BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
SOUTHERN ZONE, CHENNAI

IN THE MATTER OF:

Original Application No. 19 of 2013 (SZ)

Meenavargal Membattu Sangam ... Applicant

vs

The Chief Secretary, Government of Tamil Nadu, Chennai and Others. ...Respondent(s)

Original Application No. 248/2016 (SZ)

Meenava Thanthai K.R. Selvaraj Kumar, Meenavar Nala Sangam. ... Applicant

vs

The State of Tamil Nadu, Rep.by its Secretary to Government, Chennai and Others ...Respondent(s)

Original Application No. 224 of 2016 (SZ)

Meenava Thanthai K.R. Selvaraj Kumar ... Applicant

vs

The Chief Secretary, Government of Tamil Nadu, Secretariat, Chennai and Others. ... Respondent(s)

Appeal No. 51/2017 (SZ)

M/s. Manali Petrochemicals Limited ... Appellant

vs

The Central Pollution Control Board, New Delhi and Others ... Respondent(s)

Appeal No.52 of 2017 (SZ)

M/s. Manali Petrochemicals Limited ... Appellant

vs

The Central Pollution Control Board, New Delhi and Others. ... Respondent(s)

INDEX

S Suresh

DEPONENT

S. SURESH
REGIONAL DIRECTOR
CENTRAL POLLUTION CONTROL BOARD
REGIONAL DIRECTORATE (SOUTH)
MIN. OF ENV, FORESTS & CC, GOVT. OF INDIA
BENGALURU - 560 079. MOB : 9480672128

Place : Bengaluru
Date : 28.10.2020

Report of the Joint Committee

(as per Hon'ble Tribunal, Southern Zone, Chennai order dated 08.02.2020, 11.06.2020 & 07.09.2020 in OA nos. 19/2013, 224/2016, 248/2016 and Appeal nos. 51/2017 & 52/2017)

1. Background:

The Honourable National Green Tribunal, Southern Zone, Chennai, in the matter of OA nos. 19/2013, 224/2016, 248/2016 and appeal nos. 51/2017 & 52/2017 directed on 08.02.2020 as;

"….. we feel it appropriate to appoint a joint committee comprising of Central Pollution Control Board, State Pollution Control Board, a senior scientist from National Institute of Ocean Technology (NIOT) and senior scientist dealing with environment engineering (Chemical) from Anna University to inspect the units in question and find out the present status of the functioning of the units namely M/s. Manali Petrochemical Limited and M/s. Tamilnadu Petrochemical limited and ascertain as to whether they are maintaining and managing all pollution control mechanism and whether the discharge of effluent from these industries to sea confirms with the specified norms prescribed by the PCB and the impact of effluents in the sea water and if there is any deficiency found and the sea water quality has not improved, then suggest the remedial measures by which the quality of sea water can be improved and who has to carry out these remedial measures and also assess the environmental compensation against the defaulting units who are responsible for polluting sea water by applying "Polluters Pay" principle and submit a report to this Tribunal within a period of three months.

The remedial measure should contain the short term as well as long term measures to be adopted by the units. They may also consider as to whether the units have complied with the recommendations made by the earlier committee for improvement of the quality of the sea water and if so to what extent that has been complied with and the impact of that compliance in the quality of sea water and if it is not sufficient to suggest more recommendations as a remedial measures to remedy the situation and make the quality of the sea water in conformity with the norms and the time required for completing the remedial measures. They may also conduct a detailed study regarding the effect of contamination caused on the flora and fauna of the aquatic and marine life".

In compliance to the Hon'ble tribunal order, the committee carried out inspection &monitoring of Source Emission, ETP & Marian outfall during March 04 to 06, 2020 and submitted interim report on 11.06.2020 seeking further time to file final report.

Further Hon'ble tribunal in its order dated 11.06.2020, directed as follows;

"5. Under these circumstances, we feel it appropriate to grant two months time to the committee to submit the report along with the remediation measures if any, required on the basis of the Analysis Report and also suggest alternate methods if any, required for noncompliance of certain suggestions and recommendation given for efficient management of pollution control mechanism which they have mentioned in the 'remarks' column of the compliance of recommendation in the interim report.

The committee is directed to submit the report to this Tribunal on or before 7.9.2020"

NIOT requested further time for submission of marine study report, accordingly, CPCB has submitted request seeking further four weeks time for filing the report. Upon the request Hon'ble Tribunal has grant time till 02.11.2020 to the committee to submit the report as directed.

2. Analysis results of the sample collected in individual units:

In the committee meeting held on 4.3.2020, it was decided to collect samples at the inlet and outlet of ETPs of all the four units and requested all units to discharge the treated wastewater at same time. Accordingly, on 6.3.2020 samples were collected at the inlet & outlet of ETP and also instant readings of the flow were noted. The analytical results are given below.

M/s. Manali Petrochemicals Limited, Unit I:

Parameter	**Inlet**	**Outlet**	**Marine disposal standards**
pH	11.5	6.3	5.5-9.0
TSS mg/L	109	60	100
COD mg/L	1053	165	250
BOD mg/L	254	05	100
Fluoride mg/L	1.36	0.82	15
O&G mg/L	--	12.5	20
Hexavalent chromium mg/L	BDL	BDL	1.0
Sulphate mg/L	202	254	1000
Free ammonia (as NH3) mg/L	1.32	NIL	05
Ammonia as N mg/L	1.1	BDL	--
Phenols mg/L	BDL	BDL	5.0
Petroleum hydrocarbons mg/L	--	10.8	--

From the above analysis results, it shows that all the parameters are meeting the prescribed standards. Percent reduction of treatment efficiency in terms of BOD and COD is 98% and 84% respectively.

During the time of sample collection, flow was found to be 88.1cubic meter/ hour. Hence, total amount of treated effluent discharged in to the sea will be 2114 cubic meter/ day. Based on flow, overall BOD load discharged in to the sea will be 10.6 kg/day.

M/s. Manali Petrochemicals Limited, Unit II:

Parameter	Inlet	Outlet	Marine disposal standards
pH	11.4	6.4	5.5-9.0
TSS mg/L	160	66	100
COD mg/L	1324	139	250
BOD mg/L	285	3.8	100
Fluoride mg/L	1.79	0.88	15
O&G mg/L	--	16	20
Hexavalent chromium mg/L	BDL	BDL	1.0
Sulphate mg/L	173	160	1000
Free ammonia (as NH_3) mg/L	1.32	NIL	05
Ammonia as N mg/L	1.1	BDL	--
Phenols mg/L	BDL	0.03	5.0
Petroleum hydrocarbons mg/L	--	12.3	--

From the above analysis results, it shows that all the parameters are meeting the prescribed standards. Percent reduction of treatment efficiency in terms of BOD and COD is 98.5% and 89% respectively.

During the time of sample collection, flow was found to be 95 cubic meter/ hour. Hence, total amount of treated effluent discharged in to the sea will be 2280 cubic meter/ day. Based on flow, overall BOD load discharged in to the sea will be 8.7 kg/day.

M/s. Tamilnadu Petrochemicals Limited:

M/s. Tamilnadu Petrochemicals Limited has three units Epichlorohydrin Plant (ECH), Heavy Chemicals Division (HCD) &Linear Alkyl Benzene Plant (LAB). Earlier M/s TPL was discharging treated effluent from all the plants to marine. At present the treated effluent from HCD & LAB plant is used in the ECH plant process. The treated effluent from ECH is discharged to marine.

Parameter	Inlet	Outlet	Marine disposal standards
pH	11.8	6.8	5.5-9.0
TSS mg/L	91	63	100
COD mg/L	626	92	250
BOD mg/L	29	4.7	100
Fluoride mg/L	1.4	1.02	15
O&G mg/L	--	2.7	20
Hexavalent chromium mg/L	BDL	BDL	1.0
Sulphate mg/L	46.7	41.5	1000
Free ammonia (as NH_3) mg/L	2.4	NIL	05

Ammonia as N mg/L	2.0	1.1	--
Phenols mg/L	BDL	BDL	5.0
Petroleum hydrocarbons mg/L	--	2.3	--

From the above analysis results, it shows that all the parameters are meeting the prescribed standards. Percent reduction of treatment efficiency in terms of BOD and COD is 84% and 85% respectively.

During the time of sample collection, flow was found to be 43.2 cubic meter/ hour. Hence, total amount of treated effluent discharged in to the sea will be 1037 cubic meter/ day. Based on flow, overall BOD load discharged in to the sea will be 4.9 kg/day.

M/s. Kothari Petrochemicals Limited:

Parameter	Inlet	Outlet	Marine disposal standards
pH	8.0	7.2	5.5-9.0
TSS mg/L	09	47	100
COD mg/L	36	150	250
BOD mg/L	03	9.4	100
Fluoride mg/L	0.65	1.05	15
O&G mg/L	--	BDL	20
Hexavalent chromium mg/L	BDL	BDL	1.0
Sulphate mg/L	179	**1739**	**1000**
Free ammonia (as NH_3) mg/L	1.6	1.1	05
Ammonia as N mg/L	21.9	**91.1**	**50**
Phenols mg/L	0.02	BDL	5.0
Petroleum hydrocarbons mg/L	--	BDL	--

From the above analysis results, it shows that except sulphate and ammonical nitrogen, remaining parameters are meeting the prescribed standards. But the sulphate and ammonical nitrogen is found within the limit after confluence of treated effluent from all other industry. Since the unit is discharging RO reject, percent reduction could not be evaluated.

During the time of sample collection, flow was found to be 3.6 cubic meter/ hour. Hence, total amount of treated effluent discharged in to the sea will be 86.4 cubic meter/ day. Based on flow, overall BOD load dumped in to the sea will be 0.8 kg/day.

2.1 Analysis results of the sample collected in pipeline:

All the four units have laid common pipeline of overall length 10.6 km and discharge their treated effluent in to sea. Treated effluent from M/s. Kothari petrochemicals, is mixed with treated effluent of M/s. Manali petrochemicals limited unit II and joins the main pipeline near Sathyamurthynagar. Treated effluent of M/s. Tamilnadu petrochemicals limited is mixed with treated effluent of M/s. Manali petrochemicals limited unit I and treated effluent from all the four units is carried to sea through dedicated pipeline. The units have made arrangements for sample collection at mixing point of MPL II and KPL and MPL I and TPL and near shore (near to Junction road) before the pipeline enters the sea. In all the junctions, flow meters have been installed to measure the instant flow and cumulative flow.

On 6.3.2020, samples were collected simultaneously from the two junctions and also near to the shore before sea disposal. The results are given below.

Parameter	**After confluence of MPL II and KPL**	**After confluence of MPL I and TPL**	**After confluence of all four units**	**Marine disposal standards**
pH	6.2	6.4	6.4	**5.5-9.0**
SS mg/L	46	76	71	**100**
COD mg/L	93	110	125	**250**
BOD mg/L	3.7	2.3	5.6	**100**
Fluoride mg/L	--	--	0.84	**15**
O&G mg/L	--	--	3.5	**20**
Hexavalent chromium mg/L	--	--	BDL	**1.0**
Sulphate mg/L	--	--	153	**1000**
Free ammonia (as NH_3) mg/L	--	--	NIL	**05**
Ammonia as N mg/L	--	--	6.1	**--**
Phenols mg/L	--	--	BDL	**5.0**
Petroleum hydrocarbons mg/L	--	--	BDL	**--**

After confluence of all the four units, cumulative flow was found to be 260 cubic meter/ hour or 6240 cubic meter/day. Based on flow, overall BOD load discharged in to the sea by all the units will be 35 kg/day. From the above analysis results, it shows that, overall the treated effluent from all the four units are meeting the tolerance limit prescribed by TNPCB.

3. Analysis results of Source emission:

Monitoring of source emission in the boilers installed at all the industries were also carried out, the analysis results are shown below with oxygen correction factor.

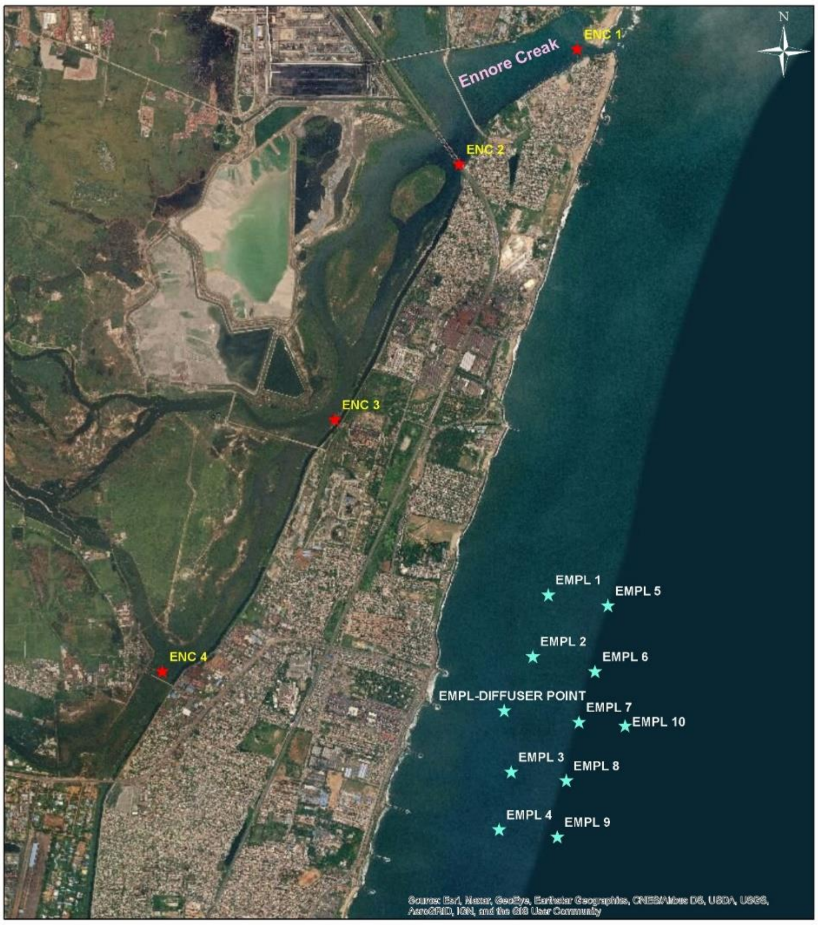
Parameter	**MPL I Boiler**	**Standard (Gas)**	**MPL II Boiler**	**Standard (Oil)**	**KPL CPP Boiler**	**Standard (Rice Husk)**
PM mg/Nm^3	9.1	**10**	76.3	**100**	51.8	**50**
Sulphur dioxide mg/Nm^3	19.2	**50**	111.7	**1700**	53.4	
Oxides of nitrogen mg/Nm^3	94.2	**350**	262.5	**450**	188.6	

Parameter	**TPL HCD Boiler**	**TPL PO Boiler**	**TPL LAB heater stack**	**HCl plant**	**Standard**
PM mg/Nm^3	6.7	7.85	9.8	--	**10**
Sulphur dioxide mg/Nm^3	25.3	36.9	27.5	--	**50**
Oxides of nitrogen mg/Nm^3	160	70.7	114.8	--	**350**
Acid mist mg/Nm3	--	--	--	BDL(DL:04)	**35**

The analysis results show that the emissions are within the standard norms except PM of M/s KPL CPP Boiler stack.

4. Summary of Marine Water Quality:

The marine water quality study was carried out through NIOT, Chennai. The report submitted by NIOT is attached as **Annexure A**. The study area consisted of 1 km wide x 2 km long stretch along the Ennore coast to include the near field and far field area of the MPL outfall. The adjoining Ennore creek has also been sampled due to its proximity to the discharge site and possible flushing of its input to the North Chennai coastal waters. The common treated effluent discharge outfall of M/s. MPL, M/s TPL & M/s KPL is located in Ennore coast, East coast of India. The sampling stations were located at 500 m and 1000 m distances along three transects to the north, east and south of outfall.



The results of selected parameters and comparison with previous study records reveal that there are spatial and temporal variations within the study area. Increase in nutrient parameters like nitrate recorded maximum value of 20.4 µmol./l is comparable to values recorded in samples collected during low tide at the Ennore creek during the study (Annexure I: Table 2). The BOD values were also relative to quantities recorded in Ennore creek samples (Annexure I: Table 1). The sediment heavy metal content also recorded higher values than the offshore discharge site indicates the possibility of pollutants input from nearby sources which cannot be ruled out. It is well known that this Ennore creek is traversed by Manali industrial belt and Buckingham canal loaded with industrial, domestic sewage load. Considering the proximity of Ennore creek and its pollutant loading to the coastal waters, there is likely to be the synergistic effect on nutrient loading in the coastal waters off North Chennai due to possible flushing from Ennore Creek. It leads to increase in background concentrations of the study area in addition to sources like Royapuram fisheries harbour, Chennai Port, Royapuram sewage outfall and several other industries discharging in this area, which account for the values recorded during the sampling surveys carried out in March 2020.

The studies on biological characteristics reveal the following:

- The increase in nutrient load reflected in improvement plankton population is corroborated.
- A slight drop in benthic population in the near field of offshore discharge may be attributed to the synergistic effects of various discharges from partner industries sharing the common effluent discharge along Ennore coast. The effect of toxicant on the benthic population in the certain station needs to be studied by whole effluent toxicity bioassay. It warrants detailed long term monitoring studies in the receiving waters (off Chennai coast) as well as at the discharge locations of the various industries.
- All these observations have been validated with the effluent quality of industrial discharge collected by CPCB and are within the discharge limits. Given that the benthos in receiving waters (marine waters are observed to vary; 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, molluscs, etc.).
- The levels of toxic chemicals are found to be within the acceptable levels, and therefore the concentrations of the other chemicals shall have to be reviewed. It is possible that

chlorides used in the processes may be released into the receiving water body. Studies show that chloride concentrations produce corrosion in wastewater pipelines and are likely to inhibit marine biota growth. However, these aspects have to be confirmed only through seasonal, comprehensive field studies over a long period.

5. **Environmental Compensation Calculation:**

M/s Kothari Petro Chemicals Ltd., exceeded the norms of discharge for the parameter sulphate and Ammonical nitrogen which is 1739 mg/l & 91.1 mg/l against the standard norms 1000 mg/l& 50 mg/l respectively After mixing with other industrial treated effluent, it reaches the standard norms before discharge into sea.

Moreover, the Particulate Emission (PM) of CPP boiler is measured as 51.8 mg/Nm3 against the standard 50 mg/Nm3.

Considering the above, environmental compensation is calculated using Pollution Index Formula (EC = PI * N * R * S * LF)

PI = Pollution Index, RED category industry **(PI = 80)**

R = Rupees Factor **(R = 250)**

S = Scale of Operation, Large Scale **(S = 1.5)**

LF = Location Factor, CEPI Area **(LF = 2)**

N= Number of days, **(N = 40 days)** date of committee sampling 06.03.2020 to date of TNPCB sampling 15.05.2020 (compliance). The industry was not in operation during 24.03.2020 to 23.04.2020 due to COVID19 pandemic situation, so this period was not considered for calculation.

EC = 80 * 40 * 250 * 1.5 * 2 = Rs. 24,00,000 = Rs 24 lakhs.

The interim compensation calculated for the period of 40 days is Rs24 Lakhs.

6. Compliance of Recommendation submitted by Previous Committees/Reports:

Recommendation of the two member expert committee was constituted with Dr. Palanivelu, Anna University, Chennai and Dr. N. Vedharaman, CLRI, Chennai as per order dated 22.7.2014 in O.A. No. 19/2013		Present Committee View/ Suggestions
1.	M/s MPL I & II should make effort to do away with the present chlorohydrin route and switch to catalytic process of manufacturing PO. As this process is a sustainable one and eliminates the use of hazardous chlorine gas and lime which ultimately end up as waste.	It is informed that: As per Expert committee advice MPL carried out the study to identify the suitable catalytic process. For this small capacity plant catalytic process technology is not viable. Only available for very high capacity plant (minimum 600 TPD). New The investment for the change of process (large capacity plant) is Rs 4000 Cr and no market scope in India. In the catalytic process pollutant load is higher than present chlorohydrin route. Industry may keep exploring possibilities as suggested by previous committee.
2.	M/s MPL I & II and other industries should look in to possibilities of zero liquid discharge with suitable technologies like RO to get water and reject for suitable by product recovery. This will eliminate the sea disposal of treated effluent.	i) **MPL I & II and TPL (ECH – PO):** 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. ii) Possibilities shall also be explored for achieving complete or Partial ZLD. iii) Possibility of using treated effluent generated from M/s KPL shall be explored by M/s MPL or M/s TPL. So M/s KPL shall take necessary steps in collaboration with M/s MPL or M/s TPL.

3.	Necessary arrangements may be made well in advance to replace the pipe according to its life time to ensure environmental safety.	The effluent line was originally laid and commissioned in the year 1990 and replaced the line in 2011. Pressure & Leak test was carried out through M/s Aquatiq Diving, whereas, the life of the pipeline for replacement is not mentioned.

Summary of NIOT Report (August 2015)	**Present Committee View/ Suggestions**
The results of selected parameters reveal that there is no spatial or temporal variation in the study area. The concentration of metals shows lower values in the offshore location MPL 10, when compared to the other locations. The background concentrations of the study area are significantly high possibly due to the influence of Royapuram fishers harbour, Chennai Port, Royapuram outfall and several other industries discharging in this area. From these results it can be concluded that the study area was moderately polluted, which may be attributed to the several sources. The studies on biological characteristics reveal the following: ➢ The near shore coastal belt shows minor variation in biological characteristics ➢ Various discharges along Ennore coast may induce synergistic effect of toxicant on the benthic population in certain station and in depth studies are warranted. The MPL EIA report does not contain the biological data for comparison. The scope of present short term study is too limited to conclude any discernible trends on the possible impact on environment	It is suggested to carry out continuous study 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.

Recommendation of Joint Committee Report (CPCB & TNPCB) submitted on May 02, 2016 & September, 2016			
	M/s MPL (Plant I & II)	M/s TPL	M/s KPL
All units are required to install flow meters to maintain proper records of water consumption, effluent generation from different section of process along with material balance and water balance and same to be made available to TNPCB/CPCB during inspection.	Complied	Installed flow meters. But yet to connect inlet flow meter.	Installed flow meters. Presently connected discharge flow meter only. But yet to connect all other flow meters.
To install at least three intermediate flow meters in the marine disposal pipeline where provisions are made to collect samples to assess the quantity of effluent pumped from the units and quantity of effluent discharged. This also helps to quick identification of any leaks in the pipeline. These flow meters shall connect to TNPCB/CPCB monitoring centre.	Flow meters installed in the common sea discharge pipeline are yet to be connected.		
To take up detailed marine study by considering the actual quality and quantity of effluent discharged to verify the availability of dilution in the sea and its impact on marine species.	It is suggested to carry out continuous study for a period of five years (twice in a year). Accordingly, remedial measures shall be suggested.		
All units are required to conduct toxicity studies for their effluent and also for combined effluents. The results shall be submitted to TNPCB including species used for the study.			

7. Conclusion/ Suggestions:

The analysis results of the samples collected during the committee inspection confirms to the discharge norms of the treated effluent into the sea as prescribed by TNPCB. But, Sulphate & Ammonical Nitrogen of M/s Kothari Petrochemical Limited found to be higher than prescribed norms. However, after mixing with other industries treated effluent, sulphate & Ammonical nitrogen value reduces and confirms to norms before discharge into sea.

TNPCB shall direct the industries to submit the compliance report on the following and to take appropriate action as per suggestions made by the committee.

1. M/s Kothari Petrochemicals Ltd., shall be directed to remit the interim compensation of Rs. 24 Lakhs for non-compliance.

2. **Short Term:**

a) 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.

(Target: One Month)

b) 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.

(Target: Two Month)

c) 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.

(Target: Two Year)

d) Since M/s TPL is reusing the treated 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.

(Target: Three Month)

e) 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.

(Target: Six Month)

f) M/s 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.

(Target: One Year)

g) 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.

3. Long Term:

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.

So, it is suggested to have a comprehensive impact assessment study to assess the quality of water and biological impacts in the receiving waters which shall cover larger extents (spatial) along the coast and two seasons (pre monsoon / post monsoon). The study area shall cover Ennore Creek, North Chennai Coastal waters from Pulicat to Muthukadu in the South to cover pollution signals during all seasons as there is northerly drift for 8 months and southerly drift for 4 months in a year. Therefore, representative samples shall be analysed to map the variation in space and time.

In order to have a detail study, it is suggested to carry out continuous study 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.

TNPCB shall provide list of marine outfall units & other source of pollution including source point data of industrial outfalls (including Ennore creek) and others such as municipal discharges, data from Kamarajar port, Chennai port, Fishing harbour etc. TNPCB shall utilise the Environmental Compensation fund for this study and same may be recovered after the polluter identification. The studies can be conducted by national institutes such as NIOT or any other reputed institutes.

NIOT has observed the marine life quality improvement, after dredging activity carried out during Ennore Port development. Therefore, possible means to improve the marine water / life quality shall be suggested based on data.

R. Rajkumar
Scientist D
Central Pollution Control Board
Regional Directorate (Chennai)

M. Malaiyandi
Joint Chief Environmental Engineer
Monitoring Office
Tamilnadu Pollution Control Board
Chennai

Dr.Vijaya Ravichandran
Scientist G
Coastal and Environmental Engineering &
Group Head, Seafront Development
National Institute of Ocean Technology
Chennai

Dr. V.T. Perarasu
Associate Professor,
Dept. of Chemical Engg.,
Anna University, Chennai

Annexure A

MPL Marine outfall survey report

Description of the study area

The study area consisted of 1 km wide x 2 km long stretch along the Ennore coast to include the near field and far field area of the MPL outfall. The adjoining Ennore creek has also been sampled due to its proximity to the discharge site and possible flushing of its input to the North Chennai coastal waters. M/S.Manali Petrochemicals Ltd. treated effluent discharge outfall is located in Ennore coast, East coast of India. The sampling stations were located at 500m and 1000m distances along three transects to the north, east and south of outfall.

Sampling protocol

Water samples were collected from 10 sampling locations nearby effluent outfall area & 4 stations along the creek with respect to the tidal cycle (Fig.1). The Niskin water sampler was used to collect water samples and transferred to pre-cleaned 2liter polypropylene bottles. Sediment samples were collected using a Van Veen Grab, transferred to clean polythene bags and transported to the laboratory.

The BOD samples were fixed immediately after collection using Winkler's A & B. The collected samples were stored at 4˚C in the icebox for nutrients and other parameters analysis. Samples were stored as per the standard requirement of various water quality parameters and preserved with standard preservatives. Most of the samples require to be preserved in sub-zero conditions on-board immediately after collection.Acid rinsed bottles used to collect the samples for metal analysis and amber bottles used for organic analysis.The collected water samples were analyzed for dissolved oxygen (DO), salinity, nutrients, PHC & heavy metals. Air & Water temperature was measured under field condition using a water quality YSI Probe. The collected water& sediment samples were immediately handed over to CPCB officials located at Manali Petrochemicals LTD, Chennai. After that, samples were transferred to Glens Innovation Labs PVT LTD for laboratory analysis.

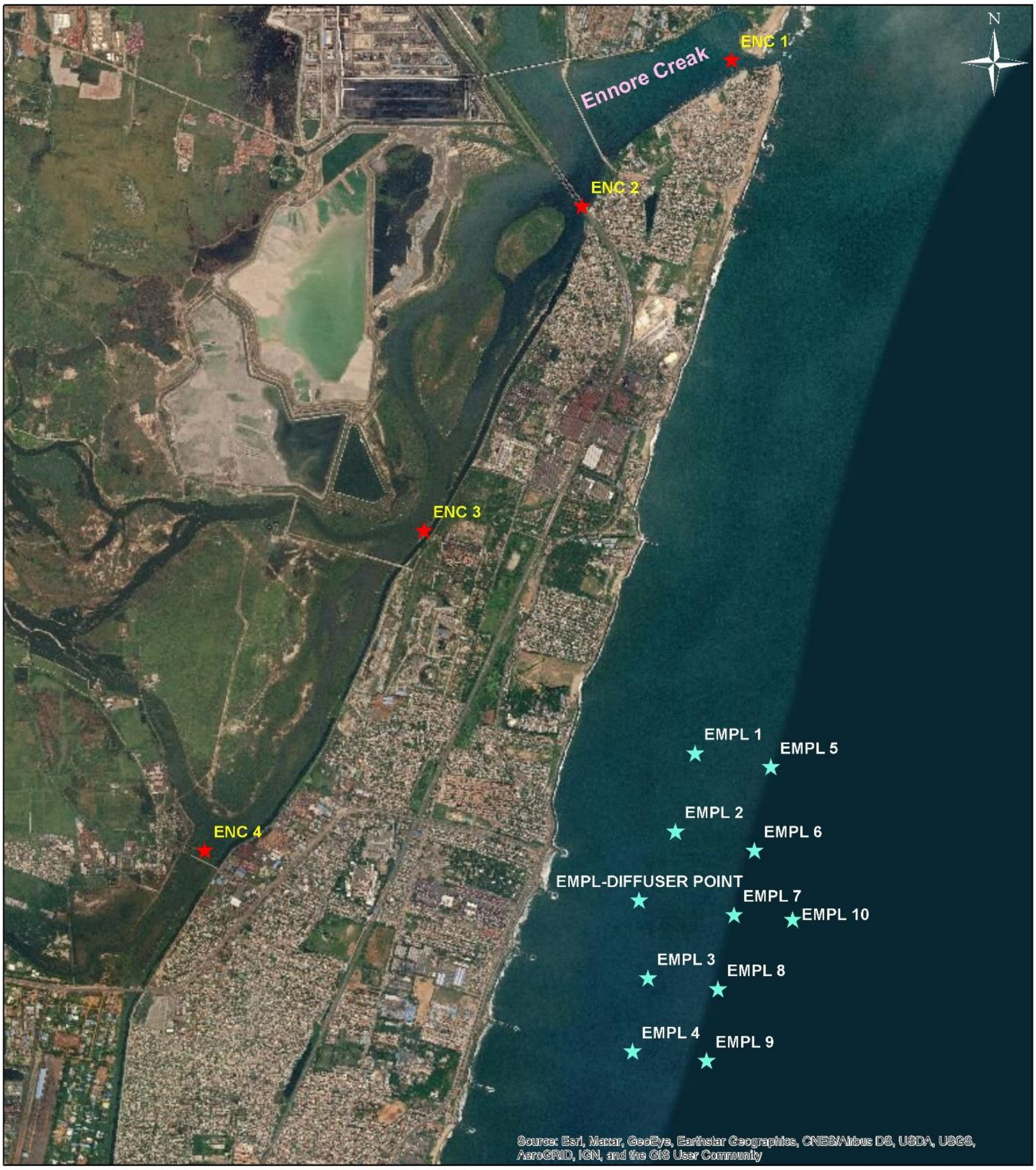


Fig.1 Depicting Sampling locations along with the offshore discharge sites

Table1.The sampling locations near the outfall area of MPL at Ennore coast, East coast of India.

S No	Sampling locations	Longitude and Latitude	Remarks
1	EMPL1	13°11'23.61"N80°19'33.79"E	North of outfall
2	EMPL2	13°11'06.27"N 80°19'29.36"E	Northof outfall
3	EMPL3	13°10'33.68" N80°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	Northeastof outfall
7	EMPL7	13°10'47.74"N 80°19'42.69"E	500m away from outfall area (Eastern side)
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)
11	ENC 1	13^{o}13'52"N 80^{o}19'48"E	Ennore creek mouth
12	ENC 2	13^{o}13'25"N 80^{o}19'08"E	Near railway bridge
13	ENC 3	13^{o}12'13"N 80^{o}18'32"E	Near to ETPS intake point
14	ENC 4	13^{o}11'02"N 80o17'42"E	Downstream of Ammulvoyal junction

Samples were adequately handled, and all necessary quality assurance and quality control (QA/QC) measures such as preservation, storage, and labelling followed. All sample containers were pre-treated by washing in dilute hydrochloric acid and rinsed with distilled water.

The following sections discuss the present data obtained from laboratory analysis of samples collected during March 2020 and comparison with previous data available with NIOT during the various surveys carried out in the same area during 2015intending to establish any possible trend.

Temperature

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

It varied between 28.3 and 29.1°C during the study period. In general, surface temperatures showed minor variations with time of the day. Water temperature is influenced by several factors, such as the intensity of solar radiation, evaporation, and sewage influx.

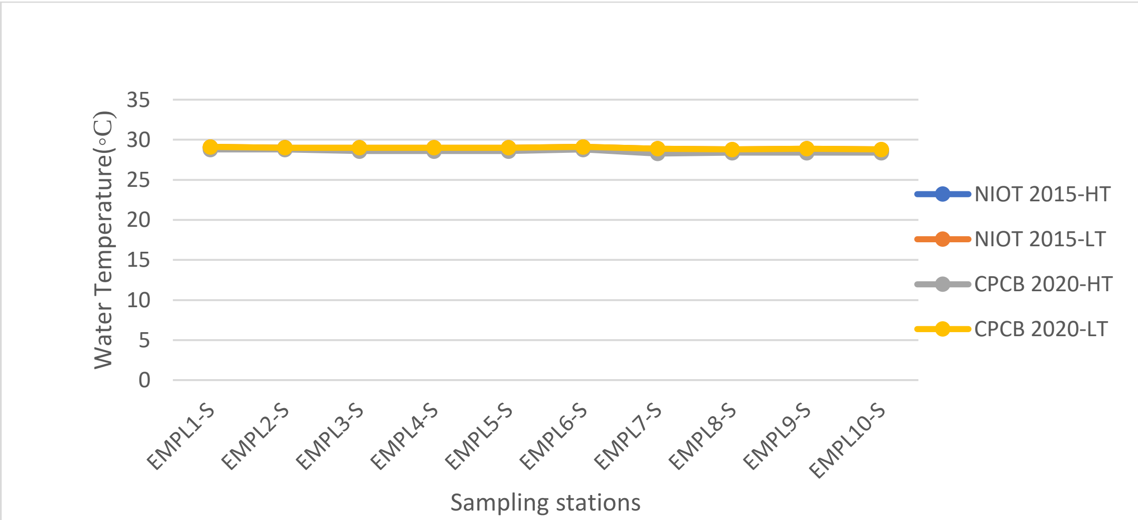


Fig.2 Water temperature variation in the surface waters around MPL offshore discharge

Salinity

Salinity value ranges between 34.9 and 39.4 PSU at coastal waters. The maximum values of 37.9 PSU recorded at surface waters of EMPL8 during low tide with a bottom value of 35.3

PSUmay be a spike of analytical abnormality (outlier value). Further, it needs multiple samples of&in-depth studies to confirm the same.

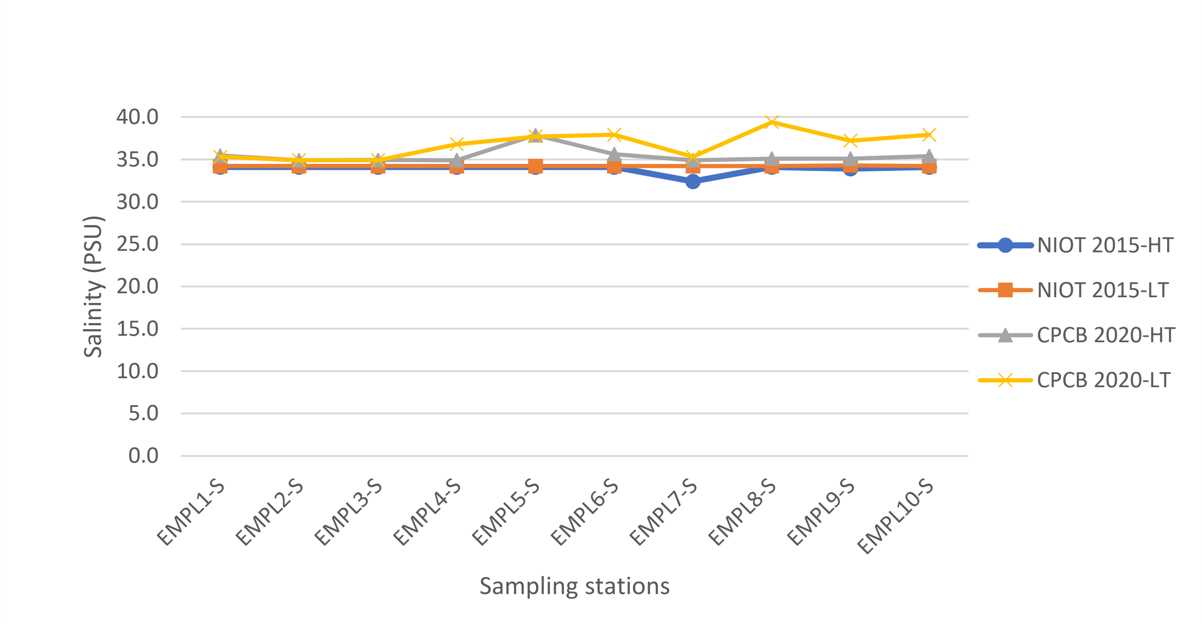


Fig.3 Salinity variationin the surface waters around MPL offshore discharge

pH

The variation of observed pH in the samples ranged between 7.50 and 7.90in the surface waters of the study area. The Observed pH values are within the range of normal coastal waters.

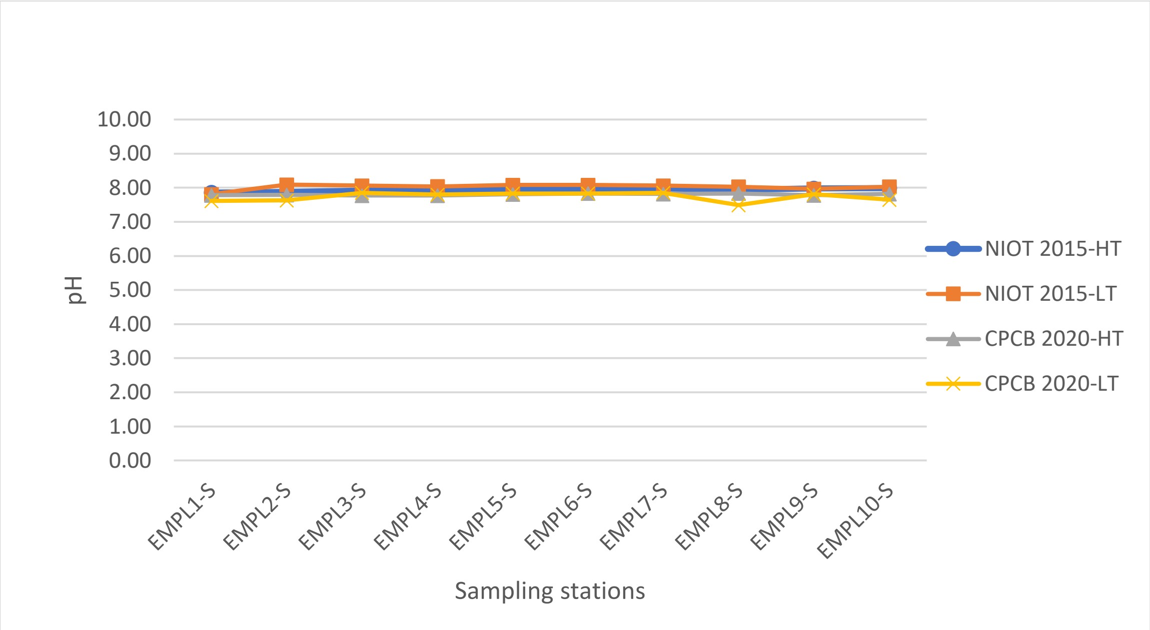


Fig.4 pH variation in the surface waters around MPL offshore discharge

Total Suspended Solids (TSS)

The variation of observed suspended solids is 3.1 to 6.4 mg/l during the study period. Maximum was recorded at EMPL5 during high tide at surface waters, and the bottom water recorded 4.5 mg/l. Reduction in TSS values is observed with compared to 2015 study.

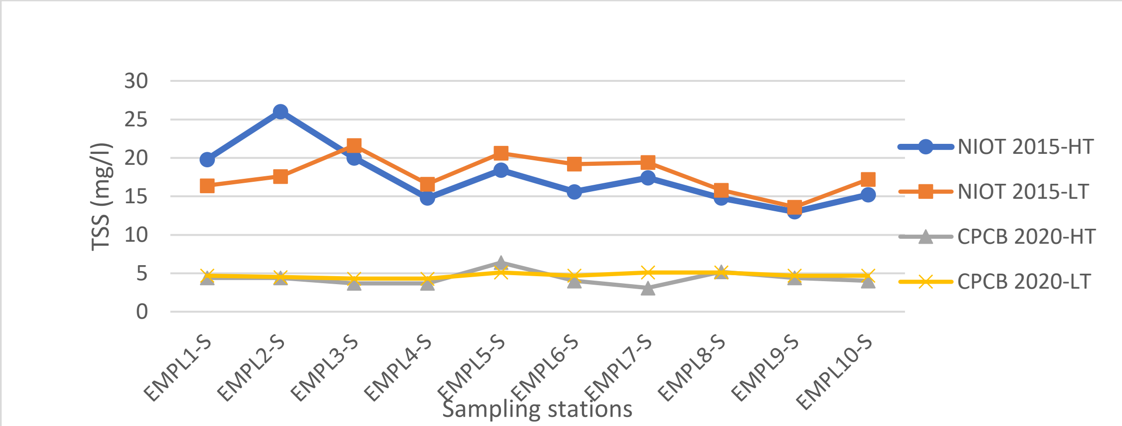


Fig.5 Total suspended solid variationin the surface waters around MPL offshore discharge

Dissolved Oxygen (DO)

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

The observed dissolved oxygen ranged between 5.4 to 6.4 mg/l at surface waters. The minimum value was recorded during low tide of EMPL4 station and the bottom water recorded 6.4mg/l. The DO values conform to SeaWater Quality Standards SW I to SW IV prescribed by CPCB.

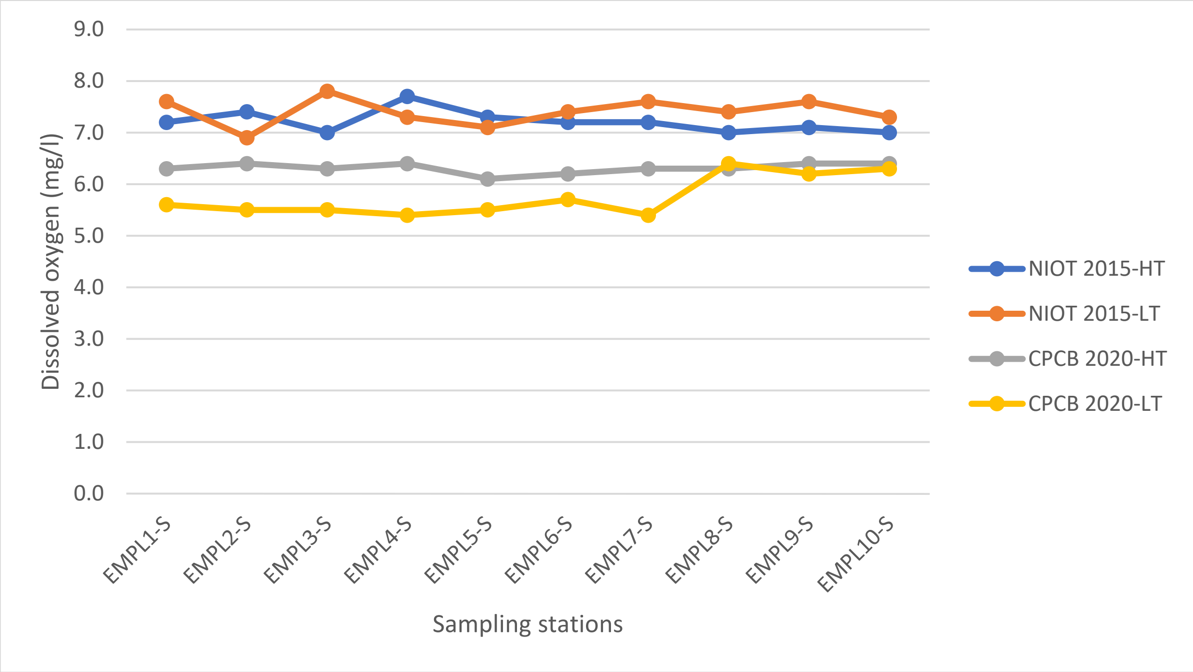


Fig.6 Dissolved oxygen variation in the surface waters around MPL offshore discharge

Biological Oxygen Demand

In general, BOD values in surface water varied between 2.8 to 3.2 mg/l. The bottom water values are lesser than the surface waters. There is a slight increase in BOD levels compared to 2015 levels. However, it is within the limits of SWIV& SWII criteria.

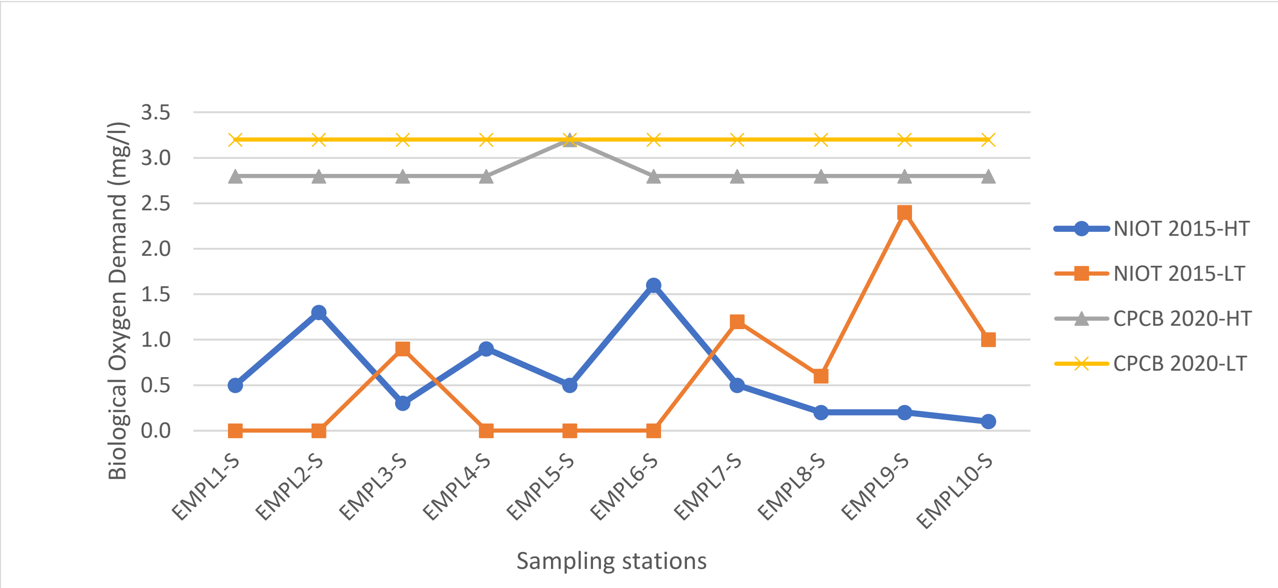


Fig.7 BOD variation in the surface waters around MPL offshore discharge

Nutrients

The water chemistry of the sea is a result of the hydrodynamics and biological activity, which cause variations in nutrient concentrations. Enhanced concentrations generally imply anthropogenic inputs. Very high concentrations can result in eutrophication, resulting in DO problems.

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 recorded 2.91 µmol./lat EMPL1 and all the other stations are below the detectable limits. However, the bottom water samples during low tide, all the stations recorded 2.91 µmol./ldespite the values of below detectable quantity in surface waters during this period. The unusual increase in ammoniacal nitrogen values requires detailed studies.

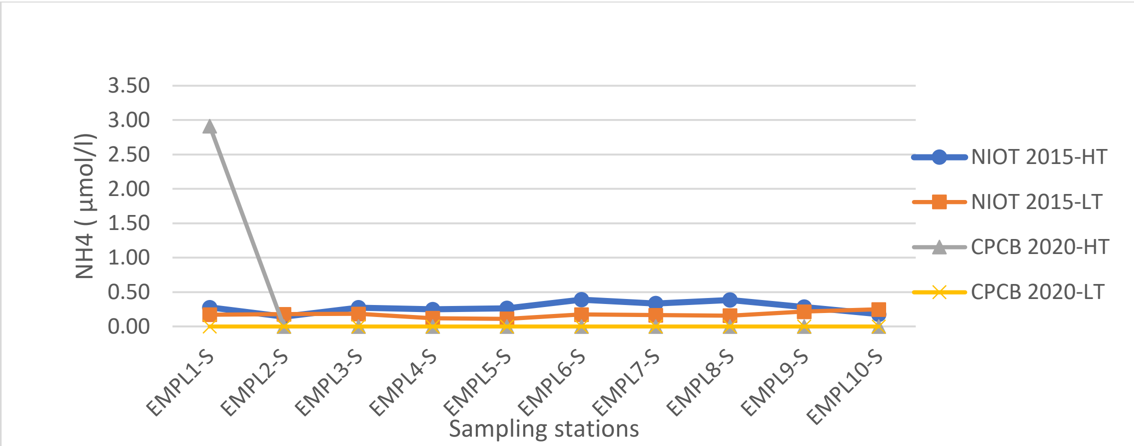


Fig.8Ammoniacal nitrogen variation in the surface waters around MPL offshore discharge

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 and would accumulate in the sediments if left unutilized by plankton or bacterial decomposition.

In general, Nitrate values varied from10.0to 20.4 µmol./lrecorded during the study period. The maximum value found to be reported at all the stations except EMPL9 at low tide during the study period. However, the bottom water samples recorded 4.9 to 9.9 µmol./l in both the tides. The nitrate values recorded a significant increase when compared to 2015 studies.

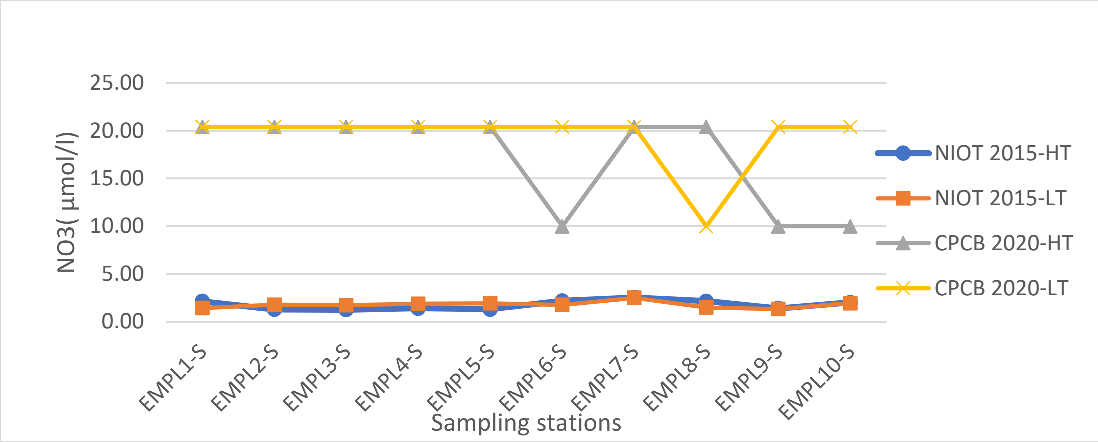


Fig.9 Nitrate nitrogen variation in the surface waters around MPL offshore discharge

c. Nitrite Nitrogen

The transitional Nitrogen product Nitrite varied between 0.04 to 0.67 µmol./l in surface waters during the study period. The maximum value was recorded at EMPL4 and the minimum values in all the stations during low tide. The measured values were comparedwith the previous observations during 2015 by NIOT. Nitrite concentrations recorded a decrease within five years. The same trend of surface water also been documented in bottom waters.

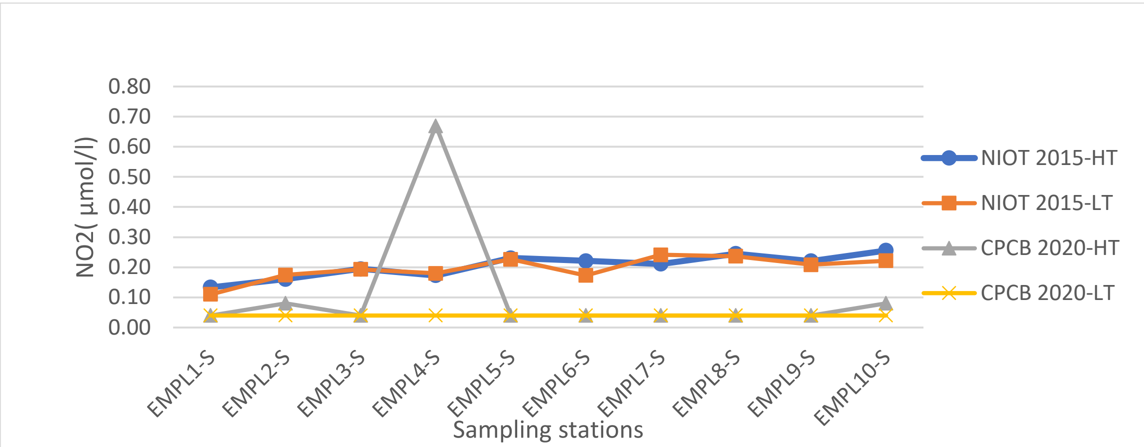


Fig.10 Nitrite nitrogen variation in the surface waters around MPL offshore discharge

d. Phosphate Phosphorous

In general, the Phosphate phosphorous concentrations recorded a constant concentration of 0.21 µmol./l at all the station despite the tidal and depth variation. A manifold decrease in phosphate concentration is observed when compared to 2015 condition.

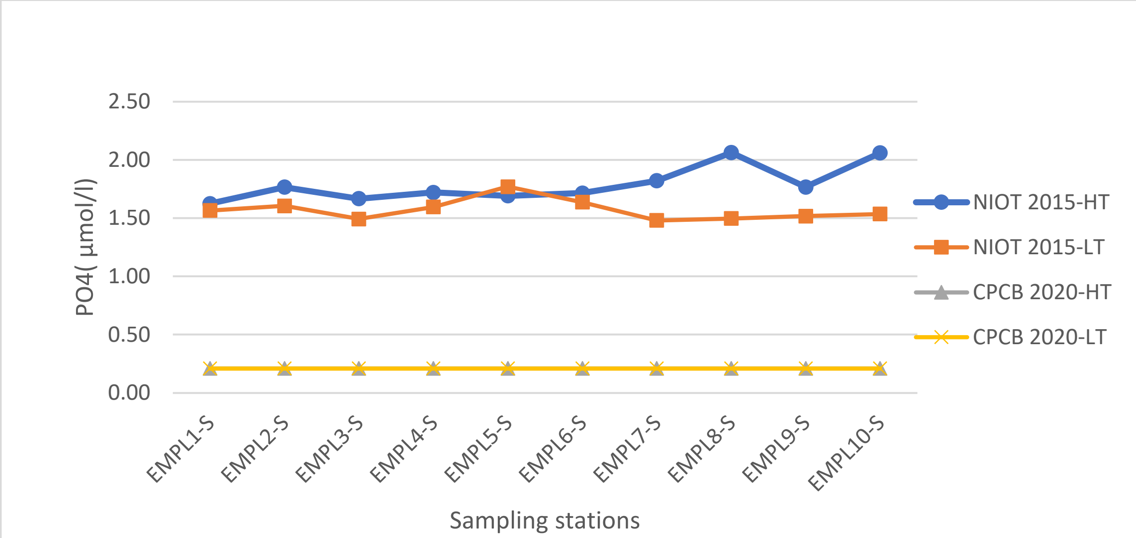


Fig.11Phosphate variation in the surface waters around MPL offshore discharge

Petroleum hydrocarbon (PHC)

Petroleum hydrocarbons are the primary constituents in oil, gasoline, diesel, and a variety of solvents and penetrating oils. Petroleum hydrocarbon residue in the surface water column found to be nil during the survey period. Compared to previous studies, and the present observation recorded many folds decrease in concentration.

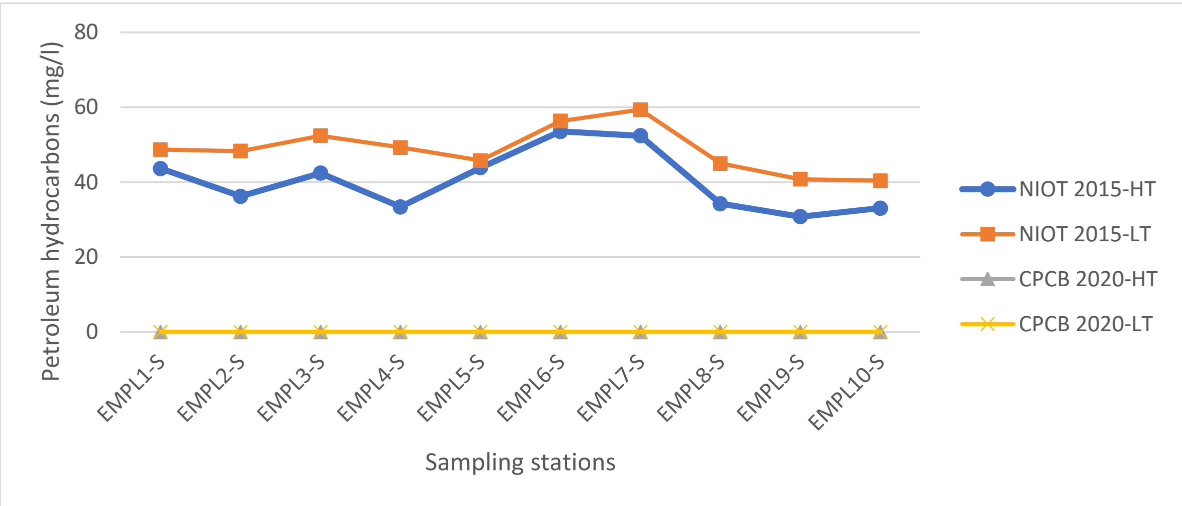


Fig.12 PHC variation in the surface waters around MPL offshore discharge

Heavy Metals

The heavy metals like Arsenic, Nickel, Copper, Chromium, Cadmium, Zinc, Lead, Selenium, Cobalt, Manganese, and Mercury were analyzed in water and sediment. The range ofmetal concentrations is below the detectable limit in most of the stations when compared to previous studies of 2015. However, Manganese recorded some quantifiable measures of Mn

(0.004 to 0.286 µg/l) in the bottom water samples. The results are not showing any trend among the location as well as tides.

SEDIMENTS

Sediments are seafloor materials which eroded from land to ocean through rivers or wind. The constituent ofthe 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 marine sediments in the MPL offshore discharge sites along Ennore coast. The selected metals concentrations of sediments are shown in Table(Annexure 1: Table No.5).

The range of Ni (BDL to 3.81µg/g), Co (BDL to 3.09 µg/g), Cu (BDL to 3.18 µg/g), Cd (BDL), Pb(1.47 to 3.70 µg/g), Cr (4.48 to 9.69 µg/g), Hg (BDL to 3.18 µg/g),Fe (2332.74to 5221.67 mg/kg),Mn (11.58 to 50.93 mg/kg) and Zn (3.16 to 12.50 mg/kg) are observed in the sediment. The lower concentrations of most of the metals are found in the location EMPL 9. Thehigher concentration of Ni, Co, Cu, Cd, Cr,Fe atEMPL 5 and Mn at EMPL 9 and Hg atEMPL10are recorded respectively.

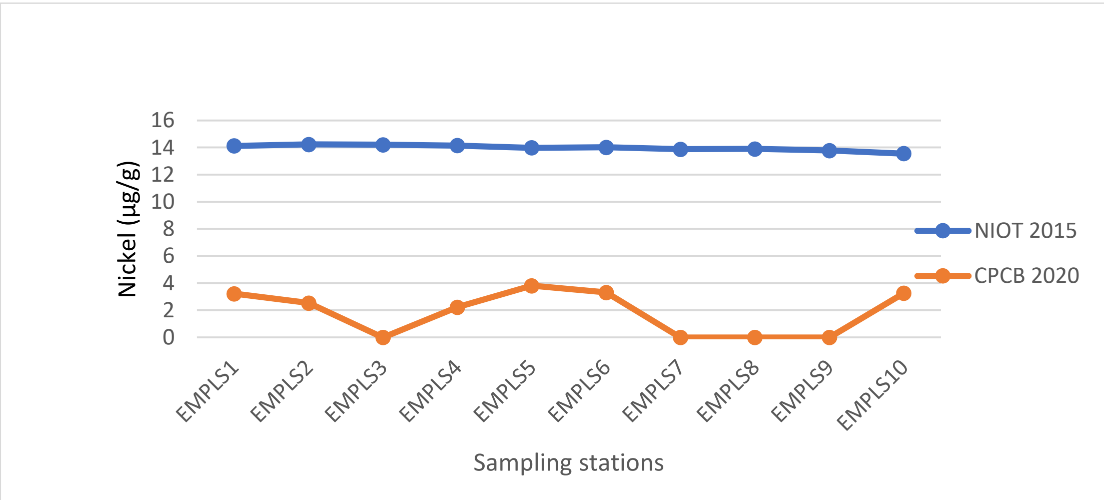


Fig. 13Nickel variation in the seafloor sediments around MPL offshore discharge

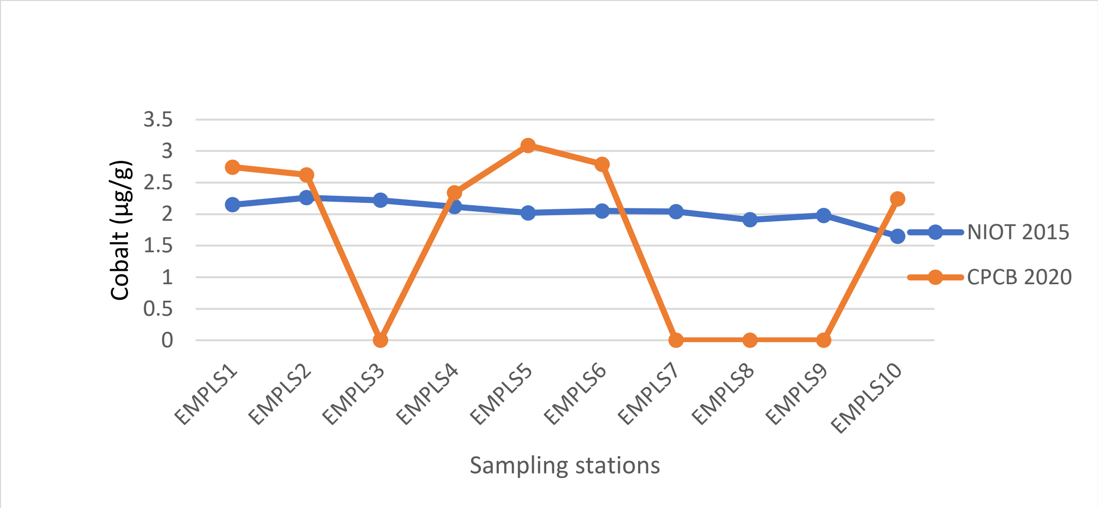


Fig. 14Cobalt variation in the seafloor sediments around MPL offshore

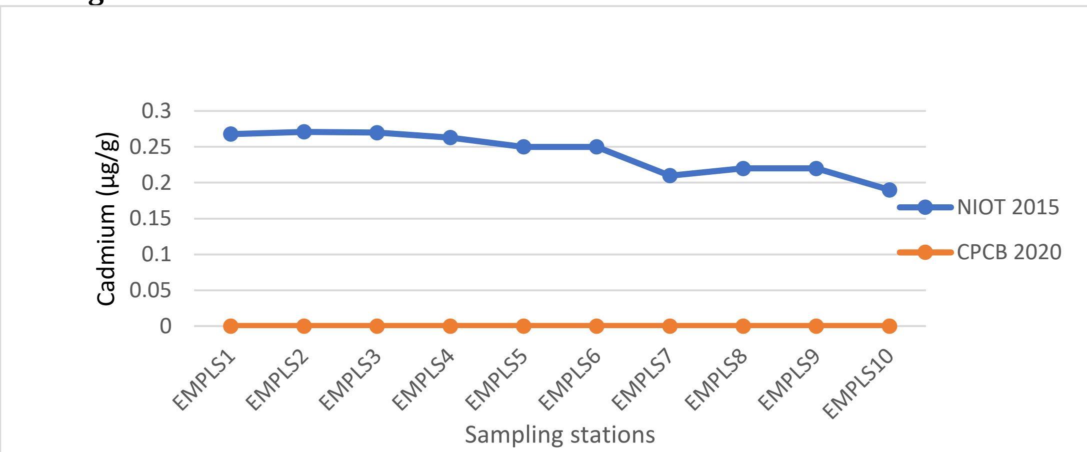


Fig.15Cadmium variationin the seafloor sediments around MPL offshore

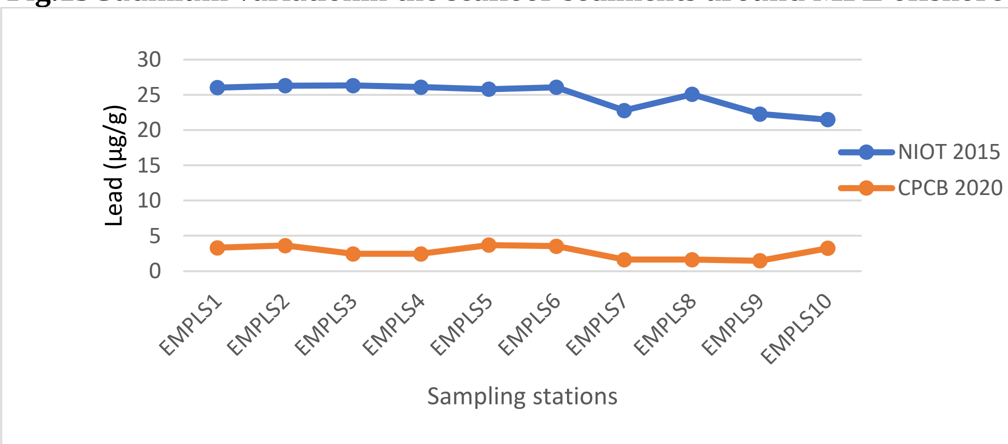


Fig. 16Leadvariation in the seafloor sediments around MPL offshore discharge

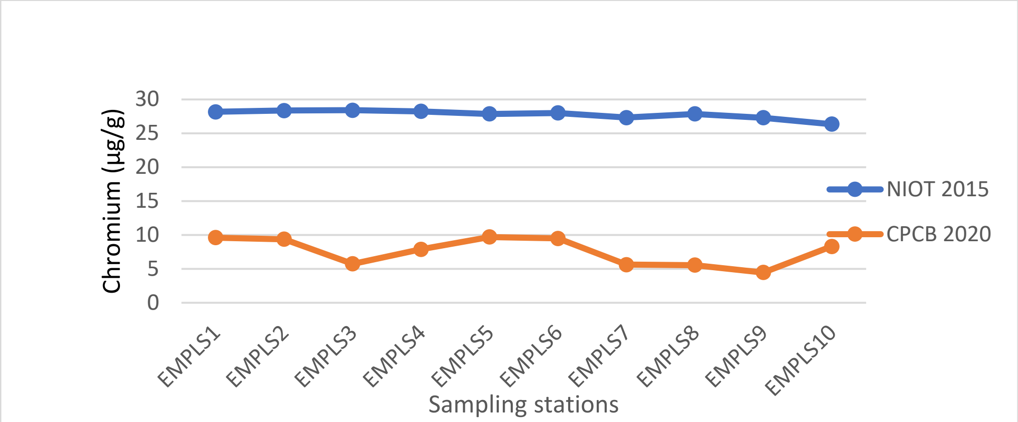


Fig. 17Chromiumvariation in the seafloor sediments around MPL offshore discharge

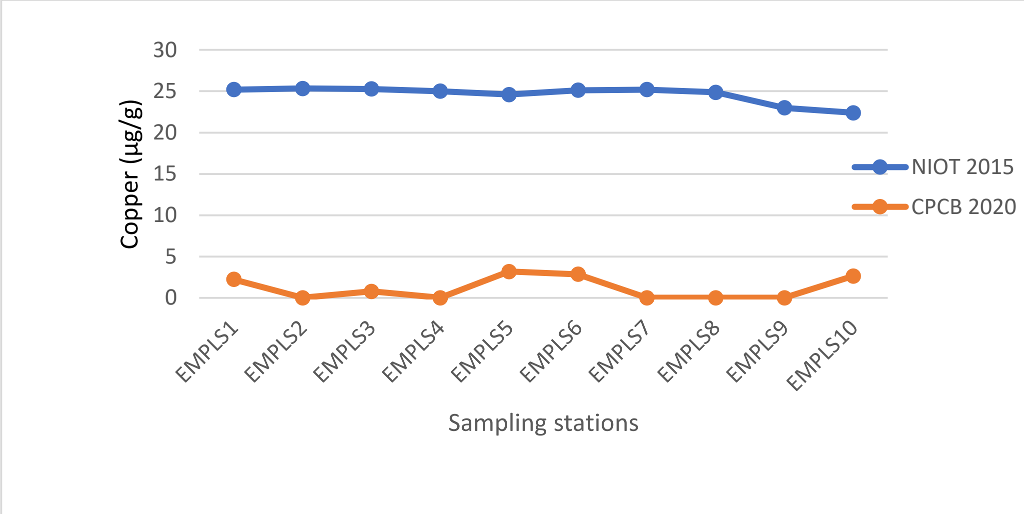


Fig. 18Coppervariation in the seafloor sediments around MPL offshore discharge

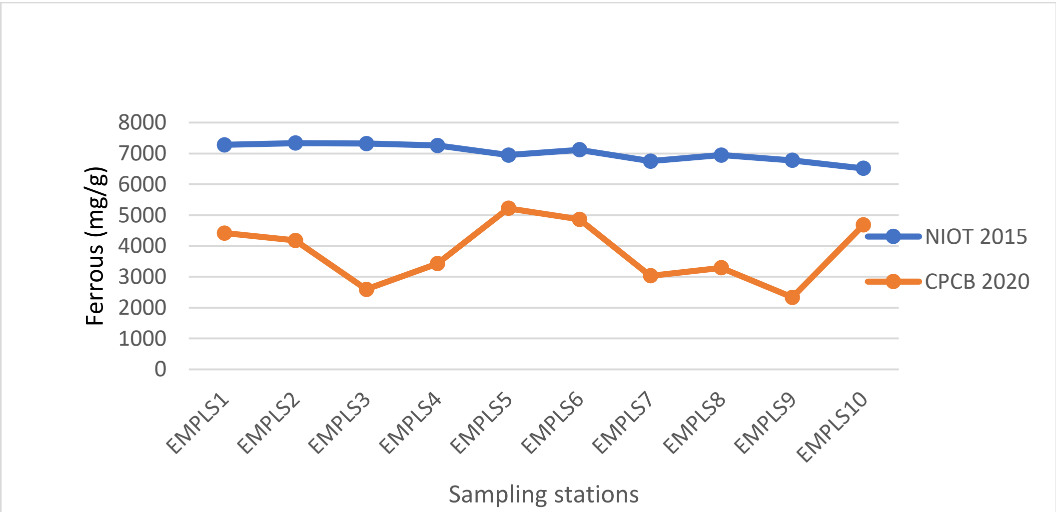


Fig. 19Ferrous variationin the seafloor sediments around MPL offshore discharge

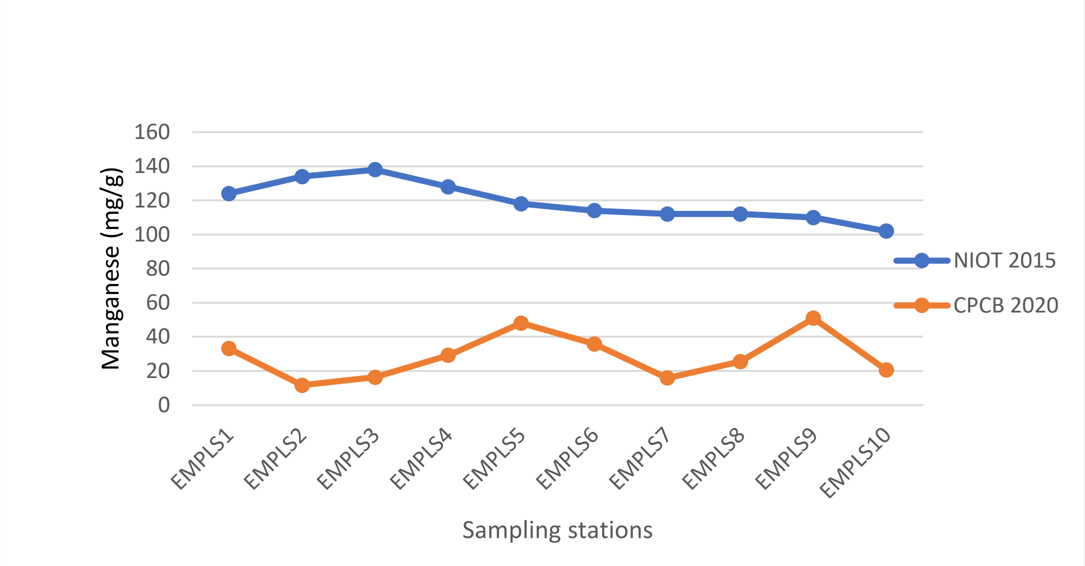


Fig.20 Manganesevariation in the seafloor sediments around MPL offshore

Petroleum hydrocarbon concentration of sediment at all the stations is below detectable levels.

BIOLOGICAL OCEANOGRAPHIC STATUS

Biological analysis in the study area describes the population dynamics of marine lives 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.

BIOLOGICAL DATA COLLECTION

The impact of MPL discharge on biological oceanographic characteristic was studied at 10 locations in the vicinity of the outfall. The surveys were synoptic, carried out over tidal cycles covered within a day. Hydrographic measurements, water and sediment quality were also assessed at the same 10 locations. Impact of the outfall needs to be assessed by comparing the present biological data with the previous NIOT studies during 2015.

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 is mostly dependent on the settling organic matter from the water column in the form of live phytoplankton, dead plankton, detritus, faecal 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. The most critical role of the marine plants is to provide a substrate for vascular, microscopic and macroscopic algae (periphyton). Besides, they trap sediments and food, providing a habitat for young fish where 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, namely, 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 SAMPLING

Chlorophyll, phytoplankton, zooplankton and macrobenthos were measured for assessing the biological characteristics. Niskin water sampler, Plankton nets, and grab samples were utilized for sample collection. Collected samples were preserved in sub-zero condition, formaldehyde and rose bengal dye solution. Standard procedures were used for analysis and quality control. 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 indicate the presence of 20 species phytoplankton and the cell counts ranging from 1826 Nos./L to 5880 Nos./L along the sampling locations EMPL1 to EMPL10. The diatom species *Biddulphia regia* was found to be a major contributor to the total population of phytoplankton. This species belongs to blooming type along the Indian coast. Detailed data table at Annexure-II: Tables 1 to 2.

Among the Phytoplankton *Biddulphia regia, Rhizosolenia imbricate, R. styliformis, Thalassionemanitzschioides, Nitzschia sp., Chaetoceroslaevis, skeletonemacostatum, Chaetocerosdecipiens,* were found to be dominant along the study area. The phytoplankton population density is higher compared to past studies during 2015. The diversity index scores indicated the moderately healthy nature of the environment and recorded a rise in diversity also. It may be attributed to the significant increase in nitrate-nitrogen values(Fig.2.1).

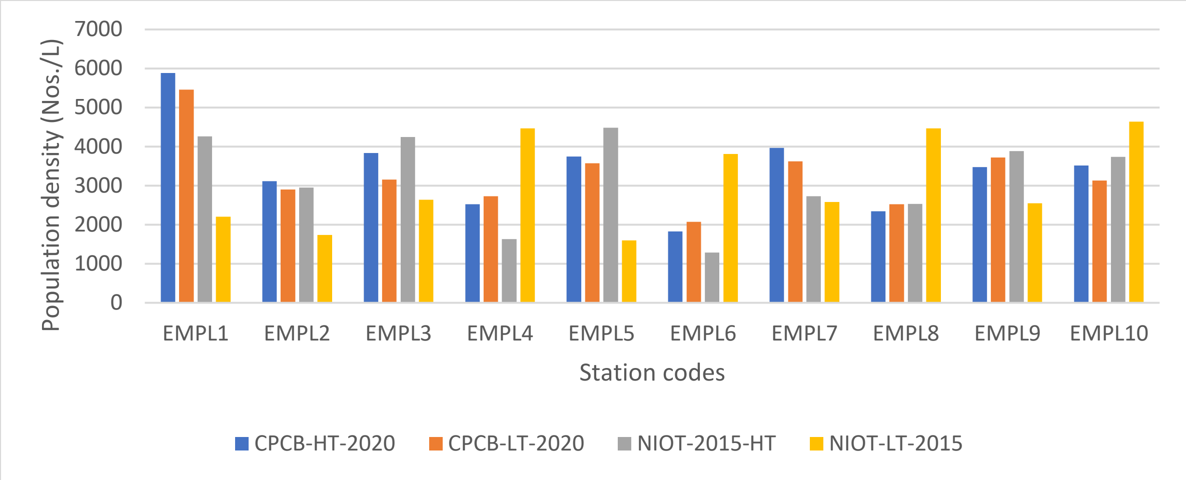


Fig. 21 Phytoplankton population density variation in the surface waters around MPL offshore discharge location during the study period

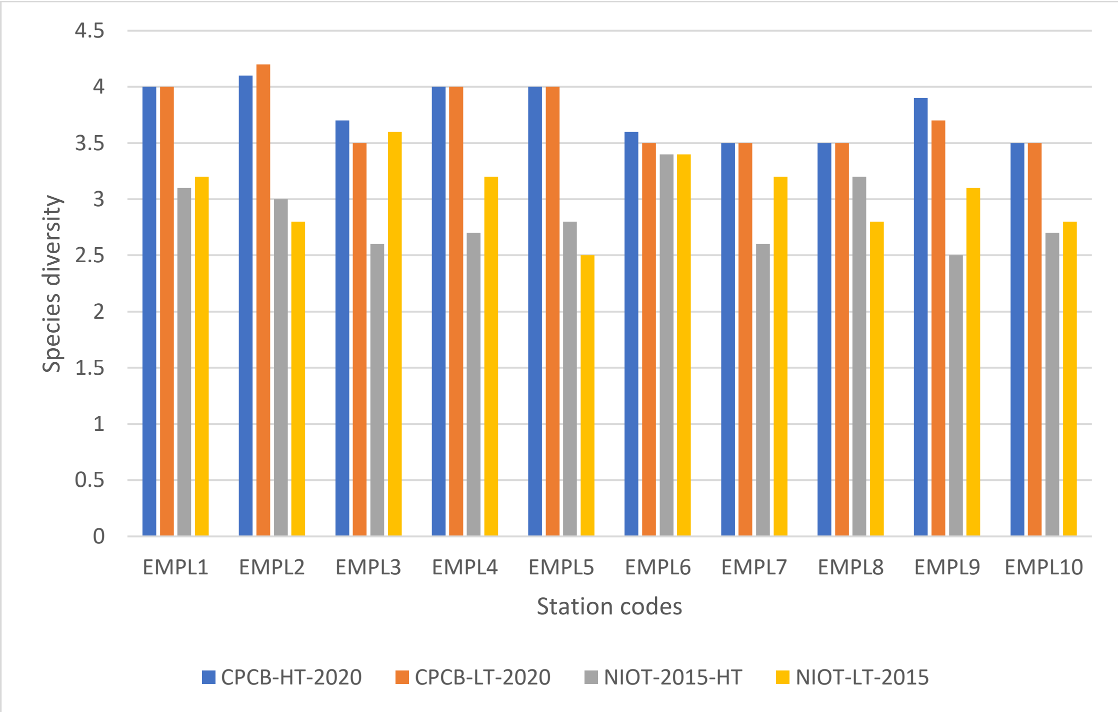


Fig. 22 Phytoplankton species diversity variation in the surface waters around MPL offshore discharge location during the study period

ZOOPLANKTON

Zooplankton is composed of floating organisms, including the larval stages of many economically important species of prawn and fishes. The density of the population varied from 1180 to 3093 Nos./ m^3 during the sampling period between EMPL 1 to EMPL 10. A total number of 13 species were recorded in the coastal waters. *Calanoid*, *Cladocerans*, *Appendicularians*, *Naupli larvae* and fish eggs are the dominant forms of zooplankton recorded during the survey. A significant increase in zooplankton population at EMPL4 where the Nitrite content recorded a hike in concentration followed by a decrease in phytoplankton population density. It may be attributed to the zooplankton grazing potential. The zooplankton trend does not reflect any abnormalities.

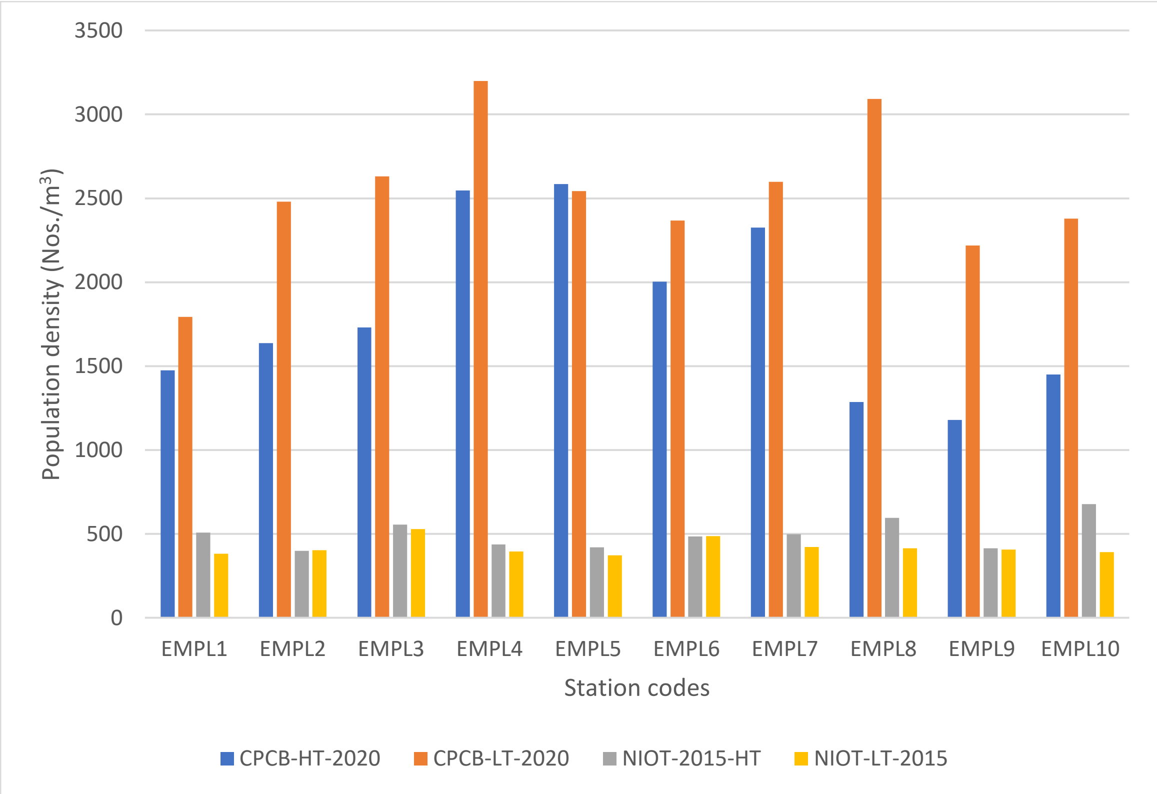


Fig. 23 Zooplankton population density variation in the surface waters around MPL offshore discharge location during the study period

BENTHOS

The subtidal benthic organisms recorded moderate fluctuation of standing stock and diversity. In terms of population, macrobenthos varied between 91 and 329 Nos./m^2. The faunal composition consisted of *Gastropods*, *Bivalves*, *Polychaetes*, *and Nematodes* as the dominant group. The minimum density recorded at EMPL2 and its proximity to the discharge site may be attributed to this drop. The site (EMPL2) located 500m away in the northeastern side of the discharge site. However, 2015 observations also recorded a decline in benthic biota at EMPL7 located 500m away from the discharge site in the southwestern direction. It may be traceable by whole effluent toxicity bioassay studies of USEPA. However, various effluent discharges along the Ennore coastal waters alongwith the MPL discharge needs to be considered and subdue the effluent specific impact on biosystems along this coast. Hence, further studies are warranted to establish the effect of the discharge site.

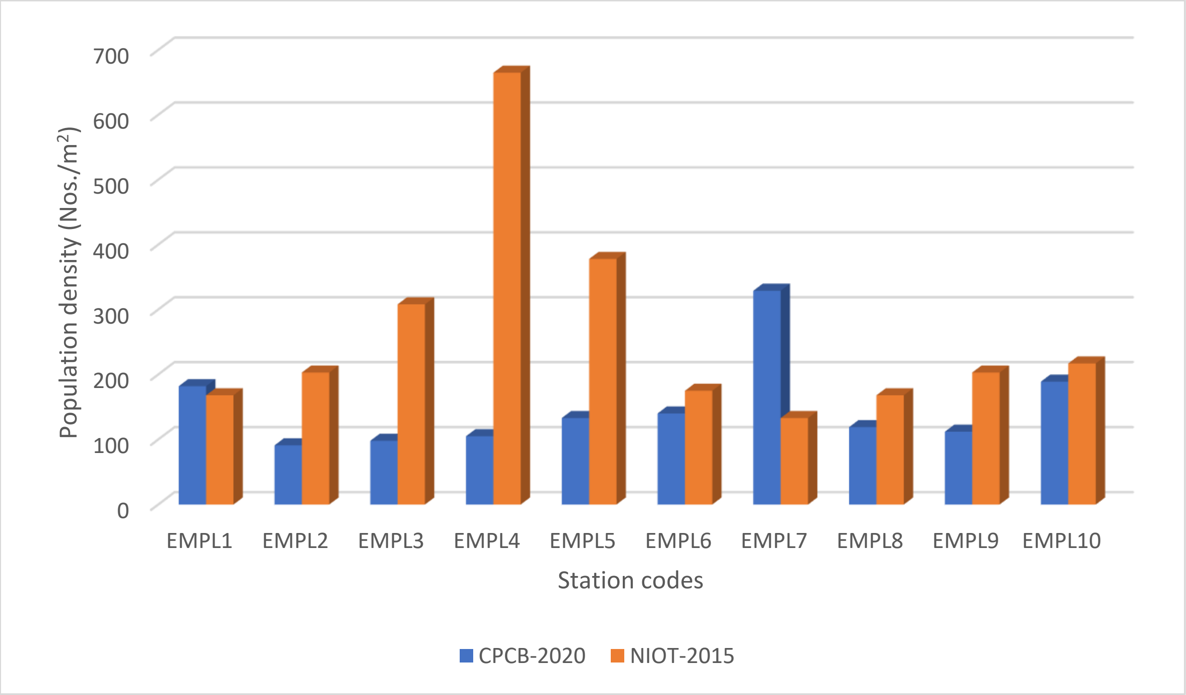


Fig. 24 Benthos population density variation in the sea bottom sediments around MPL offshore discharge location during the study period

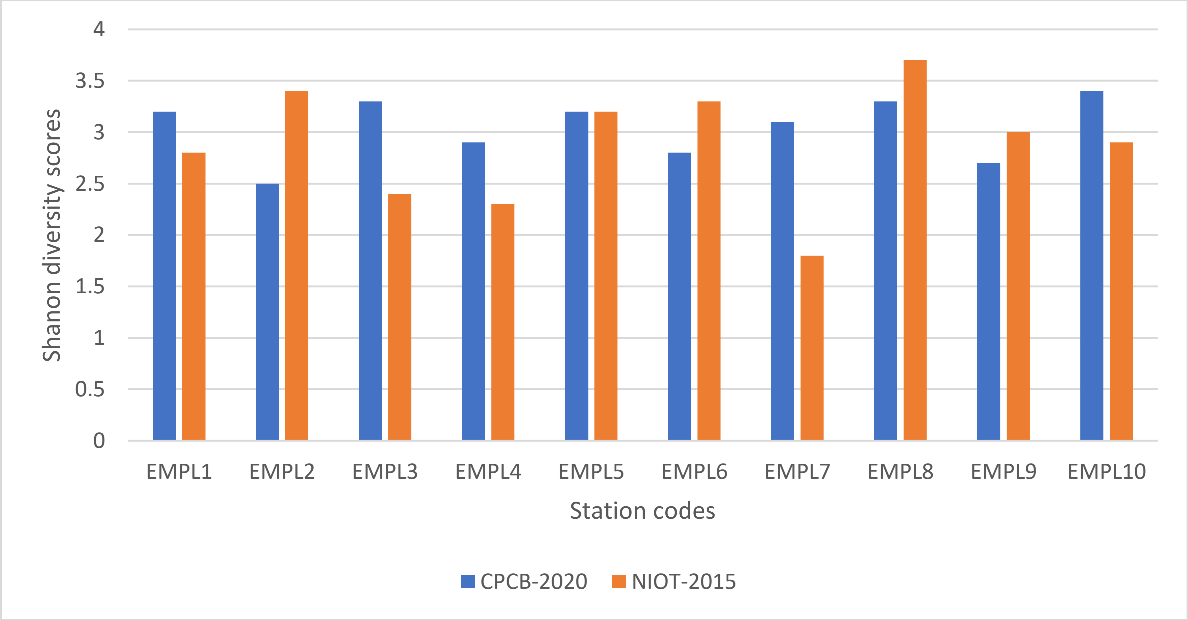


Fig. 25 Benthos population diversity variation in the sea bottom sediments around MPL offshore discharge location during the study period

SUMMARY

The results of selected parameters and comparison with previous study records reveal that there arespatial and temporal variations within the study area.Increase in nutrient parameters like nitrate recorded maximum value of 20.4 µmol./lis comparable to values recorded in samples collected during low tide at the Ennore creek during the study (AnnexureI: Table 2). The BOD values werealso relative to quantities recorded inEnnore creeksamples(Annexure I: Table 1). The sediment heavy metal content also recorded higher values than the offshore discharge site indicates the possibility of pollutants input from nearby sources which cannot be ruled out. It is well known that this Ennore creek is traversed by Manali industrial belt and Buckingham canal loaded with industrial, domestic sewage load. Considering the proximity of Ennore creek and its pollutant loading to the coastal waters, there is likely to bethe synergistic effect on nutrient loading in the coastal waters off North Chennai due to possible flushing from Ennore Creek. It leads to increase in background concentrations of the study area in addition to sources like Royapuram fisheries harbour, Chennai Port, Royapuramsewage outfall and several other industries discharging in this area, which account for the values recorded during the sampling surveys carried out in March 2020.

The values recorded in the receiving waters off North Chennai coastal waters need to be compared with the values of various parameters analyzed in the discharge waters of MPL to reach any conclusion.

The studies on biological characteristics reveal the following:

- The increase in nutrient load reflected in improvement plankton population is corroborated.
- A slight drop in benthic population in the near field of offshore discharge may be attributed to the synergistic effects of various discharges from partner industries sharing the common effluent discharge along Ennore coast. Theeffect of toxicant on the benthic population in the certain station needs to be studied by whole effluent toxicity bioassay. It warrants detailed long term monitoring studies in the receiving waters (off Chennai coast) as well asat the discharge locations of the various industries.
- All these observations have been validated with the effluent quality of industrial discharge collected by CPCB and are within the discharge limits. Given that the benthos in receiving waters (marine waters are observed to vary, 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, molluscs, etc.).

- The levels of toxic chemicals are found to be within the acceptable levels, and therefore the concentrations of the other chemicals shall have to be reviewed. It is possible that chlorides used in the processes may be released into the receiving water body. Studies show that chloride concentrations produce corrosion in wastewater pipelines and are likely to inhibit marine biota growth. However, these aspects have to be confirmed only through seasonal, comprehensive field studies over a long period.

Annexure I

Table 1 Physico-chemical parameters variation along the MPL offshore discharge site & adjoining Ennore creek

Sample ID as per Glens Innovation Lab record	Report ID	Depth (m)	Tide	Air Temperature (ºC)	Water Temperature (ºC)	pH	DO (mg/L)	BOD (mg/L)	Salinity (PSU)	TSS (mg/L)
EN-S-HT-01	EMPL1-S	0	HT	28.9	28.8	7.78	6.3	2.8	35.5	4.4
EN-S-HT-02	EMPL2-S	0	HT	28.9	28.8	7.79	6.4	2.8	34.9	4.4
EN-S-HT-03	EMPL3-S	0	HT	29.0	28.6	7.77	6.3	2.8	34.9	3.7
EN-S-HT-04	EMPL4-S	0	HT	29.0	28.6	7.77	6.4	2.8	34.9	3.7
EN-S-HT-05	EMPL5-S	0	HT	29.1	28.6	7.81	6.1	3.2	37.9	6.4
EN-S-HT-06	EMPL6-S	0	HT	29.2	28.8	7.83	6.2	2.8	35.6	4.0
EN-S-HT-07	EMPL7-S	0	HT	28.9	28.3	7.82	6.3	2.8	34.9	3.1
EN-S-HT-08	EMPL8-S	0	HT	29.0	28.4	7.83	6.3	2.8	35.1	5.2
EN-S-HT-09	EMPL9-S	0	HT	29.0	28.4	7.78	6.4	2.8	35.1	4.4
EN-S-HT-10	EMPL10-S	0	HT	29.0	28.4	7.82	6.4	2.8	35.4	4.0
EN-B-HT-01	EMPL1-B	9.5	HT	28.9	27.9	7.79	6.4	2.8	37.2	3.2
EN-B-HT-02	EMPL2-B	10.2	HT	28.9	28.0	7.92	5.1	3.2	34.6	5.0
EN-B-HT-03	EMPL3-B	9.5	HT	29.0	28.6	7.69	6.8	2.8	36.3	18.9
EN-B-HT-04	EMPL4-B	9.6	HT	29.0	27.8	7.83	6.8	2.8	36.7	3.2
EN-B-HT-05	EMPL5-B	11.6	HT	29.1	28.6	7.76	6.7	2.8	34.9	4.5
EN-B-HT-06	EMPL6-B	11.6	HT	29.2	28.5	7.69	6.8	2.8	36.7	4.5
EN-B-HT-07	EMPL7-B	11.6	HT	28.9	28.4	7.82	6.8	2.8	35.4	4.5
EN-B-HT-08	EMPL8-B	12.3	HT	29.0	28.1	7.82	6.9	3.2	35.4	4.0
EN-B-HT-09	EMPL9-B	11.5	HT	29.0	28.1	7.93	6.8	2.8	36.8	4.0
EN-B-HT-10	EMPL10-B	12.6	HT	29.0	27.9	7.87	6.8	2.8	35.4	4.5
EN-S-LT-01	EMPL1-S	0	LT	31.1	29.1	7.61	5.6	3.2	35.3	4.7

Sample ID as per Glens Innovation Lab record	**Report ID**	**Depth (m)**	**Tide**	**Air Temperature (ºC)**	**Water Temperature (ºC)**	**pH**	**DO (mg/L)**	**BOD (mg/L)**	**Salinity (PSU)**	**TSS (mg/L)**
EN-S-LT-02	EMPL2-S	0	LT	30.9	29.0	7.63	5.5	3.2	34.9	4.5
EN-S-LT-03	EMPL3-S	0	LT	31.0	29.0	7.85	5.5	3.2	34.9	4.3
EN-S-LT-04	EMPL4-S	0	LT	30.9	29.0	7.8	5.4	3.2	36.8	4.3
EN-S-LT-05	EMPL5-S	0	LT	31.0	29.0	7.83	5.5	3.2	37.7	5.1
EN-S-LT-06	EMPL6-S	0	LT	31.1	29.1	7.83	5.7	3.2	37.9	4.7
EN-S-LT-07	EMPL7-S	0	LT	30.9	28.9	7.85	5.4	3.2	35.3	5.1
EN-S-LT-08	EMPL8-S	0	LT	30.8	28.8	7.49	6.4	3.2	39.4	5.1
EN-S-LT-09	EMPL9-S	0	LT	30.9	28.9	7.81	6.2	3.2	37.2	4.7
EN-S-LT-10	EMPL10-S	0	LT	30.9	28.8	7.65	6.3	3.2	37.9	4.7
EN-B-LT-01	EMPL1-B	9.5	LT	31.1	28.7	7.84	6.4	2.8	37.9	4.6
EN-B-LT-02	EMPL2-B	10.2	LT	30.9	28.6	7.78	6.4	2.8	34.8	4.0
EN-B-LT-03	EMPL3-B	9.5	LT	31.0	28.4	7.77	6.4	2.8	35.3	3.8
EN-B-LT-04	EMPL4-B	9.6	LT	30.9	28.9	7.76	6.4	3.2	34.9	3.6
EN-B-LT-05	EMPL5-B	11.6	LT	31.0	30.8	7.83	6.1	2.8	34.8	3.2
EN-B-LT-06	EMPL6-B	11.6	LT	31.1	29.0	7.75	6.1	2.8	35.4	2.4
EN-B-LT-07	EMPL7-B	11.6	LT	30.9	29.0	7.76	5.3	3.2	35.4	2.6
EN-B-LT-08	EMPL8-B	12.3	LT	30.8	28.8	7.84	6.3	2.8	35.3	5.3
EN-B-LT-09	EMPL9-B	11.5	LT	30.9	28.6	7.91	6.3	2.8	35.4	2.0
EN-B-LT-10	EMPL10-B	12.6	LT	30.9	28.7	7.86	6.4	2.8	37.2	3.2
ENC-S-HT-01	ENC1-S	0	HT	29.5	29.1	7.84	6.9	2.8	37.9	4.9
ENC-S-HT-02	ENC2-S	0	HT	30.1	29.8	7.58	4.5	3.2	34.6	2.9
ENC-S-HT-03	ENC3-S	0	HT	29.8	29.9	7.63	6.7	2.8	25.2	17.9
ENC-S-HT-04	ENC4-S	0	HT	30.2	30.1	7.86	5.6	3.2	17.1	2.8
ENC-S-LT-01	ENC1-S	0	LT	30.5	30.3	7.93	6.8	2.8	35.4	3.6

Sample ID as per Glens Innovation Lab record	Report ID	Depth (m)	Tide	Air Temperature (ºC)	Water Temperature (ºC)	pH	DO (mg/L)	BOD (mg/L)	Salinity (PSU)	TSS (mg/L)
ENC-S-LT-02	ENC2-S	0	LT	31.2	31.1	7.62	5.5	3.2	26.8	15.8
ENC-S-LT-03	ENC3-S	0	LT	31.1	31.7	7.76	6.9	2.8	20.2	17.1
ENC-S-LT-04	ENC4-S	0	LT	31.5	31.4	7.42	6.7	3.2	15.4	3.2

Table 2 Nutrient variation along the MPL offshore discharge site & adjoining Ennore creek

Sample ID as per Glens Innovation Lab record	Report ID	Depth (m)	Tide	Ammonia (µmol/L)	Nitrate (µmol/L)	PO4 (µmol/L)	NO2 (µmol/L)
EN-S-HT-01	EMPL1-S	0	HT	2.91	20.4	0.21	0.04
EN-S-HT-02	EMPL2-S	0	HT	BLQ	20.4	0.21	0.08
EN-S-HT-03	EMPL3-S	0	HT	BLQ	20.4	0.21	0.04
EN-S-HT-04	EMPL4-S	0	HT	BLQ	20.4	0.21	0.67
EN-S-HT-05	EMPL5-S	0	HT	BLQ	20.4	0.21	0.04
EN-S-HT-06	EMPL6-S	0	HT	BLQ	9.99	0.21	0.04
EN-S-HT-07	EMPL7-S	0	HT	BLQ	20.4	0.21	0.04
EN-S-HT-08	EMPL8-S	0	HT	BLQ	20.4	0.21	0.04
EN-S-HT-09	EMPL9-S	0	HT	BLQ	9.99	0.21	0.04
EN-S-HT-10	EMPL10-S	0	HT	BLQ	9.99	0.21	0.08
EN-B-HT-01	EMPL1-B	9.5	HT	BLQ	9.99	0.21	0.04
EN-B-HT-02	EMPL2-B	10.2	HT	BLQ	9.99	0.21	0.04
EN-B-HT-03	EMPL3-B	9.5	HT	BLQ	243	0.21	0.04
EN-B-HT-04	EMPL4-B	9.6	HT	BLQ	9.99	0.21	0.04
EN-B-HT-05	EMPL5-B	11.6	HT	BLQ	4.2	0.21	0.04

Sample ID as per Glens Innovation Lab record	Report ID	Depth (m)	Tide	Ammonia (µmol/L)	Nitrate (µmol/L)	PO4 (µmol/L)	NO2 (µmol/L)
EN-B-HT-06	EMPL6-B	11.6	HT	BLQ	9.99	0.21	0.08
EN-B-HT-07	EMPL7-B	11.6	HT	BLQ	9.99	0.21	0.04
EN-B-HT-08	EMPL8-B	12.3	HT	BLQ	9.99	0.21	0.08
EN-B-HT-09	EMPL9-B	11.5	HT	BLQ	9.99	0.21	0.08
EN-B-HT-10	EMPL10-B	12.6	HT	BLQ	9.99	0.21	0.12
EN-S-LT-01	EMPL1-S	0	LT	BLQ	20.4	0.21	0.04
EN-S-LT-02	EMPL2-S	0	LT	BLQ	20.4	0.21	0.04
EN-S-LT-03	EMPL3-S	0	LT	BLQ	20.4	0.21	0.04
EN-S-LT-04	EMPL4-S	0	LT	BLQ	20.4	0.21	0.04
EN-S-LT-05	EMPL5-S	0	LT	BLQ	20.4	0.21	0.04
EN-S-LT-06	EMPL6-S	0	LT	BLQ	20.4	0.21	0.04
EN-S-LT-07	EMPL7-S	0	LT	BLQ	20.4	0.21	0.04
EN-S-LT-08	EMPL8-S	0	LT	BLQ	9.99	0.21	0.04
EN-S-LT-09	EMPL9-S	0	LT	BLQ	20.4	0.21	0.04
EN-S-LT-10	EMPL10-S	0	LT	BLQ	20.4	0.21	0.04
EN-B-LT-01	EMPL1-B	9.5	LT	2.91	9.99	0.21	0.04
EN-B-LT-02	EMPL2-B	10.2	LT	2.91	9.99	0.21	0.04
EN-B-LT-03	EMPL3-B	9.5	LT	2.91	4.2	0.21	0.04
EN-B-LT-04	EMPL4-B	9.6	LT	2.91	4.2	0.21	0.04
EN-B-LT-05	EMPL5-B	11.6	LT	2.91	9.99	0.21	0.04
EN-B-LT-06	EMPL6-B	11.6	LT	2.91	4.2	0.21	0.04
EN-B-LT-07	EMPL7-B	11.6	LT	2.91	4.2	0.21	0.04
EN-B-LT-08	EMPL8-B	12.3	LT	2.91	9.99	0.21	0.04
EN-B-LT-09	EMPL9-B	11.5	LT	2.91	4.2	0.21	0.04
EN-B-LT-10	EMPL10-B	12.6	LT	2.91	4.2	0.21	0.04

Sample ID as per Glens Innovation Lab record	**Report ID**	**Depth (m)**	**Tide**	**Ammonia (µmol/L)**	**Nitrate (µmol/L)**	**PO4 (µmol/L)**	**NO2 (µmol/L)**
ENC-S-HT-01	ENC1-S	0	HT	5.41	4.2	0.21	0.54
ENC-S-HT-02	ENC2-S	0	HT	2.91	4.2	0.67	1.25
ENC-S-HT-03	ENC3-S	0	HT	50	20.4	1.33	1.29
ENC-S-HT-04	ENC4-S	0	HT	142	20.4	1.75	14.5
ENC-S-LT-01	ENC1-S	0	LT	BLQ	20.4	0.21	0.04
ENC-S-LT-02	ENC2-S	0	LT	55	9.99	1.91	10.7
ENC-S-LT-03	ENC3-S	0	LT	111	20.4	2.1	0.75
ENC-S-LT-04	ENC4-S	0	LT	BLQ	20.4	0.96	2.54

Table 3 Heavy Metals variation along the MPL offshore discharge site & adjoining Ennore creek

Sample ID as per Glens Innovation Lab record	Report ID	Depth (m)	Tide	Arsenic (µg/L)	Nickel (µg/L)	Copper (µg/L)	Chromium (µg/L)	Cadmium (µg/L)	Zinc (µg/L)	Lead (µg/L)	Selenium (µg/L)	Cobalt (µg/L)	Manganese (µg/L)	Mercury (µg/L)
EN-S-HT-01	EMPL1-S	0	HT	BLQ	BLQ	BLQ	BLQ	BLQ	0.034	BLQ	BLQ	BLQ	0.007	BLQ
EN-S-HT-02	EMPL2-S	0	HT	BLQ	BLQ	BLQ	BLQ	BLQ	0.009	BLQ	BLQ	BLQ	0.014	BLQ
EN-S-HT-03	EMPL3-S	0	HT	BLQ	BLQ	BLQ	BLQ	BLQ	0.047	BLQ	BLQ	BLQ	0.014	BLQ
EN-S-HT-04	EMPL4-S	0	HT	BLQ	BLQ	BLQ	BLQ	BLQ	0.004	BLQ	BLQ	BLQ	0.010	BLQ
EN-S-HT-05	EMPL5-S	0	HT	BLQ	BLQ	BLQ	BLQ	BLQ	0.005	BLQ	BLQ	BLQ	0.004	BLQ
EN-S-HT-06	EMPL6-S	0	HT	BLQ	BLQ	BLQ	BLQ	BLQ	0.030	BLQ	BLQ	BLQ	0.006	BLQ
EN-S-HT-07	EMPL7-S	0	HT	BLQ	BLQ	BLQ	BLQ	BLQ	0.004	BLQ	BLQ	BLQ	0.038	BLQ
EN-S-HT-08	EMPL8-S	0	HT	BLQ	BLQ	BLQ	BLQ	BLQ	0.006	BLQ	BLQ	BLQ	0.013	BLQ
EN-S-HT-09	EMPL9-S	0	HT	BLQ	BLQ	BLQ	BLQ	BLQ	0.007	BLQ	BLQ	BLQ	0.005	BLQ
EN-S-HT-10	EMPL10-S	0	HT	BLQ	BLQ	BLQ	BLQ	BLQ	0.007	BLQ	BLQ	BLQ	BLQ	BLQ
EN-B-HT-01	EMPL1-B	9.5	HT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.190	BLQ
EN-B-HT-02	EMPL2-B	10.2	HT	BLQ	0.004	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.008	BLQ
EN-B-HT-03	EMPL3-B	9.5	HT	BLQ	0.017	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.253	BLQ
EN-B-HT-04	EMPL4-B	9.6	HT	BLQ	0.018	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.011	BLQ
EN-B-HT-05	EMPL5-B	11.6	HT	BLQ	0.010	BLQ	2.94	BLQ	0.019	BLQ	BLQ	BLQ	0.286	BLQ
EN-B-HT-06	EMPL6-B	11.6	HT	BLQ	0.017	BLQ	BLQ	BLQ	0.004	BLQ	BLQ	BLQ	0.115	BLQ
EN-B-HT-07	EMPL7-B	11.6	HT	BLQ	0.014	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.010	BLQ
EN-B-HT-08	EMPL8-B	12.3	HT	BLQ	0.005	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.073	BLQ
EN-B-HT-09	EMPL9-B	11.5	HT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.024	BLQ
EN-B-HT-10	EMPL10-B	12.6	HT	BLQ	0.008	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.005	BLQ

Sample ID as per Glens Innovation Lab record	**Report ID**	**Depth (m)**	**Tide**	**Arsenic (µg/L)**	**Nickel (µg/L)**	**Copper (µg/L)**	**Chromium (µg/L)**	**Cadmium (µg/L)**	**Zinc (µg/L)**	**Lead (µg/L)**	**Selenium (µg/L)**	**Cobalt (µg/L)**	**Manganese (µg/L)**	**Mercury (µg/L)**
EN-S-LT-01	EMPL1-S	0	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
EN-S-LT-02	EMPL2-S	0	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.004	BLQ
EN-S-LT-03	EMPL3-S	0	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
EN-S-LT-04	EMPL4-S	0	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
EN-S-LT-05	EMPL5-S	0	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
EN-S-LT-06	EMPL6-S	0	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
EN-S-LT-07	EMPL7-S	0	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
EN-S-LT-08	EMPL8-S	0	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.010	BLQ
EN-S-LT-09	EMPL9-S	0	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.006	BLQ
EN-S-LT-10	EMPL10-S	0	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
EN-B-LT-01	EMPL1-B	9.5	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.007	BLQ
EN-B-LT-02	EMPL2-B	10.2	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
EN-B-LT-03	EMPL3-B	9.5	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
EN-B-LT-04	EMPL4-B	9.6	LT	BLQ	0.006	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
EN-B-LT-05	EMPL5-B	11.6	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
EN-B-LT-06	EMPL6-B	11.6	LT	BLQ	0.005	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
EN-B-LT-07	EMPL7-B	11.6	LT	BLQ	0.005	BLQ	BLQ	BLQ	0.007	BLQ	BLQ	BLQ	BLQ	BLQ
EN-B-LT-08	EMPL8-B	12.3	LT	BLQ	0.006	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.023	BLQ
EN-B-LT-09	EMPL9-B	11.5	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
EN-B-LT-10	EMPL10-B	12.6	LT	BLQ	0.004	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
ENC-S-HT-01	ENC1-S	0	HT	BLQ	0.005	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.007	BLQ

Sample ID as per Glens Innovation Lab record	Report ID	Depth (m)	Tide	Arsenic (µg/L)	Nickel (µg/L)	Copper (µg/L)	Chromium (µg/L)	Cadmium (µg/L)	Zinc (µg/L)	Lead (µg/L)	Selenium (µg/L)	Cobalt (µg/L)	Manganese (µg/L)	Mercury (µg/L)
ENC-S-HT-02	ENC2-S	0	HT	BLQ	0.005	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
ENC-S-HT-03	ENC3-S	0	HT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.079	BLQ
ENC-S-HT-04	ENC4-S	0	HT	BLQ	0.007	BLQ	BLQ	BLQ	0.004	BLQ	BLQ	BLQ	0.111	BLQ
ENC-S-LT-01	ENC1-S	0	LT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
ENC-S-LT-02	ENC2-S	0	LT	BLQ	BLQ	BLQ	BLQ	BLQ	0.005	BLQ	BLQ	BLQ	0.030	BLQ
ENC-S-LT-03	ENC3-S	0	LT	BLQ	0.011	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.088	BLQ
ENC-S-LT-04	ENC4-S	0	LT	BLQ	0.009	0.005	BLQ	BLQ	0.015	BLQ	BLQ	BLQ	0.210	BLQ

Table 4 PHC and Faecal Coliform variation along the MPL offshore discharge site & adjoining Ennore creek

Sample ID as per Glens Innovation Lab record	Report ID	Depth (m)	Tide	Petroleum hydrocarbons (mg/L)	Oil & Grease (mg/L)	Total Coliform (MPN/100ml)	Faecal Coliform (MPN/100ml)
EN-S-HT-01	EMPL1-S	0	HT	BLQ	BLQ	23	13
EN-S-HT-02	EMPL2-S	0	HT	BLQ	BLQ	23	8
EN-S-HT-03	EMPL3-S	0	HT	BLQ	BLQ	34	14
EN-S-HT-04	EMPL4-S	0	HT	BLQ	BLQ	60	21
EN-S-HT-05	EMPL5-S	0	HT	BLQ	BLQ	90	22
EN-S-HT-06	EMPL6-S	0	HT	BLQ	BLQ	50	26
EN-S-HT-07	EMPL7-S	0	HT	BLQ	BLQ	27	11
EN-S-HT-08	EMPL8-S	0	HT	BLQ	BLQ	30	17
EN-S-HT-09	EMPL9-S	0	HT	BLQ	BLQ	50	11
EN-S-HT-10	EMPL10-S	0	HT	BLQ	BLQ	50	14
EN-B-HT-01	EMPL1-B	9.5	HT	BLQ	BLQ	40	13
EN-B-HT-02	EMPL2-B	10.2	HT	BLQ	BLQ	50	27
EN-B-HT-03	EMPL3-B	9.5	HT	BLQ	BLQ	60	21
EN-B-HT-04	EMPL4-B	9.6	HT	BLQ	BLQ	60	21
EN-B-HT-05	EMPL5-B	11.6	HT	BLQ	BLQ	50	21
EN-B-HT-06	EMPL6-B	11.6	HT	BLQ	BLQ	60	21
EN-B-HT-07	EMPL7-B	11.6	HT	BLQ	BLQ	30	17
EN-B-HT-08	EMPL8-B	12.3	HT	BLQ	BLQ	33	14
EN-B-HT-09	EMPL9-B	11.5	HT	BLQ	BLQ	34	13
EN-B-HT-10	EMPL10-B	12.6	HT	BLQ	BLQ	50	14
EN-S-LT-01	EMPL1-S	0	LT	BLQ	BLQ	40	8
EN-S-LT-02	EMPL2-S	0	LT	BLQ	BLQ	50	14
EN-S-LT-03	EMPL3-S	0	LT	BLQ	BLQ	50	14

Sample ID as per Glens Innovation Lab record	Report ID	Depth (m)	Tide	Petroleum hydrocarbons (mg/L)	Oil & Grease (mg/L)	Total Coliform (MPN/100ml)	Faecal Coliform (MPN/100ml)
EN-S-LT-04	EMPL4-S	0	LT	BLQ	BLQ	70	26
EN-S-LT-05	EMPL5-S	0	LT	BLQ	BLQ	22	8
EN-S-LT-06	EMPL6-S	0	LT	BLQ	BLQ	33	11
EN-S-LT-07	EMPL7-S	0	LT	BLQ	BLQ	70	26
EN-S-LT-08	EMPL8-S	0	LT	BLQ	BLQ	26	9
EN-S-LT-09	EMPL9-S	0	LT	BLQ	BLQ	34	8
EN-S-LT-10	EMPL10-S	0	LT	BLQ	BLQ	22	8
EN-B-LT-01	EMPL1-B	9.5	LT	BLQ	BLQ	34	13
EN-B-LT-02	EMPL2-B	10.2	LT	BLQ	BLQ	30	17
EN-B-LT-03	EMPL3-B	9.5	LT	BLQ	BLQ	60	14
EN-B-LT-04	EMPL4-B	9.6	LT	BLQ	BLQ	34	13
EN-B-LT-05	EMPL5-B	11.6	LT	BLQ	BLQ	50	13
EN-B-LT-06	EMPL6-B	11.6	LT	BLQ	BLQ	34	17
EN-B-LT-07	EMPL7-B	11.6	LT	BLQ	BLQ	70	14
EN-B-LT-08	EMPL8-B	12.3	LT	BLQ	BLQ	60	26
EN-B-LT-09	EMPL9-B	11.5	LT	BLQ	BLQ	40	17
EN-B-LT-10	EMPL10-B	12.6	LT	BLQ	BLQ	23	8
ENC-S-HT-01	ENC1-S	0	HT	BLQ	BLQ	34	11
ENC-S-HT-02	ENC2-S	0	HT	BLQ	BLQ	33	14
ENC-S-HT-03	ENC3-S	0	HT	BLQ	BLQ	110	30
ENC-S-HT-04	ENC4-S	0	HT	BLQ	BLQ	140	33
ENC-S-LT-01	ENC1-S	0	LT	BLQ	BLQ	34	13
ENC-S-LT-02	ENC2-S	0	LT	BLQ	BLQ	70	14
ENC-S-LT-03	ENC3-S	0	LT	BLQ	BLQ	80	27

Sample ID as per Glens Innovation Lab record	Report ID	Depth (m)	Tide	Petroleum hydrocarbons (mg/L)	Oil & Grease (mg/L)	Total Coliform (MPN/100ml)	Faecal Coliform (MPN/100ml)
ENC-S-LT-04	ENC4-S	0	LT	BLQ	BLQ	90	50

Table 5 Heavy metals, PHC & TOC variation along the MPL offshore discharge site & adjoining Ennore creek

Sample code as per Glens Innovation Lab record	Report ID	Manganese (mg/kg)	Zinc (mg/kg)	Cadmium (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Cobalt (mg/kg)	Nickel (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Petroleum hydrocarbons (mg/kg)	TOC (%)
EN20030007-01	EMPLS1	33.12	10.95	BDL	3.30	BDL	2.74	3.21	9.60	2.22	4416.29	BDL	BDL
EN20030007-02	EMPLS2	11.58	8.23	BDL	3.62	BDL	2.62	2.54	9.37	BDL	4180.36	BDL	BDL
EN20030007-03	EMPLS3	16.25	5.09	BDL	2.45	BDL	BDL	BDL	5.75	0.78	2593.85	BDL	BDL
EN20030007-04	EMPLS4	29.17	8.03	BDL	2.45	BDL	2.34	2.23	7.88	BDL	3428.34	BDL	BDL
EN20030007-05	EMPLS5	48.04	12.50	BDL	3.70	BDL	3.09	3.81	9.69	3.18	5221.67	BDL	BDL
EN20030007-06	EMPLS6	35.78	10.28	BDL	3.53	BDL	2.79	3.32	9.49	2.86	4864.51	BDL	BDL
EN20030007-07	EMPLS7	15.81	4.54	BDL	1.62	BDL	BDL	BDL	5.62	BDL	3033.43	BDL	BDL
EN20030007-08	EMPLS8	25.50	4.96	BDL	1.62	BDL	BDL	BDL	5.54	BDL	3290.54	BDL	BDL

Sample code as per Glens Innovation Lab record	Report ID	Manganese (mg/kg)	Zinc (mg/kg)	Cadmium (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Cobalt (mg/kg)	Nickel (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Petroleum hydrocarbons (mg/kg)	TOC (%)
EN20030007-09	EMPLS9	50.93	3.16	BDL	1.47	BDL	BDL	BDL	4.48	BDL	2332.74	BDL	BDL
EN20030007-10	EMPLS10	20.56	7.84	BDL	3.24	3.18	2.24	3.26	8.32	2.64	4683.99	BDL	BDL
EN20030007-11	ENCS1	22.92	1607.02	14.23	27.04	BDL	7.14	23.39	75.55	117.76	23947.16	BDL	1.09
EN20030007-12	ENCS2	19.20	1084.73	10.71	19.65	BDL	5.40	17.22	59.18	89.76	19624.39	BDL	0.86
EN20030007-13	ENCS3	14.27	263.74	2.52	7.76	BDL	3.01	6.60	21.68	29.36	7139.08	BDL	0.45
EN20030007-14	ENCS4	BDL	2.70	BDL	0.66	BDL	BDL	BDL	3.55	BDL	1026.54	BDL	BDL

ANNEXURE II

Table 1: Phytoplankton population variation along MPL offshore discharge sites and adjoining Ennore creek system during HT

Station code	Population (No/l)	Faunal Groups	*Percentage of species contribution*
EMPL 1	5880	19	*Biddulphia regia (7.14), Biddulphia sinensis (4.29), Biddulphia mobiliensis (2.86)*, *Rhizosolenia imbricata (11.43), Rhizosolenia stolterfothii (1.43), Rhizosolenia alata (2.86), Coscinodiscus radiatus (1.43), Ceratium tripos (4.29), Ceratium fusus (7.14), Thalassionema frauenfeldii (4.29), Guinardia flaccida (10.00), Guinardia striata (4.29), Skeletonema costatum (7.14), Leptocylindrus sp (4.29), Asterionella japonica (7.14), Streptotheca thamensis (2.86), Chaetoceros decipiens (5.71), Chaetoceros coarctatus (10.00), & Grammatophora marina (1.43).*
EMPL 2	3108	20	*Biddulphia regia (4.05), Biddulphia sinensis (2.70), Rhizosolenia imbricata (4.05), Rhizosolenia stolterfothii (8.11), Rhizosolenia robusta (5.41), Rhizosolenia bergonii (2.70), Coscinodiscus radiatus (6.76), Ceratium tripos (4.05), Ceratium fusus (9.46), Thalassionema frauenfeldii (5.41), Guinardia flaccida (8.11), Guinardia striata (2.70), Skeletonema costatum (12.16), Asterionella japonica (5.41), Streptotheca thamensis (2.70), Bellerochea malleus (1.35), Chaetoceros decipiens (1.35), Chaetoceros coarctatus (6.76), Grammatophora marina (4.05) & Trichodesmium sp. (2.70).*
EMPL 3	3831	15	*Biddulphia regia (13.89), Rhizosolenia imbricata (3.97), Rhizosolenia stolterfothii (7.94), Rhizosolenia calcar-avis (9.92), Coscinodiscus radiatus (11.90), Coscinodiscus granii (1.98), Ceratium fusus (7.94), Ceratium furca (3.97), Dinophysis caudata (5.30), Thalassionema frauenfeldii (5.95), Guinardia flaccida (3.97), Asterionella japonica (0.48), Streptotheca thamensis (3.97), Skeletonema costatum (3.97), Nitzschia sp (1.78) & Chaetoceros decipiens (9.92).*
EMPL 4	2196	19	*Biddulphia regia (1.64), Biddulphia mobiliensis (8.74), Rhizosolenia imbricata (4.37), Rhizosolenia stolterfothii (3.28), Rhizosolenia alata (7.65), Rhizosolenia robusta (5.46), Rhizosolenia calcar-avis (8.74), Rhizosolenia bergonii (3.28), Coscinodiscus radiates (9.84), Coscinodiscus granii (2.19), Coscinodiscus centralis (4.37), Ceratium tripos (3.28), Ceratium furca (6.56), Ceratium fusus (5.46), Thalassionema frauenfeldii (6.56), Guinardia flaccida (12.02), Skeletonema costatum (2.19), Streptotheca thamensis (1.09), & Chaetoceros decipiens (3.28).*

Station code	**Population (No/l)**	**Faunal Groups**	***Percentage of species contribution***
EMPL 5	3740	20	*Biddulphia regia (14.12), Rhizosolenia imbricata (5.88), Rhizosolenia alata (4.71), Rhizosolenia robusta (8.24), Coscinodiscus centralis (4.71), Coscinodiscus radiatus (7.06), Ceratium fusus (3.53), Thalassionema frauenfeldii (7.06), Guinardia flaccida (4.71), Skeletonema costatum (3.53), Leptocylindrus sp (1.18), Asterionella japonica (2.35), Anabaena sp (1.18), Streptotheca thamensis (2.35), Bellerochea malleus (4.71), Pleurosigma sp (3.53), Nitzschia sp (1.18), Chaetoceros decipiens (7.06), Chaetoceros coarctatus (9.41) & Chaetoceros gracilis (3.53).*
EMPL 6	1826	13	*Biddulphia regia (8.43), Biddulphia sinensis (4.82), Rhizosolenia imbricata (9.64), Coscinodiscus radiatus (12.05), Ceratium tripos (4.82), Ceratium furca (9.64), Thalassionema frauenfeldii (4.82), Guinardia flaccid (9.64), Skeletonema costatum (7.23), Streptotheca thamensis (9.64), Bellerochea malleus (2.41), Chaetoceros decipiens (12.05) & Chaetoceros coarctatus (4.82).*
EMPL 7	3963	13	*Biddulphia mobiliensis (13.12), Rhizosolenia imbricata (9.84), Coscinodiscus granii (6.56), Ceratium tripos (9.84), Ceratium fusus (16.40), Ceratium longiceps (3.23), Thalassionema frauenfeldii (4.92), Guinardia flaccid (3.28), Skeletonema costatum (11.48), Streptotheca thamensis (1.64), Chaetoceros decipiens (4.92), Chaetoceros coarctatus (9.84) & Trichodesmium sp. (4.92).*
EMPL 8	2340	13	*Biddulphia regia (15.56), Biddulphia sinensis (4.44), Rhizosolenia imbricata (8.89), Coscinodiscus radiatus (1.11) Ceratium tripos (4.44), Ceratium furca (8.89), Thalassionema frauenfeldii (4.44), Guinardia flaccida (8.89), Skeletonema costatum (6.67), Streptotheca thamensis (8.89), Nitzschia sp (2.22), Chaetoceros decipiens (11.11), & Chaetoceros coarctatus (4.44).*
EMPL 9	3472	16	*Biddulphia regia (14.52), Biddulphia sinensis (3.23), Rhizosolenia imbricata (6.45), Rhizosolenia calcar-avis (8.06), Coscinodiscus centralis (6.45), Ceratium arcticum (3.23), Ceratium fusus (6.45), Dinophysis caudata (4.84), Dictyocha spp. (3.23), Guinardia flaccida (4.84), Guinardia striata (8.06), Leptocylindrus sp (6.45), Bellerochea malleus (4.84), Pleurosigma sp. (6.45), Nitzschia sp. (4.84) & Chaetoceros decipiens (8.06).*
EMPL 10	3510	13	*Biddulphia regia (1.53), Biddulphia sinensis (9.26), Rhizosolenia imbricata (14.81), Rhizosolenia stolterfothii (5.56), Rhizosolenia alata (3.70), Rhizosolenia calcar-avis (5.56), Dinophysis caudate (3.70), Thalassionema frauenfeldii (3.70), Guinardia flaccida (12.96), Streptotheca thamensis (12.96), Pleurosigma sp (5.56), Chaetoceros decipiens (14.81) & Chaetoceros coarctatus (5.56).*

Station code	**Population (No/l)**	**Faunal Groups**	***Percentage of species contribution***
ENC 1	2736	20	*Biddulphia regia (7.02), Rhizosolenia imbricata (5.26), Rhizosolenia stolterfothii (3.51), Rhizosolenia bergonii (1.75), Coscinodiscus radiatus (5.26), Ceratium fusus (5.26), Dinophysis caudata (3.51), Dictyocha spp. (7.02), Guinardia striata (3.51), Skeletonema costatum (8.77), Leptocylindrus sp (7.02), Asterionella japonica (5.26), Anabaena sp (3.51), Streptotheca thamensis (7.02), Bellerochea malleus (3.51), Pleurosigma sp (5.26), Nitzschia sp (7.02), Chaetoceros decipiens (5.26), Chaetoceros gracilis (1.75) & Grammatophora marina (3.51).*
ENC 2	1110	4	*Anabaena sp (24.32), Spirulina sp. (35.14), Scenedesmus dimorphis (21.62) & Pediastrum duplex (18.92).*

Table 2: Phytoplankton population variation along MPL offshore discharge sites and adjoining Ennore creek system during LT

Station code	**Population (No/l)**	**Faunal Groups**	***Percentage of species contribution***
MPL 1	5382	18	*Biddulphia regia (8.70), Biddulphia sinensis (2.90), Rhizosolenia imbricata (14.49), Rhizosolenia stolterfothii (4.35), Rhizosolenia alata (7.25), Coscinodiscus radiatus (4.35), Ceratium tripos (5.80), Ceratium fusus (4.35), Thalassionema frauenfeldii (1.45), Guinardia flaccida (5.80), Guinardia striata (2.90), Skeletonema costatum (5.80), Leptocylindrus sp (7.25), Asterionella japonica (4.35), Streptotheca thamensis (5.80), Chaetoceros decipiens (4.35), Chaetoceros coarctatus (5.80), & Grammatophora marina (4.35).*
EMPL 1	3002	18	*Biddulphia mobiliensis (5.06), Rhizosolenia imbricata (2.53), Rhizosolenia stolterfothii (6.33), Rhizosolenia robusta (5.06), Rhizosolenia bergonii (7.59), Coscinodiscus radiatus (6.33), Ceratium tripos (3.80), Ceratium fusus (5.06), Thalassionema frauenfeldii (6.33), Guinardia flaccida (7.59), Guinardia striata (5.06), Skeletonema costatum (1.27), Asterionella japonica (8.86), Streptotheca thamensis (7.59), Chaetoceros decipiens (3.80), Chaetoceros coarctatus (2.53), Grammatophora marina (5.06) & Trichodesmium sp. (6.33).*

Station code	**Population (No/l)**	**Faunal Groups**	***Percentage of species contribution***
EMPL 2	3920	18	*Biddulphia regia (8.93), Biddulphia mobiliensis (5.36), Rhizosolenia imbricata (7.14), Rhizosolenia alata (3.57), Rhizosolenia calcar-avis (7.14), Rhizosolenia bergonii (1.79), Coscinodiscus radiatus (8.93), Coscinodiscus granii (5.36), Ceratium tripos (5.36), Ceratium furca (7.14), Ceratium fusus (3.57), Thalassionema frauenfeldii (3.57), Guinardia flaccida (1.79), Guinardia striata (3.57), Streptotheca thamensis (8.93), Skeletonema costatum (7.14), Chaetoceros coarctatus (3.57), Chaetoceros decipiens (5.36) & Grammatophora marina (1.79).*
EMPL 3	2704	17	*Biddulphia regia (12.50), Biddulphia mobiliensis (8.65), Rhizosolenia imbricata (4.81), Rhizosolenia stolterfothii (1.92), Rhizosolenia robusta (2.88), Rhizosolenia calcar-avis (5.77), Coscinodiscus radiatus (9.62), Coscinodiscus granii (2.88), Coscinodiscus centralis (4.81), Ceratium tripos (4.81), Ceratium furca (6.73), Ceratium fusus (5.77), Thalassionema frauenfeldii (3.85), Guinardia flaccida (13.46), Skeletonema costatum (4.81), Streptotheca thamensis (2.88), & Chaetoceros decipiens (3.85).*
EMPL 4	3570	18	*Biddulphia regia (12.94), Rhizosolenia imbricata (7.06), Rhizosolenia alata (3.53), Rhizosolenia robusta (5.88), Coscinodiscus radiatus (10.59), Ceratium fusus (4.71), Thalassionema frauenfeldii (9.41), Guinardia flaccida (2.53), Skeletonema costatum (3.53), Leptocylindrus sp (2.53), Asterionella japonica (4.71), Streptotheca thamensis (3.53), Bellerochea malleus (2.35), Pleurosigma sp (8.24), Nitzschia sp (3.53), Chaetoceros decipiens (4.71), Chaetoceros coarctatus (7.06) & Chaetoceros gracilis (3.53).*
EMPL 5	2116	13	*Biddulphia regia (13.04), Biddulphia sinensis (8.70), Rhizosolenia imbricata (6.52), Coscinodiscus radiatus (8.70), Coscinodiscus centralis (2.17), Ceratium tripos (6.52), Ceratium furca (8.70), Thalassionema frauenfeldii (2.17), Guinardia flaccid (6.52), Skeletonema costatum (4.35), Bellerochea malleus (10.87), Chaetoceros decipiens (13.04) & Chaetoceros coarctatus (8.70).*
EMPL 6	3886	12	*Biddulphia mobiliensis (14.93), Rhizosolenia imbricata (11.94), Coscinodiscus radiatus (5.97), Ceratium tripos (10.45), Ceratium fusus (8.96), Thalassionema frauenfeldii (5.97), Guinardia flaccid (1.49), Skeletonema costatum (7.46), Streptotheca thamensis (5.97), Chaetoceros decipiens (7.46), Chaetoceros coarctatus (11.94) & Trichodesmium sp. (7.46).*
EMPL 7	2464	12	*Biddulphia regia (18.18), Biddulphia sinensis (2.27), Rhizosolenia imbricata (6.82), Coscinodiscus radiatus (7.95) Ceratium furca (13.64), Thalassionema frauenfeldii (6.82), Guinardia flaccida (5.68), Skeletonema costatum (5.68), Streptotheca thamensis (11.36), Nitzschia sp (4.55), Chaetoceros decipiens (10.23), & Chaetoceros coarctatus (6.82).*

Station code	**Population (No/l)**	**Faunal Groups**	***Percentage of species contribution***
EMPL 8	3456	15	*Biddulphia regia (10.94), Biddulphia sinensis (6.25), Rhizosolenia imbricata (7.81), Coscinodiscus centralis (14.06), Ceratium arcticum (6.25), Ceratium fusus (4.69), Thalassionema frauenfeldii (7.81), Guinardia flaccida (1.56), Guinardia striata (3.13), Skeletonema costatum (6.25), Asterionella japonica (4.69), Pleurosigma sp. (7.81), Nitzschia sp. (3.13), Chaetoceros decipiens (6.25) & Chaetoceros coarctatus (9.38).*
EMPL 9	3480	13	*Biddulphia regia (5.00), Rhizosolenia imbricata (16.67), Rhizosolenia stolterfothii (6.67), Rhizosolenia calcar-avis (8.33), Ceratium longiceps (5.00), Dinophysis caudate (6.67), Thalassionema frauenfeldii (1.67), Guinardia flaccida (15.00), Streptotheca thamensis (10.00), Pleurosigma sp (3.33), Chaetoceros decipiens (15.00), Chaetoceros coarctatus (3.33) & Trichodesmium sp. (3.33).*
EMPL 10	2756	15	*Biddulphia regia (5.66), Rhizosolenia imbricata (9.43), Rhizosolenia stolterfothii (5.66), Coscinodiscus radiatus (9.43), Ceratium fusus (9.43), Thalassionema frauenfeldii (1.89), Guinardia flaccida (5.66), Skeletonema costatum (1.89), Asterionella japonica (11.32), Anabaena sp (5.66), Streptotheca thamensis (9.43), Bellerochea malleus (5.66), Pleurosigma sp (1.89), Chaetoceros decipiens (7.55) & Trichodesmium sp. (9.43).*
ENC 2	1064	4	*Anabaena sp (21.05), Spirulina sp. (39.47), Scenedesmus dimorphis (15.79) & Pediastrum duplex (23.68).*

Table 3: Zooplankton population variation along MPL offshore discharge sites and adjoining Ennore creek system during HT

Station code	**Population (No/m^3)**	**Faunal Groups**	**Major groups (%)**
EMPL 1	1476	12	*Calanoid copepods (10.16), Cyclopoid copepods (5.42), Sagitta (3.93), Medusa (1.02), Siphonophores (5.08), Cladocerans (35.57), Mysids (6.78), Brachyuran larvae (2.03), Fish eggs and larvae (3.25), Lucifer (22.02), Polychaete larvae (3.93) & Nauplius (0.81)*
EMPL 2	1638	11	*Calanoid copepods (13.80), Cyclopoid copepods (0.61), Sagitta (2.81), Siphonophores (1.28), Cladocerans (48.35), Appendicularians (1.95), Mysids (8.79), Fish eggs and larvae (0.92), Lucifer (19.54), Polychaete larvae (0.98) & Nauplius (0.98)*

EMPL 3	1731	13	*Calanoid copepods (10.40), Cyclopoid copepods (5.20), Sagitta (7.22), Medusa (1.10), Siphonophores (7.22), Cladocerans (32.93), Appendicularians (6.93), Mysids (1.04), Brachyuran larvae (1.44), Fish eggs and larvae (2.60), Lucifer (21.66), Polychaete larvae (1.44) & Nauplius (0.81)*
EMPL 4	2546	12	*Calanoid copepods (11.00), Cyclopoid copepods (2.08), Sagitta (1.10), Medusa (2.36), Siphonophores (2.55), Cladocerans (40.85), Appendicularians (1.18), Mysids (3.53), Fish eggs and larvae (5.89), Lucifer (21.41), Polychaete larvae (3.34) & Nauplius (4.71)*
EMPL 5	2586	11	*Calanoid copepods (5.08), Cyclopoid copepods (6.03), Sagitta (4.06), Cladocerans (46.40), Appendicularians (1.93), Mysids (3.87), Brachyuran larvae (2.90), Fish eggs and larvae (2.90), Lucifer (17.40), Polychaete larvae (2.90) & Nauplius (5.80)*
EMPL 6	2003	12	*Calanoid copepods (6.14), Cyclopoid copepods (2.15), Sagitta (8.89), Medusa (3.15), Siphonophores (1.05), Cladocerans (37.59), Appendicularians (0.60), Mysids (5.24), Fish eggs and larvae (2.10), Lucifer (26.21), Polychaete larvae (6.14) & Nauplius (0.75)*
EMPL 7	2325	12	*Calanoid copepods (3.53), Cyclopoid copepods (4.65), Sagitta (1.94), Medusa (1.20), Siphonophores (2.49), Cladocerans (52.90), Mysids (9.98), Brachyuran larvae (1.08), Fish eggs and larvae (1.08), Lucifer (15.14), Polychaete larvae (2.49) & Nauplius (3.53)*
EMPL 8	1287	13	*Calanoid copepods (14.69), Cyclopoid copepods (2.18), Sagitta (1.09), Medusa (1.09), Siphonophores (5.59), Cladocerans (40.02), Appendicularians (1.09), Mysids (8.24), Brachyuran larvae (2.10), Fish eggs and larvae (1.09), Lucifer (20.05), Polychaete larvae (1.09) & Nauplius (1.71)*
EMPL 9	1180	12	*Calanoid copepods (7.20), Cyclopoid copepods (6.10), Sagitta (1.53), Medusa (0.76), Siphonophores (3.47), Cladocerans (47.12), Appendicularians (6.10), Mysids (6.44), Fish eggs and larvae (1.69), Lucifer (16.78), Polychaete larvae (1.27) & Nauplius (1.53)*
EMPL 10	1450	11	*Calanoid copepods (10.90), Cyclopoid copepods (2.93), Sagitta (7.59), Medusa (4.69), Siphonophores (9.10), Cladocerans (39.24), Mysids (3.03), Fish eggs and larvae (1.52), Lucifer (10.48), Polychaete larvae (7.59) & Nauplius (3.03)*
ENC 1	630	11	*Calanoid copepods (20.32), Cyclopoid copepods (4.44), Sagitta (1.90), Medusa (0.48), Cladocerans (36.83), Appendicularians (2.22), Mysids (2.38), Fish eggs and larvae (6.83), Lucifer (3.97), Polychaete larvae (12.06) & Nauplius (8.57)*
ENC 2	497	10	*Calanoid copepods (19.72), Cyclopoid copepods (10.46), Medusa (0.40), Cladocerans (41.05), Appendicularians (1.61), Mysids (2.41), Fish eggs and larvae (5.63), Lucifer (3.62), Polychaete larvae (8.05) & Nauplius (7.04)*

Table 4: Zooplankton population variation along MPL offshore discharge sites and adjoining Ennore creek system during LT

Station code	Population (No/m^3)	Faunal Groups	Major groups (%)
EMPL 1	1794	11	*Calanoid copepods (8.03), Cyclopoid copepods (0.89), Medusa (0.89), Siphonophores (3.01), Cladocerans (38.35), Appendicularians (1.78), Mysids (12.19), Fish eggs and larvae (1.74), Lucifer (27.87), Polychaete larvae (1.74) & Nauplius (3.48)*
EMPL 2	2480	12	*Calanoid copepods (8.63), Cyclopoid copepods (0.20), Sagitta (1.39), Medusa (2.78), Siphonophores (1.39), Cladocerans (37.38), Appendicularians (0.48), Mysids (9.73), Fish eggs and larvae (4.17), Lucifer (31.98), Polychaete larvae (1.39) & Nauplius (0.48)*
EMPL 3	2631	10	*Calanoid copepods (3.76), Cyclopoid copepods (2.62), Sagitta (2.20), Cladocerans (47.78), Appendicularians (2.27), Mysids (11.35), Fish eggs and larvae (2.27), Lucifer (24.90), Polychaete larvae (2.27) & Nauplius (0.57)*
EMPL 4	3199	11	*Calanoid copepods (6.31), Cyclopoid copepods (2.56), Sagitta (1.59), Siphonophores (4.78), Cladocerans (61.39), Appendicularians (1.47), Mysids (5.10), Fish eggs and larvae (1.28), Lucifer (13.91), Polychaete larvae (1.03) & Nauplius (0.56)*
EMPL 5	2543	12	*Calanoid copepods (11.84), Cyclopoid copepods (0.98), Harapacticoid (2.91), Medusa (3.97), Siphonophores (5.70), Cladocerans (50.29), Appendicularians (1.30), Mysids (5.27), Fish eggs and larvae (0.71), Lucifer (15.81), Polychaete larvae (0.47) & Nauplius (0.75)*
EMPL 6	2367	12	*Calanoid copepods (6.34), Cyclopoid copepods (3.13), Sagitta (1.35), Medusa (1.31), Siphonophores (3.72), Cladocerans (56.61), Appendicularians (1.86), Mysids (4.06), Fish eggs and larvae (1.31), Lucifer (17.11), Polychaete larvae (2.70) & Nauplius (0.51)*
EMPL 7	2599	11	*Calanoid copepods (20.62), Cyclopoid copepods (0.69), Sagitta (2.46), Siphonophores (3.23), Cladocerans (47.98), Mysids (7.08), Brachyuran larvae (1.61), Fish eggs and larvae (1.73), Lucifer (12.50), Polychaete larvae (1.23) & Nauplius (0.85)*
EMPL 8	3093	12	*Calanoid copepods (15.06), Cyclopoid copepods (2.29), Sagitta (1.33), Medusa (2.29), Siphonophores (2.29), Cladocerans (47.69), Appendicularians (2.29), Mysids (7.25), Fish eggs and larvae (2.29), Lucifer (15.06), Polychaete larvae (1.78) & Nauplius (0.39)*
EMPL 9	2219	12	*Calanoid copepods (13.50), Cyclopoid copepods (1.58), Harapacticoid (0.99) Sagitta (1.44), Medusa (2.43), Siphonophores (0.72), Cladocerans (43.88), Mysids (16.88), Fish eggs and larvae (5.06), Lucifer (8.44), Polychaete larvae (1.69) & Nauplius (3.38)*

EMPL 10	2378	8	*Calanoid copepods (7.69), Cyclopoid copepods (2.56), Medusa (5.13), Siphonophores (2.56), Cladocerans (48.72), Mysids (10.26), Lucifer (20.51) & Nauplius (2.56)*
ENC 1	802	12	*Calanoid copepods (19.45), Cyclopoid copepods (1.50), Harapacticoid (0.50) Sagitta (2.0), Medusa (1.25), Cladocerans (39.40), Appendicularians (1.75), Mysids (2.49), Fish eggs and larvae (7.23), Lucifer (5.49), Polychaete larvae (10.72) & Nauplius (8.23)*
ENC 2	615	11	*Calanoid copepods (17.56), Cyclopoid copepods (0.65), Sagitta (0.81), Medusa (0.81), Cladocerans (46.83), Appendicularians (1.30), Mysids (4.07), Fish eggs and larvae (5.69), Lucifer (7.32), Polychaete larvae (8.46) & Nauplius (6.50)*

Table 5: Benthos population variation along MPL offshore discharge sites and adjoining Ennore creek system during HT

Station code	***Total (Nos./m²)***	***Percentage of species contribution***
EMPL 1	182	*Tube worm (3.855), Arca sp.(15.38), Anadara granosa (11.54), Meretrix casta (7.69), Donax sp. (23.08), Astarte elliptica (3.85), Meretrix meretrix (15.38), Cerethedia sp. (3.85) & Clithon oualaniense (15.38).*
EMPL 2	91	*Tube worm (7.69), Terebellides sp.(7.69), Angulus tenuis (7.69), Arca sp.(7.69), Anadara granosa (7.69), Meretrix casta (7.69), Donax sp. (15.38), Cerethedia sp. (23.08), Parvanachis obesa (7.69) & Cellena radiata (7.69).*
EMPL 3	98	*Goniada sp.(4.5),Terebellides sp.(2.3), Arca sp.(9.1), Pecten sp.(40.9), Donax sp.(6.8), Meretrix meretrix(2.3), Umbonium vestiarium(27.3), Balanus sp.(2.3),Oliva sp.(4.5).*
EMPL 4	105	*Tube worm (20.00), Terebellides sp. (6.67), Arca sp.(6.67), Anadara granosa (13.33), Donax sp.(13.33), Meretrix meretrix (13.33), Cerethedia sp. (20.00) & Umbonium vestiarium (6.67).*
EMPL 5	133	*Cirratulus cirratus (15.79), Ancistrosyllis sp.(10.53), Tube worm (5.26), Arca sp.(10.53), Anadara granosa(5.26), Donax sp. (10.53), Meretrix meretrix (15.79), Cerethedia sp. (10.53), Umbonium vestiarium (10.53) & Sand Dollar (5.26).*
EMPL 6	140	*Prionospio sp.(5.00), Tube worm (15.00), Angulus tenuis (5.00), Arca sp. (5.00), Anadara granosa (10.00), Donax sp.(15.00), Meretrix meretrix (20.00), Cerethedia sp. (5.00), Umbonium vestiarium(10.00) & Turtella sp. (10.00).*
EMPL 7	329	*Tube worm (6.38), Terebellides sp (4.26), Arca sp. (10.64), Anadara granosa (14.89), Meretrix casta (8.51), Pecten sp. (2.13), Astarte elliptica (4.26), Donax sp. (23.40), Meretrix meretrix (19.15), Cerethedia sp. (2.13) & Umbonium vestiarium (4.26).*
EMPL 8	119	*Tube worm (11.76), Terebellides sp. (5.86), Angulus tenuis (5.88), Arca sp. (5.88), Meretrix casta (11.76), Pecten sp. (5.88), Donax sp.(17.65), Meretrix meretrix (11.76), Cerethedia sp.(11.76), Umbonium vestiarium(5.88) & Oliva sp.(5.88).*

Station code	***Total (Nos./m²)***	***Percentage of species contribution***
EMPL 9	112	*Terebellides sp. (6.25), Arca sp.(12.50), Anadara granosa (12.50), Meretrix casta (18.75), Donax sp.(31.25), Meretrix meretrix(6.25), Cerethedia sp. (6.25) & Umbonium vestiarium (6.25).*
EMPL 10	189	*Prionospio sp.(3.70), Cirratulus cirratus (3.70), Para heteromastus tenuis (3.70), Tube worm(18.52), Terebellides sp.(7.41), Angulus tenuis (7.41), Arca sp.(7.41), Anadara granosa (11.11), Meretrix casta (14.81), Donax sp.(7.41), Meretrix meretrix(11.11) & Cerethedia sp.(3.70).*
ENC 1	98	*Prionospio sp.(14.29), Angulus tenuis (14.29), Donax sp.(14.29), Meretrix meretrix(14.29), Cerethedia sp.(14.29) & Clithon oualaniense (28.57).*