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## PREFACE

Environmental monitoring programme is a vital process of any management plan of a development project. Concern over the state of environment has grown worldwide since the sixties, due to decline in environmental quality, and various efforts have been taken for environmental protection in our country. Accordingly, the Ministry of Environment & Forests, Govt. of India, became the nodal agency in regulating developmental activities enforcing environmental sampling and monitoring.

**Dredging Corporation of India Ltd (DCI)**, is one among the Public Sector Undertakings of India, provides dredging services to the Major Ports of the country in India and is a pioneer organization in the field of dredging and maritime development. Mormugao Port Trust (MPT), Goa, entrusted the work of Capital Dredging of the approach channel, turning circle, berths 5,6,7 and approach for capsized vessels at Mormugao port, Goa.

**Dredging Corporation of India Ltd (DCI)**, Visakhapatnam took the services from **M/s. Richardson & Cruddas (1972) Ltd, Chennai-98(A Govt.of India Undertaking)**, for environmental monitoring in and around the dredging and dumping areas of Mormugao port through their **Work order No. DCI/HSE/IMS/28 dtd. 19.02.2016**. Accordingly, the sample of marine water and sediment during dredging was collected on: **18.05.2016**. The samples collected during dredging were analysed and presented in this report. **The analysis data reveals that the marine water and sediment quality is well within the standards prescribed by Ministry of Environment and Forest (MoEF).**

Grateful thanks are due to **Dr. P.K.Sethi, Joint General Manager (HSE)** and all other supporting staff of **Dredging Corporation of India Ltd (DCI)** for the opportunity provided to be associated in this endeavor.

Place: Chennai  
Date: 16.06.2016

**(E.BALAKRISHNAIAH)**  
Unit In-charge

## METHODOLOGY

### SAMPLING METHODOLOGY:

#### Marine Water

Marine Water samples were collected using a bottom sampler. On-site test such as pH, salinity, Temp., EC, Turbidity etc. were carried out immediately after the sample collection. The samples intended for chemical, heavy metal and bacteriological analyses are preserved with necessary reagents and analysed in the laboratory. The plankton samples were collected using plankton net of diameter of 0.35 m, No.25 mesh size 63  $\mu$ . The plankton net was towed for 15 minute at the sampling locations for collection of samples for estimation of Phytoplankton and Zooplankton.

#### The Parameter covered are:-

**Physical Properties:** pH, EC, Colour, Odour, Salinity, Temperature, Turbidity, TSS

**Chemical Properties:** DO, COD, BOD, Oil & Grease, Nutrients, Sulphates, Chlorides

**Heavy Metals:** Fe, Zn, Mg, Cd, Cr, Hg

**Marine Biology:** primary productivity, Chlorophyll and Phytoplankton & Zooplankton

#### Sediment

Marine sediment samples were collected using a Peterson's Grab Sampler. The collected sediment samples were segregated on the site for analysis of physico-chemical parameters, heavy metals and benthic communities. The sediment sample for benthic communities subject to sieving for recording the macro benthos and then the samples and preserved with Rose Bengal and Formalin Solution for further analysis of Benthic communities

#### The Parameter covered are:

**Physico-chemical Properties:** Texture, pH, Organic Matter, Nutrients, Oil and Grease.

**Heavy Metals** : Fe, Mn, Cd, Ni, Cr, Hg, Zn and Pb

**Benthic Communities** : Macro & Meio Benthic Flora and Fauna

**METHODOLOGY PROTOCOL FOR MARINE WATER ANALYSIS**

S.No.	Parameters	Methodology Protocol
<b>Physical properties</b>		
1	pH	IS 3025 Part 11 (Reaff. 2006)
2	Colour	IS 3025 Part 4 (Reaff. 2006)
3	Odour	IS 3025 Part 5 (Reaff. 2006)
4	Electrical Conductivity	IS 3025 Part 14 (Reaff. 2006)
5	Temperature	IS 3025 Part 9 (Reaff. 2006)
6	Salinity	APHA 22ndEdn. 2520
7	Turbidity	IS 3025 Part 10 (Reaff. 2006)
8	Total Suspended Solids	IS 3025 Part 17 (Reaff.2006)
<b>Chemical properties</b>		
9	Dissolved Oxygen	IS 3025 Part 38 (Reaff. 2009)
10	COD	APHA 22st Edn. 5220 B
11	BOD-3 Days, 27°C	APHA 22st Edn. 5210 B
12	Oil & Grease	IS 3025 Part 39 (Reaff. 2009)
13	Chlorides (as Cl)	IS 3025 Part 32 (Reaff. 2009)
14	Fluorides (as F)	IS 3025 Part 60 (Reaff: 2008)
15	Sulphates (as SO <sub>4</sub> )	IS 3025 Part 24 (Reaff. 2009)
16	Total Nitrogen (as N)	IS 3025 Part 34 (Reaff. 2009)
17	Nitrate Nitrogen (as NO <sub>3</sub> -N)	IS 3025 Part 34 (Reaff. 2009)
18	Total Phosphate (as PO <sub>4</sub> -P)	IS 3025 Part 31 (Reaff. 2009)
<b>Heavy metals</b>		
19	Iron	APHA 22ndEdn. 3500-Fe
20	Zinc	APHA 22ndEdn. 3500-Zn
21	Magnesium	APHA 22nd Edn. 3500-Mg
22	Cadmium	APHA 22ndEdn. 3500-Cd
23	Chromium	APHA 22ndEdn. 3500-Cr
24	Mercury	APHA 22ndEdn. 3500-Hg
<b>Biological parameters</b>		
25	Phyto& Zoo Planktons and Pigments	APHA 22ndEdn. 10200

**METHODOLOGY PROTOCOL FOR SEDIMENT QUALITY ANALYSIS**

<b>S.No.</b>	<b>Parameters</b>	<b>Methodology Protocol</b>
<b>Physical properties</b>		
1	pH	IS 3025 Part 11 (Reaff. 2006)
2	Organic matters	IS 2720 Part 22 (Reaff.1995)
3	Nutrients	IS 10158 -1982
4	Oil & Grease	IS 3025 Part 39 (Reaff. 2009)
<b>Heavy metals</b>		
5	Iron	EPA 7380
6	Manganese	EPA 7460
7	Cadmium	EPA 7130
8	Nickel	EPA 7520
9	Chromium	EPA 7090
10	Mercury	EPA 7471 B
11	Zinc	EPA 7950
12	Lead	EPA 7420
<b>Benthic Communities</b>		
13	Macro benthos	<b>APHA 22ndEdn. 10500</b>
14	Meio benthos	<b>APHA 22ndEdn. 10700</b>

## **Monitoring and Testing of Marine water & Sediment samples for Capital Dredging inside the Mormugao Port, Goa.**

### **Summary Report**

Marine water and sediment samples were collected in seven stations at Mormugao Port, as per the locations identified by the DCI. The survey made on **18.05.2016** for dredging phase.

Physico-chemical parameters such as Temperature, Colour, Odour, Salinity, pH, Dissolved oxygen, COD, BOD, Turbidity, Total Suspended Solids, Chlorides, Sulphates, nutrients and Heavy metals were estimated by standard methods. Biological variables have also been studied and this includes Phytoplankton, Zooplankton and its Biomass. Sediment samples were collected and analyzed the pH, Total Organic Carbon, Total Phosphorus, Total Nitrogen, Soil Texture, Heavy metals and Macro and Meio benthos.

The observations made during this period revealed the following information which has been grouped in terms of three variables such as physical, chemical and biological. The sea surface temperature varied between 27.0°C to 30.0°C and there was no significant variation in temperature with the distance from the shore. The salinity ranged from 31.16 to 32.56‰. The pH of the seawater samples observed from 8.15 to 8.31. The measured turbidity varied between 10 to 22 NTU. The TSS value varied from 13 to 29 mg. The concentration of cadmium in water was found to be <0.001mg/l. The chromium values was found to be <0.001mg/l, Ferrous from 0.58 to 0.78 mg/l, Magnesium from 1594 to 1795 mg/l and Zinc from 0.39 to 0.52 mg/l. The concentration of mercury shows the BDL (<0.001mg/l) level. The population density of Phytoplankton varied from 4380 to 6390 Cell/L. The higher phytoplankton density was recorded at station **SPOIL GROUND -I**, The species such as, *Coscinodiscus ecentricus*, *Coscinodiscus centralis*, *Chaetocerosaffinis*, *Pleurosigmanormanii*, *Cerataulinaorientalis* and *Thalassionemanitzschoides* were

found to be common in all stations monitored. The numerical abundance of zooplankton varied from 3670 to 5960 Organisms/m<sup>3</sup>. The higher zooplankton density was recorded at station SPOIL GROUND -I. Zooplankton consists of *Paracalanusparvus*, *Oithonasimilis*, *Corycaeusdanae*, *Favellaphilipiensis*, *Copepod nauplii* and *Sagitta spwre* found to be dominant species commonly distributed in all the stations monitored.

The concentrations of Ferrous in sediments were ranging from 4892 to 5762 µg/g. Manganese from 38.94 to 49.62 µg/g. Cadmium in sediments ranged between 0.49 to 0.83 µg/g. Nickel from 1.84 to 2.79 µg/g. The chromium varied from 14.68 to 18.92µg/g. The concentration of mercury varied from 0.18 to 0.37µg/g. The concentrations of Zinc varied from 20.55 to 24.67µg/g and the Lead from 12.69 to 17.06µg/g. The numerical abundance of the macro benthic fauna varied from 1780 to 2860 No/square meter and the Meiobenthic varied between 190 to 298 No/10cm<sup>2</sup>

### **Concluding Remarks**

As per the Env. Monitoring made during **dredging phase (18.05.2016)** suggests the following conclusion

- The marine water quality at 7 locations were found to be well within the primary water quality criteria for class SW - IV waters (Harbour water)
- The sediment quality at 7 locations were found to be well within the hazardous waste management rules 2003 (schedule 2)





**POSITIONS OF PRE DETERMINED LOCATIONS FOR SEA WATER / SEDIMENT SAMPLE  
AT MORMUGAO PORT, GOA**

Sample Collected on: **18.05.2016**

Sl. No:	Nomenclature	in UTM		in Geo-graphic	
		NORTHINGS	EASTINGS	Lat (N)	Long (E)
<b>DUMPING AREA</b>					
1	<b>SPOIL GROUND -II</b>	1707770	356028	15° 26' 34".68	73° 39' 29".23
2	<b>SPOIL GROUND -I</b>	1707776	358665	15° 26' 35".40	73° 40' 57".70
<b>DREDGING AREA</b>					
3	<b>A0</b>	1703826	363248	15° 24' 27".77	73° 43' 32".23
4	<b>A1</b>	1704150	365424	15° 24' 38".73	73° 44' 45".16
5	<b>A2</b>	1704443	367017	15° 24' 48".56	73° 45' 38".54
6	<b>A3</b>	1704749	368846	15° 24' 58".86	73° 46' 39".82
7	<b>Between A4 &amp; A5</b>	1705021	370622	15° 25' 08.04	73° 47' 39".35

# **Marine Water Quality data**

**PHYSICAL PROPERTIES**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **18.05.2016**

Sl. No.	Sample description	pH	Colour (Hazen unit)	Odour	EC (micro mhos/cm)	W.T (°C)	Salinity (ppt)	Turbidity (NTU)	TSS (mg/l)
<b>DUMPING AREA</b>									
1	<b>SPOIL GROUND -II</b>	8.18	8	Odourless	51400	27.5	31.26	10	13
2	<b>SPOIL GROUND -I</b>	8.15	10	Odourless	51100	27.0	31.16	12	14
<b>DREDGING AREA</b>									
3	<b>A0</b>	8.19	11	Odourless	51900	28.5	32.52	13	16
4	<b>A1</b>	8.30	12	Odourless	51800	29.0	32.24	15	18
5	<b>A2</b>	8.21	16	Odourless	52800	29.5	32.18	19	27
6	<b>A3</b>	8.31	18	Odourless	53600	30.0	32.56	22	29
7	<b>Between A4 &amp; A5</b>	8.19	15	Odourless	53100	30.0	31.92	15	20

**CHEMICAL PROPERTIES–WATER**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **18.05.2016**

Sl. No.	Sample description	DO (mg/l)	COD (mg/l)	BOD (mg/l)	Oil & Grease (mg/l)	Chloride (mg/l)	Sulphate (mg/l)
1.	<b>SPOIL GROUND –II</b>	5.3	75	1	<1	18952	3162
2.	<b>SPOIL GROUND –I</b>	5.4	76	2	<1	18826	3205
3.	<b>A0</b>	5.1	78	1	<1	18924	3285
4.	<b>A1</b>	5.0	78	2	<1	19142	3269
5.	<b>A2</b>	5.4	82	2	<1	19586	3429
6.	<b>A3</b>	5.5	85	2	<1	19654	3492
7.	<b>Between A4 &amp; A5</b>	5.2	79	1	<1	19264	3342

**NUTRIENTS – WATER**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **18.05.2016**

S. No.	Station Code	Parameters (mg/l)			
		Amm.Nitrogen	Total Nitrogen	Total Phosphate	SiO <sub>2</sub>
1.	<b>SPOIL GROUND -II</b>	1.4	2.9	1.2	19.5
2.	<b>SPOIL GROUND -I</b>	1.5	2.8	1.3	19.9
3.	<b>A0</b>	1.5	3.1	1.3	20.4
4.	<b>A1</b>	1.4	3.1	1.2	19.8
5.	<b>A2</b>	1.7	3.5	1.3	20.6
6.	<b>A3</b>	1.9	3.8	1.5	21.9
7.	<b>Between A4 &amp; A5</b>	1.5	3.2	1.2	20.4

**HEAVY METALS – WATER**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **18.05.2016**

Sl. No.	Station Code	Parameter (mg/l)					
		Fe	Zn	Mg	Cd	Cr	Hg
1.	<b>SPOIL GROUND –II</b>	0.58	0.39	1594	<0.001	<0.001	<0.001
2.	<b>SPOIL GROUND –I</b>	0.65	0.46	1692	<0.001	<0.001	<0.001
3.	<b>A0</b>	0.56	0.43	1682	<0.001	<0.001	<0.001
4.	<b>A1</b>	0.62	0.45	1659	<0.001	<0.001	<0.001
5.	<b>A2</b>	0.71	0.50	1712	<0.001	<0.001	<0.001
6.	<b>A3</b>	0.78	0.52	1795	<0.001	<0.001	<0.001
7.	<b>Between A4 &amp; A5</b>	0.68	0.49	1692	<0.001	<0.001	<0.001

**BIOLOGICAL CHARACTERISTICS**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **18.05.2016**

S. No.	Station Code	Chl a (mg/m <sup>3</sup> )	Phaeopigment (mg/m <sup>3</sup> )	Net Primary Productivity (mg C/ m <sup>3</sup> /d)
1	<b>SPOIL GROUND -II</b>	2.64	0.65	0.24
2	<b>SPOIL GROUND -I</b>	2.95	0.76	0.25
3	<b>A0</b>	2.76	0.66	0.24
4	<b>A1</b>	2.94	0.69	0.22
5	<b>A2</b>	3.25	0.76	0.25
6	<b>A3</b>	3.31	0.86	0.27
7	<b>Between A4 &amp; A5</b>	3.05	0.72	0.23

**PHYTOPLANKTON**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **18.05.2016**

Sl. No	Species (Cells/l)	Location ID			
		SPOIL GROUND -II	SPOIL GROUND -I	A0	A1
	<b>Bacillariophyceae</b>				
1.	<i>Bacteriastrumcomosum</i>	220	220	250	170
2.	<i>Cerataulinaorientalis</i>	240	270	230	220
3.	<i>Chaetocerosaffinis</i>	230	220	250	190
4.	<i>Chaetocerosindicus</i>	240	210	220	*
5.	<i>Coscinodiscus centralis</i>	210	220	210	240
6.	<i>Coscinodiscus ecentricus</i>	220	210	240	250
7.	<i>Coscinodiscus granii</i>	250	220	230	250
8.	<i>Coscinodiscus gigas</i>	250	210	250	370
9.	<i>Ditylumbrightwelli</i>	350	240	230	290
10.	<i>Gyrosigmabalticum</i>	280	250	220	280
11.	<i>Leptocylindrusdanicus</i>	240	250	240	*
12.	<i>Lithodesmiumundulatum</i>	220	240	290	290
13.	<i>Odontellamobiliensis</i>	360	250	250	310
14.	<i>Pleurosigmanormanii</i>	270	260	210	250
15.	<i>Skeletonemacostatum</i>	250	240	200	310
16.	<i>Stephanophysispalmeriana</i>	290	310	240	*
17.	<i>Thalassionemanitzschioides</i>	310	260	310	350
18.	<i>Thalassiothrixfrauenfeldii</i>	210	250	210	250
19.	<i>Triceratiumfavus</i>	200	220	200	*
20.	<i>Triceratiumreticulatum</i>	160	230	160	220
	<b>Cyanophyceae</b>				
21.	<i>Anabeananastoc</i>	110	120	130	*
22.	<i>Microcystissp.</i>	240	*	250	310
23.	<i>Tricodesmiumerythraeum</i>	210	320	140	240
24.	<i>Rhizosoleniastyliformis</i>	290	280	150	280
	<b>Dinoflagellates</b>				
25.	<i>Ceratiumfurca</i>	180	250	220	240
26.	<i>Ceratiummacroceros</i>	150	240	220	240
27.	<i>Ceratiumtripos</i>	210	250	210	250
<b>Total</b>		<b>6390</b>	<b>6240</b>	<b>5960</b>	<b>5800</b>

\* - Organisms not present



**PHYTOPLANKTON**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **18.05.2016**

Sl. No	Species (Cells/l)	A2	A3	Between A4 & A5
	<b>Bacillariophyceae</b>			
1.	<i>Bacteriastrumcomosum</i>	190	110	200
2.	<i>Cerataulinaorientalis</i>	220	140	190
3.	<i>Chaetocerosaffinis</i>	150	150	170
4.	<i>Chaetocerosindicus</i>	210	110	220
5.	<i>Coscinodiscus centralis</i>	190	140	240
6.	<i>Coscinodiscus ecentricus</i>	*	*	260
7.	<i>Coscinodiscus granii</i>	110	*	220
8.	<i>Coscinodiscus gigas</i>	210	110	210
9.	<i>Ditylumbrightwelli</i>	220	240	*
10.	<i>Gyrosigmabalticum</i>	220	230	250
11.	<i>Leptocylindrusdanicus</i>	150	*	350
12.	<i>Lithodesmiumundulatum</i>	250	250	260
13.	<i>Odontellamobiliensis</i>	190	290	*
14.	<i>Pleurosigmanomanii</i>	220	260	340
15.	<i>Skeletonemacostatum</i>	250	*	320
16.	<i>Stephanophysispalmeriana</i>	190	310	310
17.	<i>Thalassionemanitzschioides</i>	150	230	*
18.	<i>Thalassiothrixfrauenfeldii</i>	110	*	210
19.	<i>Triceratiumfavus</i>	*	140	250
20.	<i>Triceratiumreticulatum</i>	100	170	*
	<b>Cyanophyceae</b>			
21.	<i>Anabeananastoc</i>	130	100	240
22.	<i>Microcystissp.</i>	150	110	110
23.	<i>Tricodesmiumerythraeum</i>	140	170	130
24.	<i>Rhizosoleniaalata</i>	260	180	220
25.	<i>Rhizosoleniastyliformis</i>	140	110	250
	<b>Dinoflagellates</b>			
26.	<i>Ceratiumfurca</i>	210	260	*
27.	<i>Ceratiummacroceros</i>	150	220	100
28.	<i>Ceratiumtripos</i>	160	110	240
29.	<i>Protooperidiniumoceanicum</i>	170	240	220
	<b>Total</b>	<b>4840</b>	<b>4380</b>	<b>5510</b>

\* - Organisms not present

**ZOOPLANKTON**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **18.05.2016**

Sl. No	Species (Organisms/m <sup>3</sup> )	Location ID			
		SPOIL GROUND -II	SPOIL GROUND -I	A0	A1
	<b>Copepoda</b>				
1	<i>Acartiaspinicauda</i>	210	260	250	220
2	<i>Acartiaerythrea</i>	150	290	180	210
3	<i>Acrocalanusgipper</i>	220	250	220	190
4	<i>Acrocalanusgracilis</i>	250	210	150	250
5	<i>Centropagesfurcatus</i>	250	250	270	210
6	<i>Nannocalanus minor</i>	220	250	*	240
7	<i>Paracalanusparvus</i>	260	310	210	220
8	<i>Pontelladanae</i>	220	220	220	210
9	<i>Temoraturbinata</i>	220	*	210	260
10	<i>Oithonabrevicornis</i>	320	*	250	250
11	<i>Oithonarigida</i>	210	340	310	250
12	<i>Oithonasimilis</i>	210	290	*	*
13	<i>Corycaeusdanae</i>	180	250	220	220
14	<i>Copilia mirabilis</i>	220	210	260	280
	<b>Spirotricha</b>				
15	<i>Favella brevis</i>	180	260	250	240
16	<i>Favellaphilipiensis</i>	220	260	220	290
17	<i>Tintinnopsistubulosa</i>	190	*	290	210
18	<i>Tintinnopsistocantinensis</i>	320	310	310	*
19	<i>Tintinnopsiscylinderica</i>	160	250	250	210
	<b>Others</b>				
20	<i>Lucifer hansperi</i>	240	110	190	200
21	<i>Sagitta sp</i>	220	250	160	250
22	<i>Oikopleuradioica</i>	300	*	240	140
23	<i>Oikopleuraparva</i>	180	210	210	160
	<b>Larval Forms</b>				
24	<i>Bivalve Veliger</i>	210	260	110	210
25	<i>Barnaclenauplii</i>	220	250	210	*
26	<i>Copepod nauplii</i>	180	230	200	220
27	<i>Crustacean nauplii</i>	200	220	250	200
	<b>Total</b>	<b>5960</b>	<b>5740</b>	<b>5640</b>	<b>5340</b>

\* - Organisms not present

**ZOOPLANKTON**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **18.05.2016**

Sl. No	Species (Organisms/m <sup>3</sup> )	Location ID		
		A2	A3	Between A4 & A5
	<b>Copepoda</b>			
1	<i>Acartiaspinicauda</i>	180	110	150
2	<i>Acartiaerythrea</i>	*	210	150
3	<i>Acrocalanusgipper</i>	210	150	*
4	<i>Acrocalanusgracilis</i>	180	220	250
5	<i>Centropagesfurcatus</i>	220	150	210
6	<i>Nannocalanus minor</i>	*	*	180
7	<i>Paracalanusparvus</i>	250	210	210
8	<i>Pontelladanae</i>	*	150	*
9	<i>Temoraturbinata</i>	210	*	150
10	<i>Oithonabrevicornis</i>	*	110	240
11	<i>Oithonarigida</i>	220	*	150
12	<i>Oithonasimilis</i>	240	210	240
13	<i>Corycaeusdanae</i>	210	150	250
14	<i>Copilia mirabilis</i>	260	*	190
	<b>Spirotricha</b>			
15	<i>Favella brevis</i>	*	210	*
16	<i>Favellaphilipiensis</i>	260	190	210
17	<i>Tintinnopsistubulosa</i>	230	210	240
18	<i>Tintinnopsistocantinensis</i>	*	190	150
19	<i>Tintinnopsiscylindrica</i>	250	150	180
	<b>Others</b>			
20	<i>Lucifer hansperi</i>	260	150	210
21	<i>Sagitta sp</i>	220	190	190
22	<i>Oikopleuradioica</i>	150	*	280
23	<i>Oikopleuraparva</i>	*	240	*
	<b>Larval Forms</b>			
24	<i>Bivalve Veliger</i>	210	180	220
25	<i>Barnaclenauplii</i>	190	*	*
26	<i>Copepod nauplii</i>	220	150	220
27	<i>Crustacean nauplii</i>	*	140	210
	<b>Total</b>	<b>4170</b>	<b>3670</b>	<b>4480</b>

\* - Organisms not present

# **SEDIMENT**

# **Quality data**

**pH, NUTRIENTS & TOTAL ORGANIC CARBON, OIL & GREASE – SEDIMENT**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **18.05.2016**

S. No.	Station Code	pH	Total Nitrogen (µg/g)	Total Phosphorus (µg/g)	Total Organic Carbon (mg/g)	O & G (µg/g)
1.	<b>SPOIL GROUND -II</b>	8.4	12.69	8.67	3.76	0.683
2.	<b>SPOIL GROUND -I</b>	8.5	12.94	8.98	3.92	0.697
3.	<b>A0</b>	8.6	12.68	8.05	4.32	0.592
4.	<b>A1</b>	8.3	12.62	8.27	3.68	0.675
5.	<b>A2</b>	8.5	14.23	9.04	4.35	0.753
6.	<b>A3</b>	8.5	14.92	9.21	4.95	0.812
7.	<b>Between A4 &amp; A5</b>	8.4	13.26	8.59	3.98	0.713

## TEXTURE- SEDIMENT

Sample Collected at: **MORMUGAO PORT, GOA**

Sample Collected on: **18.05.2016**

S. No.	Station Code	Grain Size Distribution (%)		
		Sand	Silt	Clay
1.	<b>SPOIL GROUND -II</b>	3.3	19.6	77.1
2.	<b>SPOIL GROUND -I</b>	3.1	18.7	78.2
3.	<b>A0</b>	8.3	20.3	71.4
4.	<b>A1</b>	8.8	20.2	71.0
5.	<b>A2</b>	8.6	21.0	80.4
6.	<b>A3</b>	9.1	21.8	69.1
7.	<b>Between A4 &amp; A5</b>	9.1	21.6	69.3

### HEAVY METALS – SEDIMENT

Sample Collected at: **MORMUGAO PORT, GOA**

Sample Collected on: **18.05.2016**

Sl. No.	Station Code	$\mu\text{g/g}$							
		Fe	Mn	Cd	Ni	Cr	Hg	Zn	Pb
1.	<b>SPOIL GROUND –II</b>	4892	38.94	0.49	1.84	14.68	0.18	20.55	12.69
2.	<b>SPOIL GROUND –I</b>	5139	45.62	0.67	2.68	16.28	0.21	20.68	14.92
3.	<b>A0</b>	5023	43.26	0.58	1.92	16.45	0.19	21.62	13.29
4.	<b>A1</b>	4925	42.25	0.55	2.00	16.58	0.22	21.62	14.23
5.	<b>A2</b>	5682	48.57	0.79	2.56	18.07	0.31	23.68	16.82
6.	<b>A3</b>	5762	49.62	0.83	2.79	18.92	0.37	24.67	17.06
7.	<b>Between A4 &amp; A5</b>	5236	45.28	0.65	2.08	17.64	0.28	22.54	15.28

## MACROBENTHOS DISTRIBUTION IN THE SEDIMENT

Sample Collected at: **MORMUGAO PORT, GOA**

Sample Collected on: **18.05.2016**

Sl. No	Species (No/m <sup>2</sup> )	Location ID			
		SPOIL GROUND -II	SPOIL GROUND -I	A0	A1
	<b>Polychaetes</b>				
1	<i>Armandialongicaudata</i>	150	150	150	110
2	<i>Capitellacapitata</i>	220	170	220	90
3	<i>Cirriformiasp</i>	210	180	110	110
4	<i>Goniada emerita</i>	110	120	*	*
5	<i>Nephtysdibranchis</i>	*	*	150	120
6	<i>Nereis sp.</i>	180	160	180	170
7	<i>Notomastusaberans</i>	*	220	120	130
8	<i>Perinereiscapensis</i>	*	210	160	*
9	<i>Platynereiscalodonta</i>	220	220	210	210
10	<i>Prionospiocirrifera</i>	200	110	120	*
11	<i>Prionospiopinnata</i>	*	140	120	110
	<b>Bivalves</b>				
12	<i>Donaxveligers</i>	160	100	110	*
13	<i>Meretrixveligers</i>	120	*	140	110
	<b>Gastropods</b>		*		
14	<i>Littorinaveligers</i>	150	*	120	160
15	<i>Naticaveligers</i>	180	110	*	120
16	<i>Nassariusvariegatus</i>	160	160	150	150
17	<i>Turrisveligers</i>	140	180	*	140
	<b>Crustaceans</b>				
18	<i>Ampithoeromondi</i>	120	110	90	120
19	<i>Angelieraphreaticola</i>	220	100	110	120
20	<i>Gynodiastylis sp.</i>	110	110	*	110
21	<i>Paragnathiaformica</i>	210	100	110	110
	<b>Total</b>	<b>2860</b>	<b>2650</b>	<b>2370</b>	<b>2190</b>

\* - Organisms not present



## MACROBENTHOS DISTRIBUTION IN THE SEDIMENT

Sample Collected at: **MORMUGAO PORT, GOA**

Sample Collected on: **18.05.2016**

Sl. No	Species (No/m <sup>2</sup> )	Location ID		
		A2	A3	A4 & A5
	<b>Polychaetes</b>			
1	<i>Armandialongicaudata</i>	150	90	90
2	<i>Capitellacapitata</i>	120	80	120
3	<i>Cirriformiasp</i>	150	*	110
4	<i>Goniada emerita</i>	*	110	110
5	<i>Nephtysdibranchis</i>	140	90	90
6	<i>Nereis sp.</i>	160	110	120
7	<i>Notomastusaberans</i>	150	90	*
8	<i>Perinereiscapensis</i>	*	100	110
9	<i>Platynereiscalodonta</i>	120	110	150
10	<i>Prionospiocirrifera</i>	90	90	90
11	<i>Prionospiopinnata</i>	80	110	110
	<b>Bivalves</b>			
12	<i>Donaxveligers</i>	*	90	100
13	<i>Meretrixveligers</i>	120	100	150
	<b>Gastropods</b>			
14	<i>Littorinaveligers</i>	*	100	90
15	<i>Naticaveligers</i>	110	110	110
16	<i>Nassariusvariegatus</i>	90	*	*
17	<i>Turrisveligers</i>	110	*	120
	<b>Crustaceans</b>			
18	<i>Ampithoeromondi</i>	110	90	80
19	<i>Angelieraphreaticola</i>	120	100	110
20	<i>Gynodiastylis sp.</i>	*	110	120
21	<i>Paragnathiaformica</i>	120	100	110
	<b>Total</b>	<b>1940</b>	<b>1780</b>	<b>2090</b>

\* - Organisms not found

**MEIOBENTHOS distribution in the sediment**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **18.05.2016**

Sl. No	Species (No/10cm <sup>2</sup> )	Location ID			
		SPOIL GROUND -II	SPOIL GROUND - I	A0	A1
	<b>Foraminiferans</b>				
1	<i>Ammonia beccarii</i>	18	16	12	12
2	<i>Bolivinasp.</i>	21	19	15	10
3	<i>Cibicidesrefulgens</i>	19	15	10	*
4	<i>Globorotaliahiruste</i>	18	*	11	15
5	<i>Loxostomumsp.</i>	20	10	9	15
6	<i>Miliamminasp.</i>	19	18	18	17
7	<i>Milionellasp.</i>	10	16	16	16
8	<i>Nonionsp</i>	19	18	13	12
	<b>Nematodes</b>				
9	<i>Daptonemaconicum</i>	*	15	15	12
10	<i>Draconemasp.</i>	16	*	12	10
11	<i>Greeffiellasp.</i>	*	12	10	12
12	<i>Microlaimussp.</i>	18	10	12	14
13	<i>Neochromodorasp.</i>	16	13	12	10
14	<i>Spiriniasp.</i>	19	17	*	14
15	<i>Synonchussp.</i>	*	12	10	10
16	<i>Theristussp.</i>	22	15	16	11
17	<i>Viscosiasp.</i>	15	18	15	14
	<b>Ostrocodes</b>				
18	<i>Cypridiessp.</i>	15	10	12	*
19	<i>Cytheromorphasp.</i>	*	12	12	10
20	<i>Neocytheideissp.</i>	15	15	*	12
21	<i>Tanellaindica</i>	*	15	15	10
22	<i>Tanellakingmaii</i>	18	*	12	10
	<b>Total</b>	<b>298</b>	<b>276</b>	<b>257</b>	<b>246</b>

\* - Organisms not present

**MEIOBENTHOS distribution in the sediment**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **18.05.2016**

Sl. No	Species (No/10cm <sup>2</sup> )	Location ID		
		A2	A3	A4 & A5
	<b>Foraminiferans</b>			
1	<i>Ammonia beccarii</i>	10	7	10
2	<i>Bolivinasp.</i>	9	9	10
3	<i>Cibicidesrefulgens</i>	*	10	11
4	<i>Globorotaliahiruste</i>	10	*	12
5	<i>Loxostomumsp.</i>	10	*	9
6	<i>Miliamminasp.</i>	9	9	10
7	<i>Milionellasp.</i>	*	10	11
8	<i>Nonionsp</i>	12	10	10
	<b>Nematodes</b>			
9	<i>Daptonemaconicum</i>	10	9	11
10	<i>Draconemasp.</i>	10	10	14
11	<i>Greeffiellasp.</i>	12	12	12
12	<i>Microlaimussp.</i>	14	10	*
13	<i>Neochromodorasp.</i>	17	9	12
14	<i>Spiriniasp.</i>	5	*	10
15	<i>Synonchussp.</i>	9	*	11
16	<i>Theristussp.</i>	18	16	11
17	<i>Viscosiasp.</i>	12	12	10
	<b>Ostrocodes</b>			
18	<i>Cypridiessp.</i>	10	*	9
19	<i>Cytheromorphasp.</i>	*	14	10
20	<i>Neocytheideissp.</i>	14	16	10
21	<i>Tanellaindica</i>	*	12	13
22	<i>Tanellakingmaii</i>	10	15	*
	<b>Total</b>	<b>201</b>	<b>190</b>	<b>216</b>

\* - Organisms not present

# Standards

1. Marine water
2. Hazardous waste Management and Handling Rules 2003 – List of waste and Concentration Limits

## Marine Water Quality Standards

### Primary Water Quality Criteria for Class SW-IV Waters (For Harbour Waters)

S.No.	Parameter	Standards	Rationale/Remarks
1.	pH range	6.5-9.0	To minimize corrosive and scaling effect. .
2.	Dissolved Oxygen	3.0 mg/l or 40 percent saturation value, whichever is higher.	Considering bio-degradation of oil and inhibition to is oxygen production through photosynthesis.
3.	Colour and Odour	No noticeable colour or offensive odour.	None from reactive chemicals which may corrode paints/metallic surfaces.
4.	Floating Matters Oil, grease and scum (including Petroleum products)	10 mg/l	Floating matter should be free from excessive living organisms, which may clog or coat operative parts of marine vessels/equipment.
5.	Fecal Coliform	500/100 ml (PAN)	Not exceeding 1000/100 ml in 20 percent of samples in the year and in 3 consecutive samples in monsoon months.
6.	Biochemical Oxygen Demand (3 days at 27°C)	5 mg/l	To maintain water relatively free from pollution caused by sewage and other decomposable wastes
7.	Biochemical Oxygen Demand (BOD) (3 days at 27°C)	3 mg/l	Restricted for bathing (aesthetic quality of water). Also prescribed by IS:2296 1974.

Source : EPA, 1986  
[GSR 7, dated Dec. 22, 1998]

### Hazardous waste Management and Handling Rules 2003

Richardson & Cruddas (1972) Ltd., Chennai.

**SCHEDULE - 2**  
**[See rule 3(i) (b)]**  
**LIST OF WASTE SUBSTANCES WITH CONCENTRATION LIMITS**

**Classes**

**Class A**

**Concentration limit: 50 mg/kg**

- A1 Antimony and antimony compounds
- A2 Arsenic and arsenic compounds
- A3 beryllium and cadmium compounds
- A4 Cadmium and beryllium compounds
- A5 Chromium (VI) compounds
- A6 Mercury and mercury compounds
- A7 Selenium and selenium compounds
- A8 Tellurium and tellurium compounds
- A9 Thallium and thallium compounds
- A10 Inorganic cyanide compounds (cyanides)
- A11 Metal carbonyls
- A12 Napthalene
- A13 Anthracene
- A14 Phenanthrene
- A15 Chrysene, benzo(a) anthracene, fluoranthene, benzo(a) pyrene, benzo(K)fluoranthene, indeno(1, 2, 3-ed) pyrene and benzo(ghi)perylene
- A16 Halogenated fused aromatic rings, e.g. polychlorobiphenyls plus derivatives
- A17 Halogenated aromatic compounds
- A18 Benzene
- A19 Dieldrin, aldrin, and endrin
- A20 Organotin compounds

**Class B**

**Concentration limit: 5,000 mg/kg**

- B1 Chromium (III) compounds
- B2 Cobalt compounds
- B3 Copper compounds
- B4 Lead and lead compounds
- B5 Molybdenum compounds
- B6 Nickel compounds
- B7 Tin compounds
- B8 Vanadium compounds
- B9 Tungsten compounds
- B10 Silver compounds
- B11 Organic halogen compounds
- B12 Organic phosphorus compounds
- B13 Organic peroxides

- B14 Organic nitro-and nitroso-compounds
- B15 Organic azo-and azo-oxy compounds
- B16 Nitriles
- B17 Amines
- B18 (Iso-and thio-) cyanates
- B19 Phenol and phenolic compounds
- B20 Mercaptans
- B21 Asbestos
- B22 Drilling, cutting, grinding and rolling oil or emulsions thereof
- B23 Halogen-silanes
- B24 Hydrazine(s)
- B25 Fluorine
- B26 Chlorine
- B27 Bromine
- B28 White phosphorus
- B29 Ferro-silicon and alloys
- B30 Manganese-silicon
- B31 Halogen-containing substances which produce acidic vapours on contact with damp air or water, e.g. silicon tetrachloride, aluminum chloride, titanium tetrachloride

### **Class C**

#### **Concentration limit: 20,000 mg/kg**

- C1 Ammonia and ammonium compounds
- C2 Inorganic peroxides
- C3 Barium compounds, except barium sulphate
- C4 Fluorine compounds
- C5 Phosphorus compounds, except the phosphates of aluminum, calcium and iron
- C6 Bromates, (hypo)bromites
- C7 Chlorates, (hypo)chlorites
- C8 Aromatic compounds
- C9 Organic silicon compounds
- C10 Organic sulphur compounds
- C11 Iodates
- C12 Nitrates, nitrites
- C13 Sulphides
- C14 Zinc compounds
- C15 Salts of per-acids
- C16 Acid halides, acid amides
- C17 Acid anhydrides

## **Class D**

### **Concentration limit: 50,000 mg/kg**

D1 Sulphur

D2 Inorganic acids

D3 Metal bisulphates

D4 Oxides and hydroxides except those of: hydrogen, carbon, silicon, iron, aluminum, titanium, manganese, magnesium, calcium

D5 Aliphatic and naphthenic hydrocarbons

D6 Organic oxygen compounds

D7 Organic nitrogen compounds

D8 Nitrides

D9 Hydrides

## **Class E**

### **Regardless of concentration limit**

E.1 Highly flammable substances

E.2 Substances which generate dangerous quantities of highly flammable gases on contact with water or damp air.

\* All on dry weight basis