etc., unused paint, diesel oil and other debris will be collected and disposed as per norms to prevent any adverse impact on the land environment and to maintain the aesthetics.

Operation Phase: Anticipated impacts on land environment associated with port operations can arise from spillages during cargo handling, storage, waste management and disposal activities.

Mitigation measures:

- Fuels, paints and lubricants will be stored at designated covered site with containment and concrete floor to prevent ground contamination and restrict spill.
- Solid waste from labour camp and barges will be collected and properly disposed.
- The ground will be leveled, compacted and strengthened with green belt as proposed.
- Usage of non-recyclable plastics will be discourage inside the port.

Socio economics

No R&R (Rehabilitation & Resettlement) is required for the project. The expansion project will generate direct and indirect employment in terms of contracts, transportation and related activities. About 100 workers will be engaged during the construction phase and 100 personnel will be employed during the operation phase of the project.

9.4.2. Marine Environment

Piling for constructing the walkway and dredging for maintaining draft for navigational channel and disposal of dredged material can have impact on seawater quality, shoreline and flora and fauna. Numerical modeling using MIKE 21 by IITM has concluded that no significant changes in bed level are envisaged.

Piling and dredging have potential to disperse the bed sediment in the water column and increase the suspended sediments. The characteristic of the seabed sediment suggests that the texture is of sand and silt; and minor part inside the channel is clayey. The fine sediment particles dispersed in water may remain in suspension for some time but would be advected and dispersed easily under the influence of tidal currents. The piling and dredging would impact though locally, the sub tidal benthic communities. Thus, the benthos at pile footprint would be lost permanently while at dredged sites their recolonization would eventually occur. Since the sediment texture is mainly comprised of fine and medium sand and not hard, the noise due to piling is expected to be low. As the baseline data suggests there is limited commercial fishing inside the river mouth and there are no turtles and marine mammals within the project site, the anticipated impact is expected to be temporary and insignificant.

Mitigation Measures:

- Efficient piling and dredging equipment will be deployed and the dredging will be confined to the planned area only.
- Vessel-generated waste will not be allowed to be discharged within the port marine environment. The waste will be collected and disposed as per norms.
- Regular mock drills and training will be provided to the concerned port personnel for combating oil spills.

9.5. Risk Assessment and Disaster Management Plan

Disaster Management Plan including natural disasters has also been prepared and included in the report. Necessary safety procedures will be followed to minimize the impact of risks involved.

As the project is located on the coast, the area is vulnerable to natural disasters. Although, these are rare events, proper and effective coordination with local, national agencies and Govt., bodies will be the key to manage such events. Necessary facilities for emergency management will be provided to the workers. Emergency facilities include Lifesaving jackets, ropes, demarcation of Assembly Points, Evacuation Routes and Medical Facilities. An Emergency Disaster Management Cell will be formed to deal with emergency situations.

9.6. Project benefits

The proposed project will generate direct and indirect employment generation opportunities. About 1 % of project cost is allocated for Corporate Environment Responsibility (CER). This will help in improving the infrastructure such as drinking water supply, sanitation and health, education, skill development etc., in nearby villages.

9.7. Environment Management Plan

EMC is in place to ensure the implementation of Environment Management Plan. Periodic review and audits will be conducted for checking the effectiveness of implementation of mitigation measures listed in the EIA report. Both terrestrial and marine environment management plan are suggested to mitigate the impacts of the project during construction and operational phase of project. The Port Department will report environmental performance and monitoring results regularly to statutory authorities. The separate environmental budget of about Rs. 100 Lakh will be allocated for the proposed project.

9.8. Conclusion

Baseline environment study has been conducted to establish the prevailing status of the study area within 10 km from the project site. The significant environment parameters for the terrestrial and marine environment are compared with the available National Standards. The impact assessment shows that there are no significant negative impacts due to proposed project activities on surrounding environment. The implementation of suggested mitigation measures and environment management plan will ensure to keep the anticipated impacts to minimum so that the project will be completed without any significant change in baseline environment status.

10. DISCLOSURE OF CONSULTANTS ENGAGED

Indomer Coastal Hydraulics (P) Ltd., Chennai is a NABET-QCI accredited EIA consultant organization appointed for the proposed project "EIA study for the development of the existing Puducherry Minor Port by carrying out capital dredging and construction of a pile supported bridge between drainage channel and navigational channel under "Sagarmala" scheme in Uppalam, Puducherry".

Indomer is an ISO 9001:2008 certification company with QCI – NABET Accreditation for Sector 27: Oil & gas transportation pipeline (crude and refinery/petrochemical products), passing through National Parks/sanctuaries/coral reefs/ecologically sensitive Areas including LNG Terminal and Sector 33: Ports, Harbours, jetties, marine terminals, breakwaters and dredging.

All data are collected at site using the latest technology, equipment and analysis was done by Indomer, NABL accredited Laboratory with experience of Functional Area Expert (FAE) appropriate impact, mitigation and EMP were suggested. The prescribed ToRs given by the MoEFCC have been point wise complied with and included in the EIA report. We stand on the authenticity of data submitted in the EIA report "EIA study for the development of the existing Puducherry Minor Port by carrying out capital dredging and construction of a pile supported bridge between drainage channel and navigational channel under "Sagarmala" scheme in Uppalam, Puducherry".

Certified

(P. Chandramohan)
Managing Director

Quality Council of India

National Accreditation Board for Education & Training

CERTIFICATE OF ACCREDITATION

Indomer Coastal Hydraulics (P) Ltd.
63, Gandhi Road, Alwar Thirunagar
Chennai - 600 087.

Accredited as **Category - A** organization under the QCI-NABET Scheme for Accreditation of EIA Consultant Organizations: Version 3 for preparing EIA-EMP reports in the following Sectors:

Sl. No.	Sector Description	Sector (as per)		Cat.
		NABET	MoEFCC	
1	Oil & gas transportation pipeline (crude and refinery/ petrochemical products), passing through national parks/ sanctuaries/coral reefs /ecologically sensitive areas including LNG terminal	27	6 (a)	A
2	Ports, harbours, break waters and dredging	33	7 (e)	A

Note: Names of approved EIA Coordinators and Functional Area Experts are mentioned in RA AC minutes dated Oct. 06, 2017 posted on QCI-NABET website.

The Accreditation shall remain in force subject to continued compliance to the terms and conditions mentioned in QCI-NABET's letter of accreditation bearing no. QCI/NABET/ENV/ACO/18/0564 dated Jan. 05, 2018.The accreditation needs to be renewed before the expiry date by Indomer Coastal Hydraulics, Chennai following due process of assessment

Sr. Director, NABET
Dated: Jan. 05, 2018

Certificate No.
NABET/ EIA/1720/ RA 0082

Valid till
12.09.2020

For the updated List of Accredited EIA Consultant Organizations with approved Sectors please refer to QCI-NABET website.

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ANNEXURE I

Method of Collection and Analysis

1. TERRESTRIAL ENVIRONMENT

1.1. Air Sampling

Frequency and monitoring

Ambient air quality monitoring was carried out twice in a week in each location during the study period. It was ensured that the equipment was placed at a height of at least 3 to 4 m above the ground level at each monitoring station, for neglecting the effects of wind-blown ground dust. Also, distance of the sampler from any air flow obstacle i.e. buildings, walls, was more than two times the height of the obstacle. The equipment was placed at open space free from trees and vegetation which otherwise act as a sink of pollutants resulting in lower levels in monitoring results. Monitoring has been carried out as per the latest CPCB and MoEFCC guidelines and notifications.

Respirable Dust Samplers (AAS 217 BL) of Ecotech Instrument Pvt. Ltd. make were installed for monitoring Suspended Particulate Matter (SPM), Particulate Matter 10 (PM_{10}) and gaseous pollutants like SO_2, NOx, Ozone, Ammonia & heavy metals. The concentration of Particulate Matter 2.5 ($PM_{2.5}$) was monitored by installing Ecotech make Fine Particulate Sampler (AAS 127).

Parameters, Sampling & Analytical Techniques with NAAQ Standards

With a view to collecting the samples, Ecotech Instruments Make Calibrated Respirable Dust Samplers (AAS 217 BL) along with Gaseous attachment and Fine Particulate Matter ($PM_{2.5}$– AAS 127) have been used. The instruments were capable of drawing air at a flow rate of 0.6 to 1.5 m^3/min with very little pressure drop for RDS and $PM_{2.5}$ is designed to operate at an air flow rate of 16.67m^3/hr. Filter papers (EPM 2000, Whatman & Whatman 46.2 dia) were used for the collection of Particulate matters & Heavy metals. SO_2 & NO_x were collected by drawing air at a flow-rate of 0.2 liters per minute (lpm) through an absorbing solution for the duration of 24 hrs. Ammonia and Ozone were collected drawing air flow rate of 0.5 liter per minute (lpm) for the duration of 1 hour. Sampling and analysis methodology adopted is given in Table below.

Sampling & Analysis Methodology

Sl. No.	Parameter	Unit	Methodology
1	PM_{10}	$\mu g/m^3$	IS 5182: PART-23, 2006
2	$PM_{2.5}$	$\mu g/m^3$	CPCB
3	SO_X	$\mu g/m^3$	IS 5182: PART-02, 2001 (RA 2012)
4	NO_X	$\mu g/m^3$	IS 5182: PART-06, 2006 (RA 2012)
5	CO	mg/m^3	IS 5182: PART-10, 1999
6	O_3	$\mu g/m^3$	IS 5182: PART-9, 1999
7	Pb	$\mu g/m^3$	IS 5182: PART-22, 2004
8	NH_3	$\mu g/m^3$	AWMA Method 401
9	C_6H_6	$\mu g/m^3$	IS 5182: PART-11, 2006

1.2. Terrestrial water sampling Methodology

Reconnaissance survey was undertaken and monitoring stations were finalized based on:

- Location of residential areas representing different activities/likely impact areas; and
- Likely areas, which can represent baseline conditions.

Three surface water and Four groundwater samples were collected during study period. The samples were collected for analysis of physico-chemical, heavy metals and bacteriological parameters in order to assess the effect of industrial and other activities. The samples collection procedure followed by 'Standard Methods for the Examination of Water and Wastewater' published by American Public Health Association (APHA), IS 3025 and IS 10500. Samples for physico-chemical analysis were collected in polyethylene and glass bottle and preserved as per standard procedure. Samples collected for metal content were acidified with 1 ml HNO_3. Samples for bacteriological analysis were collected in sterilized glass bottles.

Grab samples: Surface and Ground water samples were collected at a specific spot at a site over a short period of time. In this terrestrial environmental impact assessment study at 10 km radius, Grab samples of the above water samples were collected at all location.

Water storage and preservation procedure

Sl. No	Parameter	Sample collection	Sample size	Storage/ preservation
1	pH	Grab sampling plastic/ glass container	50 ml	On site analysis
2	Electrical conductivity	Grab sampling plastic/ glass container	50 ml	On site parameter
3	Total Dissolved Solids	Grab sampling plastic/ glass container	100 ml	Refrigeration, can be stored for 7 days
4	Oil & Grease	Wide mouth glass container	500 ml	Add HCl to pH>2, refrigeration, 28 days
5	Hardness	Grab sampling plastic/ glass container	100 ml	Add HNO_3 to pH<2, refrigeration; 6 months
6	Chloride	Grab sampling plastic/ glass container	50 ml	Not required; 28 days
7	Sulphate	Grab sampling plastic/ glass	100 ml	Refrigeration; 28 days

Sl. No	Parameter	Sample collection	Sample size	Storage/ preservation
		container		
8	Sodium, Potassium	Plastic container	100 ml	Not required; 6 months
9	Nitrates	Plastic container	100 ml	Refrigeration; 48 hrs
10	Alkalinity	Plastic/ glass containers	100 ml	Refrigeration; 14 days
11	Heavy metals	Plastic/ Glass rinsed with 1+1 HNO_3	500 ml	HNO_3 to pH>2; Grab sample; 6 months

Source: Standard Methods for the Examination of Water and Wastewater, Published By APHA, 22nd Edition, 2012.

The error in ion-balance computation, considering the relationship between the total cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and the total anions (NO^{3-}, SO_4^{2-}, HCO_3^{-} and Cl^{-}) for each set of complete analyses of water sample, is observed to be within the range of acceptability (±3%) used in most laboratories (APHA 22nd Edtn). The analytical procedures are described in Table below.

Analytical procedure for water quality

Sl. No.	Parameters	Analytical Method	Reference
1	pH	pH meter	IS : 3025 (Part-11)
2	Turbidity	Nephelo Meter	IS : 3025 (Part-10)
3	Total Dissolve Solids	Gravimetric	IS : 3025 (Part-16)
4	Alkalinity as $CaCO_3$	Titrimetrically	IS : 3025 (Part-23)
5	Total Hardness as $CaCO_3$	Titrimetrically	IS : 3025 (Part-21)
7	Calcium as Ca	Titrimetrically	IS : 3025 (Part-40)
8	Magnesium as Mg	Calculation	APHA 22st edition,3500 Mg B:2012
9	Sodium	Flame Photometric	APHA 22st edition, 3500 Na B:2012
10	Potassium	Flame Photometric	APHA 22st edition,3500 K-B:2012
11	Chloride as Cl	Argentometric	IS : 3025 (Part-32)
12	Sulphate as SO_4	Turbidimetric	IS : 3025 (Part-24)
13	Nitrate as NO_3	Spectrophotometric	IS : 3025 (Part-34)
14	Phosphate	Spectrophotometric	IS : 3025 (Part-31)
15	Fluoride as F	Spectrophotometric	APHA 22st edition,4500 F-D:2012
16	Dissolve Oxygen	Winkler Method	IS:3025 (Part-38), Reaffirmed 2009
17	Oil & Grease	Gravimetric	IS:3025 (Part 39), 1991 (Reaffirmed 2003)
18	Total suspended solids	Gravimetric method	IS: 3025 (part 17) – 1984 (RA 2012)
19	COD	Open reflux method	APHA 23rd edition 2017
20	BOD	Oxygen depletion method	IS 3025 (part 44) : 1993 (RA 2014)

1.3. Soil

For studying soil profile of the region, sampling stations were selected to assess the existing soil conditions in and around the project area representing various land use conditions. The physical parameter and chemical parameter were determined. The soil samples were collected by random grid method of 10 m x 10 m grid by ramming a core-cutter into the soil up to a depth of 20 cm. One composite sample has been collected from each grid, by mixing of eight sub-samples and reducing the weight to approximately 500 g by conning and quartering method. The samples were packed in polyethylene bags and assigned a number. The collected samples were then air dried at room temperature (30 to 35°C) in the laboratory and lightly crushed with mortar-pastel and passed through 2 mm sieve.

Soil analysis methodology

Sl. No	Parameters	Analytical Method	Reference
1	Texture	Sieve analysis & Hydrometer	IS2720-Part 4
2	Moisture Content	Gravimetric	Department of Agriculture & Cooperation, Page No. 76-77:2011
3	pH	pH meter	IS2720- Part 26, 1987 by pH meter
4	Conductivity (1:2)	Conductivity meter	Department of Agriculture & Cooperation, Page No. 81-82:2011
5	Organic Matter	Walkly & Black method	IS2720-(Part 22),1972, Reaffirmed 2001
6	Water holding capacity	Laboratory method	-
7	Organic Carbon	Calculation	IS2720-(Part 22),1972, Reaffirmed 2001 (By Calculation)
8	Potassium	Flame Photometric	TM-S/13
9	Phosphorus	Spectrophotometric	TM-S/11
10	Nitrogen	Distillation & Titration	TM-S/17
11	Porosity	Laboratory method	TM-S/33
12	Calcium	Titrimetric method	FAO method – Pg. No. 44
13	Magnesium	Titrimetric method	FAO method – Pg. No. 44
14	Sodium	Flame photometric	FAO method – Pg. No. 44
15	Cation exchange capacity	Flame photometric	FAO method – Pg. No. 54
16	Exchangeable sodium percent	Flame photometric	FAO method – Pg. No. 56

1.4. Noise

Noise monitoring was carried out with using sound level meter (Ecotech make- SLM 100) at 4 stations, once in study period. The noise levels were measured using sound level meter. Noise level monitoring was carried out for 24 hours. Noise levels measured over a given period of time of interval, enable to describe scenario of noise using statistical techniques. Hourly Leq values have been computed for day time and night time separately.

Sampling techniques

The SLM100 is a "Type A" Integrating Sound Level Meter designed to meet the requirements of IS 15575 (Part1) 2005. The instrument has a frequency weighting of "A" type and allows the user to select Slow or Fast mode of measurement. A built-in Data Logger can record all the important Sound Level parameters in Non-Volatile Flash memory for 24 hours making detailed field data collection availability with ease. Each record consists of the LEQ, MIN and MAX Sound Pressure Level and Sound Exposure Level (SEL) observed during the recording interval. A built-in Real Time Clock maintains a Date and Time stamp in the recorded data.

2. MARINE ENVIRONMENT

2.1. Seawater

Collection

The seawater samples were collected at 7 stations. The water samples were collected at three different depths i.e., surface, mid depth and bottom. Van Dorn water samplers was used for collecting the water samples at subsurface.

Samples for dissolved oxygen was collected in 125 ml capacity DO bottles immediately after the sampler was hauled up. The bottles were rinsed with the same water sample. DO samples were fixed immediately with Winkler reagents by adding 2 ml of manganese chloride and 2 ml of alkaline potassium iodide (KI). The stopper was then inserted and the bottle shaken vigorously for about 1 minute to bring each molecule of dissolved oxygen in contact with manganese (II) hydroxide. After fixation of oxygen, the precipitate was allowed to settle. The DO bottles were kept in dark and transported to the laboratory for analysis. Samples for Biochemical Oxygen Demand (BOD) was also collected in the similar fashion as described for DO in 125 ml glass BOD bottles. Winkler A and Winkler B were added and analysed after 5 days of incubation at 20°C in a BOD incubator.

Water samples for salinity, total suspended solids, and nutrients were collected and stored in PVC bottles directly from the water sampler, after rinsing the same with the water sample. For heavy metal analysis, water samples were stored in PVC bottles adding Nitric acid <2 pH as preservative. The samples were then transported to the laboratory in an ice box. Water samples for Petroleum hydrocarbons were collected separately in amber coloured glass bottles. The sample for Phenol was collected in a pre-cleaned 1 liter plastic container.

Analysis

Sl. No	Parameters	Protocol
Seawater quality		
1	Temperature	IS 3025: Part 35
2	pH	IS 2720: Part 26
3	Salinity	IS 3025: Part 34
4	Dissolved Oxygen	IS 3025: Part 38
5	BOD	IS 3025: Part 44
6	Turbidity	IS 3025: Part 10
7	Ammonia	APHA 4500-NH_3 (F)
8	Nitrite	IS 3025: Part 34
9	Nitrate	IS 3025: Part 34
10	Dissolved phosphate	IS 3025: Part 31
11	Total Nitrogen	IS 3025: Part 34
12	Total Phosphorous	IS 3025: Part 31
13	Total Suspended Solids (TSS)	IS 3025: Part 17
14	Cadmium	IS 3025: Part 41
15	Calcium	IS 3025: Part 40 (RA 2009)
16	Chromium	IS 3025: Part 52
17	Magnesium	
18	Fluoride	APHA 23rd edition 2017
19	Iron	IS 3025: part 53 (RA 2009)

2.2. Seabed Sediment

Collection

The seabed sediments were collected at 7 stations. After collection, the scooped sample was transferred to polythene bags, labeled and stored under refrigerated conditions.

Analysis

Sl. No	Parameters	Protocol
1	Soil texture	IS : 2720: Part 4
2	Total Organic Carbon	IS : 2720: Part 22
3	Total Nitrogen	IS : 14684: Part 23
4	Total Phosphorous	IS : 10158 - 1982
5	Calcium carbonate	IS : 2720: Part 23
6	Cadmium	USEPA 3050 B
7	Lead	USEPA 3050 B
8	Iron	USEPA 3050 B
9	Chromium	USEPA 3050 B

2.3. Marine biological parameters

Primary Productivity: Primary production was estimated from 7 stations (SS1 to SS7). From the water sampler, the samples were immediately transferred to 125 ml DO bottles (two light bottles

and one dark bottle). The sample in the first bottle was used immediately to determine the initial level of dissolved oxygen (DO) content followed by Winkler method. The light and dark bottles were incubated under water for a period of 6 hr and dissolved oxygen was measured. Primary productivity was calculated by oxygen method. Oxygen values were converted to carbon values by applying the equation.

Phytoplankton: Phytoplankton samples were collected from 7 stations (SS1 to SS7), for both qualitative and quantitative analyses.

Phytoplankton samples for quantitative analyses were taken by collecting 1 liter of surface water in plastic container and preserved with Lugol's iodine solution. The analysis of phytoplankton samples include initial concentration of water sample to 15 ml volume based on settling and siphoning procedure. Quantitative estimation of phytoplankton was done by counting in Sedge wick-Rafter cell counter. It involved calculation of the number of cells of each species of phytoplankton in one liter of sea water.

For the qualitative analysis, phytoplankton samples were collected using circular standard plankton net (60 µ mesh and 60 cm mouth diameter). The net was towed at subsurface for 5 minutes. After the collection, samples were preserved in 4% buffered formaldehyde and analyzed under an inverted microscope following the standard literature (R. Subrahmanyan, 1946; C.P. Gopinathan, 1976 and Thomas, 1997).

Zooplankton: Zooplankton samples were collected using circular zooplankton net (300 µ mesh and 60 cm mouth diameter). The samples were collected during day time to calculate their biomass, population and bio diversity. The net was towed for 5 minutes. After the collection, samples were preserved in 5% buffered formaldehyde. The biomass value of zooplankton was calculated using the displacement volume method. The faunal composition and the relative abundance of different zooplankton taxa were sorted out and identified from aliquots upto species level as far as possible. All taxonomic observation and measurements were made on preserved samples. Specimens were identified based on the standard manuals (Kasturirangan, 1963; and Conway et al. 2003). The estimated abundance (density) for the different groups was expressed as nos. /100m^3.

Flowmeter: Digital Flowmeter (model - 2030R) duly calibrated by the company was used for estimating the volume of flow into the net towed for 5 minutes for the collection of phytoplankton and zooplankton. The flow meter consists of an impeller and a counter. The impeller is directly connected to the counter which records each revolution of the impeller. The flow meter has to be attached to the mouth region of the plankton net.

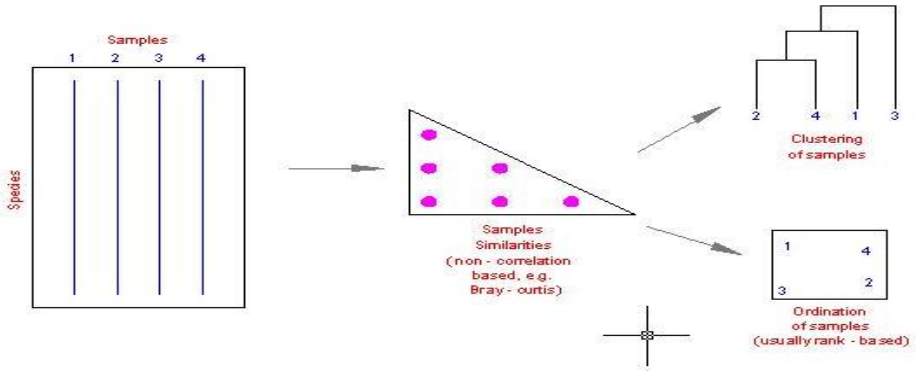
Macro Benthos: Seabed sediment samples were collected using Van Veen grab from 7 stations (SB1 to SB7). The intertidal benthic samples were collected from 3 stations (IB1, IB2 and IB3) along the shore. The benthic organisms were separated by sieving through 500 micron mesh and preserved using formaldehyde and Rose Bengal stain. The samples were sorted and identified upto groups/genera level using stereo microscope. The wet weight was taken to calculate the biomass of benthic organisms.

Microbiology: The microbiological samples were collected from 7stations (SS1 to SS7). The total coliform from each location were identified by membrane filter technique (APHA 9060 A & B). Samples were collected clean, sterile and non-reactive glass or plastic bottles. Microbial analysis is started as soon as possible after collection to avoid unpredictable changes. Spread plate method was used to culture the microorganisms. The agar media used for analysis were: Nutrient agar, MacConkey agar, Thiosulphate Citrate Bile Sucrose agar, Xylose Lysine Deoxycholate agar, M-Enterococcus agar and Cetrimide agar. Plates were incubated at 37˚C for 48 hrs. After incubation, the colonies were counted and identified based on their colour characteristics.

Fisheries: The information on fisheries were collected from local fishing villages and also from the Commissioner of Fisheries, Department of Fisheries, Government of Puducherry.

Coastal sand dune vegetation: Coastal plants, in this study are considered as those higher plants other than the mangroves, which are directly influenced by the sea. These plants present in the intertidal and supratidal region. Those plants which are rooted in the substrate near the shore, which is saline and contains a very high content of marine sediments, are also included.

Statistical Analyses: Statistical analyses were performed for phytoplankton, zooplankton and macro benthos. All statistical calculations and graphs were generated using computer software package PRIMER V.6.1.9. Its scope is the analysis of data arising in community ecology and environmental science which is multivariate in character (many species, multiple environmental variables). Sample data were compiled into square matrix (species x samples) and square root transformed to counter act the weight of dominant species without severely diminishing their importance. The transformed species - by - sample was then converted into a triangular sample-by-sample similarity matrix by calculating the Bray - Curtis similarity index between all samples - pairs, based on joint species abundance, and presence and absence. Ecological data were then analyzed for similarity of population using agglomerative hierarchical cluster analysis based on the Bray - Curtis similarity index and an average linkage Dendrogram were produced.



Stages in a multivariate analysis based on similarity coefficients

Diversity measures were calculated from the untransformed data for each sample. Indices calculated were: Margalef's species evenness coefficient (J'), the Shannon-Wiener diversity coefficient (H') and Simpson's diversity index (1-λ). The cumulative dominance plot was also constructed to compare the biodiversity between the samples.