

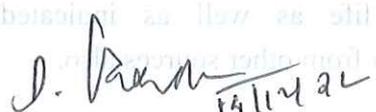
Annexure-A

D Recommendations of Joint Committee Report submitted on October 28, 2020		
	Short Term:	
Sl.No	Recommendation	Compliance status
1	At present, M/s KPL is discharging the RO reject into the Marine, in order to reduce the quantum of marine discharge as well as for use of raw water, possibilities shall be explored by M/s MPL or M/s TPL for utilizing RO reject generated from M/s. KPL in their process.	<p>The units reported that the reuse of RO reject from M/s.KPL is not feasible due to the following reasons;</p> <p>The sample taken from KPL sea discharge point during Oct '20. The results of the effluent analysis reveal high chlorides, TDS, Conductivity, and Silica.</p> <p>The effluent with above characteristics is not suitable for MPL PO process. This will affect the process, plant operation, equipment's and product specification.</p> <p>It is further reported by the unit authorities that due to the presence of chlorides, Ammoniacal nitrogen and Sulphate content in the R.O reject, the same is not suitable to utilise in the process.</p>
2	If the RO Reject found suitable for utilization, then the discharge of M/s KPL shall be stopped and sent to M/s MPL or M/s TPL.	Not Applicable
3	Action plan on phase wise revamping of treatment units of the ETP in M/s MPL Unit I and M/s TPL (all three plants HCD, LAB & ECH – PO) shall be submitted, since physical damages found during the visit. Action plan shall be submitted within a month.	<p>Complied.</p> <p>Both the units have carried out repair works of the damaged treatment units and assured to continue the same.</p>
4	Since M/s TPL is reusing the treated	Complied

	<p>effluent generated from HCD & LAB plant in the ECH – PO plant, online flow meters shall be installed at HCD & LAB plant to quantify the utilization of treated effluent. Moreover, the online effluent monitoring system installed for the parameters pH, TSS, COD, BOD etc. at HCD/LAB plant shall be relocated to the common discharge pipeline after confluence of all treated effluent and installation of display board showing effluent quality to the general public.</p>	<p>Online effluent monitoring system for the parameters pH, TSS, COD, BOD installed at the LAB Plant - ETP is relocated to the common discharge pipeline, after confluence of all treated effluent and the data is connected to display board.</p>
e.	<p>In order to assess the sea water quality, Continuous Marine Water Quality Monitoring system shall be installed at discharge point for the parameters Temperature, Conductivity, Salinity, Turbidity and Total Dissolved Solids (TDS), Dissolved Oxygen (DO), pH, Chlorophyll, fluorescent Dissolved Organic Matter (fDOM) and phycoerythrin-a pigment of blue-green algae etc. The recorded data shall be shared to NIOT & TNPCB for assessing the marine quality.</p>	<p>Being Complied</p> <p>M/s. MPL, who manages the common discharge line that disposes the treated effluent from all three plants (TPL, MPL and KPL) to sea, has taken initiative to install Continuous Marine Water Quality Monitoring system at discharge point and recorded data will be shared to TNPCB.</p> <p>As reported by the units the cost of the system will be shared by M/s. MPL, TPL and KPL and purchase order was placed to M/s. Norinco Pvt. Ltd.</p> <p>The target date of completion is by March 2023.</p>
5	<p>MPL plant I & II and M/s TPL: A pilot scale study shall be carried out with DISC membrane or any other suitable technology for reducing the discharge of treated effluent in to the sea. Possibilities shall also be explored for achieving complete or partial ZLD. Action plan shall be submitted within a month.</p>	<p>Being Complied</p> <ul style="list-style-type: none"> • The unit authority has reported that NEERI has informed vide mail dated 12.10.2022, that the validation trials are still being carried out at their laboratory and the final proposal will be submitted after successful validation of the trials.. • The units have informed that upon receipt of a technically feasible

		proposal from NEERI, work order will be issued to NEERI.
6	Calibration of the flow meters installed in the discharge pipeline shall be carried out periodically and ensure no difference in each of the flow meters.	<p>Complied</p> <p>Flow meters are being calibrated periodically, as per ISO guidelines to ensure no difference in flow meters and records are being maintained.</p>
	Long Term:	
1.	<p>NIOT has suggested long term study in both the report (2015 & 2020) to assess the marine water quality and flora & fauna marine life as well as indicated the pollution from other sources also.</p> <p>So, it is suggested to have a comprehensive impact assessment study to assess the quality for a period of five years (twice in a year), in which the impact & sources of pollution shall be identified. Accordingly, remedial measures shall be suggested.</p>	<p>Being Complied</p> <p>As directed by the Honourable NGT(SZ), all the three units (M/s. TPL, M/s. MPL & M/s. KPL) have jointly appointed a consultancy to conduct the study regarding the feasibility of introducing ZLD for discharge of effluent generated within their unit to avoid marine discharge to protect marine environment in a phased manner.</p> <ul style="list-style-type: none"> • The units had approached the NIOT and NEERI to carry out the ZLD feasibility study for the treated effluent. • As reported by the unit authorities, the NIOT has expressed their inability to take up the ZLD feasibility study, vide their letter dated 11.04.2022 since they are not expertise in the field. (Copy enclosed). • The unit authorities have reported that NEERI has submitted the draft proposal to carry out ZLD feasibility on 08.06.2022. • The unit authorities have reported that NEERI has informed vide mail dated 12.10.2022, that the

<p>As directed by the Hon'ble</p>	<p>being completed</p>	<p>validation trials are still being carried out at their laboratory and the final proposal will be submitted after successful validation of the trials..</p> <ul style="list-style-type: none"> The units have informed that upon receipt of a technically feasible proposal from NEERI, work order will be issued to NEERI. <p>On receipt of the submission of the proposal from NEERI, the same will be reviewed by the CPCB and TNPCB.</p>
-----------------------------------	------------------------	---

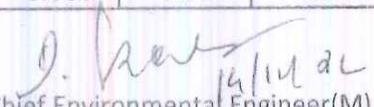

Joint Chief Environmental Engineer (Monitoring),
Tamil Nadu Pollution Control Board,
Chennai Zone.

- The units had approached the NLOT and NEERI to carry out the NLD feasibility study for the treated effluent.
- As reported by the unit authorities, the NLOT has expressed their inability to take up the NLD feasibility study, vide their letter dated 11.04.2022 since they are not equipped in the field (copy enclosed).
- The unit authorities have reported that NEERI has submitted the draft proposal to carry out NLD feasibility on 08.08.2022.
- The unit authorities have reported that NEERI has informed vide mail dated 22.10.2022 that the

ANNEXURE-B₂

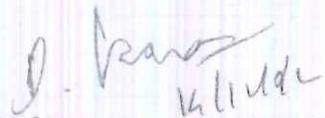
**Consolidated RoA of treated trade effluent collected from the unit of
M/s.MPL Unit-I, for the period March 2022 to June 2022**

Sl. No.	Parameters	Marine disposal standards (All values are in mg/L except pH)	Mar-22'	Apr-22'	May-22	Jun-22
1	pH	5.5 - 9	7.24	6.84	7.16	7.26
2	Total Suspended Solids	100	24	22	24	22
3	Total Dissolved Solids	-	24612	25200	25110	21086
4	Chlorides	-	14995	18994	20993	17642
5	Sulphates	1000	218	230	174	160
6	BOD for 3 days at 27°C	100	6	6	9	5
7	COD	250	56	48	40	32
8	Phosphate	-	<0.15	0.59	-	<0.15
9	Cyanide	0.2	< 0.005	< 0.005	<0.005	<0.005
10	Phenolic Compounds	5	< 0.005	< 0.005	<0.005	<0.005
11	Fluoride	15	< 1	1.88	<1	<1
12	TRC	1	< 1	< 1	<1	<1
13	Calcium	-	24850	19639	16433	20841
14	Total Chromium	2	< 0.003	< 0.003	<0.003	<0.003
15	Hexavalent Chromium	1	< 0.01	< 0.01	<0.01	<0.01
16	Copper	3	< 0.0015	< 0.0015	<0.0015	0.6264
17	Zinc	1.5	< 0.0015	< 0.0015	<0.0015	<0.015
18	Lead	1	< 0.015	< 0.015	<0.015	<0.015
19	Cadmium	2	< 0.008	< 0.008	<0.008	0.3629


 Joint Chief Environmental Engineer(M),
 Tamil Nadu Pollution Control Board,
 Chennai Zone.

**Consolidated RoA of treated trade effluent collected from the unit of M/s.MPL
Unit-II, for the period March 2022 to June 2022**

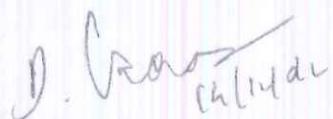
S.No.	PARAMETER	UNIT	DATE			
			24-03-2022	30-04-2022	19-05-2022	30.06.2022
1	pH	-	7.32	7.24	7.38	7.15
2	Total Suspended Solids	mg/L	30	20	22	22
3	Total Dissolved Solids	mg/L	24986	23592	23100	20756
4	Chlorides	mg/L	18994	14995	18994	15660
5	Sulphates	mg/L	161	179	159	162
6	BOD for 3 days at 27°C	mg/L	5	3	6	8
7	COD	mg/L	40	24	24	48
8	Phosphate	mg/L	< 0.15	0.55	-	<0.15
9	Cyanide	mg/L	< 0.005	< 0.005	< 0.005	<0.005
10	Phenolic Compounds	mg/L	< 0.005	< 0.005	< 0.005	<0.005
11	Fluoride	mg/L	< 1	1.72	< 1	<1
12	TRC	mg/L	< 1	< 1	< 1	<1
13	Calcium	mg/L	21643	18036	16032	20040
14	Total Chromium	mg/L	< 0.003	< 0.003	< 0.003	<0.003
15	Hexavalent Chromium	mg/L	< 0.01	< 0.01	< 0.01	<0.01
16	Copper	mg/L	< 0.0015	< 0.0015	< 0.0015	0.4197
17	Zinc	mg/L	0.1421	< 0.0015	< 0.0015	<0.0015
18	Lead	mg/L	< 0.015	< 0.015	< 0.015	<0.015
19	Cadmium	mg/L	< 0.008	< 0.008	< 0.008	0.4331


 Joint Chief Environmental Engineer(M),
 Tamil Nadu Pollution Control Board,
 Chennai Zone.

Consolidated RoA of RO Reject collected from the unit of
M/s.Kothari Petrochemicals Limited, for the period March 2022 to
June 2022

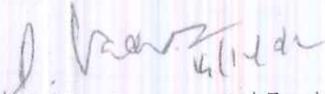
SN	Pollutant water parameter	UNIT	Prescribed limit	05.03.2022	30.06.2022
				RO Reject	R.O Reject
1	pH	Number	5.5 to 9	7.53	6.83
2	Total Suspended Solids	mg/ L	100	18	26
3	Total Dissolved Solids	mg/ L	-	9654	7100
4	Chlorides	mg/ L	-	2010	4100
5	Sulphate	mg/ L	1000	2918	34
6	Oils & Grease	mg/ L	20	-	
7	BOD 3 days @ 27°C	mg/ L	100	9	13
8	COD	mg/ L	250	88	176
9	Phosphate	mg/ L	-	-	<0.15
10	Cyanide	mg/ L	1.5	<0.05	<0.005
11	Phenolic Compounds	mg/ L	5	<0.1	<0.005
12	Sulphide	mg/ L	5	<1	<1
15	Ammoniacal Nitrogen	mg/ L	-	12.6	
16	TKN	mg/ L	100	28.4	
17	Total Chromium	mg/ L	2	<0.05	<0.003
18	Hexavalent Chromium	mg/ L	1	<0.05	<0.01
19	Copper	mg/ L	3	0.148	<0.0015
20	Zinc	mg/ L	1.5	0.238	<0.0015
21	Lead	mg/ L	1	<0.07	0.0473
22	Cadmium	mg/ L	2	<0.013	0.1754
23	Nickel	mg/ L	3	<0.05	0.4024
24	Total Iron	mg/ L	-	0.462	0.3439
25	Mercury	mg/ L	0.01	FNA	NA
26	Phosphorus	mg/ L	-	FNA	-

*Note- The plant was under shutdown during the month of April 2022 & May 2022 and hence, effluent samples not collected.


 Joint Chief Environmental Engineer(M),
 Tamil Nadu Pollution Control Board,
 Chennai Zone.

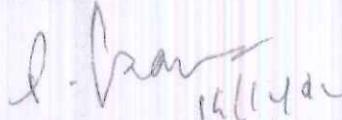
**Consolidated RoA of treated trade effluent collected from the
unit of M/s.TPL-Lab, for the period March 2022 to May 2022**

S.No	Parameter	24.03.2022	30.04.2022	19.05.2022
1	pH	8.68	8.64	8.48
2	TSS, mg/l	28	10	6
3	TDS, mg/l	1152	860	984
4	Chlorides, mg/l	550	300	380
5	Sulphates, mg/l	38	166	201
6	Oil & grease, mg/l	---	---	-
7	BOD, mg/l	13	5	3
8	COD, mg/l	136	40	48
9	Phosphate, mg/l	0.16	0.55	-
10	Cyanide, mg/l	<0.005	<0.005	<0.005
11	Phenolic compound, mg/l	<0.005	<0.005	<0.005
12	Fluoride, mg/l	< 1.0	2.21	<1
13	TRC, mg/l	<1.0	<1.0	<1
14	Calcium, mg/l	265	156	92
15	Total chromium	< 0.003	< 0.003	<0.003
16	Hexavalent Chromium, mg/l	< 0.01	< 0.01	<0.01
17	Zinc, mg/l	---	<0.0015	<0.015


 Joint Chief Environmental Engineer(M),
 Tamil Nadu Pollution Control Board,
 Chennai Zone.

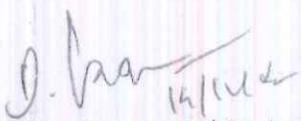
**Consolidated RoA of treated trade effluent collected from the unit
of M/s.TPL-HCD, for the period March 2022 to May 2022**

S. No	Parameter	24.03.2022	30.04.2022	19.05.2022
1	pH	7.73	8.36	8.72
2	TSS, mg/l	40	20	10
3	TDS, mg/l	5664	7324	3784
4	Chlorides, mg/l	2749	3799	1999
5	Sulphates, mg/l	556	486	263
6	BOD, mg/l	22	10	7
7	COD, mg/l	216	80	56
8	Phosphate, mg/l	0.2	0.59	<0.15
9	Cyanide, mg/l	<0.005	<0.005	<0.005
10	Phenolic Compound, mg/l	<0.005	<0.005	<0.005
11	Fluoride, mg/l	<1.0	1.37	<1
12	TRC, mg/l	<1.0	<1.0	<1
13	Sulphide, mg/l	<1.0	<1.0	<1
14	Calcium, mg/l	136	152	48
15	Ammoniacal Nitrogen	-	-	<2
16	Total chromium	<0.003	<0.003	<0.003
17	Hexavalent Chromium, mg/l	<0.01	<0.01	<0.01
18	Copper, mg/l	<0.0015	<0.0015	<0.0015
19	Zinc, mg/l	0.0185	0.0546	0.1402
20	Lead, mg/l	<0.015	<0.015	<0.015
21	Cadmium, mg/l	<0.008	<0.008	<0.008
22	Nickel, mg/l	<0.006	<0.006	<0.006


 Joint Chief Environmental Engineer (M,
 Tamil Nadu Pollution Control Board,
 Chennai Zone.

**Consolidated RoA of treated trade effluent collected from the unit of
M/s.TPL-ECH, for the period March 2022 to May 2022**

S. No	Parameter	24.03.2022	30.04.2022	19.05.2022
1	pH	7.36	7.24	6.68
2	TSS, mg/l	16	20	14
3	TDS, mg/l	12728	13050	27818
4	Chlorides, mg/l	7298	7498	9997
5	Sulphates, mg/l	35	76	78
6	Oil & Grease, mg/l	---	---	-
7	BOD, mg/l	7	10	21
8	COD, mg/l	48	72	200
9	Phosphate, mg/l	0.16	0.62	-
10	Cyanide, mg/l	< 0.005	< 0.005	<0.005
11	Phenolic compound, mg/l	< 0.005	< 0.005	<0.005
12	Fluoride, mg/l	< 1.0	< 1.0	<1
13	TRC, mg/l	< 1.0	< 1.0	<1
14	Calcium, mg/l	5772	6653	6012
15	Total chromium	< 0.003	< 0.003	<0.003
16	Hexavalent Chromium, mg/l	< 0.01	< 0.01	<0.01
17	Copper	0.0572	---	0.056
18	Zinc, mg/l	<0.0015	0.1045	0.045
19	lead, mg/l	<0.015	---	<0.015
20	Cadmium, mg/l	<0.008	---	<0.008
21	Nickel, mg/l	<0.006	---	0.1023


 Joint Chief Environmental Engineer (M,
 Tamil Nadu Pollution Control Board,
 Chennai Zone.

**Marine Impact Assessment Studies for
the Combined Marine Outfall from
M/s. MPL, TPL and KPL, Manali,
at the Bay of Bengal off
North Chennai Coast**

(Period 2021-22)

Final Report

Prepared by



National Institute of Ocean Technology

Chennai – 600 100

August 2022



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

NATIONAL INSTITUTE OF OCEAN TECHNOLOGY

NIOT Campus, Velachery-Tambaram Road,

Pallikaranai, Chennai-600 100

Tel: +91 044 66783440,

Fax: +91 044 22460275

Email: postmaster@niot.res.in Web: www.niot.res.in

Report Summary

M/s. Manali Petrochemicals Limited (MPL), M/s. Tamil Nadu Petrochemicals Limited (TPL) – PO Plant & M/s. Kothari Petrochemicals Limited (KPL) is located in Manali Industrial Area and discharges its treated effluent after meeting the prescribed norms from their respective Effluent Treatment Plant (ETP) through a common pipeline to the marine outfall at 800 m away from the shore in North Chennai.

This report details the results of monitoring studies carried out along the North Chennai coast and compares status of environmental parameters with measurements carried out in 2015, which has been used as the baseline. Overall all the parameters are found to conform to Seawater Quality Standards (SW-IV) for harbor waters as per CPCB norms. The pH values are 7.7 to 8.0 against the SWIV standards of 6.5 to 9.0, found to be within the permitted limits. The vital dissolved oxygen concentrations comply with the coastal water quality criteria of not less than 3 mg/l against the 7 mg/l prevailing along the study area. Biochemical oxygen demands are 1.8 mg/l against the standard requirement of not more than 5mg/l and found within the limits of coastal waters' water quality standards. An increase in stable constitute like nitrate (20.1mg/L) is observed without any corresponding variation in the ammonia or nitrite values may have its source from an adjoining Ennore creek which recorded 25 $\mu\text{mol/l}$ during the same period. The diatoms and dinoflagellate were the significant contributors to the total population of phytoplankton. A variation in benthic population is attributable to the seasonal changes, flow directions and synergistic effects of various discharges along the Bay of Bengal off North Chennai Coast.



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Client		Client's representative			
Manali Petrochemicals Limited Ponneri High Road Chennai-600068		Whole Time Director (Operations) Manali Petrochemicals Limited Ponneri High Road Chennai-600068			
Project		Project No			
Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL, and KPL, Manali, at the Bay of Bengal off North Chennai Coast		NIOT/CEE/MPL/1176			
Revision	Description	By	Checked	Approved	Date
1	Draft Report	PPJ	VR	PJ	02/08/2022
2	Final Report	PPJ	VR	PJ	23/08/2022
Keywords		Classification			
		<input type="checkbox"/> Open <input type="checkbox"/> Internal <input checked="" type="checkbox"/> Proprietary			
Distribution			No. of copies		
MPL, Chennai					
NIOT, Chennai.			2		



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

CONTENTS

1. INTRODUCTION.....	4
1.1 SCOPE OF STUDY.....	4
2. STUDY AREA.....	5
3. MATERIALS AND METHODS.....	6
4. RESULTS AND DISCUSSION.....	7
4.1 PHYSICAL OCEANOGRAPHY.....	7
4.1.1 TIDE.....	7
4.1.2 WATER CURRENT.....	9
4.2 WATER QUALITY PARAMETERS.....	11
4.2.1 PHYSIO-CHEMICAL PARAMETERS.....	11
PETROLEUM HYDROCARBON (PHC)	18
SEDIMENTS.....	22
BIOTIC ENVIRONMENT.....	26
BIOLOGICAL OCEANOGRAPHIC STATUS.....	26
BIOLOGICAL DATA COLLECTION.....	27
BIOLOGICAL SAMPLING.....	27
PHYTOPLANKTON.....	27
BENTHOS.....	29
SUMMARY & CONCLUSIONS.....	31
8. REFERENCES.....	33
APPENDIX - A.....	34



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

1. INTRODUCTION

Manali is an industrial center located in the suburban area of North Chennai. There are several medium and large-scale industries in this region, of which Manali Petrochemicals Limited (MPL), Tamil Nadu Petroproducts Limited and Kothari Petrochemicals Limited are few major petrochemical industries.

MPL discharges its treated effluents through a typical effluent treatment facility and releases them through a pipeline at a depth of 10 meters into the Bay of Bengal off the North Chennai coast. TPL – PO Plant and KPL are also discharging their treated effluents after meeting the prescribed standards through above mentioned common pipeline into the sea

M/s. Manali Petrochemicals Limited, Chennai, has entrusted a Marine Impact Assessment Study of its combined marine outfall off North Chennai Coast to NIOT vide work order number MPL/DIR (O)/NIOT/2021/01 dated 07th October 2021. Presently MPL, TPL & KPL discharges treated effluent from their Effluent Treatment Plant (ETP) after meeting the prescribed marine standards through a common pipeline to marine outfall located 800m away from the shore in North Chennai in about 10m water depths.

While it is well established that the environmental impacts of aromatic petroleum hydrocarbons from petrochemical industries are often harmful and toxic to life forms, hydrocarbons are closely linked to all aspects of present society, especially as fuel for transportation and industrial activities. According to Environment, Health and Safety (EHS) regulations, companies must implement effective environmental management systems to protect natural resources and reduce environmental impact. This monitoring study attempts to evaluate any possible ecological impact of the treated effluent outfall off North Chennai coast.

1.1 SCOPE OF STUDY

NIOT has undertaken water quality and biology sample studies in and around the marine outfall area, The data collected has been compared with the baseline conditions to determine any effect the discharge may have on the marine environment water quality, flora and fauna. Steps in the study involves:

- The field studies assess physical, chemical, and biological water quality, sediment quality, and biology in near and far field regions surrounding the outfall by collecting water and sediment samples followed by laboratory analysis.



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

3. MATERIALS AND METHODS

Water samples were collected from 10 sampling locations in and around the outfall area and four locations inside Ennore creek (Table.1) during March 2022 covering two tidal cycles, i.e., High and Low tides. The Niskin water sampler & polypropylene bucket were used to collect surface & depth water samples and transferred to pre-cleaned 1-liter polypropylene bottles following standard protocols. The collected samples were stored at 4°C in an ice box for nutrients, BOD other parameters analysis. Acid rinsed bottles were used to collect the samples for metal analysis, and amber bottles were used for organic analysis. Water samples were analyzed for dissolved oxygen (DO), Salinity, water temperature, and pH under field conditions using a multi-parameter water quality probe. Water samples were immediately transferred to the laboratory for analyzing nutrients, Total Suspended Solids (TSS), metals, and Petroleum Hydro Carbon (PHC). The analyses have been carried out in conformance with standard methods (APHA, 2005; Grasshoff *et al.*, 1999).

Table 1. Sampling locations near the marine outfall area at Bay of Bengal off North Chennai Coast.

S.No.	Sampling locations	Longitude and Latitude	Remarks
1	EMPL1	13°11'23.61"N 80°19'33.79"E	North of outfall
2	EMPL2	13°11'06.27"N 80°19'29.36"E	North of outfall
3	EMPL3	13°10'33.68"N 80°19'23.03"E	South of outfall
4	EMPL4	13°10'17.42"N 80°19'19.52"E	South of outfall
5	EMPL5	13°11'20.55"N 80°19'51.07"E	Northeast of outfall
6	EMPL6	13°11'02.02"N 80°19'47.35"E	Northeast of outfall
7	EMPL7	13°10'47.74"N 80°19'42.69"E	500m away from the outfall area (Eastern side)



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

S.No.	Sampling locations	Longitude and Latitude	Remarks
8	EMPL8	13°10'31.24"N 80°19'39.03"E	Southeast of outfall
9	EMPL9	13°10'15.38"N 80°19'36.42"E	Southeast of outfall
10	EMPL10	13°10'46.71"N 80°19'56.05"E	1km away from the outfall (Eastern side)C
11	ENC 1	13° 13'52"N 80° 19'48"E	Ennore creek mouth
12	ENC 2	13° 13'25"N 80° 19'08"E	Near railway bridge
13	ENC 3	13° 13'25"N 80° 19'08"E	Near to ETPS intake point
14	ENC 4	13° 11'02"N 80°17'42"E	Downstream of Ammulvoyal junction

Samples were handled with all necessary quality assurance and quality control (QA/QC) measures such as preservation, storage, and labeling being followed. All sample containers were pretreated by washing in dilute hydrochloric acid and rinsed with distilled water. The instruments were calibrated using NIST traceable standards and certified reference materials (CRM) before and after measurements.

4. RESULTS AND DISCUSSION

4.1 PHYSICAL OCEANOGRAPHY

4.1.1 Tide

"The rhythmic rise and fall of sea water level due to the gravitational force of sun and moon is called the tide." In the present study, the tides (High and Low tide) measurements of the Bay of Bengal off North Chennai Coast are given below and in Fig. 2.



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

DATE	TIME	TIDE (m)	
16 th March 22	01:40	0.13	LT
	07:33	0.76	HT
	13:19	0.11	LT
	19:44	0.97	HT
17 th March 22	02:04	0.05	LT
	08:02	0.86	HT
	13:51	0.07	LT
	20:08	1.03	HT
18 th March 22	02:27	0.01	LT
	08:32	1.94	HT
	14:25	0.04	LT
	20:36	1.06	HT
19 th March 22	02:54	0.06	LT
	09:04	1.01	HT
	15:00	0.04	LT
	21:05	1.07	HT

The tide level changes ranged from 0.01 to 0.13 m in low and 1.01 to 1.07m in high tidal water near the outfall location with respect to Chart Datum during the study period.

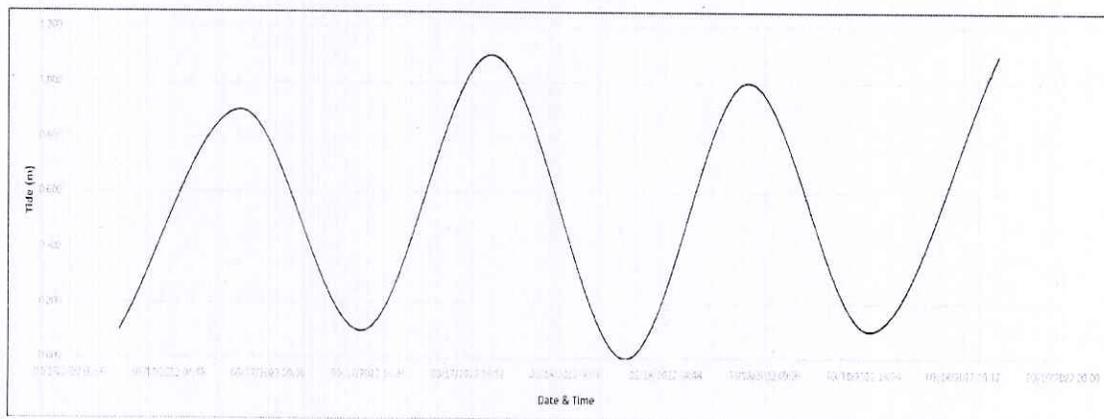


Fig. 2 Variations of the tide (m) along the study area



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

4.1.2 Water Current

Ocean current is a continuous, directed movement of seawater generated by forces acting upon this, such as breaking waves, wind, Coriolis effect, temperature, and salinity differences.

The measurement of ocean current in the study area at location EMPL 7 is presented in Fig. 3. During the study period, the current ocean speed varied from 2.63 cm/s to 24.25 cm/s with an average of 14.10 cm/s, and the current direction is towards the north, with the predominant current direction being NE (56°). The current direction was observed parallel to the coastline during the observation period. The 2015 studies also recorded the same magnitude & direction of water current along the study area.

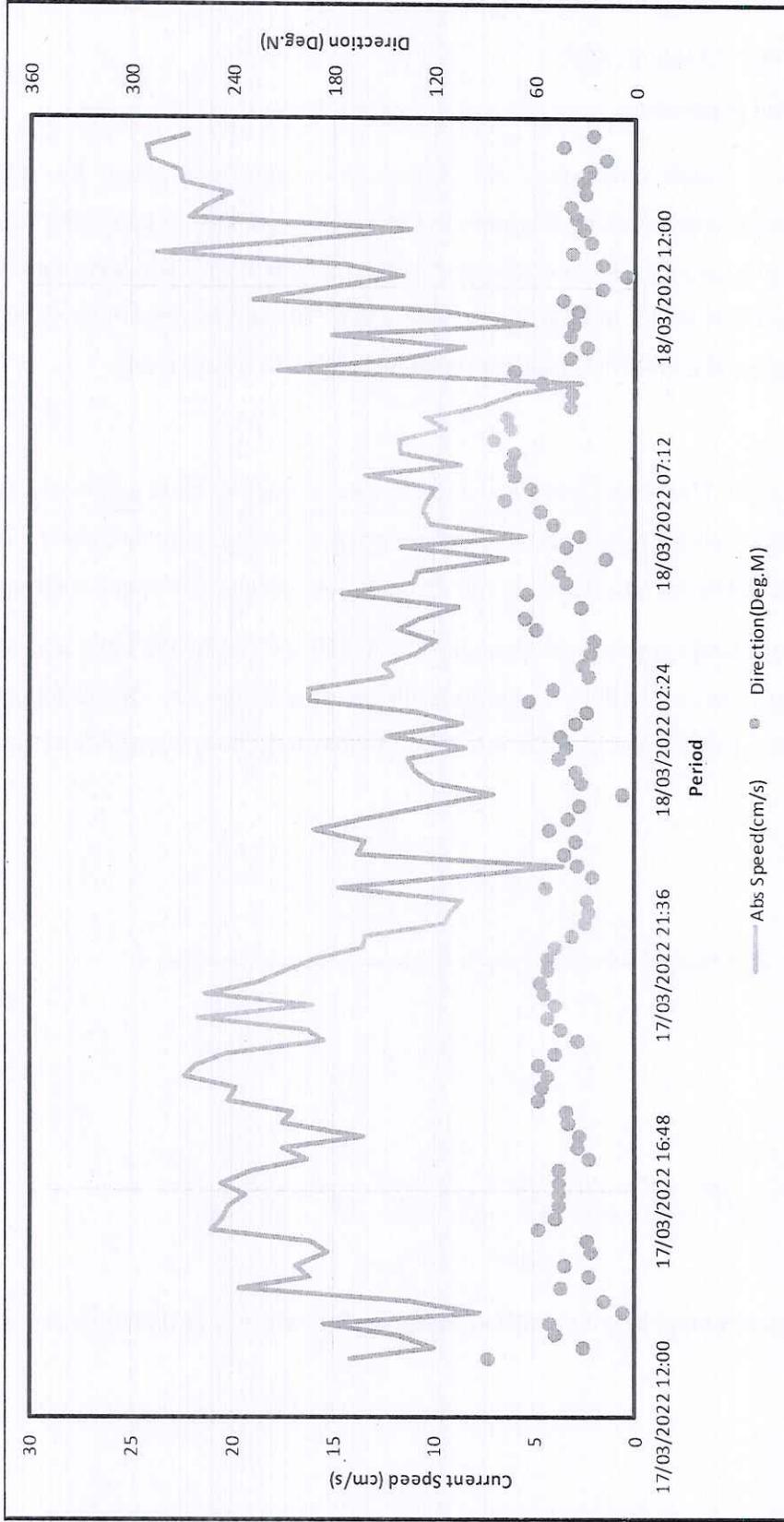


Fig. 3 Variations of current speed and direction during 2022



4.2 WATER QUALITY PARAMETERS

4.2.1 Physio-chemical parameters

Water quality study helps understand the ecosystem response/behavior by quantitative measurement of the influence of manmade activities on the ecosystem in terms of physicochemical characteristics like pH, salinity, DO, nutrients and metals, etc., in the aquatic ecosystem which are further likely to manifest in the biological characteristics. The mean, minimum and maximum values of physico-chemical characters are presented in Table 1 in Annexure A.

Temperature

Temperatures affect the kinetics of chemical and physical processes such as dissolved oxygen, photosynthesis, and metabolic processes and thus control the water quality. Seawater temperature measured during the different tidal cycles recorded negligible variation in space and time.

The temperature in the study area varied between 28.7 and 29.0°C during the study period. Surface temperatures generally showed minor variations with the time of the day. Water temperature is influenced by several factors, such as the intensity of solar radiation, evaporation, and sewage influx.

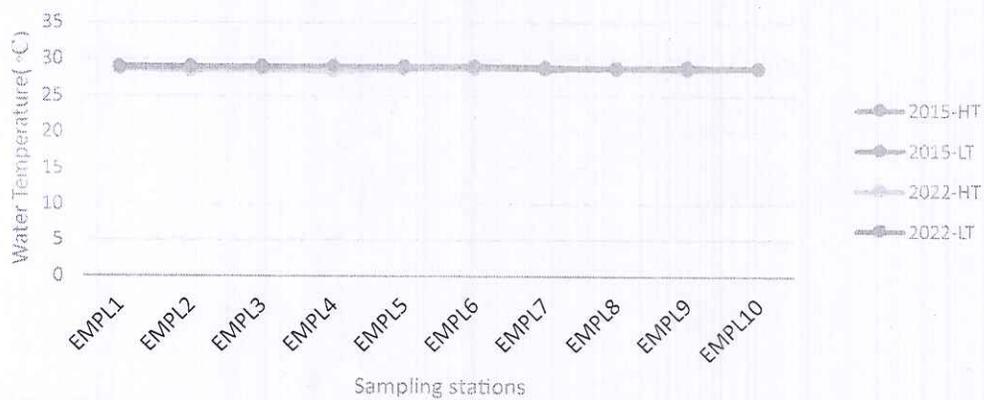


Fig. 4 Water temperature variation in the surface waters in the study area



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Salinity

Salinity values ranged between 31.7 and 32.3 PSU in coastal waters. The maximum values of 32.25 PSU were recorded at surface waters of EMPL4 during low tide, with a bottom value of 32.32 PSU at bottom waters. The values are comparable with baseline conditions.

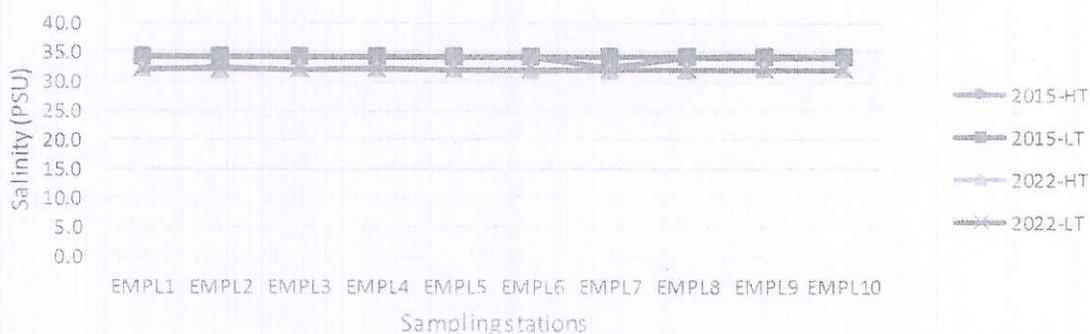


Fig. 5 Salinity variation in the surface waters in the study area

pH

The variation of pH observed in the samples ranged between 7.7 and 8.0 in the surface waters of the study area. The observed pH values are within the range of normal coastal waters and show negligible variation when compared to values observed in 2015. The pH values are 7.7 to 8.0 against the SWIV standards of 6.5 to 9.0, found to be within the permitted limits.

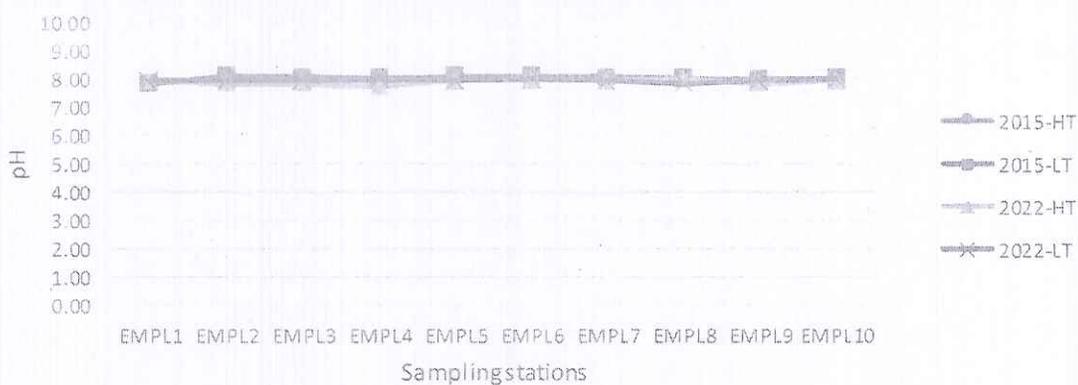


Fig. 6 pH variation in the surface waters in the study area



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Total Suspended Solids (TSS)

The variation of suspended solids was 17.8 to 28.4 mg/l during the study period. The maximum value was recorded at EMPL3 during high tide at surface waters, and the bottom water was recorded 30.6 mg/l at EMPL5 during low tide. TSS values are comparable with the 2015 study and recorded a slight increase.

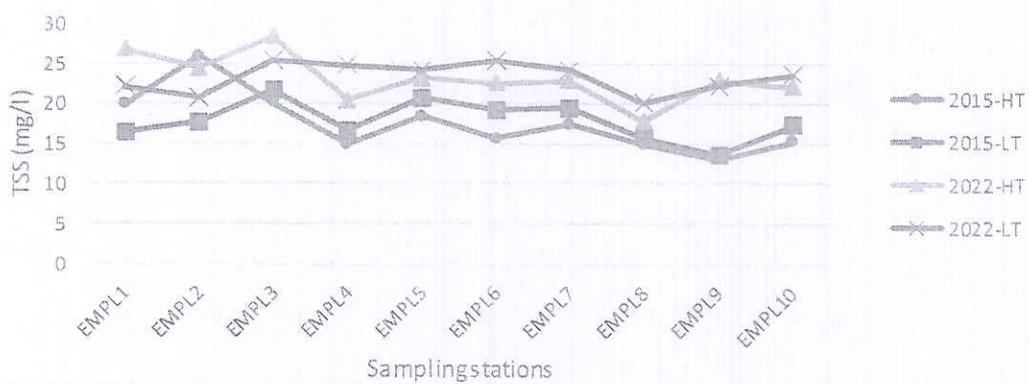


Fig. 7 Total suspended solid variation in the surface waters in the study area

Dissolved Oxygen (DO)

Dissolved oxygen in water depends on several factors: salinity, temperature, wind velocity, reaeration, organic matter, productivity, and the presence of pollutants.

The observed dissolved oxygen ranged from 7.3 to 8.8 mg/l at surface waters. The minimum value was recorded during low tide at the EMPL3 station, and the bottom water recorded a minimum of 6.8 mg/l at EMPL7. The DO values conform to Seawater Quality Standards SW II prescribed by CPCB.



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

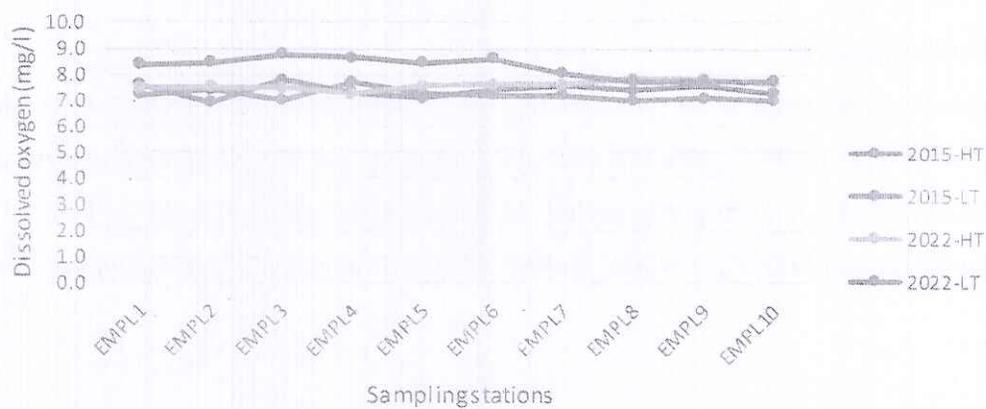


Fig. 8 Dissolved oxygen variation in the surface waters in the study area

Biological Oxygen Demand

BOD values in surface water varied between 1.1 to 1.6 mg/l. The bottom water values are lesser than the surface waters. While a slight increase in BOD levels compared to 2015 levels is recorded. It is within the limits of SW IV criteria.

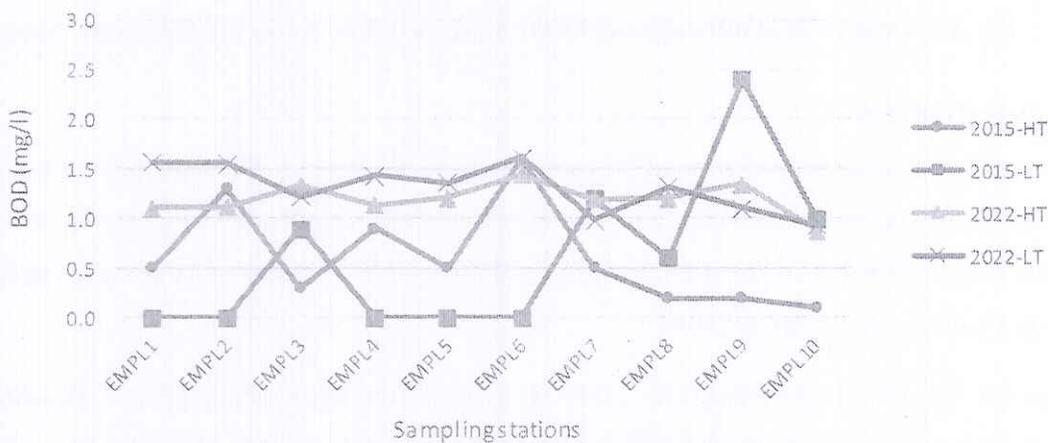


Fig. 9 BOD variation in the surface waters in the study area

Nutrients

The water chemistry of the sea results from hydrodynamics and biological activity, which cause variations in nutrient concentrations. Enhanced concentrations generally imply anthropogenic inputs. On the other hand, very high concentrations can result in eutrophication, resulting in DO problems.



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

In general, nutrient concentrations in the seawater are very low; minor increases or decreases can alter primary productivity. The concentration ranges of nutrients are as follows.

a. Ammonia Nitrogen

The ammonia values range from 0.11 to 0.88 $\mu\text{mol./l}$ among various stations, and the maximum value is recorded at EMPL8 surface waters. The bottom water samples recorded a maximum of 0.88 $\mu\text{mol./l}$ at EMPL8 during this period. In addition, the unusual spike at EMPL3 & 8 in ammoniacal nitrogen values needs to be studied in detail for seasonal variations/possibility of other sources.

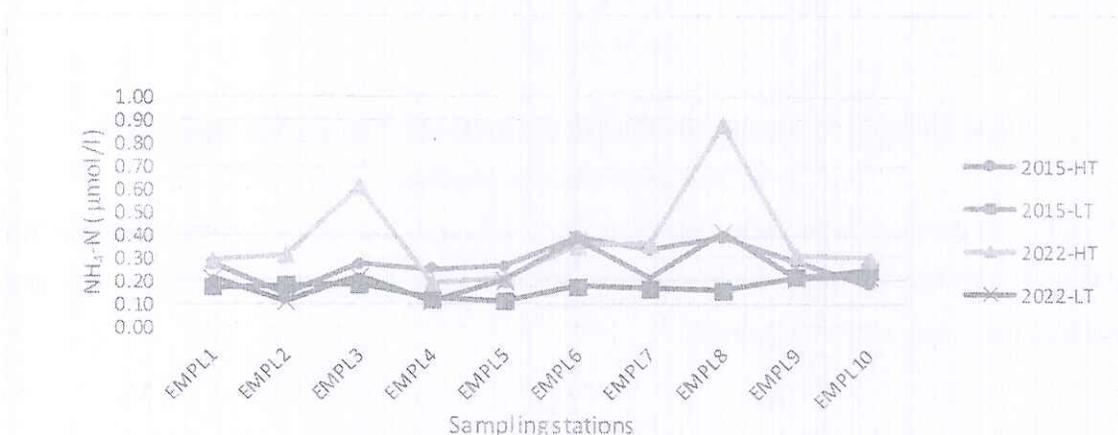


Fig. 10 Ammoniacal nitrogen variation in the surface waters in the study Area

b. Nitrate Nitrogen

Among the three inorganic forms of Nitrogen, Nitrate Nitrogen is likely to be abundant at all stations, as it is thermodynamically the most stable oxidation level of nitrogen in the presence of oxygen in seawater. It also accumulates in the sediments if left unutilized by plankton or bacterial decomposition in the water column.

In general, Nitrate values varied from 2.3 to 20.1 $\mu\text{mol./l}$ during the study period. The maximum value was found to be reported at EMPL1 & EMPL5 stations in samples collected during low tide. The bottom water samples also recorded the same range of 2.1 to 20.2 $\mu\text{mol./l}$ as surface waters. The nitrate values recorded a significant increase when compared to 2015 studies. The marked increase was noted along the nearshore stretches in proximity to diffusers. The adjoining coastal creek recorded high values of 20 to 25 $\mu\text{mol./l}$, which may be a source of elevated concentration at nearshore stations and augmented by the contributions from Cooum & Adyar. The current



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

direction also supports the same as the flow travels towards the NE direction. Therefore, it appears that shore parallel flows may influence high nitrate content leading to a possible increase along nearshore stations EMPL1 to EMPL5. In general, nitrate nitrogen is a thermodynamically more stable form combined with inorganic nitrogen in well-oxygenated waters and variations due to biological activity along coastal waters (Zepp, 1997). Hence, the implications of higher concentrations need long term studies.

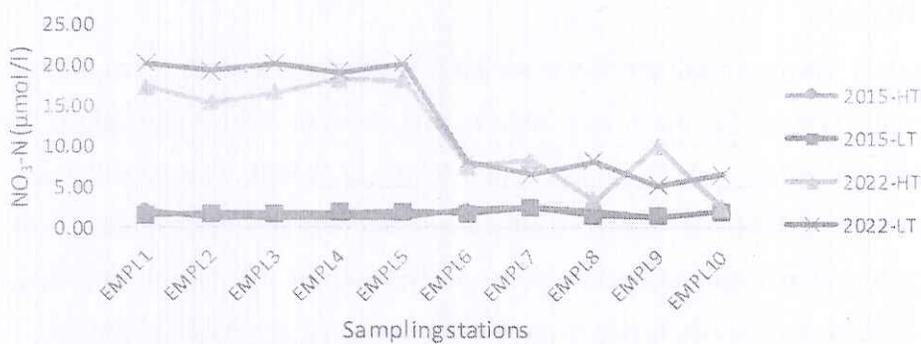


Fig. 11 Nitrate nitrogen variation in the surface waters in the study area

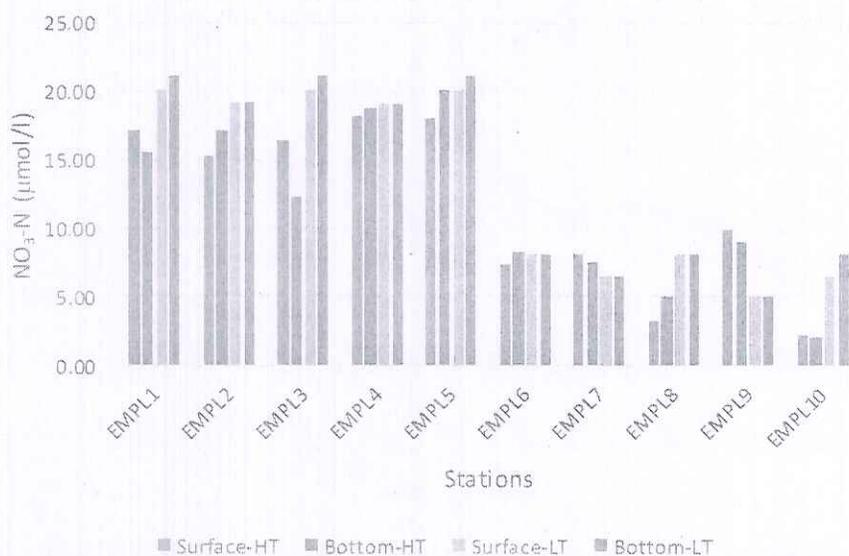


Fig. 12a Nitrate nitrogen variation in the surface & bottom waters in the study area



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

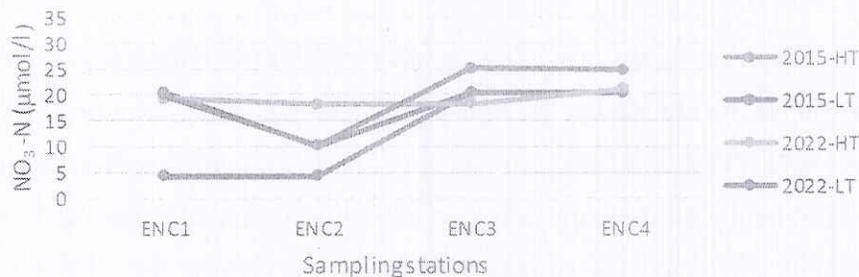


Fig. 12b Nitrate nitrogen variation in the surface waters in Ennore creek

c. Nitrite Nitrogen

The transitional Nitrogen product Nitrite varied between 0.01 to 0.08 $\mu\text{mol/l}$ in surface waters during the study period. The maximum value was recorded at EMPL8 during high tide. There is a slight increase in nitrite values along offshore stations (EMPL 6 to EMPL10) compared to nearshore stations (EMPL1 to EMPL5), which is lower than the 2015 values. Generally natural nitrogen cycling at offshore stations favours degradation of nitrate concentrated at nearshore stations, indicating nutrient diffusion towards deeper regions envisages a healthy coastal process aiding pollutant dilution along the study area. The same trend of surface water has been observed in bottom waters.

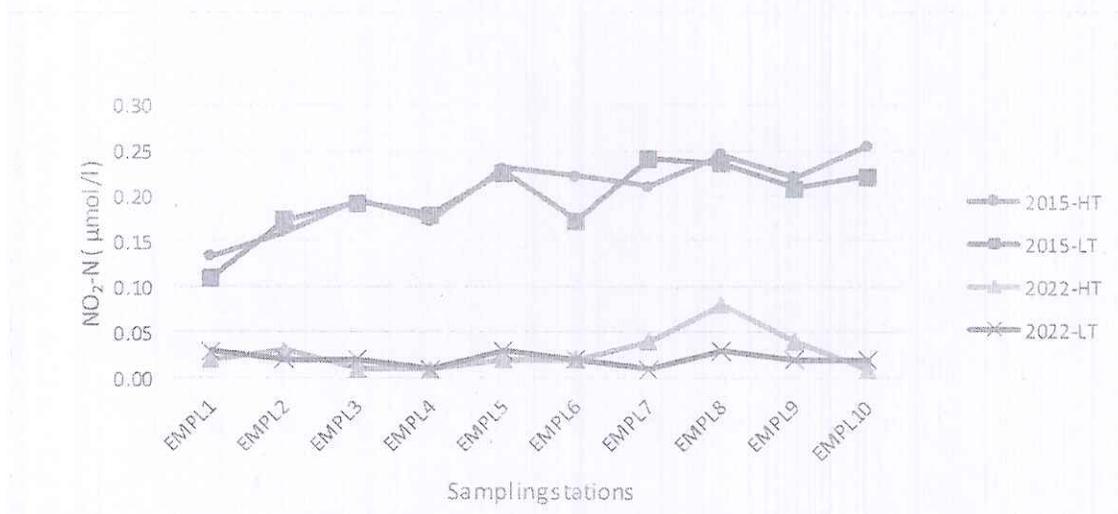


Fig. 13 Nitrite nitrogen variation in the surface waters in the study area



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

d. Phosphate Phosphorous

In general, the Phosphate phosphorous concentrations varied between 0.11 to 0.32 $\mu\text{mol./l}$ in surface waters at all the stations. A significant decrease in phosphate concentration is observed compared to the 2015 condition. The bottom waters also recorded the same trend as surface waters.

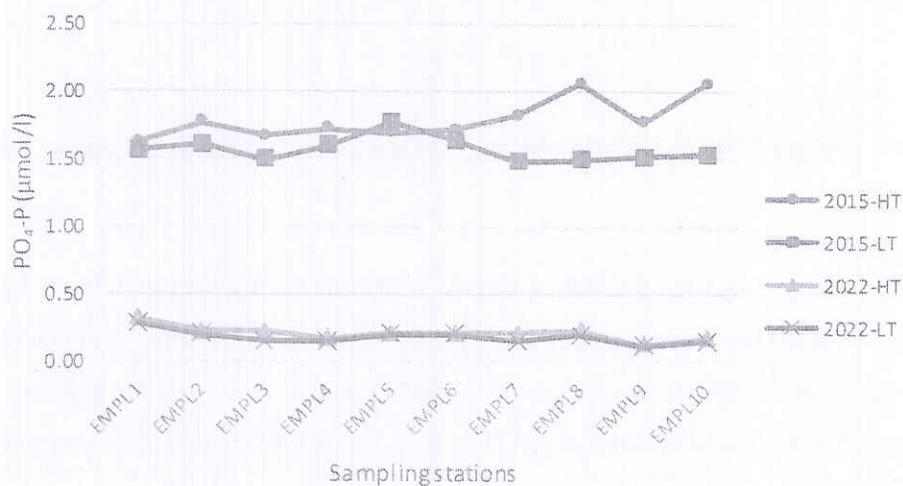


Fig. 14 Phosphate variation in the surface waters in the study area

Petroleum hydrocarbon (PHC)

Petroleum hydrocarbons are the primary constituents in oil, gasoline, diesel, and various solvents and penetrating oils. Petroleum hydrocarbon residue in the surface water column was found to be very minimal during the survey period. The present observation recorded a significant decrease in concentration compared to previous studies.



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

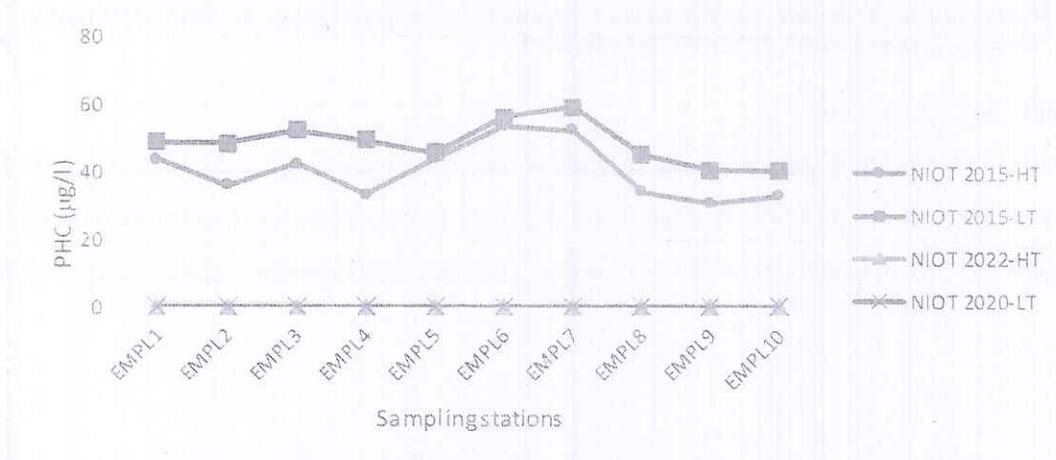


Fig.15 PHC variation in the surface waters in the study area

Heavy Metals

Heavy metals like Arsenic, Nickel, Copper, Chromium, Cadmium, Zinc, Lead, Cobalt, Manganese, and Mercury were analyzed in water and sediment. The range of metal concentrations in surface waters is far less from the previous studies of 2015, except for copper. The mercury concentrations are below detectable levels. However, the results do not show any trend among the location or tides.

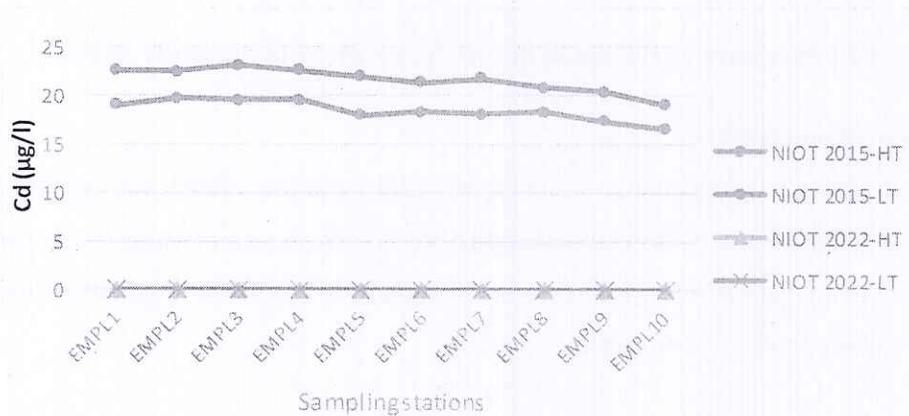


Fig. 16 Cadmium variation in the surface waters in the study area



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

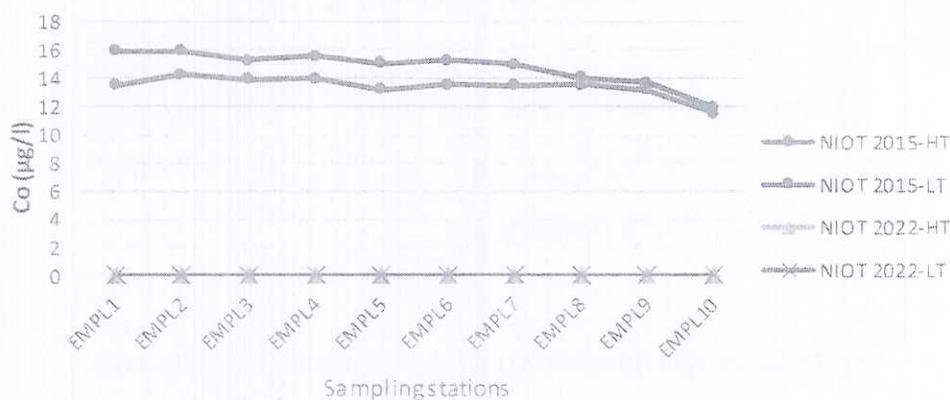


Fig. 17 Cobalt variation in the surface waters in the study area

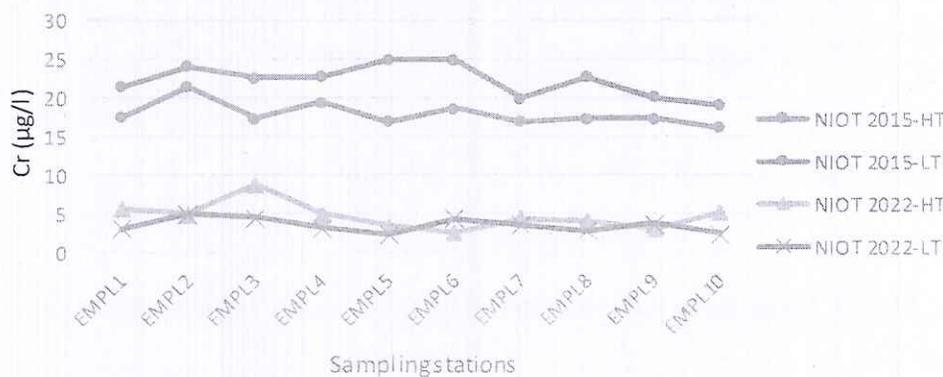


Fig. 18 Chromium variation in the surface waters in the study area

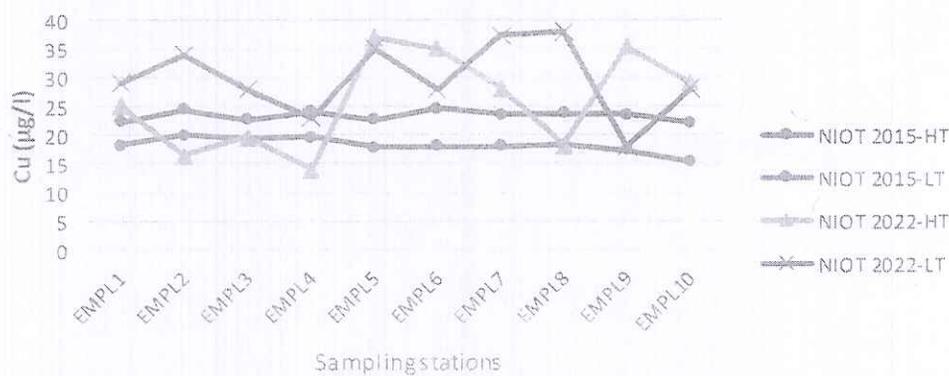


Fig. 19 Copper variation in the surface waters in the study area



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

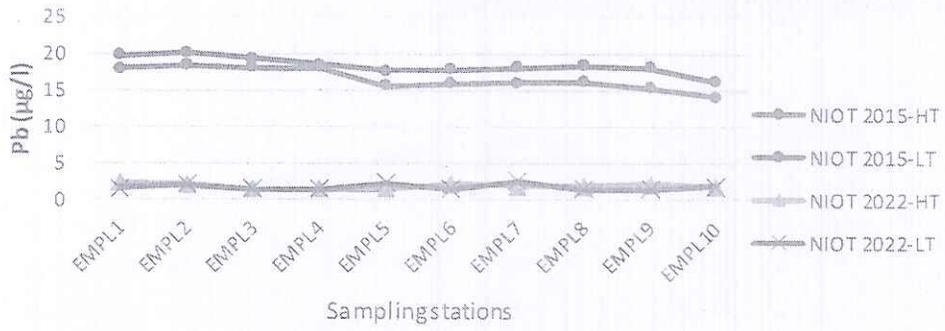


Fig. 20 Lead variation in the surface waters in the study area

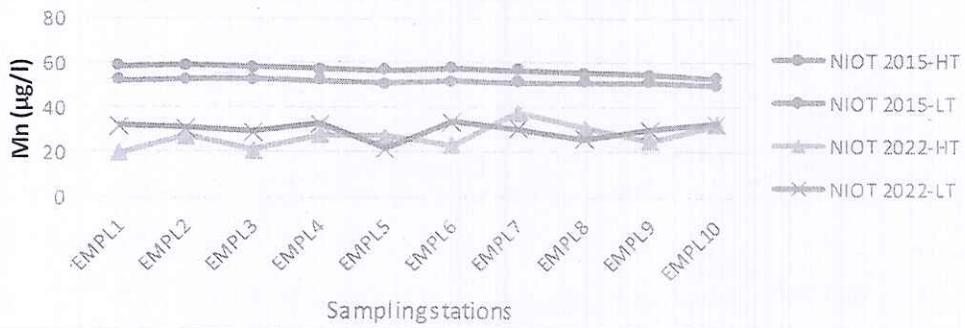


Fig. 21 Manganese variation in the surface waters in the study area

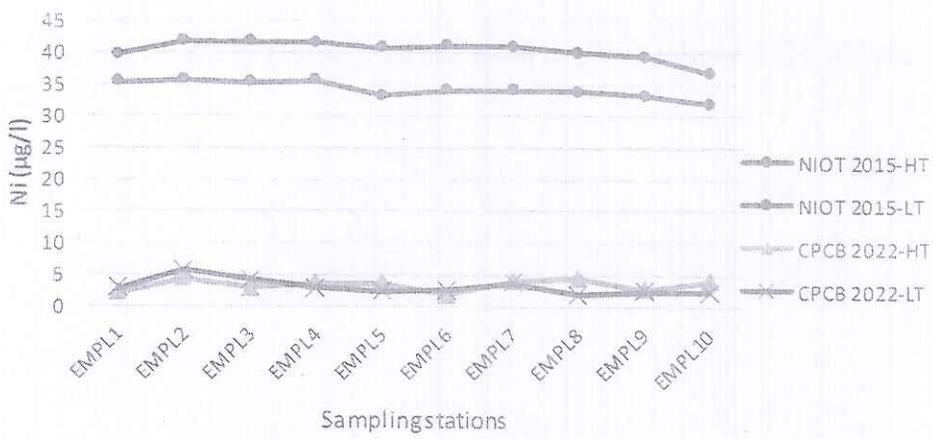


Fig. 22 Nickel variation in the surface waters in the study area



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

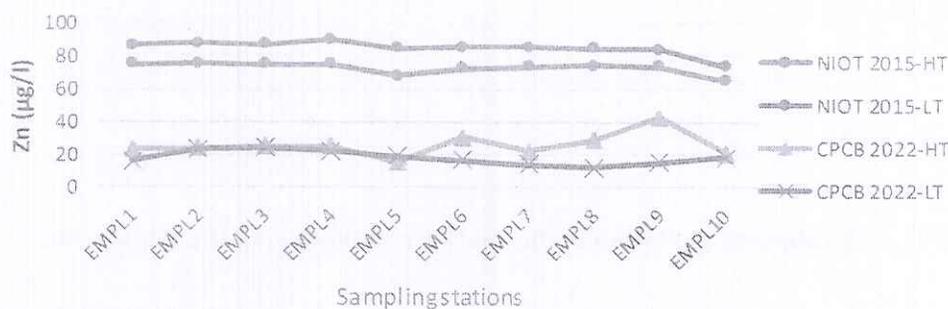


Fig. 23 Zinc variation in the surface waters in the study area

SEDIMENTS

Sediments are seafloor materials eroded from land to the ocean through rivers or wind. The constituent of the sediments depends upon the local geological condition and other anthropogenic activities. Sediments are major nutrient sources for the aquatic faunas. The present study monitors the quality of sediments in the combined marine outfall area along the Bay of Bengal off the North Chennai coast. The selected metal concentrations of sediments are shown in Table (Annexure A: Table 4 & 4a).

The range of Ni (7.0 to 13.00 mg/kg), Co (1.51 to 3.90 mg/kg), Cu (30 to 75 mg/kg), Cd (BDL), Pb (1.38 to 3.73 mg/kg), Cr (9.10 to 21.00 mg/kg), Hg (BDL), Fe (1359 to 4547 mg/kg), Mn (64 to 322 mg/kg) and Zn (106 to 220 mg/kg) are observed in the sediment. Concentrations of most of the metals are found to be low in the locations EMPL 6 to EMPL10 except Mn, Zn, Cu, and Co. Higher concentrations of some metals are recorded from EMPL1 to EMPL5.



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

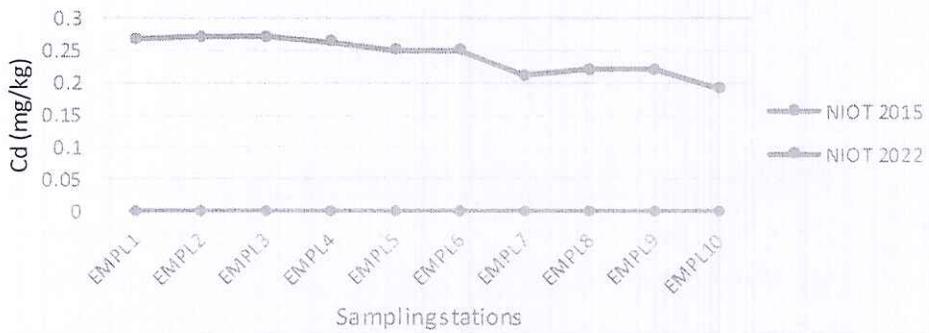


Fig. 24 Cadmium variation in the seafloor sediments in the study area

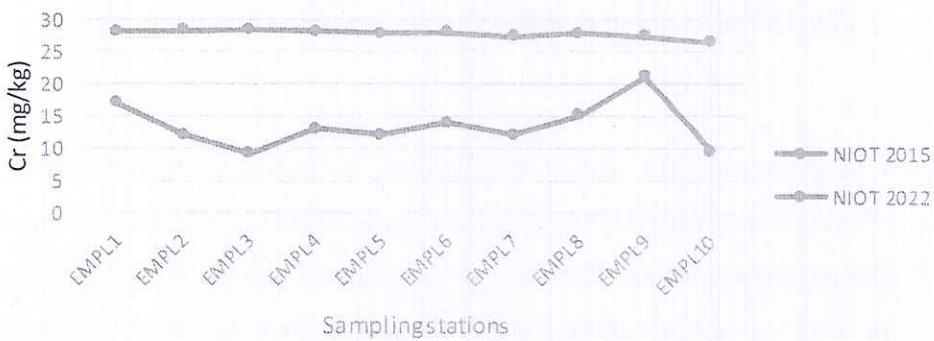


Fig. 25 Chromium variation in the seafloor sediments in the study area

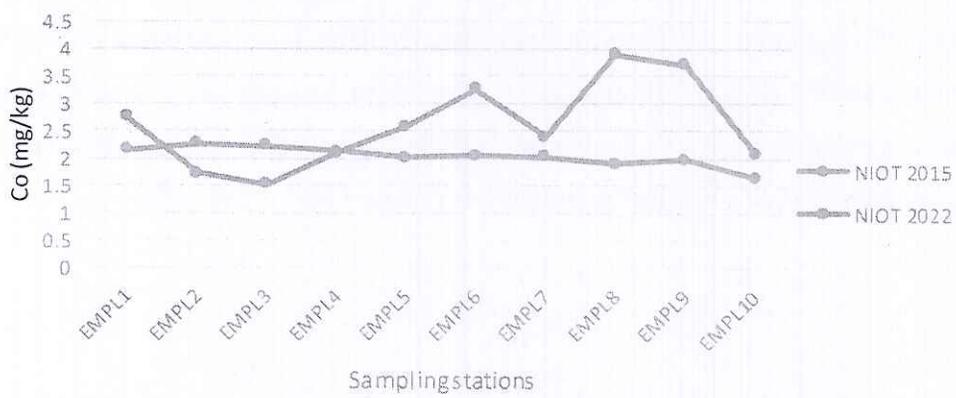


Fig. 26 Cobalt variation in the seafloor sediments in the study area



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

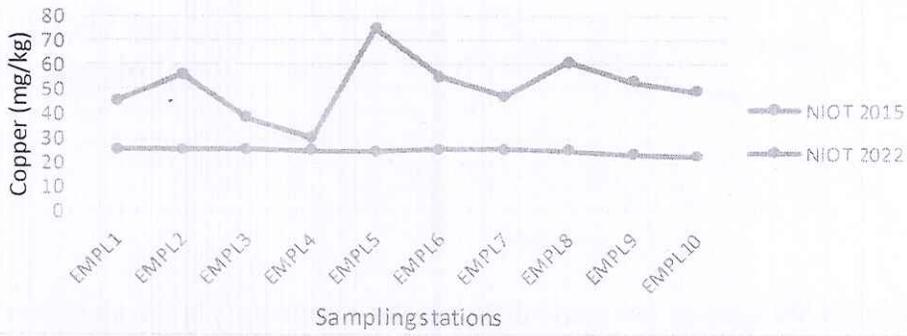


Fig. 27 Copper variation in the seafloor sediments in the study area

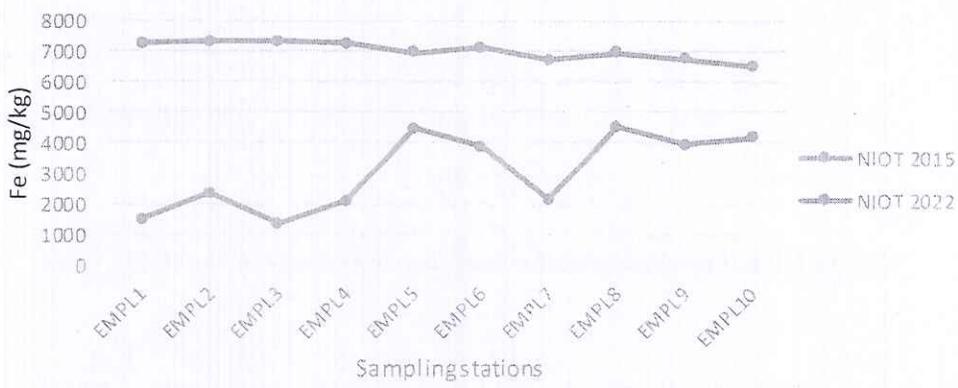


Fig. 28 Ferrous variation in the seafloor sediments in the study area

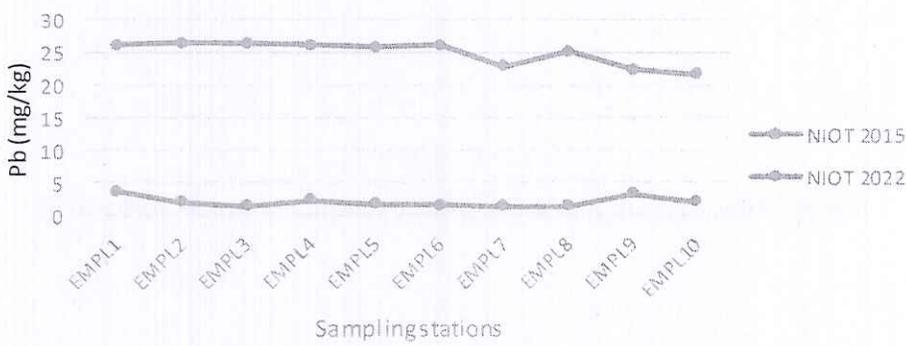


Fig. 29 Lead variation in the seafloor sediments in the study area



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

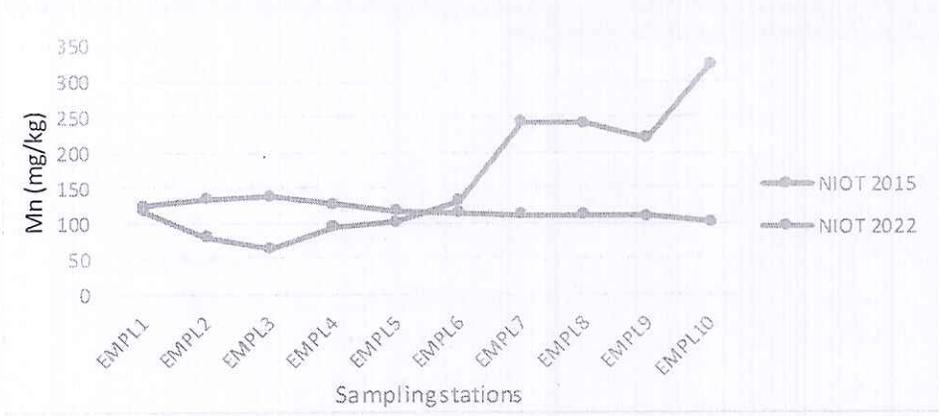


Fig. 30 Manganese variation in the seafloor sediments in the study area

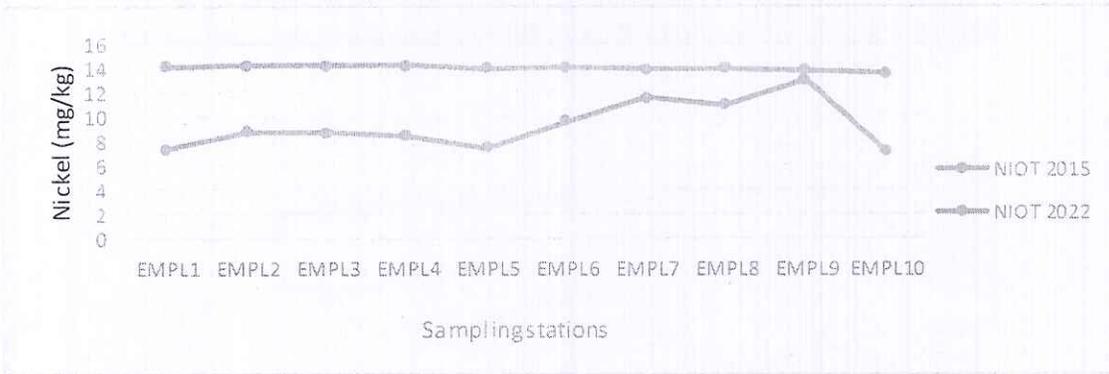


Fig. 31 Nickel variation in the seafloor sediments in the study area

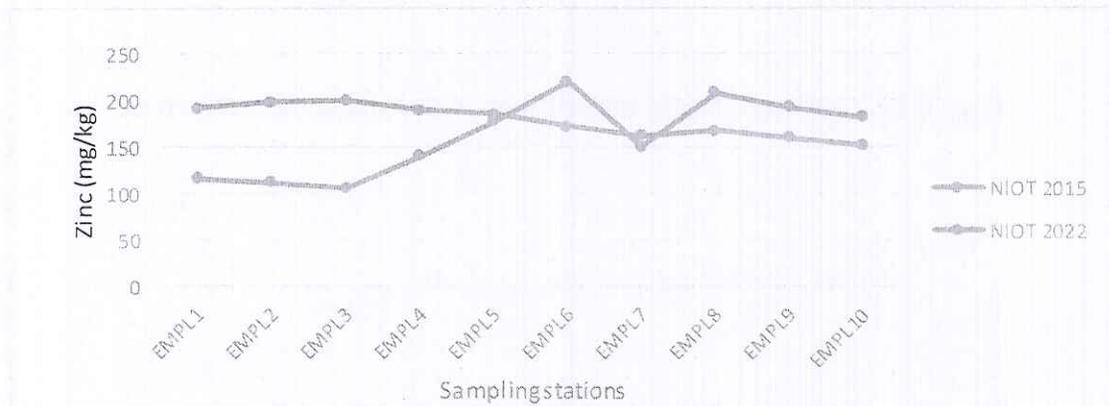


Fig. 32 Zinc variation in the seafloor sediments in the study area



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

BIOTIC ENVIRONMENT

In most aquatic habitats, the three biotic communities are the pelagic community of the open waters, the benthic community living in the bottom deposits, and the fringing community where water is shallow. The pelagic community consists of the neutrally buoyant plankton community and the larger active swimming animals called the nekton.

The benthic community mostly depends on the settling organic matter from the water column in the form of live phytoplankton, dead plankton, detritus, fecal pellets, etc. The percentage of organic matter reaching the benthos is diminished with increasing depth as the community of planktonic consumers progressively removes sinking material. Thus, the shallower waters have a relatively larger benthic community, as the food supply is high. In too shallow areas, where light penetrates, there is a sharp increase in biomass.

The fringing community in the marine environment depends on the type of substrate and climate. In areas of high wave and current action, the rocky areas may be dominated by algae known as seaweeds that attach to the bottom without roots. Uptake of nutrients takes place over the entire surface. Shores with lesser water movement where sedimentation occurs tend to have rooted plants, intertidal marshes, and seagrass beds. Marine plants' most critical role is providing a substrate for vascular, microscopic, and macroscopic algae (periphyton). Besides, they trap sediments and food, providing a habitat for young fish that large predators cannot follow.

The distribution of the various communities is typically classified by the trophic levels in a food chain (or energy chain). Typically, the first level consists of primary producers (phytoplankton). The second level consists of the primary consumers, zooplankton, while the secondary consumers consist of larger animals or nekton. The top of the food chain would be humans. The biotic sampling consisted of evaluating the phytoplankton and zooplankton communities. Sediment samples were analyzed for macrobenthos.

BIOLOGICAL OCEANOGRAPHIC STATUS

Biological analysis in the study area describes the population dynamics of marine communities and their interaction with the surrounding environment in space and time. The current study reveals the status of various planktonic and benthic lives in and around the outfall Appendix- A provides detailed primary data.



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

BIOLOGICAL DATA COLLECTION

Biological oceanographic characteristics were studied at 10 locations in the vicinity of the outfall to monitor any possible change/impact. The surveys were synoptic and carried out over two tidal cycles. Hydrographic measurements, water, and sediment quality were also assessed at the same 10 locations. The results of the present study are compared with the previous NIOT studies during 2015, which is considered a baseline for evaluating any possible change.

BIOLOGICAL SAMPLING

Chlorophyll, phytoplankton, zooplankton, and macrobenthos were measured to assess the biological characteristics. Plankton nets and grab samples were utilized for sample collection. Collected samples were preserved in formaldehyde and rose bengal dye solution. Standard procedures were used for analysis and quality control. In addition, diversity analysis was carried out to establish the population dynamics along with different stations concerning various time scales based on the location of the effluent discharge point.

PHYTOPLANKTON

Analysis of phytoplankton samples indicates the presence of 30 species of phytoplankton with cell counts ranging from 1229 Nos./L to 4235 Nos./L along the sampling locations EMPL1 to EMPL10. The population contribution of more than 5% was categorized as dominant species. The possible bloom-forming diatoms and dinoflagellate were the major contributors to the total population of phytoplankton. Marked reduction in phytoplankton population density at EMPL 7 1000m away from the eastern side of discharge pipeline and need further studies. Detailed data table at Annexure A: Tables 5 & 5a.

Among the Phytoplankton *Chaetoceros coarctatus*, *Chaetoceros laevis*, *Chaetoceros peruvianus*, *Ceratium tripos*, *Ceratium furca*, *Ceratium fusus*, *Ceratium macroceros* were found to be dominant along the study area. The phytoplankton population density shows variations with sampling location compared to past studies in 2015. The diversity index scores indicated the moderately healthy nature of the environment and recorded no marked changes in diversity.



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

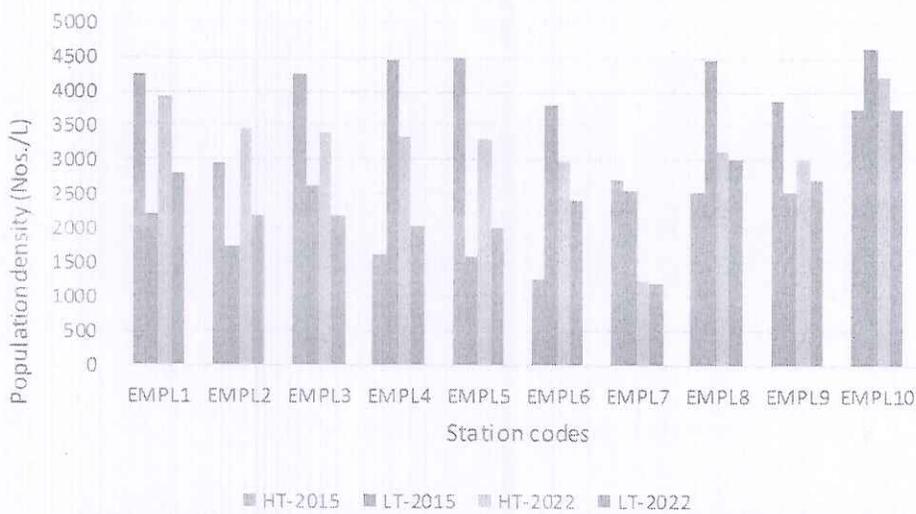


Fig. 33 Comparison of phytoplankton population density in the surface waters

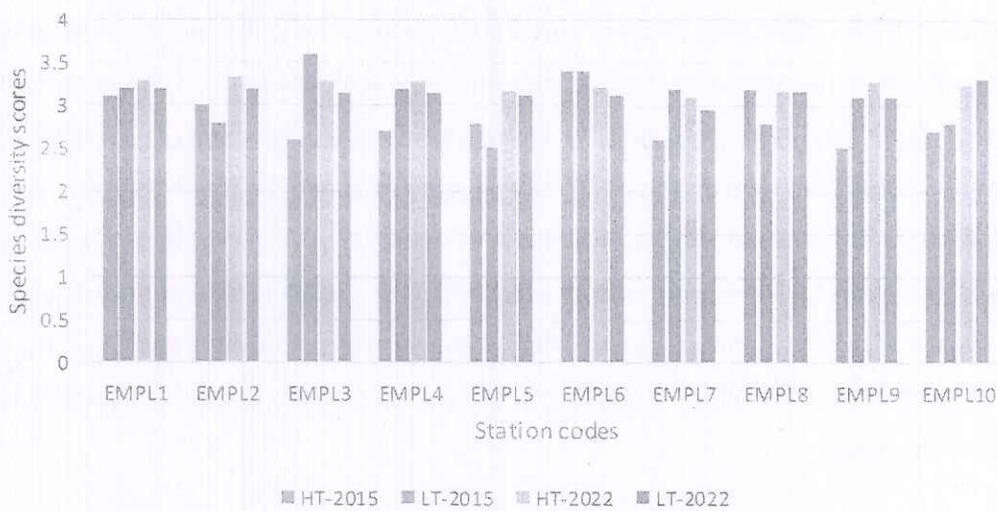


Fig. 34 Comparison of phytoplankton species diversity in the surface waters

Zooplankton is composed of floating organisms, including the larval stages of many economically important species of prawns and fishes. The density of the population varied from 369 to 694 Nos./ m³ during the sampling period between EMPL 1 to EMPL 10. A total number of 24 species were recorded in the coastal waters. *Calanoid*, *Cladocerans*, Fish larvae, and Fish eggs are the dominant forms of zooplankton recorded during the survey. The zooplankton trend does not reflect any abnormalities.



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

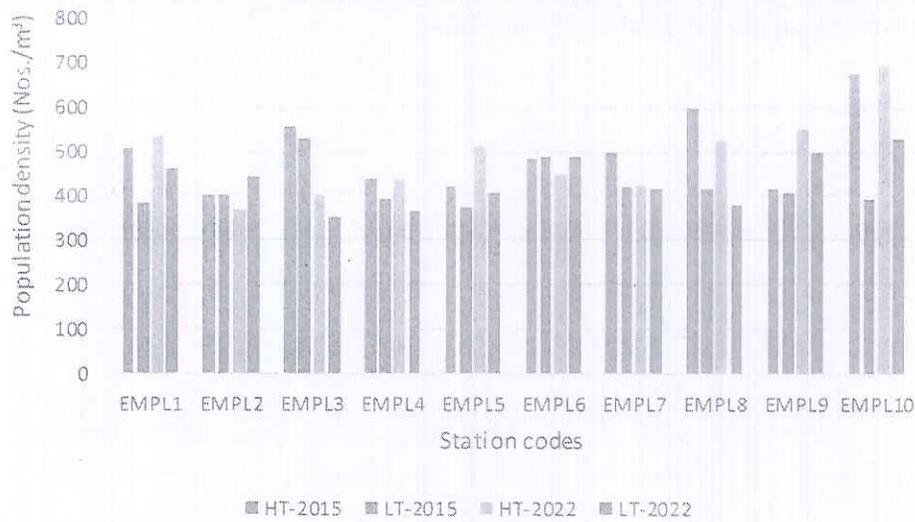


Fig. 35 Zooplankton population density variation in the surface waters

BENTHOS

The subtidal benthic organisms recorded moderate fluctuation of standing stock and diversity. In terms of population, macrobenthos varied between 245 and 651 Nos./m². The faunal composition consisted of *Gastropods*, *Bivalves*, and *Polychaetes* as the dominant group. The minimum density was recorded at EMPL3. However, overall, there is a significant increase in the population density all along the sampling location compared with 2015 records, except at EMPL4 may be traceable by whole effluent toxicity bioassay studies of USEPA. The various effluent discharges along the Bay of Bengal off North Chennai Coast and the combined marine outfall from MPL, TPL and KPL need to be considered for evaluating the effluent-specific impact on biosystems, which is beyond the scope of this study.



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

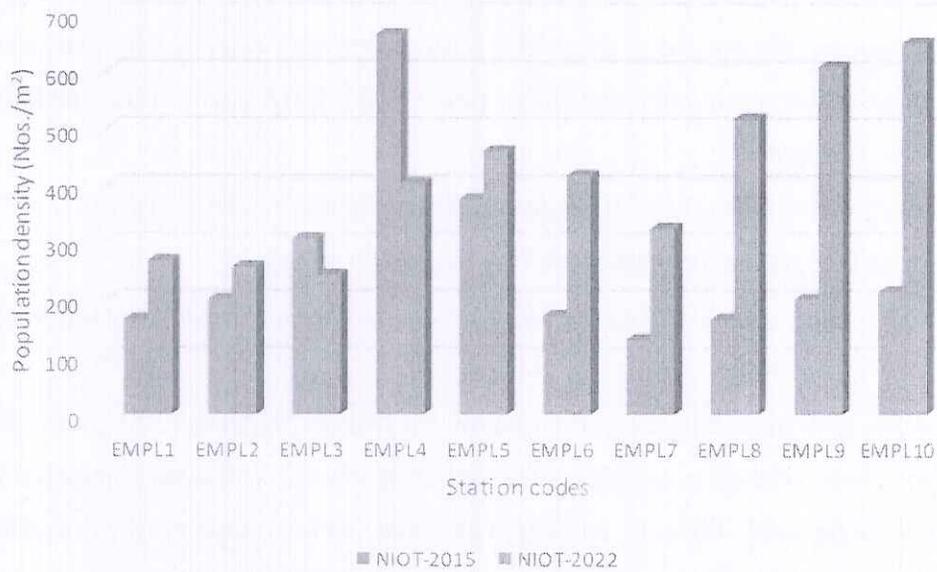


Fig. 36 Benthos population density variation in bottom sediments

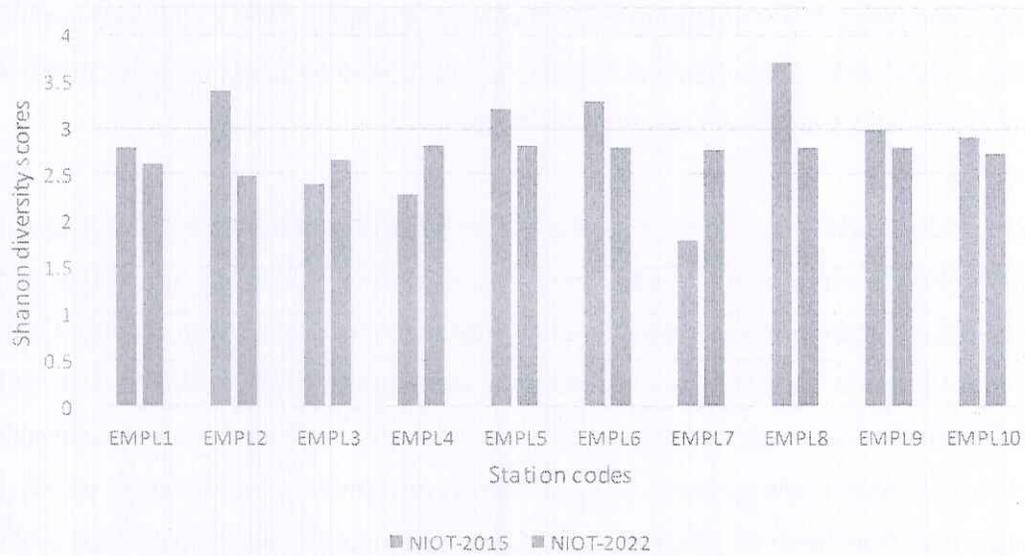


Fig. 37 Benthos population diversity variation in bottom sediments



SUMMARY & CONCLUSIONS

The results of selected parameters and comparison with previous study records reveal spatial and temporal variations within the study area. All physico-chemical water quality parameter shows negligible change when compared to baseline values (NIOT-2015 records) and conform to SW-IV water quality standards.

- pH values varied from 7.7 to 8.0 against the SWIV standards of 6.5 to 9.0).
- Dissolved Oxygen concentrations of 7mg/l against < 3 mg/L
- BOD concentrations are 1.8 mg/l against the standard requirement of not more than 5mg/l.

The water quality parameter that showed variation was Nitrate-Nitrogen (20.1 $\mu\text{mol./l}$) which is comparable to values recorded in samples collected during low tide within the Ennore creek during the 2022 study (Annexure I: Table 1). It needs to be noted that the nitrate-Nitrogen variation is not accompanied by corresponding variation in ammonia and nitrite concentrations and therefore linking it sewage discharges need to be ruled out. Given the concentrations are higher in the nearshore waters, it is essential to determine the source. Given that nitrate is a stable compound in the oxidation process, it is not a parameter of concern as per the SW-IV standards and not in the regulatory framework. The variation in plankton and benthos requires to be monitored for temporal / seasonal variations for any possible influence.

The heavy metal content in sediments are significantly lower than baseline values for Cadmium, Chromium, Ferrous and Lead, while there are negligible variations in Nickel and Zinc concentrations. Higher concentrations than the baseline values have been recorded to Cobalt, Copper and Manganese at the far-shore sampling locations (EMPL5 to EMPL 10). It is well known that this Ennore creek is traversed by Manali industrial belt and Buckingham canal with industrial and domestic sewage loads. Considering the proximity of Ennore creek which receives agricultural runoff in the rivers discharging the Creek and industrial discharges, there is likelihood of synergistic effect on the coastal waters off North Chennai in addition to flushing from Cooum, Adyar Rivers. Other sources like Royapuram fisheries harbor, Chennai Port, Royapuram sewage outfall, and several other industries discharging in this area also account for the coastal water quality concentrations along North Chennai coastal waters.



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Monitoring studies along North Chennai coastal waters during the study period reveal the following:

- Significant improvement in the plankton population diversity is recorded
- Significant improvement in benthic population density and diversity is recorded around the outfall location when compared with 2015 values except at nearshore locations EMP3 and EMPL4 which warrants detailed long-term monitoring studies in the receiving waters (off Chennai coast) as well as at the discharge locations of the various industries.
- The toxic chemicals are found to be within acceptable levels.

While the present observations do not indicate any significant variation and in general conforms with the coastal water quality standards for SW-IV, the observations must be validated with the effluent quality of industrial discharge as per CPCB norms. Given that there is a likelihood of influence of seasonal circulation of currents in the North Chennai Coastal waters and synergistic impacts of other sources in the areas on the benthic and biology, it is suggested to conduct whole effluent toxicity studies. These tests are expected to reveal the influence of other possible chemicals not in the regulatory control influence the sustainability of marine biota (Fishes, mollusks, etc.).



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

8. REFERENCES

1. APHA., 2005. Standard Methods for the Examination of Water and Waste Water, 21th Edition. American Public Health Association, Washington DC.
2. Methods of Sea water analysis 1999 3rd edition, Verlag Chemie, Weinheim, Grasshoff, K., Ehrhardt, M. and Kremling, K. Germany. 419-600.
3. Central Pollution Control Board (CPCB), Primary Water Quality Criteria for Class SW-V Waters (For Navigation and Controlled Waste Disposal); *WATER QUALITY STANDARDS FOR COASTAL WATERS MARINE OUTFALLS*, The Environment (Protection) Rules, 1986.
4. Marine environment impact study for the combined treated effluents discharged into the sea for Tamil Nadu Petroproducts ltd., and Manali petrochemicals ltd., by Environment consultant Hubert Enviro care system (p) ltd., December 2012.
5. Zepp, R.G., 1997. Interactions of marine biogeochemical cycle and photodegradation of dissolved organic carbon and dissolved organic nitrogen. In: Gianguzza, A.; Pelizzetti, E.; Sammarkano, S.; Ed.; *Marine Chemistry, Kluwer Academic Publication, London*, PP.: 329-352.



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

APPENDIX - A

Table 1. Physio-Chemical parameters variation around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek during the high tide period

Station code	Tide	Lat	Long	AT (°C)	WT (°C)	Sal (PSU)	TSS (mg/l)	pH	DO (mg/l)
EMPL 1 S	HT	13°11'23.61"N	80°19'33.79"E	29.9	28.6	32.1	26.8	7.9	7.48
EMPL 1 B					28.5	32.23	22	7.8	7.46
EMPL 2 S	HT	13°11'06.27"N	80°19'29.36"E	29.5	28.4	31.95	24.4	7.8	7.52
EMPL 2 B					28.3	32.2	23.8	7.7	7.46
EMPL 3 S	HT	13°10'33.68"N	80°19'23.03"E	29.5	28.5	32.06	28.4	7.8	7.48
EMPL 3 B					28.5	32.15	28	7.8	7.46
EMPL 4 S	HT	13°10'17.42"N	80°19'19.52"E	29.2	28.3	32.01	20.4	7.7	7.26
EMPL 4 B					28.3	32.08	25	7.9	7.48
EMPL 5 S	HT	13°11'20.55"N	80°19'51.07"E	30.8	28.5	32.01	23.2	7.9	7.55
EMPL 5 B					28.4	32.27	24.2	7.9	7.50
EMPL 6 S	HT	13°11'02.02"N	80°19'47.35"E	31.8	28.6	31.66	22.6	7.9	7.65
EMPL 6 B					28.5	32.24	22.2	8	7.51
EMPL 7 S	HT	13°10'47.74"N	80°19'42.69"E	30.1	28.6	31.97	22.8	7.9	7.62
EMPL 7 B					28.4	32.22	22.4	7.8	6.81
EMPL 8 S	HT	13°10'31.24"N	80°19'39.03"E	32	28.7	31.93	17.8	8	7.85
EMPL 8 B					28.4	32.15	22.8	7.9	7.58
EMPL 9 S	HT	13°10'15.38"N	80°19'36.42"E	31.8	28.4	32.07	22.8	7.8	7.83
EMPL 9 B					28.5	31.99	20.6	7.9	7.37
EMPL10 S	HT	13°10'46.71"N	80°19'56.05"E	31.9	28.6	32.06	22	7.9	7.67
EMPL10 B					28.4	32.29	24.8	7.9	7.43
ENC 1	HT	13°13'52"N	80°19'48"E	32	33.3	33.39	22.8	7.5	5.83
ENC 2	HT	13°13'25"N	80°19'08"E	31.8	30.3	33.17	47.2	7.8	4.7
ENC 3	HT	13°12'13"N	80°18'32"E	30.8	29.7	22.8	24.8	7.8	5.22
ENC 4	HT	13°11'02"N	80°17'42"E	28.3	30	20.76	40.6	6.8	3.17



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Table 1a. Physio-Chemical parameters variation around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek during the high tide period

Station code	Tide	Lat	Long	BOD (mg/l)	Turbidity (NTU)	NO ₂ (μmol/l)	NO ₃ (μmol/l)	NH ₄ (μmol/l)	PO ₄ (μmol/l)
EMPL 1 S	HT	13°11'23.61"N	80°19'33.79"E	1.1	1.76	0.02	17.20	0.29	0.32
EMPL 1 B				0.98	3.15	0.01	15.50	0.21	0.22
EMPL 2 S	HT	13°11'06.27"N	80°19'29.36"E	1.12	2.6	0.03	15.30	0.31	0.22
EMPL 2 B				0.88	1.71	0.03	17.20	0.21	0.21
EMPL 3 S	HT	13°10'33.68"N	80°19'23.03"E	1.34	1.99	0.01	16.50	0.61	0.22
EMPL 3 B				1.11	2.50	0.01	12.30	0.31	0.15
EMPL 4 S	HT	13°10'17.42"N	80°19'19.52"E	1.14	2.19	0.01	18.20	0.19	0.17
EMPL 4 B				0.72	9.89	0.03	18.80	0.22	0.17
EMPL 5 S	HT	13°11'20.55"N	80°19'51.07"E	1.21	1.54	0.02	18.10	0.21	0.21
EMPL 5 B				1	2.02	0.06	20.20	0.22	0.21
EMPL 6 S	HT	13°11'02.02"N	80°19'47.35"E	1.44	1.65	0.02	7.50	0.35	0.21
EMPL 6 B				1.11	1.81	0.04	8.30	0.29	0.19
EMPL 7 S	HT	13°10'47.74"N	80°19'42.69"E	1.2	1.75	0.04	8.20	0.36	0.21
EMPL 7 B				0.88	1.70	0.01	7.60	0.41	0.22
EMPL 8 S	HT	13°10'31.24"N	80°19'39.03"E	1.21	1.56	0.08	3.30	0.88	0.23
EMPL 8 B				0.88	1.23	0.02	5.10	0.29	0.20
EMPL 9 S	HT	13°10'15.38"N	80°19'36.42"E	1.35	2.23	0.04	9.90	0.31	0.12
EMPL 9 B				0.94	2.05	0.04	9.10	0.29	0.12
EMPL 10 S	HT	13°10'46.71"N	80°19'56.05"E	0.88	2.05	0.01	2.30	0.30	0.17
EMPL 10 B				0.54	1.61	0.09	2.10	0.28	0.17
ENC 1	HT	13°13'52"N	80°19'48"E	0.93	3.94	0.19	19.20	4.89	0.87
ENC 2	HT	13°13'25"N	80°19'08"E	1.29	10.91	0.15	18.20	11.30	0.81
ENC 3	HT	13°12'13"N	80°18'32"E	3.21	17.34	0.15	18.30	55.20	4.10
ENC 4	HT	13°11'02"N	80°17'42"E	9.23	22.34	0.14	21.10	111.20	0.91



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Table 1b. Physio-Chemical parameters variation around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek during the high tide period.

Station code	Tide	Lat	Long	Silicate (μmol/l)	Chl A (μg/L)	Fecal Coliforms (CFU/100 ml)	Total Coliform (CFU/100 ml)	PHC (μg/l)	Oil and Grease (mg/l)
EMPL 1 S	HT	13°11'23.61"N	80°19'33.79"E	0.92	3.21	800	1200	0.02	10
EMPL 1 B				0.83	0.45	500	900		
EMPL 2 S	HT	13°11'06.27"N	80°19'29.36"E	0.65	3.31	1000	1300	0.02	15
EMPL 2 B				0.59	0.28	600	900		
EMPL 3 S	HT	13°10'33.68" N	80°19'23.03"E	0.63	1.75	700	1500	0.01	8
EMPL 3 B				0.58	1.22	400	1200		
EMPL 4 S	HT	13°10'17.42"N	80°19'19.52"E	0.75	1.95	1100	2100	0.02	21
EMPL 4 B				0.66	1.35	400	1400		
EMPL 5 S	HT	13°11'20.55"N	80°19'51.07"E	0.49	3.57	900	2200	0.03	16
EMPL 5 B				0.55	0.63	400	1300		
EMPL 6 S	HT	13°11'02.02"N	80°19'47.35"E	0.7	3.1	1300	2400	0.02	12
EMPL 6 B				0.62	0.69	800	1500		
EMPL 7 S	HT	13°10'47.74"N	80°19'42.69"E	0.44	1.9	700	2700	0.01	9
EMPL 7 B				0.48	0.06	300	1600		
EMPL 8 S	HT	13°10'31.24"N	80°19'39.03"E	0.39	2.01	1000	2200	0.02	10
EMPL 8 B				0.45	0.52	600	1700		
EMPL 9 S	HT	13°10'15.38"N	80°19'36.42"E	0.59	2.31	1200	2300	0.02	30
EMPL 9 B				0.47	0.21	500	1700		
EMPL 10S	HT	13°10'46.71"N	80°19'56.05"E	0.33	1.92	700	1000	0.03	6
EMPL 10B				0.41	0.12	300	800		
ENC 1	HT	13°13'52"N	80°19'48"E	2.51	0.81	96000	123000	0.03	9
ENC 2	HT	13°13'25"N	80°19'08"E	4.61	0.92	52000	89000	0.06	20
ENC 3	HT	13°12'13"N	80°18'32"E	3.33	24.88	77000	103000	0.08	32
ENC 4	HT	13°11'02"N	80°17'42"E	5.83	13.12	125000	400000	0.08	35



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Table 2. Physio-Chemical parameters variation around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek during the low tide period

Station code	Tide	Lat	Long	AT (°C)	WT (°C)	Sal (PSU)	TSS (mg/l)	pH	DO (mg/l)
EMPL 1 S	LT	13°11'23.61"N	80°19'33.79"E	32.8	28.9	32	22	7.9	8.38
EMPL 1 B					28.6	32.2	21.4	8	7.91
EMPL 2 S	LT	13°11'06.27"N	80°19'29.36"E	32.5	28.9	32.2	20.6	7.9	8.45
EMPL 2 B					28.6	32.23	24.8	7.9	7.78
EMPL 3 S	LT	13°10'33.68" N	80°19'23.03"E	34.9	28.9	32.07	25.4	7.9	8.75
EMPL 3 B					28.4	32.18	21.8	7.9	7.63
EMPL 4 S	LT	13°10'17.42"N	80°19'19.52"E	33	29	32.25	24.8	8	8.66
EMPL 4 B					28.9	32.32	20.2	7.9	7.51
EMPL 5 S	LT	13°11'20.55"N	80°19'51.07"E	32.8	28.8	32.12	24.2	7.9	8.45
EMPL 5 B					28.2	32.29	30.6	7.8	7.66
EMPL 6 S	LT	13°11'02.02"N	80°19'47.35"E	31.5	28.9	32.04	25.4	8	8.62
EMPL 6 B					28.5	32.01	25.4	7.8	7.63
EMPL 7 S	LT	13°10'47.74"N	80°19'42.69"E	30.1	28.7	32.01	24.2	7.9	8.04
EMPL 7 B					28.5	32.11	24.4	7.8	7.98
EMPL 8 S	LT	13°10'31.24"N	80°19'39.03"E	32.1	28.7	32.12	20	7.8	7.76
EMPL 8 B					28.5	32.21	22.8	7.8	7.59
EMPL 9 S	LT	13°10'15.38"N	80°19'36.42"E	32.1	28.7	32.11	22.2	7.9	7.74
EMPL 9 B					28.4	32.23	25.2	7.9	7.59
EMPL 10 S	LT	13°10'46.71"N	80°19'56.05"E	32.1	28.7	32.13	23.6	8	7.74
EMPL 10 B					28.3	32.26	22.2	7.9	7.58
ENC 1	LT	13°13'52"N	80°19'48"E	31.6	32.3	32.09	21	7.9	4.61
ENC 2	LT	13°13'25"N	80°19'08"E	32.4	32.1	26.19	59	7.2	2.55
ENC 3	LT	13°12'13"N	80°18'32"E	31.7	31.6	16.7	45.8	7.8	10.6
ENC 4	LT	13°11'02"N	80°17'42"E	31.2	32.1	18.7	43.2	6.9	20.26



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Table 2a. Physio-Chemical parameters variation around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek during the low tide period

Station code	Tide	Lat	Long	BOD (mg/l)	Turbidity (NTU)	NO ₂ (μmol/l)	NO ₃ (μmol/l)	NH ₄ (μmol/l)	PO ₄ (μmol/l)
EMPL 1 S	LT	13°11'23.61"N	80°19'33.79"E	1.56	1.73	0.03	20.1	0.21	0.28
EMPL 1 B				0.84	6.12	0.02	21.1	0.19	0.21
EMPL 2 S	LT	13°11'06.27"N	80°19'29.36"E	1.55	2.12	0.02	19.2	0.11	0.20
EMPL 2 B				0.75	3.50	0.02	19.2	0.11	0.15
EMPL 3 S	LT	13°10'33.68" N	80°19'23.03"E	1.22	1.95	0.02	20.1	0.22	0.15
EMPL 3 B				0.59	4.32	0.03	21.2	0.12	0.12
EMPL 4 S	LT	13°10'17.42"N	80°19'19.52"E	1.43	2.15	0.01	19.1	0.11	0.15
EMPL 4 B				1.00	4.48	0.01	19.1	0.11	0.20
EMPL 5 S	LT	13°11'20.55"N	80°19'51.07"E	1.36	2.04	0.03	20.1	0.20	0.20
EMPL 5 B				0.93	5.16	0.03	21.1	0.20	0.20
EMPL 6 S	LT	13°11'02.02"N	80°19'47.35"E	1.62	1.53	0.02	8.1	0.38	0.20
EMPL 6 B				0.88	5.57	0.02	8.1	0.21	0.20
EMPL 7 S	LT	13°10'47.74"N	80°19'42.69"E	0.98	1.60	0.01	6.5	0.21	0.15
EMPL 7 B				0.71	3.91	0.03	6.5	0.35	0.20
EMPL 8 S	LT	13°10'31.24"N	80°19'39.03"E	1.32	1.51	0.03	8.1	0.41	0.19
EMPL 8 B				0.87	1.55	0.02	8.1	0.21	0.19
EMPL 9 S	LT	13°10'15.38"N	80°19'36.42"E	1.11	1.14	0.02	5.1	0.21	0.11
EMPL 9B				1	3.11	0.02	5.1	0.17	0.11
EMPL10S	LT	13°10'46.71"N	80°19'56.05"E	0.93	1.21	0.02	6.5	0.22	0.15
EMPL10B				0.88	1.42	0.02	8.1	0.23	0.15
ENC 1	LT	13°13'52"N	80°19'48"E	1.2	8.79	0.2	19.8	30.1	0.78
ENC 2	LT	13°13'25"N	80°19'08"E	1.94	15.54	0.09	10.2	78.2	0.68
ENC 3	LT	13°12'13"N	80°18'32"E	3.97	89.42	0.09	25.2	60.2	4.21
ENC 4	LT	13°11'02"N	80°17'42"E	11.65	9.22	0.18	24.7	102.3	1.01



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Table 2b. Physio-Chemical parameters variation around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek during the low tide period

Station code	Tide	Lat	Long	Silicate ($\mu\text{mol/l}$)	Chl A ($\mu\text{g/L}$)	Fecal Coliforms (CFU/100ml)	Total Coliform (CFU/100ml)
EMPL 1 S	LT	13°11'23.61"N	80°19'33.79"E	0.86	3.69	600	1000
EMPL 1 B				0.77	2.15	400	800
EMPL 2 S	LT	13°11'06.27"N	80°19'29.36"E	0.62	3.2	800	900
EMPL 2 B				0.39	1.21	300	700
EMPL 3 S	LT	13°10'33.68" N	80°19'23.03"E	0.54	5.92	500	1400
EMPL 3 B				0.47	0.74	300	1100
EMPL 4 S	LT	13°10'17.42"N	80°19'19.52"E	0.48	7.21	1200	1900
EMPL 4 B				0.48	0.98	300	1300
EMPL 5 S	LT	13°11'20.55"N	80°19'51.07"E	0.56	2.78	900	2000
EMPL 5 B				0.61	0.97	500	1200
EMPL 6 S	LT	13°11'02.02"N	80°19'47.35"E	0.61	6.49	900	2200
EMPL 6 B				0.5	0.94	600	1300
EMPL 7 S	LT	13°10'47.74"N	80°19'42.69"E	0.33	3.01	800	2200
EMPL 7 B				0.25	3.71	400	1400
EMPL 8 S	LT	13°10'31.24"N	80°19'39.03"E	0.22	1.81	900	1900
EMPL 8 B				0.37	0.29	700	1300
EMPL9S	LT	13°10'15.38"N	80°19'36.42"E	0.44	0.62	800	1800
EMPL9B				0.31	0.71	600	1300
EMPL10S	LT	13°10'46.71"N	80°19'56.05"E	0.27	0.87	500	800
EMPL10B				0.22	0.72	300	500
ENC 1	LT	13°13'52"N	80°19'48"E	2.22	0.97	55000	132000
ENC 2	LT	13°13'25"N	80°19'08"E	4.1	9.13	41000	80000
ENC 3	LT	13°12'13"N	80°18'32"E	2.89	12.28	59000	92000
ENC 4	LT	13°11'02"N	80°17'42"E	5.18	10.75	94000	359000



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Table 3. Heavy metal concentration variation in the water around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek during the high tide period

Station code	Fe ($\mu\text{g/L}$)	Cd ($\mu\text{g/L}$)	Cr ($\mu\text{g/L}$)	Co ($\mu\text{g/L}$)	Cu ($\mu\text{g/L}$)	Pb ($\mu\text{g/L}$)
ENC 1	1060	BDL	3.87	BDL	21.9	1.43
ENC 2	991	BDL	3.63	BDL	18.9	1.41
ENC 3	934	BDL	2.79	0.506	35.5	1.21
ENC 4	1409	BDL	4.65	1	48.1	1.3
EMPL1 S	479	BDL	5.7	BDL	25.2	2.3
EMPL1 B	588	BDL	5.6	BDL	39.8	2.2
EMPL2 S	460	BDL	5	BDL	16.5	2.2
EMPL 2 B	501	BDL	3.9	BDL	18.99	1.8
EMPL 3 S	318	BDL	8.8	BDL	19.6	1.5
EMPL 3B	388	BDL	5	BDL	33.5	1.6
EMPL 4 S	770	BDL	5	BDL	14	1.4
EMPL 4B	433	BDL	4.1	BDL	24	1.5
EMPL 5S	494	BDL	3.5	BDL	37	1.5
EMPL 5 B	543	BDL	3.6	BDL	48.1	1.5
EMPL 6 S	457	BDL	2.5	BDL	35	2.2
EMPL 6 B	378	BDL	7.8	BDL	42	2.4
EMPL 7 S	465	BDL	4.3	BDL	28.2	1.8
EMPL 7 B	462	BDL	2.6	BDL	27.5	2.4
EMPL 8 S	317	BDL	4.1	BDL	18.3	1.9



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Station code	Fe ($\mu\text{g/L}$)	Cd ($\mu\text{g/L}$)	Cr ($\mu\text{g/L}$)	Co ($\mu\text{g/L}$)	Cu ($\mu\text{g/L}$)	Pb ($\mu\text{g/L}$)
EMPL 8 B	473	BDL	2.6	BDL	24	4.3
EMPL 9 S	550	BDL	3	BDL	35.5	2.1
EMPL 9 B	425	BDL	3.7	BDL	40	2.1
EMPL 10 S	646	BDL	5.1	BDL	29	1.9
EMPL 10 B	1063	BDL	7.1	BDL	44	1.8



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Table 3a. Heavy metal concentration variation in the water around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek during the high tide period

Station code	Mn (µg/L)	Hg (µg/L)	Ni (µg/L)	Zn (µg/L)	Al (µg/L)
ENC 1	35	BDL	3.39	18	486
ENC 2	26	BDL	2.81	22	454
ENC 3	102	BDL	4.58	4.58	404
ENC 4	107.8	BDL	9.6	9.6	1334
EMPL 1 S	19.7	BDL	2.1	23.5	432
EMPL 1 B	23.9	BDL	3.4	18	427
EMPL 2 S	27.4	BDL	4.3	24	1107
EMPL 2 B	33	BDL	2.4	31.4	381
EMPL 3 S	21	BDL	2.8	25.2	348
EMPL 3 B	30	BDL	3.1	29	545
EMPL 4 S	28	BDL	3.6	25	917
EMPL 4 B	30	BDL	4	36	836
EMPL 5 S	27.5	BDL	3.7	15.3	751
EMPL 5 B	32	BDL	3.5	24.2	895
EMPL 6 S	23.5	BDL	1.9	30.7	312
EMPL 6 B	30	BDL	3.7	38	385
EMPL 7 S	38	BDL	4	22	1035
EMPL 7 B	37	BDL	2.5	15.4	548
EMPL 8 S	31	BDL	4.4	29	1004
EMPL 8 B	34	BDL	2.3	31	413
EMPL 9 S	25	BDL	2.7	43	494
EMPL 9 B	25.3	BDL	2.3	21	308
EMPL 10 S	32.5	BDL	3.9	21	964
EMPL 10 B	36.2	BDL	4	29.5	1752



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Table 4. Heavy metal concentration variation in the water around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek during the low tide period

Station code	Fe ($\mu\text{g/L}$)	Cd ($\mu\text{g/L}$)	Cr ($\mu\text{g/L}$)	Co ($\mu\text{g/L}$)	Cu ($\mu\text{g/L}$)
ENC 1	1367	BDL	5	BDL	11.2
ENC 2	903	BDL	7.45	0.66	26
ENC 3	3817	BDL	3.18	0.59	43
ENC 4	1137	BDL	6.1	1.19	40
EMPL 1 S	596	BDL	3.1	BDL	29
EMPL 1 B	590	BDL	7.5	BDL	36
EMPL 2 S	489	BDL	5	BDL	34
EMPL 2 B	752	BDL	5.2	BDL	48
EMPL 3 S	620	BDL	4.5	BDL	28
EMPL 3 B	704	BDL	3.4	BDL	33
EMPL 4 S	911	BDL	3.2	BDL	23
EMPL 4 B	560	BDL	2.5	BDL	26
EMPL 5 S	656	BDL	2.3	BDL	35
EMPL 5 B	581	BDL	3.1	BDL	39.2
EMPL 6 S	695	BDL	4.4	BDL	28
EMPL 6 B	554	BDL	3.6	BDL	40
EMPL 7 S	861	BDL	3.6	BDL	37.4
EMPL 7 B	893	BDL	2.2	BDL	40.2
EMPL 8 S	602	BDL	2.78	BDL	38
EMPL 8 B	314	BDL	3.37	BDL	52
EMPL 9 S	664	BDL	3.7	BDL	18
EMPL 9 B	1093	BDL	3.25	BDL	25
EMPL 10 S	964	BDL	2.45	BDL	28
EMPL 10 B	781	BDL	3.48	BDL	32



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Table 4a. Heavy metal concentration variation in the water around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek during the low tide period

Station code	Pb (µg/L)	Mn (µg/L)	Hg (µg/L)	Ni (µg/L)	Zn (µg/L)	Al (µg/L)
ENC 1	1.13	30	BDL	3.3	19	673
ENC 2	1.74	22	BDL	5.12	39	394
ENC 3	1.57	132	BDL	4.62	22	613
ENC 4	1.5	117	BDL	8.7	28	1209
EMPL1 S	1.6	32	BDL	2.7	16	522
EMPL1 B	2.4	39	BDL	5.6	24	1413
EMPL2 S	2	31.2	BDL	5.7	23	1039
EMPL 2 B	1.5	41	BDL	2.3	18.3	298
EMPL 3 S	1.5	29.1	BDL	4.2	24	1723
EMPL 3B	1.3	32	BDL	3.5	27	1185
EMPL 4 S	1.5	33.1	BDL	2.9	22	3609
EMPL 4B	4.4	39	BDL	2.3	16.3	377
EMPL 5S	2.34	22	BDL	2.3	19	402
EMPL 5 B	1.6	26.8	BDL	2	20.2	394
EMPL 6 S	1.4	34	BDL	2.6	16.6	355
EMPL 6 B	1.7	37	BDL	2.5	26.1	347
EMPL 7 S	2.5	30.5	BDL	3.6	14.2	1164
EMPL 7 B	1.6	29.6	BDL	2	14.8	398
EMPL 8 S	1.41	26	BDL	1.88	12.3	311
EMPL 8 B	1.69	35	BDL	2.87	32	616
EMPL 9 S	1.51	30	BDL	2.4	15	691
EMPL 9 B	1.46	24	BDL	2.88	24	429
EMPL10S	1.86	33	BDL	2.21	18	459
EMPL10B	1.66	33	BDL	3.78	19	983



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Table 5. Heavy metal concentration variation in the seafloor sediment around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek

Station code	Fe (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Co (mg/kg)	Cu (mg/kg)	Pb (mg/kg)
ENC-1	9397	BDL	17	1.4	33	3.6
ENC-2	8369	1.255	14	5.5	77	11
ENC-3	7427	1.61	37	5.1	63	5.2
ENC-4	8887	0.52	47	4.2	58	9.64
EMPL 1	1507	BDL	17	2.75	45	3.73
EMPL 2	2355	BDL	12	1.72	56	2.08
EMPL 3	1359	BDL	9.1	1.51	38	1.38
EMPL 4	2097	BDL	13	2.1	30	2.4
EMPL 5	4476	BDL	12	2.58	75	1.69
EMPL 6	3885	BDL	14	3.27	55	1.51
EMPL 7	2144	BDL	12	2.38	47	1.4
EMPL 8	4547	BDL	15	3.9	61	1.4
EMPL 9	3960	BDL	21	3.7	53	3.3
EMPL 10	4197	BDL	9.5	2.1	49	1.98

Table 5a. Heavy metal concentration variation in the seafloor sediment around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek

Station code	Mn (mg/kg)	Hg (mg/kg)	Ni (mg/kg)	Zn (mg/kg)	Al (mg/kg)
ENC-1	73	BDL	9	128	1721
ENC-2	106	BDL	25	245	12449
ENC-3	142	BDL	16	232	9830
ENC-4	196	BDL	13	113	6264
EMPL 1	117	BDL	7.32	116	2894
EMPL 2	81	BDL	8.8	112	1895
EMPL 3	64	BDL	8.67	106	1778
EMPL 4	94	BDL	8.4	140	2299
EMPL 5	102	BDL	7.4	177	2556
EMPL 6	132	BDL	9.6	220	3487
EMPL 7	243	BDL	11.5	150	2946
EMPL 8	241	BDL	10.9	208	8356
EMPL 9	220	BDL	13	193	7955
EMPL 10	322	BDL	7.1	182	1730



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Table 6. Phytoplankton population density variation in the coastal waters around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek during high tide

Station code	Population (No/l)	Faunal Groups	Major groups (%)
ENC-1	718	24	<i>Biddulphia aurita</i> (1.7), <i>Biddulphia sinensis</i> (11.9), <i>Rhizosolenia imbricata</i> (1.7), <i>Rhizosolenia alata</i> (3.4), <i>Rhizosolenia styliiformis</i> (1.7), <i>Coscinodiscus centralis</i> (1.7), <i>Coscinodiscus radiatus</i> (11.9), <i>Coscinodiscus sp</i> (1.7), <i>Thalassionema nitzschioides</i> (1.7), <i>Guinardia flaccida</i> (1.7), <i>Skeletonema costatum</i> (3.4), <i>Anabaena sp</i> (1.7), <i>Bellerochea malleus</i> (3.4), <i>Navicula sp</i> (5.1), <i>Pleurosigma sp</i> (1.7), <i>Nitzschia sp</i> (3.4), <i>Chaetoceros coarctatus</i> (1.7), <i>Chaetoceros laevis</i> (8.5), <i>Triceratium reticulatum</i> (11.9), <i>Licmophora abbreviata</i> (8.5), <i>Ceratium tripos</i> (1.7), <i>Ceratium furca</i> (5.1), <i>Ceratium fusus</i> (3.4), <i>Ceratium macroceros</i> (1.7).
ENC-2	657	24	<i>Biddulphia aurita</i> (7.4), <i>Biddulphia sinensis</i> (5.6), <i>Rhizosolenia imbricata</i> (3.7), <i>Rhizosolenia stolterfothii</i> (5.6), <i>Rhizosolenia alata</i> (5.6), <i>Rhizosolenia robusta</i> (1.9), <i>Coscinodiscus centralis</i> (5.6), <i>Coscinodiscus radiatus</i> (1.9), <i>Coscinodiscus sp</i> (3.7), <i>Thalassionema nitzschioides</i> (1.9), <i>Guinardia flaccida</i> (1.9), <i>Leptocylindrus sp</i> (3.7), <i>Anabaena sp</i> (1.9), <i>Bellerochea malleus</i> (1.9), <i>Navicula sp</i> (1.9), <i>Pleurosigma sp</i> (5.6), <i>Nitzschia sp</i> (9.3), <i>Chaetoceros coarctatus</i> (5.6), <i>Chaetoceros laevis</i> (1.9), <i>Triceratium reticulatum</i> (9.3), <i>Licmophora abbreviate</i> (3.7), <i>Ceratium tripos</i> (1.9), <i>Ceratium furca</i> (3.7), <i>Ceratium macroceros</i> (5.6).
ENC-3	815	27	<i>Biddulphia aurita</i> (4.5), <i>Biddulphia sinensis</i> (1.5), <i>Rhizosolenia imbricata</i> (6.0), <i>Rhizosolenia stolterfothii</i> (3.0), <i>Rhizosolenia alata</i> (1.5), <i>Rhizosolenia robusta</i> (4.5), <i>Coscinodiscus centralis</i> (7.5), <i>Coscinodiscus radiatus</i> (4.5), <i>Coscinodiscus sp</i> (3.0), <i>Thalassionema nitzschioides</i> (6.0), <i>Guinardia flaccida</i> (4.5), <i>Skeletonema costatum</i> (3.0), <i>Asterionella japonica</i> (1.5), <i>Anabaena sp</i> (9.0), <i>Streptotheca thamensis</i> (1.5), <i>Bellerochea malleus</i> (6.0), <i>Pleurosigma sp</i> (1.5), <i>Nitzschia sp</i> (6.0), <i>Chaetoceros coarctatus</i> (3.0), <i>Chaetoceros laevis</i> (4.5), <i>Chaetoceros peruvianus</i> (1.5), <i>Triceratium reticulatum</i> (3.0), <i>Licmophora abbreviata</i> (1.5), <i>Ceratium tripos</i> (4.5), <i>Ceratium furca</i> (3.0), <i>Ceratium fusus</i> (1.5), <i>Ceratium macroceros</i> (3.0).
EMPL-1	3931	31	<i>Biddulphia aurita</i> (0.6), <i>Biddulphia sinensis</i> (3.1), <i>Rhizosolenia imbricata</i> (3.7), <i>Rhizosolenia stolterfothii</i> (3.1), <i>Rhizosolenia alata</i> (4.0), <i>Rhizosolenia styliiformis</i> (2.5), <i>Rhizosolenia robusta</i> (2.8), <i>Coscinodiscus centralis</i> (2.5), <i>Coscinodiscus radiatus</i> (2.8), <i>Coscinodiscus sp</i> (3.1), <i>Thalassionema nitzschioides</i> (3.4), <i>Guinardia flaccida</i> (2.5), <i>Skeletonema costatum</i> (0.6), <i>Leptocylindrus sp</i> (1.2), <i>Asterionella japonica</i> (3.4), <i>Anabaena sp</i> (1.5), <i>Streptotheca thamensis</i> (0.6), <i>Bellerochea malleus</i> (1.5), <i>Navicula sp</i> (6.8), <i>Pleurosigma sp</i> (4.6), <i>Bacillaria paradoxa</i> (1.5), <i>Nitzschia sp</i> (3.1), <i>Chaetoceros decipiens</i> (4.0), <i>Chaetoceros coarctatus</i> (3.1), <i>Chaetoceros laevis</i> (5.6), <i>Chaetoceros peruvianus</i> (5.6), <i>Ceratium tripos</i> (6.5), <i>Ceratium furca</i> (5.9), <i>Ceratium fusus</i> (4.3), <i>Ceratium macroceros</i> (4.6), <i>Dinophysis tripos</i> (1.2).



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Station code	Population (No/l)	Faunal Groups	Major groups (%)
EMPL-2	3469	32	<i>Biddulphia aurita</i> (1.1), <i>Biddulphia sinensis</i> (2.8), <i>Rhizosolenia imbricate</i> (3.5), <i>Rhizosolenia stolterfothii</i> (3.2), <i>Rhizosolenia alata</i> (3.5), <i>Rhizosolenia styliformis</i> (1.8), <i>Rhizosolenia robusta</i> (3.2), <i>Coscinodiscus centralis</i> (3.9), <i>Coscinodiscus radiatus</i> (2.8), <i>Coscinodiscus sp</i> (3.2), <i>Thalassionema nitzschioides</i> (3.5), <i>Guinardia flaccida</i> (3.2), <i>Skeletonema costatum</i> (1.1), <i>Leptocylindrus sp</i> (0.7), <i>Asterionella japonica</i> (3.9), <i>Anabaena sp</i> (1.4), <i>Streptotheca thamensis</i> (5.3), <i>Bellerochea malleus</i> (1.8), <i>Navicula sp</i> (4.9), <i>Pleurosigma sp</i> (4.2), <i>Bacillaria paradoxa</i> (1.8), <i>Nitzschia sp</i> (2.8), <i>Chaetoceros decipiens</i> (3.5), <i>Chaetoceros coarctatus</i> (2.8), <i>Chaetoceros laevis</i> (4.6), <i>Chaetoceros peruvianus</i> (6.0), <i>Triceratium reticulatum</i> (0.4), <i>Ceratium tripos</i> (6.0), <i>Ceratium furca</i> (5.3), <i>Ceratium fusus</i> (4.6), <i>Ceratium macroceros</i> (3.2), <i>Dinophysis tripos</i> (0.7).
EMPL-3	3396	31	<i>Biddulphia aurita</i> (0.7), <i>Biddulphia sinensis</i> (3.9), <i>Rhizosolenia imbricate</i> (2.9), <i>Rhizosolenia stolterfothii</i> (5.7), <i>Rhizosolenia alata</i> (3.2), <i>Rhizosolenia styliformis</i> (2.5), <i>Rhizosolenia robusta</i> (3.6), <i>Coscinodiscus centralis</i> (2.9), <i>Coscinodiscus radiatus</i> (1.8), <i>Coscinodiscus sp</i> (4.3), <i>Thalassionema nitzschioides</i> (2.9), <i>Guinardia flaccida</i> (3.6), <i>Skeletonema costatum</i> (1.8), <i>Leptocylindrus sp</i> (1.1), <i>Asterionella japonica</i> (3.6), <i>Anabaena sp</i> (1.1), <i>Streptotheca thamensis</i> (0.7), <i>Bellerochea malleus</i> (1.4), <i>Navicula sp</i> (3.6), <i>Pleurosigma sp</i> (2.9), <i>Bacillaria paradoxa</i> (0.7), <i>Nitzschia sp</i> (3.6), <i>Chaetoceros decipiens</i> (3.9), <i>Chaetoceros coarctatus</i> (7.5), <i>Chaetoceros laevis</i> (3.6), <i>Chaetoceros peruvianus</i> (5.0), <i>Ceratium tripos</i> (5.4), <i>Ceratium furca</i> (6.1), <i>Ceratium fusus</i> (4.7), <i>Ceratium macroceros</i> (4.3), <i>Dinophysis tripos</i> (1.1).
EMPL-4	3347	32	<i>Biddulphia aurita</i> (0.4), <i>Biddulphia sinensis</i> (3.6), <i>Rhizosolenia imbricata</i> (3.3), <i>Rhizosolenia stolterfothii</i> (5.1), <i>Rhizosolenia alata</i> (4.0), <i>Rhizosolenia styliformis</i> (1.8), <i>Rhizosolenia robusta</i> (3.3), <i>Coscinodiscus centralis</i> (7.3), <i>Coscinodiscus radiatus</i> (2.9), <i>Coscinodiscus sp</i> (3.6), <i>Thalassionema nitzschioides</i> (3.3), <i>Guinardia flaccida</i> (2.9), <i>Skeletonema costatum</i> (0.7), <i>Leptocylindrus sp</i> (0.4), <i>Asterionella japonica</i> (3.3), <i>Anabaena sp</i> (1.5), <i>Streptotheca thamensis</i> (4.4), <i>Bellerochea malleus</i> (0.7), <i>Navicula sp</i> (1.8), <i>Pleurosigma sp</i> (3.6), <i>Bacillaria paradoxa</i> (0.4), <i>Nitzschia sp</i> (3.3), <i>Chaetoceros decipiens</i> (4.0), <i>Chaetoceros coarctatus</i> (4.7), <i>Chaetoceros laevis</i> (3.6), <i>Chaetoceros peruvianus</i> (5.1), <i>Triceratium reticulatum</i> (1.1), <i>Ceratium tripos</i> (5.8), <i>Ceratium furca</i> (4.4), <i>Ceratium fusus</i> (4.0), <i>Ceratium macroceros</i> (5.1), <i>Dinophysis tripos</i> (0.7).
EMPL-5	3303	29	<i>Biddulphia sinensis</i> (3.3), <i>Rhizosolenia imbricata</i> (3.7), <i>Rhizosolenia stolterfothii</i> (4.4), <i>Rhizosolenia alata</i> (4.4), <i>Rhizosolenia styliformis</i> (2.6), <i>Rhizosolenia robusta</i> (3.7), <i>Coscinodiscus centralis</i> (3.3), <i>Coscinodiscus radiatus</i> (2.9), <i>Coscinodiscus sp</i> (3.3), <i>Thalassionema nitzschioides</i> (4.1), <i>Guinardia flaccida</i> (3.7), <i>Skeletonema costatum</i> (0.7), <i>Leptocylindrus sp</i> (0.7), <i>Asterionella japonica</i> (3.7), <i>Anabaena sp</i> (1.1), <i>Streptotheca thamensis</i> (0.2), <i>Bellerochea malleus</i> (0.7), <i>Pleurosigma sp</i> (1.8), <i>Bacillaria paradoxa</i> (0.7), <i>Nitzschia sp</i> (3.7), <i>Chaetoceros decipiens</i> (4.4), <i>Chaetoceros coarctatus</i> (4.1), <i>Chaetoceros laevis</i> (7.4), <i>Chaetoceros peruvianus</i> (7.0), <i>Ceratium tripos</i> (7.0), <i>Ceratium furca</i> (5.5), <i>Ceratium fusus</i> (5.9), <i>Ceratium macroceros</i> (5.2), <i>Dinophysis tripos</i> (0.7).
EMPL-6	2970	30	<i>Biddulphia aurita</i> (0.4), <i>Biddulphia sinensis</i> (4.1), <i>Rhizosolenia imbricata</i> (3.7), <i>Rhizosolenia stolterfothii</i> (4.1), <i>Rhizosolenia alata</i> (3.7), <i>Rhizosolenia styliformis</i> (2.5), <i>Rhizosolenia robusta</i> (3.3), <i>Coscinodiscus centralis</i> (3.7), <i>Coscinodiscus radiatus</i> (2.9), <i>Coscinodiscus sp</i> (3.3), <i>Thalassionema nitzschioides</i> (3.7), <i>Guinardia flaccida</i> (3.7), <i>Skeletonema costatum</i> (0.8), <i>Leptocylindrus sp</i> (1.2), <i>Asterionella japonica</i> (4.5), <i>Anabaena sp</i> (1.6), <i>Bellerochea malleus</i> (1.2), <i>Navicula sp</i> (1.2), <i>Pleurosigma sp</i> (1.6), <i>Nitzschia sp</i> (2.0), <i>Chaetoceros decipiens</i> (3.3), <i>Chaetoceros coarctatus</i> (4.1), <i>Chaetoceros laevis</i> (7.4), <i>Chaetoceros peruvianus</i> (8.6), <i>Triceratium reticulatum</i> (0.4), <i>Ceratium tripos</i> (7.4), <i>Ceratium furca</i> (4.5), <i>Ceratium fusus</i> (4.9), <i>Ceratium macroceros</i> (4.9), <i>Dinophysis tripos</i> (1.2).



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Station code	Population (No/l)	Faunal Groups	Major groups (%)
EMPL-7	1229	28	<i>Biddulphia sinensis</i> (7.9), <i>Rhizosolenia imbricata</i> (5.9), <i>Rhizosolenia stouterfothii</i> (6.9), <i>Rhizosolenia alata</i> (5.0), <i>Rhizosolenia styliformis</i> (4.0), <i>Rhizosolenia robusta</i> (3.0), <i>Coscinodiscus centralis</i> (2.0), <i>Coscinodiscus radiatus</i> (3.0), <i>Coscinodiscus sp</i> (2.0), <i>Thalassionema nitzschioides</i> (1.0), <i>Guinardia flaccida</i> (2.0), <i>Leptocylindrus sp</i> (1.0), <i>Asterionella japonica</i> (3.0), <i>Anabaena sp</i> (1.0), <i>Streptotheca thamensis</i> (2.0), <i>Bellerochea malleus</i> (1.0), <i>Pleurosigma sp</i> (2.0), <i>Nitzschia sp</i> (10.9), <i>Chaetoceros decipiens</i> (2.0), <i>Chaetoceros coarctatus</i> (3.0), <i>Chaetoceros laevis</i> (8.9), <i>Chaetoceros peruvianus</i> (4.0), <i>Triceratium reticulatum</i> (2.0), <i>Ceratium tripos</i> (5.0), <i>Ceratium furca</i> (4.0), <i>Ceratium fusus</i> (2.0), <i>Ceratium macroceros</i> (5.0), <i>Dinophysis tripos</i> (1.0).
EMPL-8	3128	30	<i>Biddulphia sinensis</i> (3.1), <i>Rhizosolenia imbricata</i> (3.9), <i>Rhizosolenia stouterfothii</i> (4.3), <i>Rhizosolenia alata</i> (3.9), <i>Rhizosolenia styliformis</i> (1.9), <i>Rhizosolenia robusta</i> (3.5), <i>Coscinodiscus centralis</i> (3.9), <i>Coscinodiscus radiatus</i> (3.5), <i>Coscinodiscus sp</i> (3.9), <i>Thalassionema nitzschioides</i> (1.9), <i>Guinardia flaccida</i> (3.1), <i>Skeletonema costatum</i> (0.8), <i>Leptocylindrus sp</i> (1.2), <i>Asterionella japonica</i> (4.3), <i>Anabaena sp</i> (1.6), <i>Streptotheca thamensis</i> (0.4), <i>Bellerochea malleus</i> (0.4), <i>Navicula sp</i> (1.9), <i>Pleurosigma sp</i> (1.2), <i>Bacillaria paradoxa</i> (0.4), <i>Nitzschia sp</i> (3.1), <i>Chaetoceros decipiens</i> (3.9), <i>Chaetoceros coarctatus</i> (8.9), <i>Chaetoceros laevis</i> (8.2), <i>Chaetoceros peruvianus</i> (7.8), <i>Triceratium reticulatum</i> (0.8), <i>Ceratium tripos</i> (5.1), <i>Ceratium furca</i> (3.9), <i>Ceratium fusus</i> (5.1), <i>Ceratium macroceros</i> (4.3)
EMPL-9	3006	31	<i>Biddulphia aurita</i> (1.6), <i>Biddulphia sinensis</i> (2.8), <i>Rhizosolenia imbricata</i> (3.6), <i>Rhizosolenia stouterfothii</i> (4.0), <i>Rhizosolenia alata</i> (4.9), <i>Rhizosolenia styliformis</i> (2.4), <i>Rhizosolenia robusta</i> (4.0), <i>Coscinodiscus centralis</i> (3.6), <i>Coscinodiscus radiatus</i> (4.0), <i>Coscinodiscus sp</i> (3.2), <i>Thalassionema nitzschioides</i> (2.8), <i>Guinardia flaccida</i> (3.6), <i>Skeletonema costatum</i> (1.2), <i>Leptocylindrus sp</i> (2.0), <i>Asterionella japonica</i> (3.6), <i>Anabaena sp</i> (2.0), <i>Streptotheca thamensis</i> (2.8), <i>Bellerochea malleus</i> (0.8), <i>Navicula sp</i> (1.6), <i>Pleurosigma sp</i> (0.4), <i>Bacillaria paradoxa</i> (0.8), <i>Nitzschia sp</i> (2.8), <i>Chaetoceros decipiens</i> (4.5), <i>Chaetoceros coarctatus</i> (5.7), <i>Chaetoceros laevis</i> (6.9), <i>Chaetoceros peruvianus</i> (5.7), <i>Ceratium tripos</i> (5.7), <i>Ceratium furca</i> (3.2), <i>Ceratium fusus</i> (4.5), <i>Ceratium macroceros</i> (4.0), <i>Dinophysis tripos</i> (0.8).
EMPL-10	4235	31	<i>Biddulphia aurita</i> (0.6), <i>Biddulphia sinensis</i> (2.9), <i>Rhizosolenia imbricata</i> (3.4), <i>Rhizosolenia stouterfothii</i> (4.0), <i>Rhizosolenia alata</i> (4.3), <i>Rhizosolenia styliformis</i> (2.6), <i>Rhizosolenia robusta</i> (3.4), <i>Coscinodiscus centralis</i> (3.7), <i>Coscinodiscus radiatus</i> (4.3), <i>Coscinodiscus sp</i> (3.7), <i>Thalassionema nitzschioides</i> (3.2), <i>Guinardia flaccida</i> (3.4), <i>Skeletonema costatum</i> (1.1), <i>Leptocylindrus sp</i> (2.0), <i>Asterionella japonica</i> (4.0), <i>Anabaena sp</i> (0.6), <i>Streptotheca thamensis</i> (0.9), <i>Navicula sp</i> (2.3), <i>Pleurosigma sp</i> (1.7), <i>Bacillaria paradoxa</i> (0.9), <i>Nitzschia sp</i> (1.1), <i>Chaetoceros decipiens</i> (3.7), <i>Chaetoceros coarctatus</i> (7.2), <i>Chaetoceros laevis</i> (7.5), <i>Chaetoceros peruvianus</i> (5.2), <i>Triceratium reticulatum</i> (0.3), <i>Ceratium tripos</i> (5.7), <i>Ceratium furca</i> (4.9), <i>Ceratium fusus</i> (6.3), <i>Ceratium macroceros</i> (4.3), <i>Dinophysis tripos</i> (0.6).



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Table 6a. Phytoplankton population density variation in the coastal waters around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek during low tide

Station code	Population (No/l)	Faunal Groups	Major groups (%)
ENC-1	657	17	<i>Biddulphia aurita</i> (9.3), <i>Biddulphia sinensis</i> (5.6), <i>Rhizosolenia stolterfothii</i> (3.7), <i>Rhizosolenia robusta</i> (3.7), <i>Coscinodiscus centralis</i> (13.0), <i>Thalassionema nitzschioides</i> (1.9), <i>Skeletonema costatum</i> (3.7), <i>Anabaena sp</i> (3.7), <i>Belleriochea malleus</i> (1.9), <i>Navicula sp</i> (7.4), <i>Pleurosigma sp</i> (9.3), <i>Nitzschia sp</i> (3.7), <i>Chaetoceros decipiens</i> (1.9), <i>Chaetoceros peruvianus</i> (3.7), <i>Triceratium reticulatum</i> (7.4), <i>Licmophora abbreviata</i> (18.5), <i>Ceratium tripos</i> (1.9).
ENC-2	511	20	<i>Biddulphia aurita</i> (11.9), <i>Biddulphia sinensis</i> (4.8), <i>Rhizosolenia stolterfothii</i> (11.9), <i>Rhizosolenia robusta</i> (2.4), <i>Coscinodiscus centralis</i> (4.8), <i>Coscinodiscus radiatus</i> (2.4), <i>Thalassionema nitzschioides</i> (4.8), <i>Skeletonema costatum</i> (2.4), <i>Asterionella japonica</i> (9.5), <i>Anabaena sp</i> (2.4), <i>Belleriochea malleus</i> (4.8), <i>Navicula sp</i> (2.4), <i>Pleurosigma sp</i> (9.5), <i>Nitzschia sp</i> (4.8), <i>Chaetoceros laevis</i> (4.8), <i>Licmophora abbreviata</i> (2.4), <i>Ceratium tripos</i> (4.8), <i>Ceratium furca</i> (2.4), <i>Ceratium fusus</i> (4.8), <i>Dinophysis tripos</i> (2.4).
ENC-3	535	18	<i>Biddulphia aurita</i> (4.5), <i>Biddulphia sinensis</i> (6.8), <i>Rhizosolenia stolterfothii</i> (9.1), <i>Rhizosolenia robusta</i> (2.3), <i>Coscinodiscus centralis</i> (4.5), <i>Thalassionema nitzschioides</i> (2.3), <i>Skeletonema costatum</i> (4.5), <i>Leptocylindrus sp</i> (2.3), <i>Asterionella japonica</i> (4.5), <i>Belleriochea malleus</i> (9.1), <i>Navicula sp</i> (6.8), <i>Pleurosigma sp</i> (9.1), <i>Nitzschia sp</i> (6.8), <i>Chaetoceros decipiens</i> (2.3), <i>Chaetoceros peruvianus</i> (2.3), <i>Licmophora abbreviata</i> (11.4), <i>Ceratium tripos</i> (2.3), <i>Ceratium furca</i> (9.1).
EMPL-1	2799	30	<i>Biddulphia aurita</i> (0.4), <i>Biddulphia sinensis</i> (2.6), <i>Rhizosolenia imbricata</i> (4.8), <i>Rhizosolenia stolterfothii</i> (3.9), <i>Rhizosolenia alata</i> (4.3), <i>Rhizosolenia styliformis</i> (3.5), <i>Rhizosolenia robusta</i> (1.3), <i>Coscinodiscus centralis</i> (3.9), <i>Coscinodiscus radiatus</i> (6.5), <i>Coscinodiscus sp</i> (3.5), <i>Thalassionema nitzschioides</i> (0.4), <i>Guinardia flaccida</i> (1.3), <i>Skeletonema costatum</i> (0.9), <i>Leptocylindrus sp</i> (0.9), <i>Asterionella japonica</i> (5.2), <i>Anabaena sp</i> (0.4), <i>Streptotheca thamensis</i> (2.2), <i>Belleriochea malleus</i> (0.4), <i>Navicula sp</i> (8.3), <i>Pleurosigma sp</i> (4.3), <i>Nitzschia sp</i> (3.0), <i>Chaetoceros decipiens</i> (3.5), <i>Chaetoceros coarctatus</i> (3.0), <i>Chaetoceros laevis</i> (4.3), <i>Chaetoceros peruvianus</i> (5.2), <i>Ceratium tripos</i> (7.0), <i>Ceratium furca</i> (4.3), <i>Ceratium fusus</i> (3.5), <i>Ceratium macroceros</i> (5.7), <i>Dinophysis tripos</i> (1.3).
EMPL-2	2191	28	<i>Biddulphia sinensis</i> (2.8), <i>Rhizosolenia imbricata</i> (4.4), <i>Rhizosolenia stolterfothii</i> (2.2), <i>Rhizosolenia alata</i> (5.0), <i>Rhizosolenia styliformis</i> (2.8), <i>Rhizosolenia robusta</i> (0.6), <i>Coscinodiscus centralis</i> (5.6), <i>Coscinodiscus radiatus</i> (5.0), <i>Coscinodiscus sp</i> (4.4), <i>Thalassionema nitzschioides</i> (2.8), <i>Guinardia flaccida</i> (2.2), <i>Skeletonema costatum</i> (0.6), <i>Leptocylindrus sp</i> (1.1), <i>Asterionella japonica</i> (3.9), <i>Streptotheca thamensis</i> (4.4), <i>Belleriochea malleus</i> (1.1), <i>Navicula sp</i> (5.6), <i>Pleurosigma sp</i> (3.9), <i>Nitzschia sp</i> (2.8), <i>Chaetoceros decipiens</i> (2.2), <i>Chaetoceros coarctatus</i> (2.8), <i>Chaetoceros laevis</i> (4.4), <i>Chaetoceros peruvianus</i> (6.7), <i>Ceratium tripos</i> (5.6), <i>Ceratium furca</i> (6.1), <i>Ceratium fusus</i> (4.4), <i>Ceratium macroceros</i> (5.6), <i>Dinophysis tripos</i> (1.1).



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Station code	Population (No/l)	Faunal Groups	Major groups (%)
EMPL-3	2178	27	<i>Biddulphia aurita</i> (0.6), <i>Biddulphia sinensis</i> (4.5), <i>Rhizosolenia imbricata</i> (2.8), <i>Rhizosolenia stolterfothii</i> (3.9), <i>Rhizosolenia alata</i> (4.5), <i>Rhizosolenia styliformis</i> (2.2), <i>Rhizosolenia robusta</i> (1.7), <i>Coscinodiscus centralis</i> (5.6), <i>Coscinodiscus radiatus</i> (5.0), <i>Coscinodiscus sp</i> (5.6), <i>Thalassionema nitzschioides</i> (1.1), <i>Guinardia flaccida</i> (2.2), <i>Leptocylindrus sp</i> (0.6), <i>Asterionella japonica</i> (7.8), <i>Anabaena sp</i> (1.1), <i>Streptotheca thamensis</i> (2.8), <i>Navicula sp</i> (1.7), <i>Pleurosigma sp</i> (3.4), <i>Nitzschia sp</i> (4.5), <i>Chaetoceros decipiens</i> (1.7), <i>Chaetoceros coarctatus</i> (6.7), <i>Chaetoceros laevis</i> (5.6), <i>Chaetoceros peruvianus</i> (4.5), <i>Ceratium tripos</i> (5.6), <i>Ceratium furca</i> (4.5), <i>Ceratium fusus</i> (5.6), <i>Ceratium macroceros</i> (4.5).
EMPL-4	2032	29	<i>Biddulphia sinensis</i> (5.4), <i>Rhizosolenia imbricata</i> (3.0), <i>Rhizosolenia stolterfothii</i> (3.6), <i>Rhizosolenia alata</i> (5.4), <i>Rhizosolenia styliformis</i> (1.8), <i>Rhizosolenia robusta</i> (1.2), <i>Coscinodiscus centralis</i> (6.0), <i>Coscinodiscus radiatus</i> (7.2), <i>Coscinodiscus sp</i> (4.8), <i>Thalassionema nitzschioides</i> (1.2), <i>Guinardia flaccida</i> (1.8), <i>Skeletonema costatum</i> (1.2), <i>Asterionella japonica</i> (4.2), <i>Anabaena sp</i> (0.6), <i>Streptotheca thamensis</i> (5.4), <i>Bellerochea malleus</i> (0.6), <i>Navicula sp</i> (1.2), <i>Pleurosigma sp</i> (4.2), <i>Nitzschia sp</i> (2.4), <i>Chaetoceros decipiens</i> (3.0), <i>Chaetoceros coarctatus</i> (6.0), <i>Chaetoceros laevis</i> (3.0), <i>Chaetoceros peruvianus</i> (2.4), <i>Triceratium reticulatum</i> (0.6), <i>Ceratium tripos</i> (7.8), <i>Ceratium furca</i> (6.0), <i>Ceratium fusus</i> (5.4), <i>Ceratium macroceros</i> (4.2), <i>Dinophysis tripos</i> (0.6).
EMPL-5	2008	28	<i>Biddulphia sinensis</i> (3.0), <i>Rhizosolenia imbricata</i> (6.1), <i>Rhizosolenia stolterfothii</i> (4.8), <i>Rhizosolenia alata</i> (3.6), <i>Rhizosolenia styliformis</i> (3.0), <i>Rhizosolenia robusta</i> (2.4), <i>Coscinodiscus centralis</i> (6.1), <i>Coscinodiscus radiatus</i> (4.8), <i>Coscinodiscus sp</i> (5.5), <i>Thalassionema nitzschioides</i> (1.2), <i>Guinardia flaccida</i> (2.4), <i>Skeletonema costatum</i> (1.2), <i>Leptocylindrus sp</i> (0.6), <i>Asterionella japonica</i> (3.0), <i>Anabaena sp</i> (1.8), <i>Streptotheca thamensis</i> (0.6), <i>Navicula sp</i> (1.2), <i>Pleurosigma sp</i> (1.8), <i>Bacillaria paradoxa</i> (0.6), <i>Nitzschia sp</i> (4.8), <i>Chaetoceros coarctatus</i> (5.5), <i>Chaetoceros laevis</i> (2.4), <i>Chaetoceros peruvianus</i> (3.6), <i>Ceratium tripos</i> (8.5), <i>Ceratium furca</i> (7.9), <i>Ceratium fusus</i> (5.5), <i>Ceratium macroceros</i> (6.7), <i>Dinophysis tripos</i> (1.2).
EMPL-6	2434	28	<i>Biddulphia aurita</i> (1.5), <i>Biddulphia sinensis</i> (4.0), <i>Rhizosolenia imbricata</i> (2.5), <i>Rhizosolenia stolterfothii</i> (2.0), <i>Rhizosolenia alata</i> (3.0), <i>Rhizosolenia styliformis</i> (4.5), <i>Rhizosolenia robusta</i> (1.0), <i>Coscinodiscus centralis</i> (7.5), <i>Coscinodiscus radiatus</i> (8.5), <i>Coscinodiscus sp</i> (5.0), <i>Guinardia flaccida</i> (1.0), <i>Skeletonema costatum</i> (1.5), <i>Asterionella japonica</i> (8.0), <i>Anabaena sp</i> (0.5), <i>Streptotheca thamensis</i> (5.0), <i>Bellerochea malleus</i> (1.0), <i>Navicula sp</i> (5.5), <i>Pleurosigma sp</i> (4.0), <i>Nitzschia sp</i> (4.5), <i>Chaetoceros coarctatus</i> (5.5), <i>Chaetoceros laevis</i> (4.0), <i>Chaetoceros peruvianus</i> (3.0), <i>Triceratium reticulatum</i> (0.5), <i>Ceratium tripos</i> (4.5), <i>Ceratium furca</i> (5.5), <i>Ceratium fusus</i> (2.0), <i>Ceratium macroceros</i> (2.5), <i>Dinophysis tripos</i> (2.0).



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Station code	Population (No/l)	Faunal Groups	Major groups (%)
EMPL-7	1205	26	<i>Biddulphia aurita</i> (1.0), <i>Biddulphia sinensis</i> (2.0), <i>Rhizosolenia imbricata</i> (2.0), <i>Rhizosolenia stolterfothii</i> (3.0), <i>Rhizosolenia alata</i> (4.0), <i>Rhizosolenia styliiformis</i> (1.0), <i>Rhizosolenia robusta</i> (5.0), <i>Coscinodiscus centralis</i> (9.1), <i>Coscinodiscus radiatus</i> (10.1), <i>Coscinodiscus sp</i> (4.0), <i>Guinardia flaccida</i> (1.0), <i>Skeletonema costatum</i> (2.0), <i>Leptocylindrus sp</i> (1.0), <i>Asterionella japonica</i> (3.0), <i>Streptotheca thamensis</i> (5.0), <i>Bellerochea malleus</i> (1.0), <i>Navicula sp</i> (5.0), <i>Pleurosigma sp</i> (9.1), <i>Nitzschia sp</i> (12.1), <i>Chaetoceros coarctatus</i> (2.0), <i>Chaetoceros laevis</i> (1.0), <i>Chaetoceros peruvianus</i> (1.0), <i>Ceratium tripos</i> (6.1), <i>Ceratium furca</i> (2.0), <i>Ceratium fusus</i> (2.0), <i>Ceratium macroceros</i> (5.0).
EMPL-8	3018	28	<i>Biddulphia sinensis</i> (3.6), <i>Rhizosolenia imbricata</i> (3.2), <i>Rhizosolenia stolterfothii</i> (3.6), <i>Rhizosolenia alata</i> (4.0), <i>Rhizosolenia styliiformis</i> (2.4), <i>Rhizosolenia robusta</i> (2.8), <i>Coscinodiscus centralis</i> (4.8), <i>Coscinodiscus radiatus</i> (7.3), <i>Coscinodiscus sp</i> (5.6), <i>Guinardia flaccida</i> (0.8), <i>Skeletonema costatum</i> (0.4), <i>Leptocylindrus sp</i> (0.8), <i>Asterionella japonica</i> (6.9), <i>Anabaena sp</i> (1.6), <i>Streptotheca thamensis</i> (3.2), <i>Bellerochea malleus</i> (0.8), <i>Navicula sp</i> (4.8), <i>Pleurosigma sp</i> (7.7), <i>Bacillaria paradoxa</i> (0.4), <i>Nitzschia sp</i> (3.6), <i>Chaetoceros decipiens</i> (2.8), <i>Chaetoceros coarctatus</i> (4.4), <i>Chaetoceros laevis</i> (5.6), <i>Chaetoceros peruvianus</i> (3.6), <i>Ceratium tripos</i> (4.0), <i>Ceratium furca</i> (4.8), <i>Ceratium fusus</i> (4.0), <i>Ceratium macroceros</i> (2.0).
EMPL-9	2702	27	<i>Biddulphia sinensis</i> (3.6), <i>Rhizosolenia imbricata</i> (4.5), <i>Rhizosolenia stolterfothii</i> (5.0), <i>Rhizosolenia alata</i> (3.6), <i>Rhizosolenia styliiformis</i> (4.5), <i>Rhizosolenia robusta</i> (4.1), <i>Coscinodiscus centralis</i> (5.0), <i>Coscinodiscus radiatus</i> (9.5), <i>Coscinodiscus sp</i> (4.5), <i>Thalassionema nitzschioides</i> (2.3), <i>Guinardia flaccida</i> (1.8), <i>Leptocylindrus sp</i> (1.4), <i>Asterionella japonica</i> (6.8), <i>Anabaena sp</i> (0.9), <i>Streptotheca thamensis</i> (4.1), <i>Bellerochea malleus</i> (0.5), <i>Navicula sp</i> (5.9), <i>Pleurosigma sp</i> (6.3), <i>Nitzschia sp</i> (4.5), <i>Chaetoceros decipiens</i> (0.9), <i>Chaetoceros coarctatus</i> (5.4), <i>Chaetoceros laevis</i> (5.0), <i>Chaetoceros peruvianus</i> (5.0), <i>Ceratium tripos</i> (2.3), <i>Ceratium furca</i> (1.8), <i>Ceratium fusus</i> (0.9), <i>Dinophysis tripos</i> (0.5)
EMPL-10	3761	30	<i>Biddulphia sinensis</i> (3.2), <i>Rhizosolenia imbricata</i> (2.9), <i>Rhizosolenia stolterfothii</i> (3.6), <i>Rhizosolenia alata</i> (2.6), <i>Rhizosolenia styliiformis</i> (2.3), <i>Rhizosolenia robusta</i> (4.9), <i>Coscinodiscus centralis</i> (3.9), <i>Coscinodiscus radiatus</i> (4.5), <i>Coscinodiscus sp</i> (3.6), <i>Thalassionema nitzschioides</i> (2.6), <i>Guinardia flaccida</i> (2.9), <i>Skeletonema costatum</i> (3.6), <i>Leptocylindrus sp</i> (2.9), <i>Asterionella japonica</i> (5.8), <i>Anabaena sp</i> (2.6), <i>Streptotheca thamensis</i> (5.2), <i>Bellerochea malleus</i> (2.3), <i>Navicula sp</i> (5.5), <i>Pleurosigma sp</i> (5.8), <i>Bacillaria paradoxa</i> (0.6), <i>Nitzschia sp</i> (4.5), <i>Chaetoceros decipiens</i> (3.2), <i>Chaetoceros coarctatus</i> (4.9), <i>Chaetoceros laevis</i> (4.2), <i>Chaetoceros peruvianus</i> (3.2), <i>Triceratium reticulatum</i> (0.6), <i>Ceratium tripos</i> (1.6), <i>Ceratium furca</i> (2.6), <i>Ceratium fusus</i> (2.3), <i>Ceratium macroceros</i> (1.6)



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Table 7. Zooplankton population density variation in the coastal waters around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek during high tide

Station code	Population (No/m ³)	Faunal Groups	Major groups (%)
ENC-1	156	16	<i>Salpa fusiformis</i> (4.1), <i>Pleurobrachia pileus</i> (24.5), <i>Pareucalanus attenuates</i> (4.1), <i>Subeucalanus subcrassus</i> (10.2), <i>Acrocalanus gibber</i> (14.3), <i>Acrocalanus gracilis</i> (6.1), <i>Acrocalanus longicornis</i> (6.1), <i>Oithona brevicornis</i> (4.1), <i>Oithona spinirostris</i> (2.0), <i>Macrosetella gracillis</i> (4.1), <i>Calanopia minor</i> (2.0), <i>Lucifer hansenii</i> (2.0), <i>Sagitta bipunctata</i> (4.1), <i>Fish larvae</i> (6.1), <i>Crab Zoea</i> (4.1), <i>Tunicate larvae</i> (2.0).
ENC-2	118	13	<i>Salpa fusiformis</i> (13.5), <i>Pleurobrachia pileus</i> (10.8), <i>Pareucalanus attenuates</i> (13.5), <i>Subeucalanus subcrassus</i> (8.1), <i>Acrocalanus gibber</i> (10.8), <i>Acrocalanus gracilis</i> (8.1), <i>Pseudodiaptomus serricaudatus</i> (5.4), <i>Lucifer hansenii</i> (5.4), <i>Sagitta bipunctata</i> (8.1), <i>Polychaete worm</i> (2.7), <i>Fish eggs</i> (5.4), <i>Fish larvae</i> (2.7), <i>Exoskeleton molt of Barnacle</i> (5.4).
ENC-3	115	12	<i>Salpa fusiformis</i> (11.1), <i>Pleurobrachia pileus</i> (5.5), <i>Pareucalanus attenuates</i> (19.4), <i>Subeucalanus subcrassus</i> (8.3), <i>Acrocalanus gibber</i> (5.5), <i>Acrocalanus gracilis</i> (11.1), <i>Pseudodiaptomus serricaudatus</i> (2.8), <i>Oithona spinirostris</i> (13.8), <i>Macrosetella gracillis</i> (5.5), <i>Lucifer hansenii</i> (2.8), <i>Sagitta bipunctata</i> (5.5), <i>Exoskeleton molt of Barnacle</i> (8.3).
EMPL-1	535	24	<i>Salpa fusiformis</i> (1.8), <i>Pleurobrachia pileus</i> (3.0), <i>Pareucalanus attenuates</i> (9.5), <i>Subeucalanus subcrassus</i> (6.5), <i>Acrocalanus gibber</i> (4.8), <i>Acrocalanus gracilis</i> (6.5), <i>Acrocalanus longicornis</i> (3.6), <i>Pseudodiaptomus serricaudatus</i> (5.4), <i>Oithona brevicornis</i> (4.2), <i>Oithona spinirostris</i> (4.2), <i>Macrosetella gracillis</i> (6.5), <i>Calanopia minor</i> (2.4), <i>Temora turbinata</i> (4.8), <i>Penilia avirostris</i> (3.6), <i>Lucifer hansenii</i> (4.2), <i>Sagitta bipunctata</i> (1.2), <i>Okiopleura parva</i> (2.4), <i>Mysidae sp.</i> (2.4), <i>Polychaete worm</i> (3.6), <i>Fish eggs</i> (8.3), <i>Fish larvae</i> (4.2), <i>Crab Zoea</i> (2.4), <i>Cyprid larvae</i> (2.4), <i>Tunicate larvae</i> (1.8)
EMPL-2	369	21	<i>Salpa fusiformis</i> (0.9), <i>Pleurobrachia pileus</i> (2.6), <i>Pareucalanus attenuates</i> (12.1), <i>Subeucalanus subcrassus</i> (7.8), <i>Acrocalanus gibber</i> (5.2), <i>Acrocalanus gracilis</i> (7.8), <i>Acrocalanus longicornis</i> (3.5), <i>Pseudodiaptomus serricaudatus</i> (6.0), <i>Oithona brevicornis</i> (5.2), <i>Oithona spinirostris</i> (4.3), <i>Macrosetella gracillis</i> (7.8), <i>Calanopia minor</i> (1.7), <i>Temora turbinata</i> (5.2), <i>Penilia avirostris</i> (3.5), <i>Lucifer hansenii</i> (4.3), <i>Mysidae sp.</i> (1.7), <i>Polychaete worm</i> (3.5), <i>Fish eggs</i> (10.4), <i>Fish larvae</i> (4.3), <i>Crab Zoea</i> (1.7), <i>Tunicate larvae</i> (0.9).
EMPL-3	401	22	<i>Salpa fusiformis</i> (1.6), <i>Pleurobrachia pileus</i> (3.2), <i>Pareucalanus attenuates</i> (11.9), <i>Subeucalanus subcrassus</i> (7.9), <i>Acrocalanus gibber</i> (5.6), <i>Acrocalanus gracilis</i> (7.9), <i>Acrocalanus longicornis</i> (4.0), <i>Pseudodiaptomus serricaudatus</i> (6.4), <i>Oithona brevicornis</i> (5.6), <i>Oithona spinirostris</i> (4.8), <i>Macrosetella gracillis</i> (4.8), <i>Calanopia minor</i> (2.4), <i>Temora turbinata</i> (5.6), <i>Penilia avirostris</i> (4.0), <i>Sagitta bipunctata</i> (0.8), <i>Okiopleura parva</i> (2.4), <i>Mysidae sp.</i> (2.4), <i>Polychaete worm</i> (4.0), <i>Fish eggs</i> (6.4), <i>Fish larvae</i> (4.8), <i>Crab Zoea</i> (2.4), <i>Tunicate larvae</i> (1.6).
EMPL-4	439	23	<i>Salpa fusiformis</i> (2.9), <i>Pleurobrachia pileus</i> (0.7), <i>Pareucalanus attenuates</i> (12.3), <i>Subeucalanus subcrassus</i> (8.7), <i>Acrocalanus gibber</i> (3.6), <i>Acrocalanus gracilis</i> (9.4), <i>Acrocalanus longicornis</i> (5.1), <i>Pseudodiaptomus serricaudatus</i> (2.2), <i>Oithona spinirostris</i> (3.6), <i>Macrosetella gracillis</i> (5.8), <i>Calanopia minor</i> (3.6), <i>Temora turbinata</i> (2.9), <i>Penilia avirostris</i> (5.1), <i>Lucifer hansenii</i> (2.2), <i>Sagitta bipunctata</i> (2.9), <i>Okiopleura parva</i> (2.9), <i>Mysidae sp.</i> (3.6), <i>Polychaete worm</i> (2.2), <i>Fish eggs</i> (8.0), <i>Fish larvae</i> (5.8), <i>Crab Zoea</i> (3.6), <i>Cyprid larvae</i> (2.2), <i>Tunicate larvae</i> (0.7).



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Station code	Population (No/m ³)	Faunal Groups	Major groups (%)
EMPL-5	510	23	<i>Salpa fusiformis</i> (3.7), <i>Pleurobrachia pileus</i> (5.0), <i>Pareucalanus attenuates</i> (6.9), <i>Subeucalanus subcrassus</i> (8.7), <i>Acrocalanus gibber</i> (5.6), <i>Acrocalanus gracilis</i> (8.7), <i>Acrocalanus longicornis</i> (5.6), <i>Pseudodiaptomus serricaudatus</i> (5.0), <i>Oithona brevicornis</i> (3.1), <i>Oithona spirostris</i> (5.0), <i>Macrosetella gracillis</i> (3.7), <i>Calanopia minor</i> (4.4), <i>Temora turbinata</i> (6.9), <i>Penilia avirostris</i> (5.6), <i>Lucifer hanseni</i> (2.5), <i>Sagitta bipunctata</i> (1.9), <i>Okiopleura parva</i> (3.1), <i>Mysidae sp.</i> (2.5), <i>Polychaete worm</i> (3.7), <i>Fish eggs</i> (2.5), <i>Crab Zoea</i> (1.2), <i>Cyprid larvae</i> (0.6), <i>Tunicate larvae</i> (3.7).
EMPL-6	449	24	<i>Salpa fusiformis</i> (2.8), <i>Pleurobrachia pileus</i> (4.3), <i>Pareucalanus attenuates</i> (9.2), <i>Subeucalanus subcrassus</i> (8.5), <i>Acrocalanus gibber</i> (7.1), <i>Acrocalanus gracilis</i> (8.5), <i>Acrocalanus longicornis</i> (5.0), <i>Pseudodiaptomus serricaudatus</i> (4.3), <i>Oithona brevicornis</i> (2.1), <i>Oithona spirostris</i> (4.3), <i>Macrosetella gracillis</i> (2.8), <i>Calanopia minor</i> (3.5), <i>Temora turbinata</i> (8.5), <i>Penilia avirostris</i> (7.8), <i>Lucifer hanseni</i> (2.1), <i>Sagitta bipunctata</i> (1.4), <i>Okiopleura parva</i> (2.1), <i>Mysidae sp.</i> (1.4), <i>Polychaete worm</i> (2.8), <i>Fish eggs</i> (1.4), <i>Fish larvae</i> (2.1), <i>Crab Zoea</i> (3.5), <i>Cyprid larvae</i> (1.4), <i>Tunicate larvae</i> (2.8)
EMPL-7	427	24	<i>Salpa fusiformis</i> (2.2), <i>Pleurobrachia pileus</i> (5.2), <i>Pareucalanus attenuates</i> (11.2), <i>Subeucalanus subcrassus</i> (8.2), <i>Acrocalanus gibber</i> (6.7), <i>Acrocalanus gracilis</i> (11.9), <i>Acrocalanus longicornis</i> (4.5), <i>Pseudodiaptomus serricaudatus</i> (5.2), <i>Oithona brevicornis</i> (1.5), <i>Oithona spirostris</i> (3.7), <i>Macrosetella gracillis</i> (3.7), <i>Calanopia minor</i> (4.5), <i>Temora turbinata</i> (7.5), <i>Penilia avirostris</i> (6.0), <i>Lucifer hanseni</i> (1.5), <i>Sagitta bipunctata</i> (3.7), <i>Okiopleura parva</i> (1.5), <i>Mysidae sp.</i> (0.7), <i>Polychaete worm</i> (2.2), <i>Fish eggs</i> (0.7), <i>Fish larvae</i> (1.5), <i>Crab Zoea</i> (3.0), <i>Cyprid larvae</i> (0.7), <i>Tunicate larvae</i> (2.2).
EMPL-8	525	24	<i>Salpa fusiformis</i> (3.0), <i>Pleurobrachia pileus</i> (5.5), <i>Pareucalanus attenuates</i> (10.3), <i>Subeucalanus subcrassus</i> (7.9), <i>Acrocalanus gibber</i> (6.7), <i>Acrocalanus gracilis</i> (7.9), <i>Acrocalanus longicornis</i> (3.0), <i>Pseudodiaptomus serricaudatus</i> (5.5), <i>Oithona brevicornis</i> (3.6), <i>Oithona spirostris</i> (1.8), <i>Macrosetella gracillis</i> (4.2), <i>Calanopia minor</i> (4.9), <i>Temora turbinata</i> (5.5), <i>Penilia avirostris</i> (6.1), <i>Lucifer hanseni</i> (2.4), <i>Sagitta bipunctata</i> (4.2), <i>Okiopleura parva</i> (2.4), <i>Mysidae sp.</i> (1.8), <i>Polychaete worm</i> (3.0), <i>Fish larvae</i> (1.8), <i>Crab Zoea</i> (3.6), <i>Cyprid larvae</i> (1.8), <i>Tunicate larvae</i> (3.0).
EMPL-9	551	23	<i>Salpa fusiformis</i> (4.0), <i>Pleurobrachia pileus</i> (3.5), <i>Pareucalanus attenuates</i> (8.1), <i>Subeucalanus subcrassus</i> (5.8), <i>Acrocalanus gibber</i> (4.6), <i>Acrocalanus gracilis</i> (5.8), <i>Acrocalanus longicornis</i> (2.9), <i>Pseudodiaptomus serricaudatus</i> (5.8), <i>Oithona brevicornis</i> (4.6), <i>Oithona spirostris</i> (3.5), <i>Macrosetella gracillis</i> (5.8), <i>Calanopia minor</i> (4.6), <i>Temora turbinata</i> (4.6), <i>Penilia avirostris</i> (2.9), <i>Lucifer hanseni</i> (3.5), <i>Sagitta bipunctata</i> (2.9), <i>Mysidae sp.</i> (2.9), <i>Polychaete worm</i> (2.9), <i>Fish eggs</i> (9.8), <i>Fish larvae</i> (4.6), <i>Crab Zoea</i> (2.9), <i>Cyprid larvae</i> (1.7), <i>Tunicate larvae</i> (2.3).
EMPL-10	694	24	<i>Salpa fusiformis</i> (2.3), <i>Pleurobrachia pileus</i> (3.2), <i>Pareucalanus attenuates</i> (8.3), <i>Subeucalanus subcrassus</i> (6.0), <i>Acrocalanus gibber</i> (4.6), <i>Acrocalanus gracilis</i> (6.0), <i>Acrocalanus longicornis</i> (3.7), <i>Pseudodiaptomus serricaudatus</i> (5.0), <i>Oithona brevicornis</i> (4.6), <i>Oithona spirostris</i> (4.1), <i>Macrosetella gracillis</i> (6.0), <i>Calanopia minor</i> (2.8), <i>Temora turbinata</i> (4.6), <i>Penilia avirostris</i> (3.7), <i>Lucifer hanseni</i> (4.1), <i>Sagitta bipunctata</i> (1.8), <i>Okiopleura parva</i> (2.8), <i>Mysidae sp.</i> (2.8), <i>Polychaete worm</i> (3.7), <i>Fish eggs</i> (7.3), <i>Fish larvae</i> (4.1), <i>Crab Zoea</i> (3.7), <i>Cyprid larvae</i> (2.8), <i>Tunicate larvae</i> (2.3).



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Table 7a. Zooplankton population density variation in the coastal waters around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek during low tide

Station code	Population (No/m ³)	Faunal Groups	Major groups (%)
ENC-1	140	14	<i>Salpa fusiformis</i> (6.8), <i>Pleurobrachia pileus</i> (15.9), <i>Pareucalanus attenuates</i> (6.8), <i>Subeucalanus subcrassus</i> (15.9), <i>Acrocalanus gibber</i> (6.8), <i>Acrocalanus gracilis</i> (9.1), <i>Acrocalanus longicornis</i> (2.3), <i>Oithona spirostris</i> (11.4), <i>Macrosetella gracillis</i> (4.5), <i>Calanopia minor</i> (2.3), <i>Sagitta bipunctata</i> (4.5), <i>Fish larvae</i> (6.8), <i>Crab Zoea</i> (4.5), <i>Tunicate larvae</i> (2.3),
ENC-2	102	9	<i>Salpa fusiformis</i> (9.4), <i>Pleurobrachia pileus</i> (6.2), <i>Pareucalanus attenuates</i> (15.6), <i>Acrocalanus gibber</i> (21.9), <i>Acrocalanus gracilis</i> (6.2), <i>Acrocalanus longicornis</i> (6.2), <i>Temora turbinata</i> (9.4), <i>Sagitta bipunctata</i> (12.5), <i>Exoskeleton molt of Barnacle</i> (12.5)
ENC-3	99	10	<i>Salpa fusiformis</i> (3.2), <i>Pleurobrachia pileus</i> (3.2), <i>Pareucalanus attenuates</i> (12.9), <i>Acrocalanus gibber</i> (9.7), <i>Acrocalanus gracilis</i> (22.5), <i>Acrocalanus longicornis</i> (9.7), <i>Oithona spirostris</i> (19.3), <i>Penilia avirostris</i> (3.2), <i>Sagitta bipunctata</i> (6.4), <i>Exoskeleton molt of Barnacle</i> (9.7).
EMPL-1	462	24	<i>Salpa fusiformis</i> (2.6), <i>Pleurobrachia pileus</i> (2.8), <i>Pareucalanus attenuates</i> (5.0), <i>Subeucalanus subcrassus</i> (14.7), <i>Acrocalanus gibber</i> (4.3), <i>Acrocalanus gracilis</i> (5.0), <i>Acrocalanus longicornis</i> (3.4), <i>Pseudodiaptomus serricaudatus</i> (8.9), <i>Oithona brevicornis</i> (12.1), <i>Oithona spirostris</i> (8.7), <i>Macrosetella gracillis</i> (3.0), <i>Calanopia minor</i> (1.1), <i>Temora turbinata</i> (0.6), <i>Penilia avirostris</i> (3.5), <i>Lucifer hanseni</i> (0.7), <i>Sagitta bipunctata</i> (1.7), <i>Okiopleura parva</i> (0.9), <i>Mysidae sp.</i> (3.9), <i>Polychaete worm</i> (2.8), <i>Fish eggs</i> (6.1), <i>Fish larvae</i> (3.0), <i>Crab zoea</i> (3.2), <i>Cyprid larvae</i> (1.1), <i>Tunicate larvae</i> (0.9)
EMPL-2	443	24	<i>Salpa fusiformis</i> (2.2), <i>Pleurobrachia pileus</i> (3.6), <i>Pareucalanus attenuates</i> (6.5), <i>Subeucalanus subcrassus</i> (12.9), <i>Acrocalanus gibber</i> (5.0), <i>Acrocalanus gracilis</i> (4.3), <i>Acrocalanus longicornis</i> (2.9), <i>Pseudodiaptomus serricaudatus</i> (7.9), <i>Oithona brevicornis</i> (10.1), <i>Oithona spirostris</i> (8.6), <i>Macrosetella gracillis</i> (3.6), <i>Calanopia minor</i> (2.2), <i>Temora turbinata</i> (1.4), <i>Penilia avirostris</i> (2.9), <i>Lucifer hanseni</i> (1.4), <i>Sagitta bipunctata</i> (2.2), <i>Okiopleura parva</i> (1.4), <i>Mysidae sp.</i> (2.9), <i>Polychaete worm</i> (3.6), <i>Fish eggs</i> (5.0), <i>Fish larvae</i> (4.9), <i>Crab Zoea</i> (3.6), <i>Cyprid larvae</i> (1.4), <i>Tunicate larvae</i> (1.4).
EMPL-3	350	21	<i>Salpa fusiformis</i> (0.9), <i>Pleurobrachia pileus</i> (1.8), <i>Pareucalanus attenuates</i> (3.6), <i>Subeucalanus subcrassus</i> (10.0), <i>Acrocalanus gibber</i> (7.3), <i>Acrocalanus gracilis</i> (3.6), <i>Acrocalanus longicornis</i> (6.4), <i>Pseudodiaptomus serricaudatus</i> (9.1), <i>Oithona brevicornis</i> (3.6), <i>Oithona spirostris</i> (5.5), <i>Macrosetella gracillis</i> (6.4), <i>Calanopia minor</i> (4.5), <i>Penilia avirostris</i> (10.0), <i>Lucifer hanseni</i> (2.7), <i>Sagitta bipunctata</i> (3.6), <i>Mysidae sp.</i> (1.8), <i>Polychaete worm</i> (2.7), <i>Fish eggs</i> (4.5), <i>Fish larvae</i> (5.5), <i>Crab Zoea</i> (3.6), <i>Tunicate larvae</i> (2.7).
EMPL-4	366	20	<i>Salpa fusiformis</i> (1.7), <i>Pareucalanus attenuates</i> (11.3), <i>Subeucalanus subcrassus</i> (9.6), <i>Acrocalanus gibber</i> (7.8), <i>Acrocalanus gracilis</i> (5.2), <i>Acrocalanus longicornis</i> (2.6), <i>Pseudodiaptomus serricaudatus</i> (7.0), <i>Oithona brevicornis</i> (4.4), <i>Oithona spirostris</i> (6.1), <i>Macrosetella gracillis</i> (1.7), <i>Calanopia minor</i> (8.7), <i>Temora turbinata</i> (2.6), <i>Penilia avirostris</i> (5.2), <i>Lucifer hanseni</i> (1.7), <i>Sagitta bipunctata</i> (3.5), <i>Okiopleura parva</i> (0.9), <i>Mysidae sp.</i> (2.6), <i>Fish eggs</i> (12.2), <i>Fish larvae</i> (1.7), <i>Crab Zoea</i> (3.5).



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Station code	Population (No/m ³)	Faunal Groups	Major groups (%)
EMPL-5	404	23	<i>Salpa fusiformis</i> (2.4), <i>Pleurobrachia pileus</i> (0.8), <i>Pareucalanus attenuates</i> (11.0), <i>Subeucalanus subcrassus</i> (9.5), <i>Acrocalanus gibber</i> (7.9), <i>Acrocalanus gracilis</i> (5.5), <i>Acrocalanus longicornis</i> (3.2), <i>Pseudodiaptomus serricaudatus</i> (7.1), <i>Oithona brevicornis</i> (4.7), <i>Oithona spirostris</i> (6.3), <i>Macrosetella gracillis</i> (2.4), <i>Calanopia minor</i> (5.5), <i>Temora turbinata</i> (3.2), <i>Penilia avirostris</i> (3.9), <i>Lucifer hanseni</i> (2.4), <i>Sagitta bipunctata</i> (3.9), <i>Okiopleura parva</i> (0.8), <i>Mysidae sp.</i> (3.2), <i>Polychaete worm</i> (0.8), <i>Fish eggs</i> (8.7), <i>Fish larvae</i> (2.4), <i>Crab Zoea</i> (3.9), <i>Cyprid larvae</i> (0.8).
EMPL-6	487	23	<i>Salpa fusiformis</i> (2.6), <i>Pleurobrachia pileus</i> (3.9), <i>Pareucalanus attenuates</i> (6.5), <i>Subeucalanus subcrassus</i> (12.4), <i>Acrocalanus gibber</i> (5.2), <i>Acrocalanus gracilis</i> (4.6), <i>Acrocalanus longicornis</i> (3.3), <i>Pseudodiaptomus serricaudatus</i> (5.2), <i>Oithona brevicornis</i> (9.8), <i>Oithona spirostris</i> (8.5), <i>Macrosetella gracillis</i> (3.9), <i>Calanopia minor</i> (2.6), <i>Penilia avirostris</i> (3.3), <i>Lucifer hanseni</i> (2.0), <i>Sagitta bipunctata</i> (2.6), <i>Okiopleura parva</i> (2.0), <i>Mysidae sp.</i> (3.3), <i>Polychaete worm</i> (3.9), <i>Fish eggs</i> (5.2), <i>Fish larvae</i> (2.0), <i>Crab Zoea</i> (3.9), <i>Cyprid larvae</i> (1.3), <i>Tunicate larvae</i> (2.0).
EMPL-7	417	24	<i>Salpa fusiformis</i> (1.5), <i>Pleurobrachia pileus</i> (3.1), <i>Pareucalanus attenuates</i> (6.1), <i>Subeucalanus subcrassus</i> (13.0), <i>Acrocalanus gibber</i> (6.9), <i>Acrocalanus gracilis</i> (7.6), <i>Acrocalanus longicornis</i> (5.3), <i>Pseudodiaptomus serricaudatus</i> (4.6), <i>Oithona brevicornis</i> (10.7), <i>Oithona spirostris</i> (8.4), <i>Macrosetella gracillis</i> (3.1), <i>Calanopia minor</i> (4.6), <i>Temora turbinata</i> (2.3), <i>Penilia avirostris</i> (2.3), <i>Lucifer hanseni</i> (1.5), <i>Sagitta bipunctata</i> (1.5), <i>Okiopleura parva</i> (0.8), <i>Mysidae sp.</i> (2.3), <i>Polychaete worm</i> (3.1), <i>Fish eggs</i> (6.1), <i>Fish larvae</i> (0.8), <i>Crab Zoea</i> (3.1), <i>Cyprid larvae</i> (0.8), <i>Tunicate larvae</i> (0.8).
EMPL-8	379	22	<i>Salpa fusiformis</i> (2.5), <i>Pleurobrachia pileus</i> (1.7), <i>Pareucalanus attenuates</i> (10.9), <i>Subeucalanus subcrassus</i> (9.2), <i>Acrocalanus gibber</i> (8.4), <i>Acrocalanus gracilis</i> (4.2), <i>Acrocalanus longicornis</i> (1.7), <i>Pseudodiaptomus serricaudatus</i> (10.1), <i>Oithona brevicornis</i> (9.2), <i>Oithona spirostris</i> (7.6), <i>Macrosetella gracillis</i> (4.2), <i>Calanopia minor</i> (5.0), <i>Temora turbinata</i> (4.2), <i>Penilia avirostris</i> (1.7), <i>Lucifer hanseni</i> (4.2), <i>Sagitta bipunctata</i> (0.8), <i>Mysidae sp.</i> (2.5), <i>Polychaete worm</i> (1.7), <i>Fish eggs</i> (2.5), <i>Fish larvae</i> (5.9), <i>Crab Zoea</i> (0.8), <i>Tunicate larvae</i> (0.8).
EMPL-9	500	23	<i>Salpa fusiformis</i> (2.5), <i>Pleurobrachia pileus</i> (1.9), <i>Pareucalanus attenuates</i> (10.2), <i>Subeucalanus subcrassus</i> (5.7), <i>Acrocalanus gibber</i> (7.0), <i>Acrocalanus gracilis</i> (4.5), <i>Acrocalanus longicornis</i> (3.2), <i>Pseudodiaptomus serricaudatus</i> (7.0), <i>Oithona brevicornis</i> (7.6), <i>Oithona spirostris</i> (6.4), <i>Macrosetella gracillis</i> (5.1), <i>Calanopia minor</i> (5.7), <i>Penilia avirostris</i> (3.2), <i>Lucifer hanseni</i> (5.1), <i>Sagitta bipunctata</i> (2.5), <i>Okiopleura parva</i> (0.6), <i>Mysidae sp.</i> (3.8), <i>Polychaete worm</i> (3.2), <i>Fish eggs</i> (7.0), <i>Fish larvae</i> (3.2), <i>Crab Zoea</i> (1.9), <i>Cyprid larvae</i> (1.3), <i>Tunicate larvae</i> (1.3).
EMPL-10	532	23	<i>Salpa fusiformis</i> (2.4), <i>Pleurobrachia pileus</i> (1.8), <i>Pareucalanus attenuates</i> (6.0), <i>Subeucalanus subcrassus</i> (11.4), <i>Acrocalanus gibber</i> (4.8), <i>Acrocalanus gracilis</i> (4.2), <i>Acrocalanus longicornis</i> (3.0), <i>Pseudodiaptomus serricaudatus</i> (7.2), <i>Oithona brevicornis</i> (10.2), <i>Oithona spirostris</i> (7.8), <i>Macrosetella gracillis</i> (3.6), <i>Calanopia minor</i> (3.0), <i>Temora turbinata</i> (2.4), <i>Penilia avirostris</i> (3.6), <i>Lucifer hanseni</i> (4.2), <i>Sagitta bipunctata</i> (2.4), <i>Okiopleura parva</i> (1.2), <i>Mysidae sp.</i> (3.0), <i>Polychaete worm</i> (2.4), <i>Fish eggs</i> (7.2), <i>Fish larvae</i> (3.0), <i>Crab Zoea</i> (3.6), <i>Tunicate larvae</i> (1.8).



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL
Manali at Bay of Bengal off North Chennai Coast

Table 8. Benthos population density variation in the coastal waters around marine Outfall area at Bay of Bengal off North Chennai Coast & Ennore creek, during the study period

Station code	Population (No/m ²)	Faunal Groups	Major groups (%)
ENC-1	105	10	<i>Amphinome Rostrata</i> (6.7), <i>Diopatra Neapolitana</i> (6.7), <i>Anadara granosa</i> (13.3), <i>Cardium setosum</i> (6.7), <i>Donax faba</i> (13.3), <i>Mesodesma sp</i> (13.3), <i>Turritella attenuata</i> (20.0), <i>Clithon oualaniense</i> (6.7), <i>Theodoxus danubialis</i> (6.7), <i>Balanus amphitrite</i> (6.7).
ENC-2	98	10	<i>Capitella capitata</i> (21.4), <i>Sabellaria Cementarium</i> (7.1), <i>Meretrix meretrix</i> (7.1), <i>Cardium setosum</i> (7.1), <i>Donax faba</i> (7.1), <i>Mesodesma sp</i> (7.1), <i>Turritella attenuata</i> (7.1), <i>Cerithidea cingulata</i> (7.1), <i>Telescopium telescopium</i> (14.3), <i>Balanus amphitrite</i> (14.3).
ENC-3	63	6	<i>Capitella capitata</i> (22.2), <i>Sabellaria Cementarium</i> (33.3), <i>Mesodesma sp</i> (11.1), <i>Turritella attenuata</i> (11.1), <i>Cerithidea cingulata</i> (11.1), <i>Balanus amphitrite</i> (11.1)
ENC-4	42	5	<i>Capitella capitata</i> (16.7), <i>Meretrix meretrix</i> (16.7), <i>Mesodesma sp</i> (16.7), <i>Cerithidea cingulate</i> (16.7), <i>Balanus amphitrite</i> (33.3).
EMPL-1	270	16	<i>Amphinome Rostrata</i> (5.2), <i>Diopatra Neapolitana</i> (2.6), <i>Tomopteris Helgolandica</i> (1.4), <i>Capitella capitata</i> (10.4), <i>Meretrix meretrix</i> (10.4), <i>Anadara granosa</i> (7.8), <i>Cardium setosum</i> (5.2), <i>Donax faba</i> (13.0), <i>Turritella attenuata</i> (5.2), <i>Trochus sp</i> (7.8), <i>Natica sp</i> (2.6), <i>Umbonium vestiarius</i> (10.4), <i>Telescopium telescopium</i> (2.6), <i>Murex sp</i> (5.2), <i>Clithon oualaniense</i> (2.6), <i>Balanus amphitrite</i> (7.8).
EMPL-2	259	14	<i>Amphinome Rostrata</i> (8.1), <i>Diopatra Neapolitana</i> (5.4), <i>Capitella capitata</i> (13.5), <i>Sabellaria Cementarium</i> (2.7), <i>Meretrix meretrix</i> (13.5), <i>Anadara granosa</i> (10.8), <i>Cardium setosum</i> (8.1), <i>Donax faba</i> (10.8), <i>Turritella attenuata</i> (8.1), <i>Cerithidea cingulata</i> (2.7), <i>Trochus sp</i> (2.7), <i>Telescopium telescopium</i> (5.4), <i>Oliva olive</i> (2.7), <i>Balanus amphitrite</i> (5.4).
EMPL-3	245	16	<i>Amphinome Rostrata</i> (5.7), <i>Diopatra Neapolitana</i> (2.9), <i>Tomopteris Helgolandica</i> (8.6), <i>Capitella capitata</i> (11.4), <i>Meretrix meretrix</i> (11.4), <i>Anadara granosa</i> (8.6), <i>Cardium setosum</i> (5.7), <i>Donax faba</i> (8.6), <i>Turritella attenuata</i> (5.7), <i>Cerithidea cingulata</i> (8.6), <i>Natica sp</i> (2.9), <i>Umbonium vestiarius</i> (5.7), <i>Telescopium telescopium</i> (2.9), <i>Murex sp</i> (2.9), <i>Theodoxus danubialis</i> (2.9), <i>Balanus amphitrite</i> (5.7).
EMPL-4	406	18	<i>Amphinome Rostrata</i> (6.9), <i>Tomopteris Helgolandica</i> (3.4), <i>Capitella capitata</i> (5.2), <i>Meretrix meretrix</i> (10.3), <i>Anadara granosa</i> (3.4), <i>Donax faba</i> (8.6), <i>Mesodesma sp</i> (1.7), <i>Turritella attenuata</i> (6.9), <i>Cerithidea cingulata</i> (8.6), <i>Trochus sp</i> (3.4), <i>Natica sp</i> (5.2), <i>Umbonium vestiarius</i> (6.9), <i>Telescopium telescopium</i> (5.2), <i>Oliva olive</i> (3.4), <i>Murex sp</i> (5.2), <i>Clithon oualaniense</i> (3.4), <i>Theodoxus danubialis</i> (5.2), <i>Balanus amphitrite</i> (6.9).
EMPL-5	462	19	<i>Amphinome Rostrata</i> (7.6), <i>Diopatra Neapolitana</i> (3.0), <i>Tomopteris Helgolandica</i> (1.5), <i>Capitella capitata</i> (6.1), <i>Meretrix meretrix</i> (10.6), <i>Anadara granosa</i> (4.5), <i>Cardium setosum</i> (3.0), <i>Donax faba</i> (7.6), <i>Mesodesma sp</i> (3.0), <i>Turritella attenuata</i> (4.5), <i>Cerithidea cingulata</i> (7.6), <i>Trochus sp</i> (9.1), <i>Natica sp</i> (1.5), <i>Umbonium vestiarius</i> (3.0), <i>Telescopium telescopium</i> (6.1), <i>Oliva olive</i> (4.5), <i>Murex sp</i> (6.1), <i>Clithon oualaniense</i> (3.0), <i>Balanus amphitrite</i> (7.6).
EMPL-6	420	18	<i>Amphinome Rostrata</i> (6.7), <i>Diopatra Neapolitana</i> (3.3), <i>Tomopteris Helgolandica</i> (1.7), <i>Capitella capitata</i> (3.3), <i>Meretrix meretrix</i> (8.3), <i>Anadara granosa</i> (6.7), <i>Cardium setosum</i> (1.7), <i>Donax faba</i> (6.7), <i>Turritella attenuata</i> (6.7), <i>Cerithidea cingulata</i> (11.7), <i>Trochus sp</i> (6.7), <i>Natica sp</i> (5.0), <i>Umbonium vestiarius</i> (5.0), <i>Telescopium telescopium</i> (8.3), <i>Oliva olive</i> (3.3), <i>Murex sp</i> (3.3), <i>Clithon oualaniense</i> (5.0), <i>Balanus amphitrite</i> (6.7).
EMPL-7	326	18	<i>Amphinome Rostrata</i> (6.4), <i>Diopatra Neapolitana</i> (4.3), <i>Tomopteris Helgolandica</i> (3.3), <i>Capitella capitata</i> (10.7), <i>Meretrix meretrix</i> (8.6), <i>Anadara granosa</i> (6.4), <i>Cardium setosum</i> (6.4), <i>Donax faba</i> (10.7), <i>Mesodesma sp</i> (2.1), <i>Turritella attenuata</i> (2.1), <i>Cerithidea cingulata</i> (6.4), <i>Trochus sp</i> (4.3), <i>Umbonium vestiarius</i> (4.3), <i>Telescopium telescopium</i> (2.1), <i>Oliva olive</i> (2.1), <i>Murex sp</i> (6.4), <i>Clithon oualaniense</i> (4.3), <i>Balanus Amphitrite</i> (8.6).



Marine Impact Assessment Studies for the Combined Marine Outfall from M/s. MPL, TPL and KPL Manali at Bay of Bengal off North Chennai Coast

Station code	Population (No/m ²)	Faunal Groups	Major groups (%)
EMPL-8	518	18	<i>Amphinome Rostrata</i> (6.8), <i>Diopatra Neapolitana</i> (5.4), <i>Capitella capitata</i> (9.5), <i>Sabellaria Cementarium</i> (2.7), <i>Meretrix meretrix</i> (8.1), <i>Anadara granosa</i> (6.8), <i>Cardium setosum</i> (5.4), <i>Donax faba</i> (9.5), <i>Mesodesma sp</i> (4.1), <i>Turritella attenuata</i> (4.1) <i>Cerithidea cingulata</i> (4.1), <i>Trochus sp</i> (5.4), <i>Natica sp</i> (1.4), <i>Umbonium vestiarium</i> (2.7), <i>Telescopium telescopium</i> (5.4), <i>Oliva olive</i> (4.1), <i>Murex sp.</i> (6.8), <i>Balanus amphitrite</i> (8.1).
EMPL-9	609	17	<i>Amphinome Rostrata</i> (6.9), <i>Diopatra Neapolitana</i> (5.7), <i>Capitella capitata</i> (9.2), <i>Meretrix meretrix</i> (8.0), <i>Anadara granosa</i> (6.9), <i>Cardium setosum</i> (5.7), <i>Donax faba</i> (9.2), <i>Mesodesma sp</i> (4.6), <i>Turritella attenuata</i> (4.6) <i>Cerithidea cingulata</i> (4.6), <i>Trochus sp</i> (5.7), <i>Natica sp</i> (2.3), <i>Umbonium vestiarium</i> (3.4), <i>Telescopium telescopium</i> (5.7), <i>Oliva olive</i> (4.6), <i>Murex sp.</i> (6.9), <i>Balanus amphitrite</i> (5.7).
EMPL-10	651	17	<i>Amphinome Rostrata</i> (4.3), <i>Diopatra Neapolitana</i> (6.5), <i>Tomopteris Helgolandica</i> (1.1), <i>Capitella capitata</i> (5.4), <i>Sabellaria Cementarium</i> (1.1), <i>Meretrix meretrix</i> (11.8), <i>Anadara granosa</i> (7.5), <i>Donax faba</i> (9.7), <i>Mesodesma sp</i> (5.4), <i>Turritella attenuata</i> (5.4), <i>Trochus sp</i> (6.5), <i>Natica sp</i> (4.3), <i>Umbonium vestiarium</i> (4.3), <i>Telescopium telescopium</i> (6.5), <i>Oliva olive</i> (5.4), <i>Murex sp.</i> (8.6), <i>Balanus amphitrite</i> (6.5).



राष्ट्रीय समुद्र प्रौद्योगिकी संस्थान
NATIONAL INSTITUTE OF OCEAN TECHNOLOGY

पृथ्वी प्रणाली विज्ञान संगठन/Earth Systems Sciences Organisation

(पृथ्वी विज्ञान मंत्रालय, भारत सरकार)

(Ministry of Earth Sciences, Government of India)

एन.आई.ओ.टी. केम्पस, वेलच्चेरि ताम्बरम मैन रोड, पल्लिकरणै, चेन्नै-६०० १०० भारत.
NIOT Campus, Velachery - Tambaram Main Road, Pallikaranai, Chennai-600 100 INDIA.



डॉ. जी.ए. रामदास

निदेशक

Dr. G.A. RAMADASS
Director

NIOT/DIR/CEE/2K2

11th April 2022

To

Shri.M.Karthikeyan
Whole Time Director (Operations)
Manali Petrochemicals Limited
Ponneri High Road, Manali
Chennai – 600 068

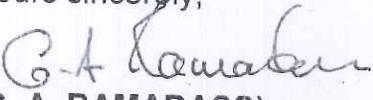
Sir,

Sub : ZLD feasibility study of Treated Effluent for M/s.Manali Petro Chemicals Ltd.
Ref : Your letter MPL-ZLD/NIOT/2022, dt.06TH April 2022

Thank you for your letter dt.06.04.2022 and your interest to carry out the work through NIOT. It is not possible to undertake this study requested as it is not NIOT core-competance/research. We regret our inability to undertake this study. We shall be happy to be associated with Manali Petro Chemicals Ltd. in future.

With warm regards,

Yours sincerely,


(G. A. RAMADASS)