CONTENTS

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 capsize 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: **28.04.2016**. 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: 10.05.2016

(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 µ. 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-chemicall Properties: Texture, pH, Organic Matter, Nutrients, Oil and Grease.
Heavy Metals **:** Fe, Mn, Cd, Ni, Cr, Hg, Zn and Pb
Benthic Communities **:** Macro & Mieo Benthic Flora and Fauna

METHODOLOGY PROTOCOL FOR MARINE WATER ANALYSIS

S.No.	Parameters	Methodology Protocol
Physical properties		
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)**
Chemical properties		
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_4)	**IS 3025 Part 24 (Reaff. 2009)**
16	Total Nitrogen (as N)	**IS 3025 Part 34 (Reaff. 2009)**
17	Nitrate Nitrogen (as NO_3-N)	**IS 3025 Part 34 (Reaff. 2009)**
18	Total Phosphate (as PO_4-P)	**IS 3025 Part 31 (Reaff. 2009)**
Heavy metals		
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**
Biological parameters		
25	Phyto & Zoo Planktons and Pigments	**APHA 22nd Edn. 10200**

METHODOLOGY PROTOCOL FOR SEDIMENT QUALITY ANALYSIS

S.No.	Parameters	Methodology Protocol
Physical properties		
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)
Heavy metals		
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
Benthic Communities		
13	Macro benthos	**APHA 22nd Edn. 10500**
14	Meio benthos	**APHA 22nd Edn. 10700**

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 **28.04.2016** 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 28.0°C to 30.0°C and there was no significant variation in temperature with the distance from the shore. The salinity ranged from 30.06 to 33.21‰. The pH of the seawater samples observed from 8.08 to 8.56. The measured turbidity varied between 10 to 18 NTU. The TSS value varied from 12 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 0.50 to 0.75 mg/l, Magnesium from 1524 to 1724 mg/l and Zinc from 0.32 to 0.46 mg/l. The concentration of mercury shows the BDL (<0.001mg/l) level. The population density of Phytoplankton varied from 4198 to 6280 Cell/L. The higher phytoplankton density was recorded at station **SPOIL GROUND -I,** The species such as, 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 3870 to 5760 Organisms/m3. The higher zooplankton density was recorded at station SPOIL GROUND -I. Zooplankton consists of Paracalanus parvus, Oithona similis, Corycaeuas 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 4068 to 5742 µg/g. Manganese from 32.62 to 48.62 µg/g. Cadmium in sediments ranged between 0.48 to 0.86 µg/g. Nickel from 1.78 to 2.68 µg/g. The chromium varied from 12.42 to 17.93 µg/g. The concentration of mercury varied from 0.15 to 0.39 µg/g. The concentrations of Zinc varied from 19.99 to 27.68 µg/g and the Lead from 11.56 to 15.92 µg/g. The numerical abundance of the macro benthic fauna varied from 1520 to 2530 No/square meter and the Meiobenthic varied between 175 to 255 No/**10cm^2**

Concluding Remarks

As per the Env. Monitoring made during **dredging phase (28.04.2016)** 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: **28.04.2016**

Sl. No:	Nomenclature	in UTM		in Geo-graphic	
		NORTHINGS	EASTINGS	Lat (N)	Long (E)
DUMPING AREA					
1	**SPOIL GROUND –II**	1707785	356075	15° 26' 35".18	73° 39' 30".81
2	**SPOIL GROUND -I**	1707791	358704	15° 26' 35".90	73°40' 59".09
DREDGING AREA					
3	**A0**	1703829	363263	15° 24' 27".87	73° 43' 32".74
4	**A1**	1704187	365477	15° 24’ 39”. 95	73° 44’ 46”. 93
5	**A2**	1704450	367089	15° 24' 48". 81	73° 45' 40".95
6	**A3**	1704754	368711	15° 24' 59".00	73° 46' 35".30
7	**Between A4 & A5**	1705016	370600	15° 25' 7.87	73° 47' 38".62

Marine Water Quality data

PHYSICAL PROPERTIES

Sample Collected at: **MORMUGAO PORT, GOA**
Sample Collected on: **28.04.2016**

Sl. No.	Sample description	pH	Colour (Hazen unit)	Odour	EC (micro mhos/cm)	W.T (°C)	Salinity (ppt)	Turbidity (NTU)	TSS (mg/l)
DUMPING AREA									
1	**SPOIL GROUND -II**	8.39	10	Odourless	50982	27.5	31.26	14	17
2	**SPOIL GROUND -I**	8.28	11	Odourless	51627	28.0	30.79	14	22
DREDGING AREA									
3	**A0**	8.17	7	Odourless	52698	29.5	32.18	10	14
4	**A1**	8.26	9	Odourless	52481	29.0	31.69	12	13
5	**A2**	8.25	13	Odourless	53950	29.5	32.59	18	25
6	**A3**	8.36	14	Odourless	53012	30.0	32.14	15	16
7	**Between A4 & A5**	8.15	12	Odourless	52149	30.0	30.08	11	24

CHEMICAL PROPERTIES –WATER

Sample Collected at: **MORMUGAO PORT, GOA**
Sample Collected on: **28.04.2016**

Sl. No.	Sample description	DO (mg/l)	COD (mg/l)	BOD (mg/l)	Oil & Grease (mg/l)	Chloride (mg/l)	Sulphate (mg/l)
1.	**SPOIL GROUND -II**	5.2	76	1	<1	18249	2945
2.	**SPOIL GROUND -I**	5.4	78	2	<1	18958	3186
3.	**A0**	4.9	81	2	<1	19258	3297
4.	**A1**	4.7	79	2	<1	18756	3155
5.	**A2**	5.1	76	1	<1	19958	3495
6.	**A3**	5.3	83	2	<1	19562	3372
7.	**Between A4 & A5**	4.9	75	1	<1	18495	3029

NUTRIENTS – WATER

Sample Collected at: **MORMUGAO PORT, GOA**
Sample Collected on**: 28.04.2016**

S. No.	Station Code	Parameters (mg/l)			
		Amm.Nitrogen	Total Nitrogen	Total Phosphate	SiO_2
1.	**SPOIL GROUND -II**	1.2	2.6	1.1	19.2
2.	**SPOIL GROUND -I**	1.4	2.9	1.2	19.9
3.	**A0**	1.5	3.2	1.3	20.3
4.	**A1**	1.3	2.8	1.2	19.6
5.	**A2**	1.8	3.7	1.4	21.8
6.	**A3**	1.6	3.6	1.4	20.9
7.	**Between A4 & A5**	1.3	2.8	1.1	19.5

HEAVY METALS – WATER

Sample Collected at: **MORMUGAO PORT, GOA**
Sample Collected on**: 28.04.2016**

Sl. No.	Station Code	Parameter (mg/l)					
		Fe	Zn	Mg	Cd	Cr	Hg
1.	**SPOIL GROUND -II**	0.52	0.36	1562	<0.001	<0.001	<0.001
2.	**SPOIL GROUND -I**	0.62	0.40	1624	<0.001	<0.001	<0.001
3.	**A0**	0.67	0.42	1672	<0.001	<0.001	<0.001
4.	**A1**	0.59	0.38	1604	<0.001	<0.001	<0.001
5.	**A2**	0.74	0.49	1765	<0.001	<0.001	<0.001
6.	**A3**	0.70	0.45	1702	<0.001	<0.001	<0.001
7.	**Between A4 & A5**	0.58	0.37	1583	<0.001	<0.001	<0.001

BIOLOGICAL CHARACTERISTICS

Sample Collected at: **MORMUGAO PORT, GOA**
Sample Collected on**: 28.04.2016**

S. No.	Station Code	Chl a (mg/m^3)	Phaeopigment (mg/m^3)	Net Primary Productivity ($mg\ C/\ m^3/d$)
1	**SPOIL GROUND -II**	2.57	0.60	0.20
2	**SPOIL GROUND -I**	2.82	0.72	0.23
3	**A0**	2.86	0.78	0.23
4	**A1**	2.66	0.68	0.22
5	**A2**	3.28	0.85	0.26
6	**A3**	3.15	0.81	0.25
7	**Between A4 & A5**	2.59	0.62	0.20

PHYTOPLANKTON

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

Sample Collected on: **28.04.2016**

Sl. No	Species (Cells/l)	Location ID			
		SPOIL GROUND -II	SPOIL GROUND -I	A0	A1
	Bacillariophyceae				
1.	*Bacteriastrum comosum*	270	220	230	260
2.	*Cerataulina orientalis*	250	150	220	220
3.	*Chaetoceros affinis*	220	250	250	270
4.	*Chaetoceros indicus*	230	210	220	290
5.	*Coscinodiscus centralis*	210	220	210	240
6.	*Coscinodiscus ecentricus*	240	210	240	250
7.	*Coscinodiscus granii*	250	180	230	280
8.	*Coscinodiscus gigas*	250	210	220	290
9.	*Ditylum brightwelli*	370	240	230	310
10.	*Gyrosigma balticum*	280	310	280	*
11.	*Leptocylindrus danicus*	240	250	240	280
12.	*Lithodesmium undulatum*	220	240	220	290
13.	*Odontella mobiliensis*	360	110	250	310
14.	*Pleurosigma normanii*	270	260	210	250
15.	*Skeletonema costatum*	250	240	200	310
16.	*Stephanophysis palmeriana*	290	310	240	*
17.	*Thalassionema nitzschioides*	310	260	310	350
18.	*Thalassiothrix frauenfeldii*	210	250	210	250
19.	*Triceratium favus*	200	190	200	*
20.	*Triceratium reticulatum*	160	310	160	220
	Cyanophyceae				
21.	*Anabeana nastoc*	110	120	130	*
22.	*Microcystis sp.*	240	*	250	310
23.	*Tricodesmium erythraeum*	210	320	140	240
24.	*Rhizosolenia styliformis*	290	280	150	280
	Dinoflagellates				
25	*Ceratium furca*	180	250	160	240
26.	*Ceratium macroceros*	150	240	200	240
27.	*Ceratium tripos*	210	250	210	250
Total		**6470**	**6080**	**5810**	**6230**

* - Organisms not present

PHYTOPLANKTON

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

Sample Collected on**: 28.04.2016**

Sl. No	Species (Cells/l)	A2	A3	Between A4 & A5
	Bacillariophyceae			
1.	*Bacteriastrum comosum*	130	150	200
2.	*Cerataulina orientalis*	210	140	330
3.	*Chaetoceros affinis*	200	170	230
4.	*Chaetoceros indicus*	210	110	220
5.	*Coscinodiscus centralis*	190	140	240
6.	*Coscinodiscus ecentricus*	200	*	210
7.	*Coscinodiscus granii*	110	*	350
8.	*Coscinodiscus gigas*	210	110	210
9.	*Ditylum brightwelli*	150	240	*
10.	*Gyrosigma balticum*	190	230	250
11.	*Leptocylindrus danicus*	150	210	350
12.	*Lithodesmium undulatum*	110	250	260
13.	*Odontella mobiliensis*	120	290	220
14.	*Pleurosigma normanii*	100	260	340
15.	*Skeletonema costatum*	250	160	320
16.	*Stephanophysis palmeriana*	190	310	310
17.	*Thalassionema nitzschioides*	250	230	250
18.	*Thalassiothrix frauenfeldii*	110	*	210
19.	*Triceratium favus*	*	140	250
20.	*Triceratium reticulatum*	100	170	310
	Cyanophyceae			
21.	*Anabeana nastoc*	130	100	240
22.	*Microcystis sp.*	150	110	110
23.	*Tricodesmium erythraeum*	140	170	130
24.	*Rhizosolenia alata*	110	240	110
25.	*Rhizosolenia styliformis*	140	110	110
	Dinoflagellates			
26	*Ceratium furca*	210	260	*
27.	*Ceratium macroceros*	110	220	100
28.	*Ceratium tripos*	110	110	290
29	*Protoperidinium oceanicum*	170	240	220
Total		**4450**	**4870**	**6370**

*** - Organisms not present**

ZOOPLANKTON

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

Sample Collected on: **28.04.2016**

Sl. No	Species (Organisms/m^3)		Location ID		
		SPOIL GROUND -II	SPOIL GROUND -I	A0	A1
	Copepoda				
1	*Acartia spinicauda*	250	250	190	210
2	*Acartia erythrea*	210	210	*	200
3	*Acrocalanus gipper*	220	210	190	*
4	*Acrocalanus gracilis*	150	220	*	250
5	*Centropages furcatus*	250	250	270	210
6	*Nannocalanus minor*	150	*	250	240
7	*Paracalanus parvus*	190	*	210	110
8	*Pontella danae*	160	190	*	210
9	*Temora turbinata*	220	200	210	110
10	*Oithona brevicornis*	320	250	180	140
11	*Oithona rigida*	210	180	*	*
12	*Oithona similis*	210	200	190	250
13	*Corycaeuas danae*	180	110	220	220
14	*Copilia mirabilis*	220	210	210	260
	Spirotricha				
15	*Favella brevis*	180	200	250	240
16	*Favella philipiensis*	220	180	220	180
17	*Tintinnopsis tubulosa*	190	*	290	210
18	*Tintinnopsis tocantinensis*	320	110	*	*
19	*Tintinnopsis cylinderica*	160	180	190	210
	Others				
20	*Lucifer hansperi*	240	210	*	200
21	*Sagitta sp*	220	180	160	250
22	*Oikopleura dioica*	300	*	*	140
23	*Oikopleura parva*	180	210	210	160
	Larval Forms				
24	*Bivalve Veliger*	210	200	110	210
25	*Barnacle nauplii*	220	160	210	*
26	*Copepod nauplii*	180	110	200	220
27	*Crustacean nauplii*	200	140	250	200
Total		**5760**	**4360**	**4210**	**4630**

*** - Organisms not present**

ZOOPLANKTON

Sample Collected at: **MORMUGAO PORT, GOA**
Sample Collected on: **28.04.2016**

Sl. No	Species (Organisms/m^3)	Location ID		
		A2	A3	Between A4 & A5
	Copepoda			
1	*Acartia spinicauda*	110	100	240
2	*Acartia erythrea*	*	210	*
3	*Acrocalanus gipper*	210	*	210
4	*Acrocalanus gracilis*	180	220	250
5	*Centropages furcatus*	220	150	210
6	*Nannocalanus minor*	*	180	200
7	*Paracalanus parvus*	250	210	210
8	*Pontella danae*	*	150	*
9	*Temora turbinata*	210	*	260
10	*Oithona brevicornis*	*	110	240
11	*Oithona rigida*	160	*	230
12	*Oithona similis*	240	210	240
13	*Corycaeuas danae*	210	150	250
14	*Copilia mirabilis*	210	*	260
	Spirotricha			
15	*Favella brevis*	*	210	*
16	*Favella philipiensis*	260	190	210
17	*Tintinnopsis tubulosa*	230	210	240
18	*Tintinnopsis tocantinensis*	*	190	210
19	*Tintinnopsis cylinderica*	180	240	180
	Others			
20	*Lucifer hansperi*	180	150	210
21	*Sagitta sp*	190	190	190
22	*Oikopleura dioica*	*	*	280
23	*Oikopleura parva*	110	240	360
	Larval Forms			
24	*Bivalve Veliger*	210	180	220
25	*Barnacle nauplii*	190	*	*
26	*Copepod nauplii*	220	210	220
27	*Crustacean nauplii*	*	140	210
Total		**3770**	**3840**	**5330**

*** - Organisms not present**

SEDIMENT

Quality data

pH, NUTRIENTS & TOTAL ORGANIC CARBON, OIL & GREASE – SEDIMENT

Sample Collected at: **MORMUGAO PORT, GOA**
Sample Collected on: **28.04.2016**

S. No.	Station Code	pH	Total Nitrogen (µg/g)	Total Phosphorus (µg/g)	Total Organic Carbon (mg/g)	O & G (µg/g)
1.	**SPOIL GROUND -II**	8.5	12.35	8.52	3.35	0.591
2.	**SPOIL GROUND -I**	8.6	13.24	9.12	4.06	0.568
3.	**A0**	8.5	13.61	8.94	4.25	0.624
4.	**A1**	8.2	13.06	8.69	3.99	0.522
5.	**A2**	8.6	14.02	9.29	4.98	0.802
6.	**A3**	8.4	13.56	9.04	4.63	0.792
7.	**Between A4 & A5**	8.3	12.67	8.99	3.68	0.637

TEXTURE – SEDIMENT

Sample Collected at: **MORMUGAO PORT, GOA**
Sample Collected on**: 28.04.2016**

S. No.	Station Code	Grain Size Distribution (%)		
		Sand	Silt	Clay
1.	**SPOIL GROUND -II**	3.1	19.4	77.5
2.	**SPOIL GROUND -I**	3.0	18.5	78.5
3.	**A0**	8.4	20.8	70.8
4.	**A1**	9.1	20.4	70.5
5.	**A2**	8.8	21.3	69.9
6.	**A3**	9.2	21.9	68.9
7.	**Between A4 & A5**	9.4	21.8	68.8

HEAVY METALS – SEDIMENT

Sample Collected at: **MORMUGAO PORT, GOA**
Sample Collected on: **28.04.2016**

Sl. No.	Station Code	µg/g							
		Fe	Mn	Cd	Ni	Cr	Hg	Zn	Pb
1.	**SPOIL GROUND –II**	4162	34.62	0.55	1.72	13.54	0.24	21.59	13.76
2.	**SPOIL GROUND –I**	5129	44.62	0.71	2.37	17.96	0.19	26.95	15.47
3.	**A0**	5249	45.21	0.76	2.45	16.82	0.26	23.68	15.92
4.	**A1**	5249	38.92	0.67	2.28	16.58	0.28	26.85	14.97
5.	**A2**	5769	49.26	0.89	2.78	18.62	0.22	24.56	16.58
6.	**A3**	5624	48.76	0.78	2.65	17.83	0.39	23.95	16.25
7.	**Between A4 & A5**	4368	35.48	0.62	1.86	14.92	0.15	22.92	12.58

MACROBENTHOS DISTRIBUTION IN THE SEDIMENT

Sample Collected at: **MORMUGAO PORT, GOA**
Sample Collected on: **28.04.2016**

Sl. No	Species (No/m^2)	Location ID			
		SPOIL GROUND -II	SPOIL GROUND -I	A0	A1
	Polychaetes				
1	*Armandia longicaudata*	150	150	150	140
2	*Capitella capitata*	160	120	110	150
3	*Cirriformia sp*	210	110	110	150
4	*Goniada emerita*	110	90	*	*
5	*Nephtys dibranchis*	*	*	210	120
6	*Nereis sp.*	150	160	120	110
7	*Notomastus aberans*	*	220	120	110
8	*Perinereis capensis*	210	210	110	*
9	*Platynereis calodonta*	220	110	210	210
10	*Prionospio cirrifera*	200	110	110	*
11	*Prionospio pinnata*	*	140	100	160
	Bivalves				
12	*Donax veligers*	120	100	90	*
13	*Meretrix veligers*	120	*	110	240
	Gastropods		*		
14	*Littorina veligers*	110	*	110	160
15	*Natica veligers*	150	110	*	120
16	*Nassarius variegatus*	160	160	110	140
17	*Turris veligers*	140	180	*	150
	Crustaceans				
18	*Ampithoe romondi*	120	110	100	*
19	*Angeliera phreaticola*	120	100	150	250
20	*Gynodiastylis sp.*	110	110	*	110
21	*Paragnathia formica*	110	100	110	110
Total		**2670**	**2390**	**2130**	**2430**

*** - Organisms not present**

MACROBENTHOS DISTRIBUTION IN THE SEDIMENT

Sample Collected at: **MORMUGAO PORT, GOA**
Sample Collected on: **28.04.2016**

Sl. No	Species (No/m^2)	Location ID		
		A2	A3	Between
	Polychaetes			
1	*Armandia longicaudata*	100	90	140
2	*Capitella capitata*	110	80	210
3	*Cirriformia sp*	90	*	110
4	*Goniada emerita*	*	110	150
5	*Nephtys dibranchis*	140	120	110
6	*Nereis sp.*	110	110	210
7	*Notomastus aberans*	150	110	*
8	*Perinereis capensis*	*	120	150
9	*Platynereis calodonta*	90	110	150
10	*Prionospio cirrifera*	*	100	110
11	*Prionospio pinnata*	*	110	110
	Bivalves			
12	*Donax veligers*	*	90	100
13	*Meretrix veligers*	120	100	110
	Gastropods			
14	*Littorina veligers*	*	110	120
15	*Natica veligers*	60	110	110
16	*Nassarius variegatus*	90	*	*
17	*Turris veligers*	110	*	120
	Crustaceans			
18	*Ampithoe romondi*	90	110	210
19	*Angeliera phreaticola*	110	130	110
20	*Gynodiastylis sp.*	*	110	120
21	*Paragnathia formica*	120	130	110
Total		**1490**	**1950**	**2560**

***- Organisms not found**

MEIOBENTHOS distribution in the sediment

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

Sample Collected on: **28.04.2016**

Sl. No	Species (No/10cm^2)	Location ID			
		SPOIL GROUND -II	SPOIL GROUND - I	A0	A1
	Foraminiferans				
1	*Ammonia beccarii*	15	12	10	14
2	*Bolivina sp.*	19	15	12	11
3	*Cibicides refulgens*	18	10	*	*
4	*Globorotalia hiruste*	16	*	8	14
5	*Loxostomum sp.*	19	*	9	15
6	*Miliammina sp.*	18	12	18	16
7	*Milionella sp.*	*	15	15	15
8	*Nonion sp*	18	10	12	14
	Nematodes				
9	*Daptonema conicum*	*	14	11	12
10	*Draconema sp.*	16	*	10	10
11	*Greeffiella sp.*	*	11	7	13
12	*Microlaimus sp.*	18	*	14	14
13	*Neochromodora sp.*	15	10	12	12
14	*Spirinia sp.*	19	19	*	12
15	*Synonchus sp.*	*	12	10	10
16	*Theristus sp.*	20	16	15	11
17	*Viscosia sp.*	14	15	16	14
	Ostrocodes				
18	*Cypridies* sp.	12	12	*	*
19	*Cytheromorpha* sp.	*	10	10	10
20	*Neocytheideis* sp.	15	15	*	*
21	*Tanella indica*	*	19	14	16
22	*Tanella kingmaii*	18	*	12	10
Total		**270**	**227**	**215**	**243**

*** - Organisms not present**

MEIOBENTHOS distribution in the sediment

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

Sample Collected on: **28.04.2016**

Sl. No	Species (No/10cm^2)	Location ID		
		A2	A3	Between A4 &
	Foraminiferans			
1	*Ammonia beccarii*	11	8	12
2	*Bolivina sp.*	12	9	14
3	*Cibicides refulgens*	*	9	10
4	*Globorotalia hiruste*	10	*	15
5	*Loxostomum sp.*	15	*	9
6	*Miliammina sp.*	11	9	10
7	*Milionella sp.*	*	12	14
8	*Nonion sp*	13	10	12
	Nematodes			
9	*Daptonema conicum*	*	12	19
10	*Draconema sp.*	10	15	16
11	*Greeffiella sp.*	15	12	14
12	*Microlaimus sp.*	14	14	*
13	*Neochromodora sp.*	17	13	19
14	*Spirinia sp.*	5	*	15
15	*Synonchus sp.*	9	*	11
16	*Theristus sp.*	18	16	18
17	*Viscosia sp.*	12	12	12
	Ostrocodes			
18	*Cypridies* sp.	10	*	*
19	*Cytheromorpha* sp.	*	14	10
20	*Neocytheideis* sp.	14	16	14
21	*Tanella indica*	*	12	13
22	*Tanella kingmaii*	10	15	*
Total		**206**	**208**	**257**

*** - 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, which ever 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 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