PERIODIC MONITORING OF MARINE ENVIRONMENT FOR MSPL OUTFALL, BHAVNAGAR, GUJARAT

Monitoring Report - 2 of 4/2021-22
August 2021

PROJECT CODE: 656041920

MADHU SILICA PRIVATE LIMITED
BHAVNAGAR, GUJARAT

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Client	Madhu Silica Private Limited, Bhavnagar.
Project Title	Periodic Monitoring of Marine Environment for MSPL Outfall, Bhavnagar, Gujarat for the year 2021-22.
Project Code	656041920

Abstract

Madhu Silica Private Limited (MSPL) is discharging 10 MLD treated industrial effluent in Bhavnagar Creek for which MoEFCC-CRZ clearance was obtained vide F. No. 11-6/2015-IA-III dt. 29.06.2015.

Subsequently, MSPL has been submitting the Periodic Monitoring Reports every 3 months.

Status of reports for year 2021-22:

- May 2021 – 1 of 4 – Report not done due to COVID 19 Pandemic second wave. Sampling could not be done due to transport restrictions.
- Aug 2021 – 2 of 4 – Present report

**Due to COVID-19 Nationwide lockdown and strict interstate travel protocols, quarterly monitoring study for the period March 2021 – May 2021 was not conducted. The task of quarterly monitoring study for June 2021 to August 2021 is taken up immediately after the interstate relaxations and this forms as the 2nd season Quarterly Monitoring Report for the year 2021-22.*

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1. PROJECT DESCRIPTION

Madhu Silica Pvt. Ltd. (MSPL), Bhavnagar, is the largest manufacturer of precipitated Silica in India and it is the 3rd largest company in the world. MSPL with its allied company Aqua gel Chemicals Pvt. Ltd., is having seven established plants capable of manufacturing around 95000 MT of precipitated Silica per annum. It has recently established a state of art plant with capacity of 45000 MT/Annum in Bhavnagar. The company has a large business associate network in India and Asia, Middle East, Latin America, US & Europe. Apart from the large Indian market, the company exports their products to more than 40 countries. The company has on its credit ISO 9001:2008, ISO 14001:2004, OHSAS 18001:2007, FAMI-QS, FDA certified and registered for each.

MSPL has planned for capacity expansion in 28 acres of land towards total installed capacity of precipitate Silica of 95000 MT/Annum. Under this development process, MSPL has obtained permission to discharge additional 10 MLD (417 m^3/hour) treated industrial effluent in the marine environment. It has laid a submarine pipeline with diffuser on the creek bed for discharging the effluent.

MSPL obtained MoEFCC clearance vide F. No. 11-6/2015-IA-III dt. 29.06.2015. The post project monitoring is being carried out for four seasons in a year to comply the conditions of MoEFCC covering the aspects of seawater quality, seabed sediment quality and marine benthic flora & fauna. The monitoring studies are being carried out from May 2017 i.e. since the commencement of project on quarterly basis. The periodic monitoring reports are being regularly submitted to the Regional Office of MoEFCC, Bhopal. This report forms as the second periodic monitoring (August 2021) for the year 2021 - 2022.

Due to COVID-19 second pandemic Nationwide lockdown and strict interstate travel protocols, quarterly monitoring study for the period Mar 2021 – May 2021 was not conducted. The task of quarterly monitoring study for Jun 2021 to Aug 2021 is taken up immediately after the interstate relaxations and this forms as the 2nd season Quarterly Monitoring Report for the year 2021-22.

The location map is shown in Fig. 1 and the effluent outfall location is shown in Fig. 2.

2. SCOPE OF MONITORING

Periodic monitoring near the outfall location as suggested in the Post Project Monitoring Plan of the EIA report was recommended by the MoEFCC. Accordingly, MSPL has asked Indomer Coastal Hydraulics (P) Ltd, Chennai, to take up periodic monitoring programme. It was proposed to conduct quarterly monitoring covering four times in a year i.e., in the months of May, August, November and February every year during the project operational period.

Indomer Coastal Hydraulics (P) Ltd., Chennai is an ISO 9001:2015 organization, NABL and QCI - NABET accredited organization vide NABET/EIA/2023/RA 0207 dt. 29.06.2021 for *Sector 27: Oil & Gas Transportation pipeline (crude and refinery/petrochemical products), passing through national parks/ sanctuaries/ coral reefs/ ecologically sensitive areas including LNG Terminal* and *Sector 33: Ports, harbours, jetties, marine terminals, breakwaters and dredging.*

QCI-NABET accreditation certificate is attached as Annexure I.

3. DATA COLLECTION FOR MONITORING

The creek water, creek bed sediments and biological samples were collected at three locations around the outfall points (SS1 to SS3) in August 2021. The samples for intertidal benthos were also collected at three locations (IB1 to IB3). The details of the sampling locations are given in Table 1 and shown in Fig. 2. The monitoring work covered is listed below:

i) Creek water quality parameters at three locations at surface and bottom:

Temperature
pH
Salinity
Dissolved Oxygen (DO)
Total Dissolved Solids (TDS)
Biochemical Oxygen Demand (BOD)
Chemical Oxygen Demand (COD)
Ammonium
Nitrite
Nitrate
Total nitrogen
Phosphate
Total phosphorus
Turbidity
Total Suspended Solids (TSS)
Cadmium
Lead
Mercury
Total Chromium
Phenols and
Total Petroleum Hydrocarbons

ii) Creek bed sediment quality parameters at three locations:

Sediment Texture
Total Nitrogen
Total Phosphorous
Total organic carbon
Calcium carbonate
Cadmium
Lead
Mercury
Total Chromium
Phenols and
Total Petroleum Hydrocarbons
iii) Biological parameters at three locations on:

Primary Productivity
Phytoplankton, its biomass and diversity
Zooplankton, its biomass and diversity
Sub-tidal and inter-tidal macrobenthos, its biomass and diversity and
Microbial population in creek water and sediment

Analysis: All the water and sediment parameters were analyzed by Indomer Coastal Hydraulics Pvt. Ltd., which is accredited by the National Accreditation Board for Testing and Calibration Laboratories (NABL) vide certificate no. TC – 5232/13.01.2019. Analysis of Total Petroleum Hydrocarbons in creek water and sediment samples was outsourced to NABL accredited Laboratory. NABL accreditation certificate of Indomer is attached as Annexure II.

Sample Analysis Protocol: Creek water and creek bed sediment samples were analyzed as per the IS/APHA/USEPA standard methods, details of which are given below.

Sl.No.	Parameters	Protocol
Water quality		
1	Temperature	IS 3025 : Part 9
2	pH	IS 2720 : Part 11
3	Salinity	IND/SOP/WQ/13
4	Dissolved Oxygen	IS 3025 : Part 38
5	Total Dissolved Solids	IS 3025 : Part 16
6	BOD	IS 3025 : Part 44
7	COD	IS 3025 : Part 58
8	Turbidity	IS 3025 : Part 10
9	Ammonium	IS 3025 : Part 34
10	Nitrite	IS 3025 : Part 34
11	Nitrate	IS 3025 : Part 34
12	Phosphate	IS 3025 : Part 31
13	Total Nitrogen	IS 3025 : Part 34
14	Total Phosphorous	IS 3025 : Part 31
15	Total Suspended Solids	IS 3025 : Part 17
16	Cadmium	IS 3025 : Part 2
17	Lead	IS 3025 : Part 2
18	Chromium	IS 3025 : Part 2
19	Mercury	IND/SOP/WQ/35
20	Phenols	IS 3025 : Part 43
21	Petroleum Hydrocarbons	TNRCC method 1055
Sediment quality		
1	Soil texture	IS 2720 : Part 4
2	Total Organic Carbon	IS 2720 : Part 22
3	Total Nitrogen	IS 14684 – 1999
4	Total Phosphorous	IS 10158 – 1982
5	Calcium carbonate	IS 2720 : Part 23
6	Cadmium	USEPA 3050 B
7	Lead	USEPA 3050 B
8	Chromium	USEPA 3050 B
9	Mercury	USEPA 3050 B
10	Phenols	USEPA 8041 & 3545 A
11	Petroleum Hydrocarbons	TNRCC method 1055

Biological parameters

Primary Productivity: Primary production will be estimated from appropriate study area sampling stations. From the water sampler, the samples must be immediately transferred to 125 ml DO bottles (two light bottles and one dark bottle). The sample in the first bottle will be used

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

Phytoplankton: Phytoplankton samples will be collected from appropriate study area sampling stations, for both qualitative and quantitative analyses.

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

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

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

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

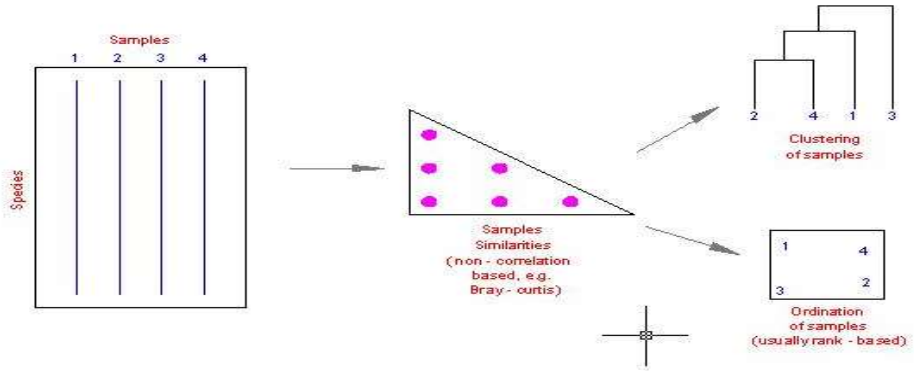
Macro Benthos: Seabed sediment samples will be collected using Van Veen grab from sampling stations. The intertidal benthic samples will be collected from appropriate stations. The benthic organisms will be separated by sieving through 500 micron mesh and preserved using formaldehyde and Rose Bengal stain. The samples will be sorted and identified upto groups/genera level using stereo microscope. The wet weight will be taken to calculate the biomass of benthic organisms.

Microbiology: The microbiological samples will be collected from appropriate study area sampling stations. The total coliform from each location will be identified by membrane filter technique (APHA 9060 A & B). Samples will be collected clean, sterile and non-reactive glass or plastic bottles. Microbial analysis is started as soon as possible after collection to avoid unpredictable changes. Spread plate method will be used to culture the microorganisms. The agar media used for analysis were: Nutrient agar, MacConkey agar, Thiosulphate Citrate Bile Sucrose agar, Xylose

Lysine Deoxycholate agar, M-Enterococcus agar and Cetrimide agar. Plates were incubated at 37° C for 48 hrs. After incubation, the colonies will be counted and identified based on their colour characteristics.

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

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



Stages in a multivariate analysis based on similarity coefficients

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

4. RESULTS

4.1. Water quality

The estimated creek water quality parameters on temperature, pH, salinity, total dissolved solids, dissolved oxygen, ammonium-nitrogen, nitrite-nitrogen, nitrate-nitrogen, total nitrogen, phosphate-phosphorus, total phosphorus, total suspended solids, and turbidity are presented in Table 2. Biochemical Oxygen Demand and Chemical Oxygen Demand are presented in Table 3. Results of the heavy metals cadmium, lead, total chromium, mercury, phenols and total petroleum hydrocarbons are presented in Table 4.

During the present study, creek water salinity ranged from 27.5 to 29.5 PSU and pH range was 7.23 to 7.48. The values of salinity and pH are slightly less compared to previous study, which may be due to freshwater influx and effect of monsoon rain runoff in the creek water. Very high amount of fresh water flow was observed in the creek during the sample collection. Hence, salinity and pH values were low in the creek water.

The range of TSS (1254 to 1454 mg/l) was found to be high compared to the previous sampling period of February 2021. Dissolved oxygen values ranged from 5.2 to 5.8 mg/l, which is a small fluctuation, to the earlier reported values. BOD values were also found to be normal (<2 mg/l) like earlier periods at all the three stations.

Ammonium, Nitrite, Nitrate, Total Nitrogen, Phosphate and Total Phosphorus concentration levels show seasonal variation and however all the nutrients values are observed to be within the normal range. Cadmium levels ranged from 2.1 to 2.6 µg/l and Chromium concentration ranged from 2.1 to 2.5 µg/l. However, the metals were observed to be in trace level in the study areas. Similarly, phenols and total petroleum hydrocarbons were also found to be below detectable levels during the present study.

Creek water values for Turbidity, TSS, DO, BOD, nutrients, heavy metals and other organic compounds were found to be in normal range. Hence, it can be confirmed that treated effluent is discharged into the creek environment at appropriate time and with appropriate intervals.

4.2. Sediment quality

The creek bed sediment quality parameters collected at 3 locations (SB1, SB2 and SB3) are given in Tables 5 and 6. Results of cadmium, lead, total chromium, mercury, phenols and total petroleum hydrocarbons in sediments are presented in Table 7. Sediment texture, during the present study period, was of silt clay nature, at all stations. Total phosphorus, calcium carbonate, total nitrogen and total organic carbon values at all stations, varied slightly, compared to pre-project period study. Total nitrogen values ranged from 21.2 to 28.6 mg/kg at the three stations. Cadmium, mercury, lead, phenols and total petroleum hydrocarbon levels were found to be below detectable limit, at all the three stations. However, marginal difference was observed in the chromium level, between the pre-project period and the present study (23.8 to 25.4 mg/kg).

During present study, sediment nature was found to be of silt clay texture. The levels of trace metals mercury and lead at all three stations along with phenols and petroleum hydrocarbons in the sediment were found to be below detectable level. Chromium values ranged from 23.8 to 25.4 mg/kg at all three stations. In general, these conditions reflect that the creek bed sediments are in normal condition and remain uncontaminated.

4.3. Biological parameters

Phytoplankton and primary productivity: Phytoplankton are the primary source of food in the marine environment. The concentration and numerical abundance of the phytoplankton indicate the fertility of a region. The phytoplankton population depends primarily upon the nutrients present in the creek water and the sunlight for photosynthesis. This primary production is an important source of food, for the higher organisms, in the marine environment. The measured primary production results indicate that the area is moderately productive, and the values varied between 330 and 390 mgC/m^3/day; the recorded average value is 360 mgC/m^3/day (Table 8).

Various phytoplankton groups were observed, and their percentage composition and numerical abundance are shown in Tables 9 and 10. Phytoplankton diversity fluctuated from 21 to 25 species. Bacillariophyceae (diatoms) formed the major group followed by Dinophyceae (dinoflagellates) and Cyanophyceae (blue green algae). Phytoplankton population density varied from 1950 to 2750 cells/l (Table 11). In the present study, the number of species and population density observed were slightly low, compared to previous report (Table 19).

Phytoplankton population mostly consists of Bacillariophyceae (71.53%), Dinophyceae (19.71%) and Cyanophyceae (8.76%). During the study period, *Coscinodiscus centralis* was the most dominant species in the study area followed by *Trichodesmium erythraeum*, *Odontella mobiliensis, Ceratium furca, Coscinodiscus* sp. and *Planktoniella sol.*

Zooplankton: The numerical abundance of zooplankton varied from 8300 to 11840 nos./100m^3 (Table 12). The highest zooplankton population was observed at SS2 and the lowest was observed at SS3. The zooplankton biomass varied from 10.6 to 12.2 ml/100m^3 (Table 13). In the present study, zooplankton density and biomass showed marginal variations, when compared to previous study (Table 19). The most dominant zooplankton species were *Acartia erythraea, Centropages furcatus*, *Acrocalanus* sp., *Oithona* sp. and *Temora turbinata* than the other species.

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

Sub-tidal benthos: The numerical abundance of the benthic fauna varied from 360 to 480 nos./m^2 (Table 14). The subtidal fauna population was slightly higher, when compared to previous study period (Table 19).

Inter-tidal benthos: The intertidal faunal population is shown in Table 14. The existence of fauna appeared to be moderate in the three (IB1 to IB3) locations. The numerical abundance of the intertidal benthic fauna varied between 165 and 240 nos./m^2 which is slightly higher than the earlier recorded values (Table 19).

Microbiology:

Bacterial counts in the water and sediment samples were analyzed and presented in Tables 15 and 16. In the water samples, population density ranged from 0.01 to 5.21×10^3 CFU/ml. In the sediment, the population density ranged from 0.02 to 5.24×10^4 CFU/g. Bacterial population was slightly higher in sediment samples compared to the water samples. In general, there is not much of a variation observed between the present and earlier values both in creek water and sediment.

Primary production, phytoplankton, zooplankton, are found to be in normal values. The sub-tidal and inter-tidal benthic population showed normal range at all three stations during the study. Bacterial population in water and sediments also indicated normal range.

5. ENVIRONMENTAL STATUS - COMPARISON WITH PRE-PROJECT PERIOD

Comparison of water quality, sediment quality and biological parameter results were carried out between the pre-project period (May 2013) and the periodic monitoring results of August 2021 as given in Tables 17, 18 and 19. Comparison of water quality, sediment quality and biological parameters during monitoring period (February 2020 – August 2021) are shown in Figures 3, 4 and 5 respectively.

Water Quality

It is inferred that the water quality parameters showed normal range as applicable for the creek waters in Bhavnagar and they are comparable with the pre-project period results. The differences are very marginal, and they are due to seasonal variation which is common for creek waters.

Sediment quality

Sediment texture was predominantly towards silt clay in nature during present study and other chemical properties are observed to be in normal range and there is no significant change in the creek bed sediment quality.

Biological Parameters

Primary production, Phytoplankton and Zooplankton population were showing marginal seasonal variation but within normal range in the present observation, attributing to optimum water quality conditions. The sub-tidal and intertidal benthic population showed only marginal difference between pre-project period and monitoring period of August 2021.

Microbiology

There are no changes observed in bacterial population, in water and sediments, among the different sampling periods in this creek.

Table 1. Details of sampling locations

Station	UTM Coordinates (WGS 84)		Water depth (m)	Sampling depth* (m)
	X (m)	Y (m)		
WATER AND SEDIMENT SAMPLING				
SS1 & SB1	204022	2414736	2.7	S & B
SS2 & SB2	204458	2414511	2.9	S & B
SS3 & SB3	204951	2414447	3.1	S & B
INTERTIDAL BENTHOS				
IB1	204178	2414637	Intertidal zone	
IB2	204435	2414473	Intertidal zone	
IB3	204650	2414381	Intertidal zone	

**S = creek surface, B = creek bottom*

Table 2. Water quality parameters at Bhavnagar creek (August 2021)

Station	Water depth*	Temp. (°C)	Salinity (PSU)	pH	DO (mg/l)	TSS (mg/l)	Turbidity (NTU)	Ammonium (µmol/l)	Nitrite (µmol/l)	Nitrate (µmol/l)	Total Nitrogen (µmol/l)	Phosphate (µmol/l)	Total Phosphorus (µmol/l)
SS1	S	27.5	27.5	7.23	5.8	1396	635	3.27	1.98	15.7	21.0	1.67	2.23
	B	27.0	27.9	7.48	5.5	1454	661	2.66	2.11	16.6	21.4	1.74	2.96
SS2	S	27.5	28.5	7.26	5.6	1346	612	3.05	1.70	14.2	19.0	1.45	2.34
	B	27.1	28.9	7.27	5.4	1408	640	2.77	1.85	15.2	19.9	1.49	2.71
SS3	S	27.6	29.2	7.33	5.5	1254	570	2.94	1.54	14.3	18.8	1.42	2.93
	B	27.0	29.5	7.32	5.2	1396	635	2.61	1.67	15.6	19.9	1.50	3.10

**S = creek surface, B = creek bottom*

Table 3. Biochemical Oxygen Demand and Chemical Oxygen Demand at Bhavnagar creek water (August 2021)

Station	Water depth*	BOD (mg/l)	COD (mg/l)
SS1	S	1.1	22.4
	B	1.3	23.6
SS2	S	1.0	22.8
	B	1.2	24.0
SS3	S	1.0	20.4
	B	1.2	21.6

**S = creek surface, B = creek bottom*

Table 4. Concentration of Heavy Metals, Phenols and Total Petroleum Hydrocarbons at Bhavnagar creek water (August 2021)

Station	Water depth*	Heavy metals (µg/l)				Phenols (mg/l)	Total Petroleum Hydrocarbons (µg/l)
		Cadmium	Mercury	Lead	Chromium		
SS1	S	2.3	<1.0	<1.0	2.3	<0.001	<0.1
	B	2.6	<1.0	<1.0	2.5	<0.001	<0.1
SS2	S	2.2	<1.0	<1.0	2.2	<0.001	<0.1
	B	2.4	<1.0	<1.0	2.5	<0.001	<0.1
SS3	S	2.1	<1.0	<1.0	2.1	<0.001	<0.1
	B	2.4	<1.0	<1.0	2.3	<0.001	<0.1

**S = creek surface, B = creek bottom*

Table 5. Sediment Texture at Bhavnagar creek (August 2021)

Station	D_{50} (mm)	Sand (%)			Description of Soil
		Medium Sand	Fine Sand	Silt & Clay	
SB1	0.09	1.6	79.8	18.6	Fine Sand
SB2	0.10	3.0	86.8	10.2	Fine Sand
SB3	0.11	6.0	87.2	6.8	Fine Sand

Table 6. Sediment quality parameters at Bhavnagar creek (August 2021)

Station	Total Organic Carbon (%)	Total Nitrogen (mg/kg)	Total Phosphorus (mg/kg)	Calcium Carbonate (%)
SB1	0.46	28.6	12.6	16.8
SB2	0.58	24.8	14.6	20.6
SB3	0.62	21.2	15.2	24.4

Table 7. Concentration of Heavy Metals, Phenols and Total Petroleum Hydrocarbons in Sediments at Bhavnagar creek (August 2021)

Station	Heavy metals (mg/kg)				Phenols (mg/kg)	Total Petroleum Hydrocarbons (µg/kg)
	Cadmium	Mercury	Lead	Chromium		
SB1	<0.1	<0.1	<0.1	23.8	<0.5	<0.5
SB2	<0.1	<0.1	<0.1	24.6	<0.5	<0.5
SB3	<0.1	<0.1	<0.1	25.4	<0.5	<0.5

Table 8. Primary productivity at Bhavnagar creek water (August 2021)

Station	Gross Photosynthetic activity	Net Photosynthetic activity	Primary production ($mgC/m^3/day$)
SS1	1.1	0.8	330
SS2	1.3	0.9	390
SS3	1.2	0.8	360
		Average	**360**

Table 9. Phytoplankton species composition* at Bhavnagar creek water (August 2021)

Sl. No.	Species	Station		
		SS1	SS2	SS3
Class: Bacillariophyceae (Diatoms)				
Order: Centrales				
1	*Bacteriastrum* sp.	+	+	+
2	*Chaetoceros* sp.	+	-	-
3	*Coscinodiscus* sp.	+	+	+
4	*Coscinodiscus centralis*	+	+	+
5	*Hemiaulus* sp.	+	+	-
6	*Helicotheca* sp.	+	-	-
7	*Odontella mobiliensis*	+	+	+
8	*Odontella sinensis*	-	+	-
9	*Planktoniella sol*	+	+	+
10	*Rhizosolenia* sp.	+	+	+
11	*Rhizosolenia cylindrus*	-	+	-
12	*Skeletonema* sp.	-	+	-
13	*Triceratium* sp.	+	+	+
	Subtotal	**10**	**11**	**7**
Order: Pennales				
14	*Amphora* sp.	+	-	-
15	*Asterionella* sp.	+	+	+
16	*Bacillaria paradoxa*	-	-	+
17	*Guinardia striata*	-	+	-
18	*Navicula* sp.	+	+	+
19	*Navicula henneydii*	-	+	+
20	*Nitzschia* sp.	+	-	+
21	*Pleurosigma* sp.	+	+	-
22	*Pleurosigma directum*	-	+	+
23	*Gyrosigma* sp.	+	+	+
24	*Thalassionema nitzschioides*	-	+	+
	Subtotal	**6**	**8**	**8**
Class: Dinophyceae (Dinoflagellates)				
25	*Ceratium furca*	+	-	+

Sl. No.	Species	Station		
		SS1	SS2	SS3
26	*Ceratium fusus*	-	+	-
27	*Ceratium macroceros*	-	+	+
28	*Ceratium tripos*	+	-	-
29	*Dinophysis* sp.	-	+	+
30	*Diplopsalopsis* sp.	-	+	+
31	*Prorocentrum micans*	+	-	-
32	*Protoperidinium* sp.	-	+	+
33	*Protoperidinium depressum*	+	-	+
	Subtotal	**4**	**5**	**6**
Class: Cyanophyceae (Blue-greens)				
34	*Trichodesmium erythraeum*	+	+	+
	Total	**21**	**25**	**22**

*Net sample

Table 10. Phytoplankton numerical abundance* (cells/l) at Bhavnagar creek water (August 2021)

Sl. No.	Genus / Species	SS1	SS2	SS3	Total	(%)
Phylum: Heterokontophyta						
Class: Bacillariophyceae (Diatoms)						
Order: Centrales						
1	*Bacteriastrum* sp.	50	100	50	200	2.92
2	*Coscinodiscus* sp.	100	150	150	400	5.84
3	*Coscinodiscus centralis*	200	250	200	650	9.49
4	*Hemiaulus* sp.	150	150	-	300	4.38
5	*Helicotheca* sp.	100	-	-	100	1.46
6	*Odontella mobiliensis*	200	200	150	550	8.03
7	*Odontella sinensis*	-	50	-	50	0.73
8	*Planktoniella sol*	100	150	100	350	5.11
9	*Rhizosolenia* sp.	50	100	100	250	3.65
10	*Skeletonema* sp.	-	50	-	50	0.73
11	*Triceratium* sp.	100	100	100	300	4.38
Order: Pennales						
12	*Amphora* sp.	100	-	-	100	1.46
13	*Asterionella* sp.	50	100	50	200	2.92
14	*Guinardia striata*	-	50	-	50	0.73

Sl. No.	Genus / Species	SS1	SS2	SS3	Total	(%)
15	*Navicula* sp.	100	150	100	350	5.11
16	*Navicula henneydii*	-	50	50	100	1.46
17	*Nitzschia* sp.	50	100	100	250	3.65
18	*Pleurosigma* sp.	50	50	-	100	1.46
19	*Pleurosigma directum*	-	100	100	200	2.92
20	*Gyrosigma* sp.	100	100	50	250	3.65
21	*Thalassionema nitzschioides*	-	50	50	100	1.46
Class: Dinophyceae (Dinoflagellates)						
22	*Ceratium furca*	100	200	200	500	7.30
23	*Ceratium macroceros*	-	100	100	200	2.92
24	*Ceratium tripos*	50	-	-	50	0.73
25	*Dinophysis* sp.	50	50	100	200	2.92
26	*Diplopsalopsis* sp.	-	50	50	100	1.46
27	*Prorocentrum micans*	50	-	-	50	0.73
28	*Protoperidinium* sp.	-	50	50	100	1.46
29	*Protoperidinium depressum*	50	-	100	150	2.19
Class: Cyanophyceae (Blue greens)						
30	*Trichodesmium erythraeum*	150	250	200	600	8.76
	Total	**1950**	**2750**	**2150**	**6850**	**100**

* Bottle sample

Table 11. Phytoplankton population at Bhavnagar creek water (August 2021)

Station	No of genera or species (*net sample)	Population (cells/l) (*bottle sample)
SS1	21	1950
SS2	25	2750
SS3	22	2150

Table 12. Numerical abundance of zooplankton (nos./100m^3) at Bhavnagar creek water (August 2021)

Sl. No.	Genus / Species	Station				
		SS1	SS2	SS3	Total	%
Phylum: Protozoa						
Order: Tintinnids (Ciliate groups)						
1	*Favella* sp.	639	338	-	978	3.40
2	*Tintinnopsis* sp.	-	338	332	670	2.33
Phylum: Mollusca						
3	Gastropod larvae	320	338	-	658	2.29
Phylum: Annelida						
4	Polychaete larvae	-	338	-	338	1.18
Phylum: Arthropoda						
Order: Copepoda						
Sub-order: Calanoida						
5	*Acrocalanus* sp.	959	1015	664	2638	9.17
6	*Acartia danae*	639	677	-	1316	4.57
7	*Acartia erythraea*	1279	1691	1328	4298	14.94
8	*Clausocalanus minor*	-	338	332	670	2.33
9	*Centropages furcatus*	959	1353	664	2976	10.34
10	*Eucalanus* sp.	-	677	332	1009	3.51
11	*Labidocera* sp.	320	-	332	652	2.27
12	*Temora turbinata*	320	677	664	1660	5.77
13	*Temora discaudata*	-	338	332	670	2.33
14	Copepod nauplii	320	-	332	652	2.27
Sub-order: Cyclopoida						
15	*Corycaeus danae*	320	-	332	652	2.27
16	*Corycaeus catus*	320	338	-	658	2.29
17	*Oithona* sp.	639	1015	664	2318	8.06
18	*Oncaea venusta*	-	338	332	670	2.33
Sub-order: Harpacticoida						
19	*Euterpina acutifrons*	320	677	332	1328	4.62
20	*Microsetella* sp.	320	-	332	652	2.27
Other Crustaceans						
21	Shrimp larvae	-	338	-	338	1.18
22	*Lucifer* sp.	320	-	332	652	2.27
Phylum: Chaetognatha						
23	*Sagitta* sp.	320	338	332	990	3.44
Phylum: Chordata						
24	Fish larvae	320	338	-	658	2.29
25	*Oikopleura* sp.	-	338	332	670	2.33
Total		**8632**	**11840**	**8300**	**28772**	**100**

Table 13. Zooplankton diversity, abundance and biomass at Bhavnagar creek water (August 2021)

Station	No. of genera or species	Population (nos./100 m^3)	Biomass (ml/100 m^3)
SS1	17	8632	11.5
SS2	20	11840	12.2
SS3	18	8300	10.6

Table 14. Subtidal and Intertidal benthic population at Bhavnagar creek (August 2021)

Sl. No.	Groups	Subtidal benthic population (nos./m^2)			Intertidal benthic Population (nos./m^2)		
		SB1	SB2	SB3	IB1	IB2	IB3
Phylum: Annelida Class: Polychaeta							
1	*Ancistrosyllis* sp.	-	40	-	-	-	-
2	*Armandia* sp.	40	-	40	-	15	-
3	*Capitella capitella*	80	120	80	30	30	45
4	*Dorvillea* sp.	40	40	40	-	-	-
5	*Cossura* sp.	-	40	-	-	-	-
6	*Perinereis* sp.	40	-	40	30	45	30
7	*Nereis diversicolor*	-	40	-	-	-	-
8	*Prionospio pinnata*	40	-	40	30	45	30
9	*Pisione indica*	-	40	-	-	15	-
10	Unidentified polychaetes	-	40	80	15	15	15
Phylum: Arthropoda							
11	Amphipoda	40	-	40	30	15	30
12	Isopoda	-	40	-	-	15	15
Phylum: Mollusca							
13	Unidentified bivalves	40	40	40	30	45	15
14	Unidentified gastropods	40	40	-	-	-	-
	Total	**360**	**480**	**400**	**165**	**240**	**180**

Table 15. Bacterial population at Bhavnagar creek water (x 10^3CFU/ml) (August 2021)

Media	Type of Bacteria	Stations		
		SS1	SS2	SS3
Nut Agar	TVC	4.86	5.21	5.16
Mac Agar	TC	0.43	0.46	0.47
Mac Agar	FC	0.32	0.33	0.34
Mac Agar	ECLO	0.15	0.18	0.21
XLD Agar	SHLO	0.19	0.21	0.19
TCBS Agar	VLO	0.16	0.17	0.18
TCBS Agar	VPLO	0.15	0.16	0.17
TCBS Agar	VCLO	0.01	0.20	0.04

Table16. Bacterial population at Bhavnagar creek sediments (x 10^4CFU/g) (August 2021)

Media	Type of Bacteria	Stations		
		SB1	SB2	SB3
Nut Agar	TVC	5.11	5.14	5.24
Mac Agar	TC	0.52	0.56	0.58
Mac Agar	FC	0.33	0.34	0.35
Mac Agar	ECLO	0.16	0.18	0.16
XLD Agar	SHLO	0.20	0.21	0.23
TCBS Agar	VLO	0.18	0.19	0.19
TCBS Agar	VPLO	0.16	0.17	0.18
TCBS Agar	VCLO	0.02	0.03	0.04

TVC - Total Viable Counts; TC - Total Coliforms; FC- Faecal coliform; ECLO - *Escherichia coli* like organisms; SHLO - *Shigella* like organisms; VLO - *Vibrio* like organisms; VPLO - *Vibrio parahaemolyticus* like organisms; VCLO-*Vibrio cholerae* like organisms.

Table17. Comparison of Water quality parameters between Pre-Project period (May 2013) and Monitoring period (August 2021)

Sl. No.	Parameters	Unit	Pre-project period	Monitoring period				Remarks
			May 2013	February 2020	August 2020	February 2021	August 2021	
			Range	Range	Range	Range	Range	
1	Temperature	(°C)	32-34	25.4-25.9	25.5-26.1	26.5-26.8	27.0-27.6	Seasonal variation
2	pH	-	8.0-8.2	7.94-8.04	7.52-7.67	7.88-7.97	7.23-7.48	Seasonal variation
3	Salinity	ppt	36-37	32.5-33.4	6.8-7.2	32.5-33.4	27.5-29.5	Seasonal variation
4	Turbidity	NTU	>1000	750-996	538-965	610-880	570-661	Seasonal variation
5	TSS	mg/l	980-13052	1645-2241	1095-2124	1270-1584	1254-1454	Seasonal variation
6	DO	mg/l	3.84-4.32	5.3-5.6	5.7-6.0	5.35-5.6	5.2-5.8	No significant change
7	BOD	mg/l	1.44-3.20	0.8-1.1	1.2-1.4	0.9-1.3	1.0-1.3	No significant change
8	COD	mg/l	37.3-52.5	21.4-23.4	23.4-25.6	18.8-21.6	20.4-24	Seasonal variation
9	Ammonium	µmol/l	0.43-0.74	1.5-2.1	1.9-3.2	1.5-2.2	2.61-3.27	Seasonal variation
10	Nitrite	µmol/l	1.56-3.47	0.4-0.8	1.4-1.8	0.53-0.91	1.54-2.11	Seasonal variation
11	Nitrate	µmol/l	3.76-7.78	2.9-3.6	16.9-18.2	3.12-4.10	14.2-16.6	Seasonal variation
12	Total Nitrogen	µmol/l	13.92-26.36	5.3-6.9	22.3-22.6	5.55-7.25	18.8-21.4	Seasonal variation
13	Phosphate	µmol/l	0.38-2.77	0.94-1.30	1.73-2.17	0.79-0.97	1.42-1.74	Seasonal variation
14	Total Phosphorus	µmol/l	5.23-7.22	2.80-3.24	2.16-2.63	2.53-3.35	2.23-3.1	Seasonal variation
15	Cadmium	µg/l	<1.0	1.8-2.6	0.65-0.73	1.8-2.2	2.1-2.6	No significant change
16	Mercury	µg/l	<1.0	<1.0	<1.0	<1.0	<1.0	No change
17	Lead	µg/l	<1.0	<1.0	<1.0	<1.0	<1.0	No change
18	Chromium	µg/l	2.95-5.64	2.2-2.9	1.1-1.3	2.24-2.48	2.1-2.5	Seasonal variation
19	Phenols	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	No change
20	Total Petroleum Hydrocarbons	µg/l	<0.05	<0.1	<0.1	<0.1	<0.1	No change

*For May 2021, samples was not collected due to nationwide ban on travel due to COVID-19 pandemic.

Table 18. Comparison of Sediment quality parameters between Pre-Project period (May 2013) and Monitoring period (August 2021)

Sl. No.	Parameters	Unit	Pre-project period	Monitoring period				Remarks
			May 2013	February 2020	August 2020	February 2021	August 2021	
			Range	Range	Range	Range	Range	
1	Soil texture	-	Fine sand	Fine sand	Fine Sand	Fine Sand	Fine Sand	Seasonal variation
2	Total Phosphorous	mg/kg	0.26-0.38	16.1-17.2	4.5-8.0	15.8-18.6	12.6-15.2	Seasonal variation but within normal range
3	Total Nitrogen	mg/kg	0.86-1.22	10.6-17.5	23.5-36.1	16.4-26.4	21.2-28.6	Seasonal variation but within normal range
4	Total Organic Carbon	%	0.47-0.77	0.43-1.04	0.33-0.50	0.20-1.17	0.46-0.62	Seasonal variation but within normal range
5	Calcium Carbonate	%	5.76-7.72	6.5-8.5	15.7-18.2	12.5-20.6	16.8-24.4	Seasonal variation but within normal range
6	Cadmium	mg/kg	<1.0	<0.1	<0.1	<0.1	<0.1	No change
7	Chromium	mg/kg	30.48-35.08	32.6-38.5	38.8-42.4	22.4-32.6	23.8-25.4	Marginal change but within normal range
8	Mercury	mg/kg	<1.0	<0.1	<0.1	<0.1	<0.1	No change
9	Lead	mg/kg	<1.0	<0.1	<0.1	<0.1	<0.1	No change
10	Phenols	mg/kg	<0.05	<0.5	<0.5	<0.5	<0.5	No change
11	Petroleum Hydrocarbons	µg/kg	2.12-3.37	<0.5	<0.5	<0.5	<0.5	No change

*For May 2021, samples was not collected due to nationwide ban on travel due to COVID-19 pandemic.

Table 19. Comparison of Biological parameters between Pre-Project period (May 2013) and Monitoring period (August 2021)

Sl. No.	Parameters	Unit	Pre-project period	Monitoring period				Remarks
			May 2013	February 2020	August 2020	February 2021	August 2021	
Phytoplankton								
1	Primary Productivity	mgC/m^3/day	240-480	300-360	330-390	330-420	330-390	No significant change
2	Species composition	nos./100m^3	12-31	16-19	23-26	16-21	21-25	Seasonal variation
3	Abundance	nos./l	399-2530	1400-1900	1750-1850	1450-2900	1950-2750	No significant change
Zooplankton								
4	Biomass	ml/100m^3	5.14-14.85	8.2-15.2	8.7-10.0	9.6-11.7	10.6-12.2	No significant change
5	Abundance	nos./100m^3	7368-50048	5534-7479	6063-7097	7159-10034	8300-11840	Seasonal variation
Benthos								
6	Subtidal	nos./m^2	20-30	280-400	240-360	280-400	360-480	No significant change
7	Intertidal	nos./m^2	20-40	75-120	165-195	150-210	165-240	No significant change
Microbial count								
8	Water	nos. x10^3/ml	0.01-5.31	0.01-5.28	0.02-5.18	0.02-5.02	0.01-5.21	No significant change
9	Sediment	nos. x10^4/g	0.01-5.48	0.01-5.36	0.01-5.29	0.01-5.21	0.02-5.24	No significant change

*For May 2021, samples was not collected due to nationwide ban on travel due to COVID-19 pandemic.

Collection of water sample

Onboard testing

Collection of sediment sample

Collection of plankton sample

Collection of Intertidal benthos sample

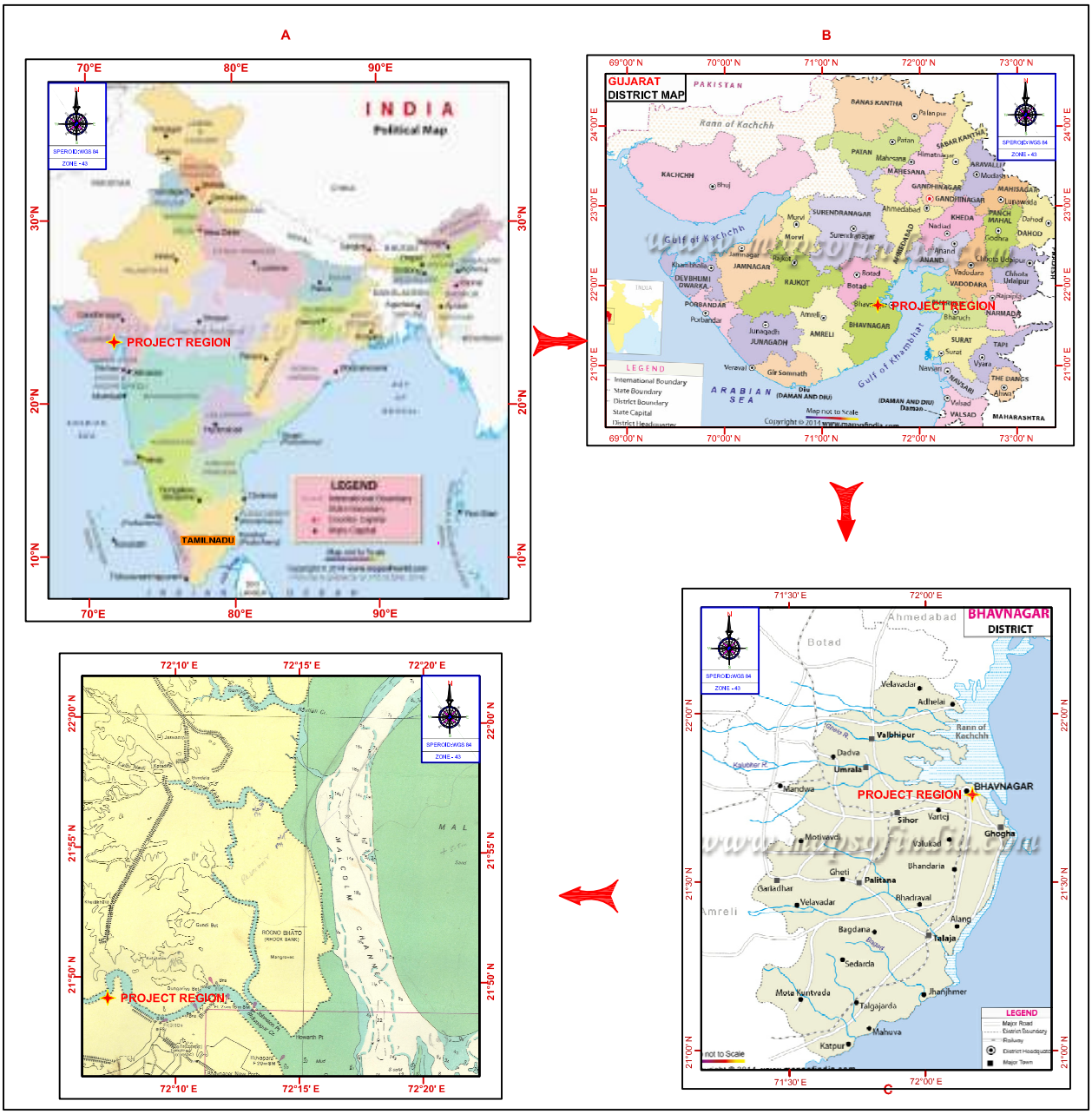


FIG.1. LOCATION MAP

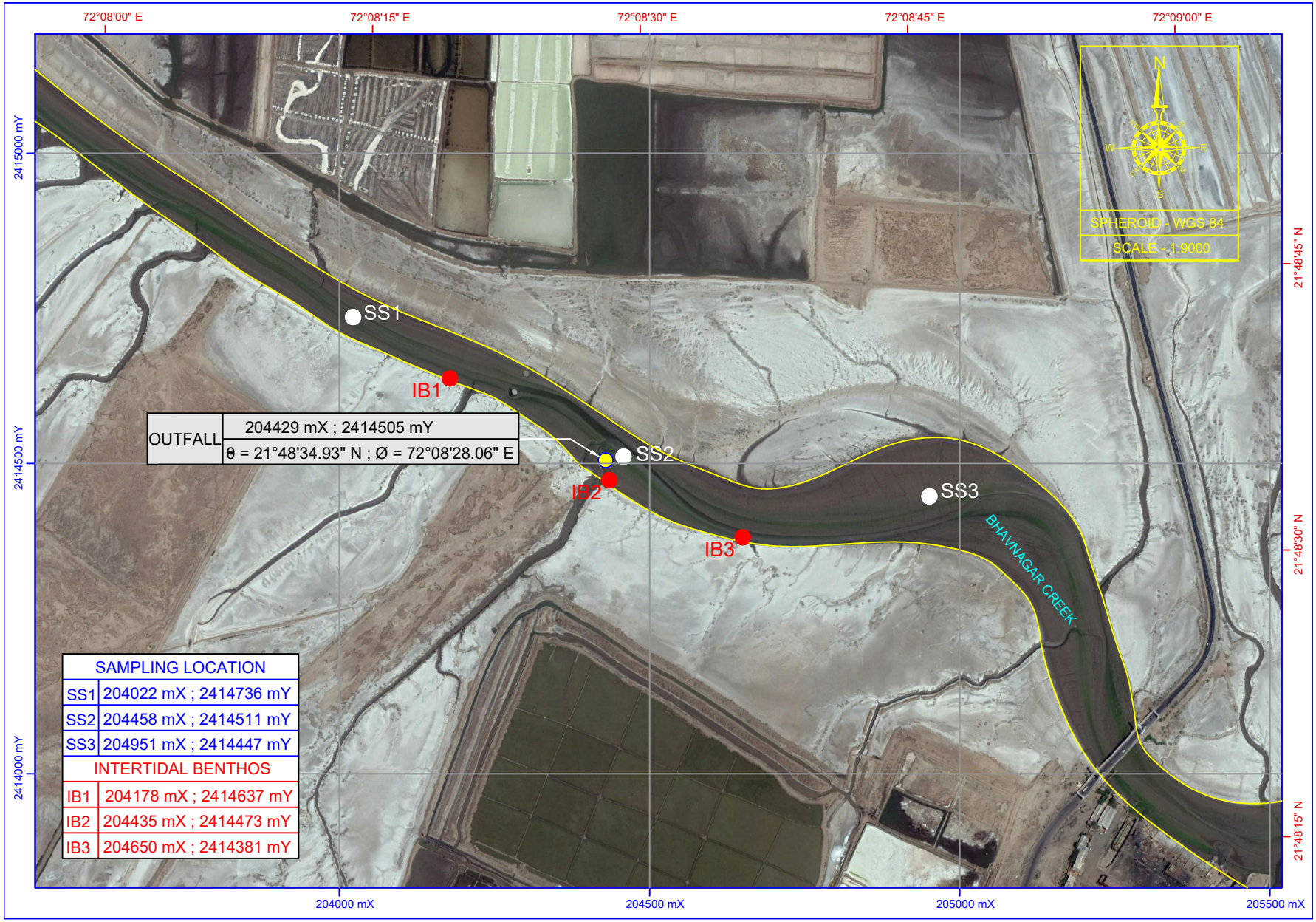


FIG. 2 . SAMPLING LOCATIONS

Annexure I – QCI NABET accreditation certificate

Quality Council of India

National Accreditation Board for Education & Training

CERTIFICATE OF ACCREDITATION

Indomer Coastal Hydraulics (P) Ltd.

63, Gandhi road, Alwarthirunagar, Chennai 600087

The organization is accredited as Category-A under the QCI-NABET Scheme for Accreditation of EIA Consultant Organization, Version 3: for preparing EIA-EMP reports in the following Sectors –

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

Note: Names of approved EIA Coordinators and Functional Area Experts are mentioned in RAAC and Supplementary MoM dated Jan 27, 2021, and June 08, 2021 respectively posted on QCI-NABET website.

The Accreditation shall remain in force subject to continued compliance to the terms and conditions mentioned in QCI-NABET's letter of accreditation bearing no. QCI/NABET/ENV/ACO/21/1784 dated June 29, 2021. The accreditation needs to be renewed before the expiry Indomer Coastal Hydraulics (P) Ltd. following due process of assessment.

Sr. Director, NABET
Dated: June 29, 2021

Certificate No.
NABET/EIA/2023/RA 0207

Valid till
Sept 13, 2023

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

Annexure II – NABL accreditation certificate

National Accreditation Board for Testing and Calibration Laboratories

NABL

CERTIFICATE OF ACCREDITATION

INDOMER COASTAL HYDRAULICS PRIVATE LIMITED

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2017

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

NO 63, GANDHI ROAD, ALWAR THIRUNAGAR, CHENNAI, TAMIL NADU, INDIA

in the field of

TESTING

Certificate Number: TC-5232

Issue Date: 13/01/2019 **Valid Until:** 12/01/2021*

* The validity is extended for one year up to 12.01.2022
*Transition to 2017 version completed w.e.f 22.04.2021 valid until 12.01.2022

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the relevant requirements of NABL.
(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)

Name of Legal Identity : INDOMER COASTAL HYDRAULICS PRIVATE LIMITED

Signed for and on behalf of NABL

N. Venkateswaran
Chief Executive Officer