BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL,
SOUTHERN ZONE- CHENNAI
O.A NO. 180 of 2023
AND
O. A NO.183 OF 2023

IN THE MATTER OF

Tribunal on its own motion SUOMOTU based on the Visual media titled Chennai Rains Makkalai Vathaikkum Oil Companies-Shocking Story - Michaung Ground Report covered by on VIKATAN TV Chennai dt.06.12.2023

with

The District Collector Chennai District

And Ors. ...Respondents

AND

R.L. Srinivasan, Chennai. ...Applicant (s)

Versus

The Tamil Nadu Coastal Zone Management Authority,

Rep. by its Member Secretary, Chennai and Ors. ...Respondent(s)

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Filed by
Thiru.S. Sai Sathya Jith,
Advocate, Chennai.

1

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REPORT FILED ON BEHALF OF THE RESPONDENT -
TAMIL NADU POLLUTION CONTROL BOARD

I, J. Josephine Sahayarani, D/o. Jesu Rajan, aged about 58 years, having my office at 76, Mount Salai, Guindy, Chennai-600032, do hereby solemnly affirm and sincerely state as follows:-

1. I am the Joint Chief Environmental Engineer, Tamil Nadu Pollution Control Board (TNPCB), Chennai -600 032, and I am authorized to file this Report duly approved by the Chairperson as on behalf of the Respondent Tamil Nadu Pollution Control Board (TNPCB). I am well acquainted with the facts of the case from the records.

2. It is respectfully submitted that the TNPCB has filed its detailed report on 11.12.2023, a detailed status cum action taken report on 10.1.2024,

J. Josephine 6/9/2024

JOINT CHIEF ENVIRONMENTAL ENGINEER
TAMIL NADU POLLUTION CONTROL BOARD
No.76, MOUNT SALAI, GUINDY,
CHENNAI-600 032.

18.12.2023, 21.12.2023 and 26.02.2024 and it may be pleased to take part and parcel of this case.

3. It is respectfully submitted that as per the directions of the Hon'ble Tribunal in its order dated 02.04.2024, after receipt of the report from the IIT - Madras and NIO - Goa, let the TNPCB compute the extent of damage caused due to the oil spill on the mangroves is submitted herein.

4. It is respectfully submitted that Indian Institute of Technology, Madras has submitted reports on 01.07.2024 titled Oil Spill and Impact Assessment at Ennore during Michaung Cyclone (Summary Report) & Assessment of Ennore Oil Spill during Michaung Cylcone (Detailed Report)

5. It is respectfully submitted that National Institute Of Oceanography, Goa submitted final report on 02.08.2024 titled "Pilot Studies for assessing Environmental Benefits for cleaning/bioremediation of oil spillage at designated locations in the Ennore Creek, Buckingham Canal, and Kosasthalaiyar River through the application of Biodispersant Comprising of Alkyl poly glucosides, Fatty Acids, & Botanical Extracts"

6. It is respectfully submitted that Environment, Climate Change and Forests (EC.3) Department, Government of Tamil Nadu had constituted a Technical Team vide G.O (Ms) No.178 dated 10.12.2023 with the following Experts/officers to ascertain the cause of the oil leak in the Ennore Creek area,

   a) Thiru.R.Kannan, Member Secretary, TNPCB - Chairman
   b) Dr.G.Saravanan, Principal Scientist, Chennai Zonal Centre, CSIR-NEERI –Member
   c) Ms.H.D.Varalaxmi, Scientist-E & Regional Director, Regional Directorate, Central Pollution Control Board, Chennai – Member
   d) Thiru V. Kumar, Commandant, Indian Coast Guard – Member
   e) Prof V.T.Perarasu, Department of Chemical Engineering, Anna University Chennai – Member.

7. It is respectfully submitted that Environment, Climate Change and Forests (EC.3) Department, Government of Tamil Nadu vide letter dated 24.06.2024 had instructed TNPCB to obtain comments of the above said

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JOINT CHIEF ENVIRONMENTAL ENGINEER
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No.76, MOUNT SALAI, GUINDY,
CHENNAI-600 032.

3

Expert Committee on the Report regarding Oil Spill Assessment at Ennore conducted by IIT Madras.

8. It is respectfully submitted that the meeting was conducted by TNPCB with the technical team members, IIT, Madras, NIO, Goa consist of Member Secretary, TNPCB, Regional Director, CPCB, Principal Scientist, NEERI, Anna University, Commandant, Indian Coast Guard on 03.09.2024 at TNPCB. Corporate Office Guindy regarding oil spill impact assessment study and bioremediation study conducted in the aftermath of oil spill incident at Ennore creek in December 2023. (Minutes of meeting enclosed in the Annexure - 1).

9. It is respectfully submitted that on the assessment of Ennore oil spill during Cyclone Michaung it is stated that to find out the source and pathway of the spill, the overall area was divided into three assessment regions and 20 areas were identified as oil-contaminated areas. The volume of oil is estimated in soil, in oil pools, as sheen on Buckingham Canal & Kosasathalaiyar river, in residential and industrial areas and on river banks and mangroves. On estimation, the oil present in the environment is 647 cu.m. or 517 tonnes (most conservative) to 3212 cu.m. or 2569 tonnes (least conservative).[IIT Report is enclosed as Annexure - II]

10. It is respectfully submitted that National Institute of Oceanography (NIO), Goa has submitted the pilot study on assessing environmental benefits for cleaning /bioremediation of oil spillage through the application of Biodispersants. They have conducted their study in 4 different locations (1 Control location & 3 Treatment locations). The total dosage for the three locations T1, T2 & T3 was fixed as 300 L, 300 Land 400 L respectively. Water Quality parameters such as pH, salinity, DO, BOD, TBC (Total Bacterial Count), TVC (Total Viral count), Chlorophyll, bulk PHC and sediment samples for TVC, TBC, bulk PHC were analyzed. Upon analysis, the location with higher concentration showed better results. However, NIO stated that the entire study is done at pilot scale and overall optimization of process parameters like dosage, area of treatment, treatment time etc, are required to gain exhaustive results.[NIO Report is enclosed as Annexure-III]

11. It is respectfully submitted that the above mentioned team has concluded with the following remarks:-

6/9/2024

JOINT CHIEF ENVIRONMENTAL ENGINEER
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No.76, MOUNT SALAI, GUINDY,
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a. In the final report by the Technical Team which was submitted to the Government in January 2024, the team had inferred that the quantity of oil washed away might be more than 400 KL. This was derived by the team based on the information such as slop oil quantity from daily operation, crude receipt quantities, total sludge accumulation in the premises, characteristics of slop oil, cleaning frequency etc.,

b. Now, IIT in their report has given their most conservative estimate as 647 cu.m. or 517 tonnes which is close to the technical team's observations.

c. Therefore, the total spilled oil may be considered as 647 cu.m or 517 tonnes for computation of damages caused. Assessment of the environmental damage caused by the oil spillage and the cost of restitution of environment will be calculated by the methodology adopted in the research publication "Oil spill & cleanup costs by Cao Thi Thu Trang, Institute of Marine environment & Resource, Vietnam". This methodology of cost calculation was used in similar NGT matter in OA No. 18 of 2020/EZ (Praveen Kumar Singh Vs Damodar Valley corporation &Ors.).

d. With this, the team will compute the Environmental Compensation within a period of 2 weeks.

e. Further, with regard to the bioremediation study by NIO, Goa, the team opined that the overall study including the dosage fixation was conducted in a trial & error basis. Therefore, extensive, long term studies with systemic approach & optimization is required to conclude about the efficiency of the bio-dispersants.

Therefore, it is humbly prayed that this Hon'ble National Green Tribunal, (SZ), may be pleased to pass such order or further or other orders as this Hon'ble Tribunal may deem fit and proper in the facts and circumstances of this case and thus render justice.

6/9/2024

JOINT CHIEF ENVIRONMENTAL ENGINEER
TAMIL NADU POLLUTION CONTROL BOARD
No.76, MOUNT SALAI, GUINDY,
CHENNAI-600 032.

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VERIFICATION

I, J. Josephine Sahayarani, D/o. Jesu Rajan, working as Joint Chief Environmental Engineer, having office at No. 76, Anna Salai, Guindy,Chennai-32, do hereby submit that the above contents are true to the best of my knowledge and belief through records.

J. Josephine Sahayarani
6/9/2024

JOINT CHIEF ENVIRONMENTAL ENGINEER
TAMIL NADU POLLUTION CONTROL BOARD
No.76, MOUNT SALAI, GUINDY,
CHENNAI-600 032.

7

ASSESSMENT OF ENNORE OIL SPILL DURING MICHAUNG CYLCONE

March 2024

Environment Engineering Division

Department of Civil Engineering

Indian Institute of Technology Madras, Chennai – 600036

Executive Summary

The "MICHAUNG" cyclonic storm caused extensive oil spillage from Chennai Petroleum Corporation Limited (M/s CPCL). The resulting contamination adversely affected biodiversity, daily life, and livelihoods in the impacted regions. IIT Madras research team conducted a comprehensive field assessment, mapping oil contamination across 20 zones. Notable hotspots included stormwater outlets of M/s CPCL, residential areas and industrial areas in Ennore. Field surveys, mapping efforts using drones, questionnaire surveys provided deep insights into the extent of oil contamination. Oil pools, sheens, and stains were observed in residential, industrial, and natural areas, threatening biodiversity, and public health.

Two sources of the oil spill into the environment were identified. One being the storm water discharge outlet at the south-eastern wall of CPCL into the Buckingham Canal and the other being the storm water canal discharging into surplus canal of Kosasthalaiyar River. The flood levels of the Kosasthalaiyar River rose to 5 to 6 ft above the Buckingham Canal bund level causing the entry of oil and water into the adjoining residential areas of Ernavoor and Sathyamoorthy Nagar. The mangroves along the banks and the islands in Kosasthalaiyar River were impacted up to a height of 10 ft near the surplus canal and 3 ft in other areas with complete loss of mangrove saplings. The team observed several dead fish and crabs and oil coated birds.

Laboratory analysis of water, soil and sediment samples revealed Total Petroleum Hydrocarbon (TPH) concentrations ranging from 0.28 to 7.21 g/L in water and 13.6 to 46.55 g/kg in sediments. The estimated volume of oil contamination in the environment ranged from 517 tonnes to 2097 tonnes without including oily sludge collected by CPCL and oil in inaccessible islands and sediments of Kosasthalaiyar River. The oil estimates from our assessment (517 tonnes) and the oily sludge removed by CPCL (395 tonnes) together sums up to 912 tonnes without including the inaccessible areas and bottom sediments of B Canal and K river. Fingerprinting analysis using GC-MS suggests that it could be slop oil or furnace oil or mix of both.

The Tamil Nadu Pollution Control Board's survey of M/s CPCL premises has suspected breaches in stormwater drainage systems and potential risks associated with oil storage and handling practices. An assessment of the open tanks in M/s CPCL premises indicated that 417 tonnes of oil could have been stored before flooding which is much less than 912 tonnes of oil estimated. This mismatch suggests that the flood induced release from the open tanks

may not have been the sole reason of the oil spill. Other possibilities could be breach of oil from enclosed storage tanks of CPCL premises. Urgent remedial actions are imperative to mitigate the environmental and socio-economic consequences of this oil spillage. Efforts should focus on environmental restoration, alongside regulatory measures to enhance industrial safety.

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1. Introduction

A severe cyclonic storm named "MICHAUNG" which formed over the Bay of Bengal, resulted in exceptionally heavy rainfall in the coastal districts of North Tamil Nadu and South Andhra Pradesh states (IMD, 2023). Chennai city experienced significant rainfall, with the Nungambakkam Meteorological Station recording a maximum of 530 mm between December 2 and 4, 2023. This extreme weather event had detrimental effects on the daily lives, livelihoods, and biodiversity of the affected regions.

Chennai Petroleum Corporation Limited, also known as CPCL, which stands as one of the foremost public sector refining companies in India, found itself at the centre of another crisis. Cyclone Michaung led to the leakage of oil deposits from M/s CPCL's guard ponds and stormwater drain ponds. These deposits were released on the flood plains of Kosasthalaiyar River and into the Buckingham Canal. The oil was carried along with the flood water through these waterways ultimately reaching the Ennore Creek and contaminating the Bay of Bengal.

The IIT Madras research team started their field campaign to assess the oil spill contaminations in water and sediments for a 12 km stretch in Buckingham Canal. The field campaign encompassed various activities, including flow measurements in Buckingham Canal, the collection of water and sediment samples, and mapping the spread of oil contamination in the affected area. This preliminary assessment report provides in-depth findings from both field investigations and laboratory analysis, offering insights into the severity of the oil spill contamination. Additionally, it provides a summary of the coast guard's estimation of the oil spill, along with insights gathered from the Tamil Nadu Pollution Control Board (TNPCB) Committee Report.

Figure 1: Oil spread near Ennore railway bridge

Figure 2: Oil contamination in Buckingham Canal

2. Mapping the Extent of Oil Contamination

IITM started their on-site investigations after the first response measures undertaken by CPCL. By then, oily sludge of 395 tonnes floating on the river and the banks were contained using booms and removed using skimmers (The Hindu Bureau, 2023). During our physical

survey by boat and by road between 14th and 26th December 2023, we observed oil marks along the banks of the Kosasthalaiyar River (K River) and the Buckingham Canal (B Canal), identifying 20 zones where oil accumulation was notably high.

Zone 1: Entry Point 1 - Storm water canal discharge into surplus canal of Kosasthalaiyar River
Zone 2: Kattukuppam
Zone 3: B/w railway and road bridge
Zone 4: Near Ennore railway bridge
Zone 5: Thazhankuppam
Zone 6: Ennorekuppam
Zone 7: Nettukuppam
Zone 8: Bridge pier/island in K River - Sadayankuppam
Zone 9: Oil overflowed along B Canal
Zone 10: In mangrove islands
Zone 11: Ernavoor and Sathyamoorthy Nagar residential area
Zone 12: Ernavoor and Sathyamoorthy Nagar industry/marsh accessible areas
Zone 13: Storm water drain outside M/s CPCL
Zone 14: Storm water drains inside M/s CPCL
Zone 15: Land area within M/s CPCL, IAL, Steel
Zone 16: Oil staining the soil embankment in B Canal and K River
Zone 17: Oil staining the mangroves
Zone 18: River and canal sediments
Zone 19: Marine sediments and oil lost to sea
Zone 20: Entry Point 2 - Storm water discharge outlet at the south-eastern wall of CPCL into the Buckingham Canal

There was a large amount of oil stagnation near Ennore Creek (Zone 19) due to the combination of tidal activity and the river mouth's influence. In this season, the wave and tidal movements tend to carry particles toward the shoreline in a southwest direction. As a result, it takes longer for substances such as oil, to be dispersed back into the ocean. Zone 1 is a hotspot where a large influx of oil came from the storm water drain from M/s CPCL, entering the floodplains of K River, and eventually contaminating the river. In all the

accessible zones we had collected soil, water and some river sediment samples and quantified the oil that had been contaminated.

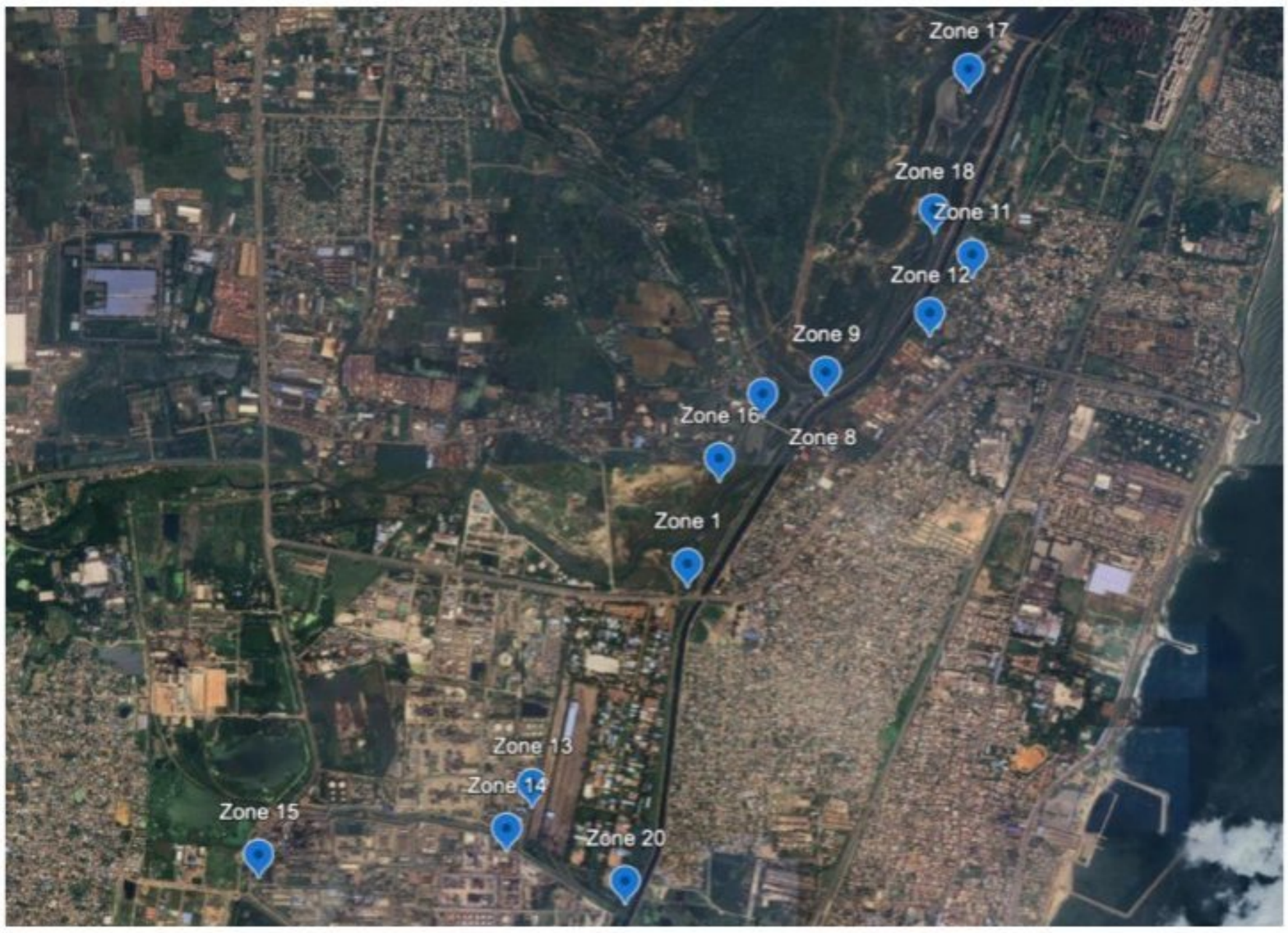

Figure 3: Contamination Zones from CPCL premises to the midstream of Buckingham Canal

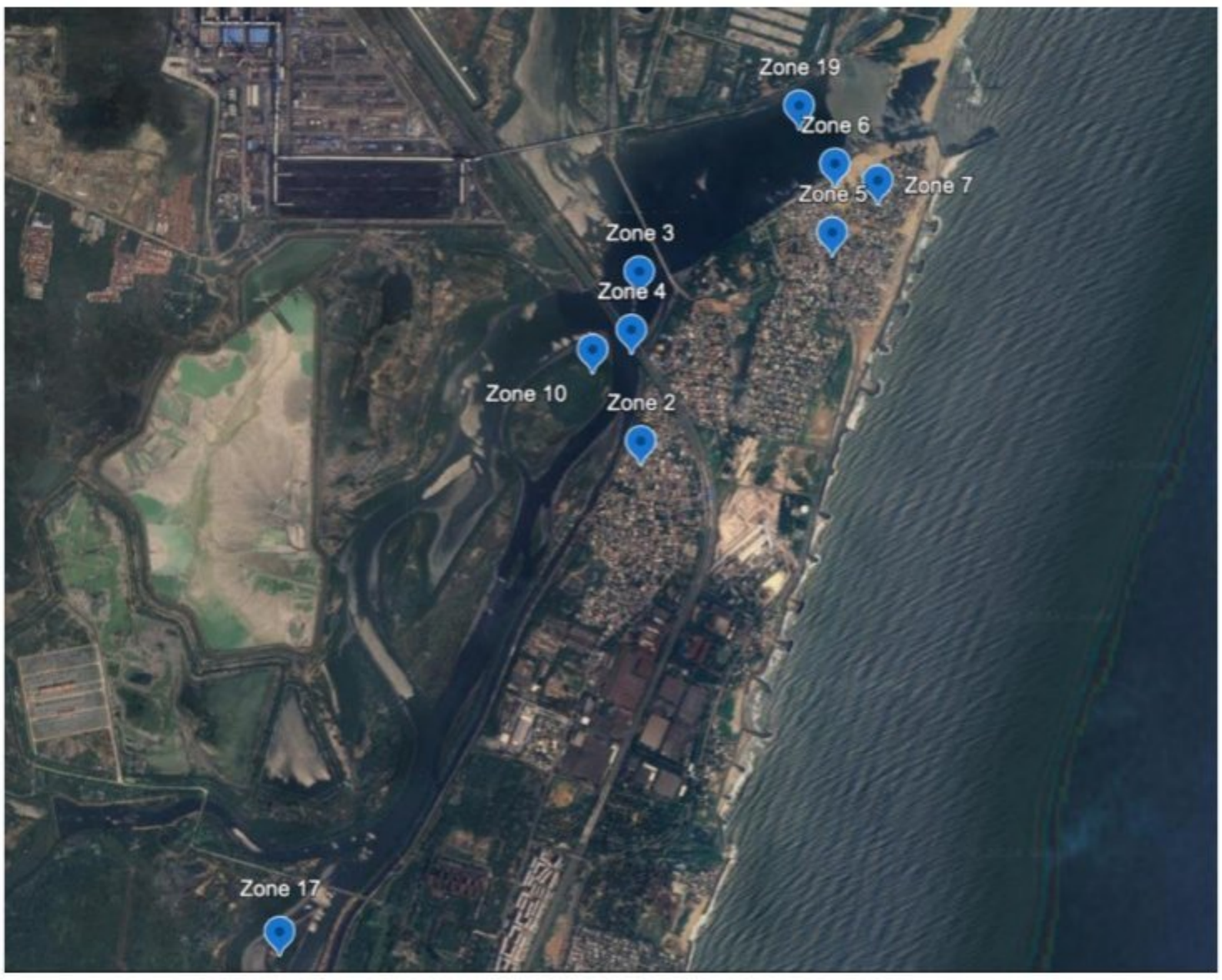

Figure 4: Contamination Zones from midstream of Buckingham Canal to Ennore Creek

During the flood event, B Canal experienced overflow of oil mixed water, inundating the residential areas of Ernavoor (Zone 11). Lamp posts positioned within the residential vicinity along the B Canal exhibited signs of oil spillage, while flood-affected houses showed oil stains on their walls, reaching heights of 5 to 6 feet. The overflowing oil mixed water adversely affected vegetation, residential buildings, vehicles, and the open wells that serve as sources of groundwater. The field images below provide visual representation of the extent of oil contamination within the residential zones of Ernavoor.

Figure 5: Highest oil mixed water level 7.5 feet above normal water level during the cyclone

Figure 6: Collection of samples from the oil overflown along the banks of B Canal.

Figure 7: Oil marks observed in the residential localities of Ernavoor.

Assessment Regions:

The extensive presence of heavy oil was detected in various locations along our route, indicating a significant spill. IIT Madras team surveyed along the B Canal and K river to identify the extent of the spill along the width and length of the waterways. We have divided the assessment regions to three stretches:

1. Downstream from Ennore Thermal Power Station (ETPS) to Creek:

Figure 8: Assessment Region 1 - Downstream from ETPS to Creek Area

The depicted figure illustrates the flow of oil, represented by red arrows, along the B Canal and K River after the floodwaters receded. Dotted lines signify the presence of oil stains along all banks of these water bodies and islands. Hotspots, where substantial oil deposits occurred, are highlighted as red patches along the eastern banks of the Creek, extending from Kattukuppam to Nettukuppam.

2. Midstream from Ennore Thermal Power Station (ETPS) to Manali High Road Bridge:

The midstream stretch of B Canal extending from the junction of K River and surplus canal from Redhills up to ETPS is the crucial area to pay attention. The surplus from Puzhal and Poondi Lakes discharged high quantum of water into the two K River branches which trapped the oil in this mid-stream stretch. The flood water rose to 7 to 9 ft in this section carrying the

oil with it, over the B Canal bank into the adjoining residential and industrial areas of Ernavoor and Sathyamoorthy Nagar. Once the flood water/surplus water receded, the oil must have flown downstream into the Kattukuppam all the way to Nettukuppam.

Figure 9: Assessment Region 2 - Midstream From ETPS to Manali High Road Bridge

3. Upstream of B Canal from Manali High Road to Kodungaiyur

Two oil discharges from the M/s CPCL stormwater drain have occurred in the locations: one in the south (entry point 2), directly into the B Canal, and another in the north (entry point 1), flowing through the stormwater drain adjacent to India Additives, into the flood plains of K river (Zone 1 indicated by the large red patch). Stormwater drains within M/s CPCL were tracked, revealing breaches in the outlet and walls, with all drains and tanks heavily stained with oil. Numerous open oil-water collection tanks were present at ground level, lacking preventive measures to contain oil during flooding or to prevent its escape from the premises.

Figure 10: Assessment Region 3 - Upstream of B Canal from Manali High Road to Kodungaiyur showing the entry point of oil into the Buckingham Canal and Kosasthalaiyar River

The soil samples collected at Zone 1 had oil markings present up to 2m (max.) depth from the surface. This may have long-term impacts on the region as it is mostly an unconfined aquifer where there are possibilities of contamination of the ground water.

Figure 11: Drone image of Zone 1

Figure 12: Close up view of Zone 1

Verified through drone camera images, the dark patches in the above image signify the presence of oil pools surrounding the stormwater outlets flowing towards the K River. Extensive sampling of soil and water at this contaminated site revealed high oil content. Upstream from this contaminated site, deposits of oil-contaminated sludge are still present, likely resulting from backflow from this leakage point. However, no significant oil spill or sludge deposition was observed beyond 100 meters from this location, indicating that Zone 1 is likely the initial point of oil spillage or the source itself.

Figure 13: Earth moving machinery at the oil spill site

Figure 14: B canal possibly breached and oil stain covered.

Numerous earthmoving machines were on-site (Figure 13), along with several laborers tasked with covering the oil stains in the floodplain. Arrows pointing towards the two locations in the Buckingham Canal (Figure 14) distinctly indicate that the bund has been reworked following the oil spill, with one section appearing clean and the other section visibly stained with oil.

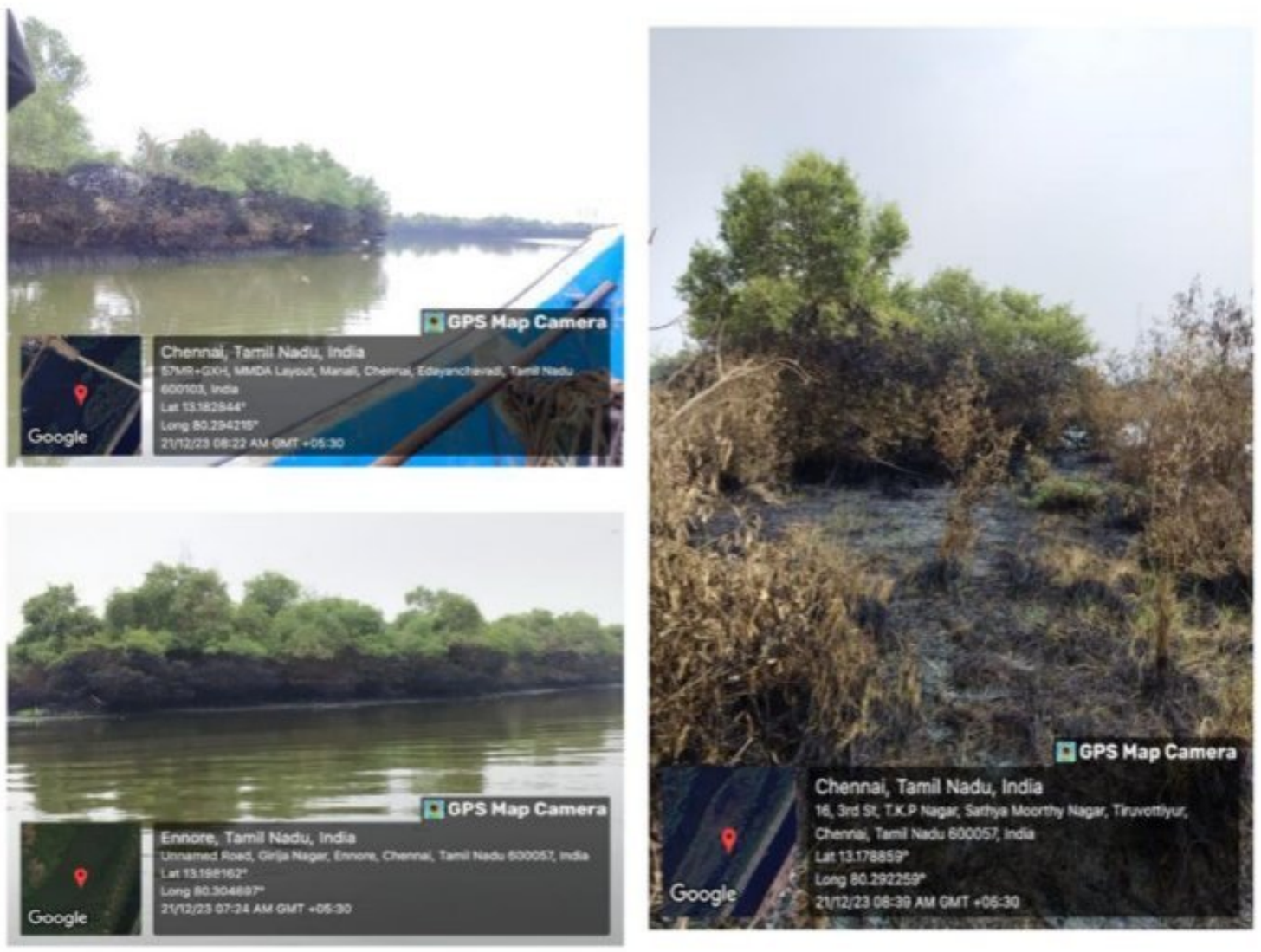

Figure 15: Mangroves with severe oil contamination

Figure 16: Dead birds, crabs, and fishes found in the contaminated site

The oil spill has posed a significant threat to biodiversity (Figure 15 and 16) in the affected area, impacting mangroves and various organisms such as crabs, fishes, and birds.

3. Field Assessments and Sampling

Field assessments were conducted along Buckingham Canal utilizing boats and by road in areas inaccessible by boat. Water and sediment samples were systematically collected at 500-meter intervals. Water samples, including any oil present, were obtained from both the top and bottom of the canal using a bailer. The depth of the canal was measured with a staff gauge, and flow velocity was assessed using an ultrasonic flow sensor. Sampling locations along a 12 km stretch from Indian Oil Cooperation Limited (IOCL) in Tondiarpet to Ennore Creek in Buckingham Canal are illustrated in Figure 2. Soil sediments and oil deposits were collected using a grab sampler and analysed in the laboratory for Total Petroleum Hydrocarbon (TPH) via gravimetry and gas-chromatography analysis.

Figure 17: Sampling locations along Buckingham Canal

Figure 18: Collecting sediment samples using a grab sampler

Figure 19: Sediment sample collection from midstream and banks

Figure 20: Depth measurement

Figure 21: Sampling of soil cores

Figure 22: Collecting water samples using a bailer

3.1 Drone Surveys

A drone survey was carried out to quantify the oil contamination spatially. Drones were employed to capture the hyper-spectral aerial images, that will help us differentiate water from oil. The drone images captured (Figure 24) show the oil sheen floating on B canal and K River.

Figure 23: Capturing high-resolution images using drone survey

Figure 24: Drone images showing oil contamination in B Canal and K River

3.2 Water Characteristics Measured Insitu:

In-situ water quality measurements, such as pH and total dissolved solids (TDS), were taken using a field probe, revealing pH values ranging from 7.4 to 8.0 and TDS values between 500 and 850 mg/L. The table below shows the insitu-water characteristics of the water samples.

Table 1: Insitu- water characteristics

Sample ID	Latitude	Longitude	Water level [m]	pH		TDS [mg/L]	
				Top water	Bottom water	Top water	Bottom water
SL 1	13.2200	80.31833	0.5	7.88	-	842	-
SL 2	13.21666	80.31638	1	7.97	7.80	804	855
SL 3	13.21305	80.31416	1	7.95	8.04	852	845
SL 4	13.20916	80.3125	1	7.92	7.99	844	840
SL 5	13.205	80.31027	1.5	7.88	7.94	824	824
SL 6	13.20217	80.30834	-				
SL 7	13.15433	80.28454	-	7.66	-	671	-
SL 8	13.1415	80.27866	-	7.63	7.73	683	700
SL 9	13.16015	80.2876	-	7.47	7.44	761	795
SL 10	13.16441	80.28916	-	7.7	7.65	740	744
SL 11	13.16938	80.28973	-	7.78	7.67	786	765
SL 12	13.17541	80.29114	-	7.61	7.54	733	752
SL 13	13.17923	80.29366	-	7.51	7.59	732	741
SL 14	13.18276	80.29591	-	7.66	-	634	-
SL 15	13.19324	80.30388	-	7.66	7.62	736	739
SL 16	13.18568	80.29944	-	7.87	7.72	759	751
SL 17	13.18949	80.30199	-	7.81	7.52	770	778
Nettukuppam	13.2311	80.32602	0.9	7.71	7.78	496	758
Thazhankuppam	13.22935	80.32321	0.8	7.77	7.68	581	624
DonBosco	13.22817	80.32137	0.6	7.93	8.00	457	498
EnnoreBridge	13.22726	80.3205	0.5	7.06	7.12	586	560
Salt Bungalow	13.22573	80.31999	0.7	7.04	7.11	536	924

3.3 Flow Measurement

Water flow measurements were carried out using an ultrasonic flow measurement device - FLOWFLAT. The velocity values ranged from 0.1 m/s to 0.7 m/s. The measurements were conducted in 10 locations within the B Canal and Ennore Creek at different depths based on the location's available flow depth. The table below summarises the velocity magnitudes in the B Canal and Ennore Creek.

Table 2: Velocity values in different locations of B Canal

ID	Velocity [m/s]	Depth of flow [m]	Depth of velocity measurement [m]
L2	0.255	0.5	0.15
	0.385		0.40
L3	0.645	1	0.40
	0.734		0.90
L4	0.334	1	0.30
	0.390		0.90
L5	0.400	1.5	0.50
	0.452		1.00
	0.496		1.20
L6	0.214	0.3	0.25
L7	0.308	0.15	0.10
L10	0.104	0.2	0.10
	0.117		0.15
L12	0.150	0.38	0.15
	0.472		0.35
Nettukuppam	0.214	0.9	0.30
	0.243		0.6
Thazhankuppam	0.105	0.8	0.3

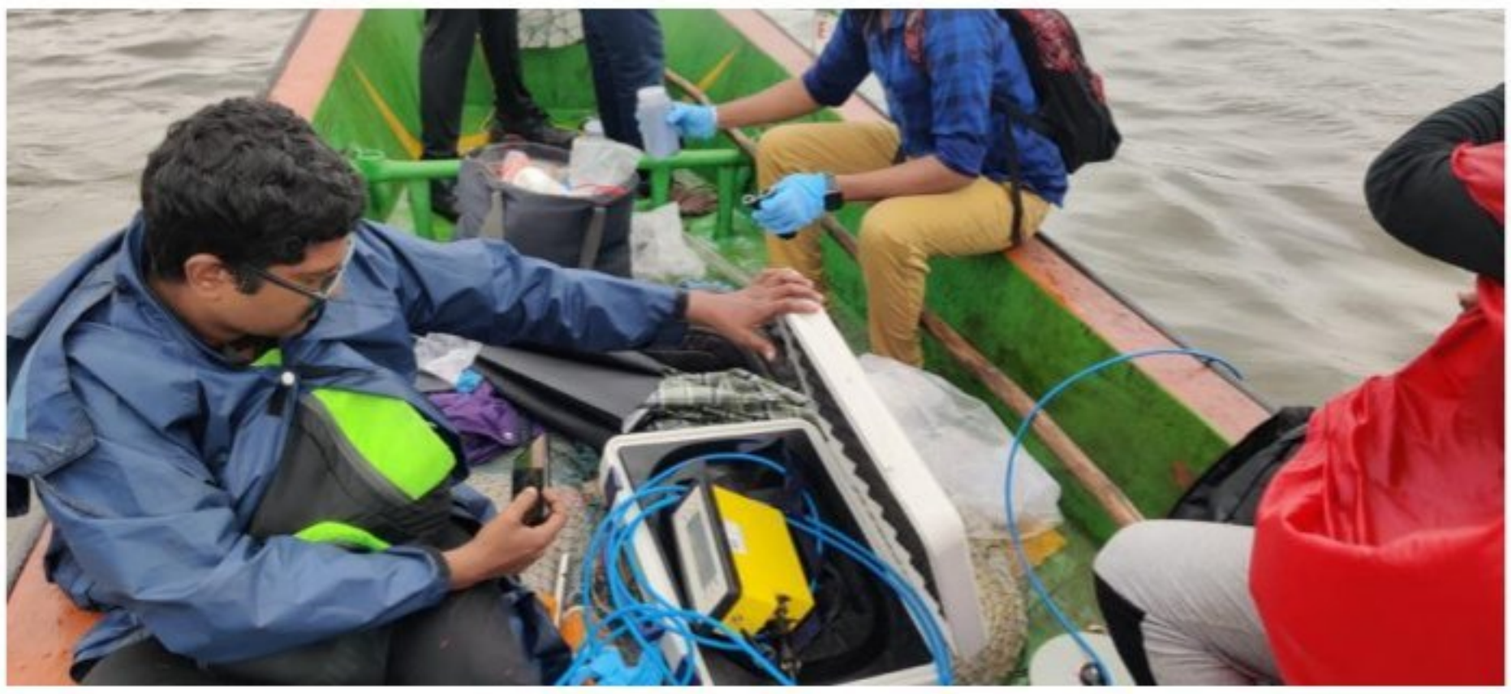

Figure 25: Water quality using field probe and flow measurement using FLOWFLAT

3.4 Flood Water Level Measurement at M/s CPCL Premises

The installation of water level meters at M/s CPCL by IIT Madras provided valuable data regarding the timing and extent of the peak water level, particularly noting the peak occurring on December 5th, 2023. This suggests that a significant influx of water has exacerbated the spread and impact of the oil spill in several ways.

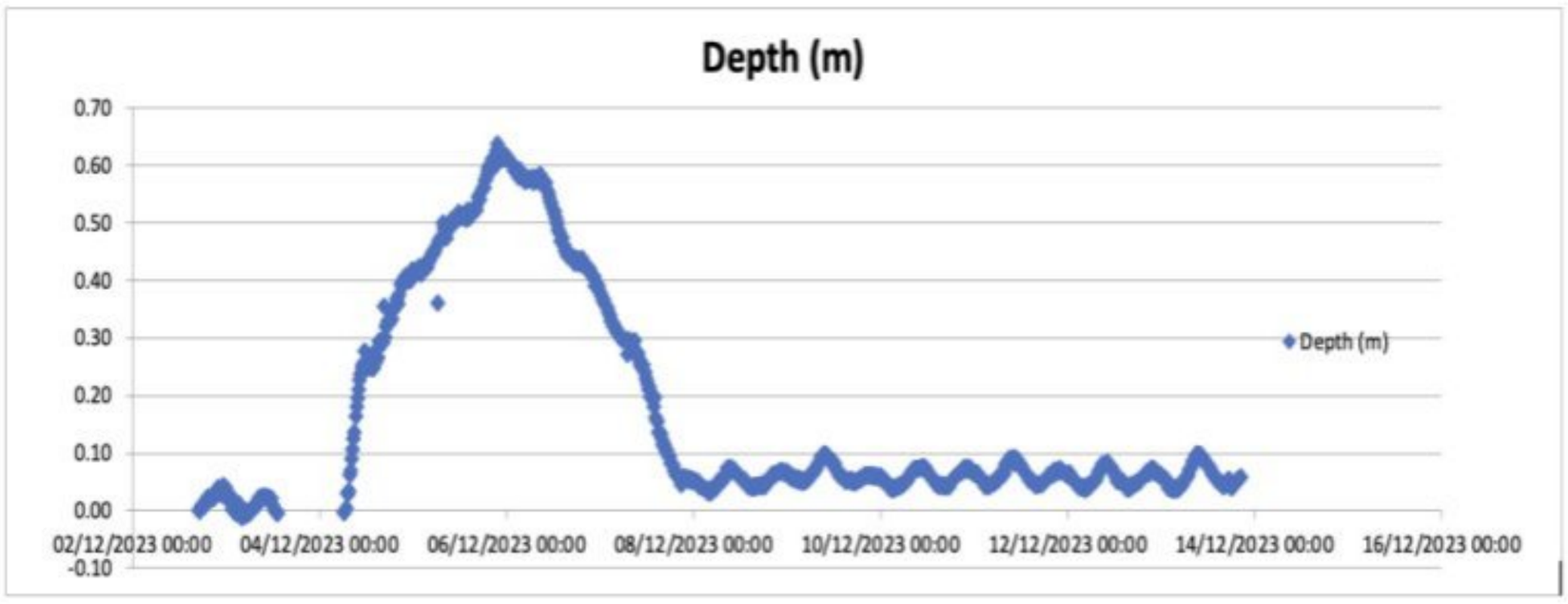

Figure 26: Water level metre at M/s CPCL West Gate

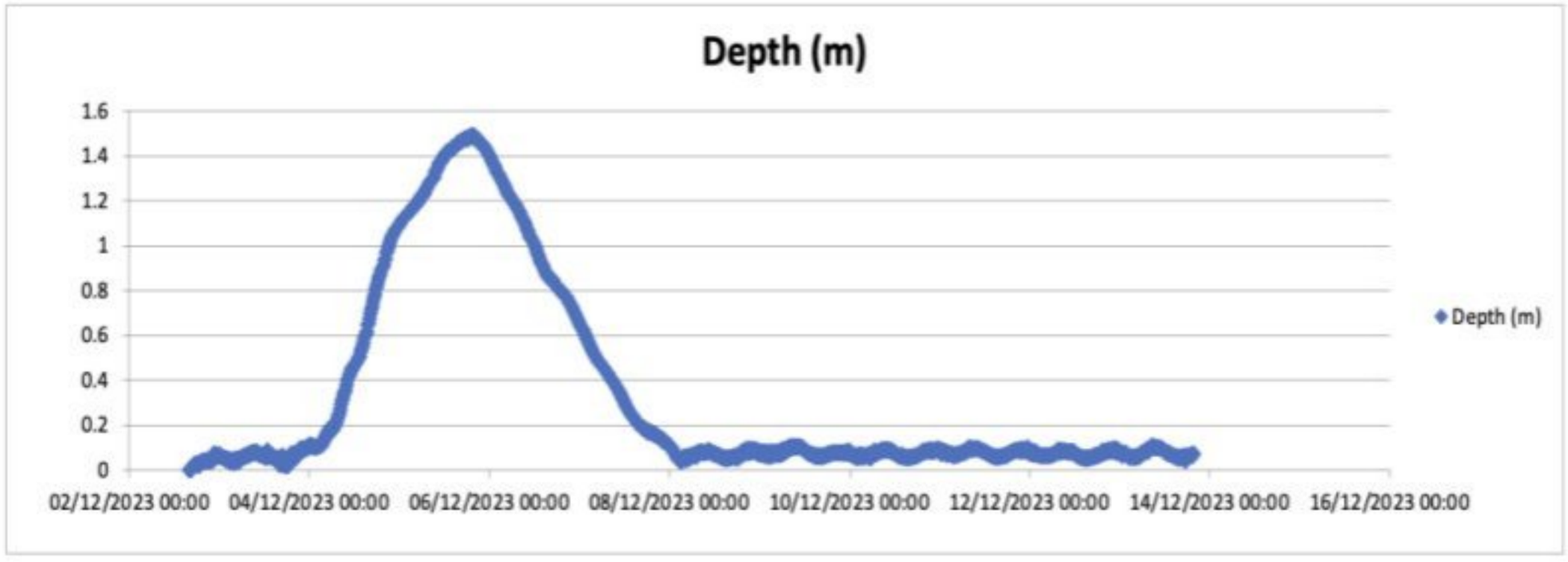

Figure 27: Water level metre at Bottling plant at CPCL

4. Laboratory Analysis

Oily sludge, a semi-solid waste, contains hazardous hydrocarbon substances and is composed of an emulsion of water, petroleum hydrocarbons, heavy metals, and solid particles. Water and sediment samples collected continuously over a three day period in various locations along the B Canal and Ennore Creek were subjected to analysis for Total Petroleum Hydrocarbon (TPH) utilizing both gravimetric and gas chromatography-mass spectrometry (GC-MS) methods. The TPH content in water ranged from 0.28 to 7.21 grams per litre (g/L), while in sediments, it ranged from 13.6 to 46.55 grams per kilogram (g/kg). These findings indicate the extent of hydrocarbon contamination in both the aquatic environment and sedimentary deposits within the affected areas.

Table 3: TPH concentrations in water and sediments/soil

Contaminations in 7 Zones which notably showed a high level of oil contamination		**Water**	**Sediment/Soil**
Location	**Area [sq.m.]**	**TPH conc (g/L)**	**TPH (g/Kg)**
Zone 1 Entry Point 1 - Storm water canal discharge into surplus canal of Kosasthalaiyar River	100601	1-2.27	13.6-30.44
Zone 2 (Kattukuppam)	3007	6.195 - 7.21	NA
Zone 3 (B/w railway and road bridge)	3163	5.32-7.13	18-31.8
Zone 4 (Near Ennore railway bridge)	2886	1.02-2.5	15.32-41
Zone 5 (Thazhankuppam)	5139	0.28-0.54	38-40.38
Zone 6 (Ennorekuppam)	3742	sample not collected	sample not collected
Zone 7 (Nettukuppam)	3232	2.45-3.01	46-46.55
Location	**Area [sq.m.]**	**TPH conc (g/L)**	**TPH (g/Kg)**
Buckingham Canal	121765	0.43-3.29	33-110
Kosasthalaiyar River	1032988	0.44-0.97	17-38.9
Residential areas near B Canal (oil pool)	11403	NA	24-120

Gas Chromatography Mass Spectrometry analysis was conducted to determine the type of oil that was spilled during the floods. A total of four samples, specifically the field sample, crude oil, furnace oil, and slop oil, were subjected to analysis using GC- MS. The chromatogram of the field sample was compared with those of crude oil, furnace oil, and slop oil to accurately identify the source of the oil. Upon examination of the chromatogram patterns, a precise retention time match was identified between the field sample and furnace oil. However, upon analysing the individual compounds in each chromatogram (across all four samples) for their m/z fragmentation pattern, it was noted that many compounds in the field sample (such as Decane, Dodecane, Tridecane, Hexadecane, Phytane, etc.) corresponded with those in slop oil and furnace oil. Consequently, it is plausible that the oil present in the flood water originated from either furnace oil or slop oil. To precisely identify the source of the oil type, bio-marker fingerprinting analysis is required.

5. Quantification of Oil in the Contaminated Areas

The total oil present in the major environmental compartments during our sampling events in the 19 zones can be summarized into five categories:

a. Oil present in soil:

The soil contamination extent was surveyed by boat and by road through physical investigation and through drone investigation to identify the impacted zones. The total area of the impacted zones were estimated using Google Earth Pro. The depth of soil contamination varied between 1-2.5 feet in Zone 1 to 8. Estimates referring to the results of laboratory analysis an average oil concentration of 30g/kg was considered for the estimates. The volume of oil that could be entrapped in the soil is within the range of 487 cu.m. to 1623 cu.m.

Table 4: Volume of oil estimated in soil

Oil contamination in Soil		Volume of soil contaminated (cu.m.)	Mass of soil contaminated (kg)	Oil measured in soil (concentration ~30g/kg)	Oil in cu.m.	Assuming only 30% of the soil is contaminated
Location	**Area (sq.m.)**	**Upto 1 foot depth cu.m.**				**Sn = 0.3**
Zone 1: Entry Point 1 - Storm water canal discharge into surplus canal of Kosasthalaiyar River	30296	9088.8	24085.32	722.55	903.19	**270.95**
Zone 2 (Kattukuppam)	3007	902.1	2390.56	71.71	89.64	**26.89**
Zone 3 (B/w railway and road bridge)	3163	948.9	2514.58	75.43	94.29	**28.28**
Zone 4 (near Ennore railway bridge)	2886	865.8	2294.37	68.83	86.03	**25.81**
Zone 5 (Thazhankuppam)	5139	1541.7	4085.50	122.56	153.20	**45.96**
Zone 6 (Ennorekuppam)	3742	1122.6	2974.89	89.24	111.55	**33.46**
Zone 7 (Nettukuppam)	3232	969.6	2569.44	77.08	96.35	**28.90**
Zone 8 (bridge pier/ island in K River near Sadayankuppam)	3000	900	2385	71.55	89.43	**26.83**
Total volume of oil in cu.m. accounted so far are conservative estimates.					1623.73	**487.12**

Figure 28: Soil Contamination Zones

Figure 29: Soil Contamination Zones

b. Oil pools in islands and B Canal overflow:

Oil was found ponding along the B Canal in the upstream stretch where maximum flood levels had taken the oil above the bank of the canal and into the eastern residential and industrial areas. Oil was also found ponding within the mangrove islands after the flood water receded. Largest oil ponding was observed in Zone 1. Area of the contamination zones for oil pools were estimated using Google Earth Pro. The volume of oil ponded could be anywhere between 31.4 cu.m. to 314 cu.m.

Table 5: Volume of oil estimated in oil pools

Oil pools in hotspots	Area (sq.m.)	1 mm ponding depth	5 mm ponding depth	10 mm ponding depth	Lowest Estimate (1mm)
Overflowed along B canal	11403	11.40	57.01	114.03	**11.40**
In mangrove islands	10000	10	50	100	**10**
Oil pool near pipelines	10000	10	50	100	**10**
Total volume of oil in cu.m.		31.40	157.01	314.03	**31.40**

Figure 30: Oil pools on K river flood plain

c. Oil sheen on B Canal and K River:

Oil sheen was found on B Canal and K river, where the volume of oil has been calculated for 10 micron and 50 micron sheen thickness. Area of the contamination zones for oil sheen were provided by the coast guard. A conservative estimate would be between 1.21 cu.m. to 10.32 cu.m for 10 micron thickness. It should be noted that CPCL has already removed major part of the oily sludge floating on the river using booms and skimmers amounting to 395 tonnes.

Table 6: Volume of oil as oil sheen estimated on B Canal and K River

Oil sheen in water courses from drone				
Location	**Area (sq.m)**	**Sheen thickness - 10 micron**	**Sheen Thickness - 50 micron**	**Lowest Estimate (10 micron)**
Buckingham Canal	121765	1.21	6.08	**1.21**
Kosasthalaiyar River	1032988	10.32	51.64	**10.32**
Total volume of oil in cu.m.			57.73	**11.54**

d. Oil present in residential and industrial areas:

A survey team was deployed to assess the spread of oil in the residential and industrial zone. The team marked the oil level and referenced it with Mean Sea level using DGPS survey at every location. Three levels of inundation with total area inundated and the oil level in each zone was marked in different colours.

The area under each zone is given below along with presumed depth of oil which was present when the flood water inundated their area. The average quantum of oil inundation is estimated as 117 cu.m. assuming only 0.1 mm of oil.

Figure 31: Map showing three levels of inundation

Table 7: Volume of oil estimated in residential and industrial areas

Oil mark in the residential areas (physical survey)	Area [sq.m.]	0.1 mm oil layer	0.5 mm oil layer	1 mm oil layer	5 mm oil layer	Lowest Estimate (0.1 mm)
Ernavoor high impact > 1m	452959	45.29	226.47	452.95	2264.79	**45.29**
Ernavoor medium impact 0.5 to 1.0.m	628017	62.80	314.00	628.01	3140.08	**62.80**
Ernavoor low impact <0.5 m	31700	3.17	15.85	31.7	158.5	**3.17**
Behind IOCL	66135	6.61	33.06	66.13	330.67	**6.61**
Total volume of oil in cu.m.		117.88	589.40	1178.81	5894.05	**117.88**

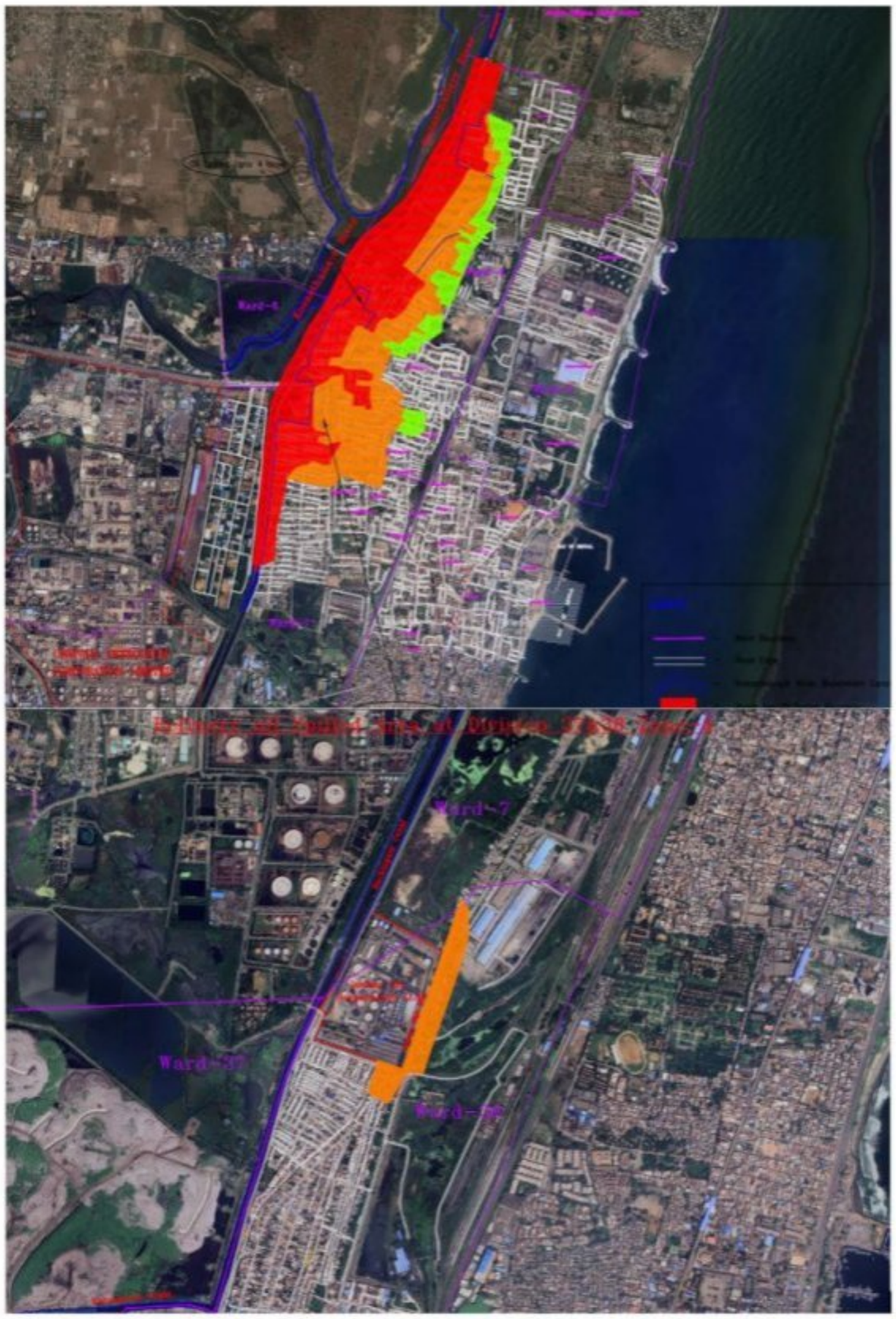

Figure 32: Close up view of the affected residential and industrial areas

e. Oil stains on mangroves and river banks:

Based on the observed length and height of the stains left behind on the banks of the K river and B canal, we estimated the oil on the river banks and mangroves assuming different thicknesses of oil layer starting from 0.01 mm, 0.1 mm and 1 mm. The average volume of oil inundation is conservatively estimated as 0.3849 cu.m. assuming only 0.01 mm of oil was floating on water.

Figure 33: Classifying the K river with the height of the oil mark in different stretches

Table 8: Volume of oil estimated on mangroves and river bank

Oil stain on banks	Length in km	Height of oil mark in m	0.01 mm	0.1 mm	1 mm	Lowest Estimate (0.01 mm)
Buckingham canal sections	15.1	0.3	0.04	0.45	4.53	**0.04**
Kosasthalaiyar section 1 (CPCL pipe line to B Canal intersection)	11.4	0.3	0.03	0.34	3.42	**0.03**
Kosasthalaiyar section 2 (CPCL pipeline to B Canal intersection)	5.8	0.3	0.01	0.17	1.74	**0.01**
Kosasthalaiyar section 3 (CPCL to Kaatukuppam)	4.7	0.3	0.01	0.14	1.41	**0.01**
Ennore Creek (Kattukuppam to Kosathalaiyar River mouth)	1.9	0.3	0.0057	0.057	0.57	**0.0057**
Oil stain on mangroves						
Kosasthalaiyar section 1, 2ft oil mark	11.4	0.6	0.068	0.68	6.84	**0.068**
Kosasthalaiyar section 2, 5ft oil mark	5.8	1.5	0.087	0.87	8.7	**0.087**
Kosasthalaiyar section 3, 8ft oil mark	4.7	2.4	0.11	1.12	11.28	**0.11**
Total volume of oil in cu.m.			0.38	3.84	38.49	**0.38**

Overall Estimates:

The oil present in the environment as observed between December 14th TO 24th, 2023 and reconfirmed on February 22nd, 2024 based on our best possible estimates and accessibility are below:

a. Oil present in soil – Estimated between 487 to 1623 cu.m. (*Not including M/s CPCL land area, inaccessible industry areas and marsh areas)
b. Oil pools in islands and B canal overflow – Estimated between 31.4 cu.m. to 314 cu.m.
c. Oil sheen on B Canal and K River: Estimated between 11.55cu.m. to 57.74 cu.m.
d. Oil stains and inundation in residential area – Estimated between 117 to 589 cu.m.
e. Oil stains on mangroves and river banks – Estimated between 0.3849 to 38.49 cu.m.

In summary the oil present in the environment is 647 cu.m. or 517 tonnes (most conservative) to 2622 cu.m. or 2097 tonnes (least conservative). The range is provided here considering the uncertainty of the depth of oil in pools, extent of depth and uniformity of soil contamination, film thickness on mangroves and walls of the residential areas.

Also these estimates has not been considered:

1. ***Floating oily Sludge removed by CPCL from the surface water and banks of Kosasthalaiyar river and Buckingham canal (395 tonnes as reported in the news media).***
2. ***Sediments - Only random samples (Oil concentration: 1000-30,000mg/kg) had been taken and a complete assessment cannot be done due to flowing water. We can take it up in future studies which will be conducted in more detail for impact assessment.***
3. ***Water – Variable with time and space due to continuous leaching of oil from banks and soil and sediment. However, it remains relatively minor compared to soil contamination.***
4. ***Other upstream locations inside and outside CPCL inundated by high flood where oil was observed.***
5. ***Inaccessible islands and marshlands of Kosasthalaiyar River.***
6. ***Oil released into sea and coasts beyond Ennore Creek.***

7. ***CPCL premises – Soil and Storm water drains within premises which were observed to have oil.***

6. Oil Estimates in Open Tanks of M/s CPCL

Google Earth images were used to assess the open tanks in M/s CPCL close to the two storm water outlets. The total area of these open tanks are worked out as 95,058 sq.m.

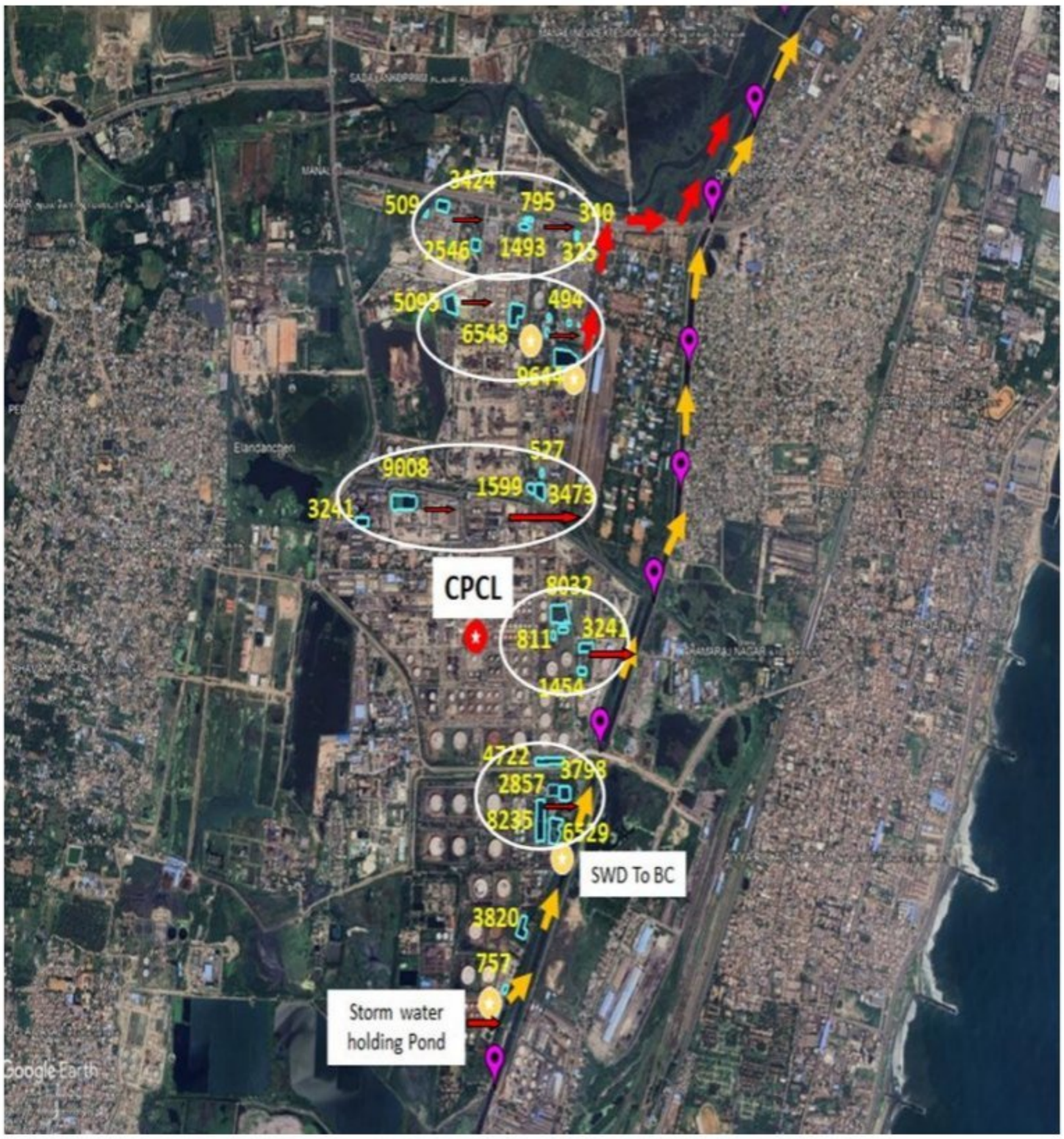

Figure 34: Open tank locations and area in sq.m.

We identified 12 out of 29 tanks containing oil-contaminated water, with six of them discharging into the stormwater drain located north of M/s CPCL (Zone 1), while the remaining six drained into the southern drain of the premises (Zone 20). Table 9 provides an

average estimate of the volume of oil stored in these tanks based on varying oil thicknesses of 1 mm, 5 mm and 10 mm.

Table 9: Location and area of open tanks present in M/s CPCL

Tank ID	Latitude	Longitude	Open tank Area sq.m]
0	13.1585	80.2839	3241
1	13.1747	80.278	2547
2	13.159	80.2821	812
3	13.1592	80.2826	1192
4	13.1598	80.2825	8032
5	13.1644	80.274	9008
6	13.1648	80.2809	1599
7	13.1647	80.2814	3473
8	13.1654	80.2816	527
9	13.17	80.2829	9645
10	13.1719	80.2802	6544
11	13.1764	80.2762	3424
12	13.1757	80.281	795
13	13.1754	80.2807	1493
14	13.1723	80.2766	5096
15	13.1714	80.2832	483
16	13.1713	80.2837	129
17	13.1751	80.2836	341
18	13.1749	80.2836	326
19	13.1761	80.2752	509
20	13.1711	80.2819	714
21	13.1717	80.282	491
22	13.1637	80.2716	3241
23	13.1476	80.2802	3820
24	13.1514	80.2821	6529
25	13.1518	80.2813	8236
26	13.1528	80.2826	3799
27	13.1576	80.2836	1454
28	13.1529	80.282	2857
29	13.1541	80.2818	4702

Table 10: Volume of oil estimated in the open tanks of M/s CPCL

	Tanks that drain to northern storm water drain	**Tanks that drain into southern storm water drain**
	6544	3799
	9645	2857
	491	8236
	1599	6529
	3473	4701
	527	3820
Total area of tanks sq.m.	**22279**	**29942**
Volume of oil in tanks in cu.m. assuming 1 mm	22.27	29.94
Volume of oil in tanks in cu.m. assuming 5 mm	111.39	149.71
Volume of oil in tanks in cu.m. assuming 10 mm	222.79	299.42

The volume of oil estimated in these exposed tanks amounts to 522 cubic meters or 417 tonnes, representing an oil thickness of 10 mm. The oil estimates from our assessment (517 tonnes) and the oily sludge removed by CPCL (395 tonnes) together sums up to 917 tonnes without including the inaccessible areas and bottom sediments of B Canal and K river. This mismatch suggests that the flood induced release from the open tanks may not have been the sole reason of the oil spill. Other possibilities could be breach of oil from other storage tanks of CPCL premises. Fingerprinting analysis using GC-MS suggests that it could be slop oil or furnace oil or mix of both.

7. Coast Guard Assessment:

On the 14th or 15th of December 2023, an assessment was conducted by the coast guard to estimate the oil spill, ten days after the flooding incident. Despite the passage of time,

remnants of oil and sheen were still detected in both inland water bodies and the sea. Estimates were derived from observations made via their helicopter-mounted camera, revealing approximately 11.6 cubic meters of oil in inland water and 12.4 cubic meters in the sea.

It's important to note that these figures may underestimate the actual volume of oil present, as there could have been higher levels of oil in the intervening days between the spill release and the assessment on December 15th. Additionally, the assessment did not fully account for the oil present in various other environments. This includes oil present in the soil, pooled on land surfaces, present on islands, coating the banks of rivers, and the stains on mangrove forests. The assessment also did not consider oil dispersed within water columns or deposited within sediments. Therefore, the actual extent of the oil contamination may be greater than indicated by the coast guard's estimate. For more detailed infirmation please refer to Appendix A

8. Tamil Nadu Pollution Control Board's Survey of M/s CPCL Premises:

The Tamil Nadu Pollution Control Board deployed its technical team to conduct an inspection at M/s CPCL, where they identified areas of concern. A Technical Committee Report was subsequently released, evaluating various sections including the stormwater drainage system, petcoke processing area, the ETP area, sludge storage tanks and ponds, sludge bioremediation process area, and crude oil storage area. Numerous observations were documented during the inspection, indicating potential areas of environmental risk.

According to the report, the average quantity of slop oil collected from different sources of the M/s CPCL premises and stored in slop tanks typically ranges between 50 KLD to 150 KLD. However, during the flood, this collection process would likely have been halted, presenting a substantial risk of washout from the ponds and effluent treatment plants. Additionally, the accumulation of oil-bearing sludge in the sludge ponds that occurred due to the maintenance of eight crude oil/sludge storage tanks, also posed a potential risk of overflow into nearby drains and water bodies during the flood. The team estimated that more than 400 KL of slop oil may have been washed away due to rising water levels. Despite

severe weather alerts, M/s CPCL reportedly lacked sufficient precautionary measures to address oil spillage, highlighting a critical gap in disaster preparedness. For more information on quantity of slop oil collected, total quantity of sludge, mass balance etc., please refer to Appendix B.

9. Recommendations and Scope for Future Work

Recommendations for Future Actions:

1. Conduct Post-Restoration Assessments: It is imperative to conduct thorough assessments after the restoration efforts of Kosasthalaiyar River, its sediments, islands, mangroves and flood plains at the surplus canal before declaring previously contaminated zones as safe. If oil residues are found restoration activity should be initiated again considering the sensitivity of the ecosystem including soil, water, flora and fauna.
2. Enhance Storage Infrastructure: Consider elevating oil sludge and slop oil storage tanks or implementing dykes to contain any potential spills. These measures can help minimize the risk of contamination and mitigate the impact of future accidents.
3. Prevent Oil Discharge from Stormwater Locations: Implement measures to prevent the discharge of oil from stormwater locations, such as installing appropriate containment systems or improving drainage infrastructure.
4. Buckingham Canal Dredging: Given the heavy siltation and long term contamination of oil in the canal consider dredging the canal to enhance its carrying capacity. This action can help improve water flow and reduce the risk of further contamination but can be more challenging as well.
5. Prevention of contamination: Continuous monitoring of the storm water drains in the Ennore industrial area and Buckingham Canal is mandatory to prevent and track contamination from industries and residential areas.

Scope for Future Work:

1. To conduct comprehensive assessments to quantify the level of contamination in water and sediment samples collected from Buckingham Canal and Ennore Creek. This data

will provide more valuable insights into the extent of pollution and aid in planning remediation efforts.

2. To quantify the amount of oil discharged into the sea during the spill event. Accurate measurements will help in assessing the environmental impact accurately.
3. To conduct detailed investigations in inaccessible areas to obtain more accurate estimates of contamination. Utilize advanced technologies and sampling techniques to access remote or challenging locations.
4. To bioremediate excavated soil in covered sheds with proper monitoring, thereby restoring contaminated soil to a healthier state.
5. Environmental Impact Assessment of the spill on water, soil, flora and fauna and Social Impact Assessment of the communities.

These recommendations and future work will contribute to better understanding and management of oil spill impacts in the Ennore region, ultimately leading to improved environmental protection and avoiding future oil spills.

10. Conclusion

The oil spill in Ennore water bodies during the Michaung Cyclone, has led to extensive environmental degradation and socio-economic impacts in the affected regions of North Chennai. This preliminary assessment report underlines the severity and spatial extent of the oil contamination in Buckingham Canal, Kosasthalaiyar River and its surrounding areas.

Field investigations revealed oil accumulation in various zones along the banks, islands and surplus canals of the Kosasthalaiyar River and banks of Buckingham Canal, with significant hotspots identified. The spillage not only contaminated water bodies but also inundated residential areas, causing damage to property, vegetation, and livelihoods. Moreover, the spill has posed a significant threat to biodiversity - affecting mangroves, birds and aquatic organisms. The quantification of the impact will be assessed in Phase 2 of the project.

The field surveys and mapping of the oil spill's aerial extent using drones provided valuable insights into the movement of oil and spatial distribution of contamination. Laboratory analysis of water and sediment samples confirmed widespread total petroleum hydrocarbon

contamination indicating the intensity of the contamination. Flooding of CPCL's open tanks during the flood was suspected as a primary source of the spill by Tamil Nadu Pollution Control Board. The estimates derived from IITM's comprehensive analysis indicates approximately more than 1000 tonnes could have been released to the environment.

Addressing the aftermath of the oil spill requires collaborative efforts from various stakeholders, implementing the recommendations outlined in this report, undertaking further research and continuous monitoring to mitigate the impacts of the oil spill and restore the well-being of affected communities and ecosystems in the Ennore region.

11. Appendix

A. Coast Guard Assessment

BUCKINGHAM CANAL/ KOSATHALAIYAR RIVER AREA

Dear Madam,

1. Kindly refer to your letter T6/TNPCB/F.12753/RL/2023 dated 13 Dec 23.

2. TNPCB vide letter ibid requested assistance of this Headquarters for estimation of quantum of Oil Spill in Ennore Creak, Buckingham Canal and Kosathalaiyar River area. Accordingly, this Headquarters deputed an expert team for quantity assessment of oil spill in the above areas.

3. **Oil Spill Quantity assessment at Ennore Creek/ Buckingham Canal/ Kosathalaiyar River Area**.

(a) **Oiled Area Measurement: -**

Ser	Name of Canal/River	Area in Sq.Mtr	Oiled Area
(i)	Buckingham canal	6100 x 60 =366000	90% = 329400
(ii)	Kosathalaiyar river	4900 x 260 =1274000	30% = 382200
(iii)	Ennore creek	1550 x 950 =1472500	10% = 147250

(b) **Appearance Coverage Allocation: -**

Ser	Name of Canal/River	Sheen	Rainbow	Metal
(i)	Buckingham canal	10%	70%	20%
(ii)	Kosathalaiyar river	10%	40%	10%
(iii)	Ennore creek	10%	30%	10%

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(c) **Thickness band of above appearance: -**

(i) Sheen : 0.04 µm to 0.3 µm
(ii) Rainbow : 0.3 µm to 5.0 µm
(iii) Metal : 5.0 µm to 50 µm

(d) **Minimum Volume of spilled oil calculations: -**

Ser	Name of Canal/River	Sheen (0.04 µm)	Rainbow (0.3 µm)	Metal (5.0 µm)
(i)	Buckingham canal	(329400X10%) X 0.00000004 = 0.0013	(329400 x 70%) x 0.0000003= 0.0692	(329400 x 20%) x 0.000005 =0.3294
(ii)	Kosathalaiyar river	(382200X10%) X 0.00000004= 0.0015	(382200 x 70%) x 0.0000003 = 0.0803	(382200 x 20%) x 0.000005 =0.3822
(iii)	Ennore creek	(147250X10%) X 0.00000004= 0.0006	(147250 x 70%) x 0.0000003 = 0.0309	(147250 x 20%) x 0.000005 = 0.1473
Minimum Volume of Spilled Oil				**1.043 K**

(e) **Maximum Volume of spilled oil calculations: -**

Ser	Name of Canal/River	Sheen (0.3 µm)	Rainbow (5.0 µm)	Me… (50 µm)
(i)	Buckingham canal	(329400X10%) X 0.0000003 = 0.009882	(329400 x 70%) x 0.000005 = 1.1529	(329400 x 20%) x 0.000050 =3.294
(ii)	Kosathalaiyar river	(382200X10%) X 0.0000003 = 0.01147	(382200 x 70%) x 0.000005 =1.3377	(382200 x 20%) x 0.000050=3.822
(iii)	Ennore creek	(147250X10%) X 0.0000003= 0.00442	(147250 x 70%) x 0.000005 =0.5154	(147250 x 20%) x 0.000050= 1.4725
Maximum Volume of Spilled Oil				**11.620 KL Appx**

4. **Oil Spill Quantity Assessment at Sea**. The assessment of spill at sea was carried out through aerial recce / ships. It was observed that traces of spilled oil were found in appx 20 Sq.Km area from Kasathalaiyar river mouth to Kasimedu Harbour.

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Based on the observation, the quantity assessment is as follows: -

(a) **Oiled Area Measurement**

(i) Area from Helo data : 20 Sq.Km
(ii) Area covered with oil : 50%
(iii) Oiled Area : 20 x 50% = 10 Sq.Km

(b) **Appearance Coverage Allocation**

(i) Sheen : 80 %
(ii) Rainbow : 20%

(c) **Thickness band of above appearance**

(i) Sheen : 0.04 µm to 0.3 µm
(ii) Rainbow : 0.3 µm to 5.0 µm

(d) **Minimum Volume of spilled oil: -**

(i) Appearance Sheen : 10 Km^2 x 80% x 0.04 µm = 0.32 M^3
(ii) Appearance Rainbow: 10 Km^2 x 20% x 0.3 µm = 0.6 M^3
(iii) **Minimum Volume:** 0.32 M^3 + 0.6 M^3 = **0.92 M^3 (0.92 KL)**

(e) **Maximum Volume of spilled oil: -**

(i) Appearance Sheen : 10 Km^2 x 80% x 0.3 µm =2.4 M^3
(ii) Appearance Rainbow: 10 Km^2 x 20% x 5 µm = 10 M^3
(iii) **Maximum Volume:** 2.4 M^3 + 10 M^3 = **12.4 M^3 (12.4**

Regards,

Your sincerely,

(AS Ali)
Commandant
Regional Ops & Plans Officer
for Commander
Coast Guard Region (East)

B. Tamil Nadu Pollution Control Board's Survey of M/s CPCL Premises

6. Findings of the Team based on the information provided by the M/s CPCL:

As per the suggestions of the Team TNPCB requested M/s CPCL to provide certain details viz; quantity of slop oil, O&M details, the mass balance of raw materials, sludge storage, etc. M/s CPCL has submitted the following details vide letter dated 14.12.2023, the details are as below;

<table>
<tr><th>SI NO</th><th>Information requested</th><th>Information provided by CPCL</th></tr>
<tr><td>i</td><td>Oily waste material collected from day to day operations, from all the storm water ponds, ETPs and other sources and its quantity, its storage method and disposals details</td><td>Slop Oil quantity collected from storm water ponds, ETPs and other sources for the last three months is furnished below
<table>
<tr><td>Month</td><td>Quantity, KL</td></tr>
<tr><td>September</td><td>1939</td></tr>
<tr><td>October</td><td>4528</td></tr>
<tr><td>November</td><td>1238</td></tr>
</table>
Slop oil is stored in Slop Tanks and reprocessed with Crude.</td></tr>
<tr><td>ii</td><td>Whether cleaning operation carried out before Michaung flood, its collection details.</td><td>Details of major activities carried out as part of pre monsoon preparedness is furnished below:
▪ Storm water canal cleaning
▪ Building roof cleaning
▪ Dewatering pumps checking & availability</td></tr>
<tr><td>iii</td><td>Whether all the refineries are in operation during the flood, if not details shall be furnished. Further receipt of crude oil from 1st December 2023 to 9th December 2023 shall be furnished</td><td>Out of 3 Refineries, only one Refinery was in operation during flood. Other two Refineries were under circulation.
Details of Crude Oil Receipt from 01.12.23 to 09.12.23 is furnished below:
<table>
<tr><td>Date</td><td>Crude receipt in TMT</td></tr>
<tr><td>01.12.23</td><td rowspan="4">No receipt</td></tr>
<tr><td>02.12.23</td></tr>
<tr><td>03.12.23</td></tr>
<tr><td>04.12.23</td></tr>
<tr><td>05.12.23 20.48 hrs to 07.12.23 06.00 hrs</td><td>135</td></tr>
<tr><td>09.12.23 18.54 hrs to 11.12.23 hrs 07.12 hrs</td><td>99</td></tr>
</table></td></tr>
<tr><td>iv</td><td>Total quantity of Sludge stored inside the premises and its</td><td>Quantity of Sludge Stored in CPCL is 2300 KL in sludge pond. The sludge would be mechanically treated to extract oil and residual material would be</td></tr>
</table>

<table>
<tr><td></td><td>method of disposal</td><td>bioremediated. Extract oil would be reprocessed thro' crude tanks</td></tr>
<tr><td>v</td><td>Frequency of conducting spillage deduction along with details of records maintained.</td><td>Spillage Detection & Repair study is carried out yearly once in CPCL and the report is submitted to TNPCB regularly. The latest report is submitted in Jan 23 (Annexure-A)</td></tr>
<tr><td>vi</td><td>Mass balance of raw material and product manufactured</td><td>Mass balance in Tons/ day furnished below
<table><tr><td>Crude through put</td><td>28.8</td></tr><tr><td>LPG</td><td>1.0</td></tr><tr><td>Naphtha</td><td>2.4</td></tr><tr><td>Petrol (M.S)</td><td>3.0</td></tr><tr><td>ATF</td><td>3.2</td></tr><tr><td>Diesel</td><td>15.0</td></tr><tr><td>Lobs/Wax</td><td>0.8</td></tr><tr><td>Bitumen</td><td>1.2</td></tr><tr><td>Internal fuel</td><td>2.2</td></tr></table></td></tr>
<tr><td>vii</td><td>Number of unused storage tanks and number of it for maintenance

The details of date of clean in progress taken for crude oil tanks, slops storage and other.</td><td>Details of idle and M&I tanks is furnished as Tanks released and under Maintenance
<table><tr><th>Sl. No.</th><th>Tank No.</th><th>Service</th><th>Remarks</th></tr><tr><td>1</td><td>343</td><td>DWO(HH)</td><td>Released in Oct 23</td></tr><tr><td>2</td><td>412</td><td>SK(LAB)</td><td>Released in Sep 23</td></tr><tr><td>3</td><td>418</td><td>ATF</td><td>Released in Oct 23</td></tr><tr><td>4</td><td>107</td><td>Crude</td><td>Released in Oct 23</td></tr><tr><td>5</td><td>820</td><td>Dry slop</td><td>Released in Sep 23</td></tr><tr><td>6</td><td>310</td><td>HN/DAO</td><td>Released in Mar'23</td></tr><tr><td>7</td><td>311</td><td>IN/HN/DAO</td><td>Released in Mar'23</td></tr><tr><td>8</td><td>309</td><td>Raff</td><td>Released in Jun'23</td></tr></table></td></tr>
</table>

		9 | 201 | RFO | Released in Jun'23 10 | 204-D-1 | VBU Feed | Released in Jun'23. 11 | 312 | IN/HN/DAO | Released in Sep'23 12 | 919 | Wax | Released in Oct'23 13 | 345 | DWO/RAFF | Released in Sep'23 Details of tanks unused tanks: Sl. No. | Tank No. | Service 1 | 806 | Slop Oil 2 | 383 | Wax 3 | 384 | Wax
viii	Details of the sludge stored in the open yard	All sludge is stored in concrete pit with impervious layer and is at higher elevation.
ix	Any operations carried out to protect the refinery to avoid untoward incidents during the flood time	➢ One Refinery out of 3 Refineries was operated to maintain product supply to market. ➢ Tractors trailers & fire truck were operated to bring Manpower & Material inside Refinery
x	The details of Characteristics of waste oil collected from ETPs & storm water collection ponds	Slop oil is a mixture of oil collected from various sources. Slop Oil is reprocessed with crude. Since the qty of slop oil is very minimal, analysis is not required. However as per instruction, one sample was analysed today (14.12.23) and the result is furnished below. a) Density-0.873 gm/cc b) Sulphur- 2.09 % c) Flash- 37 Deg C d) Viscosity @ 40 Deg C- 6.6
xi	The details of products sent to Manali customers and control mechanism provided to safe guard during no demand period	*Industry* | *Products* | *In case of No demand* *TPL* | *LABFS* | *Will be absorbed in Diesel pool / converted to ATF* *MPL* | *Propylene* | *Will be sold as LPG*

			KPL	*PBFS*			
				LPBFS			
			Cetex Petrochemicals	*Butene2*			
				MEKFS			

From the above information, the Team noticed the following;

- As per the information given at Sl. (i), it is inferred that the average slop oil collected from ETPs and other sources ranges from 50 kld to 150 kld. Due to heavy rain since December 03 and 04, 2023, the collection of slop oil might not be happened, this slop oil might be washed away due to rising of water levels in all ponds since the ponds were just above the ground level. As per this information, the quantity washed away might be more than 400 kl.
- As per the information given at Sl.(iv), it is inferred that 2300 kl oil-bearing sludge is being stored in the sludge pond. The same was observed during the team visit and noticed that the sludge stored was up to the brim level, the oil mixed sludge might be washed away to drain due to the flood which is directly leading to the Buckingham Canal.
- As per the information given at Sl(vii), it is inferred that eight crude oil storage tanks were taken for maintenance during September – October 2023. The oil-bearing sludge required to be separated through centrifugation and the same has to be taken for bio remediation. At least 90 days are required to complete one cycle of bio remediation. Eight tanks were taken for maintenance in the last three months, the oil bearing sludge might be stored in the ponds, due to the flood, these sludge might be washed away. One of the nearby industry namely M/s Indian Additives Ltd, reported to the TNPCB team on 04.12.2023 that the mixture of thick Black oil & water was gushed into their premises. The statement of industry also confirms that the probability of washing of oil-bearing sludge from their storage dykes.
- Inspite of sever cyclonic and heavy rain fall alert by IMD and Govt. of Tamil Nadu, the unit is not taken any precautionary measures to contain the oil spillage from their ponds and ETPs. And also unit is not having either flood management plan or emergency contingency plan to contain oil spillage.

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Final Report

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SSP3585

Pilot Studies for assessing Environmental Benefits for cleaning/bioremediation of oil spillage at designated locations in the Ennore Creek, Buckingham Canal, and Kosasthalaiyar River through the application of Biodispersant Comprising of Alkyl poly glucosides, Fatty Acids, & Botanical Extracts

For
Chennai Petroleum Corporation Limited
Chennai- 600 032

Through
TNPCB, Chennai

August, 2024

सीएसआईआर – राष्ट्रीयसमुद्रविज्ञानसंस्थान
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1. Background

Humanity has always needed various energy resources to develop civilization and make life more comfortable. Exploration of energy resources has played an essential role in generating and sustaining individual development and economic growth. Increased importance is presently given to the exploration and development of conventional energy resources like oil and natural gas, locally referred to as refinery outputs. The society's dependence on oil and gas has been increasing at an alarming rate.

Oil is a major pollutant in the ocean, and the spill of marine oil is one of the major threats to fragile marine life. Whatever the reason, oil spills are a significant source of hydrocarbons into the oceans and are considered a major form of pollution that adversely affects aquatic life. The purpose of any oil spill response is to minimize the environmental damage that the spill could cause.

1.1. Genesis

In the aftermath of floods due to cyclone Michaung on 04 December 2023, a massive oil spill was observed at Ennore Creek, Chennai, Tamil Nadu. The storm induced flooding ultimately spread the spill to the entire Ennore Creek and adjoining areas. As a consequence of this oil spill event, the State's Environment Department has undertaken emergency oil recovery initiatives with the engagement of many agencies to restore the environment quality on a war footing basis.

To address the concerns of oil pollution on the estuarine and coastal ecosystem, the Tamil Nadu Pollution Control Board (TNPCB) also requested the CSIR-National Institute of

Oceanography (CSIR-NIO), Goa, vide letter No. T6/TNPCB/F.12753/RL/2023 dt. 16/12/2023 to assist in perambulating the affected areas of Ennore Creek, Buckingham Canal, Kosasthalaiyar River, and other adjoining water bodies and to suggest possible bioremediation measures to mitigate the effects of oil spill on the fragile ecosystem on an immediate basis after the completion of manual and mechanical cleaning of the above-mentioned affected sites.

In response to the request of TNPCB, a Team of two scientists from CSIR-National Institute of Oceanography (CSIR-NIO), Goa (Dr. Suneel Vasimalla, Senior Scientist and Mr. R. A. Sreepada, former senior principal Scientist) visited those oil spill affected sites during 20-22 December 2023, to assess the overall situation arising out of oil spill. After a thorough reconnaissance survey of the affected areas, discussions were also held with concerned officials of TNPCB, the State Forest Department, the Environment Department, the Wetland Authority and other stakeholders. After a comprehensive assessment of the situation during the field-based survey and considering the damage to the marine ecosystem arising out of oil contamination, the CSIR-NIO team suggested applying biodispersants in the affected water bodies as an effective bioremedial measure for conserving the sensitive ecological niches.

CSIR-NIO is an authorized agency for testing and approving oil spill dispersants and related bioremediation products to combat oil spills along the Indian coast. CSIR-NIO is actively evaluating a few bio-dispersants, specifically Nano Botanical Formulations comprising Alkyl-poly glucosides, Fatty acids, and Botanical extracts, for their effectiveness in bioremediating the oil spilled areas. These “green” dispersants are preferred because they are non-toxic, made from naturally available or renewable materials, and are non-volatile. Hence, ‘Green Dispersants (Biodispersants) serve as environmentally benign alternatives to traditional synthetic chemical dispersants, specifically for bioremediating oil spills in ecosystems to achieve maximum environmental benefits. To date, the results obtained from a wide range of

laboratory tests carried out by CSIR-NIO have shown that such bio-dispersants have a high degree of oil dispersion potentials due to their characteristic in forming a reasonably stable oil emulsions for different varieties of crude oil at different salinity levels (10 to 30 ppt) with low toxicity profile. Furthermore, these biodispersants have shown significantly high bioremediation potentials in rapidly depleting the levels of total petroleum hydrocarbons within a short time frame in oil-contaminated soils (NIO/TSP-xxx/2024; TSP3241).

After a careful assessment of the affected sites and local aquatic ecosystems of the intertidal areas, mangrove belts, wetlands, etc., a suggestion was made to TNPCB to apply such bio-dispersants to bioremdiate oil-contamined sites on a trial basis. With the approval of the concerned authorities, 10 litres of one such concentrated Biodispersant comprising of Alkyl-poly glucosides, Fatty acids, and Botanical extracts were sprayed at a few selective oil-spill affected areas after being diluted 10 times with seawater) on a trial basis on 20 December 2023 in the presence of TNPCB and CPCL officials.

After witnessing the results of the trial application of biodispersant and follow-up extensive discussions with the concerned officials, the Chairperson, TNPCB, requested CSIR-NIO vide letter Nos T6/TNPCB/F.12753/RL/2023 dt. 22/12/2023 & T6/TNPCB/F.12753/RL/2023-1 dt. 22/12/2023 to submit the work proposal for the application of biodispersant products at 04 designated locations in the oil spill contaminated area. It has also been decided that 03 sites in the oil-affected area would be allowed for systematic application of Biodispersant, and 01 site would serve as a control (with no Biodispersant application) on an emergent basis. The geographic locations of 03 Treatment Sites (T1, T2 and T3) and the Control Site (C) are presented in Table 1 and depicted in Fig 2.

Following the request from TNPCB, CSIR-NIO was proposed to conduct post-treatment monitoring works (over a certain period of time) to assess the effectiveness of the herbal Nanotech Bio-dispersant. Thus, the scope of the proposed work includes (a) the application of dispersants at the designated sites identified by TNPCB for the treatment of the oil spillage, (b) the assessment of specific environmental parameters, including the quantification of Total Petroleum Hydrocarbons (TPHC) in Ennore Creek Water surficial sediment at fixed intervals (b) to impart training of TNPCB officials at CSIR-NIO.

2. Scope of the proposed study

The primary purpose of the proposed study is to conduct a comparative assessment of seawater and sediment quality parameters at 04 sites before and after bio-dispersant treatment. The results of these field-based studies would help evaluate the effectiveness of 'Herbal Nanotech Biodispersant' in bioremediating oil spillage areas with maximum environmental benefits. The following parameters were studied to monitor the water and sediment qualities during pre- and post-treatment sessions at both control (Site 'C') and treatment sites (T1, T2 & T3).

Water quality parameters:

1. Total Petroleum Hydrocarbons (TPH)
2. Dissolved Oxygen (DO.)
3. Biochemical Oxygen Demand (BOD)
4. Chlorophyll-*a*
5. Total Bacterial Counts (TBC)
6. Total Viable Counts (TVC)

Sediment quality parameters:

1. Total Petroleum Hydrocarbons (TPH)

2. Total Bacterial Counts (TBC)

3. Total Viable Counts (TVC)

2.2. Objectives of the proposed work

The overall objectives of the proposed work are:

(i) To carry out a comparative assessment of the environmental benefits of Herbal Nanotech Biodispersant Treated and Control sites by regular monitoring of key water and sediment quality parameters and quantification of total petroleum hydrocarbons (TPH).

(ii) To train 03 TNPCB scientists/officials on water quality analysis, quantification of bulk petroleum hydrocarbons, bacteriology, oil spills and their management etc.

3. Methodology

3.1. Description of study area

Ennore Creek is located on the northeast coast of Chennai, Tamil Nadu, India. It is located between 13°16′ and 13°26′N latitudes and between 80°24′ and 80°35′E longitudes. The southern branch of the Creek is well-developed with industries, utilities, residential areas and fishing hamlets. The Creek supports the livelihood of thousands of fishermen's families in the adjacent villages and sustains the traditional fishermen's community (Krishnaveni et al., 2023). The northern section of the Creek or Kosastalaiyar backwater is connected to the Ennore Thermal Power Station (ETPS), Ennore Port and Petrochemical industries (Kannan et al. 2007). The Creek is highly polluted due to mixing domestic sewage, various industrial effluents from the industrial belt, and coolant water discharge from the ETPS (Krishnaveni et al. 2023). The magnitude of various environmental issues affecting the Creek ecosystem highlighted by Krishnaveni et al. (2023) are depicted in Fig. 1. It is almost 800m long and elongated in a NE-SW direction. Ennore Creek merges with the backwater bodies and the north-south trending

channels connecting to Pulicat Lake in the north and to the tributaries of Kortalaiyar River in the south (Jayaprakash et al. 2014).

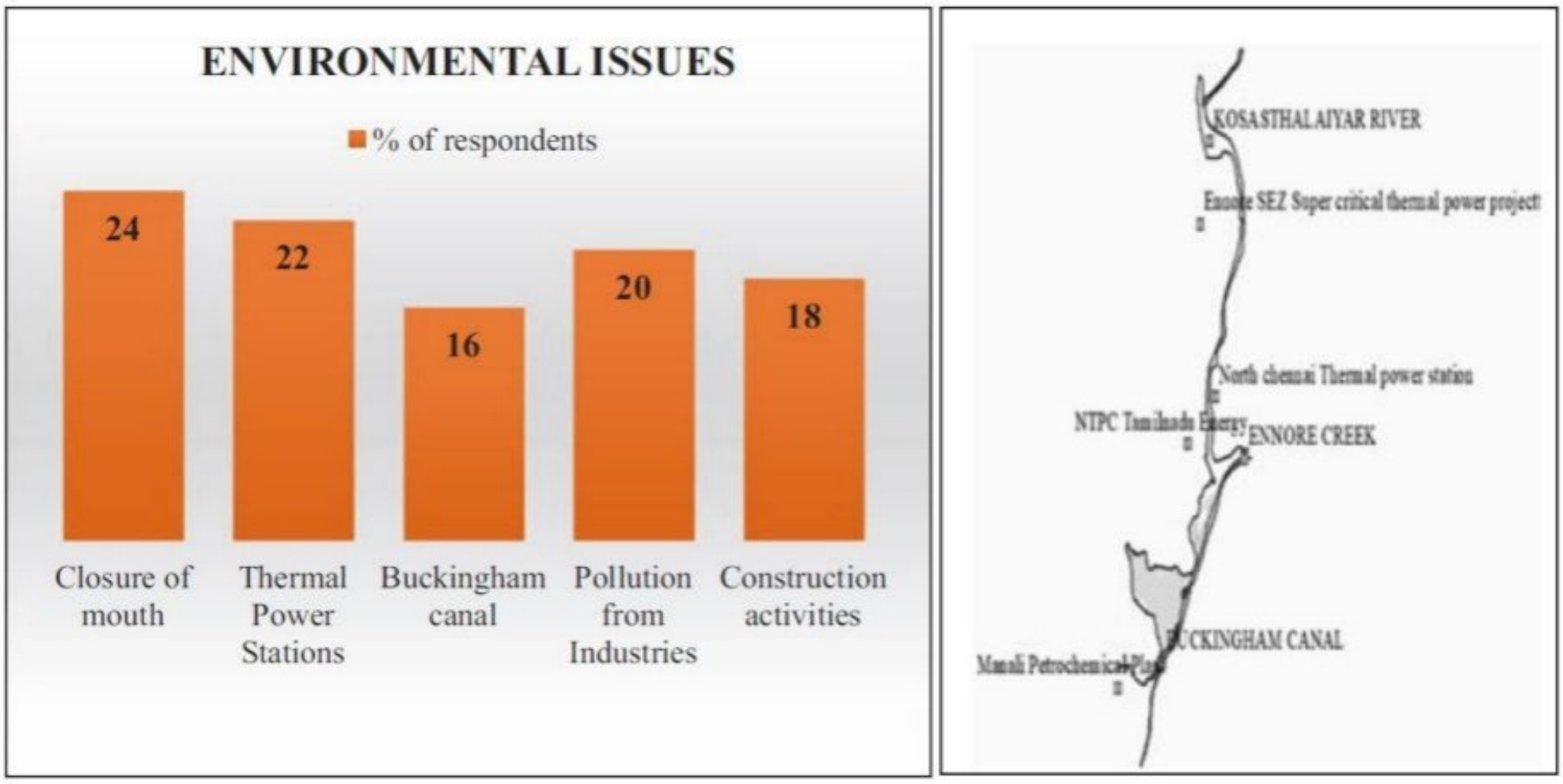

***Figure 1**. Various Environmental Issues affecting Ennore Creek based on a survey. (Picture courtesy: Krishnaveni et al. 2023).*

3.2 Environmental settings of the study region

The meteorological conditions around Ennore Creek exhibit minimum air temperatures ranging between 20°C and 28°C, and maximum temperatures vary within the range of 28°C and 37°C. The Creek is also influenced by strong winds during the southwest (SW) and northeast (NE) monsoons. This region mainly receives rainfall from the NE monsoons during October-November. The Creek was once endowed with rich biodiversity, but in due course, it has been reduced drastically due to the impacts of the release of untreated/partially treated effluents from thermal power plants and petrochemical industries into the Creek ecosystem (Subathra et al. 2013). The Creek is also connected to the Buckingham Canal (part of the National Waterway 4 (NW-4), which originates in the Godavari district of Andhra Pradesh and runs parallel to the coastline up to Villupuram District of Tamil Nadu.

3.2. Sampling strategies

For this pilot study, 04 oil contaminated sites were identified (Table. 1 and Fig. 2) to collect water and sediment samples. At those stations, the first set of field sampling (i.e., pre-treatment sampling) was undertaken by the collaborative team comprising members from CSIR-NIO, TNPCB and Chennai Petroleum Corporation Limited (CPCL) between 09 and 11 January 2024 before applying any dispersant. Then CPCL facilitated the procurement of a 1000-litre Concentrated Herbal Nanotech bio-dispersant that was applied after proper dilutions at 03 treatment sites (e.g. T1:300 Lt, T2:300 Lt and T3:400 Lt) on 10 January 2024 (Fig. 3). One of those 04 contaminated stations was designated as the Control station (Table 1 and Fig. 2) where no dispersant was applied. After the application of biodispersant through a fine jet spray, 03 more sets of post-treatment samplings for water and sediment quality assessment was carried out at 05 sampling sites (3 treatment sites, 01 control and Mouth) at the time intervals of 10, 25 and 40 days post Biodispersant application. The details of those sampling stations are mentioned in Table 1. During each sampling occasion, the surface seawater and surface sediment at those 05 designated sites (e.g. Mouth (M), Control (C), T1, T2, and T3) (Fig. 3) was collected by following the standard methods.

Table 1. *Locations of sampling stations and dates of 4 sampling sessions*

Sampling sites	**Latitude**	**Longitude**	**Sampling1**	**Sampling2**	**Sampling3**	**Sampling4**
	(N)	(E)	BDA	ADA		
Mouth (M)	13º23' 28.75"	80º 32' 92.26"	09.01.24	20.01.24	05.02.24	20.02.24
Control (C)	13º13’ 35.74”	80º 19’ 13.93”	09.01.24	20.01.24	05.02.24	20.02.24
T1	13º13’ 58.10”	80º 19’ 45.27”	09.01.24	20.01.24	05.02.24	20.02.24
T2	13º13’ 19.59”	80º 19’ 04.76”	09.01.24	20.01.24	05.02.24	20.02.24

T3	13º12’ 52.99”	80º 18’ 52.58”	09.01.24	20.01.24	05.02.24	20.02.24

BDA: Before the Dispersant Application; ADA: After the Dispersant Application

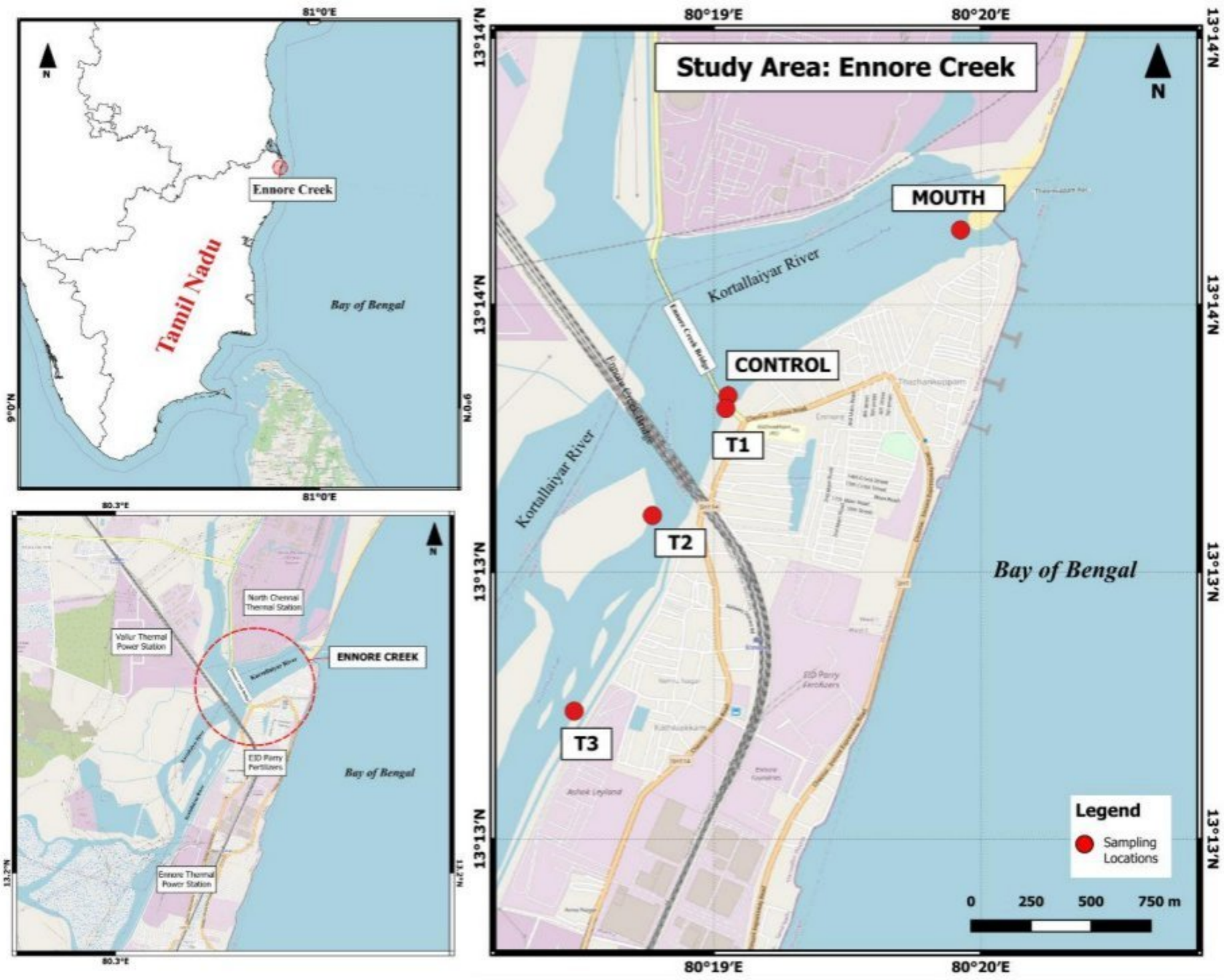

Figure 2. *Map showing the study area and sampling stations along Ennore Creek.*

Water samples were collected by using a pre-cleaned Niskin water sampler, while sediment samples were collected with a mini-core sampler. All sample collections were performed from a fishing dinghy provided by CPCL, Chennai. Figure 4 shows a few glimpses of the sampling activities at different sites along Ennore Creek. The complete details of the field sampling have been mentioned in the following section.

3.3. Field data collection, subsampling and preservation of water samples

3.3.1. Sensor-based monitoring of physiochemical parameters in surface water

At each sampling site, initially, measurements of key water quality parameters were made using an electronic sensor-based Water Quality Analyser attached to a probe fitted with multiple sensors (Model: U53/HORIBA). A key physiochemical parameters such as temperature, salinity, turbidity, pH and total dissolved solids were measured *in situ* by deploying that probe in the surface water. After sensor-based measurements, the water samples for other analytical parameters were collected.

Figure 3. *Application of bio-dispersant at selected sites at T1, T2, & T3 on 10 January 2024.*

Figure 4. *Collection of water and sediment samples at different stations by the CSIR-NIO team and TNPCB & CPCL officials.*

3.3.2. Dissolved Oxygen (DO)

For analyses of dissolved oxygen (DO), water samples from the Creek were collected in 100 ml pre-cleaned DO bottles and onboard immediately fixed with Winkler's A (Manganese chloride) and Winkler's B (alkaline potassium iodide) reagents. Immediately, the sample bottles were carefully stopped to prevent the introduction of air and thoroughly mixed. Later, standard iodometric titration with sodium thiosulfate was carried out for subsequent analysis in the laboratory.

3.3.3. Chlorophyll-a in surface water

A known volume (1000 mL) of surface seawater was collected in sterilized PP bottles and immediately filtered through GF/F filter papers (pore size, 0.7μm). After filtration, the filter papers were stored at 4.0°C in amber-colored tubes till further analysis. In the laboratory, chlorophyll *a* was extracted from filters after overnight extraction in 90% acetone in the dark at 4°C and Chl-*a* was estimated spectrophotometrically following the methods described by Parsons et al. (1984).

3.3.4. Microbiological aspects

Marine microorganisms occupy the base of the food web and form food for protozoa, invertebrate larvae and many large zooplankton and regenerate dissolved nutrients for marine photosynthesis and the formation of newer organic biomass.

The microorganisms, particularly heterotrophic bacteria, contribute substantially to the ecosystem's productivity. Identifying the role of the bacteria in biogeochemical cycles relies on the simultaneous assessment of their phylogenetic identity and ecological function. Considering that bacteria have significant links to many biological and non-biological events

in the oceans, studies on various groups of bacteria were included in the present study. Surface water samples for microbiological analyses were collected in sterilized PP bottles at each sampling location. All the water samples for microbiological analysis were stored in ice and then transported to the laboratory in an insulated ice box for further analysis.

3.3.5. Total Petroleum Hydrocarbons (TPH)

Altogether, 19 water samples were collected from five sampling stations (T1, T2, T3, Control and Mouth, Fig. 2) during each sampling occasion at Ennore Creek to analyze water quality parameters, including TPH. Creek water samples from the surface (< 0.5 m) were collected by using a Niskin's water sampler and transferred the sample to the pre-cleaned (with distilled water followed by the methanol, acetone and hexane) and oven-dried (50 °C) 1.0 Lt amber coloured glass bottles. Then, collected samples were fixed with 1.0 ml of HPLC grade n-hexane on-site and stored at 4°C till further processing. In the laboratory, TPH from water samples were extracted within 7 days after collection.

3.4. Sampling of surficial sediment

Altogether, 20 surficial sediment samples (top 2.0 cm layer of sediment) were collected at sites T1, T2, T3 and C using a mini acrylic core sampler during the course of the study. The sediment samples at a relatively deeper site, M, were collected using a van Veen Grab. Immediately after collection, a small portion of each sediment sample was aseptically transferred into fresh polythene bags using a sterile spatula before sediment samples were collected for other analyses.

Then, the rest of each sediment sample was carefully transferred into separate zip-locked polythene bags and stored at 4.0°C for TPH analyses. All these sediment samples were processed within 10 days of collection. Immediately after collection, a part of each sediment sample was stored in ice in an insulated icebox. Those samples were transported to the laboratory for analyses of microbiological and other parameters.

3.5. Processing of sediment samples and laboratory analyses

3.5.1. TPH content in the water sample

The total petroleum hydrocarbon content in the water samples was extracted in triplicates with HPLC grade n-hexane following the standard method described in IOC-UNESCO (1984). Briefly, 500 mL of each water sample was taken in a glass separating funnel, and then 25 mL of HPLC grade n-hexane was added. The mixture was vigorously shaken for 15 minutes and allowed to stand for 10 minutes. After that, the organic phase was separated out in a pre-cleaned glass beaker. A similar extraction process was repeated two more times. In the combined n-hexane extracts (organic phase), anhydrous sodium sulfate was added to absorb the residual moisture. The petroleum hydrocarbon concentrations in those extracted samples were determined using fluorescence spectroscopy (Model: Shimadzu, RF5301PC). The fluorescence of the samples was measured at an emission wavelength of 360 nm (excitation wavelength 310 nm). All blanks, standards and samples were measured in a Teflon-capped 1cm silica fluorescence cell under identical instrumental settings and conditions. Fluorescence of Chrysene calibration standards was measured similarly to quantify the TPH in the samples, and the TPH data in water samples were expressed in terms of Chrysene equivalents. The fluorescence of HPLC grade n-hexane was almost negligible, and the same was used for blank corrections. All fluorescence readings were taken in three replicates, and the average values were used to estimate the TPH concentration. The complete methodology is illustrated in the flow chart shown in Fig. 5.

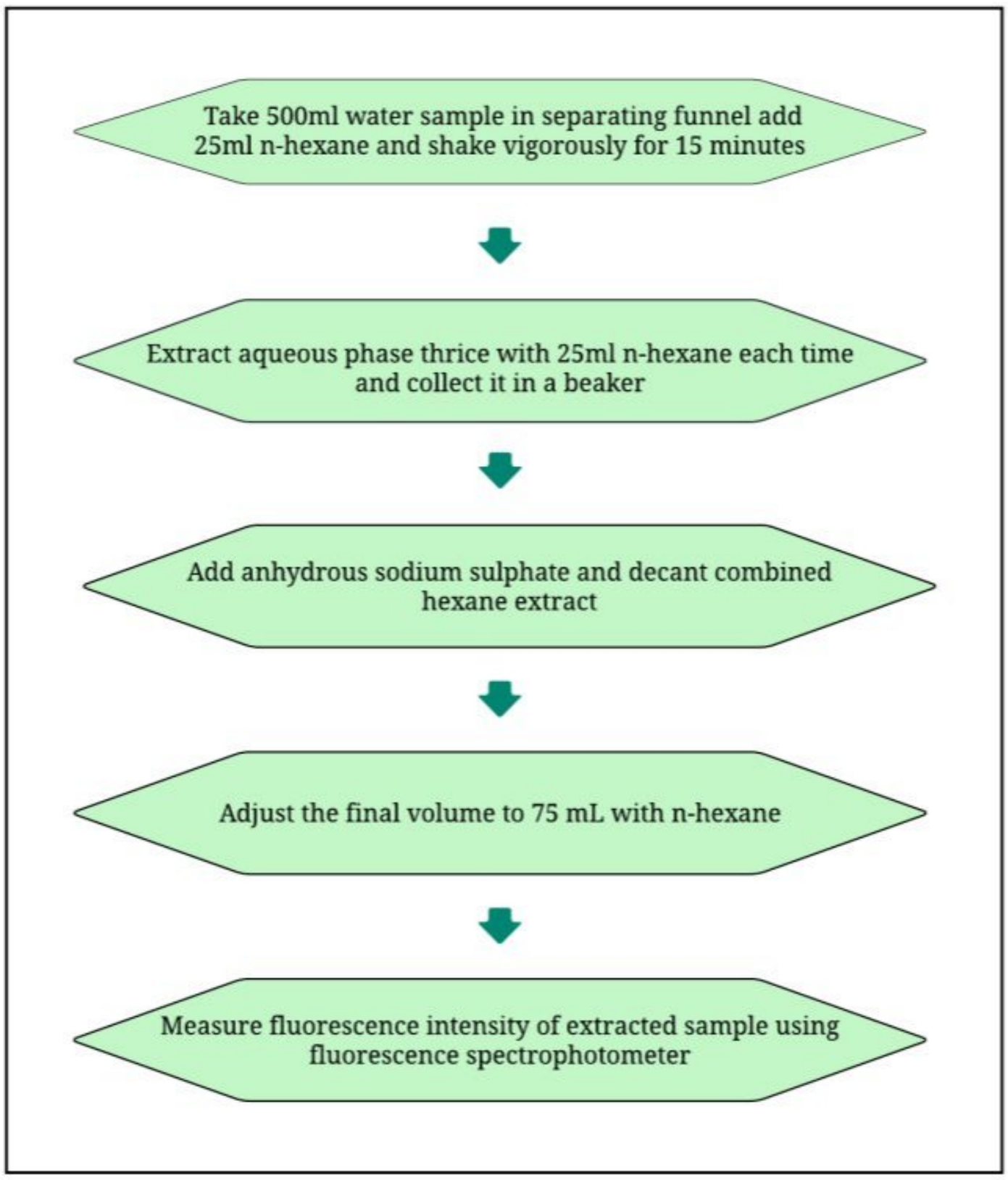

Figure 5: *Flowchart illustrating the steps involved in the estimation of TPH in water samples.*

3.5.2. Dissolved Oxygen in water sample

The water sample's dissolved Oxygen (DO) content was analyzed using Winkler's titration method. In the laboratory, the fixed DO sample of each bottle was dissolved by adding 2.0 ml of concentrated sulfuric acid. The sample bottle is then resealed with the stopper and thoroughly mixed to dissolve the precipitate completely. Then 100 ml of dissolved sample was pipetted in a flask and titrated against 0.025(N) standardized sodium thiosulfate solution using starch solution as indicator. The DO values in water samples are presented in terms of mg/L.

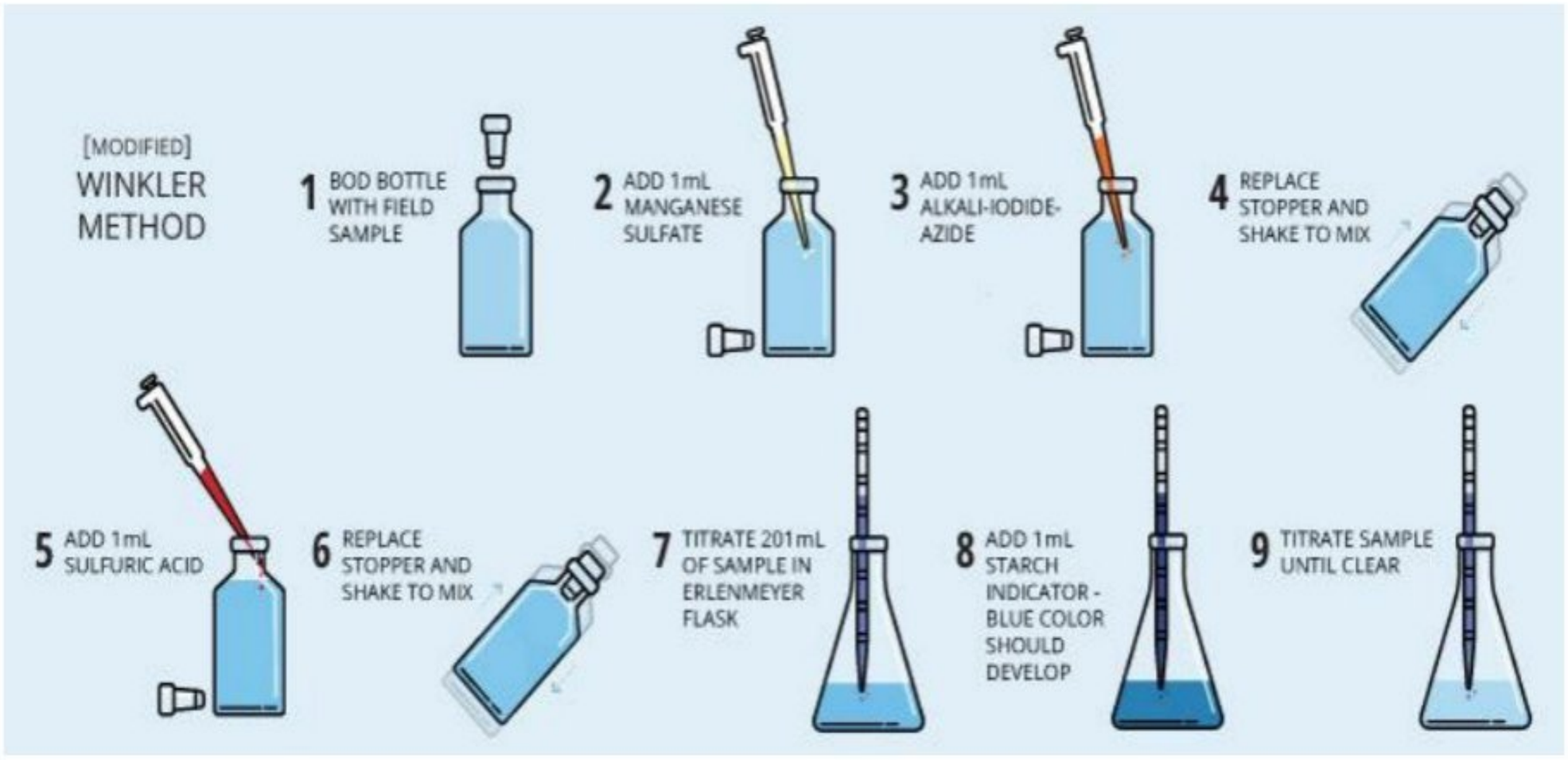

Figure 6: *Schematic Diagram of the Steps in the Winkler's Method for DO analysis (Picture courtesy: Internet)*

3.5.3. Chlorophyll-a in the water sample

In the laboratory, to estimate the total chlorophyll, 10 ml of 90% acetone is initially added to the tubes containing filter papers and then extracted at 4.0°C in the dark overnight. After incubation, the samples were centrifuged at 5000 rpm to remove the remains of filter paper from the sample and get a clear solution. The photometric absorbances of solutions were measured at 664, 647, and 630nm wavelengths using a spectrophotometer. Based on absorbance values, the chlorophyll-a content in seawater samples was estimated by using the following empirical relations (Parsons et al., 1984).

$$\text{Chl-a } (\mu g/L) = (11.85 \times E_{664}) - (1.54 \times E_{647}) - (0.08 \times E_{630})$$

$$\text{Chlorophyll-a in seawater } (mg/L) = [\text{Chl-a} \times 10]/1000 \times L$$

In which:

L = Light path of cuvette, cm

E664 = Value of absorbance at wavelength 664 nm

E647 = Value of absorbance at wavelength 647 nm

E630 = Value of absorbance at wavelength 630 nm

3.5.4. Total Bacterial Counts (TBC)

(A) Water Samples

For estimation of total bacterial counts (TBC), 50 ml of the water sample was collected in a scintillation vial, and 1.0 ml of filtered sterilized formalin was added to each scintillation vial to preserve the sample (Hobbie et al., 1977). Then, the vials were stored at 4.0ºC. Later in the laboratory, samples were stained with a DNA staining fluorochrome dye 4, 6 - diamidino-2-phenylindole (DAPI) at a 1.0 mg/ml concentration for 20 minutes. After that, using a UV filter set, an Olympus Epifluorescence Microscope was used to count those fluorochrome-stained bacterial cells at an excitation wavelength of 365 nm. The bacterial counts in water samples were expressed in the number of cells/ml.

(B) Sediment samples

1.0 gm of sediment samples were taken and fixed with formalin in the vial. Then, the vials with preserved sediment were stored at 4.0ºC, and later, using the same method explained above, they were analyzed for TBC in the laboratory.

3.5.5. Total Viable Counts (TVC)

(A) Water Samples

For viable bacterial counts, samples were diluted as per requirement, and then those samples were spread-plated (0.1 ml) on Zobell Marine Agar (Hi-media) media. Those media were incubated at (30 ±2°C) for 1-2 days. The bacterial colonies developed within that media were counted, and the final results were presented in cells/ml.

(B) Sediment Samples

1.0 gm of the sediment sample was suspended in 9.0ml of autoclaved seawater using a sterile 5.0 ml syringe. The suspension was vortexed for two minutes. The sediment was then allowed

to settle, and serial dilutions were carried out by serially transferring 1 ml of the sample to 9.0 ml autoclaved seawater. Then 0.1 ml of the sample was spread plated onto Zobell marine agar plates and incubated at (30 ± 2°C) for 1-2 days.

3.5.6. TPH in the sediment sample

Samples were extracted, purified, and analyzed according to the methods established by IOC-UNESCO (1984). Thawed frozen fresh 1g of sediment samples were saponified using a KOH-methanol mixture. The resulting saponified samples were extracted in a reflux condenser at 75°C for 90 minutes, then by cooling to room temperature and filtration through Whatman No. 1 filter paper.

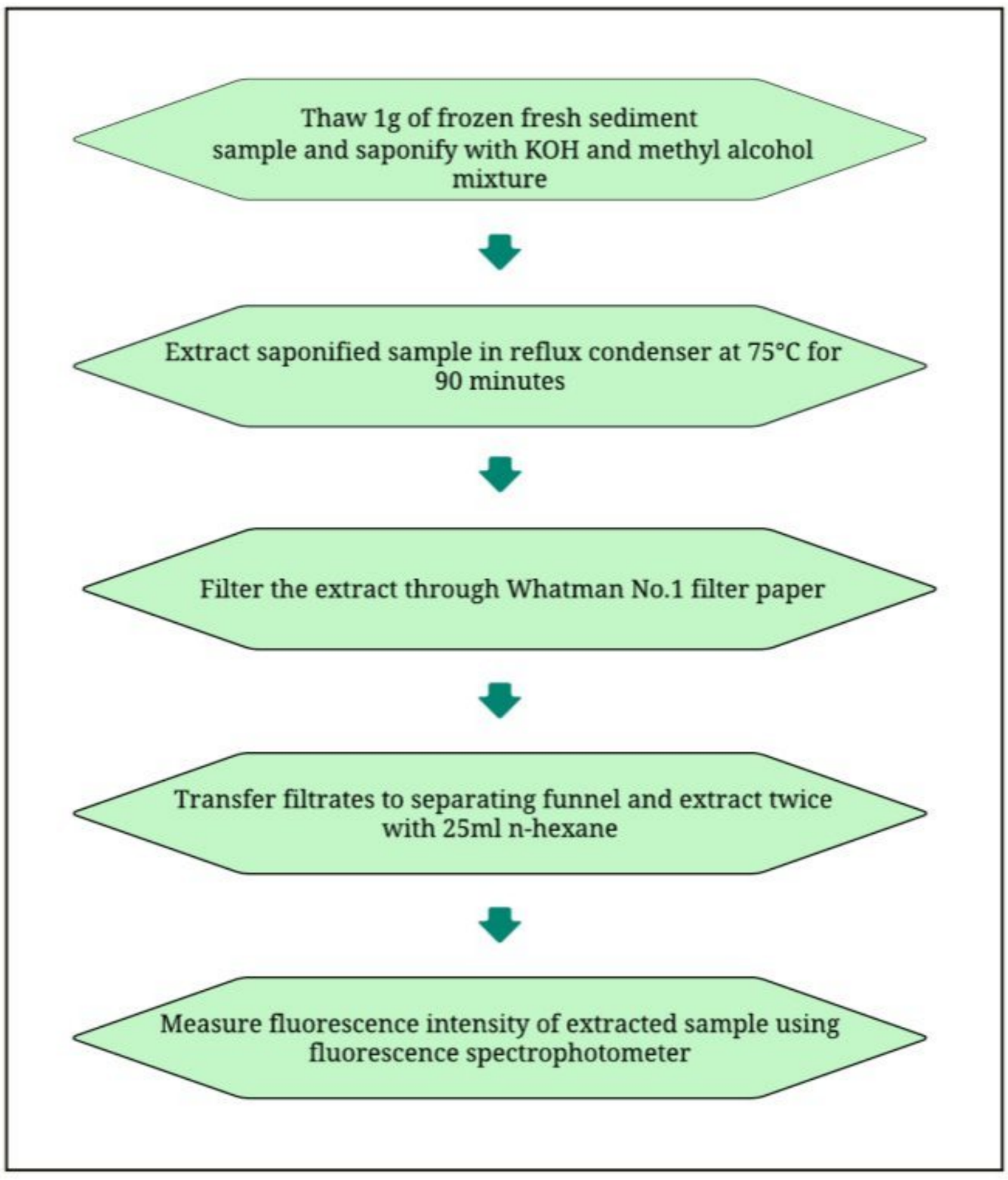

Figure 7: *Flowchart illustrating the steps involved in the extraction and estimation of TPH in sediment samples*

The filtrates were transferred to a separating funnel and extracted twice with 25 mL of n-hexane. Subsequently, the fluorescence intensity of the extracted sample was measured using a fluorescence spectrophotometer with emission at 360 nm and excitation at 310 nm. The n-Hexane was used as the solvent blank, and chrysene was employed as the calibration standard, resulting in the expression of the results in terms of chrysene equivalents.

4. Results

4.1. Key water quality parameters

All the water quality data measured with the water quality probe are presented in Table 2. The key water quality measurements made by sensor-based on showed that parameters like salinity, turbidity, and TDS showed large variations during each sampling session at different sampling sites. Irrespective of sampling sessions, the salinity showed higher values at the Mouth station (up to 32 ppt), which gradually dropped at other stations towards upstream (up to <1.0 ppt) (Table 2). Likewise, the TDS values showed similar trends along those sampling stations with higher values towards the Mouth station (M). This indicates a substantial flux of low-saline wastewater (flowing through Bakinkham Canal and Ennore Creek) mixed with high-saline coastal water in the study area. Such an extensive mixing process was further supported by a relative increase of pH in water towards the Mouth. In contrast, the spatial distribution of turbidity showed an opposite trend, with lower values recorded towards downstream, indicating more suspended matter load in the Canal and Creek waters. All these trends in measured water quality parameters were consistent during all sampling sessions.

Table 2: Data on key water quality parameters measured using water quality during different sampling sessions.

	Location	Temperature (°C)	pH	TDS (g/L)	Salinity (ppt)
Sampling - 1	**C**	30.9	8.05	9.03	8.34
	M	28	7.5	10.1	10
	T3	29.99	6.26	0.655	0.60
Sampling - 2	***Probe data is not available***				
Sampling - 3	**C**	33.5	7.83	14.8	14.37
	M	35.75	8.45	30.1	32.233
	T1	31.83	7.87	13.1	12.65
	T3	33.06	7.92	6.68	6.04
Sampling - 4	**C**	33.37	8.01	21.0	21.60
	M	35.73	8.26	28.6	30.4
	T1	34.47	7.69	18.7	19.01
	T3	33.96	8.95	10.2	9.58

Dissolved oxygen refers to the amount of oxygen dissolved in water, which is vital for the survival of aquatic organisms. Generally, the DO value in coastal waters varies depending on temperature, salinity, pressure, productivity, degree of contamination etc. In our present study, the estimated DO values in surface water at different stations of the study area were widely variable, ranging from almost below the detection level to 8.0 mg/l (Table 3). Similar to other water quality parameters, spatial variation of DO during each sampling session could be attributed to the magnitude of wastewater influx (through the Backinhagm canal) into the study area during the sampling period. A higher influx of dark-coloured sewage during low tides causes extreme depletion of DO, demarking hypoxic conditions, while it reverts back to an oxic condition when the site gets flooded with more seawater during high tides.

Table 3: Variation of Dissolved Oxygen in surface water around the study area.

Sampling site	Dissolved oxygen (mg/L)			
	Sampling1	Sampling 2	Sampling 3	Sampling 4
C	2.29	2.84	1.08	NA
M	0.95	6.75	8.09	NA
T1	0.54	6.75	1.05	NA
T2	2.16	BD*	0.12	NA
T3	4.46	4.73	0.51	NA

**BD: Below detection; NA: Not Analysed*

Finally, it has been noticed that most of the above-mentioned measured water quality parameters, particularly pH, DO, and turbidity, vary within specific ranges in surface water and have not altered much before or after bio-dispersant treatments. Therefore, it can be presumed that the application of Bio-dispersants had no negative impacts on key water quality in the study area impacted by the oil spill.

The concentration of chlorophyll-*a* in the water samples collected from the 05 stations during different sampling sessions is presented in Table 4. The chlorophyll-*a* concentrations, as indicative of primary productivity, showed ranges of 1.33 to 5.87 mg/m^3 (date), 2.54 to 10.30 mg/m^3 14.54 to 23.93 mg/m^3 (date), and 0.82 to 5.16 mg/m^3 (date). The measured chlorophyll-a concentrations were significantly increased progressively during post-treatment sessions (ADA) (i.e., sampling 2 and 3) at stations T1, T2, and T3 compared to those found at the control station. The significant increase in chlorophyll levels at stations T1, T2, and T3 during samplings 2 and 3 with the progressive samplings ADA compared to the control station indicates the enhanced phytoplankton activity, likely driven by favourable environmental conditions and possibly a reduction in TPH levels. This suggests that these stations provided favourable environmental conditions supporting phytoplankton proliferation and growth during the observation period. This is again a positive sign that the environment is recovering after the application of Biodispersant.

Table 4: Variation of chlorophyll-*a* (mg/m^3) in surface water around the study area.

Stations	Sampling 1	Sampling 2	Sampling 3	Sampling 4
C	5.87	6.86	14.54	2.71
M	4.80	2.54	23.93	0.82
T1	2.80	7.69	16.97	3.56
T2	1.39	2.86	17.45	1.71
T3	1.33	10.30	18.45	5.17

4.2. Variation of microbiological parameters in surface waters

Bacterial abundance measured in terms of Total Bacterial Count (TBC) and Total Viable Count (TVC) are commonly used to assess the microbial load in environmental samples. Monitoring TBC and TVC in any polluted water body provides critical information on the abundance of microbial species.

4.2.1. Total Bacterial Counts (TBC)

The total bacterial counts of bacteria in the surface waters ranged from 1.22 to 5.67 $\times 10^5$ during sampling-1 before the dispersant application (BDA). However, the TBC ranged from 1.72 to 4.31×10^5, 1.67 to 4.39×10^5, and 1.44 to 5.20×10^5 during 2, 3, and 4 samplings (ADA), respectively, indicating a slight increase in the lower limit of the count ADA. This increase is also seen in the control station, wherein the counts have increased nearly 2.5 times more than those at sampling 1 to 3, suggesting a natural increase. Whereas in sediments, the counts ranged from 0.85 to 1.145×10^7 during sampling-1 before the dispersant application (BDA). The counting ranges for samplings 2, 3, and 4 are 0.65 to 1.67×10^7, 0.70 to 1.36×10^7, and 0.81 to 1.49×10^7 respectively, indicating that the sediment recorded higher TBC compared to the sampling 1 (BDA) (Table 2). Though a slight increase is observed in the control station, the increase in counts in the stations T1, T2, and T3 are more significant (Table 2).

The observations from the sampling data suggest a relationship between bacterial load and Total Petroleum Hydrocarbons (TPH) levels at the T3 station. Here's a refined explanation of the findings: During sampling 2, the T3 station exhibited a higher bacterial abundance. This bacterial abundance then decreased in sampling 3, only to rise again in sampling 4. This fluctuation in bacterial populations may correlate with the observed reduction in TPH levels at the T3 station. The plausible explanation is that conditions became more favourable for bacterial growth due to the reduction in TPH levels post-application of Biodispersant. It has been documented that petroleum hydrocarbons can be toxic or inhibitory to many bacterial species; thus, a reduction in TPH could lower toxicity and provide an improved environment for the proliferation of bacterial communities. Additionally, certain bacteria can utilize hydrocarbons as a carbon source, indirectly contributing to the degradation of TPH, and as TPH levels drop, these bacteria might flourish due to the increased availability of other nutrients or reduced competition.

In summary, the data suggests that the decline in TPH at the T3 station likely created conditions conducive to bacterial growth, leading to the observed fluctuations in bacterial load across different samplings. This indicates a dynamic interaction between TPH levels and microbial populations, where the reduction of TPH possibly facilitated an environment that supported bacterial proliferation. Thus, the results suggest that sediments might have recovered from the oil spillage ADA. Such results are not seen in the water sample counts. The counts in the water samples are relatively less than the sediment counts. This may be because the surface waters are more dynamic due to the influence of flood and ebb tide in Ennore Creek.

Table 5: Variations of Total Bacterial Counts (TBC) in surface water

Sampling sessions	Stations	Total bacterial Count of Bacteria (TBC)	
		Seawater ($x10^5$ CFU/ml)	Sediment ($x10^7$ CFU/g of dry wt.)

Sampling 1	C	1.63	1.01
	M	1.22	-
	T1	5.67	1.14
	T2	2.35	0.84
	T3	2.30	0.13
Sampling 2	C	4.31	0.90
	M	2.83	-
	T1	1.72	0.65
	T2	1.86	1.41
	T3	2.17	1.67
Sampling 3	C	4.39	1.36
	M	2.84	-
	T1	1.67	0.93
	T2	1.85	1.10
	T3	2.17	0.70
Sampling 4	C	1.44	1.49
	M	5.20	-NA
	T1	1.45	1.16
	T2	2.67	0.81
	T3	Sample lost	1.43

4.2.2. Total Viable Colony Counts (TVC)

Total Viable Counts (TVC) in the seawater and sediment samples collected from the 5 stations in the study region are presented in Table 3. Total counts in the surface waters ranged from 0.0001 to 0.003×10^5 during sampling 1 (BDA) and ranged from 0.0014 to 0.04×10^5, 0.0179 to 0.97×10^5 CFU/ml, 0.0002 to 0.0029 during samplings 2, 3 and 4, respectively. Whereas in sediment, the counts ranged from 0.37 to 9.40×10^5 during sampling 1, in which the control station contained the highest 9.40×10^5 CFU/ml. But the counts ranged from 4.90 to 13.40×10^5, 0.154 to 0.209×10^5, 0.59 to 1×10^5 CFU/g of dry wt., respectively, for samplings 2, 3, and 4, indicating that the counts are significantly lower than the control station during samplings 3 and 4 (ADA). However, a significant increase in counts was observed during sampling 2, ten

days post dispersant application at stations T1 and T3. This increase in counts is a clear indication of ecosystem recovery. Overall, the TVC counts in the sediments were relatively higher in the 1-2 order magnitude than those retrieved from the water column.

Table 6: Variations of Total Viable Counts (TVC) in surface water

Sampling sessions	Stations	Total Viable Count (TVC)	
		Seawater ($x10^5$ CFU/ml)	Sediment ($x10^5$ CFU/g of dry wt.)
Sampling 1	C	0.0016	9.10
	M	0.003	-
	T1	0.0001	0.37
	T2	0.0017	0.45
	T3	0.00231	9.40
Sampling 2	C	0.0198	13.10
	M	0.04	-
	T1	0.0014	13.40
	T2	0.0253	4.90
	T3	0.0264	11.70
Sampling 3	C	0.097	0.154
	M	0.061	-
	T1	0.022	0.209
	T2	0.0179	0.158
	T3	0.071	0.207
Sampling 4	C	0.0002	NA
	M	0.0004	-
	T1	0.0014	0.61
	T2	0.0029	0.79
	T3	0.0011	0.59

TVC in the range from 1.0 $x10^1$ to 17.9 $\times$ 10^3 CFU/ml in water sample and from 0.154 $\times$ 10^5 to 13.40 $x10^5$ CFU/gm/dry wt. in sediments were recorded during the present study. The counts recorded in the present study are within the normal values recorded for similar coastal waters along the east and west coast of India.

4.3. *Total Petroleum Hydrocarbons (TPHs)*

Petroleum hydrocarbons are complex mixtures of aliphatic and aromatic compounds and the major constituents of gasoline, crude oil, lubricating oils, fuel oils, mineral oils, solvents, and mineral spirits. Among those organic compounds in petroleum hydrocarbons, some are highly toxic and may produce deleterious impacts on living organisms. They degrade very slowly in the natural environment; therefore, any such petroleum products are considered pollutants of potential concern in the environment (Kostka et al., 2020).

During the first sampling (i.e., before the application of the dispersant), the estimated TPHs in the surface water samples around the study area were 2.11 mg/L, 1.25 mg/L, 0.32 mg/L, and 0.025 mg/L at C, T1, T3, and M stations, respectively (Fig. 8). No samples were collected at T2 due to extreme low tide during the first sampling.

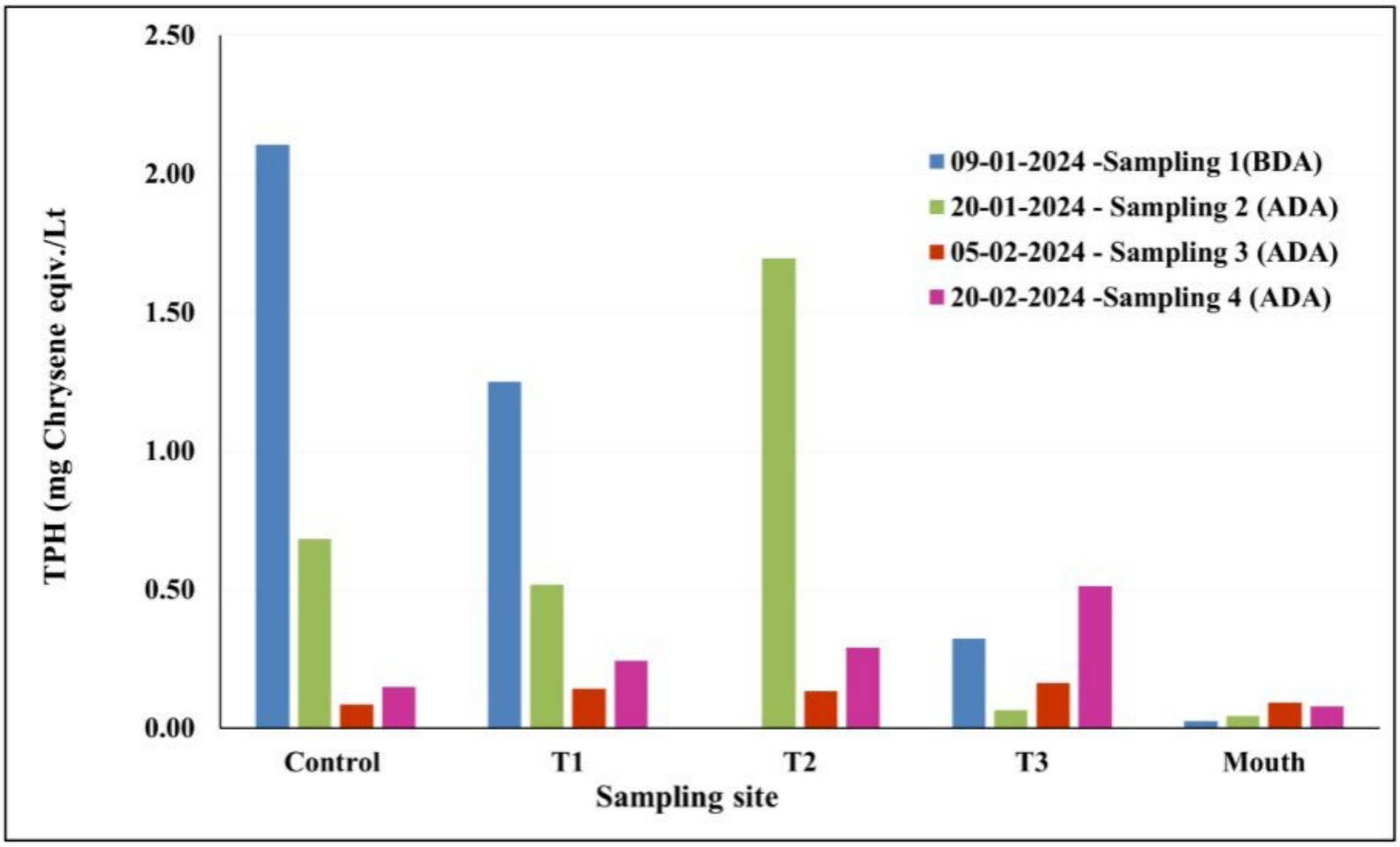

Figure 8. *Distribution of TPH in water samples of 05 sampling sites during four consecutive field samplings.*

The water in the control and T1 stations was slightly more contaminated than at stations T3 and Mouth before the dispersant application. Whereas during the post-treatment session during sampling 2 (i.e., after application of dispersant on the sediment), the degree of oil contamination among all the stations dropped down to the range between 0.044-1.69 mg/L during sampling 2; 0.09-0.16 mg/L during sampling 3 and 0.07-0.51 mg/L during sampling 4 (Fig. 8).

Like the TPHs in water, the estimated bulk petroleum hydrocarbon contents in the sediment samples collected from oil spilled sites showed a wide range of values ranging from 0.63 to 1.83 mg/g (Fig. 9) before applying the Biodispersant. The highest oil accumulation on surface sediment was recorded at station T3, followed by control site C. During sampling sessions 2, 3, and 4, after the Biodispersant application, the TPH values ranged from 0.4 – 1.18 mg/g, 0.09 – 1.65 mg/g, 0.09 – 0.95 mg/g respectively (Fig. 9).

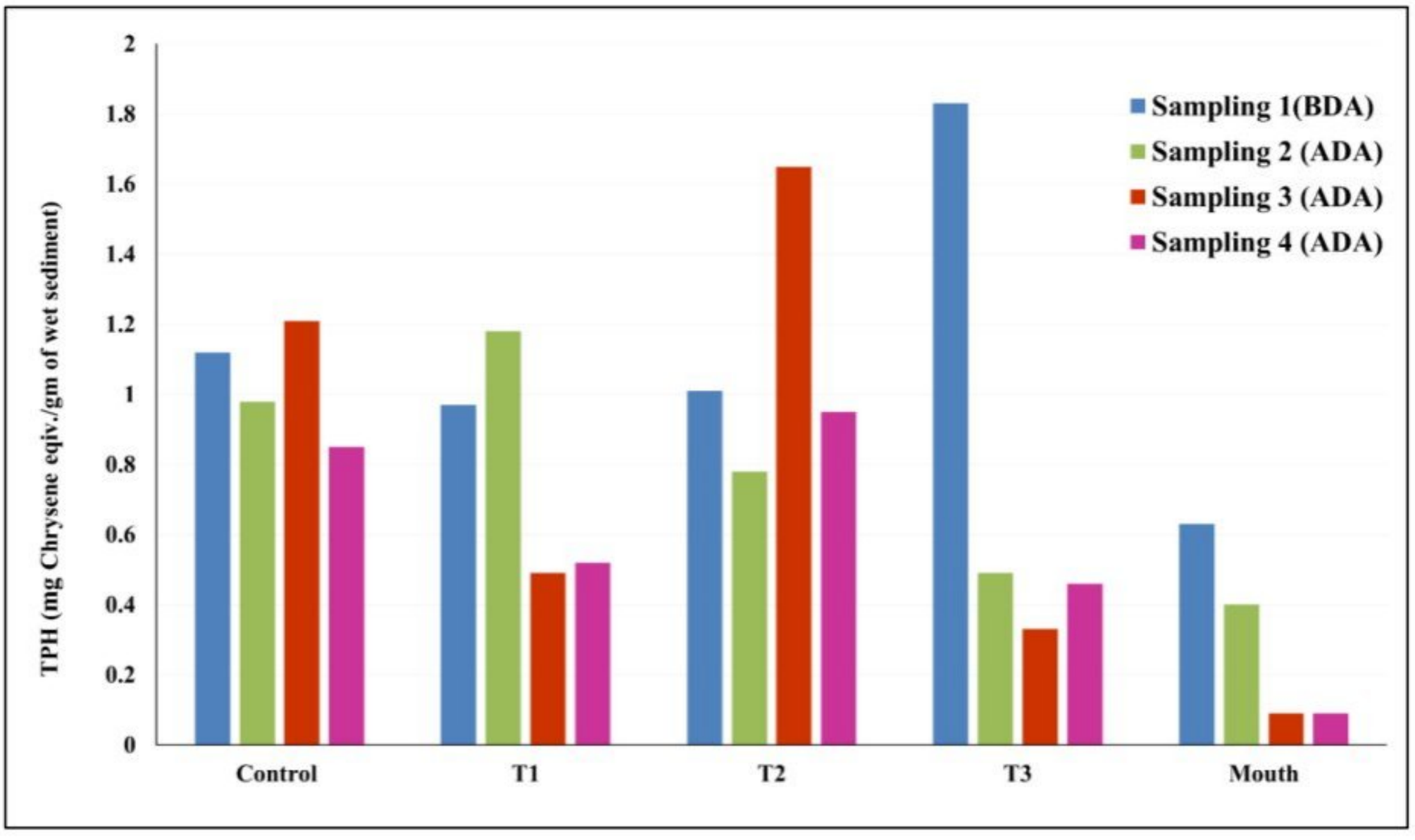

Figure 9. *Distribution of TPHs in surficial sediment of 05 sampling sites during 04 sampling sessions.*

4.4. Relative percentage depletion of TPHs in water and sediment with time

For a better understanding of the influence impacts of Biodispersant on the degradation of petroleum hydrocarbons, the relative depletion of TPHs (in percentage) has been evaluated from the concentrations of TPH recorded for results found during sampling sessions 2, 3, and 4 (i.e., after application of dispersant) with reference to the value of the concentration recorded prior to application of before applying Biodispersant (during sampling 1). Sampling 2 corresponds to 10 days after the application of Biodispersant. Similarly, Samplings 3 and 4 correspond to after 25 days and 40 days post-application of Biodispersant, respectively. Both water and sediment samples were collected from those same locations during each sampling session.

4.4.1. Relative depletion of TPH in water samples

The status of TPHs 10 days post application of Biodispersant (sampling 2), seems to have reduced by 67%, as depicted in the water samples of the control station. Such a significant drop in the concentration of TPHs in surface water at the control site could be due to the effects of natural processes, including dispersion, dilution, and precipitation of oil components, over the period. However, the TPHs of the water sample at station T1 (58%) do not show a depletion percentage as high as the control station, indicating that the applied Biodispersant does not seem to have an efficient impact on the TPH content in water. Meanwhile, the TPHs at station T3 depleted by 80%, which is 13% higher than the natural dispersion of the control site. This data suggests that the higher depletion at the T3 station could be attributed to Biodispersant application. However, very surprisingly, during the next two samplings, means sampling 3 and sampling 4, the TPHs were naturally depleted by 92-95% at the control station (C), but no such high depletions were recorded for stations T1 and T3. This 92-95% depletion in TPH concentrations at the control site may be largely due to the tidal influence of the fresh seawater,

which was found to get fully submerged during the high tide (due to proximity of site C to the Mouth compared to the other stations) and thus regular washing off Site C might have contributed to significantly higher depletion in TPH levels.

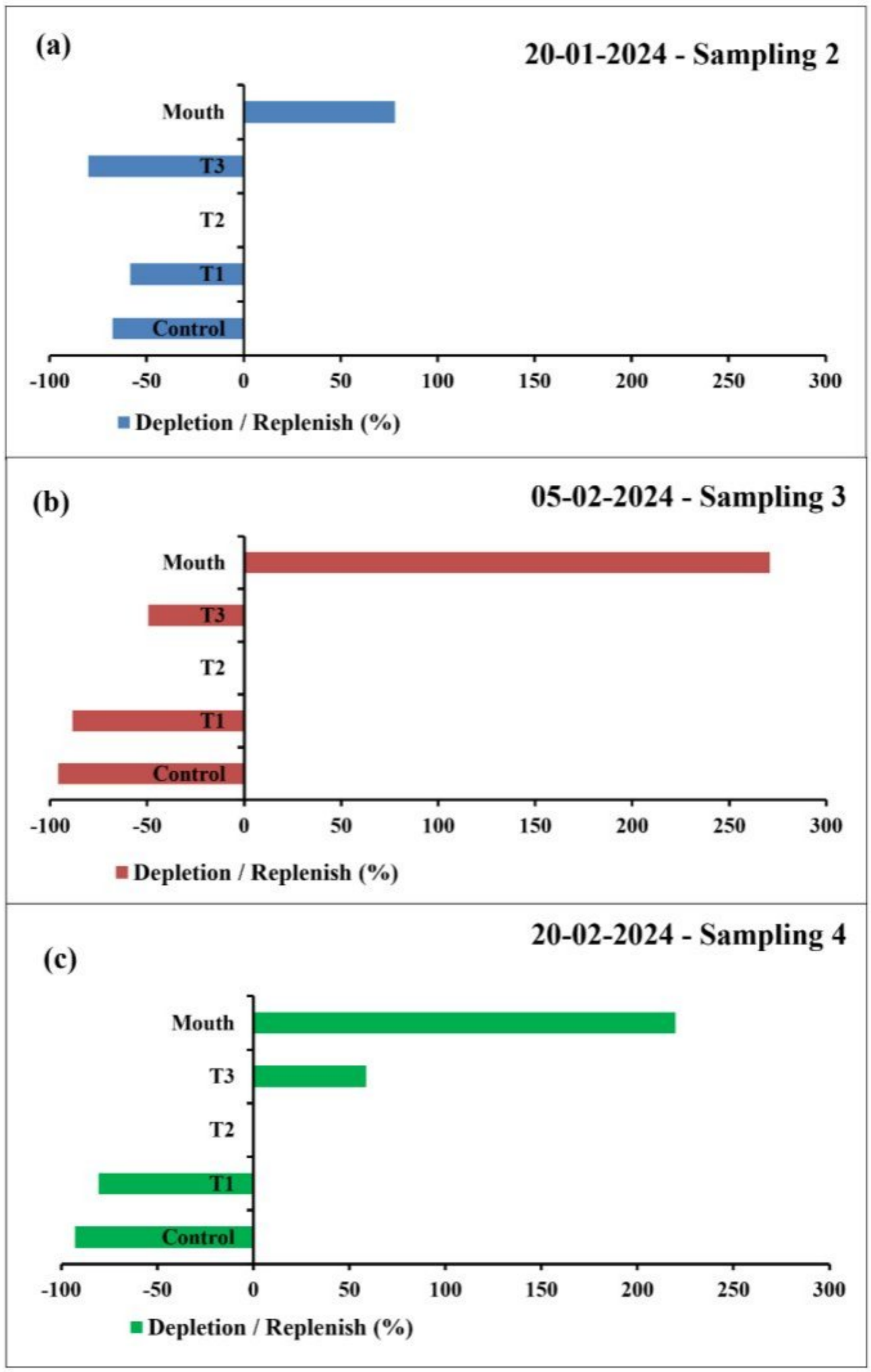

***Figure 10**. Depletion/replenish percentage of TPHs in water samples*

Thus, the Biodispersant sprayed onto the sediments exposed during the low tide apparently did not produce any prominent effects on the oil dispersed in water samples. This is quite possible as the locations T1, T2, T3, and control stations are not far from the river mouth, and robust semidiurnal tides flush the Ennore Creek every 6 hrs intervals. Concomitantly, the dynamic nature of water also discharges increased volumes of pollutants, including oil, from upstream into the study sites as the tide recedes. As discussed in the introduction, the Creek water is getting contaminated with untreated or partially treated domestic sewage, industrial effluents from the industrial belt, coolant water discharge from the ETPS, and various other industrial effluents (Krishnaveni et al., 2023). In addition to these pollutants, the waste oil released into the Buckingham Canal might have increased the overall pollution levels in the water samples, whose impact could have dominated overwhelmingly the positive impacts of the applied Bio dispersant. In addition, the designated areas where Biodispersant was sprayed were not adequately contained by the booms throughout the study, though the booms were installed. Due to the tidal influence, the waters of Biodispersant sparyed areas continuously mixed up with the surrounding waters.

4.4.2. Relative depletion of TPH in sediment samples

The TPH depletion percentage among the sediment samples collected during four samplings is illustrated in Fig. 11. It is evident from the second sampling at the control station that the TPHs were naturally depleted by 12.5% within 10 days after the dispersant application. But stations T2 and T3 showed 23% and 73% depletion percentages, respectively. This, in turn, shows a 10% and 60% higher depletion than the control station, indicating that the Biodispersant might have played a role in the higher degree of depletion of TPHs. However, such depletions were not shown in the T1 location. Exciting results were seen in the third sampling (Fig. 11b). The figure shows that the TPHs increased by 8% in the control station.

However, T1 and T3 (dispersant-applied locations) showed a depletion of 49% and 81%, respectively. During the fourth sampling, 40 days after the Biodispersant application, the control station showed only a 24% depletion. Meanwhile, stations T1, T2, and T3 showed 46%, 6%, and 74% depletion in TPH.

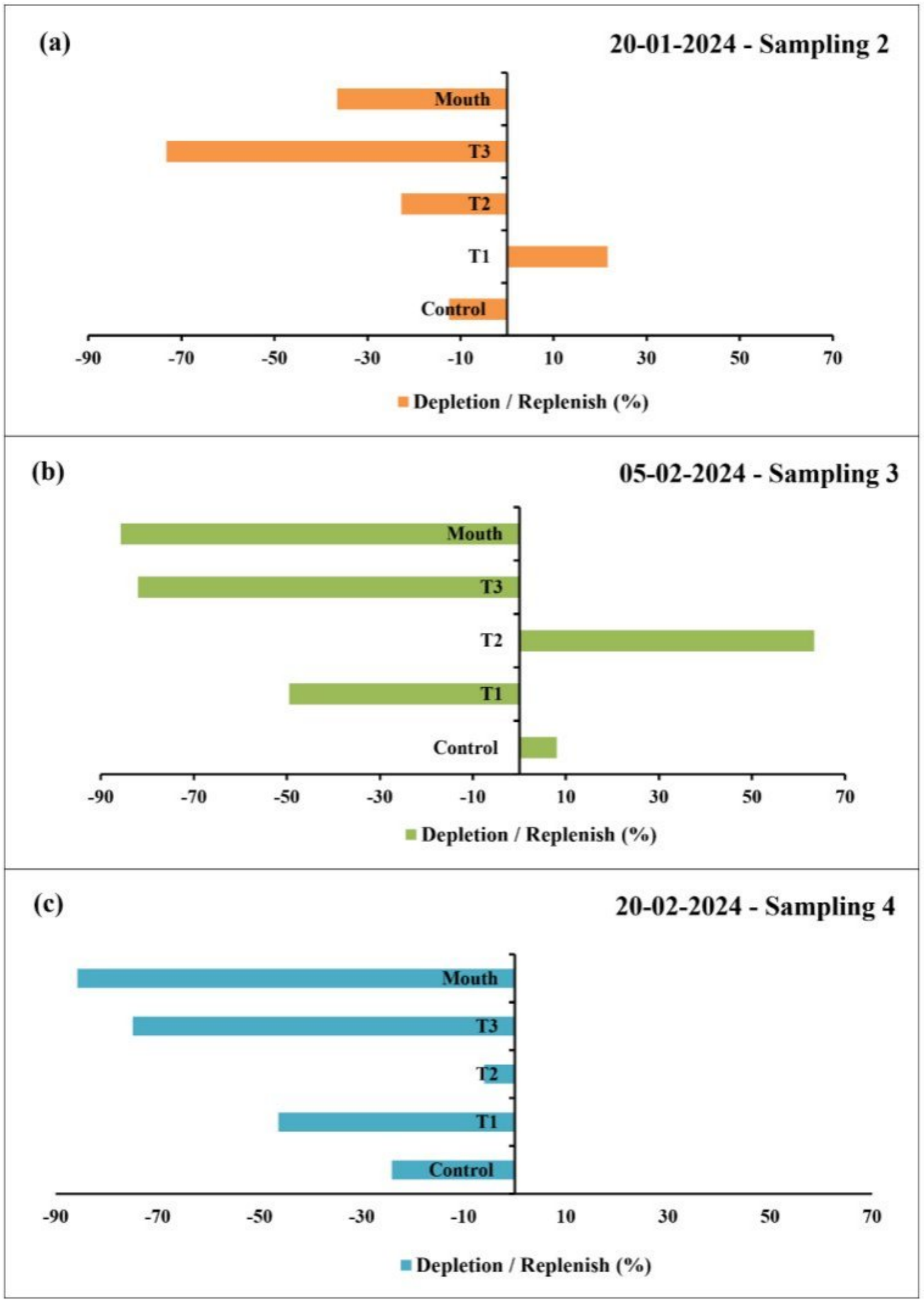

Figure 12. *Depletion percentage of TPHs in sediment samples.*

Overall, the Biodispersant application at the T2 location did not show any positive impact on the surficial sediments over there. The plausible reason could be that this location is near the Buckingham Canal, from which fresh domestic sewage and other industrial pollutants are continuously entering, which might have further increased the TPH levels in addition to the spilled oil.

5. Training on water quality parameters to TNPCB officials

The TNPCB officials Dr Vasudevan, Dr Venkatesan Perumal and Mrs Rosina Begam visited CSIR-NIO from 12 to 16 March 2024 to attend a training programme. On the first day of the 03-day training programme (i.e., on 13 March 2024), the details of sample processing and analytical techniques for microbial parameters like TVC and TBC were presented at the Biological Oceanography Division.

The second day (14 March 2024) was about the sample processing (water and sediment) and analysis of TPH in water and sediment in the Environmental Forensics Laboratory.

Hands-on training was also provided to quantify the TPH using the Spectrofluorometer. Additionally, training was given on microplastic analysis in water and sediment samples. On the last day, on 15 March 2024, an exclusive training on oil spills, impacts of oil spills on the coastal marine environment, mitigation of oil spills, application of dispersants and bioremediation agents and testing procedures of oil spill dispersants and bio-remediation agents was imparted.

The glimpses of these three days of training are depicted in Fig. 13.

Figure 13. *The snapshots of the TNPCB training programme at CSIR-NIO during 13-15 March 2024.*

6. Conclusions

- The CSIR-NIO has undertaken the pilot study. A total of four field sampling were conducted to collect surface water and sediment samples from the select locations. The first sampling was before the application of the bio dispersant (09/01/2024), followed

by samplings after 10 days (20/01/2024), 25 days (05/02/2024) and 40 days (20/02/2024) of post-application.

- The results reveal that the TPHs in water samples initially were in the range of 0.025 to 2.11 mg/L and reduced to 0.07 to 0.51 mg/L by fourth field sampling, i.e. 40 days after the biodispersant is applied.

- The TPH at station T3 reduced from 0.3 mg/L (Before Dispersant Application (BDA)) to 0.06 mg/L (After Dispersant Application (ADA)) during the second sampling, depleted 13% higher than the natural dispersion, which could be due to dispersant application. However, very surprisingly, during the next two samplings, means sampling 3 and sampling 4, the TPHs were naturally depleted by 92-95% at the control station, which could be due to the mixing of fresh seawater due to the tidal actions as this location faces the sea, and may not be due to the natural depletion. It is also possible that due to the continuous cleaning activity in the Creek area, jointly organised by CPCL and TNPCB.

- Overall, the dispersant application seems to have had no significant positive impact on the TPHs present in water samples other than at the T3 location. This is possible since the tidal influence exists every 6 hrs due to the rising and falling of high and low tides in Ennore Creek. Water is dynamic due to tidal influence; freshly added pollutants may enter the water every time, and fresh sea water may cleanse the water during every tidal cycle. Therefore, it is complicated to rely on the results of the water samples.

- Interestingly, the TPHs present in the sediment samples have shown different ranges. Initially the TPH was in the range of 0.63 to 1.83 mg/g (BDA) and reduced to the range of 0.09 to 0.95 mg/g, within 40 days after the biodispersant application. Stations T1 and

T3 showed the highest depletion of 49% and 81%, respectively, on 05 February 2024, 25 days after the dispersant application. The TPH at T1 reduced from 0.97 mg/g (BDA) to 0.49 mg/g (ADA). Similarly at T3 reduced from 1.83 mg/g (BDA) to 0.33 mg/g (ADA).

- During the fourth sampling, 40 days after the dispersant application, the control station showed only a 24% depletion. Meanwhile, the T1, T2, and T3 stations showed 46%, 6%, and 74% depletion. The TPHs at T1 reduced from 0.97 mg/g (BDA) to 0.52 mg/g (ADA). Similarly at T3 reduced from 1.83 mg/g (BDA) to 0.46 mg/g (ADA). Station T2 has shown very little depletion, reducing from 1.01 to 0.95 mg/g ADA.

- The maximum depletion of TPHs (81%) in sediments was observed at the T3 location. The reason could be that an additional 100 litres of dispersant were sprayed at this location. Therefore, even the TPHs of water at this location have shown a significant depletion (13%), but only during sampling 2, immediately after the 10 days of the dispersant application.

- No TPH depletion was observed in the sediments at the T2 location. One plausible reason could be that this station is near the Buckingham Canal, through which domestic and other industrial waste is continuously released into Ennore Creek.

- Based on the observed data for Total Viable Count (TVC), Total Bacterial Count (TBC), and chlorophyll levels, it appears that the reduction in Total Petroleum Hydrocarbons (TPH) has indeed created more favourable conditions for microbial and phytoplankton activity. Additionally, the application of biosurfactants likely played a significant role in aiding the ecosystem's recovery from the oil spillage.

- Overall, biodispersant application has a significant positive impact, especially on sediments. If the proper dilution and dosage of spraying are made, excellent results can be expected. In this study, we roughly sprayed the dispersant only once, with 300 L at T1 and T2 and 400 L at the T3 location.

- As proposed, the training for TNPCB officials was conducted at NIO Goa from 13 to 16 March 2024. Three officers from TNPCB have attended the training course.

Acknowledgements

We thank the Director, CSIR-NIO, Goa, and the Chairperson, TNPCB, Tamil Nadu, for their encouragement and support throughout the project. The officers and Scientists of TNPCB are highly acknowledged for their support during all four field samplings. The CPCL is specially thanked for arranging the boats and other logistics during sampling in Ennore Creek. We also thank Dr Jagadish Patil, Sr.Pr.Sci of CSIR-NIO, Goa, for sharing the instrument for TPH analysis. All the project staff from CSIR-NIO Goa who have been involved in the field sampling and analysis, including the project report preparation, are highly acknowledged.

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TAMIL NADU POLLUTION CONTROL BOARD

LiFE Lifestyle for Environment

MINUTES OF THE MEETING WITH TECHNICAL TEAM MEMBERS ON 03.09.2024 BY 2.30 PM AT CORPORATE OFFICE GUINDY REGARDING OIL SPILL IMPACT ASSESSMENT STUDY AND BIOREMEDIATION STUDY CONDUCTED IN THE AFTERMATH OF OIL SPILL INCIDENT AT ENNORE CREEK IN DECEMEBER 2023

List of Participants:

I. **Technical Team Members**
   a. Thiru.R.Kannan, Member Secretary, TNPCB (Chairperson to the Technical Team)
   b. Tmt. H.D.Varalaxmi, Regional Director, CPCB
   c. Dr.G.Saravanan, Principal Scientist, NEERI
   d. Prof V.T.Perarasu, Anna University
   e. Thiru. V. Vinod Kumar, Commandant, Indian Coast Guard
II. **TNPCB**
   a. Tmt. J. Josephine Sahaya Rani, JCEE, Corporate Office
   b. Dr. D. Vasudevan, JCEE (M), Chennai
   c. Tmt.S.Indiragandhi, DEE, Ambattur
   d. Thiru.Santhanakrishnan, AE, O/o.DEE, Ambattur
   e. Tmt.Rosina Begam, ES, O/o.DEL, Oragadam
   f. Tmt.S.Nandhini, AE, Corporate Office
III. **IIT, Madras**
   a. Prof.Indumathi Nambi & team
IV. **NIO, Goa**
   a. Dr.SuneelVasimalla& team (Virtual)

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At the outset, the participants formally introduced themselves and the meeting begun with Prof.Indumathi Nambi explaining their work onassessment of Ennore oil spill during Cyclone Michaung and stated that to find out the source and pathway of the spill, the overall area was divided into three assessment regions and 20 areas were identified as oil-contaminated areas. The volume of oil is estimated in soil, in oil pools, as sheen on Buckingham Canal &Kosasathalaiyar river, in residential and industrial areas and on river banks and mangroves. On estimation, the oil present in the environment is 647 cu.m. or 517 tonnes (most conservative) to 3212 cu.m. or 2569 tonnes (least conservative). Further as Phase 2 of this work, IIThas engaged Indian Council of Forest Research and Education - Institute of Forest Biodiversity, Hyderabad (ICFRE, Hyderabad)to conduct a comprehensive biodiversity impact assessment which is under progress.

Subsequent to IIT's presentation, National Institute of Oceanography (NIO), Goa presented their pilot study on assessing environmental benefits for cleaning /bioremediation of oil spillage through the application of Biodispersants. They have conducted their study in 4 different locations (1 Control location & 3 Treatment locations). The total dosage for the three

locations T1, T2 & T3 was fixed as 300 L, 300 Land 400 L respectively.Water Quality parameters such as pH, salinity, DO, BOD, TBC (Total Bacterial Count), TVC (Total Viral count), Chlorophyll, bulk PHC and sediment samples for TVC, TBC, bulk PHC were analyzed. Upon analysis, the location with higher concentration showed better results. However, NIO stated that the entire study is done at pilot scale and overall optimization of process parameters like dosage, area of treatment, treatment time etc, are required to gain exhaustive results.

On completion of both the presentation, the team made the following remarks:

- In the final report by the Technical Team which was submitted to the Government in January 2024, the team had inferred that the quantity of oil washed away might be more than 400 KL. This was derived by the team based on the information such as slop oil quantity from daily operation, crude receipt quantities, total sludge accumulation in the premises, characteristics of slop oil, cleaning frequency etc.,
- Now, IIT in their report has given their most conservative estimate as 647 cu.m. or 517 tonnes which is close to the technical team's observations.
- Therefore, the total spilled oil may be considered as 647 cu.m or 517 tonnes for computation of damages caused. Assessment of the environmental damage caused by the oil spillage and the cost of restitution of environment will be calculated by the methodology adopted in the research publication "Oil spill & cleanup costs by Cao Thi Thu Trang, Institute of Marine environment & Resource, Vietnam". This methodology of cost calculation was used in similar NGT matter in OA No. 18 of 2020/EZ (Praveen Kumar Singh Vs Damodar Valley corporation &Ors.).
- With this, the team will compute the Environmental Compensation within a period of 2 weeks.
- Further, with regard to the bioremediation study by NIO, Goa, the team opined that the overall study including the dosage fixation was conducted in a trial & error basis. Therefore, extensive, long term studies with systemic approach& optimization is required to conclude about the efficiency of the bio-dispersants.

After these above closing remarks, the meeting came to an end.

Dr.G.Saravanan,
Principal Scientist,
CSIR - NEERI

Prof V.T.Perarasu,
Anna University

Thiru. V. Vinod Kumar,
Commandant, ICG

Tmt. H.D.Varalaxmi,
Regional Director, CPCB

Thiru.R.Kannan,
Member Secretary, TNPCB

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL,
SOUTHERN ZONE- CHENNAI
O.A NO. 180 of 2023
AND
O. A NO.183 OF 2023

Tribunal on its own motion SUOMOTU based on the Visual media titled Chennai Rains Makkalai Vathaikkum Oil Companies- Shocking Story - Michaung Ground Report covered by on VIKATAN TV Chennai dt.06.12.2023

with

The District Collector Chennai District

And Ors.

...Respondents

AND

R.L. Srinivasan, Chennai.

...Applicant (s)

Versus

The Tamil Nadu Coastal Zone Management Authority & ors

...Respondent(s)

REPORT FILED ON BEHALF OF THE RESPONDENT - TAMIL NADU POLLUTION CONTROL BOARD.

Advocate for Respondent: TNPCB
Thiru.S. Sai Sathya Jith,
Advocate, Chennai.

Date:06.09.2024

Date of hearing on:09.09.2024.