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: **25.02.2016**. 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: 10.03.2016

(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 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 & Micro 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	**-**
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. 1999)**
10	BOD-3 Days, 27°C	**APHA 21st Edn. 5210 B**
11	Oil & Grease	**IS 3025 Part 39 (Reaff. 1999)**
12	Chlorides (as Cl)	**IS 3025 Part 32 (Reaff. 2003)**
13	Fluorides (as F)	**IS 3025 (Reaff: 2005)**
14	Sulphates (as SO_4)	**IS 3025 Part 24 (Reaff. 2003)**
15	Total Nitrogen (as N)	**IS 3025 Part 34 (Reaff. 1999)**
16	Nitrate Nitrogen (as NO_3-N)	**IS 3025 Part 34 (Reaff. 1999)**
17	Total Phosphate (as PO_4-P)	**IS 3025 Part 31 (Reaff :1999)**
Heavy metals		
18	Iron	**APHA 21st Edn. 3111 B**
19	Zinc	**APHA 21st Edn. 3111 B**
20	Magnesium	**APHA 21st Edn. 3500 Mg, B**
21	Cadmium	**APHA 21st Edn. 3111 B**
22	Chromium	**APHA 21st Edn. 3111 B**
23	Mercury	**APHA 21st Edn. 3112 B**
Biological parameters		
24	Phyto & Zoo Planktons	**APHA**

METHODOLOGY PROTOCOL FOR SEDIMENT QUALITY ANALYSIS

S.No.	Parameters	Methodology Protocol
Physical properties		
1	pH	IS 2720 Part 26 (Reaff .2002)
2	Organic matters	IS 2720 Part 22 (Reaff.1995)
3	Nutrients	IS 10158 –1982
4	Oil and Grease	IS 3025 Part 39 (Reaff. 1999)
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	Macrobenthos	**APHA**
14	Meiobenthos	**APHA**

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 during February2016 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 25.5°C to28.0°C and there was no significant variation in temperature with the distance from the shore. The salinity ranged from 31.24 to 33.95‰. The pH of the seawater samples observed from 8.16 to 8.36. The measured turbidity varied between 7 to 9 NTU. The TSS value varied from 10 to 14mg.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 0.36 to 0.56 mg/l, Magnesium from 1498 to 1627 mg/l and Zinc from 0.28 to 0.35mg/l. The concentration of mercury shows the BDL (<0.001mg/l) level. The population density of Phytoplankton varied from 4190 to 5950 Cell/L. The higher phytoplankton density was recorded at station **A3**, The species such as, *Bacteriastrum comosum, Coscinodiscus ecentricus, Coscinodiscus gigas, Lithodesmium undulatum, Stephanophysis palmeriana, Triceratium favus, Triceratium reticulatum, Ceratium furca* were found to be common in all stations

monitored. The numerical abundance of zooplankton varied from 3340 to 4510 Organisms/m3. The higher zooplankton density was recorded at station **A0**. Zooplankton consists of *Acartia erythrea, Temora turbinate, Copilia mirabilis, Sagitta sp* were found to be dominant species commonly distributed in all the stations monitored.

The concentrations of Ferrous in sediments were ranging from 3498 to 5262 µg/g. Manganese from 29.24 to 48.34 µg/g. Cadmium in sediments ranged between 0.36 to 0.56 µg/g. Nickel from 1.16 to 3.21 µg/g. The chromium varied from 10.21 to 17.52 µg/g. The concentration of mercury varied from 0.06 to 0.24 µg/g. The concentrations of Zinc varied from 11.69 to 26.31 µg/g and the Lead from 10.15 to 14.98 µg/g. The numerical abundance of the macro benthic fauna varied from 1400 to 2540 No/square meter and the Meiobenthic varied between 150 to 227 No/**10cm^2**

Concluding Remarks

As per the Env. Monitoring made during **dredging phase (25.02.2016)** 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					
Sl. No:	**Nomenclature**	**in UTM**		**in Geo-graphic**	
		NORTHINGS	**EASTINGS**	**Lat (N)**	**Long (E)**
DUMPING AREA					
1	**SPOIL GROUND -II**	1707847	355978	15° 26' 37".18	73° 39' 27".55
2	**SPOIL GROUND -I**	1707816	358706	15° 26' 36". 72	73° 40' 59".07
DREDGING AREA					
3	**A0**	1703817	363264	15° 24' 27". 48	73° 43' 32".77
4	**A1**	1704128	365495	15° 24’ 38”. 03	73° 44’ 47”. 54
5	**A2**	1704438	366975	15° 24' 48". 40	73° 45' 37".13
6	**A3**	1704729	368789	15° 24' 58". 20	73° 46' 37".92
7	**Between A4 & A5**	1705016	370634	15° 25' 7". 75	73° 47' 39".78

Marine Water Quality data

PHYSICAL PROPERTIES

Sample Collected at: **MORMUGAO PORT, GOA**
Sample Collected on: **25.02.2016**

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**	8.16	4	Odourless	47100	25.5	32.42	8	14
2	**SPOIL GROUND -I**	8.19	6	Odourless	48400	26.0	33.02	9	13
DREDGING AREA									
3	**A0**	8.21	5	Odourless	49100	26.5	33.95	7	10
4	**A1**	8.23	3	Odourless	47600	26.5	33.24	9	13
5	**A2**	8.28	5	Odourless	47400	27.0	32.11	7	12
6	**A3**	8.36	4	Odourless	47900	27.5	31.24	8	12
7	**Between A4 & A5**	8.32	4	Odourless	48500	28.0	32.51	7	11

CHEMICAL PROPERTIES –WATER

MORMUGAO PORT

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**	5.6	72	1	<1	18576	3114
2.	**SPOIL GROUND -I**	5.4	70	1	<1	18594	3100
3.	**A0**	5.3	86	2	<1	19432	3479
4.	**A1**	5.4	82	2	<1	19446	3274
5.	**A2**	5.4	66	1	<1	18364	3103
6.	**A3**	5.6	70	1	<1	18122	3064
7.	**Between A4 & A5**	5.0	80	2	<1	18326	3094

NUTRIENTS – WATER

MORMUGAO PORT

S. No.	Station Code	Parameters (mg/l)			
		Amm.Nitrogen	Total Nitrogen	Total Phosphate	SiO_2
1.	**SPOIL GROUND -II**	1.4	3.5	1.2	20.2
2.	**SPOIL GROUND -I**	1.2	3.6	1.2	18.9
3.	**A0**	1.4	2.9	1.3	17.8
4.	**A1**	1.3	2.8	1.4	14.8
5.	**A2**	1.5	3.0	1.2	18.2
6.	**A3**	1.2	2.8	0.9	15.6
7.	**Between A4 & A5**	1.3	3.2	0.8	14.2

HEAVY METALS - WATER

MORMUGAO PORT

Sl. No.	Station Code	Parameter (mg/l)					
		Fe	Zn	Mg	Cd	Cr	Hg
1.	**SPOIL GROUND -II**	0.56	0.32	1526	<0.001	<0.001	<0.001
2.	**SPOIL GROUND -I**	0.48	0.35	1498	<0.001	<0.001	<0.001
3.	**A0**	0.36	0.30	1532	<0.001	<0.001	<0.001
4.	**A1**	0.52	0.34	1564	<0.001	<0.001	<0.001
5.	**A2**	0.45	0.28	1627	<0.001	<0.001	<0.001
6.	**A3**	0.52	0.32	1524	<0.001	<0.001	<0.001
7.	**Between A4 & A5**	0.50	0.35	1492	<0.001	<0.001	<0.001

BIOLOGICAL CHARACTERISTICS

MORMUGAO PORT

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**	2.16	0.87	0.21
2	**SPOIL GROUND -I**	1.95	0.88	0.18
3	**A0**	2.24	0. 92	0.22
4	**A1**	2.356	0.69	0.24
5	**A2**	1.39	0.79	0.14
6	**A3**	2.48	0.86	0.20
7	**Between A4 & A5**	2.37	0.58	0.19

PHYTOPLANKTON

MORMUGAO PORT

Sl. No	Species (Cells/l)	Location ID			
		SPOIL GROUND -II	SPOIL GROUND -I	A0	A1
	Bacillariophyceae				
1.	*Bacteriastrum comosum*	180	250	270	210
2.	*Cerataulina orientalis*	240	230	*	260
3.	*Chaetoceros affinis*	190	170	*	210
4.	*Chaetoceros indicus*	260	*	210	270
5.	*Coscinodiscus centralis*	230	140	340	*
6.	*Coscinodiscus ecentricus*	210	200	240	200
7.	*Coscinodiscus granii*	*	240	180	190
8.	*Coscinodiscus gigas*	210	220	210	210
9.	*Ditylum brightwelli*	270	230	*	*
10.	*Gyrosigma balticum*	180	*	*	250
11.	*Leptocylindrus danicus*	110	210	240	190
12.	*Lithodesmium undulatum*	200	230	250	260
13.	*Odontella mobiliensis*	260	230	310	*
14.	*Pleurosigma normanii*	200	260	260	290
15.	*Skeletonema costatum*	*	*	240	*
16.	*Stephanophysis palmeriana*	210	200	330	200
17.	*Thalassionema nitzschioides*	270	230	*	270
18.	*Thalassiothrix frauenfeldii*	260	240	*	*
19.	*Triceratium favus*	270	160	210	270
20.	*Triceratium reticulatum*	170	180	310	280
	Cyanophyceae				
21.	*Anabeana nastoc*	290	*	120	*
22.	*Microcystis sp.*	*	70	*	310
23.	*Tricodesmium erythraeum*	270	170	*	210
24.	*Rhizosolenia alata*	*	*	*	*
25.	*Rhizosolenia styliformis*	120	240	230	*
	Dinoflagellates				
26	*Ceratium furca*	200	190	240	190
27.	*Ceratium macroceros*	200	260	*	260
28.	*Ceratium tripos*	*	220	*	290
29	*Protoperidinium oceanicum*	60	20	*	*
Total		**5060**	**4790**	**4190**	**4820**

*** - Organisms not present**

PHYTOPLANKTON

MORMUGAO PORT

Sl. No	Species (Cells/l)	A2	A3	Between A4 & A5
	Bacillariophyceae			
1.	*Bacteriastrum comosum*	180	250	270
2.	*Cerataulina orientalis*	240	230	160
3.	*Chaetoceros affinis*	190	170	180
4.	*Chaetoceros indicus*	260	180	210
5.	*Coscinodiscus centralis*	230	340	340
6.	*Coscinodiscus ecentricus*	210	210	240
7.	*Coscinodiscus granii*	*	230	180
8.	*Coscinodiscus gigas*	210	280	210
9.	*Ditylum brightwelli*	270	230	*
10.	*Gyrosigma balticum*	180	*	*
11.	*Leptocylindrus danicus*	210	210	240
12.	*Lithodesmium undulatum*	250	230	250
13.	*Odontella mobiliensis*	260	230	310
14.	*Pleurosigma normanii*	200	260	260
15.	*Skeletonema costatum*	*	*	240
16.	*Stephanophysis palmeriana*	210	200	330
17.	*Thalassionema nitzschioides*	270	230	*
18.	*Thalassiothrix frauenfeldii*	260	240	*
19.	*Triceratium favus*	270	160	210
20.	*Triceratium reticulatum*	170	180	310
	Cyanophyceae			
21.	*Anabeana nastoc*	*	220	*
22.	*Microcystis sp.*	290	370	300
23.	*Tricodesmium erythraeum*	200	260	*
24.	*Rhizosolenia alata*	290	*	*
25.	*Rhizosolenia styliformis*	190	240	230
	Dinoflagellates			
26	*Ceratium furca*	170	180	310
27.	*Ceratium macroceros*	200	260	*
28.	*Ceratium tripos*	200	190	240
29	*Protoperidinium oceanicum*	270	170	340
Total		**5880**	**5950**	**5360**

*** - Organisms not present**

ZOOPLANKTON
MORMUGAO PORT

Sl. No	Species (Organisms/m^3)	Location ID			
		SPOIL GROUND -II	SPOIL GROUND -I	A0	A1
	Copepoda				
1	*Acartia spinicauda*	170	*	*	180
2	*Acartia erythrea*	220	150	170	220
3	*Acrocalanus gipper*	*	*	240	*
4	*Acrocalanus gracilis*	180	150	240	250
5	*Centropages furcatus*	190	*	100	200
6	*Nannocalanus minor*	160	190	170	240
7	*Paracalanus parvus*	190	*	270	*
8	*Pontella danae*	250	210	*	290
9	*Temora turbinata*	210	230	220	240
10	*Oithona brevicornis*	*	*	180	*
11	*Oithona rigida*	180	140	*	220
12	*Oithona similis*	270	*	160	110
13	*Corycaeuas danae*	*	210	*	180
14	*Copilia mirabilis*	280	170	150	210
	Spirotricha				
15	*Favella brevis*	250	160	330	260
16	*Favella philipiensis*	170	*	*	270
17	*Tintinnopsis tubulosa*	180	170	160	*
18	*Tintinnopsis tocantinensis*	*	140	220	220
19	*Tintinnopsis cylinderica*	*	270	220	200
	Others				
20	*Lucifer hansperi*	280	180	280	220
21	*Sagitta sp*	240	140	250	280
22	*Oikopleura dioica*	240	150	160	170
23	*Oikopleura parva*	*	210	250	*
	Larval Forms				
24	*Bivalve Veliger*	210	200	160	*
25	*Barnacle nauplii*	110	130	210	200
26	*Copepod nauplii*	120	*	180	*
27	*Crustacean nauplii*	180	140	190	220
Total		**4280**	**3340**	**4510**	**4380**

*** - Organisms not present**

ZOOPLANKTON
MORMUGAO PORT

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

*** - Organisms not present**

SEDIMENT

Quality data

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

MORMUGAO PORT

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**	8.1	12.11	5.79	2.98	0.432
2.	**SPOIL GROUND -I**	8.4	9.57	7. 86	3.62	0.516
3.	**A0**	8.3	8.49	8.65	4.68	0.398
4.	**A1**	8.5	10.78	7. 54	3.86	0.591
5.	**A2**	8.4	12.85	6.57	4.85	0.467
6.	**A3**	8.6	10.29	5.98	3.56	0.352
7.	**Between A4 & A5**	8.6	12.34	7.15	2.94	0.623

TEXTURE – SEDIMENT

MORMUGAO PORT

S. No.	Station Code	Grain Size Distribution (%)		
		Sand	Silt	Clay
1.	**SPOIL GROUND -II**	2.5	18.0	89.5
2.	**SPOIL GROUND -I**	2.5	17.5	80.0
3.	**A0**	5.0	18.5	76.5
4.	**A1**	6.0	18.0	76.0
5.	**A2**	7.0	20.0	73.0
6.	**A3**	6.5	18.0	75.5
7.	**Between A4 & A5**	9.5	20.0	71.5

HEAVY METALS – SEDIMENT

MORMUGAO PORT

Sl. No.	Station Code	µg/g							
		Fe	Mn	Cd	Ni	Cr	Hg	Zn	Pb
1.	SPOIL GROUND - II	3854	31.56	0.45	3.21	10.63	0.21	24.56	14.57
2.	SPOIL GROUND -I	4028	42.31	0. 75	2.62	17.52	0.18	26.31	14.98
3.	A0	3657	34.62	0.46	1.50	13.15	0.16	18.37	10.15
4.	A1	4632	31.48	0.56	1.86	12.63	0.08	20.65	12.09
5.	A2	3498	29.24	0.42	1.16	10.37	0.24	14.36	13.52
6.	A3	4351	48.34	0.36	1.64	10.21	0.22	11.69	12.46
7.	Between A4 & A5	5262	33.24	0.42	2.56	12.02	0.06	18.39	14.16

MACROBENTHOS distribution in the sediment

MORMUGAO PORT

Sl. No	Species (No/m^2)	Location ID			
		SPOIL GROUND -II	SPOIL GROUND -I	A0	A1
	Polychaetes				
1	*Armandia longicaudata*	*	120	*	110
2	*Capitella capitata*	100	110	200	*
3	*Cirriformia sp*	100	200	100	*
4	*Goniada emerita*	120	100	120	110
5	*Nephtys dibranchis*	*	100	200	210
6	*Nereis sp.*	120	*	*	120
7	*Notomastus aberans*	*	110	200	*
8	*Perinereis capensis*	120	110	*	100
9	*Platynereis calodonta*	210	210	*	200
10	*Prionospio cirrifera*	200	*	*	*
11	*Prionospio pinnata*	*	210	110	100
	Bivalves				
12	*Donax veligers*	120	100	100	*
13	*Meretrix veligers*	*	210	100	*
	Gastropods				
14	*Littorina veligers*	*	60	*	80
15	*Natica veligers*	120	120	120	*
16	*Nassarius variegatus*	100	*	50	110
17	*Turris veligers*	110	110	20	210
	Crustaceans				
18	*Ampithoe romondi*	60	*	80	*
19	*Angeliera phreaticola*	80	60	*	50
20	*Gynodiastylis sp.*	110	150	*	*
21	*Paragnathia formica*	200	120	*	40
Total		**1870**	**2200**	**1400**	**1440**

*** - Organisms not present**

MACROBENTHOS distribution in the sediment

MORMUGAO PORT

Sl. No	Species (No/m^2)	Location ID		
		A2	A3	Between
	Polychaetes			
1	*Armandia longicaudata*	80	*	110
2	*Capitella capitata*	130	140	*
3	*Cirriformia sp*	180	100	*
4	*Goniada emerita*	100	140	110
5	*Nephtys dibranchis*	100	150	210
6	*Nereis sp.*	*	*	120
7	*Notomastus aberans*	110	160	*
8	*Perinereis capensis*	140	*	100
9	*Platynereis calodonta*	210	*	140
10	*Prionospio cirrifera*	*	*	*
11	*Prionospio pinnata*	140	110	100
	Bivalves			
12	*Donax veligers*	120	200	*
13	*Meretrix veligers*	*	*	130
	Gastropods	210	120	*
14	*Littorina veligers*	30	50	80
15	*Natica veligers*	120	210	20
16	*Nassarius variegatus*	*	*	*
17	*Turris veligers*	210	120	*
	Crustaceans			
18	*Ampithoe romondi*	120	120	80
19	*Angeliera phreaticola*	120	*	90
20	*Gynodiastylis sp.*	*	220	*
21	*Paragnathia formica*	120	*	110
Total		**2240**	**1840**	**1400**

***- Organisms not found**

MEIOBENTHOS distribution in the sediment
MORMUGAO PORT

Sl. No	Species (No/10cm^2)	Location ID			
		SPOIL GROUND -II	SPOIL GROUND - I	A0	A1
	Foraminiferans				
1	*Ammonia beccarii*	15	12	12	15
2	*Bolivina sp.*	12	10	17	8
3	*Cibicides refulgens*	*	8	*	*
4	*Globorotalia hiruste*	13	*	6	12
5	*Loxostomum sp.*	*	*	7	9
6	*Miliammina sp.*	21	18	21	17
7	*Milionella sp.*	*	18	21	14
8	*Nonion sp*	12	7	8	12
	Nematodes				
9	*Daptonema conicum*	*	*	11	12
10	*Draconema sp.*	12	17	21	20
11	*Greeffiella sp.*	*	11	7	12
12	*Microlaimus sp.*	13	14	20	16
13	*Neochromodora sp.*	12	14	14	12
14	*Spirinia sp.*	*	*	*	8
15	*Synonchus sp.*	*	*	10	11
16	*Theristus sp.*	11	6	12	8
17	*Viscosia sp.*	14	7	9	8
	Ostrocodes				
18	*Cypridies* sp.	22	10	*	*
19	*Cytheromorpha* sp.	*	9	10	8
20	*Neocytheideis* sp.	8	10	*	*
21	*Tanella indica*	*	8	*	10
22	*Tanella kingmaii*	15	*	*	15
Total		**180**	**179**	**206**	**227**

*** - Organisms not present**

MEIOBENTHOS distribution in the sediment
MORMUGAO PORT

Sl. No	Species (No/10cm^2)	Location ID		
		A2	A3	Between A4 &
	Foraminiferans			
1	*Ammonia beccarii*	7	6	20
2	*Bolivina sp.*	10	5	7
3	*Cibicides refulgens*	*	2	*
4	*Globorotalia hiruste*	12	*	8
5	*Loxostomum sp.*	*	*	7
6	*Miliammina sp.*	14	10	8
7	*Milionella sp.*	*	8	14
8	*Nonion sp*	8	7	11
	Nematodes			
9	*Daptonema conicum*	*	9	12
10	*Draconema sp.*	13	21	24
11	*Greeffiella sp.*	8	5	3
12	*Microlaimus sp.*	16	21	*
13	*Neochromodora sp.*	14	14	12
14	*Spirinia sp.*	*	*	8
15	*Synonchus sp.*	*	*	11
16	*Theristus sp.*	8	11	10
17	*Viscosia sp.*	7	9	8
	Ostrocodes			
18	*Cypridies* sp.	10	*	*
19	*Cytheromorpha* sp.	*	9	10
20	*Neocytheideis* sp.	8	10	14
21	*Tanella indica*	*	8	*
22	*Tanella kingmaii*	15	*	*
Total		**150**	**155**	**187**

*** - Organisms not present**

Standards

1. **Ambient Air quality**
2. **Marine water**
3. **Hazardous waste Management and Handling Rules 2003 – List of waste and Concentration Limits**

Ambient Air Quality Standards 2009

NATIONAL AMBIENT AIR QUALITY STANDARDS
CENTRAL POLLUTION CONTROL BOARD
NOTIFICATION

New Delhi, the 18th November, 2009

No. B-29016/20/90/PCI-L—In exercise of the powers conferred by Sub-section (2) (h) of section 16 of the Air (Prevention and Control of Pollution) Act, 1981 (Act No.14 of 1981), and in supersession of the Notification No(s). S.O. 384(E), dated 11th April, 1994 and S.O. 935(E), dated 14th October, 1998, the Central Pollution Control Board hereby notify the National Ambient Air Quality Standards with immediate effect, namely:-

NATIONAL AMBIENT AIR QUALITY STANDARDS

S. No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (notified by Central Government)	Methods of Measurement
(1)	(2)	(3)	(4)	(5)	(6)
1	Sulphur Dioxide (SO_2), µg/m³	Annual*	50	20	- Improved West and Gaeke
		24 hours**	80	80	-Ultraviolet fluorescence
2	Nitrogen Dioxide (NO_2), µg/m³	Annual*	40	30	- Modified Jacob & Hochheiser (Na-Arsenite)
		24 hours**	80	80	- Chemiluminescence
3	Particulate Matter (size less than 10µm) or PM_{10} µg/m³	Annual*	60	60	- Gravimetric - TOEM
		24 hours**	100	100	- Beta attenuation
4	Particulate Matter (size less than 2.5µm) or $PM_{2.5}$ µg/m³	Annual*	40	40	- Gravimetric - TOEM
		24 hours**	60	60	- Beta attenuation
5	Ozone (O_3) µg/m³	8 hours**	100	100	- UV photometric - Chemilminescence
		1 hour**	180	180	- Chemical Method
6	Lead (Pb) µg/m³	Annual*	0.50	0.50	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper - ED-XRF using Teflon filter
		24 hours**	1.0	1.0	
7	Carbon Monoxide (CO) mg/m³	8 hours**	02	02	- Non Dispersive Infra Red (NDIR) spectroscopy
		1 hour**	04	04	
8	Ammonia (NH_3) µg/m³	Annual*	100	100	-Chemiluminescence
		24 hours**	400	400	-Indophenol blue method

(1)	(2)	(3)	(4)	(5)	(6)
9	Benzene (C_6H_6) $\mu g/m^3$	Annual*	05	05	- Gas chromatography based continuous analyzer - Adsorption and Desorption followed by GC analysis
10	Benzo(a)Pyrene (BaP) - particulate phase only, ng/m^3	Annual*	01	01	- Solvent extraction followed by HPLC/GC analysis
11	Arsenic (As), ng/m^3	Annual*	06	06	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper
12	Nickel (Ni), ng/m^3	Annual*	20	20	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper

* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

Note. — Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation.

SANT PRASAD GAUTAM, Chairman
[ADVT-III/4/184/09/Exty.]

Note: The notifications on National Ambient Air Quality Standards were published by the Central Pollution Control Board in the Gazette of India, Extraordinary vide notification No(s). S.O. 384(E), dated 11th April, 1994 and S.O. 935(E), dated 14th October, 1998.

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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

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