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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: **14.03.2016**. 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: 29.03.2016

**(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 22nd Edn. 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 22nd Edn. 3500-Fe
20	Zinc	APHA 22nd Edn. 3500-Zn
21	Magnesium	APHA 22nd Edn. 3500-Mg
22	Cadmium	APHA 22nd Edn. 3500-Cd
23	Chromium	APHA 22nd Edn. 3500-Cr
24	Mercury	APHA 22nd Edn. 3500-Hg
<b>Biological parameters</b>		
25	Phyto & Zoo Planktons and Pigments	APHA 22nd Edn. 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 22nd Edn. 10500</b>
14	Meio benthos	<b>APHA 22nd Edn. 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 14 th March 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 25.0°C to 29.0°C and there was no significant variation in temperature with the distance from the shore. The salinity ranged from 32.84 to 33.52‰. The pH of the seawater samples observed from 8.18 to 8.31. The measured turbidity varied between 10 to 18 NTU. The TSS value varied from 14 to 28mg. 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 0.42 to 0.58 mg/l, Magnesium from 1534 to 1682 mg/l and Zinc from 0.31 to 0.43mg/l. The concentration of mercury shows the BDL (<0.001mg/l) level. The population density of Phytoplankton varied from 3595 to 6440 Cell/L. The higher phytoplankton density was recorded at station **A2**, The species such as,

Bacteriastrum comosum, Coscinodiscus ecentricus, Coscinodiscus centralis, Chaetoceros affinis, Pleurosigma normanii, Cerataulina orientalis and Thalassionema nitzschioides were found to be common in all stations monitored. The numerical abundance of zooplankton varied from 3800 to 5715 Organisms/m<sup>3</sup>. The higher zooplankton density was recorded at station **A0**. Zooplankton consists of Paracalanus parvus, Oithona similis, Corycaeus danae, Favella philipiensis, Copepod nauplii and Sagitta sp were found to be dominant species commonly distributed in all the stations monitored.

The concentrations of Ferrous in sediments were ranging from 3785 to 5632 µg/g. Manganese from 30.99 to 49.28 µg/g. Cadmium in sediments ranged between 0.52 to 0.86 µg/g. Nickel from 1.76 to 3.78 µg/g. The chromium varied from 11.23 to 17.93 µg/g. The concentration of mercury varied from 0.10 to 0.39 µg/g. The concentrations of Zinc varied from 15.48 to 27.68 µg/g and the Lead from 11.28 to 15.92 µg/g. The numerical abundance of the macro benthic fauna varied from 1240 to 2350 No/square meter and the Meiobenthic varied between 149 to 221 No/10cm<sup>2</sup>

### Concluding Remarks

As per the Env. Monitoring made during **dredging phase (14.03.2016)** 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: **14.03.2016**

Sl. No:	Nomenclature	in UTM		in Geo-graphic	
		NORTHINGS	EASTINGS	Lat (N)	Long (E)
<b>DUMPING AREA</b>					
1	<b>SPOIL GROUND -II</b>	1707370	358991	15° 26' 37".18	73° 39' 27".55
2	<b>SPOIL GROUND -I</b>	1707641	356563	15° 26' 36".72	73° 40' 59".07
<b>DREDGING AREA</b>					
3	<b>A0</b>	1703848	363199	15° 24' 27".48	73° 43' 32".77
4	<b>A1</b>	1704182	365534	15° 24' 38".03	73° 44' 47".54
5	<b>A2</b>	1704365	367178	15° 24' 48".40	73° 45' 37".13
6	<b>A3</b>	1704672	368638	15° 24' 58".20	73° 46' 37".92
7	<b>Between A4 &amp; A5</b>	1704998	370654	15° 25' 7".75	73° 47' 39".78

# **Marine Water Quality data**

**PHYSICAL PROPERTIES**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **14.03.2016**

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>	8.21	8	Odourless	50100	25.0	32.89	12	14
2	<b>SPOIL GROUND -I</b>	8.24	12	Odourless	51400	25.5	33.46	18	22
<b>DREDGING AREA</b>									
3	<b>A0</b>	8.18	8	Odourless	52100	27.5	33.52	10	16
4	<b>A1</b>	8.26	8	Odourless	50600	28.5	33.12	11	17
5	<b>A2</b>	8.24	14	Odourless	50400	28.5	32.96	18	24
6	<b>A3</b>	8.28	14	Odourless	51900	29.0	32.84	16	26
7	<b>Between A4 &amp; A5</b>	8.31	16	Odourless	51500	29.0	33.19	16	28

**CHEMICAL PROPERTIES –WATER**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **14.03.2016**

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>	5.2	75	2	<1	19230	2958
2.	<b>SPOIL GROUND -I</b>	5.1	72	1	<1	18925	3025
3.	<b>A0</b>	4.4	82	2	<1	19254	3269
4.	<b>A1</b>	4.6	85	2	<1	19523	3156
5.	<b>A2</b>	5.1	70	1	<1	18925	3246
6.	<b>A3</b>	4.7	75	2	<1	19845	3268
7.	<b>Between A4 &amp; A5</b>	5.3	82	2	<1	18947	3129

**NUTRIENTS – WATER**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **14.03.2016**

S. No.	Station Code	Parameters (mg/l)			
		Amm.Nitrogen	Total Nitrogen	Total Phosphate	SiO <sub>2</sub>
1.	<b>SPOIL GROUND -II</b>	1.5	3.3	1.1	21.3
2.	<b>SPOIL GROUND -I</b>	1.3	3.5	1.3	19.4
3.	<b>A0</b>	1.4	2.7	1.2	20.4
4.	<b>A1</b>	1.2	2.6	1.3	15.6
5.	<b>A2</b>	1.3	3.1	1.4	19.6
6.	<b>A3</b>	1.5	3.4	1.2	16.2
7.	<b>Between A4 &amp; A5</b>	1.2	3.1	1.4	22.0

**HEAVY METALS – WATER**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **14.03.2016**

Sl. No.	Station Code	Parameter (mg/l)					
		Fe	Zn	Mg	Cd	Cr	Hg
1.	<b>SPOIL GROUND -II</b>	0.58	0.38	1569	<0.001	<0.001	<0.001
2.	<b>SPOIL GROUND -I</b>	0.52	0.43	1583	<0.001	<0.001	<0.001
3.	<b>A0</b>	0.42	0.32	1546	<0.001	<0.001	<0.001
4.	<b>A1</b>	0.49	0.35	1592	<0.001	<0.001	<0.001
5.	<b>A2</b>	0.54	0.31	1682	<0.001	<0.001	<0.001
6.	<b>A3</b>	0.56	0.36	1604	<0.001	<0.001	<0.001
7.	<b>Between A4 &amp; A5</b>	0.54	0.33	1534	<0.001	<0.001	<0.001

**BIOLOGICAL CHARACTERISTICS**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **14.03.2016**

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>	2.35	0.52	0.27
2	<b>SPOIL GROUND -I</b>	2.08	0.80	0.22
3	<b>A0</b>	2.24	0.72	0.20
4	<b>A1</b>	2.17	0.59	0.16
5	<b>A2</b>	1.96	0.92	0.18
6	<b>A3</b>	2.06	0.66	0.20
7	<b>Between A4 &amp; A5</b>	2.98	0.46	0.21

**PHYTOPLANKTON**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **14.03.2016**

Sl. No	Species (Cells/l)	Location ID			
		SPOIL GROUND -II	SPOIL GROUND -I	A0	A1
	<b>Bacillariophyceae</b>				
1.	<i>Bacteriastrum comosum</i>	140	150	210	205
2.	<i>Cerataulina orientalis</i>	210	145	150	220
3.	<i>Chaetoceros affinis</i>	170	160	110	190
4.	<i>Chaetoceros indicus</i>	260	110	240	*
5.	<i>Coscinodiscus centralis</i>	220	160	240	180
6.	<i>Coscinodiscus ecentricus</i>	200	210	260	100
7.	<i>Coscinodiscus granii</i>	*	240	180	190
8.	<i>Coscinodiscus gigas</i>	220	120	240	110
9.	<i>Ditylum brightwelli</i>	270	230	110	*
10.	<i>Gyrosigma balticum</i>	*	*	*	200
11.	<i>Leptocylindrus danicus</i>	110	*	*	*
12.	<i>Lithodesmium undulatum</i>	100	260	240	280
13.	<i>Odontella mobiliensis</i>	160	310	*	*
14.	<i>Pleurosigma normanii</i>	200	260	260	290
15.	<i>Skeletonema costatum</i>	110	150	240	*
16.	<i>Stephanophysis palmeriana</i>	240	300	310	200
17.	<i>Thalassionema nitzschioides</i>	270	230	110	270
18.	<i>Thalassiothrix frauenfeldii</i>	260	*	*	*
19.	<i>Triceratium favus</i>	280	150	200	*
20.	<i>Triceratium reticulatum</i>	170	180	310	280
	<b>Cyanophyceae</b>				
21.	<i>Anabeana nastoc</i>	290	90	120	110
22.	<i>Microcystis sp.</i>	110	70	280	110
23.	<i>Tricodesmium erythraeum</i>	270	170	110	210
24.	<i>Rhizosolenia styliformis</i>	120	240	*	*
	<b>Dinoflagellates</b>				
25.	<i>Ceratium furca</i>	300	180	*	*
26.	<i>Ceratium macroceros</i>	200	260	*	260
27.	<i>Ceratium tripos</i>	*	220	110	190
	<b>Total</b>	<b>4880</b>	<b>4595</b>	<b>4030</b>	<b>3595</b>

\* - Organisms not present



**PHYTOPLANKTON**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **14.03.2016**

Sl. No	Species (Cells/l)	A2	A3	Between A4 & A5
	<b>Bacillariophyceae</b>			
1.	<i>Bacteriastrum comosum</i>	110	420	150
2.	<i>Cerataulina orientalis</i>	220	320	200
3.	<i>Chaetoceros affinis</i>	230	350	210
4.	<i>Chaetoceros indicus</i>	220	200	180
5.	<i>Coscinodiscus centralis</i>	210	180	110
6.	<i>Coscinodiscus ecentricus</i>	240	250	200
7.	<i>Coscinodiscus granii</i>	110	180	110
8.	<i>Coscinodiscus gigas</i>	220	*	205
9.	<i>Ditylum brightwelli</i>	370	210	150
10.	<i>Gyrosigma balticum</i>	280	220	110
11.	<i>Leptocylindrus danicus</i>	240	205	150
12.	<i>Lithodesmium undulatum</i>	220	250	110
13.	<i>Odontella mobiliensis</i>	360	110	120
14.	<i>Pleurosigma normanii</i>	210	80	100
15.	<i>Skeletonema costatum</i>	200	210	320
16.	<i>Stephanophysis palmeriana</i>	240	*	310
17.	<i>Thalassionema nitzschioides</i>	310	220	250
18.	<i>Thalassiothrix frauenfeldii</i>	210	320	110
19.	<i>Triceratium favus</i>	200	*	*
20.	<i>Triceratium reticulatum</i>	160	220	90
	<b>Cyanophyceae</b>			
21.	<i>Anabeana nastoc</i>	110	310	100
22.	<i>Microcystis sp.</i>	240	220	150
23.	<i>Tricodesmium erythraeum</i>	210	210	140
24.	<i>Rhizosolenia alata</i>	290	*	90
25.	<i>Rhizosolenia styliformis</i>	180	280	110
	<b>Dinoflagellates</b>			
26.	<i>Ceratium furca</i>	150	180	210
27.	<i>Ceratium macroceros</i>	210	250	110
28.	<i>Ceratium tripos</i>	200	250	100
29.	<i>Protoperidinium oceanicum</i>	250	320	*
	<b>Total</b>	<b>6440</b>	<b>5965</b>	<b>4195</b>

\* - Organisms not present

**ZOOPLANKTON**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **14.03.2016**

Sl. No	Species (Organisms/m <sup>3</sup> )	Location ID			
		SPOIL GROUND -II	SPOIL GROUND -I	A0	A1
	<b>Copepoda</b>				
1	<i>Acartia spinicauda</i>	110	210	310	*
2	<i>Acartia erythrea</i>	*	180	210	210
3	<i>Acrocalanus gipper</i>	*	*	205	*
4	<i>Acrocalanus gracilis</i>	300	220	150	220
5	<i>Centropages furcatus</i>	210	110	220	*
6	<i>Nannocalanus minor</i>	160	180	150	210
7	<i>Paracalanus parvus</i>	200	210	150	140
8	<i>Pontella danae</i>	150	180	160	200
9	<i>Temora turbinata</i>	200	*	220	180
10	<i>Oithona brevicornis</i>	250	140	320	140
11	<i>Oithona rigida</i>	180	*	210	*
12	<i>Oithona similis</i>	200	210	210	180
13	<i>Corycaeus danae</i>	110	150	180	220
14	<i>Copilia mirabilis</i>	100	*	220	180
	<b>Spirotricha</b>				
15	<i>Favella brevis</i>	200	180	180	200
16	<i>Favella philipiensis</i>	180	210	220	180
17	<i>Tintinnopsis tubulosa</i>	*	150	190	110
18	<i>Tintinnopsis tocaninensis</i>	200	140	320	*
19	<i>Tintinnopsis cylinderica</i>	140	210	160	100
	<b>Others</b>				
20	<i>Lucifer hansperi</i>	210	200	220	200
21	<i>Sagitta sp</i>	180	150	220	320
22	<i>Oikopleura dioica</i>	*	*	300	140
23	<i>Oikopleura parva</i>	210	240	180	160
	<b>Larval Forms</b>				
24	<i>Bivalve Veliger</i>	200	180	210	210
25	<i>Barnacle nauplii</i>	160	*	220	*
26	<i>Copepod nauplii</i>	110	210	180	220
27	<i>Crustacean nauplii</i>	140	140	200	200
	<b>Total</b>	<b>4100</b>	<b>3800</b>	<b>5715</b>	<b>3920</b>

\* - Organisms not present

**ZOOPLANKTON**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **14.03.2016**

Sl. No	Species (Organisms/m <sup>3</sup> )	Location ID		
		A2	A3	Between A4 & A5
	<b>Copepoda</b>			
1	<i>Acartia spinicauda</i>	*	260	*
2	<i>Acartia erythrea</i>	170	240	190
3	<i>Acrocalanus gipper</i>	150	*	150
4	<i>Acrocalanus gracilis</i>	180	*	*
5	<i>Centropages furcatus</i>	220	250	270
6	<i>Nannocalanus minor</i>	*	*	300
7	<i>Paracalanus parvus</i>	260	160	280
8	<i>Pontella danae</i>	*	200	*
9	<i>Temora turbinata</i>	190	260	210
10	<i>Oithona brevicornis</i>	*	240	180
11	<i>Oithona rigida</i>	200	190	*
12	<i>Oithona similis</i>	250	*	210
13	<i>Corycaeus danae</i>	300	170	270
14	<i>Copilia mirabilis</i>	280	250	200
	<b>Spirotricha</b>			
15	<i>Favella brevis</i>	*	*	200
16	<i>Favella philipiensis</i>	330	290	220
17	<i>Tintinnopsis tubulosa</i>	230	190	290
18	<i>Tintinnopsis tocaninensis</i>	*	*	*
19	<i>Tintinnopsis cylinderica</i>	180	150	190
	<b>Others</b>			
20	<i>Lucifer hansperi</i>	260	*	*
21	<i>Sagitta sp</i>	190	190	160
22	<i>Oikopleura dioica</i>	*	280	*
23	<i>Oikopleura parva</i>	230	360	210
	<b>Larval Forms</b>			
24	<i>Bivalve Veliger</i>	210	120	110
25	<i>Barnacle nauplii</i>	120	*	210
26	<i>Copepod nauplii</i>	220	220	200
27	<i>Crustacean nauplii</i>	*	180	250
	<b>Total</b>	<b>4170</b>	<b>4200</b>	<b>4300</b>

\* - Organisms not present

# **SEDIMENT**

# **Quality data**

**pH, NUTRIENTS & TOTAL ORGANIC CARBON, OIL & GREASE – SEDIMENT**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **14.03.2016**

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>	8.3	13.25	7.26	3.46	0.592
2.	<b>SPOIL GROUND -I</b>	8.6	11.45	8.92	4.26	0.628
3.	<b>A0</b>	8.4	10.92	9.24	4.92	0.495
4.	<b>A1</b>	8.5	11.67	8.96	4.28	0.639
5.	<b>A2</b>	8.6	13.47	7.94	4.93	0.598
6.	<b>A3</b>	8.5	12.65	8.97	4.36	0.462
7.	<b>Between A4 &amp; A5</b>	8.6	13.29	8.95	3.84	0.756

## TEXTURE – SEDIMENT

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

Sample Collected on: **14.03.2016**

S. No.	Station Code	Grain Size Distribution (%)		
		Sand	Silt	Clay
1.	<b>SPOIL GROUND -II</b>	2.8	18.5	78.7
2.	<b>SPOIL GROUND -I</b>	2.7	18.3	79.0
3.	<b>A0</b>	7.5	19.8	72.7
4.	<b>A1</b>	6.9	19.2	73.9
5.	<b>A2</b>	7.9	20.6	71.5
6.	<b>A3</b>	8.2	19.8	72.0
7.	<b>Between A4 &amp; A5</b>	9.5	21.2	69.3

### HEAVY METALS – SEDIMENT

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

Sample Collected on: **14.03.2016**

Sl. No.	Station Code	µg/g							
		Fe	Mn	Cd	Ni	Cr	Hg	Zn	Pb
1.	<b>SPOIL GROUND -II</b>	3978	32.65	0.56	3.78	11.59	0.11	25.96	15.27
2.	<b>SPOIL GROUND -I</b>	4258	43.45	0.86	2.68	17.93	0.19	27.68	15.92
3.	<b>A0</b>	3785	35.69	0.52	1.76	14.28	0.24	19.28	11.28
4.	<b>A1</b>	4925	33.50	0.67	1.92	13.27	0.14	21.25	13.68
5.	<b>A2</b>	3681	30.99	0.52	2.17	12.45	0.29	15.48	13.85
6.	<b>A3</b>	4563	49.28	0.59	2.64	11.23	0.39	18.45	13.27
7.	<b>Between A4 &amp; A5</b>	5632	35.82	0.62	2.69	13.42	0.10	19.25	15.36

**MACROBENTHOS DISTRIBUTION IN THE SEDIMENT**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **14.03.2016**

Sl. No	Species (No/m <sup>2</sup> )	Location ID			
		SPOIL GROUND -II	SPOIL GROUND -I	A0	A1
	<b>Polychaetes</b>				
1	<i>Armandia longicaudata</i>	110	120	90	100
2	<i>Capitella capitata</i>	100	110	100	*
3	<i>Cirriformia sp</i>	110	180	100	100
4	<i>Goniada emerita</i>	120	*	*	110
5	<i>Nephtys dibranchis</i>	*	100	100	110
6	<i>Nereis sp.</i>	120	*	*	120
7	<i>Notomastus aberans</i>	*	110	200	100
8	<i>Perinereis capensis</i>	100	110	*	100
9	<i>Platynereis calodonta</i>	110	210	*	210
10	<i>Prionospio cirrifer</i>	200	*	*	*
11	<i>Prionospio pinnata</i>	*	110	140	100
	<b>Bivalves</b>				
12	<i>Donax veligers</i>	120	*	*	*
13	<i>Meretrix veligers</i>	*	240	120	*
	<b>Gastropods</b>				
14	<i>Littorina veligers</i>	100	160	*	80
15	<i>Natica veligers</i>	120	120	100	*
16	<i>Nassarius variegatus</i>	100	110	50	110
17	<i>Turris veligers</i>	110	90	20	210
	<b>Crustaceans</b>				
18	<i>Ampithoe romondi</i>	60	*	80	100
19	<i>Angeliara phreaticola</i>	120	60	60	50
20	<i>Gynodiastylis sp.</i>	110	110	*	*
21	<i>Paragnathia formica</i>	110	110	80	80
	<b>Total</b>	<b>1920</b>	<b>2050</b>	<b>1240</b>	<b>1680</b>

\* - Organisms not present



## MACROBENTHOS DISTRIBUTION IN THE SEDIMENT

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

Sample Collected on: **14.03.2016**

Sl. No	Species (No/m <sup>2</sup> )	Location ID		
		A2	A3	Between
	<b>Polychaetes</b>			
1	<i>Armandia longicaudata</i>	110	110	80
2	<i>Capitella capitata</i>	110	100	120
3	<i>Cirriformia sp</i>	80	*	*
4	<i>Goniada emerita</i>	210	80	110
5	<i>Nephtys dibranchis</i>	90	150	120
6	<i>Nereis sp.</i>	*	110	90
7	<i>Notomastus aberans</i>	*	220	90
8	<i>Perinereis capensis</i>	90	110	220
9	<i>Platynereis calodonta</i>	110	90	110
10	<i>Prionospio cirrifera</i>	100	40	100
11	<i>Prionospio pinnata</i>	80	80	210
	<b>Bivalves</b>			
12	<i>Donax veligers</i>	90	100	90
13	<i>Meretrix veligers</i>	80	*	100
	<b>Gastropods</b>		*	
14	<i>Littorina veligers</i>	110	*	210
15	<i>Natica veligers</i>	90	90	110
16	<i>Nassarius variegatus</i>	*	220	*
17	<i>Turris veligers</i>	*	180	*
	<b>Crustaceans</b>			
18	<i>Ampithoe romondi</i>	80	110	180
19	<i>Angeliara phreaticola</i>	90	90	210
20	<i>Gynodiastylis sp.</i>	110	80	110
21	<i>Paragnathia formica</i>	120	100	90
	<b>Total</b>	<b>1750</b>	<b>2060</b>	<b>2350</b>

\* - Organisms not found

**MEIOBENTHOS distribution in the sediment**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **14.03.2016**

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>	20	9	10	10
2	<i>Bolivina sp.</i>	12	10	15	8
3	<i>Cibicides refulgens</i>	11	7	*	*
4	<i>Globorotalia hiruste</i>	13	*	6	15
5	<i>Loxostomum sp.</i>	8	*	7	9
6	<i>Miliammina sp.</i>	21	12	21	17
7	<i>Milionella sp.</i>	*	16	20	14
8	<i>Nonion sp</i>	10	7	18	10
	<b>Nematodes</b>				
9	<i>Daptonema conicum</i>	*	*	11	12
10	<i>Draconema sp.</i>	10	15	11	10
11	<i>Greeffiella sp.</i>	*	11	7	12
12	<i>Microlaimus sp.</i>	13	14	18	14
13	<i>Neochromodora sp.</i>	12	10	14	12
14	<i>Spirinia sp.</i>	8	*	*	8
15	<i>Synonchus sp.</i>	*	*	10	10
16	<i>Theristus sp.</i>	10	16	10	8
17	<i>Viscosia sp.</i>	14	7	9	18
	<b>Ostrocodes</b>				
18	<i>Cypridies sp.</i>	20	10	*	*
19	<i>Cytheromorpha sp.</i>	*	9	10	8
20	<i>Neocytheideis sp.</i>	7	15	9	*
21	<i>Tanella indica</i>	*	8	9	16
22	<i>Tanella kingmaii</i>	14	*	*	10
	<b>Total</b>	<b>203</b>	<b>176</b>	<b>215</b>	<b>221</b>

\* - Organisms not present

**MEIOBENTHOS distribution in the sediment**Sample Collected at: **MORMUGAO PORT, GOA**Sample Collected on: **14.03.2016**

Sl. No	Species (No/10cm <sup>2</sup> )	Location ID		
		A2	A3	Between A4 &
	<b>Foraminiferans</b>			
1	<i>Ammonia beccarii</i>	7	5	10
2	<i>Bolivina sp.</i>	7	5	7
3	<i>Cibicides refulgens</i>	*	12	6
4	<i>Globorotalia hiruste</i>	12	*	18
5	<i>Loxostomum sp.</i>	*	*	7
6	<i>Miliammina sp.</i>	12	7	8
7	<i>Milionella sp.</i>	*	8	14
8	<i>Nonion sp</i>	7	11	11
	<b>Nematodes</b>			
9	<i>Daptonema conicum</i>	*	9	6
10	<i>Draconema sp.</i>	10	20	24
11	<i>Greeffiella sp.</i>	8	5	3
12	<i>Microlaimus sp.</i>	14	21	*
13	<i>Neochromodora sp.</i>	14	12	9
14	<i>Spirinia sp.</i>	*	*	8
15	<i>Synonchus sp.</i>	*	*	11
16	<i>Theristus sp.</i>	18	11	10
17	<i>Viscosia sp.</i>	12	10	7
	<b>Ostrocodes</b>			
18	<i>Cypridies sp.</i>	10	*	*
19	<i>Cytheromorpha sp.</i>	*	9	10
20	<i>Neocytheideis sp.</i>	8	9	14
21	<i>Tanella indica</i>	*	12	9
22	<i>Tanella kingmaii</i>	10	8	*
	<b>Total</b>	<b>149</b>	<b>174</b>	<b>192</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**

### **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 Merceptans
- 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 napthenic 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