O/c

GOPALPUR PORTS LIMITED

CIN. NO. : U63032OR2006PLC008831

Ref:GPL/ENV/ 2024-25/01

April 4, 2024

To,

The Director
Ministry of Environment, Forest & Climate Change
INDIRA PARYAVARAN
JOR BAGH ROAD,
NEW DELHI – 110 003.

Subject : Development of Gopalpur Ports Ltd." : Env. Compliance.

Ref. : No.10-12/2009-IA.III dt. 30th Mar, 2011, 14th Aug.2018

Dear Sir,

With reference to the above, we are submitting herewith our compliance of the conditions as laid down in different permissions and clearances. The Compliance report till end of March 2024 is being enclosed for your kind consideration.

Yours faithfully,

For Gopalpur Ports Limited,

04/04/24

Authorized signatory

Copy to:

1. Additional Chief Secretary, Department of Forest & Wildlife, Govt. of Odisha, Secretariat, ,hubaneswar – 751 001.
2. The Chairman, Central Pollution Control Board, Parivesh Bhavan, CBD-Cum-Office Complex, East Arjun Nagar, Delhi – 110 032.
3. Addl. Principal Chief Conservator of Forests (Central), Ministry of Environment, Forest and Climate Change, Regional Office (EZ), A/3, Chandersekharpur, Bhubaneswar – 751 023.
4. The Member Secretary,Odisha State Pollution Control Board, Paribesh Bhavan, A/118, Nilakantha Nagar, Unit – VIII, Bhubaneswar - 751 012.Regional Officer, Odisha State Pollution Control Board Bharampur, Ganjam

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REGIONAL OFFICE, BERHAMPUR
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GOPALPUR PORTS LIMITED
CIN. NO. : U63032OR2006PLC008831

Ref:GPL/ENV/ 2023-24/ 02

April 6, 2023

To,

The Director
Ministry of Environment, Forest & Climate Change
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JOR BAGH ROAD,
NEW DELHI – 110 003.

Subject : Development of Gopalpur Ports Ltd." : Env. Compliance.

Ref. : No.10-12/2009-IA.III dt. 30th Mar, 2011, 14th Aug.2018

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Compliance Report for Environmental Clearance No.10-12/2009-IA-III Dated 30th March 2011

Sl. No.	Conditions	Compliance Status
6.		
(i)	"Consent for Establishment" shall be obtained from State Pollution Control Board under Air and Water Act and a copy shall be submitted to the Ministry before start of any construction work at the site.	Complied
(ii)	No construction work other than those permitted in Coastal Regulation Zone Notification, 2011 shall be carried out in Coastal Regulation Zone area.	Being complied with.
(iii)	The shore line map prepared by Institute for Ocean Management, Chennai with regard to the stretch at Gopalpur Port has been examined and it is observed that on the southern side of the port, the area is shown as high to medium accretion while, on the northern side the area is shown as low to medium erosion. This is because the net littoral drift is towards the northern side and due to the break water at the southern port there seems to be accretion at the southern breakwater and low to medium erosion on the northern side. This has to be ratified by adopting suitable sand bypass system from south break water to the northern side of the north break water.	Beach nourishment undertaken for 4 MCM in the groyne field to address the erosional aspect Environmental monitoring report (From Oct. 2022 to Mar. 2023) attached.
(iv)	Controlled and proper methods of dredging including state of the art equipment and planning the dredging operation and disposal shall be employed.	Dredging carried out by use of controlled cutter suction. Other mitigation measures implemented to curtail the turbidity.
(v)	Technically qualified institution shall be engaged	Department of Marine

	to monitor the impact right from the beginning to suggest scientifically accepted mitigation measures as and when required on annual basis at least for first 3 years, shall be obtained.	Sciences, Berhampur University have been engaged since June, 2012 to carry out the environmental monitoring of Gopalpur port.
(vi)	A high level expert committee shall be constituted including the experts for Monitoring the population of benthic life during and after the construction phase and also to ensure the compliance of other conditions stipulated in the clearance.	High level expert committee has been constituted and periodically reviews the compliance conditions stipulated in the clearance.
(vii)	An additional substratum shall be provided with the breakwaters, thereby adding to the habitat of benthic community especially flora which is very low due to the present geo physical characteristics of the area.	Additional substratum provided during construction of break water and from the studies being carried out by department of Marine Science dept., Berhampur University there is increase in habitat of benthic community.
(viii)	Oil spills if any shall be properly collected and disposed as per the Rules.	Oil Spill Contingency Plan (OSCP) is in place.
(ix)	There shall be no drawl of ground water in CRZ area.	Complied with.
(x)	Environment Management Plan as suggested shall be strictly complied with.	Complied with.
(xi)	There shall be no disposal of solid and liquid wastes into the Coastal areas.	Being complied with and taken care off.
(xii)	Sewage Treatment facility should be provided in accordance with the CRZ notification, 2011. Treated sewage shall be reused for flushing of toilets and horticulture purposes.	Sewage Treatment facility provided and the treated sewage water used for plantation..
(xiii)	The solid waste shall be properly collected, segregated and disposed as per the provision of solid Waste (Management and Handling) Rules, 2000.	Waste management Plan is in place.
(xiv)	Installation and operation of DG set if any shall	CPCB approved DG sets are

	comply with the guidelines of CPCB.	installed.
(xv)	The approach channel shall be properly demarcated with lighted buoys for safe navigation and adequate traffic control guidelines shall be framed. The fishermen shall be suitably educated and informed about the traffic guidelines.	Channel Marker Buoys have been installed for safe navigation. Fishermen Sensitization shall also be done regularly for harmony with port operation.
(xvi)	The project proponent shall set up separate environmental management cell for effective implementation of the stipulated environmental safeguards under the supervision of a Senior Executive.	Environment Management Cell has been created Headed by DGM Environment
(xvii)	The project proponent shall take up mangrove plantation/green belt in the project area, wherever possible. Adequate budget shall be provided in the Environment Management Plan for such mangrove development.	Green Belt development work is in progress following land shaping and plantation work.
(xviii)	The funds earmarked for environment management plan shall be included in the budget and this shall not be diverted for any other purposes.	Adequate fund is ear-marked and available.
(xix)	Under the provisions of Environment (Protection) Act, 1986, legal action shall be initiated against the project proponent if it was found that the construction of the project has been started without obtaining environmental clearance.	Construction of the project commenced after obtaining the Environmental Clearance. Date of project commencement is 10th Nov. 2011.
7.		
(I)	Adequate provision for infrastructure facilities including water supply, fuel and sanitation must be ensured for construction workers during the construction phase of the project to avoid any damage to the environment.	Being complied with.
(ii)	Appropriate measures must be taken while undertaking digging activities to avoid any likely degradation of water quality.	Being complied with.

(iii)	Borrow sites for each quarry sites for road construction material and dump sites must be identified keeping in view the following: a) No excavation or dumping on private property is carried out without written consent of the owner. b) No excavation or dumping shall be allowed on wetlands, forest areas or other ecologically valuable or sensitive locations. c) Excavation work shall be done in close consultation with the soil Conservation and Watershed Development Agencies working in the area, and d) Construction spoils including bituminous material and other hazardous materials must not be allowed to contaminate water courses and the dump sites for such materials must be secured so that they shall not leach into the ground water.	Being complied with.
(iv)	The construction material shall be obtained only from approved quarries. In case new quarries are to be opened, specific approvals from the competent authority shall be obtained in this regard.	Being complied with.
(v)	Adequate precautions shall be taken during transportation of the construction material so that it does not affect the environment adversely.	Being complied with.
(vi)	Full support shall be extended to the officers of this Ministry/Regional Office at Bhubaneswar by the project proponent during inspection of the project for monitoring purposes by furnishing full details and action plan including action taken reports in respect of mitigation measures and	GPL is committed to provide necessary support.

	other environmental protection activities.	
(vii)	A Six monthly monitoring report shall need to be submitted by the project proponents to the Regional Office of this Ministry at Bhubaneswar regarding the implementation of the stipulated conditions.	Being complied with.
(viii)	Ministry of Environment and Forests or any other competent authority may stipulate any additional conditions or modify the existing ones, if necessary in the interest of environment and the same shall be complied with.	GPL is committed to comply with such condition, if any.
(ix)	The Ministry reserves the right to revoke this clearance if any of the conditions stipulated are not complied with the satisfaction of the Ministry.	Taken note of.
(x)	In the event of a change in project profile or change in the implementation agency, a fresh reference shall be made to the Ministry of Environment and Forests.	Will be complied, if any.
(xi)	The project proponents shall inform the Regional Office as well as the Ministry, the date of financial closure and final approval of the project by the concerned authorities and the date of start of land development work.	Complied The Land development work commenced on 10th November 2011 after approval of the project.
(xii)	A copy of the clearance letter shall be marked to concern Panchayat / local NGO, if any, from whom any suggestion / representation have been made, received while processing the proposal.	Noted and complied.
(xiii)	Orissa Pollution control Board shall display a copy of the clearance letter at the Regional Office, District Industries Centre and Collector's Office/Tahasildar's office for 30 days.	Noted

8.	These stipulations would be enforced among others under the provisions of Water (Prevention and Control of Pollution) Act 1974, the Air (Prevention and Control of Pollution) Act 1981, the Environment (Protection) Act, 1986, the Public Liability (Insurance) Act, 1991 and EIA Notification 1994, including the amendments and rules made thereafter.	Noted
9.	All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department, Civil Aviation Department, Forest Conservation act, 1980 and Wildlife (Protection) Act, 1972 etc. shall be obtained, as applicable by project proponents from the respective competent authorities.	Agreed
10.	The project proponent shall advertise in at least two local Newspapers widely circulated in the region, one of which shall be in the vernacular language informing that the project has been accorded Environmental Clearance and copies of clearance are available with the State Pollution Control Board and may also be seen on the website of the Ministry of Environment and forests at http://www.envfor.nic.in. The advertisement should be made within 10 days from the date of receipt of the Clearance letter and a copy of the same should be forwarded to the Regional Office of this Ministry at Bhubaneswar.	Complied, Vide letter No. GPL/2011/59, dated 11/04/2011
11.	Environmental clearance is subject to final order of the Hon'ble Supreme court of India in the matter of Goa Foundation vs. Union of India in Writ Petition (Civil) No.460 of 2004 as may be applicable to this Project.	Agreed
12.	Status of compliance to the various stipulated	Complied

	environmental conditions and environmental safeguards will be uploaded by the project proponent in its website.	
13.	The project proponent shall also submit six monthly reports on the status of compliance of the stipulated EC conditions including results of monitoring data (both in hard copies as well as by e-mail) to the respective Regional Office of MoEF, the respective Zonal Office of CPCB and the SPCB.	Complied
14.	The environmental statement for each financial year ending 31st March in Form-V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall be put on the website of the company along with the status of compliance of EC conditions and shall also be sent to the respective Regional Offices of MoEF& CC by e-mail.	Complied
Additional Conditions of the EC Validity Extension Order dated 14th August 2018		
1.	The Project Proponent will submit a Certified Compliance Report within 03 months issued by the MoEF& CC, Regional Office or concerned Regional Office of the Central Pollution Control Board or the Member Secretary of the respective State Pollution Control Board for the conditions stipulated in the Environmental and CRZ Clearance issued earlier	Being Complied
2.	The development plan shall be implemented strictly in accordance to the Coastal Zone Management Plan as drawn up in compliance to the orders of the NGT in this regards. A copy of the compliance report shall be submitted within	Being Complied

	30 days to the MoEF& CC.	
3.	As per the Ministry's Office Memorandum F.No22-65/2017-Ia.III dated 1st May 2018, the project proponent is required to prepare and implement Corporate Environment Responsibility (CER) Plan. As per the para 6(II) of the said O.M appropriate funds shall be earmarked for the activities such as infrastructure creation for drinking water supply, sanitation, health, education, skill development, roads, cross drains, electrification including solar power, solid waste management facilities, scientific support and awareness to local farmers to increase yield of crop and fodder, rain water harvesting, soil moisture conservation works, avenue plantation, plantation in community areas etc. The activities proposed under CER shall be restricted to the affected area around the project. The entire activities proposed under the CER shall be treated as project and shall be monitored. The monitoring report shall be submitted to the regional office as a part of half yearly compliance report, and to the District Collector. It should be posted on the website of the Project Proponent.	As per the Para 6 (IX) of the said notification which states that *the CER is not applicable in name change, transfer, amendment involving no additional project investment*; this is not applicable to us, as there is no additional project investment.

DATA REPORT

ON

ENVIRONMENTAL MONITORING OF GOPALPUR PORT

(Consultancy Project)

October, 2022 to March, 2023

Prepared by

Dr. Pratap Kumar Mohanty,
Nodal Expert, GPL Env. Monitoring Project
& **Professor,** Department of Marine Sciences
Berhampur University
Bhanja Bihar, Berhampur, 760007

Team:
Dr. Shesdev Patro, Asst. Prof. & Consultant, BU
Dr. Asim Amitav Pattanayak, Project Scientist
Dr. Prabin Kumar Kar, Project Scientist
Mr. Balaji Behera, Project Scientist
Miss Bhubaneswari Panda, Project Fellow
Mr. N. Lochan Patra, Project Fellow

Submitted to

Gopalpur Ports Limited
Arjeepalli, Via- Chhatrapur
PIN-761020
Ganjam, Odisha, India

GOPALPUR PORT
New Era in Maritime Logistics

1. Shoreline monitoring

Table 1: Shoreline (m) analysis along Gopalpur Port South (Shoreline represents the distance in meter between bermline and the reference line in Fig. 1) from October, 2022 to March, 2023.

GPLS	SG 0km	0.5 km	1.0 km	2.5 km	3.0 km	3.5 km	4.0 km	4.5 km
OCT_22	747.7	680.0	828.2	1157.2	1036.4	985.0	878.0	780.0
NOV_22	815.0	820.1	933.5	1053.5	1154.8	826.7	684.0	736.7
DEC_22	699.3	664.1	830.6	1117.4	999.1	882.4	754.6	747.8
JAN_23	702.3	668.8	835.4	1123.5	1008.0	902.5	768.6	758.4
FEB_23	708.3	672.3	892.4	1138.9	1022.1	918.7	786.3	762.7
MAR_23	712.3	678.5	991.4	1145.6	1026.6	924.7	791.7	774.8

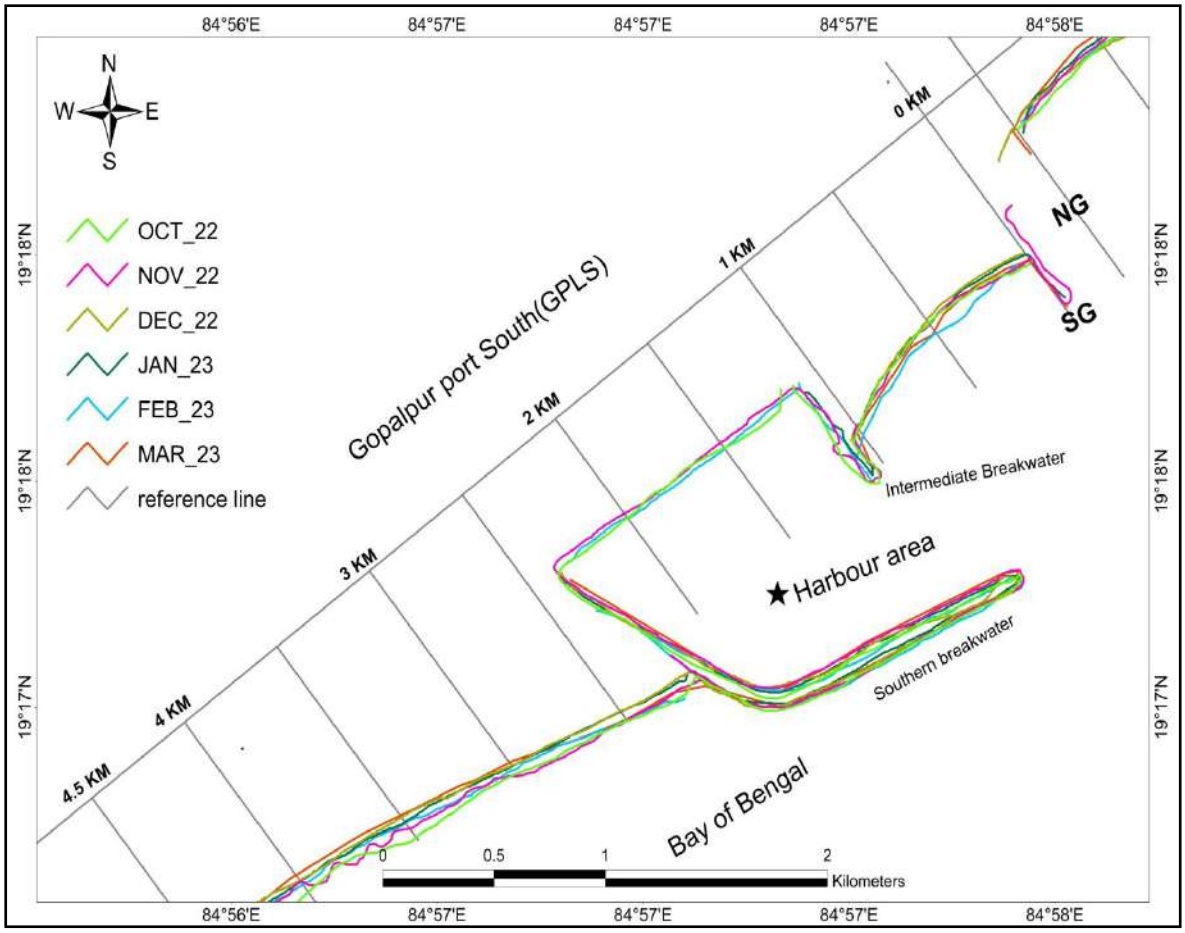

Figure 1: Shoreline change at south of Gopalpur port from October, 2022 to March, 2023.

Table 2: Shoreline (m) analysis along Gopalpur Port north (Shoreline represents the distance in meter between berm line and the reference line in Fig. 2) from October, 2022 to March, 2023.

GPLN	NG 0km	0.5 km	1.0 km	1.5 km	2.0 km	2.5 km	3.0 km	3.5 km	4.0 km	4.5 km
OCT_22	287.5	239.0	270.6	246.3	290.2	303.6	294.0	333.9	380.1	414.9
NOV_22	299.7	234.9	250.2	252.7	266.8	262.2	259.6	320.4	353.6	395.2
DEC_22	310.4	199.6	244.8	235.0	249.6	268.3	237.4	311.1	354.7	406.7
JAN_23	312.8	203.6	257.9	248.2	257.3	272.5	248.3	322.7	370.4	408.3
FEB_23	314.8	208.6	264.9	222.2	259.3	239.5	251.3	331.7	378.4	423.3
MAR_23	309.4	205.3	234.6	229.8	255.2	263.1	243.5	318.5	373.8	408.1

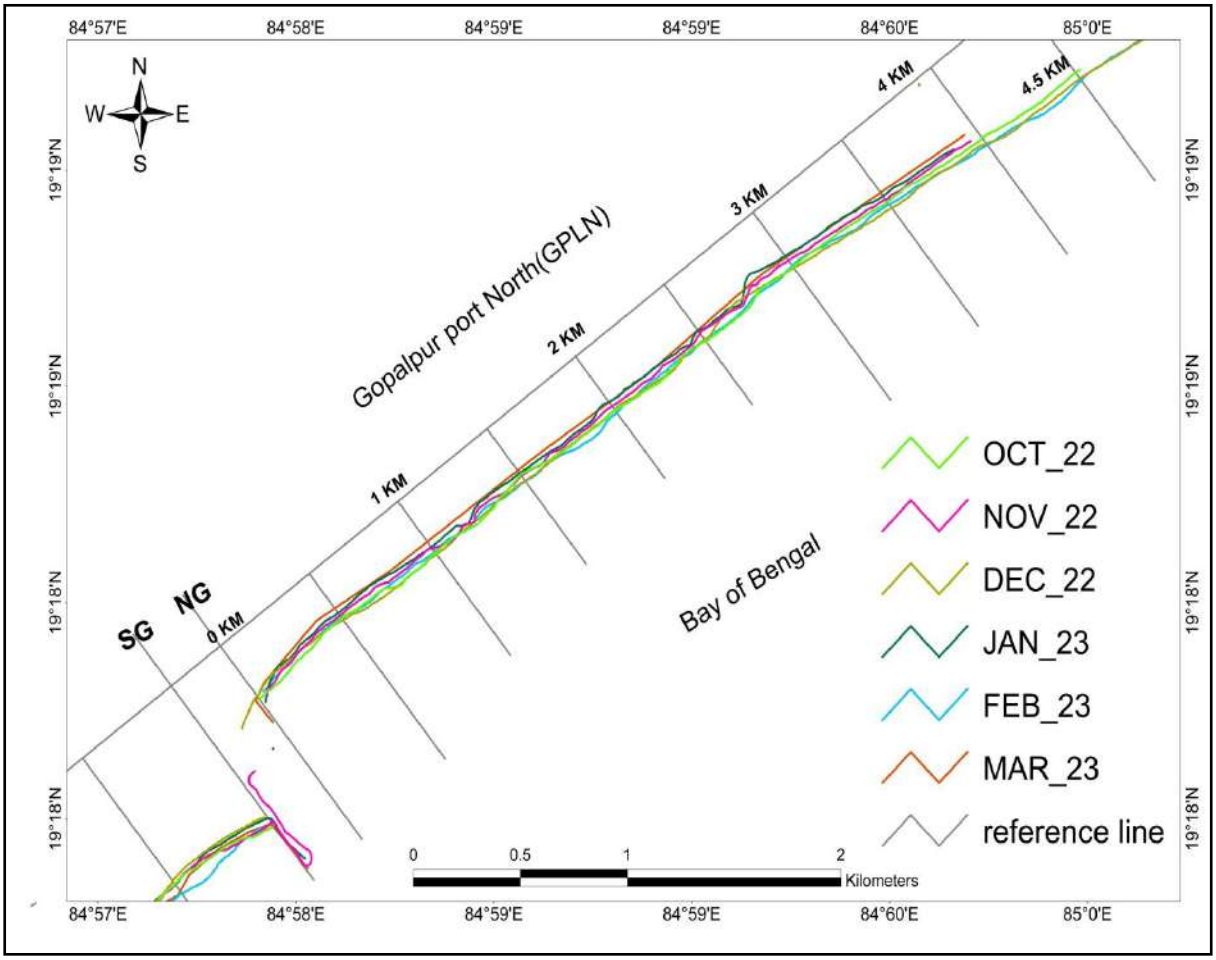

Figure 2: Shoreline changes at north of Gopalpur port from October, 2022 to March, 2023.

Table 3: Shoreline (m) analysis along Gopalpur tourist beach (Shoreline represents the distance in meter between berm line and the reference line in Fig. 3) from October, 2022 to March, 2023.

GPB	LH 0km	0.5 km	1.0 km	1.5 km	2.0 km	2.5 km	3.0 km
OCT_22	138.2	109.2	136.1	183.3	732.2	742.1	761.7
NOV_22	117.1	97.7	130.4	140.9	787.2	752.3	771.8
DEC_22	117.3	119.0	146.7	130.7	730.3	732.0	747.9
JAN_23	119.2	126.3	142.8	136.4	731.8	738.4	752.2
FEB_23	123.2	129.7	146.3	144.3	139.1	742.6	762.8
MAR_23	131.2	134.3	156.2	144.7	751.2	749.6	764.0

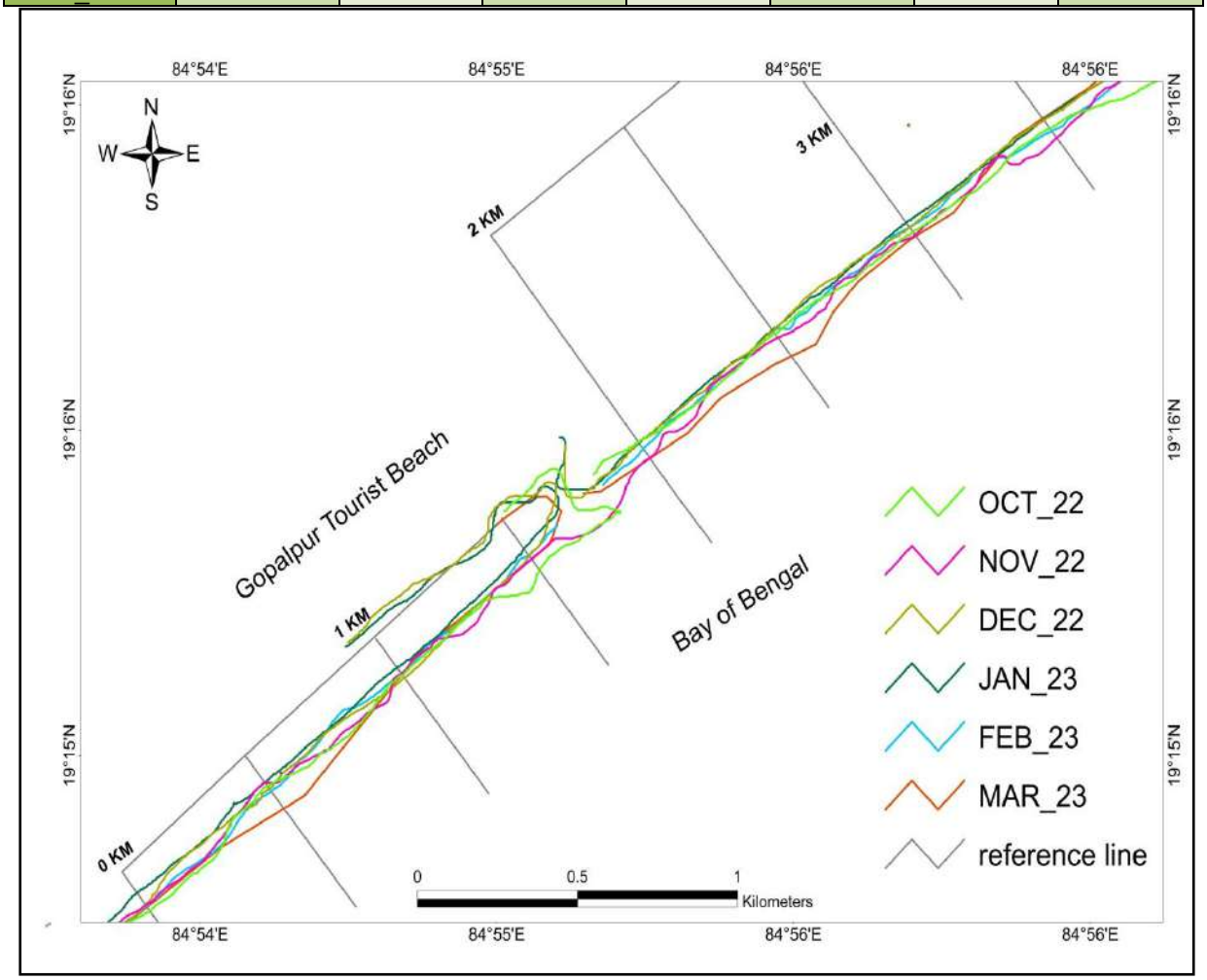

Figure 3: Shoreline change at tourist beach of Gopalpur beach from October, 2022 to March, 2023

Table 4: Area, perimeter and length of sand spit near Rushikulya Spit during October, 2022 to March, 2023.

Sand Spit			
Month	**Area (Km^2)**	**Perimeter (Km)**	**Length (Km)**
OCT_22	0.79	8.35	3.75
NOV_22	0.68	8.7	3.86
DEC_22	0.62	8.6	3.92
JAN_23	0.68	9.1	4.23
FEB_23	0.92	8.73	4.04
MAR_23	0.99	8.42	3.87

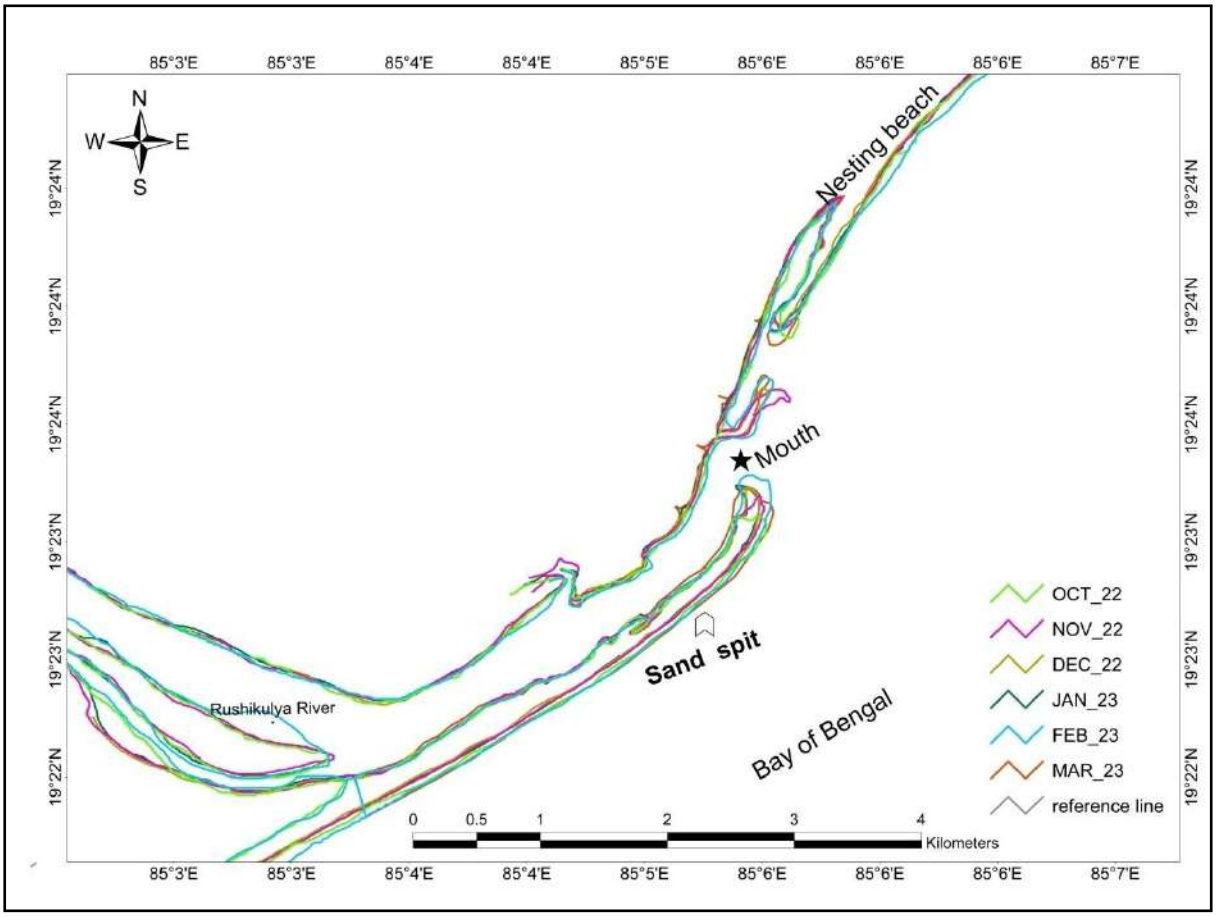

Figure 4: Shoreline changes at Rushikulya sand spit from October, 2022 to March, 2023.

Table 5: Beach width and volume along Gopalpur port South during October, 2022 to March, 2023.

Month	GPLS_1	GPLS_2	GPLS_3	GPLS_6	GPLS_7	GPLS_8	GPLS_9	GPLS_10
Beach Width (m)								
Oct_22	314.1	189.7	256.8	430.2	472.4	391.0	247.0	178.0
Nov_22	326.6	201.7	262.1	454.3	485.5	392.0	269.4	192.7
Dec_22	331.1	214.5	225.9	448.9	468.6	380.2	273.4	198.5
Jan_23	341.1	225.9	287.3	450.1	511.9	440.2	280.8	205.1
Feb_23	353.1	239.5	303.8	453.5	524.7	456.9	288.0	206.7
Mar_23	365.8	232.5	321.9	462.2	537.5	477.3	294.9	212.5
Beach Volume (m^3/m)								
Oct_22	1040.6	512.1	643.7	889.5	1264.9	1731.4	752.8	490.2
Nov_22	1090.3	554.3	659.4	914.2	1318.4	1753.5	806.1	518.3
Dec_22	1100.8	629.3	557.8	934.9	1300.5	1745.0	823.7	517.7
Jan_23	1110.8	604.4	703.4	959.1	1369.7	1829.9	810.7	555.9
Feb_23	1171.7	639.5	719.7	961.4	1391.5	1907.9	847.6	560.7
Mar_23	1219.1	653.1	722.3	956.1	1434.1	1992.3	853.6	562.5

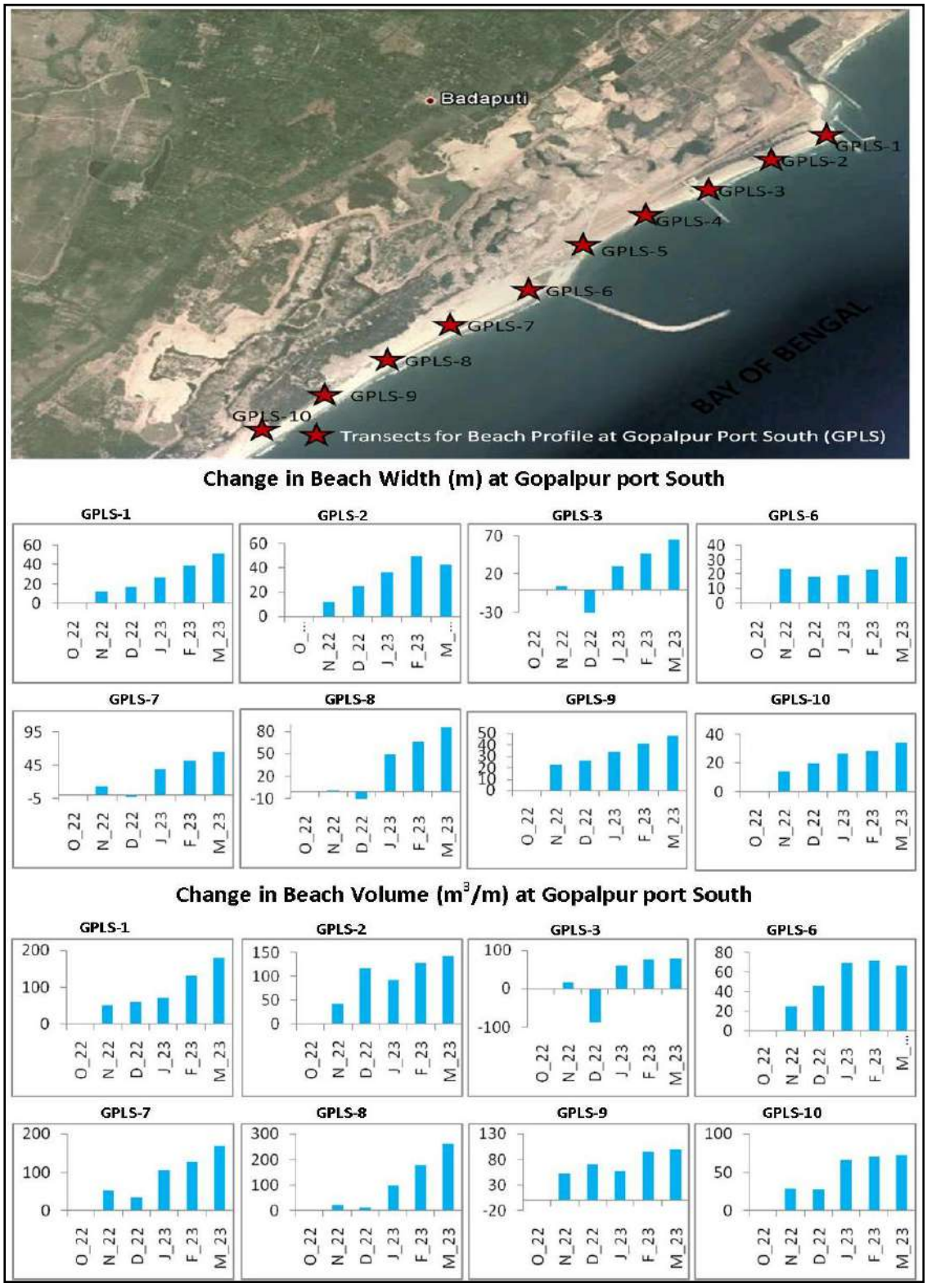

Figure 5: Beach width and volume changes from October, 2022 to March, 2023 with respect to October, 2022 at south of Gopalpur port

Table 6: Beach width and volume during October, 2022 to March, 2023 along Gopalpur port north.

Month	GPLN_1	GPLN_2	GPLN_3	GPLN_4	GPLN_5	GPLN_6	GPLN_7	GPLN_8	GPLN_9	GPLN_10
	Beach Width (m)									
Oct_22	65.7	110.5	141.1	100.7	186.1	65.8	126.5	69.3	47.2	69.9
Nov_22	69.1	118.4	149.6	104.4	189.0	70.9	131.8	75.2	58.6	73.3
Dec_22	67.3	120.8	148.8	105.0	194.2	68.1	129.7	71.5	62.6	73.6
Jan_23	70.2	137.1	154.9	111.4	199.2	76.0	141.1	78.8	66.8	81.9
Feb_23	111.7	139.1	161.7	117.2	205.4	79.2	145.5	81.6	64.2	85.2
Mar_23	77.7	148.0	158.3	125.3	203.3	81.5	148.3	85.1	71.9	89.8
	Beach Volume (m3/m)									
Oct_22	308.5	1090.6	1029.8	704.7	1097.2	308.4	991.2	419.4	265.2	390.0
Nov_22	316.2	1148.2	1071.4	656.4	1163.6	329.8	1028.2	431.6	291.8	412.5
Dec_22	314.7	1138.3	1086.1	655.3	1186.8	323.9	1019.6	426.9	303.6	426.3
Jan_23	318.1	1207.8	1147.7	698.7	1228.8	357.0	1042.7	450.0	319.4	428.9
Feb_23	345.2	1238.1	1179.2	679.7	1229.9	352.1	1071.2	457.8	313.0	457.2
Mar_23	348.8	1273.9	1190.4	736.8	1256.6	351.2	1089.5	477.0	330.4	443.3

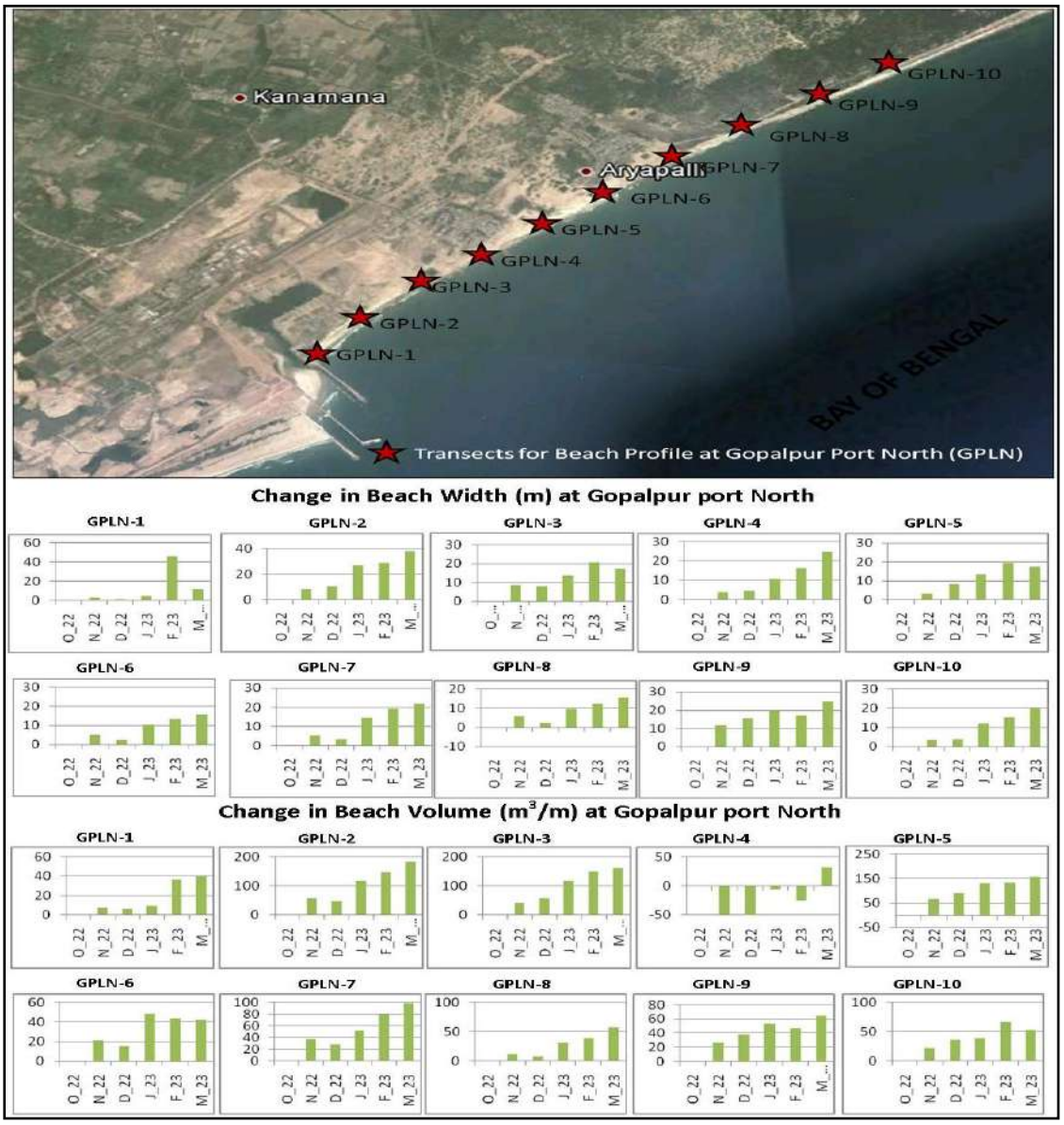

Figure 6: Beach width and volume changes from October, 2022 to March, 2023 with respect to October, 2022 at Gopalpur port north.

Table 7: Beach width and volume at Gopalpur tourist beach during October, 2022 to March, 2023.

Month	GPB_1	GPB_2	GPB_3	GPB_4	GPB_5	GPB_6	GPB_7
Beach Width (m)							
Oct_22	36.4	38.0	83.1	90.8	101.2	147.0	166.7
Nov_22	36.8	42.4	86.7	97.2	107.4	164.0	171.8
Dec_22	38.8	47.3	93.7	94.5	120.7	169.6	166.9
Jan_23	42.2	49.0	95.5	97.6	122.8	178.2	191.5
Feb_23	43.4	50.3	99.3	103.1	126.5	181.5	200.6
Mar_23	42.4	45.7	102.0	111.0	137.1	205.5	201.9
Beach Volume (m3/m)							
Oct_22	73.8	97.5	188.5	53.7	237.5	779.8	448.0
Nov_22	76.1	102.8	196.4	81.8	264.3	804.2	468.7
Dec_22	78.3	99.7	212.5	87.7	281.0	807.8	479.2
Jan_23	79.6	104.7	190.2	77.0	271.3	816.1	485.5
Feb_23	82.1	106.6	189.8	83.2	279.1	822.8	514.5
Mar_23	90.4	108.6	214.5	99.1	305.0	835.7	544.7

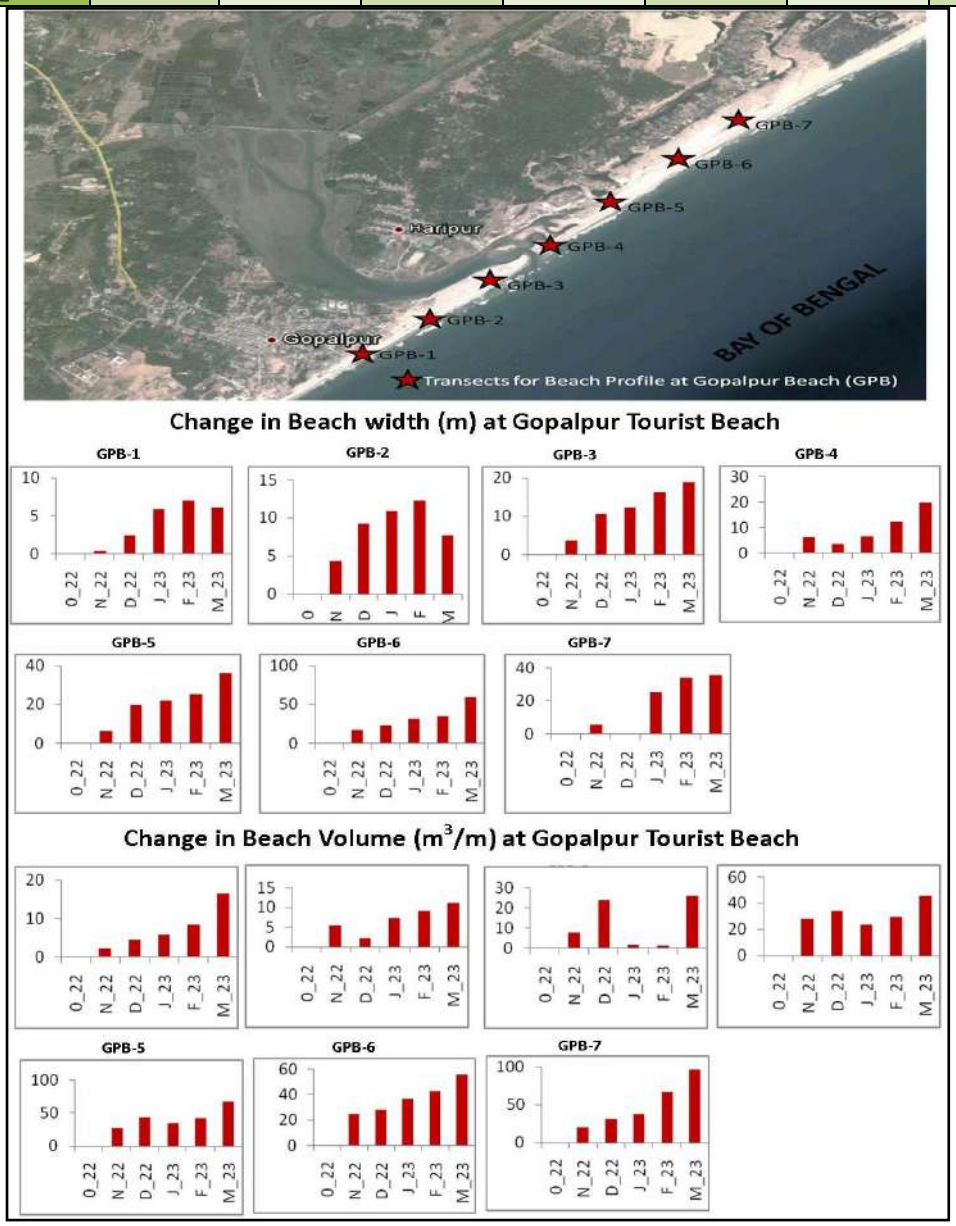

Figure 7: Beach width and volume changes from October, 2022 to March, 2023 with respect to October, 2022 at Gopalpur tourist beach.

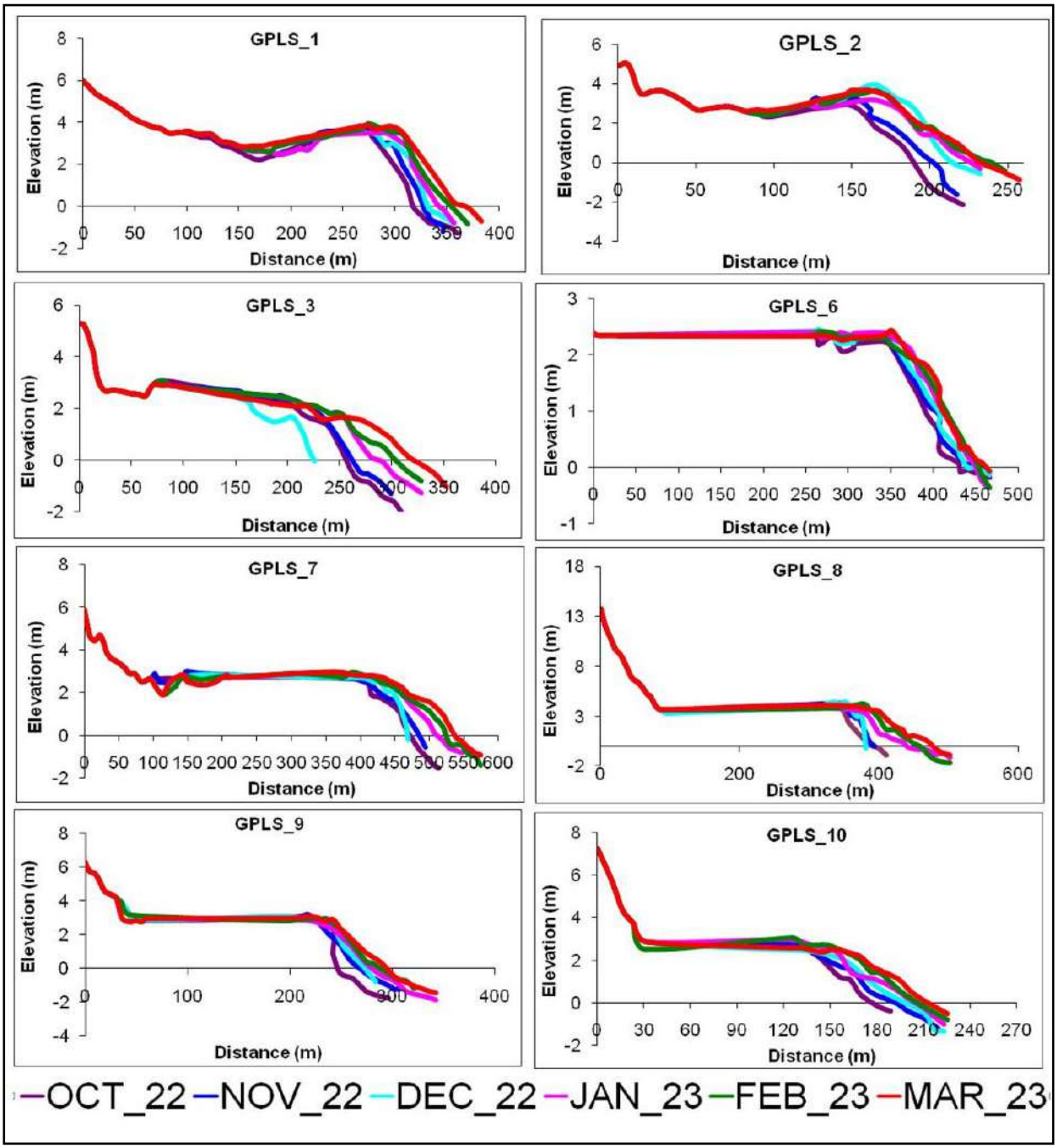

Figure 8: Beach profile at south of Gopalpur port from October, 2022 to March, 2023.

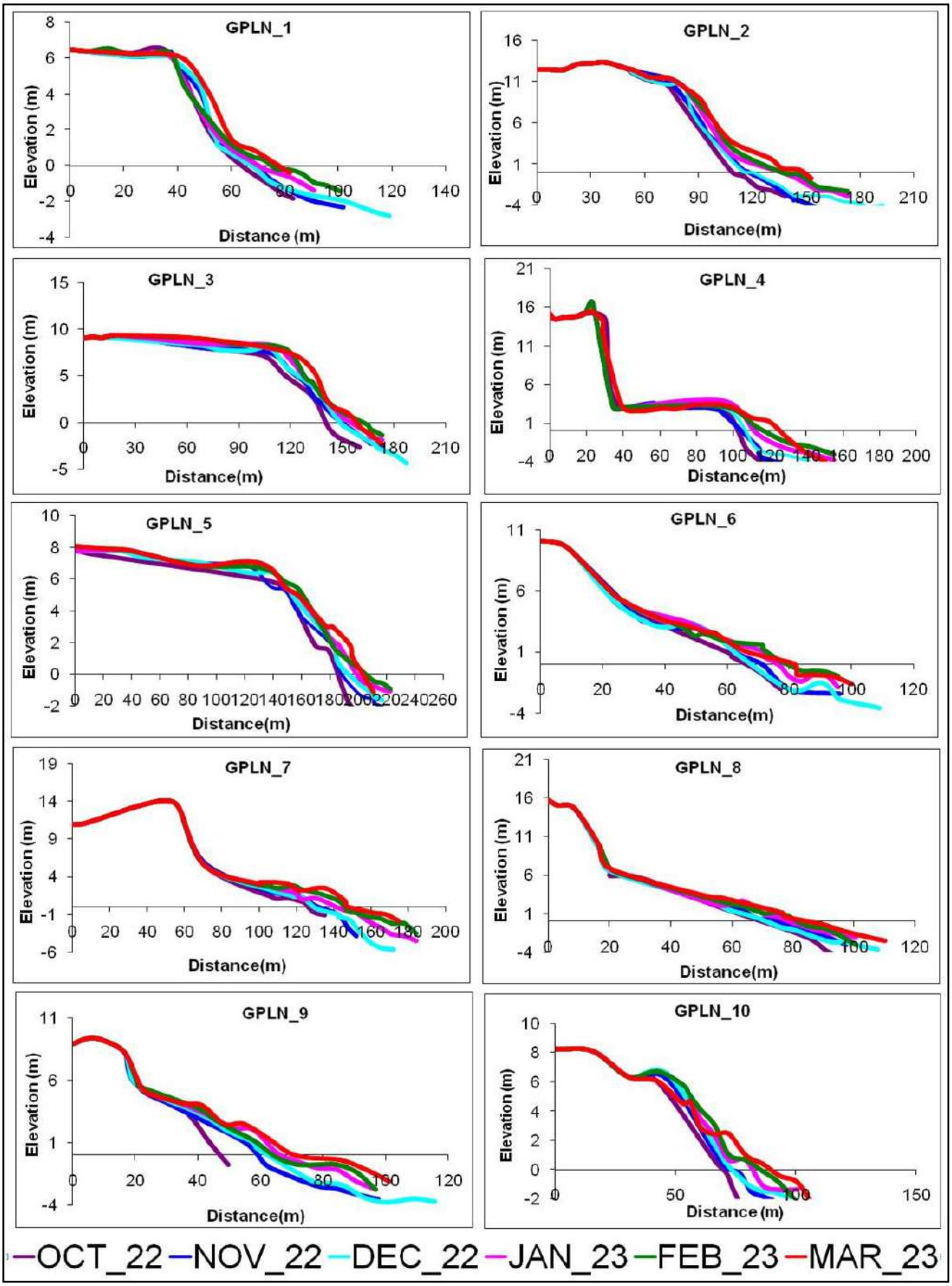

Figure 9: Beach profile at north of Gopalpur port from October, 2022 to March, 2023.

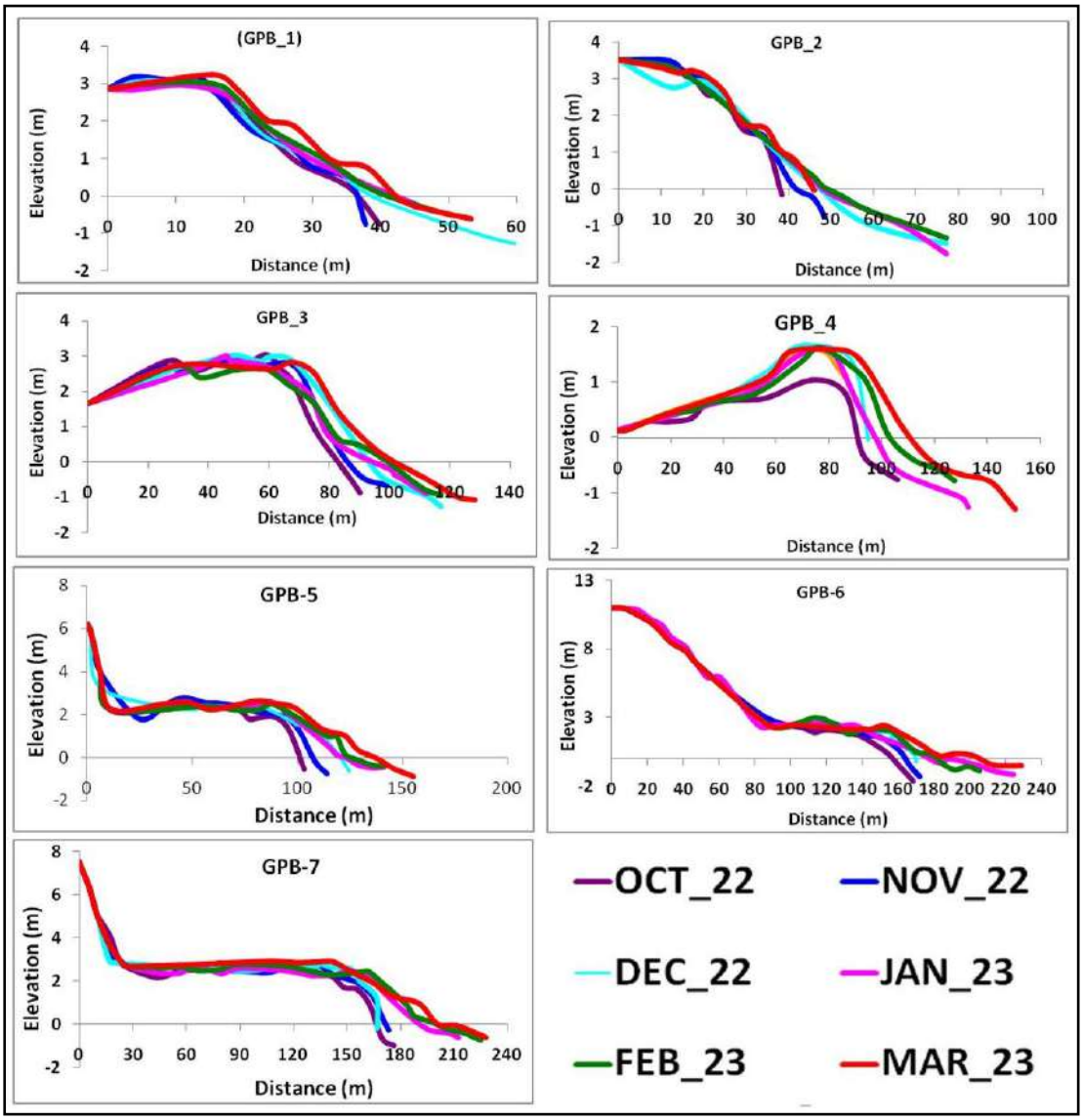

Figure 10: Beach profile at tourist beach of Gopalpur from October, 2022 to March, 2023

2. Sediment Grain size

Table 8: Sediment grain size (Mean, Sorting, Skewness and Kurtosis) at Gopalpur port south, port north, tourist beach and Rushikulya spit from October, 2022 to March, 2023.

	Gopalpur Port South											
	GPLS_1 (0 km)			GPLS_3 (1 km)			GPLS_7 (3 km)			GPLS_9 (4 km)		
	BS	MS	FS	BS	MS	FS	BS	MS	FS	BS	MS	FS
Oct_22	M	M	M	M	M	C	F	F	F	M	M	M
	MDS	MWS	MDS	MWS	MWS	MWS	MWS	MWS	MWS	MWS	MWS	MDS
	SYM	SYM	VFSK	CSK	CSK	FSK	SYM	SYM	SYM	SYM	SYM	SYM
	LPK	LPK	VPLK	LPK	LPK	MSK	LPK	MSK	MSK	LPK	MSK	PLK
Nov_22	C	C	M	M	M	M	M	M	C	C	M	M
	MDS	MWS	MDS	MDS	MDS	MDS	MDS	MDS	MDS	MDS	MDS	MDS
	SYM	CSK	SYM	CSK	CSK	CSK	CSK	CSK	CSK	SYM	SYM	CSK
	PLK	PLK	VPK	PLK	PLK	PLK	PLK	PLK	PLK	VPK	VPK	VPK
Dec_22	M	M	M	F	F	M	M	M	F	M	M	M
	MDS	MDS	MDS	MDS	MDS	MDS	MDS	MDS	MWS	MDS	MWS	MDS
	FSK	FSK	FSK	CSK	SYM	CSK	FSK	SYM	VCS	FSK	SYM	SYM
	MSK	MSK	MSK	MSK	MSK	PLK	MSK	LPK	LPK	LPK	LPK	PLK
Jan_23	M	M	F	F	M	M	M	VFS	C	F	F	F
	MWS	MWS	MWS	WS	MWS	MWS	MDS	WS	MWS	MWS	WS	WS
	SYM	SYM	SYM	SYM	CSK	CSK	SYM	SYM	SYM	SYM	SYM	SYM
	LPK	MSK	MSK	MSK	MSK	LPK	LPK	PLK	PLK	MSK	MSK	MSK
Feb_23	M	F	F	M	F	F	M	F	M	M	F	F
	MDS	MWS	MWS	MWS	MWS	MWS	MDS	MWS	PS	MWS	MWS	MWS
	CSK	SYM	SYM	SYM	CSK	CSK	SYM	SYM	FSK	FSK	SYM	SYM
	MSK	PLK	MSK	MSK	LPK	MSK	MSK	MSK	MSK	PLK	MSK	LPK
Mar_23	M	M	F	F	M	M	M	VFS	C	F	F	F
	MWS	MWS	MWS	WS	MWS	MWS	MDS	WS	MWS	MWS	WS	WS
	SYM	SYM	SYM	SYM	CSK	CSK	SYM	SYM	SYM	SYM	SYM	SYM
	LPK	MSK	MSK	MSK	MSK	LPK	LPK	PLK	PLK	MSK	MSK	MSK

	Gopalpur Port North														
	GPLN_1 (0 km)			GPLN_3 (1 km)			GPLN_5 (2 km)			GPLN_7 (3 km)			GPLN_9 (4 km)		
Oct_22	M	M	M	M	M	M	M	M	C	M	M	F	M	F	M
	MWS	MDS	MWS	MWS	MDS	MDS	MWS	MDS	MWS	MWS	MWS	PS	MDS	PS	MWS
	SYM	SYM	SYM	SYM	SYM	SYM	SYM	SYM	SYM	SYM	SYM	FSK	FSK	FSK	CSK
	LPK	PLK	LPK	PLK	MSK	MSK	MSK	LPK	MSK	MSK	MSK	VLPK	MSK	VLPK	MSK
Nov_22	M	C	C	M	M	M	M	C	M	C	M	M	C	M	M
	MDS	MDS	MDS	MDS	MDS	MDS	MDS	MWS	MDS	MDS	MDS	MDS	MWS	MDS	MDS
	SYM	CSK	CSK	CSK	CSK	SYM	CSK	CSK	VCS	SYM	CSK	CSK	CSK	SYM	CSK
	PLK	VPK	PLK	PLK	PLK	VPK	MSK	VPK	LPK	PLK	MSK	MSK	PLK	PLK	MSK
Dec_22	M	M	M	M	M	M	M	M	M	F	M	M	M	M	F
	MDS	MWS	MWS	MDS	MDS	MDS	MDS	MDS	MDS	PS	MDS	MDS	MDS	MDS	MDS
	SYM	SYM	SYM	SYM	SYM	SYM	SYM	FSK	FSK	CSK	SYM	SYM	SYM	FSK	FSK
	MSK	MSK	LPK	MSK	MSK	PLK	MSK	LPK	LPK	MSK	MSK	LPK	LPK	LPK	MSK
Jan_23	M	M	M	M	F	F	F	F	F	M	F	F	M	F	M
	MWS	MDS	MDS	MDS	MWS	MWS	MWS	MDS	MWS	MDS	MDS	MWS	MDS	MWS	MDS
	SYM	SYM	SYM	FSK	SYM	CSK	SYM	CSK	CSK	SYM	CSK	SYM	SYM	SYM	SYM
	LPK	LPK	MSK	LPK	MSK	LPK	MSK	MSK	LPK	MSK	MSK	MSK	MSK	MSK	MSK
Feb_23	M	M	M	M	M	F	C	M	M	M	M	M	M	M	M
	MDS	MDS	MDS	PS	PS	MWS	MDS	MWS	MDS	MWS	MWS	MWS	MDS	MWS	MWS
	SYM	SYM	SYM	VFSK	FSK	SYM	SYM	SYM	SYM	SYM	SYM	FSK	SYM	FSK	SYM
	PLK	LPK	LPK	PLK	PLK	MSK	MSK	LPK	MSK	MSK	LPK	MSK	LPK	LPK	LPK
Mar_23	M	M	M	M	F	F	F	F	F	M	F	F	M	F	M
	MWS	MDS	MDS	MDS	MWS	MWS	MWS	MDS	MWS	MDS	MDS	MWS	MDS	MWS	MDS
	SYM	SYM	SYM	FSK	SYM	CSK	SYM	CSK	CSK	SYM	CSK	SYM	SYM	SYM	SYM
	LPK	LPK	MSK	LPK	MSK	LPK	MSK	MSK	LPK	MSK	MSK	MSK	MSK	MSK	MSK

	Gopalpur Tourist Beach								
	GPB_2 (1.0 km)			GPB_4 (2.0 km)			GPB_6 (3.0 km)		
	BS	MS	FS	BS	MS	FS	BS	MS	FS
Oct_22	M	M	M	C	C	M	M	M	M
	MDS	MWS	MDS	MWS	MWS	MWS	MWS	MWS	MDS
	CSK	SYM	SYM	SYM	SYM	SYM	SYM	SYM	SYM
	MSK	MSK	MSK	PLK	PLK	MSK	LPK	LPK	MSK
Nov_22	M	M	M	M	M	M	M	M	C
	PS	MDS	MDS	MDS	MDS	PS	MDS	MDS	MDS
	CSK	SYM	CSK	CSK	CSK	VFS	SYM	SYM	SYM
	MSK	MSK	MSK	PLK	PLK	MSK	PLK	PLK	PLK
Dec_22	M	M	M	M	M	M	M	M	M
	MWS	MDS	MDS	MDS	MDS	MDS	MDS	MWS	MDS
	FSK	FSK	FSK	SYM	FSK	SYM	FSK	FSK	FSK
	LPK	MSK	LPK	MSK	LPK	MSK	LPK	LPK	PLK
Jan_23	M	M	F	F	F	M	F	F	M
	MDS	MDS	MWS	MDS	WS	MDS	MWS	WS	MDS
	SYM	SYM	SYM	CSK	FSK	SYM	SYM	SYM	SYM
	MSK	MSK	MSK	LPK	MSK	LPK	MSK	MSK	MSK
Feb_23	M	M	M	M	M	M	M	M	F
	MWS	MDS	MDS	MWS	MWS	MWS	MDS	MDS	MWS
	SYM	SYM	FSK	SYM	FSK	FSK	SYM	SYM	SYM
	LPK	LPK	LPK	MSK	MSK	MSK	MSK	LPK	MSK
Mar_23	M	M	F	F	F	M	F	F	M
	MDS	MDS	MWS	MDS	WS	MDS	MWS	WS	MDS
	SYM	SYM	SYM	CSK	FSK	SYM	SYM	SYM	SYM
	MSK	MSK	MSK	LPK	MSK	LPK	MSK	MSK	MSK

	Rushikulya Spit (SPIT_A)		
	BS	MS	FS
Oct_22	F	M	C
	MWS	MWS	MWS
	CSK	SYM	SYM
	MSK	MSK	MSK
Nov_22	M	M	M
	MDS	PS	MDS
	CSK	FSK	SYM
	PLK	LPK	PLK
Dec_22	M	M	M
	MDS	MDS	MDS
	FSK	FSK	SYM
	MSK	LPK	LPK
Jan_23	M	M	M
	MDS	MDS	MDS
	CSK	CSK	SYM
	PLK	MSK	PLK
Feb_23	M	M	M
	MDS	MWS	MWS
	SYM	SYM	SYM
	MSK	MSK	LPK
Mar_23	M	M	M
	MDS	MDS	MDS
	CSK	CSK	SYM
	PLK	MSK	PLK

Legends: **Mean:** **Fine Sand (F) Medium Sand (M) Coarse Sand (C) Very Fine Sand (VF)**

Sorting: **Well Sorted (WS) Moderately Well Sorted (MWS) Moderately Sorted (MDS) Poorly Sorted (PS)**

Skewness: Symmetrical (SYM), Coarse Skewed (CSK), Fine Skewed (FSK), VFSK-Very Fine skewed

Kurtosis: Platykurtic (PLK), Leptokurtic (LPK), Mesokurtic (MSK), Very Platykurtic (VPK)

3. Littoral Environment Observation

Table 9: Littoral Environmental Conditions along Gopalpur Coast from October, 2022 to March, 2023

Month	Breaker type	Breaker height (m)	Breaker angle (deg)	Wave period (sec)	Wave direction	Uprush (m/s)	Backwash (m/s)	Surf zone width(m)
Gopalpur Tourist Beach								
Oct_22	Spilling	1.56	10	11.30	SSE	1.11	1.04	90
Nov_22	Plunging	0.95	15	8.16	SE	1.04	0.52	90
Dec_22	Plunging	1.3	12	11.26	SSE	1.14	1.12	85
Jan_23	Plunging	1.15	6	11.33	ESE	1.31	0.86	112
Feb_23	Plunging	1.53	8	10.02	SSE	1.28	0.84	95
Mar_23	Plunging	1.6	12	11.26	SSE	1.14	1.12	95
Gopalpur Port								
Oct_22	Spilling	1.41	5	11.52	SE	1.20	1.00	110
Nov_22	Spilling	1.13	10	9.54	SE	1.06	0.81	90
Dec_22	Spilling	1.2	9	11.68	SSE	1.15	1.10	115
Jan_23	Spilling/ plunging	1.12	8	12.33	ESE	1.31	0.85	115
Feb_23	Plunging/ spilling	1.65	10	9.85	SSE	1.32	0.96	110
Mar_23	Spilling	1.51	9	11.68	SSE	1.15	1.1	115
Rushikulya Spit								
Oct_22	Plunging	1.53	5	11.89	SSE	1.18	0.96	90
Nov_22	Plunging	0.98	15	10.19	SSE	1.28	1.01	75
Dec_22	Plunging	1.35	11	11.65	SSE	1.15	1.07	105
Jan_23	Plunging	1.35	9	11.66	ESE	1.32	0.82	110
Feb_23	Plunging	1.6	12	8.92	ESE	1.36	0.91	115
Mar_23	Spilling	0.84	10	9.35	SE	1.08	0.99	60

4. Ambient Air Quality and noise level

Table 10: STATION-A (19^0 17' 18.69''N, 84^0 56'41.82''E) near southern breakwater (PM- Particulate matter, SO_2-Sulphur dioxide, NO_2-Oxides of nitrogen) from October, 2022 to March, 2023

STATION-A	Date	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	SO_2 (µg/m^3)	NO_2 (µg/m^3)	Noise level (dB)
Oct_22	05.10.2022	67.39	17.39	2.38	1.28	54.29
	06.10.2022	75.28	22.68	3.19	1.37	58.37
	12.10.2022	72.38	26.57	2.48	2.26	60.18
	13.10.2022	80.19	20.18	1.25	2.44	49.67
	17.10.2022	64.05	19.37	1.08	2.94	64.97
	18.10.2022	74.39	18.53	2.61	2.81	66.48
	26.10.2022	77.59	24.38	2.66	1.09	57.61
	27.10.2022	68.22	16.86	2.48	1.66	59.64
Nov_22	03.11.2022	70.27	25.29	3.24	2.15	56.34
	04.11.2022	72.85	26.57	2.35	1.29	64.32
	10.11.2022	65.21	23.19	3.25	2.35	67.11
	11.11.2022	79.54	28.27	2.64	2.37	65.2
	18.11.2022	66.29	24.87	1.56	1.94	66.29
	19.11.2022	80.11	31.28	2.65	3.01	58.37
	25.11.2022	67.25	26.28	2.97	2.59	58.64
	28.11.2022	69.21	29.59	3.84	1.68	55.37
Dec_22	02.12.2022	72.49	21.38	3.04	1.28	51.39
	03.12.2022	79.37	24.51	2.67	1.37	45.72
	09.12.2022	69.18	30.18	2.55	2.26	48.61
	10.12.2022	80.07	18.61	3.14	2.44	50.27
	19.12.2022	70.28	20.18	2.86	2.94	49.67
	20.12.2022	67.65	34.19	2.33	2.81	57.33
	22.12.2022	69.61	20.44	3.49	1.09	57.61
	23.12.2022	80.18	24.08	2.73	1.66	59.64
Jan_23	02.01.2023	75.38	24.38	2.46	1.95	48.37
	03.01.2023	81.57	29.67	2.82	1.64	45.64
	10.01.2023	80.19	34.19	3.91	2.82	52.72
	11.01.2023	76.39	42.18	3.47	2.45	61.94
	17.01.2023	84.66	44.67	4.07	1.64	57.82
	18.01.2023	88.57	34.28	2.64	2.37	60.43
	24.01.2023	80.19	29.33	2.58	2.08	58.91
	25.01.2023	87.57	30.46	4.27	3.49	57.64
Feb_23	01.02.2023	82.6	38.19	1.92	2.67	42.67
	02.02.2023	79.34	32.95	2.46	2.91	44.29
	06.02.2023	73.28	36.43	2.37	3.49	48.73
	07.02.2023	68.16	40.85	3.18	3.46	40.91
	15.02.2023	77.29	42.61	3.14	3.57	39.27
	16.02.2023	80.19	43.18	3.22	3.83	59.37
	23.02.2023	84.33	49.37	4.72	3.94	61.02
	24.02.2023	72.15	44.28	3.94	3.72	54.25
Mar_23	01.03.2023	75.63	30.18	2.37	1.95	54.38
	02.03.2023	81.05	40.19	1.94	1.67	62.18
	09.03.2023	82.67	34.27	1.97	2.18	57.19
	10.03.2023	87.34	36.18	2.94	2.67	50.42
	13.03.2023	72.64	28.61	3.18	1.64	48.92
	14.03.2023	70.19	38.94	2.83	1.55	64.37
	20.03.2023	68.33	44.67	3.44	3.48	57.38
	21.03.2023	76.94	30.73	2.67	2.57	52.18
Mean (Range)		**75.54** (64.05-88.57)	**30.33** (16.86-49.37)	**2.83** (1.08-4.72)	**2.35** (1.09-3.94)	**55.50** (39.27-67.11)
Reference value (NAAQS, 2009)		**100**	**60**	**80**	**80**	**70-75 (Env. Protection Act, 1986)**

Table 11: STATION-B (19^0 17' 48.1''N, 84^0 57' 03.3''E) near intermediate breakwater from October, 2022 to March, 2023

Station-B	Date	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	SO_2 (µg/m^3)	NO_2 (µg/m^3)	Noise level (dB)
Oct_22	05.10.2022	81.38	24.38	1.92	2.43	54.29
	06.10.2022	76.54	21.65	1.38	1.97	61.37
	12.10.2022	82.18	25.83	2.46	3.07	64.22
	13.10.2022	78.55	19.67	2.55	2.49	57.91
	17.10.2022	68.91	21.67	3.07	2.88	64.28
	18.10.2022	76.73	16.37	2.94	2.57	66.49
	26.10.2022	81.64	24.64	3.11	2.49	54.29
	27.10.2022	80.57	17.91	2.07	1.94	67.39
Nov_22	03.11.2022	71.25	26.54	2.64	1.59	69.21
	04.11.2022	77.54	28	1.64	2.38	65.27
	10.11.2022	69.21	25.17	3.11	2.64	69.15
	11.11.2022	77.98	31.58	2.34	2.58	63.28
	18.11.2022	69.74	29.18	2.94	1.97	70.02
	19.11.2022	79.55	32.67	1.57	3.28	59.31
	25.11.2022	66.28	28.27	2.82	1.28	68.37
	28.11.2022	67.25	26.81	3.64	2.91	70.85
Dec_22	02.12.2022	73.91	19.37	2.07	2.43	54.38
	03.12.2022	75.33	26.85	1.95	1.97	60.19
	09.12.2022	81.93	16.99	1.38	3.07	59.37
	10.12.2022	74.39	28.61	2.84	2.49	48.27
	19.12.2022	69.11	27.33	3.17	2.88	60.18
	20.12.2022	85.37	29.43	2.64	2.57	58.37
	22.12.2022	82.46	33.57	2.38	2.49	55.19
	23.12.2022	79.14	20.48	1.22	1.94	62.48
Jan_23	02.01.2023	86.17	26.37	2.08	1.07	52.91
	03.01.2023	84.62	28.43	1.95	1.66	64.28
	10.01.2023	90.75	24.38	2.37	2.59	67.92
	11.01.2023	73.84	22.19	3.48	3.41	57.27
	17.01.2023	80.16	34.08	2.44	2.11	62.46
	18.01.2023	86.88	19.73	1.82	3.94	55.38
	24.01.2023	82.64	27.65	2.76	1.67	67.19
	25.01.2023	87.94	20.48	3.17	2.83	51.38
Feb_23	01.02.2023	86.72	30.19	3.85	2.64	53.14
	02.02.2023	79.18	42.38	2.62	2.94	55.61
	06.02.2023	75.37	40.18	2.94	3.28	60.43
	07.02.2023	77.19	38.45	3.44	3.49	58.17
	15.02.2023	76.77	30.84	3.18	3.76	55.39
	16.02.2023	84.39	29.46	3.52	4.27	47.28
	23.02.2023	81.55	29.16	3.43	4.95	49.37
	24.02.2023	80.48	30.62	4.08	3.18	50.72
Mar_23	01.03.2023	82.64	34.29	2.64	1.67	61.38
	02.03.2023	80.73	34.08	3.18	2.94	49.17
	09.03.2023	79.23	29.47	3.64	3.76	55.61
	10.03.2023	70.94	25.92	3.55	4.28	60.18
	13.03.2023	74.82	33.44	2.72	3.73	65.73
	14.03.2023	80.34	41.92	2.91	5.61	60.49
	20.03.2023	83.46	38.73	3.57	4.19	49.37
	21.03.2023	87.05	43.64	1.28	2.86	43.18
Mean (Range)		**78.77** (66.28-90.75)	**28.31** (16.37-43.64)	**2.68** (1.22-4.08)	**2.82** (1.07-5.61)	**59.13** (43.18-70.85)
Reference value (NAAQS, 2009)		**100**	**60**	**80**	**80**	**70-75 (Env. Protection Act, 1986)**

Table 12: STATION-C (19^0 18' 29.0''N, 84^0 57' 41.1''E) near signal station/Environmental Laboratory from October, 2022 to March, 2023

STATION-C	Date	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Noise level (dB)
Oct_22	07.10.2022	83.67	25.67	2.94	1.67	62.69
	08.10.2022	81.19	24.09	3.19	2.19	64.66
	15.10.2022	76.27	19.38	3.48	3.18	67.64
	16.10.2022	68.57	22.67	3.46	3.22	64.84
	24.10.2022	81.37	27.39	2.64	1.68	64.28
	25.10.2022	84.28	20.43	3.44	2.95	67.14
	28.10.2022	82.55	18.99	4.07	2.64	60.42
	29.10.2022	80.49	27.37	2.08	2.66	55.18
Nov_22	05.11.2022	75.21	32.54	3.25	1.68	58.32
	09.11.2022	69.25	24.87	2.54	2.56	59.61
	14.11.2022	79.86	28.64	2.94	2.34	60.27
	15.11.2022	55.2	26.46	1.83	1.56	62.57
	21.11.2022	54.21	28.51	2.87	3	58.29
	22.11.2022	60.18	29.38	3.12	2.54	59.37
	29.11.2022	74.91	30.28	2.55	1.09	62.37
	30.11.2022	70.11	26.54	3.41	2.51	65.28
Dec_22	06.12.2022	76.37	32.18	2.94	1.67	61.83
	07.12.2022	84	24.08	3.19	2.67	64.37
	13.12.2022	83.91	26.11	3.48	3.16	59.48
	14.12.2022	79.18	19.46	3.46	3.08	67.22
	16.12.2022	64.29	35.66	2.64	3.49	64.38
	17.12.2022	88.37	30.48	3.44	2.57	61.94
	27.12.2022	72.61	28.92	4.07	2.67	58.65
	28.12.2022	77.94	20.55	2.08	3.44	60.46
Jan_23	05.06.2023	84.39	22.18	2.99	2.94	62.46
	06.01.2023	88.42	20.49	1.67	2.43	54.91
	12.01.2023	91.08	31.57	1.64	2.67	57.34
	13.01.2023	84.27	33.49	3.45	1.76	67.1
	20.01.2023	74.38	48.17	2.33	3.18	64.95
	21.01.2023	92.49	27.16	3.73	3.79	51.07
	27.01.2023	84.61	34.67	2.64	3.57	69.28
	28.01.2023	85.27	28.49	1.09	2.83	41.69
Feb_23	03.02.2023	84.39	39.55	3.07	3.67	54.67
	04.02.2023	88.19	41.67	2.18	3.94	59.62
	09.02.2023	76.46	44.38	2.67	3.27	62.18
	10.02.2023	85.11	32.19	3.44	3.86	67.44
	21.02.2023	86.43	46.29	3.67	5.18	69.17
	22.02.2023	82.99	43.17	2.91	3.61	57.85
	27.02.2023	81.67	40.11	4.38	4.28	59.38
	28.02.2023	87.37	32.57	5.11	2.9	52.43
Mar_23	03.03.2023	85.94	42.61	4.29	3.78	60.83
	04.03.2023	87.37	40.64	4.61	3.49	66.49
	16.03.2023	76.42	38.28	3.83	3.46	68.73
	17.03.2023	80.64	41.61	3.71	4.27	57.19
	23.03.2023	79.22	38.62	3.92	2.94	66.73
	24.03.2023	70.43	29.35	2.84	2.83	70.19
	27.03.2023	91.67	46.27	4.75	3.49	64.29
	28.03.2023	90.51	42.99	4.17	4.61	53.18
Mean (Range)		**79.66** (54.21-92.49)	**31.61** (18.99-48.17)	**3.17** (1.09-5.11)	**2.98** (1.09-5.18)	**61.47** (41.69-70.19)
Reference value (NAAQS, 2009)		**100**	**60**	**80**	**80**	**70-75 (Env. Protection Act, 1986)**

Table 13: STATION-D (19^0 18' 50.09''N, 84^0 58'09.12''E) near the entrance gate of Gopalpur port from October, 2022 to March, 2023

STATION-D	Date	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	SO_2 (µg/m^3)	NO_2 (µg/m^3)	Noise level (dB)
Oct_22	07.10.2022	73.46	21.38	2.17	2.62	62.49
	08.10.2022	77.28	19.67	3.05	2.94	54.07
	15.10.2022	68.42	24.66	2.11	3.16	68.34
	16.10.2022	69.83	17.52	1.85	2.48	66.18
	24.10.2022	80.57	24.39	1.94	1.64	57.61
	25.10.2022	76.59	22.82	2.43	2.82	59.18
	28.10.2022	83.19	26.91	2.67	2.49	67.22
	29.10.2022	65.27	16.84	3.18	2.83	60.72
Nov_22	05.11.2022	78.65	30.26	2.64	2.31	58.39
	09.11.2022	71.25	25.31	2.87	2.97	59.64
	14.11.2022	78.99	27.64	1.64	3.08	57.62
	15.11.2022	59.84	24.58	3.59	2.82	51.29
	21.11.2022	64.28	26.57	2.58	2.31	62.39
	22.11.2022	69.54	29.64	2.19	2.09	64.28
	29.11.2022	75.28	32.29	3.28	1.69	57.21
	30.11.2022	65.29	26.54	3.08	2.33	55.39
Dec_22	06.12.2022	74.39	25.18	2.17	2.84	64.27
	07.12.2022	76.28	29.11	3.05	3.19	68.19
	13.12.2022	74.69	19.57	2.11	3.44	60.55
	14.12.2022	80.16	21.06	1.85	2.67	57.37
	16.12.2022	72.66	31.67	1.94	1.94	64.19
	17.12.2022	64.28	28.54	2.43	1.66	56.52
	27.12.2022	84.37	20.86	2.67	2.17	60.18
	28.12.2022	70.82	19.83	3.18	2.37	68.27
Jan_23	05.06.2023	88.57	18.17	3	1.64	62.43
	06.01.2023	80.43	25.64	2.48	2.42	57.19
	12.01.2023	79.54	27.19	1.88	2.94	55.99
	13.01.2023	77.28	18.33	1.94	1.67	60.43
	20.01.2023	91.33	27.91	2.62	2.67	64.27
	21.01.2023	73.49	24.38	3.07	2.94	58.56
	27.01.2023	72.97	20.18	3.83	3.18	55.18
	28.01.2023	89.64	17.64	4.07	1.59	65.37
Feb_23	03.02.2023	84.39	40.82	2.67	2.33	54.34
	04.02.2023	79.38	23.11	3.43	3.49	47.62
	09.02.2023	82.64	35.86	2.99	4.05	43.18
	10.02.2023	74.28	31.68	3.52	3.84	44.37
	21.02.2023	76.19	34.61	3.84	2.92	51.94
	22.02.2023	79.37	27.66	3.59	3.22	47.62
	27.02.2023	70.92	24.18	4.27	3.73	64.86
	28.02.2023	84.91	41.33	4.95	2.08	66.57
Mar_23	03.03.2023	84.39	38.61	2.99	3.17	48.91
	04.03.2023	75.27	42.94	1.67	3.94	52.76
	16.03.2023	70.64	40.67	1.58	4.61	50.49
	17.03.2023	77.19	35.43	3.47	2.83	52.82
	23.03.2023	92.67	46.91	3.24	2.76	49.37
	24.03.2023	69.72	27.38	2.94	2.84	40.88
	27.03.2023	75.34	21.63	2.88	3.88	57.27
	28.03.2023	80.16	34.29	3.73	2.95	64.92
Mean (Range)		**76.38** (59.84-92.67)	**27.49** (16.84-46.91)	**2.82** (1.58-4.95)	**2.76** (1.59-4.61)	**57.89** (40.88-68.34)
Reference value (NAAQS, 2009)		**100**	**60**	**80**	**80**	**70-75 (Env. Protection Act, 1986)**

5. Harbour Water Quality

Table 14: Physico-chemical parameters near horbour area (Latitude- 19^0 $17^{'}$ $21^{''}$ N/Longitude-84^0 $56^{'}$ $55^{''}$E) from October, 2022 to March, 2023.

Water parameters	Oct_22	Nov_22	Dec_22	Jan_23	Feb_23	Mar_23	Range	Mean	Standard	Methods
pH	8.8	7.51	7.76	8.11	8.28	8.07	7.51-8.8	8.09	6.5-9[1]	Microprocessor based pH system Model 1012
DO (mg/l)	3.9	3.9	3.73	3.08	3.9	3.73	3.08-3.9	3.71	> 3mg/L[1]	Winkler's Titration method following Grasshoff et al (1999)
Colour & Odour	Bluish & Odourless	Brownish & Odourless	Bluish & Odourless	Bluish & Odourless	Bluish & Odourless	Brownish & Odourless	----------			-------
Fecal coliform(CFU/ml)	130	110	30	50	80	150	30-150	91.67	--	APHA, 1999
BOD (mg/L)	4.53	2.64	3.74	3.55	3.87	3.68	2.64-4.53	3.67	< 5 [1]	Winkler's Titration method following Grasshoff et al. (1999)
Salinity (PSU)	6.83	25.26	27.9	30.73	29.59	33.73	6.83-33.73	25.67	--	Mohr-Knudsen Argentometric titration method
EC (mS/Cm)	11.32	41.64	43.46	52.19	46.92	53.18	11.32-53.18	41.45	--	Hanna HI 98194 portable multi parameter water quality meter
TDS (PPT)	28.64	33.24	34.68	31.64	32.40	38.04	28.64-38.04	33.11	--	Hanna HI 98194 portable multi parameter Water Quality meter
TSM($g.l^{-1}$)	1.480	1.520	0.668	1.287	0.954	0.822	0.668-1.520	1.12	--	Filtration method using Vacuum pump and filtration unit
Sulphate(mg/L)	197.9	148.3	165.59	134	174.6	125.9	125.9-197.9	157.7	--	APHA 4500 SO_4^{2-} E
Phosphate (mg/ L)	BDL (0.008)	BDL (0.005)	BDL (0.005)	0.03	0.03	BDL	0.005-0.03	0.016	0.1 mg/L[2]	APHA 4500 PD
Nitrate (mg/L)	1.45	1.95	2.23	0.47	2.37	1.97	0.47-2.37	1.7	1.0 mg/L[2]	APHA 4500 NO_2 E
Chloride (mg/L)	13490	13443	13490	3960	19331	19783	3960-19783	13916.2	--	APHA 4500 CL^- B
PHC (mg/L)	0.16	0.16	0.13	0.14	0.15	0.13	0.13-0.16	0.1	10 mg/L[1]	EPA 3510
Lead(mg/L)	3.98	4.98	4.98	0.2	ND	0.18	0.18-4.98	2.9	0.1 mg/L[3]	APHA 311 B.C
Mercury (mg/L)	BDL (0.002)	BDL (0.001)	BDL (0.001)	BDL(0.002)	BDL (0.001)	BDL (0.002)	0.001-0.002	0.002	0.01 mg/L[3]	APHA 5500 Hg
Hexavalent Chromium(mg/L)	BDL(0.02)	BDL (0.04)	BDL (0.04)	BDL (0.02)	BDL (0.04)	BDL (0.02)	0.02-0.04	0.03	0.1 mg/L[3]	APHA 3500 Cr B

Sources:

[1] Primary water quality criteria for class SW-IV waters (Harbour) as per EPA, 1986
[2] Guidelines for coastal water quality, Dept. of Environment, Govt. of India, General notice no 620 of 1999.
[3] Central Pollution Control Board, Pollution Control Acts, Rules and Notifications, Fourth Edition, Ministry of Environment and Forests, 2001, 897pp.

6. Sediment and Soil analysis report

Table 15: Sediment quality at harbour area from October, 2022 to March, 2023

Sediment parameters	Oct_22	Nov_22	Dec_22	Jan_23	Feb_23	Mar_23	Range	Mean	Methods
Texture (Mean, sorting, skewness, kurtosis)	F MWS SYM MSK	F MWS SYM MSK	C MDS SYM PLK	M MDS SYM MSK	F MWS SYM LPK	F WS SYM MSK	……	……	Sieve Analysis method using RETSCH AS 200
pH	7.28	7.17	7.08	6.13	6.38	6.81	6.67-7.37	6.98	Potentiometric method
Sodium (mg/kg)	1.9	3.0	2.1	2.8	2.7	418.7	676-964	773.50	Flame photometry
Potassium (mg/kg)	2.2	2.3	2.4	2.1	1.9	BDL	15.8-24.6	20.09	Flame photometry
Phosphate (mg/kg)	10	5.0 (BDL)	15	79.93	49.98	59.90	0.04-0.08	0.04	Methods of analysis of soil by HLS Tandon*
Chlorides (mg/kg)	1283	2672	1860	4875.5	3482	232.2	226-879	479.50	USDA:1954 US -affirmed 2010
Sulphates (mg/kg)	206.3	366.3	265.9	628.74	433.7	478.4	61.30-249	126.97	Methods of analysis of soil by HLS Tandon*
PHC (µg/L)	0.005 (BDL)	0.007 (BDL)	BDL (0.007)	0.005	0.007	0.007	0.004-0.008	0.01	UNEP 1992
Lead (mg/kg)	0.44	0.41	0.46	BDL	BDL	BDL	0.14-1.22	0.37	EPA 3050 B
Mercury (mg/kg)	0.004 (BDL)	0.005 (BDL)	BDL (0.005)	0.004	0.005	0.005	0.003-0.008	0.01	EPA 3050 B
Hexavalent chromium (mg/kg)	0.07 (BDL)	0.09 (BDL)	BDL (0.09)	0.07	0.09	0.09	0.04-0.08	0.06	Methods of analysis of soil by HLS Tandon*
Organic carbon (%)	0.17	0.14	0.13	0.14	0.15	0.29	0.03-0.12	0.08	Methods of analysis of soil by HLS Tandon*

*Methods of analysis of Soils, Plants, Waters, Fertilizers and organic manures by HLS Tandon published by FDCO, New Delhi, 1993.

BDL- Below Detectable Limits: Phosphate<0.2 (mg/kg), PHC <0.01(µg/L), Mercury <0.01 (mg/kg), Hexavalent chromium <0.2 (mg/kg)
Texture legends as per table 8.

Table 16: Soil quality at harbour area during March, 2023

Soil Parameters	Analysis Result	Testing Method
pH	**7.22**	IS:2720(P-26):1987
Electrical Conductivity (µs/cm)	**2686**	IS:14767:2000
Available Nitrogen (%)	**<1.4**	Methods of analysis of soil by HLS Tandon*
Available Phosphorus (mg/kg)	**0.67**	
Available Potassium (mg/kg)	**11.88**	VCSPL/SOP/SOIL/15
Alkalinity (mg/kg)	**31.0**	Methods of analysis of soil by HLS Tandon*
Chloride (mg/kg)	**1986.0**	
Sulphate (mg/kg)	**292.0**	IS:2720(P-27):1987
Magnesium (%)	**0.18**	Methods of analysis of soil by HLS Tandon*
Organic Matter (%)	**<0.02**	VCSPL/SOP/SOIL/05
Iron (mg/kg)	**9.2**	EPA 3050B, 7000B
Copper (mg/kg)	**7.9**	EPA 3050B, 7000B
Manganese (mg/kg)	**78.8**	EPA 3050B
Zinc (mg/kg)	**28.6**	EPA 3050B, 7000B
Total Chromium (mg/kg)	**34.5**	EPA 3050B
Lead (mg/kg)	**5.20**	EPA 3050B
Nickel (mg/kg)	**7.6**	EPA 3050B, 7000B
Arsenic (mg/kg)	**BDL(0.04)**	EPA 3050B, 7000B
Cadmium as Cd (mg/kg)	**BDL{0.1)**	EPA 3050B, 7000B
Mercury (mg/kg)	**BDL (0.007)**	EPA 3050B, 7000B

BDL- Below Detectable Limits: Arsenic<0.5 (mg/kg), Mercury <0.01(mg/kg), Organic Matter <0.02 %, Available Nitrogen <1.4%.

*Methods of analysis of Soils, Plants, Waters, Fertilizers and organic manures by HLS Tandon published by FDCO, New Delhi, 1993.

7. Biological parameters

Table 17: Biological parameters from October, 2022 to March, 2023

Station	Parameters	Results (October, 2022 to December, 2022) (Value in average)	Results (January, 2023 to March, 2023) (Value in average)
Harbour Area Latitude- $19^0\ 17'\ 21''$ N Longitude- $84^0\ 56'\ 55''$ E	**Light penetration (m)**	1.4	1.1
	Chlorophyll (mg/m^3)	1.568	2.53
	Primary productivity ($g.C/m^3/hr$)	0.02	0.024
	Phytoplankton (no. of cells/l)	580	673
	Zooplankton (no. of individuals/l)	27	41
	Benthic meiofauna (per m^2)	9320	18640
	Benthic macrofauna (per m^2)	4800	7466

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