

## ENVIRONMENTAL MONITORING REPORT



**DETOX GROUP**



### **MONITORING OF ENVIRONMENTAL PLAN FOR JN PORT ENVIRONMENTAL MONITORING REPORT**

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Prepared by : **DETOX CORPORATION PVT. LTD,**  
3<sup>rd</sup> Floor, K.G.Chambers, Udhana Darwaja, Ring Road,

Surat – 395002, Gujarat

## TABLE OF CONTENTS

SR. NO.	PARTICULARS	PAGE NO.
<b>1.</b>	<b>AMBIENT AIR QUALITY MONITORING</b>	<b><u>3-18</u></b>
1.1	Introduction	3
1.2	Methodology	3
1.3	Results	4-15
1.4	Discussion	16
1.5	Observations & Conclusions	17-18
<b>2.</b>	<b>MARINE WATER QUALITY MONITORING [HARBOR&amp; CREEK] INCLUDING STUDY OF SEDIMENT CHARACTERISTICS</b>	<b><u>19-36</u></b>
2.1	Introduction	19
2.2	Methodology	19-20
2.3	Results	21-34
2.4	Discussion	35-36
2.5	Observations & Conclusions	36
<b>3.</b>	<b>MARINE ECOSYSTEM MONITORING</b>	<b><u>37-58</u></b>
3.1	Introduction – Marine Environment	37-38
3.2	Methodology- Zooplankton, Phytoplankton, Benthic Organisms	38-42
3.3	Results	34-43
	Aquatic Flora & Fauna	39-41
	Benthic Organisms	42
	Water Quality: Biotic	42-53
	Sediment Quality: Biotic	54
3.4	Nutrients	55-57
3.5	Observations & Conclusions	58
<b>4.</b>	<b>DRINKING WATER QUALITY MONITORING</b>	<b><u>59-63</u></b>
4.1	Introduction	59
4.2	Results	59-62
4.3	Discussion	63
4.4	Conclusions	63
<b>5.</b>	<b>ANNEXURES</b>	<b><u>64-68</u></b>
5.1	Annexure-I: Location map for Ambient Air Monitoring Stations	64
5.2	Annexure-II: National Ambient Air Quality Monitoring Standard	65
5.3	Annexure-III: Location map for Marine Water Monitoring Stations	66
5.4	Annexure-IV: Location map for Ecological monitoring Stations and Direction of Towing	67
5.5	Annexure-V: Primary Criterion for Class SW-IV Waters (For Harbor Waters)	68
5.6	Annexure-VI: Recommended Ranges of the Ecological Parameters for Arabian Sea	69
<b>6.</b>	<b>BIBLIOGRAPHY</b>	<b>70-71</b>

# 1.

# AMBIENT AIR QUALITY MONITORING

## 1.1 INTRODUCTION

As per the Environmental Monitoring Plan of Jawaharlal Nehru Port (JNP), Air monitoring locations are selected in port and outside including nearby residential and eco-sensitive areas. Locations of stations are selected based on the significance of sources, receptors and to get representative data. Three fixed stations are identified namely Port Operational Centre (POC),–Indian Molasses Company (IMC) and Residential Colony (RC). Three movable locations are also identified namely Elephanta Caves (EC), North Gate Complex (NGC) and South Gate Complex (SGC). The description of stations is given in **Table 1**. The location map of various air quality monitoring stations at JNP is depicted in **Annexure-I**.

*Table 1: Description of Ambient Air Monitoring Stations*

Station No.	Station	Location	Selection Criterion
1.	POC	At Port Operational Centre	Main Port Activity Location
2.	IMC	At IMC compound in Liquid Chemical Terminal Area	Major industrial activity centre
3.	RC	At JNP residential township	Impact on human population, receptor oriented
4.	EC	At Elephanta Caves	Impact on archeological site, receptor oriented
5.	NGC	Near North Gate Complex	Heavy traffic movement
6.	SGC	Near South Gate Complex	Heavy traffic movement

## 1.2 AIR QUALITY MONITORING METHODOLOGY

The objective behind Air Quality monitoring survey is to determine the status of existing ambient air quality in the port and to compare it with CPCB specified standards. Sampling and analysis of ambient air samples are carried out as per CPCB Guidelines for Ambient Air Quality Monitoring, Volume-I, NAAQMS/36/2012-2013. The monitoring is carried-out as per air quality parameters mentioned in the National Ambient Air Quality Monitoring Standards (NAAQMS) CPCB Notification published on 18<sup>th</sup> November 2009. **Annexure-II** represents list of air quality parameters as per NAAQS along with frequency of monitoring.

The monitoring cycle at three fixed stations i.e. POC, IMC and RC is twice a week, while at NGC and SGC it is once a week. However, monitoring at Elephanta Caves is once a month as per schedule of EMP of JNPT.

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In all above stations, sampling duration is 24 hour for PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>x</sub>, NH<sub>3</sub>, Pb, As, Ni, Benzo(α) pyrene, 8 hour for Ozone & Benzene, and Grab-sampling for CO & CO<sub>2</sub> measurements.

After a continuous operation of 8 hours of the sampler, the reagents are replaced to obtain 3 samples per day for each parameter namely, SO<sub>2</sub>, NO<sub>x</sub> and NH<sub>3</sub>. The EPM 2000 filter paper and PTFE Membrane bound filter paper are used for a period of 24 hours to obtain one sample each of PM<sub>10</sub> & PM<sub>2.5</sub> respectively. After PM<sub>10</sub> measurement, EPM 2000 filter paper is used for estimation of Pb, As, Ni and Benzo (α) pyrene.

### 1.3 RESULTS

The ambient air quality monitoring data for three fixed stations, POC, IMC & RC for the month of March, 2016 are given in **Tables 2, 3 & 4** respectively. The ambient air quality monitoring data for EC and two movable stations, NGC & SGC are given in **Tables 5, 6 & 7** respectively.

Table 2: Results of Air Pollutant Concentration at POC Station of JNP Area during the month of March, 2016

	Date	Time [Hrs]	PM <sub>10</sub> [µg/m <sup>3</sup> ]	PM <sub>2.5</sub> [µg/m <sup>3</sup> ]	SO <sub>2</sub> [µg/m <sup>3</sup> ]		NOx [µg/m <sup>3</sup> ]		NH <sub>3</sub> [µg/m <sup>3</sup> ]	
Sampling Period			24 hr	24 hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>		80 µg/m <sup>3</sup>		80 µg/m <sup>3</sup>		400 µg/m <sup>3</sup>
POC-1	01.03.2016 to 02.03.2016	7:00AM	288	81	32.85	26.44	80.50	84.77	25.95	23.17
		3:00 PM			21.63		78.36		24.05	
		11:00 PM			24.84		95.45		19.52	
POC-2	04.03.2016 to 05.03.2016	7:00AM	132	73	18.43	18.43	47.01	50.34	25.93	24.59
		3:00 PM			20.83		54.14		33.09	
		11:00 PM			16.03		49.86		14.76	
POC-3	07.03.2016 to 08.03.2016	7:00AM	196	67	21.63	20.03	42.74	46.07	25.71	20.08
		3:00 PM			15.22		51.29		19.76	
		11:00 PM			23.24		44.17		14.76	
POC-4	11.03.2016 to 12.03.2016	7:00AM	151	63	12.02	12.02	34.91	35.62	34.03	30.79
		3:00 PM			10.42		30.63		41.19	
		11:00 PM			13.62		41.32		17.14	
POC-5	14.03.2016 to 15.03.2016	7:00AM	209	76	28.85	25.37	58.41	63.37	47.85	43.57
		3:00 PM			20.03		64.03		50.71	
		11:00 PM			27.24		67.67		32.14	
POC-6	18.03.2016 to 19.03.2016	7:00AM	135	58	29.65	21.90	79.78	79.78	29.76	32.70
		3:00 PM			20.83		89.04		38.81	
		11:00 PM			15.22		70.52		29.52	
POC-7	21.03.2016 to 22.03.2016	7:00AM	158	65	19.23	18.16	45.59	46.78	18.33	23.57
		3:00 PM			24.04		52.71		23.09	
		11:00 PM			11.22		42.03		29.28	
POC-8	23.03.2016 to 24.03.2016	7:00AM	184	72	17.63	22.44	54.14	54.61	43.81	43.41
		3:00 PM			28.05		60.55		47.14	
		11:00 PM			21.63		49.15		39.28	
POC-9	28.03.2016 to 29.03.2016	7:00AM	147	56	16.03	21.10	65.54	65.77	43.09	42.38
		3:00 PM			21.63		72.66		47.14	
		11:00 PM			25.64		59.12		36.9	
Monthly Average			178	68		20.65		58.57		31.58
Standard Deviation			49	8		4.28		16.27		9.47

Table 2: Results of Air Pollutant Concentration at POC Station of JNP Area during the month of March ,2016											
	Date	Time , [Hrs]	O <sub>3</sub> [µg/m <sup>3</sup> ]	Pb [µg/m <sup>3</sup> ]	As [ng/m <sup>3</sup> ]	Ni [ng/m <sup>3</sup> ]	C <sub>6</sub> H <sub>6</sub> [µg/m3 ]	B(a)P [ng/m <sup>3</sup> ]	CO [mg/m3 ]	CO <sub>2</sub> [ppm ]	
Sampling Period			8 hr	24hr	24hr (Avg)	24hr (Avg)	8 hr	24hr (Avg)	Grab Sampling	Grab Sampling	
NAAQMS limit			100 µg/m <sup>3</sup>	1.0 µg/m <sup>3</sup>	6 ng/m <sup>3</sup>	20 ng/m <sup>3</sup>	5.0 µg/m <sup>3</sup>	1.0 ng/m <sup>3</sup>	4.0 mg/m <sup>3</sup>	-	
POC-1	01.03.2016 to 02.03.2016	7:00AM									
		3:00 PM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	<1.0	268	
		11:00 PM									
POC-2	04.03.2016 to 05.03.2016	7:00AM									
		3:00 PM	23.91	<0.05	<5.0	<1.0	1.22	<0.5	1.06	243	
		11:00 PM									
POC-3	07.03.2016 to 08.03.2016	7:00AM									
		3:00 PM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	<1.0	214	
		11:00 PM									
POC-4	11.03.2016 to 12.03.2016	7:00AM									
		3:00 PM	27.59	<0.05	<5.0	<1.0	1.08	<0.5	<1.0	239	
		11:00 PM									
POC-5	14.03.2016 to 15.03.2016	7:00AM									
		3:00 PM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	<1.0	225	
		11:00 PM									
POC-9	18.03.2016 to 19.03.2016	7:00AM									
		3:00 PM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	1.31	218	
		11:00 PM									
POC-7	21.03.2016 to 22.03.2016	7:00AM									
		3:00 PM	24.13	<0.05	<5.0	<1.0	<1.0	<0.5	<1.0	234	
		11:00 PM									
POC-8	23.03.2016 to 24.03.2016	7:00AM									
		3:00 PM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	<1.0	227	
		11:00 PM									
POC-9	28.03.2016 to 29.03.2016	7:00AM									
		3:00 PM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	<1.0	248	
		11:00 PM									
Monthly Average			25.21				1.15		1.19	235	
Standard Deviation			2.1				0.10		0.2	16.7	

Table 3: Results of Air Pollutant Concentration at IMC Station of JNP Area during the month of March, 2016

	Date	Time [Hrs]	PM <sub>10</sub> [µg/m <sup>3</sup> ]	PM <sub>2.5</sub> [µg/m <sup>3</sup> ]	SO <sub>2</sub> [µg/m <sup>3</sup> ]		NOx [µg/m <sup>3</sup> ]		NH3 [µg/m <sup>3</sup> ]	
Sampling Period			24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>		80 µg/m <sup>3</sup>		80 µg/m <sup>3</sup>		400 µg/m <sup>3</sup>
IMC-1	01.03.2016 to 02.03.2016	7:00AM			24.84		67.67		36.19	
		3:00 PM	225	88	22.44	21.90	66.25	63.87	20.24	29.13
		11:00 PM			18.43		57.70		30.95	
IMC-2	04.03.2016 to 05.03.2016	7:00AM			27.24		45.59		39.05	
		3:00 PM	380	127	17.63	22.97	35.62	41.32	27.14	31.98
		11:00 PM			24.04		42.74		29.76	
IMC-3	07.03.2016 to 08.03.2016	7:00AM			10.42		59.84		21.90	
		3:00 PM	373	101	16.83	18.43	47.73	55.56	26.67	26.03
		11:00 PM			28.05		59.12		29.52	
IMC-4	11.03.2016 to 12.03.2016	7:00AM			13.62		32.77		31.43	
		3:00 PM	217	83	11.22	13.62	28.49	36.57	38.57	34.36
		11:00 PM			16.03		48.44		33.09	
IMC-5	14.03.2016 to 15.03.2016	7:00AM			25.64		51.29		31.43	
		3:00 PM	255	96	21.63	26.44	49.15	53.19	49.76	39.84
		11:00 PM			32.05		59.12		38.33	
IMC-6	18.03.2016 to 19.03.2016	7:00AM			31.25		63.4		32.14	
		3:00 PM	193	81	18.43	26.18	59.84	61.26	37.86	32.46
		11:00 PM			28.85		60.55		27.38	
IMC-7	21.03.2016 to 22.03.2016	7:00AM			14.42		52.71		26.90	
		3:00 PM	247	90	20.83	17.89	45.59	51.76	33.09	32.38
		11:00 PM			18.43		56.99		37.14	
IMC-8	23.03.2016 to 24.03.2016	7:00AM			32.85		44.17		29.52	
		3:00 PM	239	86	38.46	32.05	37.75	43.69	24.76	29.68
		11:00 PM			24.84		49.15		34.76	
IMC-9	28.03.2016 to 29.03.2016	7:00AM			13.62		63.40		31.43	
		3:00 PM	199	74	24.04	18.70	56.28	62.45	24.52	27.78
		11:00 PM			18.43		67.67		27.38	
Monthly Average			259	92		21.59		51.96		32.30
Standard Deviation			70	15		4.90		10.89		4.70

Table 3: Results of Air Pollutant Concentration at IMC Station of JNP Area during the month of March, 2016

	Date	Time, [Hrs]	O <sub>3</sub> [µg/m <sup>3</sup> ]	Pb [µg/m <sup>3</sup> ]	As [ng/m <sup>3</sup> ]	Ni [ng/m <sup>3</sup> ]	C <sub>6</sub> H <sub>6</sub> [µg/m <sup>3</sup> ]	B(a)P [ng/m <sup>3</sup> ]	CO [mg/m <sup>3</sup> ]	CO <sub>2</sub> [ppm]
Sampling Period			8 hr	24hr	24hr (Avg)	24hr (Avg)	8 hr	24hr (Avg)	Grab Sampling	Grab Sampling
NAAQMS limit			100 µg/m <sup>3</sup>	1.0 µg/m <sup>3</sup>	6 ng/m <sup>3</sup>	20 ng/m <sup>3</sup>	5.0 µg/m <sup>3</sup>	1.0 ng/m <sup>3</sup>	4.0 mg/m <sup>3</sup>	-
IMC-1	01.03.2016 to 02.03.2016	7:00AM	<20.0	<0.05	<5.0	<1.0	1.12	<0.5	1.04	243
		3:00 PM								
		11:00 PM								
IMC-2	04.03.2016 to 05.03.2016	7:00AM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	1.28	235
		3:00 PM								
		11:00 PM								
IMC-3	07.03.2016 to 08.03.2016	7:00AM	22.81	<0.05	<5.0	<1.0	1.28	<0.5	<1.0	226
		3:00 PM								
		11:00 PM								
IMC-4	11.03.2016 to 12.03.2016	7:00AM	<20.0	<0.05	<5.0	<1.0	1.43	<0.5	<1.0	278
		3:00 PM								
		11:00 PM								
IMC-5	14.03.2016 to 15.03.2016	7:00AM	23.12	<0.05	<5.0	<1.0	<1.0	<0.5	1.16	215
		3:00 PM								
		11:00 PM								
IMC-6	18.03.2016 to 19.03.2016	7:00AM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	<1.0	259
		3:00 PM								
		11:00 PM								
IMC-7	21.03.2016 to 22.03.2016	7:00AM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	<1.0	247
		3:00 PM								
		11:00 PM								
IMC-8	23.03.2016 to 24.03.2016	7:00AM	25.19	<0.05	<5.0	<1.0	<1.0	<0.5	<1.0	259
		3:00 PM								
		11:00 PM								
IMC-9	28.03.2016 to 29.03.2016	7:00AM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	<1.0	235
		3:00 PM								
		11:00 PM								
Monthly Average			22.97				1.28		1.16	244
Standard Deviation			1.29				0.16		0.12	19

Table 4: Results of Air Pollutant Concentration at RC Station of JNP Area during the month of March ,2016												
	Date	Time , [Hrs]	PM <sub>10</sub> [µg/m <sup>3</sup> ]	PM <sub>2.5</sub> [µg/m <sup>3</sup> ]	SO <sub>2</sub> [µg/m <sup>3</sup> ]		NOx [µg/m <sup>3</sup> ]		NH3 [µg/m <sup>3</sup> ]			
Sampling Period			24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)		
NAAQMS limit			100 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>		80 µg/m <sup>3</sup>		80 µg/m <sup>3</sup>		400 µg/m <sup>3</sup>		
RC-1	01.03.2016 to 02.03.2016	7:00AM			23.24		28.49		40.47			
		3:00 PM	209	81	32.85	28.05	38.47	29.68	30.47	34.92		
		11:00 PM			28.05		22.08		33.81			
RC-2	04.03.2016 to 05.03.2016	7:00AM			16.83		69.81		23.57			
		3:00 PM	162	77	12.02	16.83	64.11	62.21	20.24	18.81		
		11:00 PM			21.63		52.71		12.62			
RC-3	07.03.2016 to 08.03.2016	7:00AM			28.85		64.11		33.81			
		3:00 PM	251	89	18.43	23.24	56.99	52.95	27.14	28.49		
		11:00 PM			22.44		37.75		24.52			
RC-4	11.03.2016 to 12.03.2016	7:00AM			14.42		35.62		22.38			
		3:00 PM	134	73	12.82	15.49	37.04	42.74	23.81	22.14		
		11:00 PM			19.23		55.56		20.24			
RC-5	14.03.2016 to 15.03.2016	7:00AM			28.85		63.40		36.43			
		3:00 PM	271	93	24.04	22.97	44.17	52.95	26.90	31.35		
		11:00 PM			16.03		51.29		30.71			
RC-6	18.03.2016 to 19.03.2016	7:00AM			20.83		43.45		34.76			
		3:00 PM	126	62	26.44	21.37	37.04	37.75	28.09	30.16		
		11:00 PM			16.83		32.77		27.62			
RC-7	21.03.2016 to 22.03.2016	7:00AM			12.82		41.32		22.38			
		3:00 PM	149	73	16.83	16.29	47.73	42.74	25.24	22.38		
		11:00 PM			19.23		39.18		19.52			
RC-8	23.03.2016 to 24.03.2016	7:00AM			23.24		64.11		21.43			
		3:00 PM	178	81	18.43	18.70	69.10	63.64	27.62	24.44		
		11:00 PM			14.42		57.70		24.28			
RC-9	28.03.2016 to 29.03.2016	7:00AM			20.83		60.55		30.24			
		3:00 PM	157	69	24.04	20.83	54.85	55.09	26.19	30.40		
		11:00 PM			17.63		49.86		34.76			
Monthly Average			182	78		21.32		48.86		27.01		
Standard Deviation			51	10		4.05		11.37		5.29		

Table 4: Results of Air Pollutant Concentration at RC Station of JNP Area during the month of March, 2016

Sampling Period	Date	Time, [Hrs]	O <sub>3</sub> [µg/m <sup>3</sup> ]	Pb [µg/m <sup>3</sup> ]	As [ng/m <sup>3</sup> ]	Ni [ng/m <sup>3</sup> ]	C <sub>6</sub> H <sub>6</sub> [µg/m <sup>3</sup> ]	B(a)P [ng/m <sup>3</sup> ]	CO [mg/m <sup>3</sup> ]	CO <sub>2</sub> [ppm]
NAAQMS limit			8 hr	24hr	24hr (Avg)	24hr (Avg)	8 hr	24hr (Avg)	Grab Sampling	Grab Sampling
			100 µg/m <sup>3</sup>	1.0 µg/m <sup>3</sup>	6 ng/m <sup>3</sup>	20 ng/m <sup>3</sup>	5.0 µg/m <sup>3</sup>	1.0 ng/m <sup>3</sup>	4.0 mg/m <sup>3</sup>	-
RC-1	01.03.2016 to 02.03.2016	7:00AM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	1.11	251
		3:00 PM								
		11:00 PM								
RC-2	04.03.2016 to 05.03.2016	7:00AM	22.81	<0.05	<5.0	<1.0	1.22	<0.5	1.05	212
		3:00 PM								
		11:00 PM								
RC-3	07.03.2016 to 08.03.2016	7:00AM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	1.20	230
		3:00 PM								
		11:00 PM								
RC-4	11.03.2016 to 12.03.2016	7:00AM	24.28	<0.05	<5.0	<1.0	<1.0	<0.5	1.56	244
		3:00 PM								
		11:00 PM								
RC-5	14.03.2016 to 15.03.2016	7:00AM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	1.42	226
		3:00 PM								
		11:00 PM								
RC-6	18.03.2016 to 19.03.2016	7:00AM	<20.0	<0.05	<5.0	<1.0	1.09	<0.5	1.35	271
		3:00 PM								
		11:00 PM								
RC-7	21.03.2016 to 22.03.2016	7:00AM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	1.18	236
		3:00 PM								
		11:00 PM								
RC-8	23.03.2016 to 24.03.2016	7:00AM	<20.0	<0.05	<5.0	<1.0	1.17	<0.5	1.27	255
		3:00 PM								
		11:00 PM								
RC-9	28.03.2016 to 29.03.2016	7:00AM	28.09	<0.05	<5.0	<1.0	<1.0	<0.5	1.33	241
		3:00 PM								
		11:00 PM								
Monthly Average Standard Deviation			25.06				1.16		1.27	241
			2.73				0.07		0.16	17

Table 5 : Results of Air Pollutant Concentration at EC Station of JNP Area during the month of March ,2016

Table 5 : Results of Air Pollutant Concentration at EC Station of JNP Area during the month of March ,2016										
	Date	Time , [Hrs]	PM <sub>10</sub> [µg/m <sup>3</sup> ]	PM <sub>2.5</sub> [µg/m <sup>3</sup> ]	SO <sub>2</sub> [µg/m <sup>3</sup> ]		NOx [µg/m <sup>3</sup> ]		NH3 [µg/m <sup>3</sup> ]	
Sampling Period			24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>		80 µg/m <sup>3</sup>		80 µg/m <sup>3</sup>		400 µg/m <sup>3</sup>
EC	17.03.2016 to 18.03.2016	7:00AM			10.42		32.77		25.47	
		3:00 PM 11:00 PM	121	28	9.62	10.95	37.04	32.77	20.48	24.60
					12.82		28.49		27.86	
Monthly Average			121	28		10.95		32.77		24.60
Standard Deviation			-	-		-		-		-

Table 5 : Results of Air Pollutant Concentration at EC Station of JNP Area during the month of March ,2016

Table 5 : Results of Air Pollutant Concentration at EC Station of JNP Area during the month of March, 2016										
	Date	Time , [Hrs]	O <sub>3</sub> [µg/m <sup>3</sup> ]	Pb [µg/m <sup>3</sup> ]	As [ng/m <sup>3</sup> ]	Ni [ng/m <sup>3</sup> ]	C <sub>6</sub> H <sub>6</sub> [µg/m3 ]	B(a)P [ng/m <sup>3</sup> ]	CO [mg/m3 ]	CO <sub>2</sub> [ppm ]
Sampling Period			8 hr	24hr	24hr (Avg.)	24hr (Avg.)	8 hr	24hr (Avg.)	Grab Sampling	Grab Sampling
NAAQMS limit			100 µg/m <sup>3</sup>	1.0 µg/m <sup>3</sup>	6 ng/m <sup>3</sup>	20 ng/m <sup>3</sup>	5.0 µg/m <sup>3</sup>	1.0 ng/m <sup>3</sup>	4.0 mg/m <sup>3</sup>	-
EC	17.03.2016 to 18.03.2016	7:00AM								
		3:00 PM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	<1.0	245
		11:00 PM								
Monthly Average			-	-	-	-	-	-	-	-
Standard Deviation			-	-	-	-	-	-	-	-

Table 6 : Results of Air Pollutant Concentration at NGC Station of JNP Area during the month of March ,2016											
	Date	Time , [Hrs]	PM <sub>10</sub> [µg/m <sup>3</sup> ]	PM <sub>2.5</sub> [µg/m <sup>3</sup> ]	SO <sub>2</sub> [µg/m <sup>3</sup> ]		NOx [µg/m <sup>3</sup> ]		NH3 [µg/m <sup>3</sup> ]		
Sampling Period			24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	
NAAQMS limit			100 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>		80 µg/m <sup>3</sup>		80 µg/m <sup>3</sup>		400 µg/m <sup>3</sup>	
NGC-1	04.03.2016 to 05.03.2016	7:00AM	201	92	37.66	30.98	86.91	78.60	24.28	26.74	
		3:00 PM			77.65		32.14				
		11:00 PM			71.23		23.81				
NGC-2	11.03.2016 to 12.03.2016	7:00AM	191	81	21.63	22.43	32.77	43.69	24.28	27.70	
		3:00 PM			45.59		37.14				
		11:00 PM			52.71		21.67				
NGC-3	18.03.2016 to 19.03.2016	7:00AM	182	72	12.02	14.96	29.21	28.97	29.05	25.32	
		3:00 PM			30.63		28.81				
		11:00 PM			27.07		18.09				
NGC-4	24.03.2016 to 25.03.2016	7:00AM	175	64	20.83	19.50	38.47	36.80	25.65	21.17	
		3:00 PM			43.45		21.67				
		11:00 PM			28.49		16.19				
Monthly Average			187	77		21.97		47.02		25.23	
Standard Deviation			11	12		6.75		21.90		2.88	

Table 6 : Results of Air Pollutant Concentration at NGC Station of JNP Area during the month of March ,2016										
	Date	Time , [Hrs]	O <sub>3</sub> [µg/m <sup>3</sup> ]	Pb [µg/m <sup>3</sup> ]	As [ng/m <sup>3</sup> ]	Ni [ng/m <sup>3</sup> ]	C <sub>6</sub> H <sub>6</sub> [µg/m <sup>3</sup> ]	B(a)P [ng/m <sup>3</sup> ]	CO [mg/m <sup>3</sup> ]	CO <sub>2</sub> [ppm ]
Sampling Period			8 hr	24hr	24hr (Avg)	24hr (Avg)	8 hr	24hr (Avg)	Grab Sampling	Grab Sampling
NAAQMS limit			100 µg/m <sup>3</sup>	1.0 µg/m <sup>3</sup>	6 ng/m <sup>3</sup>	20 ng/m <sup>3</sup>	5.0 µg/m <sup>3</sup>	1.0 ng/m <sup>3</sup>	4.0 mg/m <sup>3</sup>	-
NGC-1	04.03.2016 to 05.03.2016	7:00AM								
		3:00 PM	<20.0	<0.05	<5.0	<1.0	1.14	<0.5	1.17	232
		11:00 PM								
NGC-2	11.03.2016 to 12.03.2016	7:00AM								
		3:00 PM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	1.23	244
		11:00 PM								
NGC-3	18.03.2016 to 19.03.2016	7:00AM								
		3:00 PM	21.61	<0.05	<5.0	<1.0	<1.0	<0.5	1.36	267
		11:00 PM								
NGC-4	24.03.2016 to 25.03.2016	7:00AM								
		3:00 PM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	1.18	229
		11:00 PM								
Monthly Average			21.61	-	-	-	1.14	-	1.25	248
Standard Deviation			-	-	-	-	-	-	0.1	17.3

Table 7: Results of Air Pollutant Concentration at SGC Station of JNP Area during the month of March, 2016												
Sampling Period	Date	Time, [Hrs]	PM <sub>10</sub> [µg/m <sup>3</sup> ]	PM <sub>2.5</sub> [µg/m <sup>3</sup> ]	SO <sub>2</sub> [µg/m <sup>3</sup> ]		NO <sub>x</sub> [µg/m <sup>3</sup> ]		NH <sub>3</sub> [µg/m <sup>3</sup> ]		NAAQMS limit	
			24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
SGC-1	01.03.2016 to 02.03.2016	7:00AM 3:00 PM 11:00 PM	166	84	35.26 28.05 30.45	31.25	42.74 39.18 37.04	39.65	35.71 32.38 23.33	400 µg/m <sup>3</sup>		
SGC-2	07.03.2016 to 08.03.2016	7:00AM 3:00 PM 11:00 PM	211	91	36.86 41.67 33.65	37.39	62.69 56.28 52.71	57.23	30.71 22.61 29.76			27.69
SGC-3	14.03.2016 to 15.03.2016	7:00AM 3:00 PM 11:00 PM	102	75	27.24 20.03 28.85	25.37	47.73 43.45 38.47	43.22	41.19 30.24 33.81			35.08
SGC-4	21.03.2016 to 22.03.2016	7:00AM 3:00 PM 11:00 PM	134	80	32.85 39.26 27.24	33.12	42.03 36.33 44.88	41.08	36.43 32.14 27.14			31.90
SGC-5	28.03.2016 to 29.03.2016	7:00AM 3:00 PM 11:00 PM	119	71	38.46 42.47 32.05	37.66	38.47 33.48 37.04	36.33	30.47 25.71 34.05			30.08
Monthly Average			146	80	-	32.96	-	43.50	-			31.05
Standard Deviation			43	8	-	5.06	-	8.07	-			2.72

Table 7: Results of Air Pollutant Concentration at SGC Station of JNP Area during the month of March ,2016										
	Date	Time , [Hrs]	O <sub>3</sub> [µg/m <sup>3</sup> ]	Pb [µg/m <sup>3</sup> ]	As [ng/m <sup>3</sup> ]	Ni [ng/m <sup>3</sup> ]	C <sub>6</sub> H <sub>6</sub> [µg/m3 ]	B(a)P [ng/m <sup>3</sup> ]	CO [mg/m3 ]	CO <sub>2</sub> [ppm ]
Sampling Period			8 hr	24hr	24hr (Avg)	24hr (Avg)	8 hr	24hr (Avg)	Grab Sampling	Grab Sampling
NAAQMS limit			100 µg/m <sup>3</sup>	1.0 µg/m <sup>3</sup>	6 ng/m <sup>3</sup>	20 ng/m <sup>3</sup>	5.0 µg/m <sup>3</sup>	1.0 ng/m <sup>3</sup>	4.0 mg/m <sup>3</sup>	-
SGC-1	01.03.2016 to 02.03.2016	7:00AM								
		3:00 PM	22.62	<0.05	<5.0	<1.0	<1.0	<0.5	1.17	222
		11:00 PM								
SGC-2	07.03.2016 to 08.03.2016	7:00AM								
		3:00 PM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	1.24	263
		11:00 PM								
SGC-3	14.03.2016 to 15.03.2016	7:00AM								
		3:00 PM	<20.0	<0.05	<5.0	<1.0	1.22	<0.5	1.2	238
		11:00 PM								
SGC-4	21.03.2016 to 22.03.2016	7:00AM								
		3:00 PM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	1.18	244
		11:00 PM								
SGC-5	28.03.2016 to 29.03.2016	7:00AM								
		3:00 PM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	1.13	227
		11:00 PM								
Monthly Average			22.62	-	-	-	1.22	-	1.18	239
Standard Deviation			-	-	-	-	-	-	0.04	16

## 1.4 DISCUSSION

In **Table 8**, the average values of air pollutants are provided at various stations of JNP area for March, 2016. The values obtained are compared with respective CPCB standards described for Industrial, Residential, Rural and ecologically sensitive areas. The values obtained for As, Ni and Benzo (α) Pyrene [BaP] are below detection limits of measurements at all air monitoring stations and hence these parameters are not included in **Table 8**.

**Table 8:** Monthly Average Values of Air Pollutants at Various Stations in JNP Area during March, 2016

STATION	PM <sub>10</sub> , [μg/m <sup>3</sup> ]	PM <sub>2.5</sub> , [μg/m <sup>3</sup> ]	SO <sub>2</sub> , [μg/m <sup>3</sup> ]	NO <sub>x</sub> , [μg/m <sup>3</sup> ]	NH <sub>3</sub> , [μg/m <sup>3</sup> ]	O <sub>3</sub> , [μg/m <sup>3</sup> ]	Pb [μg/m <sup>3</sup> ]	C <sub>6</sub> H <sub>6</sub> , [μg/m <sup>3</sup> ]	CO, [mg/m <sup>3</sup> ]	CO <sub>2</sub> , [ppm]
NAAQMS	100	60	80	80	400	100	1	5	4	-
INDUSTRIAL AREA										
POC	178±49	68 ± 8	20.65 ± 4.28	58.57 ± 16.27	31.58 ± 9.47	25.21 ± 2.10	<0.01	1.15 ± 0.10	1.19 ± 0.2	235 ± 16.7
IMC	259±70	92±15	21.59±4.90	51.96±10.79	32.30±4.70	22.97 ± 1.29	<0.01	1.28 ± 0.16	1.16 ± 0.12	244 ± 19
NG	187±11	77 ± 12	21.97±6.75	47.02±21.90	25.23 ± 2.88	21.61	<0.01	1.14	1.25	248± 17.3
SG	146 ± 43	80 ± 8	32.96±5.06	43.50±8.07	31.05± 2.72	22.62	<0.01	1.22	1.18 ± 0.04	219± 10
RESIDENTIAL AREA										
RC	209± 108	81 ±10	24.23±10.59	43.12±17.0	28.23 ± 9.69	21.78±0.42	<0.01	1.3± 0.2	1.35 ± 0.09	239± 16
ECO-SENSITIVE AREA										
EC	121	28	10.95	32.77	24.6	<20.0	<0.01	<1.0	<1.0	245

During the monitoring period, the overall Ambient Air Quality of the port area was found to be well within the desired levels for various pollutants. Daily average pollutant levels are presented in **Tables 2 to 7**. However, the concentrations obtained for particulate matter PM<sub>10</sub> and PM<sub>2.5</sub> at all stations were found to be exceeding the prescribed CPCB limits of 100μg/m<sup>3</sup> and 60μg/m<sup>3</sup>, respectively. All other pollutants were recorded well below the prescribed limits.

Results for the air quality parameters at Elephanta Caves [EC] station during 17<sup>th</sup> March'16 to 18<sup>th</sup> March'16 are represented in **Table 5**, **Tables 6 & 7** provide the results for NGC and SGC air monitoring stations respectively.

In March, 2016 gaseous pollutants were well within the prescribed limits, set for industrial as well as sensitive areas.

## 1.5 OBSERVATIONS AND CONCLUSIONS

The environmental implications of a port and harbor operational activities must be considered prior to further developments. The process of environmental assessment involves an analysis of the quality of the existing environment due to the port and harbor operational activities and any degradation in the environmental quality because of the execution of additional developmental expansions within the region. Keeping in view the above said objectives, the present environmental monitoring study has been conducted for the JNP to assess Ambient Air Quality. Following are the monthly observations.

### *Observations for the month of March 2016:*

- ✓ All the public and community buildings in residential complex / township are under Renovation. Being temporary activity; it will not affect ambient air quality in the long run. Existing Ambient air Quality of all stations is well within CPCB permissible limits( Annexure-2) except for PM<sub>10</sub> and PM<sub>2.5</sub> viz, 100µg/m<sup>3</sup> and 60µg/m<sup>3</sup> , respectively , which are higher than the prescribed CPCB standards.
- ✓ *Construction of 4<sup>th</sup> Container Terminal on South side of JNPT:* Land preparation work of 4<sup>th</sup> C.T. is underway close to South Gate : The transportation of soil and earth shall be considered a vital part as it is potential source of particulates. The overall ambient air quality around the Port area shows no adverse effect. Increase in the PM<sub>10</sub> and PM<sub>2.5</sub> Concentration at South Gate may be attributed due to the earth filling activity of 4<sup>th</sup> C.T. Where there is heavy traffic movement of Dumpers carrying earth filling materials . These dumpers are seen ferrying without any tarpaulin cover.
- ✓ *Construction of NSIGT Yard is underway to the North side of JNPT:* The nearest Ambient Air Monitoring location is North gate Complex. The overall values of gaseous parameters at this location are well within the CPCB limits except for PM<sub>10</sub> and PM<sub>2.5</sub> Concentration which are found exceeding the CPCB limits. The development of yard for NSIGT and heavy vehicular movement are the probable cause of the elevated values of PM<sub>10</sub> and PM<sub>2.5</sub> Concentration at NGC.
- ✓ *Vehicular Traffic at the gates:* The monitoring of ambient air Quality at South and North gate complexes has been done once a week. These locations are protected by some controlling steps like initiative taken by the port in terms of maintenance of port vehicles & PUC checking of the vehicles visiting port area and enough green cover provided in and around the area accounting as pollutant trap. This will significantly contribute to reduce overall pollution.
- ✓ Road connecting tank farm and township is being updated with construction of over bridge on the railway crossing. Land preparation and foundation work continued during the month of February, 2016 for the Rail over bridge. Nearest location i.e. RC does not show any adverse impact due to this activity. All the AAQM parameters are well within the prescribed CPCB limits except the values of PM<sub>10</sub> and PM<sub>2.5</sub>.

**EMP for JNP | Environmental Monitoring Report – DCPL/JNPT-REPORT/EMR-02/2016**

The following measures can be taken to reduce further the PM<sub>10</sub> and PM<sub>2.5</sub> levels in and around the port area:

- ✓ Renovation work, being carried out at JNP Township, should be executed under controlled conditions like covering the close-by area with mesh cloth to prevent dust flow or using a suction system near the construction area.
- ✓ Maximum use of tar roads.
- ✓ Debris and raw material carrying trucks must be covered with tarpaulin sheet during transportation.
- ✓ Minimizing emissions by regular maintenance and PUC checkup of vehicles.
- ✓ Increasing the plantations in and around the port area as well as developing and maintaining thick green cover on both sides of the roads and tank farms.
- ✓ Cleaning and maintaining of paved and unpaved roads regularly to remove spillage of earth/soil material.
- ✓ Regular sprinkling of water at Construction of 4<sup>th</sup> Container Terminal is required to be done, as significant amount of dust is generated due to earth filling activities at the site.

	
<b>Civil Work at JNP Township</b>	<b>Land Preparation at 4<sup>th</sup> Container Terminal</b>
	
<b>Construction of yard near POC</b>	<b>NSIGT Yard filling work</b>

#### Conclusion:

From the results obtained for the month of March 2016, it can be concluded that overall Ambient Air quality of the JN Port is within CPCB limits, except the levels of PM<sub>10</sub> and PM<sub>2.5</sub>, which are higher at all locations due to port development activities.

## 2. MARINE WATER QUALITY MONITORING [HARBOR & CREEK] INCLUDING STUDY OF SEDIMENT CHARACTERISTICS

### 2.1 INTRODUCTION

For study of Marine ecology, Total 8 fixed harbor stations [W1 to W7 and W9] and 1 movable station [W8/W10] are identified. At Nhava creek 4 fixed stations [W11 to W14] are identified. All above mentioned stations are selected for studying aquatic flora and fauna as well as benthic fauna. The description of stations is mentioned in **Table 9**. The location map of various Marine ecology monitoring stations along with direction of towing is depicted in **Annexure-IV**.

### 2.2 MARINE WATER QUALITY MONITORING METHODOLOGY

The objective of Marine water quality monitoring is to assess compliance with statutory water quality objectives, to reveal long term changes in water quality and to provide a basis for the planning of pollution control strategies.

**Harbor Water Quality Monitoring** – Three samples viz., surface, mid depth and bottom waters are collected and composite for each 1<sup>st</sup>, 3<sup>rd</sup> and 5<sup>th</sup> hour of the tide from eight fixed and one moving stations and composited for each harbor water quality monitoring station. In all 54 samples are collected from nine stations.

**Creek Water Quality Monitoring**– Three samples viz., surface, mid depth and bottom waters are collected and composite from four water quality monitoring stations in the Nhava Creek during the 1<sup>st</sup>, 3<sup>rd</sup> and 5<sup>th</sup> hour of the of the tide. In all 24 Samples are collected from 4 Nhava creek stations.

**Study of Sediment Characteristics** – Sediment samples are collected from all 13 stations.

The list of parameters analyzed to assess the Marine Water Quality is presented in **Table 10** along with parameters monitored for sediment characterization. **Annexure-V** describes Primary Water Quality Criterion for **Class SW-IV** Waters (For Harbor Waters).

**Table 9: Description of Marine Water Quality Monitoring Stations**

Sr. No.	Station	Description	Date of Sampling
1.	W1	Between Elephanta and Nhava Islands, and can be identified at the last green buoy no. <u>F1Green</u> of JNPT approach channel and just opposite to ONGC Depot at the Nhava Island.	16.03.2016
2.	W2	Denoted by buoy no. <u>FG2 RED</u> of JNPT channel. It is near the Elephanta Island, and opposite to Port Craft Jetty	16.03.2016
3.	W3	Identified by the green buoy no. <u>FG2 Green</u> of JNPT approach channel and lies near the landing jetty.	17.03.2016
4.	W4	Located at Uran Patch Beacon (lighthouse on concrete platform) near the Butcher Island filling platform.	17.03.2016
5.	W5	W5 is near to the guide bund and others are along Nhava creek upto Belpada. These are selected to examine the impact of neighboring Nhava Villages and Belpadato the creek water quality.	16.03.2016
	W11 to W14		18.03.2013
6.	W6	This is a mobile station and hence its location is changed during every visit. This sampling station was selected in order to examine the variation of water quality in the area not represented by the fixed stations.	16.03.2016
7.	W7	This station is located near landing jetty. This station was selected in order to examine the water quality due to liquid cargo jetty.	17.03.2016
8.	W9	Located in between GTI and Liquid Cargo Jetty. This station is selected to examine the impact of terminal activities on water qualities	17.03.2016
9.	W8/W10	Located near proposed chemical berth. These stations are variable and selected to examine the impact of proposed chemical terminal and IVth Container terminal activities on water quality.	17.03.2016

**Table 10: List of Parameters Monitored for Marine Water Quality**

Marine Water Quality Parameters [Harbor Area & Creek Area]
<p><b>A] Physical parameters of Water:</b> Depth, Temperature, pH, Salinity, Turbidity, Total Solids, Total Dissolved Solids, Total Suspended Solids, Silica, Phosphate, Sulphate, Nitrite, Nitrate, Calcium, Magnesium, Sodium, Potassium</p> <p><b>B] Bio-chemical Analysis of Water:</b> Dissolved Oxygen, COD [Chemical Oxygen Demand], BOD [Biochemical Oxygen Demand], NH<sub>3</sub>-N, Phenol, Oil &amp; Grease, SPC [Standard Plate Count], Bacteriological count [MPN], Fecal Coliform</p> <p><b>C] Sediment Analysis:</b> Total Organic Matter, Organic Carbon, Inorganic Phosphates</p>

## 2.3 RESULTS

The marine water quality data of nine Harbor water quality monitoring stations, viz., W1 to W7 , W9 & W10 are presented in –

**Table 11** for Physico-chemical parameters,

**Table 12** for Bio-chemical parameters and

**Table 13** for Sediment samples collected at these nine locations.

The creek water quality data for four Nhava creek water quality monitoring stations are reported in –

**Table 14** for Physico-chemical parameters,

**Table 15** for Bio-chemical parameters and

**Table 16** for Sediment samples, collected at these locations.

**Table 11: Results of Physical parameters of Water Samples Collected from JNP Harbor Area during March 2016**

Location	Hour	Depth, [m]	Temp., [°C]	Temp., (Average)	pH	pH (Average)	Salinity, [ppt]	Salinity (Average)
Standard		-	-		6.5 - 9.0	-	-	
W1	1 <sup>st</sup>	Surface	28.5	28.4	7.07	7.27	32.5	31.4
		Middle						
		Bottom						
	3 <sup>rd</sup>	Surface	29.2		7.65		31.4	
		Middle						
		Bottom						
	5 <sup>th</sup>	Surface	27.6		7.09		30.4	
		Middle						
		Bottom						
W2	1 <sup>st</sup>	Surface	26.9	27.6	7.12	7.50	31.4	32.3
		Middle						
		Bottom						
	3 <sup>rd</sup>	Surface	27.8		7.65		32.4	
		Middle						
		Bottom						
	5 <sup>th</sup>	Surface	28.1		7.72		33.2	
		Middle						
		Bottom						
W3	1 <sup>st</sup>	Surface	27.6	28.1	7.72	7.74	32.4	32.7
		Middle						
		Bottom						
	3 <sup>rd</sup>	Surface	28.5		7.69		34.2	
		Middle						
		Bottom						
	5 <sup>th</sup>	Surface	28.1		7.8		31.4	
		Middle						
		Bottom						
W4	1 <sup>st</sup>	Surface	29.0	28.4	7.91	7.89	32.2	31.2
		Middle						
		Bottom						
	3 <sup>rd</sup>	Surface	28.7		7.8		30.3	
		Middle						
		Bottom						
	5 <sup>th</sup>	Surface	27.5		7.92		31.2	
		Middle						
		Bottom						

Sample Name		Depth,	Turbidity,	Turbidity (Average)	TDS,	TDS (Average)	TSS,	TSS (Average)	TS,	TS (Average)
		[m]	[NTU]		[mg/L]		[mg/L]		[mg/L]	
Standard		-	-		-		-		-	
W1	1 <sup>st</sup>	Surface	8.0	13.7	32400	34000	78	85.7	39208	39556
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	15.0		37800		85		39634	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	18.0		31800		94		39825	
		Middle								
		Bottom								
W2	1 <sup>st</sup>	Surface	12.0	15.3	32740	33783	88	97.3	41935	42200
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	15.0		33690		91		40716	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	19.0		34920		113		43949	
		Middle								
		Bottom								
W3	1 <sup>st</sup>	Surface	8.0	11.3	36590	36223	97	95.7	40267	43251
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	10.0		38070		89		46417	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	16.0		34008		101		43068	
		Middle								
		Bottom								
W4	1 <sup>st</sup>	Surface	6.0	9.0	35316	35511	79	76.0	41844	42110
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	9.0		31840		63		39376	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	12.0		39376		86		45111	
		Middle								
		Bottom								

Sample Name		Depth,	Temp.,	Temp., (Average)	pH	pH (Average)	Salinity,	Salinity (Average)
		[m]	[°C]		-	-	[ppt]	
Standard		-	-		6.5 - 9.0		-	
W5	1 <sup>st</sup>	Surface	28.5	29.0	8.12	8.08	33.4	32.1
		Middle						
		Bottom						
	3 <sup>rd</sup>	Surface	30.8		8.22		32.4	
		Middle						
		Bottom						
	5 <sup>th</sup>	Surface	27.6		7.89		30.5	
		Middle						
		Bottom						
W6	1 <sup>st</sup>	Surface	28.7	28.4	7.88	7.87	31.4	32.0
		Middle						
		Bottom						
	3 <sup>rd</sup>	Surface	27.5		7.78		33.4	
		Middle						
		Bottom						
	5 <sup>th</sup>	Surface	29.0		7.96		31.2	
		Middle						
		Bottom						
W7	1 <sup>st</sup>	Surface	27.4	28.5	7.98	7.88	30.4	30.5
		Middle						
		Bottom						
	3 <sup>rd</sup>	Surface	27.8		7.79		30.5	
		Middle						
		Bottom						
	5 <sup>th</sup>	Surface	30.4		7.88		30.6	
		Middle						
		Bottom						
W8	1 <sup>st</sup>	Surface	27.6	28.2	7.72	7.88	31.2	32.0
		Middle						
		Bottom						
	3 <sup>rd</sup>	Surface	28.1		8.01		31.4	
		Middle						
		Bottom						
	5 <sup>th</sup>	Surface	28.8		7.92		33.4	
		Middle						
		Bottom						
W9	1 <sup>st</sup>	Surface	28.4	29.4	7.69	7.80	30.6	32.4
		Middle						
		Bottom						
	3 <sup>rd</sup>	Surface	30.2		7.72		34.0	
		Middle						
		Bottom						
	5 <sup>th</sup>	Surface	28.1		7.98		32.6	
		Middle						
		Bottom						

Sample Name		Depth, [m]	Turbidity, [NTU]	Turbidity (Average)	TDS, [mg/L]	TDS (Average)	TSS, [mg/L]	TSS (Average)	TS, [mg/L]	TS (Average)
Standard		-	-	-	-	-	-	-	-	-
W5	1 <sup>st</sup>	Surface	4.0	7.3	33972	36267	48	49.0	42736	45752
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	8.0		35970		52		48104	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	10.0		38860		47		46417	
		Middle								
		Bottom								
W6	1 <sup>st</sup>	Surface	3.0	6.3	36130	34898	69	76.0	43452	44046
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	6.0		32890		72		41814	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	10.0		35674		87		46872	
		Middle								
		Bottom								
W7	1 <sup>st</sup>	Surface	7.0	9.3	36896	34214	89	91.3	45689	41913
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	10.0		32053		78		40800	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	11.0		33692		107		39251	
		Middle								
		Bottom								
W8	1 <sup>st</sup>	Surface	6.0	11.0	30186	32055	95	94.7	40365	39471
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	12.0		32858		73		38812	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	15.0		33120		116		39237	
		Middle								
		Bottom								
W9	1 <sup>st</sup>	Surface	9.0	12.3	35786	36168	77	84.3	40894	41696
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	12.0		38038		85		42439	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	16.0		34681		91		41756	
		Middle								
		Bottom								

**Table 12: Results of Bio-Chemical Analysis of Water Samples Collected from JNP Harbor Area during March 2016**

Sample Name		Depth,	DO,	DO	COD,	COD	BOD,	BOD	NH <sub>3</sub> -N,	NH <sub>3</sub> -N	
		[m]	[mg/L]	Average	[mg/L]	(Average)	[mg/L]	(Average)	[mg/L]	(Average)	
Standard		-	3.0 mg/L or 40% of saturation value		-		5		-		
W1	1 <sup>st</sup>	Surface	6.0	5.7	27	34	<2.0	<2.0	<1.0	<1.0	
		Middle									
		Bottom									
	3 <sup>rd</sup>	Surface	5.7		49		<2.0		<2.0		<1.0
		Middle									
		Bottom									
	5 <sup>th</sup>	Surface	5.5		26		<2.0		<1.0		
		Middle									
		Bottom									
W2	1 <sup>st</sup>	Surface	6.2	5.8	25	42	<2.0	<2.0	<1.0	<1.0	
		Middle									
		Bottom									
	3 <sup>rd</sup>	Surface	5.8		48		<2.0		<2.0		<1.0
		Middle									
		Bottom									
	5 <sup>th</sup>	Surface	5.4		54		<2.0		<1.0		
		Middle									
		Bottom									
W3	1 <sup>st</sup>	Surface	5.8	5.5	51	36	<2.0	<2.0	<1.0	<1.0	
		Middle									
		Bottom									
	3 <sup>rd</sup>	Surface	5.6		28		<2.0		<2.0		<1.0
		Middle									
		Bottom									
	5 <sup>th</sup>	Surface	5.1		30		<2.0		<1.0		
		Middle									
		Bottom									
W4	1 <sup>st</sup>	Surface	5.9	5.7	53	40	<2.0	<2.0	<1.0	<1.0	
		Middle									
		Bottom									
	3 <sup>rd</sup>	Surface	5.6		28		<2.0		<2.0		<1.0
		Middle									
		Bottom									
	5 <sup>th</sup>	Surface	5.5		39		<2.0		<1.0		
		Middle									
		Bottom									

Sample Name		Depth,	DO,	DO	COD,	COD	BOD,	BOD	NH <sub>3</sub> -N,	NH <sub>3</sub> -N
		[m]	[mg/L]	Average	[mg/L]	(Average)	[mg/L]	(Average)	[mg/L]	(Average)
Standard		-	3.0 mg/L or 40% of saturation value		-		5		-	
W5	1 <sup>st</sup>	Surface	5.8	5.4	54	52	<2.0	<2.0	<1.0	<1.0
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	5.2		49		<2.0		<1.0	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	5.1		54		<2.0		<1.0	
		Middle								
		Bottom								
W6	1 <sup>st</sup>	Surface	5.6	5.3	46	42	<2.0	<2.0	<1.0	<1.0
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	5.4		50		<2.0		<1.0	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	5.0		30		<2.0		<1.0	
		Middle								
		Bottom								
W7	1 <sup>st</sup>	Surface	5.3	5.1	50	44	<2.0	<2.0	<1.0	<1.0
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	5.1		54		<2.0		<1.0	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	4.9		29		<2.0		<1.0	
		Middle								
		Bottom								
W8	1 <sup>st</sup>	Surface	6.6	6.1	26	36	<2.0	<2.0	<1.0	<1.0
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	6.1		48		<2.0		<1.0	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	6.0		35		<2.0		<1.0	
		Middle								
		Bottom								
W9	1 <sup>st</sup>	Surface	6.5	6.0	31	38	<2.0	<2.0	<1.0	<1.0
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	6.3		43		<2.0		<1.0	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	5.9		41		<2.0		<1.0	
		Middle								
		Bottom								

Sample Name		Depth,	Phenol,	Phenol (Average)	O&G,	O & G (Average)	TPC,	TPC (Average)	Fecal Coliforms,	Fecal Coliforms, (Average)		
		[m]	[mg/L]		[mg/L]		[CFU/mL]		[MPN/100 mL]			
Standard		-	-		10		-		500			
W1	1 <sup>st</sup>	Surface	<0.001	<0.001	<4.0	<4.0	52		4			
		Middle										
		Bottom										
	3 <sup>rd</sup>	Surface	<0.001		<4.0		<4.0		-			-
		Middle										
		Bottom										
	5 <sup>th</sup>	Surface	<0.001		<4.0		-				-	
		Middle										
		Bottom										
W2	1 <sup>st</sup>	Surface	<0.001	<0.001	<4.0	<4.0	80		22			
		Middle										
		Bottom										
	3 <sup>rd</sup>	Surface	<0.001		<4.0		<4.0		-			-
		Middle										
		Bottom										
	5 <sup>th</sup>	Surface	<0.001		<4.0		-				-	
		Middle										
		Bottom										
W3	1 <sup>st</sup>	Surface	<0.001	<0.001	<4.0	<4.0	96		30			
		Middle										
		Bottom										
	3 <sup>rd</sup>	Surface	<0.001		<4.0		<4.0		-			-
		Middle										
		Bottom										
	5 <sup>th</sup>	Surface	<0.001		<4.0		-				-	
		Middle										
		Bottom										
W4	1 <sup>st</sup>	Surface	<0.001	<0.001	<4.0	<4.0	78		10			
		Middle										
		Bottom										
	3 <sup>rd</sup>	Surface	<0.001		<4.0		<4.0		-			-
		Middle										
		Bottom										
	5 <sup>th</sup>	Surface	<0.001		<4.0		-				-	
		Middle										
		Bottom										

Sample Name		Depth,	Phenol,	Phenol (Average)	O&G,	O & G (Average)	TPC,	TPC (Average)	Fecal Coliforms,	Fecal Coliforms, (Average)	
		[m]	[mg/L]		[mg/L]		[CFU/mL]		[MPN/100 mL]		
Standard		-	-		10		-		500		
W5	1 <sup>st</sup>	Surface	<0.001	<0.001	<4.0	<4.0	54		<2		
		Middle									
		Bottom									
	3 <sup>rd</sup>	Surface	<0.001		<4.0		-				-
		Middle									
		Bottom									
	5 <sup>th</sup>	Surface	<0.001		<4.0		-				-
		Middle									
		Bottom									
W6	1 <sup>st</sup>	Surface	<0.001	<0.001	<4.0	<4.0	32		6		
		Middle									
		Bottom									
	3 <sup>rd</sup>	Surface	<0.001		<4.0		-				-
		Middle									
		Bottom									
	5 <sup>th</sup>	Surface	<0.001		<4.0		-				-
		Middle									
		Bottom									
W7	1 <sup>st</sup>	Surface	<0.001	<0.001	<4.0	<4.0	64		12		
		Middle									
		Bottom									
	3 <sup>rd</sup>	Surface	<0.001		<4.0		-				-
		Middle									
		Bottom									
	5 <sup>th</sup>	Surface	<0.001		<4.0		-				-
		Middle									
		Bottom									
W8	1 <sup>st</sup>	Surface	<0.001	<0.001	<4.0	<4.0	54		<2		
		Middle									
		Bottom									
	3 <sup>rd</sup>	Surface	<0.001		<4.0		-				-
		Middle									
		Bottom									
	5 <sup>th</sup>	Surface	<0.001		<4.0		-				-
		Middle									
		Bottom									
W9	1 <sup>st</sup>	Surface	<0.001	<0.001	<4.0	<4.0	76		8		
		Middle									
		Bottom									
	3 <sup>rd</sup>	Surface	<0.001		<4.0		-				-
		Middle									
		Bottom									
	5 <sup>th</sup>	Surface	<0.001		<4.0		-				-
		Middle									
		Bottom									

**Table 13: Results of Sediment Samples Collected from JNP Harbour Area during March 2016**

Station Name	Organic Matter		Total Carbon		Inorganic Phosphate mg/kg
	mg/g	%	mg/g	%	
W1	149.2	14.92	69.8	6.98	243
W2	72.1	72.10	43.2	4.32	226
W3	132.5	13.25	74.3	7.43	234
W4	96.6	9.66	69.5	6.95	201
W5	102.4	10.24	40.4	4.04	329
W6	162.8	16.28	87.2	8.72	205
W7	123.5	12.35	53.9	5.39	185
W8	105.9	10.59	72.4	7.24	137
W9	183.1	18.31	78.2	7.82	304

**Table 14: Results of Physico-Chemical Analysis of Water Samples from Nhava Creek Area**

Sample Name		Depth, [m]	Temp., [°C]	Temp., (Average)	pH -	pH (Average)	Salinity, [ppt]	Salinity Average
Standard		-	-	6.5 - 9.0			-	
W11	1 <sup>st</sup>	Surface	28.4	29.0	7.92	7.85	30.9	31.6
		Middle						
		Bottom						
	3 <sup>rd</sup>	Surface	28.6		7.82		31.8	
		Middle						
		Bottom						
	5 <sup>th</sup>	Surface	30.1		7.8		32.2	
		Middle						
		Bottom						
W12	1 <sup>st</sup>	Surface	29.2	29.1	8.02	7.98	33.4	32.9
		Middle						
		Bottom						
	3 <sup>rd</sup>	Surface	28.4		8.01		31.7	
		Middle						
		Bottom						
	5 <sup>th</sup>	Surface	29.8		7.92		33.8	
		Middle						
		Bottom						
W13	1 <sup>st</sup>	Surface	30.5	28.7	7.89	7.87	31.8	30.9
		Middle						
		Bottom						
	3 <sup>rd</sup>	Surface	27.6		7.93		30.7	
		Middle						
		Bottom						
	5 <sup>th</sup>	Surface	28.1		7.8		30.2	
		Middle						
		Bottom						

W14	1 <sup>st</sup>	Surface	30.5	29.8	7.92	7.93	30.7	31.8
		Middle						
		Bottom						
	3 <sup>rd</sup>	Surface	28.6		7.90		31.4	
		Middle						
		Bottom						
	5 <sup>th</sup>	Surface	30.2		7.97		33.2	
		Middle						
		Bottom						

**Table 15: Results of Bio-Chemical Analysis of Water Samples Collected from Nhava Creek**

Sample Name		Depth, [m]	Turbidity, [NTU]	Turbidity Average	TDS, [mg/L]	TDS Average	TSS, [mg/L]	TSS Average	TS, [mg/L]	TS Average
Standard		-	-		-		-		-	
W11	1 <sup>st</sup>	Surface	12.0	15.0	36409	36591	61	91.0	43144	43532
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	15.0		39858		94		45836	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	18.0		33507		118		41615	
		Middle								
		Bottom								
W12	1 <sup>st</sup>	Surface	9.0	11.3	33170	35209	82	92.0	40327	44717
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	11.0		34602		73		46631	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	14.0		37856		121		47192	
		Middle								
		Bottom								
W13	1 <sup>st</sup>	Surface	8.0	11.3	36671	36031	77	87.3	41720	41643
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	10.0		38014		94		43052	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	16.0		33408		91		40158	
		Middle								
		Bottom								
W14	1 <sup>st</sup>	Surface	10.0	13.7	36792	35767	105	94.7	43294	45287
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	13.0		32985		81		44616	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	18.0		37523		98		47951	
		Middle								
		Bottom								

Sample Name		Depth,	DO,	DO	COD,	COD	BOD,	BOD	NH <sub>3</sub> -N,	NH <sub>3</sub> -N
		[m]	[mg/L]	Average	[mg/L]	(Average)	[mg/L]	(Average)	[mg/L]	(Average)
Standard		-	3.0 mg/L or 40% of saturation value		-		5		-	
W11	1 <sup>st</sup>	Surface	5.3	5.1	28	36	<2.0	<2.0	<1.0	<1.0
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	5.1		26		<2.0		<1.0	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	4.8		53		<2.0		<1.0	
		Middle								
		Bottom								
W12	1 <sup>st</sup>	Surface	4.9	4.4	28	32	<2.0	<2.0	<1.0	<1.0
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	4.3		42		<2.0		<1.0	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	4.1		27		<2.0		<1.0	
		Middle								
		Bottom								
W13	1 <sup>st</sup>	Surface	4.8	4.6	43	37	<2.0	<2.0	<1.0	<1.0
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	4.6		32		<2.0		<1.0	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	4.3		37		<2.0		<1.0	
		Middle								
		Bottom								
W14	1 <sup>st</sup>	Surface	4.6	4.2	47	37	<2.0	<2.0	<1.0	<1.0
		Middle								
		Bottom								
	3 <sup>rd</sup>	Surface	4.1		33		<2.0		<1.0	
		Middle								
		Bottom								
	5 <sup>th</sup>	Surface	3.8		30		<2.0		<1.0	
		Middle								
		Bottom								
Bottom										

Sample Name		Depth,	Phenol,	Phenol (Average)	O&G,	O & G (Average)	TPC,	TPC (Average)	Fecal Coliforms,	Fecal Coliforms, (Average)			
		[m]	[mg/L]		[mg/L]		[CFU/mL]		[MPN/100 mL]				
Standard		-	-		10		-		500				
W11	1 <sup>st</sup>	Surface	<0.001	<0.001	<4.0	<4.0	46		4				
		Middle											
		Bottom											
	3 <sup>rd</sup>	Surface	<0.001		<4.0		<4.0		-			-	
		Middle											
		Bottom											
	5 <sup>th</sup>	Surface	<0.001		<4.0		<4.0		-			-	
		Middle											
		Bottom											
W12	1 <sup>st</sup>	Surface	<0.001	<0.001	<4.0	<4.0	57		22				
		Middle											
		Bottom											
	3 <sup>rd</sup>	Surface	<0.001		<4.0		<4.0		-			-	
		Middle											
		Bottom											
	5 <sup>th</sup>	Surface	<0.001		<4.0		<4.0		-			-	
		Middle											
		Bottom											
W13	1 <sup>st</sup>	Surface	<0.001	<0.001	<4.0	<4.0	78		30				
		Middle											
		Bottom											
	3 <sup>rd</sup>	Surface	<0.001		<4.0		<4.0		-			-	
		Middle											
		Bottom											
	5 <sup>th</sup>	Surface	<0.001		<4.0		<4.0		-			-	
		Middle											
		Bottom											
W14	1 <sup>st</sup>	Surface	<0.001	<0.001	<4.0	<4.0	89		10				
		Middle											
		Bottom											
	3 <sup>rd</sup>	Surface	<0.001		<4.0		<4.0		-			-	
		Middle											
		Bottom											
	5 <sup>th</sup>	Surface	<0.001		<4.0		<4.0		-			-	
		Middle											
		Bottom											

**Table 16:** Results of Sediment Samples Collected from Nhava Creek during March 2016

Sample Name	Organic Matter		Total Carbon		Inorganic Phosphate
	mg/g	%	mg/g	%	mg/g
W11	86	8.6	42.3	4.23	192
W12	114	11.4	51.6	5.16	205
W13	92	9.2	46.7	4.67	234
W14	80	8.0	45.7	4.57	143

## 2.4 DISCUSSION

Observed concentration ranges of various parameters for Marine Water of Harbor and Nhava Creek regions are presented in **Tables 17 and 18** respectively. The observed values are compared with Primary Water Quality Criteria for **Class IV Waters** [Harbor Waters] given by CPCB [refer **Annexure V**].

**Table 17:** Observed Concentration Ranges of Marine Water for Various Parameters for JNP Harbor Area

Sr. No.	Parameter	Observed Range	Unit	Prescribed Limits
1	Temperature	26.9 – 30.8	°C	-
2	pH	7.07 - 8.22	-	6.5 - 9.0
3	Salinity	30.3 – 34.0	ppt	-
4	Turbidity	3 – 19	NTU	-
5	TDS	30186 – 39376	mg/L	-
6	TSS	47 – 116	mg/L	-
7	TS	38812 – 48104	mg/L	-
8	DO	4.9 – 6.5	mg/L	3.0 mg/L(min.) or 40% of saturation value
9	COD	25 - 54	mg/L	-
10	BOD	<2.0	mg/L	5 (max.)
11	NH <sub>3</sub> -N	<1.0	mg/L	-
12	Phenol	< 0.001	mg/L	-
13	Oil & Grease	<4.0	mg/L	10 (max.)
14	Total Plate Count	32 – 96	CFU/ml	-
15	Fecal Coliforms	<2- 30	MPN/100 mL	500 (max.)

**Table 18:** Observed Concentration Ranges of Marine Water for Various Parameters for Nhava Creek Area

Sr. No.	Parameter	Observed Range	Unit	Prescribed Limits
1	Temperature	27.6 – 30.5	°C	-
2	pH	7.80 – 8.02	-	6.5 - 9.0
3	Salinity	30.2 – 33.8	ppt	-
4	Turbidity	8 – 18	NTU	-
5	TDS	32985 – 39858	mg/L	-
6	TSS	61 – 121	mg/L	-
7	TS	40158 – 47951	mg/L	-
8	DO	3.8 – 5.3	mg/L	3.0 mg/L(min.) or 40% of saturation value
9	COD	26 – 53	mg/L	-
10	BOD	<2.0	mg/L	5 (max.)
11	NH <sub>3</sub> -N	<1.0	mg/L	-
12	Phenol	< 0.001	mg/L	-
13	Oil & Grease	<4.0	mg/L	10 (max.)
14	Total Plate Count	46 – 89	CFU/ml	-
15	Fecal Coliforms	4 – 30	MPN/100 mL	500 (max.)

It is seen from **Table 17** that, the values of various parameters such as pH, Dissolved Oxygen, BOD, Oil & Grease and Fecal *coliforms* obtained for water samples collected from JNP Harbor area during the month of March , 2016 are within the prescribed limits. Also, the concentration ranges observed for various parameters for water samples collected from Nhava Creek area during March, 2016 are also within prescribed limits.

Observed salinity values for Harbour and Creek water samples in the month of March, 2016 varied from 30.3 – 34.0 ppt and 30.2 – 33.8 ppt respectively [**Tables 11&14**]. The earth filling activity for the development of 4<sup>th</sup> Container Terminal and Dredging works in the region does not seem to be affecting on Marine water Quality. The ranges observed for COD values in mg/L are 25 – 54 and 26 – 53 respectively for Harbour and Creek water samples. The DO levels were found between 4.9 & 6.5 mg/L and 3.8 & 5.3 mg/L for water samples collected from Harbour and Creek areas respectively. The concentrations of Phenol and NH<sub>3</sub> - N were found to be very less in both Harbour and Creek water samples. Bacteriological parameters were also found to be far below the prescribed limits, set for Harbor region.

**Table 13** provides the results obtained for sediment quality parameters for the JNP Harbour samples. The values obtained for Organic Matter, Total Organic Carbon and Inorganic Phosphate varied from 9.66 – 16.28 %, 4.04 – 8.72 % and 137 – 329 mg/kg, respectively. **Table 16** shows the values for Organic Matter, Total Organic Carbon and Inorganic Phosphate as 8.0 to 11.4 %, 4.23 to 5.16 % and 143 – 234 mg/kg, respectively in Nhava Creek sediments during March, 2016.

## 2.5 OBSERVATIONS AND CONCLUSION

- ✓ *Construction of 4<sup>th</sup> Container Terminal on South side of JNPT: Earth Filling work and dredging work of 4<sup>th</sup> C.T. is underway.*
- ✓ *Construction of NSIGT Yard is underway to the North side of JNPT.*

It is seen from the data as reported in **Tables 11 to 18** and subsequently discussed in above paragraphs; all the parameters mentioned comply with prescribed standard limits, as given in Primary Water Quality Criteria for **Class IV Waters** [Harbor Water by CPCB for Physico-Chemical parameters and Bio-Chemical parameters.

### Conclusion:

Considering the activities in the Harbor area and the results obtained for the month of February, 2016, it can be concluded that the Port's working does not affect the Quality of the Marine water. The overall Marine water Quality of the Port's Harbor and Creek waters is in good category.

**3.****MARINE ECOSYSTEM MONITORING****INTRODUCTION:**

The Forty Second Amendment to the Constitution in 1976 underscored the importance of 'green thinking'. Article 48A enjoins the state to protect and improve the environment and safeguard the forests and wildlife in the country. Further, Article 51A (g) states that the "fundamental duty of every citizen is to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

Policy Statement for Abatement of Pollution (1992) has suggested developing relevant legislation and regulation, fiscal incentives, voluntary agreements and educational programs and information campaigns. It emphasizes the need for integration by incorporating environmental considerations into decision making at all levels by adopting frameworks namely, pollution prevention at source, application of best practicable solution, ensure polluter pays for control of pollution, focus on heavily polluted areas and river stretches and involve public in decision-making. The National Conservation Strategy and Policy Statement on Environment and Development, (1992) aimed at "integrating environmental concerns with developmental imperatives to meet the challenges by redirecting the thrust of our developmental process so that the basic needs of our people could be fulfilled by making judicious and sustainable use of natural resources." The priorities mentioned in this policy document include the sustainable use of land and water resources, prevention and control of pollution and preservation of biodiversity.

The National Water Policy, (2002) contains provisions for developing, conserving, sustainable utilizing and managing this important water resources and need to be governed by national perspectives.

**MARINE ENVIRONMENT:**

On national and state levels, we have several policies and regulation like Water (Prevention and Control of Pollution) Act, 1974, to regulate pollution discharges and restore water quality of our aquatic resources including the prescription of monitoring activities. One of the important provisions of the Water Act, 1974, is to maintain and restore the 'wholesomeness' of our aquatic resources. Water quality monitoring is one of the first steps required in the rational development and management of water resources. In the field of water quality management, there has been a steady evolution in procedures for designing system to obtain information on the changes of water quality. The monitoring comprises all activities to obtain 'information' with respect to the water system.

### **Sampling Stations:**

The monitoring of marine environment for the study of biological and ecological parameters was done on 25th and 26th January-2016 in harbour regions of JNPT and on 27th February -2016 in Nhava Creek during Spring tide period of Third quarter of Lunar Cycle. The surface water samples were collected by a water sampler from nine water quality monitoring stations described in Table 9 of JNP harbour area (viz., W1, W2, W3, W4, W5, W6, W7, W9 and W10) and four stations (W11, W12, W13 and W14) in Nhava Creek for the estimation of phytoplankton, zooplanktons density and their population. The list of parameters analyzed to assess the Marine Ecology is presented in Table 19 along with parameters monitored for sediment characterization. Annexure-VI describes recommended ranges of the Ecological parameters for Arabian Sea.

### **METHODOLOGY:**

#### **Sampling methodology adopted:**

A marine sampling is an estimation of the body of information in the population. The theory of the sampling design is depending upon the underlying frequency distribution of the population of interest. The requirement for useful water sampling is to collect a representative sample of suitable volume from the specified depth and retain it free from contamination during retrieval.

Niskin sampler was used to sample sea water from the sub surface, These bottles are non-metallic, free-flushing sampler recommended for general purpose water sampling. During the sampling this plastic cylinder, was lowered to the desired depth with both ends open. Closure of the cylinder was usually triggered by a mechanical messenger. In Niskin sampler, top and bottom cap are held open by a clamp against the tension of a rubber string connecting the through the cylinder. The action of the messenger release clamp and caps are pulled into a position closing off top and bottom of the cylinder by retaining the water column in the cylinder from the depth and time of closure. This water can be retrieved without any contamination from the upper lying water column.

50 liters of the water sample were collected from Sub surface by using Niskin sampler. The collected samples were first collected in a clean bucket to reduce the heterogeneity. From the collected water sample 1 liter of water sample were taken in an opaque plastic bottle for chlorophyll estimation. Quantitative Plankton samples were collected by filtering rest of the water sample using plankton net of 20µm mesh size.

#### **Samples Processing for chlorophyll estimation:**

Samples for the chlorophyll estimation were preserved in ice box on board in darkness to avoid degradation in opaque container covered with aluminium foil. Immediately after reaching the shore after sampling, 1 liter of collected water sample was filtered through GF/F filters (pore size 0.45 µm) by using vacuum filtration assembly. After

vacuum filtration the glass micro fiber filter paper was grunted in tissue grinder, macerating of glass fiber filter paper along with the filtrate was done in 90% aqueous Acetone in the glass tissue grinder with glass grinding tube. Glass fiber filter paper will assist breaking the cell during grinding and chlorophyll content was extracted with 10 ml of 90% Acetone, under cold dark conditions along with saturated magnesium carbonate solution in glass screw cap tubes. After an extraction period of 24 hours, the samples were transferred to calibrated centrifuge tubes and adjusted the volume to original volume with 90% aqueous acetone solution to make up the evaporation loss. The extract was clarified by using centrifuge in closed tubes. The clarified extracts were then decanted in clean cuvette and optical density was observed at wavelength 630, 664, 665 nm. By using corrected optical density, Chlorophyll-a value was calculated as given in (APHA, 1998). The extract of pigments was then measured by spectrophotometer at wavelength of 750 nm and 664 nm before acidification and at 665 nm after acidification by 0.1ml of 0.1N HCl.

## **PLANKTON:**

The entire area open water in the sea is the pelagic realm. Pelagic organisms live in the open sea. In contrast to the pelagic realm, the benthic realm comprises organisms and zone of the bottom of the sea. Vertically the pelagic realm can be dividing into two zones based on light penetration; upper photic or euphotic zone and lower dark water mass, aphotic zone below the photic zone.

The term plankton is general term for organisms have such limited powers of locomotion that they are at the mercy of the prevailing water movement. Plankton is subdivided to phytoplankton and zooplankton. Phytoplankton is free floating organisms that are capable of photosynthesis and zooplankton is the various free floating animals.

## **Phytoplankton:**

The phytoplankton includes a wide range of photosynthetic and phototrophic organisms. Marine phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are diatoms (Bacillariophyceae) and dinoflagellates (Dinophyceae). The phytoplankton those normally captured in the net from the creek near JNPT is normally dominated by these two major groups; diatoms and dinoflagellates. Very less number of phytoplankton was encountered in the sampling conducted during 16th to 17th March 2016 in Harbour area. The samples conducted from the Nahva creek during 18th March 2016 characterised by large representation of two diatoms; Pluerosogmasp and Gyrosigmasp,

## **Zooplankton:**

Zooplankton can be subdivided into holoplankton, i.e., permanent members of the plankton (e.g., Calanoid copepods), and meroplankton, i.e., temporary members in the plankton e.g., larvae of fish, shrimp, and crab). The meroplankton group consists of larval and young stages of animals that will adopt a different lifestyle once they mature. In contrast to phytoplankton which consist of a relatively smaller variety of organisms, Zooplankton are extremely divers, consist of a host of larval and adult forms representing many animal phylum.

Among the zooplankton two group always dominate than others; they are the members of sub class copepods (Phylum Athropoda), and Tintinids (Phylum Protozoa) among the net planktons. These small animals are of vital importance in marine ecosystem as one of the primary herbivores animals in the sea, and it is they provide vital link between primary producer (autotrophs) and numerous small and large marine consumers.

## **Spatial distribution of Plankton:**

A characteristic of plankton population is that they tend to occur in patches, which are varying spatially on a scale of few meters to far as few kilometres in distance. They also vary in time scale, season as well as vertically in the water column. It is this patchiness and its constant changes in time and spot, that has made it so difficult for plankton biologist to learn about the ecology of plankton. The biological factors that causes this patchiness is due to the ability of zooplankton to migrate vertically and graze out the phytoplankton at a rapid rate that can create patchiness. Similarly the active swimming ability by certain zooplankton organisms can cause to aggregate in dense group.

At its most extreme, because the water in which plankton is suspended is constantly moving, each sample taken by the plankton biologists remain a different volume of water, so each sample is unique and replicate does not exist.

Plankton may also exhibit vertical patchiness. Physical factors contribute to this type of patchiness include light intensity, nutrients and density gradients in the water column. Phytoplankton in particular tends to be unequally distributed vertically, which leads to the existence of different concentration of a chlorophyll value between photic zone and below the photic zone.

## **Methodology adopted for Plankton sampling:**

Mixed plankton sample for qualitative evaluation were obtained from the sub surface layer at each sampling locations by towing the net horizontally with the weight .After the tow of about 15-20minutes at speed of 1-1.5 m/s, plankton net was pulled up and washed down to the tail and collected the plankton adhered to plankton net in the collection bucket at the bottom by springing outer and inner surface of the net with sea

water, while the net was hanging with the mouth upward. As already mentioned for quantitative evaluation 50 L water samples were collected from subsurface layer and filtered through 20 $\mu$ m mesh size net assembly.

### **Preservation and storage:**

Both filtered plankton and those collected from the plankton net were preserved with 5% buffered formalin and stored in 1L plastic container for further processing in the laboratory.

### **Sample concentration:**

The collected plankton samples were concentrated by using centrifuge and made up to 50 ml with 5% formalin -Glycerine mixture.

### **Taxonomic evaluation:**

Before processing, the sample was mixed carefully and a subsample was taken with a calibrated Stempel-pipette. 1 ml of the concentrated plankton samples were transferred on a glass slide with automatic pipette. The plankton sample on the glass slides were stained by using Lugol's iodine and added glycerine to avoid drying while observation. The plankton samples were identified by using Labex triangular Research microscope with photographic attachment. Microphotographs of the plankton samples were taken for record as well as for confirming the identification. The bigger sized zooplankton was observed through dissecting stereomicroscope with magnification of 20-30 x. Plankton organisms in the whole slide were identified to the lowest taxon possible. A thorough literature search was conducted for the identification of the different groups of zooplankton that were encountered

### **Cell counts by drop count method:**

The common glass slide mounted with a 1ml of concentrated phytoplankton/zooplankton sample in glycerol and covered with cover slip 22x 60mm was placed under the compound microscope provided with a mechanical stage. The plankton was then counted from the microscopic field of the left top corner of the slide. Then slide is moved horizontally along the right side and plankton in each microscopic field was thus counted. When first microscopic field row was finished the next consecutive row was adjusted using the mechanical device of the stage. In this way all the plankton present in entire microscopic field are counted.

From this total number in 1ml of the concentrated plankton, total number of plankton in the original volume of sample filtered was calculated as units/L.

## **BENTHIC ORGANISMS:**

Benthos is those organisms that are associated with the sea bed or benthic habitats. Epibenthic organisms live attached to a hard substratum or rooted to a shallow depth below the surface. In fauna organisms live below the sediment–water interface. Interstitial organisms live and move in pore water among sedimentary grains.

Because the benthic organisms are often collected and separated on sieves, a classification based on the overall size is used. Macro benthos include organisms whose shortest dimension is greater than or equal to 0.5 mm. Meio benthos are smaller than 0.5mm but larger than 42 $\mu$  in size.

The terms such as macro fauna and Meio fauna generally have little relevance with taxonomic classification. The terms Meio fauna and macro fauna depend on the size. Meio fauna were considered as good bioassay of community health and rather sensitive indicators of environmental changes

### **Sample sieving:**

Sediments samples were sieved to extract the organisms. Sieving was performed carefully as possible to avoid any damage to the animals. The large portion of the sediment was split in to smaller portions and mixed with sea water in a bucket. The cohesive lumps were broken down by continuous stirring. The disaggregated sediments were then passed through the sieves.

### **Sample staining:**

Sorting of the Meio fauna from the sieve is difficult task especially in the preserved material, because organisms are not easily detectable. To facilitate the animal detection the entire sample retained on the sieve after sieving operation were stained by immersing the sieve in a flat bottom tub with 1% Rose Bengal stain; a protein stain. A staining period of 10-30 minutes is sufficient for sample detection.

## **RESULTS:**

### **CHLOROPHYLL - a & PHEOPHTIN-A**

The chlorophyll sample was collected from sub surface layer during st hour and #rd hour nad 5<sup>th</sup> hour of the tidal cycle and composite was made for each sampling locations and analysed for Chlorophyll a and after acidification for Pheophytin –a. Chlorophyll- a value was used as algal biomass indicator (APHA 1998) Algal biomass was estimated by converting Chlorophyll –a content by factor of 67. The chlorophyll-in the sampling station was comparatively low, due the very low representation by phytoplankton. Chlorophyll-a was varying from 0.644-2.457 mg/M<sup>3</sup>. Pheophytin –a level was below detectable limit in the all 13 sampling stations during sampling done in March 2016( Table – 24b).

## **PRODUCTIVITY ESTIMATION, OXYGEN METHOD:**

Productivity is defined as the rate at which inorganic carbon is converted to an organic form. Chlorophyll-bearing organisms (phytoplankton, periphytons,) serves as primary producers in the aquatic food chains. Photosynthesis ultimately results in the formation of a wide range of organic compounds, release of oxygen and reduction of Carbon dioxide (CO<sub>2</sub>) in the surrounding waters. Primary Productivity can be determined by measuring the changes in the Oxygen and CO<sub>2</sub> concentration. There are two methods of measuring the rate of carbon uptake and net photosynthesis in situ , Oxygen method and the Carbon 14 method. In both methods, clear(light) and darkened(Dark) bottles are filled with water samples and suspended at particular depth for an incubation period of several hours or samples are incubated under controlled conditions in chambers in the laboratory.

The chief advantages of the Oxygen method are that it provides estimates of gross and net productivity and respiration and those analyses can be performed with inexpensive laboratory equipment and common reagents. The dissolved oxygen (DO) concentration is determined at the beginning and end of the incubation period. Productivity is calculated on the assumption that one atom of carbon is assimilated for each molecule of oxygen released.

### **Methodology:**

Depth of euphotic zone was determined (region that receives surface illumination) with a Secchi disc. Three BOD bottles were filled with the water collected from the desired depth. Used water from the same grab sample to fill a "set" (one light, one dark and one initial bottle). One of the BOD bottle was fixed for DO estimation immediately after the collection to measures oxygen concentration by titration after words. Kept all the samples out of direct sunlight during handling. The remaining two BOD Bottles (One light and one dark ) with Introduced samples taken from each preselected depth were submerged in the same photic zone in the water for at least two hours, but never longer than it takes for oxygen –gas bubbles to form in the clear bottles or DO to be depleted in the dark bottles. At the end of the exposure period, DO in the BOD bottles ( light and dark) were fixed immediately determine DO. The increase in oxygen concentration in

the light bottle during incubation is a measure of net production which, because of the concurrent use of oxygen in respiration, is somewhat less than the total (or gross) production. The loss of oxygen in the dark bottle is used as an estimate of total plankton respiration,

Calculated the gross or net production for each incubation depth and plot by using the formula ,  $\text{mg carbon fixed/m}^3 = \text{mg oxygen released/L} \times 12/32 \times 1000\text{L/m}^3 \times K$ , where  $K$  is the photosynthetic quotient (PQ), ranging from 1 to 2 , depending on the nitrogen supply. The factor 12/32 was used to convert oxygen to carbon because under ideal conditions 1 mole of  $\text{O}_2$  (32g) is released for each mole of carbon (12 g) fixed. Productivity is defined as the rate of production and generally is reported in grams carbon fixed per sq. meter per day. (APHA, 1999).

#### PRODUCTIVITY IN THE COMPOSITE SAMPLES FROM SAMPLING STATIONS IN JNP HARBOUR AREA AND NHAVA CREEK

Tide	Sampling Station	Net Productivity ( mg carbon fixed/m <sup>3</sup> )
JNP HARBOUR AREA	W1	225.0
	W2	187.5
	W3	375.0
	W4	750.0
	W5	262.5
	W6	450.0
	W7	412.5
	W8	450.0
	W9	412.5
NHAVA CREEK	W11	450.0
	W12	150.0
	W13	112.5
	W14	112.5

#### PHYTOPLANKTON POPULATION:

For the evaluation of the Phytoplankton population in JNPT harbour area within the immediate surroundings of the port sampling was conducted from 13 sampling locations (Nine in harbour area and four in the Nhava Creek). The phytoplankton community of the sub surface water in the harbour and Nhava creek was represented by mainly two groups, Diatoms and Dinoflagellates; Diatoms were represented by 9

genera belongs to 2 classes, 5 orders, and 6 families. Dinoflagellates were represented by 6 genera, belongs to 1 class, 2 order and 4 families. Phytoplankton of the sampling stations at sub surface layer was varying from 62-114 units/ L in harbour area and 102-143 units/ L in Nhava creek.

**Table 19: List of Parameters to Monitor For Marine Ecology**

**Marine Ecology Parameters [Harbor Area & Creek Area]**

**A] Aquatic Flora & Fauna:**

Primary Productivity (Net & Gross), Phytoplankton Diversity: Population Density, Species Identification, Relative Abundance, Zooplankton Diversity: Population Density, Species Identification, Relative Abundance, Chlorophyll-a, Pheophytin-a, Secchi Depth

**B] Benthic Fauna:**

Species Identification & Density

**C] Nutrients Analysis in Water:**

Anions: Silicates,  $PO_4^{3-}$  - P,  $SO_4^{2-}$ ,  $NO_2^-$  - N,  $NO_3^-$  - N,

Cations:  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $Na^+$ ,  $K^+$

**D] Nutrient Analysis in Sediment :**

Anions: Silicates,  $PO_4^{3-}$  - P,  $SO_4^{2-}$ ,  $NO_2^-$  - N,  $NO_3^-$  - N,

Cations:  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $Na^+$ ,  $K^+$

**Table 20: Phytoplankton variations in abundance , No. Of species and diversity in composite samples from sampling stations in JNP harbour area and Nhava creek**

Tide	Sampling Station	Sub Surface water		
		Abundance In units/L	No of Species observed / total species	Diversity %
JNP HARBOUR AREA	W1	32	6/12	50
	W2	36	6/12	50
	W3	42	7/12	58.3
	W4	34	10/12	83.3
	W5	26	6/12	50
	W6	20	4/12	33.3
	W7	34	5/12	41.6
	W8	28	5/12	41.6
	W9	22	4/12	33.3
NHAVA CREEK	W11	38	6/12	50
	W12	30	6/12	50
	W13	32	5/12	41.6
	W14	36	6/12	50

**Table 21:** Abundance of phytoplankton in JNP harbour area and Nhava creek

Location	Surface		No of Sampling location	Group of phytoplankton	Range in Units/L
JNP HARBOUR AREA	Sub surface mid depth Bottom	I <sup>st</sup> hour III <sup>rd</sup> Hour and V <sup>th</sup> Hour	9	DIATOMS	20-38
				DINO FLAGELLATES	0-6
				TOTAL PHYTO PLANKTON	20-42
NHAVA CREEK	Sub surface	III <sup>rd</sup> Hour	4	DIATOMS	30-38
				DINO FLAGELLATES	0
				TOTAL PHYTO PLANKTON	30-38

#### ZOOPLANKTON POPULATION:

Zooplankton sample was collected from the sub surface layer during highest high tide period in 9 different sampling locations JNP harbour area and four locations in Nhava Creek. Zooplankton community was represented by four groups of plankton; Tintinids, Copepods, Mysids Decapoda, Urochordata Arrow worms, Ctenophores, Polychaete worms and larval forms of Copepods, Brachurian larvae, Trachophore larvae, and Bivalve larvae. Among these holoplankton of this region; Copepods were the most dominant group followed by Mysids and decapoda members. Tintinids which were dominant in the February 2016 was represented by only one species in March 2016, The Nauplius Larvae and Zoea larvae were also dominated the net plankton at all the sampling locations. During this sampling run, Trachophore larvae of Polychaete was observed in its various growing stage. The zooplankton density was varying from 158-200 No/L In Harbour area and 134-150 No/L in Nhava Creek.

**Table 22: Zooplankton variation in abundance , No. Of species and diversity in sub surface water in JNP harbour area and Nhava creek**

Tide	Sampling Station	Sub Surface water		
		Abundance In No /L	No of Species/groups observed /total species/group	Diversity %
JNP HARBOUR AREA	W1	200	26/30	86.6
	W2	176	24/30	80
	W3	161	23/30	76.6
	W4	172	23/30	76.6
	W5	183	23/30	76.6
	W6	158	24//30	80
	W7	168	23/30	76.6
	W8	199	25/30	83.3
	W9	187	22/30	73.3
NHAVA CREEK	W11	134	20/30	66.6
	W12	150	20/30	66.6
	W13	136	21/30	70.0
	W14	150	22/30	73.3

**Table 23: Abundance of zooplankton in Sub Surface water of JNP harbour and Nhava creek**

Tide	Surface		No of Sampling locations	Group of Zooplankton	Range in No/L
JNP HARBOUR AREA	Sub surface mid depth Bottom	Ist hour III <sup>rd</sup> Hour and V <sup>th</sup> Hour	9	Tintinids	0-4
				Copepods	108-132
				Mysids	0-4
				Decapoda	4-14
				Urochordata	0-2
				Arrow worms	2-6
				Ctenophores	0-2
				Polychaete worms	0-2
				Larval forms	36-58
				<b>TOTAL ZOOPLANKTON NO/L</b>	<b>158-200</b>

<b>NHAVA CREEK</b>	Sub surface	III <sup>rd</sup> Hour	4	Tintinids	2-4
				Copepods	68-84
				Mysids	0
				Decapoda	0-6
				Urochordata	2-4
				Arrow worms	2-4
				Ctenophores	0
				Polychaete worms	0
				Larval forms	50-62
				<b>TOTAL ZOOPLANKTON NO/L</b>	<b>134-150</b>

**Table 24a:** Systematic account of phytoplankton in the sampling locations in JNP harbour area and Nhava creek

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/ SPECIES	#
<b>DIATOMS</b>	<b>Bacillariophyta</b>	<b>Coscinodiscophyceae</b>	Coscinodiscales	Coscinodiscaceae	<i>Coscinodiscusp.</i>	D1
			Thalassiosirales	Skeletonemataceae	<i>Skeletonemas</i>	D2
				Thalassiosiraceae	<i>Thalassiosiras</i>	D3
		Biddulphiophycidae	Biddulphiales	Biddulphiaceae	<i>Biddulphia</i> sp.	D4
		Chaetocerotophycidae	Chaetocerotales	Chaetocerotaceae	<i>Chaetoceros</i>	D5
		Bacillariophycidae	Naviculales	Naviculaceae	<i>Navicula</i> sp.	D6
				Pleurosigmataceae	<i>Pleurosigma</i> sp.	D7
			Bacillariales	Bacillariaceae	<i>Gyrosigma</i>	D8
					<i>Bacillaria</i> sp.	D9
		Fragilariophycidae	Fragilariales	Fragilariaceae	<i>Nitzschia</i>	D10
					<i>Synedra</i> sp.	D11
<b>DINO FLAGELLATES</b>	<b>Pyrrophyta</b>	Fragilariophycidae	Peridinales	Protoperidiniaceae	<i>Protoperidinium</i> sp.	F1

**Table 24b:** Chlorophyll-a & Pheophytin-a and Algal Bio mass in composite samples in JNP Harbor and Nhava Creek sampling Locations

Sr.No.	Station	Chlorophyll-a (mg/m <sup>3</sup> )	Pheophytin- a (mg/m <sup>3</sup> )	Algal Biomass (Chlorophyll method)mg/m <sup>3</sup>
JNPHARBOUR AREA				
1	W1	0.644	BDL	43.15
2	W2	0.952	BDL	63.78
3	W3	0.22	BDL	14.74
4	W4	0.219	BDL	14.67
5	W5	0.952	BDL	63.78
6	W6	0.951	BDL	63.72
7	W7	1.243	BDL	83.28
8	W8	1.259	BDL	84.35
9	W9	0.220	BDL	14.74
NHAVA CREEK				
10	W11	0.425	BDL	28.475
11	W12	0.967	BDL	64.79
12	W13	2.457	BDL	164.6
13	W14	2.209	BDL	148.00

BDL- Below Detection Limit

**Table 25;** Quantitative evaluation of marine phytoplankton in the composite samples in JNP harbour area and Nhava creek

#	GENUS/SPECIES	ABUNDANCE IN UNITS/CELLS / L OF MARINE WATER FROM DIFFERENT SAMPLING STATIONS													
		JNP HARBOUR AREA									NHAVA CREEK				
		W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 11	W 12	W 13	W 14	
	DIATOMS														
D1	<i>Coscinodiscusmarginatus</i>	8	4	6	10	8	10	12	8	10	8	2	8	4	
D2	<i>Skeletonemasp</i>	2	4	6	4	2	0	0	0	4	2	2	0	0	
D3	<i>Thalassiosirasp</i>	0	0	4	0	6	0	0	0	0	0	0	0	0	
D4	<i>Biddulphia</i>	4	6	4	4	2	0	12	10	4	4	2	2	4	
D5	<i>Chaetoceros</i>	0	4	2	0	2	2	0	2	0	0	0	0	0	
D6	<i>Naviculasp.</i>	12	8	4	4	0	6	2	0	0	4	4	6	4	
D7	<i>Pleurosigma sp.</i>	0	0	0	0	0	2	0	0	0	12	16	14	16	
D8	<i>Gyrosigma</i>	0	0	0	0	0	0	0	0	0	8	4	2	6	
D9	<i>Bacillaria sp.</i>	4	6	4	2	0	0	4	6	4	0	0	0	0	
D10	<i>Nitzschia</i>	2	0	4	4	0	0	4	2	0	0	0	0	2	
D11	<i>Synedra sp.</i>	0	4	4	0	6	0	0	0	0	0	0	0	0	
	DIATOMS TOTAL UNITS/L	32	36	38	28	26	20	34	28	22	38	30	32	36	
DINO FLAGELLATES															
F1	<i>Dinophysis sp.</i>	0	0	4	6	0	0	0	0	0	0	0	0	0	
	DINOFLAGELLATES TOTAL UNITS/ L	0	0	4	6	0	0	0	0	0	0	0	0	0	
	TOTAL PHYTOPLANKTON UNITS/L	32	36	42	34	26	20	34	28	22	38	30	32	36	

**TABLE 26: Systematic account of zooplankton from the sampling locations in JNP harbour area and Nhava creek**

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#
TINTINIDS	PROTOZOA (CILIOPHORA)	SPIROTRICH EA	TINTINNIDA	Codonellidae	<i>Tintinnopsisacuminata</i>	
COPEPODS	ARTHROPODA CRUSTACEA	SUB CLASS COPEPODA	CALANOIDA	Calanidae	<i>Canthocalanus</i> sp	C1
					<i>Cosmocalanusdarwinii</i>	C2
				Aetideidae	<i>Euchirellaamoena</i>	C3
				Paracalanidae	<i>Acrocalanus</i>	C4
				Eucalanidae	<i>Subeucalanus</i>	C5
				Clausocalanidae	<i>Clausocalanus minor</i>	C6
				Euchaetidae	<i>Euchaeta</i>	C7
				Centropagidae	<i>Centropages</i> sp.	C8
				Pontellidae	<i>Labidocera</i>	C9
					<i>Pontellopsis</i>	C10
				Acartiidae	<i>Acartia</i>	C11
					<i>Acartiella</i>	C12
			Cyclopoida	Oithonidae	<i>Oithona</i> sp.	C13
			Harpacticoida	Euterpinae	<i>Euterpina</i> sp.	C14
				Clytemnestridae	<i>Clytemnestra scutellata</i>	C15
Mysids	ARTHROPODA CRUSTACEA	Malacostraca	Mysida	Mysidae,	Mysid shrimp	M1
Decapoda	ARTHROPODA CRUSTACEA	Malacostraca	Decapoda	Penaeidae	<i>Metapenaeus</i> sp	D1
				Solenoceridae	<i>Solenoceracrassicornis</i>	D2
				Luciferidae	<i>Lucifers</i> sp	D3
				Oplophoridae	<i>Acanthephyra</i> sp.	D4
UROCHORDA TA	CHORDATA SUB PHYLUM UROCHORDATA	APPENDICUL ARIA		FRITILLARIIDAE	<i>Fritillaria</i> sp.	U1
ARROW WORMS	CHAETOGNATH A	SAGITTOIDEA	APHRAGMOP HORA	SAGITTIDAE	<i>Sagitta</i> sp.	A1
Ctenophores	Ctenophora				<i>Pleurobrachia</i> sp.	C1
Polychaete worms	Annelida			Tomopteridae	<i>Tomopteris</i> sp.	P1
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	COPEPODA	-	-	Nauplius larvae of Copepods	L1
Brachyuraian LARVAE	ARTHROPODA CRUSTACEA	DECAPODA (BRACHYUR A)			Zoea Larvae	L2
Cirripedes larvae		Cirripedia			Cirripede Nauplius	L3
POLYCHATE LARVAE					Trachophore larvae	L4
Bivalve larvae	Mollusca	Pelcypoda			Bivalve larvae	L5

**TABLE 27: Quantitative evaluation of marine zooplankton in the sampling locations in JNP harbour area and Nhava creek**

#	GENUS/SPECIES	ABUNDANCE IN No / L OF MARINE WATER FROM DIFFERENT SAMPLING STATIONS													
		JNP HARBOUR AREA									NHAVA CREEK				
		W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 11	W 12	W 13	W 14	
TINTINIDS															
T1	<i>Tintinnopsistocantinen sis</i>	2	0	4	2	2	0	3	4	0	2	4	4	2	
	TINTINIDS TOTAL NO/L	2	0	4	2	2	0	3	4	0	2	4	4	2	
COPEPODS															
C1	<i>Canthocalanus</i> sp	8	6	4	2	2	8	10	6	4	2	8	4	4	
C2	<i>Cosmocalanus</i> darwinii	24	32	20	18	16	20	24	28	32	12	8	10	14	
C3	<i>Euchirella</i> amoena	8	10	6	10	8	4	4	2	4	0	0	0	0	
C4	<i>Acrocalanus</i>	8	4	10	12	8	6	4	8	7	6	4	2	2	
C5	<i>Subeucalanus</i>	2	4	6	4	2	0	6	5	4	0	0	0	0	
C6	<i>Clausocalanus</i> minor	20	18	10	17	22	12	18	16	14	10	12	8	10	
C7	<i>Euchaeta</i>	4	0	0	2	0	2	0	2	0	0	0	0	0	
C8	<i>Centropages</i> sp.	12	10	18	10	8	14	6	12	16	8	12	8	10	
C9	<i>Labidocera</i>	4	2	0	4	2	0	0	4	6	4	8	4	2	
C10	<i>Pontellopsis</i>	4	0	2	2	6	4	0	2	2	4	0	2	0	
C11	<i>Acartia</i>	8	6	5	4	2	8	6	10	4	6	8	4	2	
C12	<i>Acartiella</i>	4	2	0	0	6	4	2	8	6	0	4	2	6	
C13	<i>Oithona</i> sp.	6	4	2	2	4	6	8	4	2	8	10	12	16	
C14	<i>Euterpina</i> sp.	12	10	16	9	15	14	18	12	10	6	4	2	6	
C15	<i>Clytemnestra scutellata</i>	8	6	10	8	14	6	4	10	8	2	6	10	8	
	COPEPODS Total NO/L	132	114	109	104	115	108	110	129	119	68	84	68	80	
Mysids															
M1	Mysid shrimp	2	0	2	0	4	0	0	2	0	0	0	0	0	
	Mysids Total N/L	2	0	2	0	4	0	0	2	0	0	0	0	0	
Decapods															
D1	<i>Metapenaeus</i> sp	4	2	2	0	4	2	4	2	6	0	0	0	0	
D2	<i>Solenoceracrassicornis</i>	4	2	0	0	4	2	0	0	0	2	4	2	0	
D3	<i>Lucifers</i> sp	0	4	2	0	0	2	0	0	0	0	0	0	0	
D4	<i>Acanthephyra</i> sp.	4	6	2	2	0	4	5	2	6	4	2	2	0	
	Decapoda Total N/L	12	14	6	2	8	10	9	4	12	6	6	4	0	
UROCHORDATA															
U1	<i>Fritillaria</i> sp.	0	2	0	0	0	0	0	0	0	2	4	2	2	
	Urochordata Total N/L	0	2	0	0	0	0	0	0	0	2	4	2	2	
ARROW NORMS															
A1	<i>Sagitta</i> sp.	4	2	2	6	4	4	4	2	6	4	2	2	4	
	ARROW WORMS Total No/L	4	2	2	6	4	4	4	2	6	4	2	2	4	
Ctenophores															
	<i>Pleurobrachia</i> sp.	0	2	0	2	0	0	2	0	0	0	0	0	0	
	Ctenophores Total N/L	0	2	0	2	0	0	2	0	0	0	0	0	0	
Polychaete worms															

<i>Tomopteris sp.</i>	0	2	0	2	0	2	2	0	0	0	0	0	0
<b>Polychaete worms total N/L</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>LARVAL FORMS</b>													
L1 Nauplius larvae of Copepods	8	12	10	16	12	8	16	12	10	14	12	16	20
L2 Zoea Larvae	22	18	14	24	20	16	12	22	24	16	18	20	18
L3 Cirripede Nauplius	6	4	2	8	6	4	2	8	6	12	8	10	16
L4 Trachphore larvae	4	0	2	2	0	0	2	4	2	0	0	0	0
L5 Molluscan larvae	8	6	10	4	12	8	6	12	8	10	12	10	8
<b>Larval forms total no/l</b>	<b>48</b>	<b>40</b>	<b>38</b>	<b>54</b>	<b>50</b>	<b>36</b>	<b>38</b>	<b>58</b>	<b>50</b>	<b>52</b>	<b>50</b>	<b>56</b>	<b>62</b>
<b>TOTAL ZOOPLANKTON NO/L</b>	<b>200</b>	<b>176</b>	<b>161</b>	<b>172</b>	<b>183</b>	<b>158</b>	<b>168</b>	<b>199</b>	<b>187</b>	<b>134</b>	<b>150</b>	<b>136</b>	<b>150</b>
<b>Biomass by displacement ml/m3</b>	<b>0.22</b>	<b>0.10</b>	<b>0.15</b>	<b>0.15</b>	<b>0.16</b>	<b>0.12</b>	<b>0.10</b>	<b>0.20</b>	<b>0.17</b>	<b>0.15</b>	<b>0.12</b>	<b>0.15</b>	<b>0.18</b>

### BENTHIC ORGANISMS:

The benthic organism collected along with sediments by using the Vanveen grabs were represented by two groups macro benthic organisms, Polychaetes and Molluscs, their number was varying from 110-290 No/M<sup>2</sup> ( Table – 28)

**TABLE 28:** Abundance of benthic Fauna in sampling locations in JNP harbour area and Nhava creek

	ABUNDANCE IN NO/M <sup>2</sup> DIFFERENT SAMPLING STATIONS												
	REPRESENTATION BY GROUP												
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W11	W12	W13	
<b>POLYCHATES</b>													
<b>Family : Nephtyidae <i>Nephtys sp.</i></b>	10	0	20	60	40	40	0	60	20	40	20	0	
<b>Family : Nereidae <i>Nereis sp.</i></b>	20	10	40	40	70	20	40	20	60	40	20	60	
<b>Total Polychates N/m<sup>2</sup></b>	30	10	60	100	110	60	40	80	80	80	40	60	
<b>GASTROPODA( Molluscs)</b>													
<i>Architectonica sp.</i>	20	0	10	10	0	20	20	0	0	0	0	0	
<b>Total gastropods N/m<sup>2</sup></b>	20	0	10	10	0	20	20	0	0	0	0	0	
<b>TOTAL macro Benthic Fauna NUMBER/ m<sup>2</sup></b>	50	10	70	110	110	80	60	80	80	80	40	60	
<b>BIOMASS gm/m<sup>2</sup></b>	2.2	0.7	1.15	1.8	0.80	2.4	1.4	0.80	0.98	0.80	0.60	0.95	

## WATER QUALITY NUTRIENTS (BIOTIC):

**Table 29: Concentration of Nutrients in Water at JNP Harbour Area and Nhava Creek**

Station Name	Ca <sup>2+</sup> [mg/L]	Mg <sup>+</sup> [mg/L]	K <sup>+</sup> [mg/L]	Na <sup>+</sup> [mg/L]	PO <sub>4</sub> <sup>3-</sup> -P [µg/L]	NO <sub>3</sub> <sup>1-</sup> -N [µg/L]	NO <sub>2</sub> <sup>1-</sup> -N [µg/L]	SiO <sub>2</sub> <sup>2-</sup> [µg/L]	SO <sub>4</sub> <sup>2-</sup> [µg/L]
Standard	-	-	-	-	0.1 - 90	1.0 - 500	<125	10 - 5000	-
<b>JNP HARBOUR AREA</b>									
W1	454	1366	374	7993	66	1317	< 10	1390	1884
W2	441	1296	425	8436	74	1490	< 10	1000	1612
W3	481	1320	413	7507	110	1367	< 10	1183	1692
W4	427	1377	387	8048	44	1270	< 10	1213	1752
W5	446	1309	349	8253	ND	1587	< 10	ND	1612
W6	441	1345	424	8608	ND	1640	< 10	ND	1540
W7	438	1346	389	8073	ND	1440	< 10	ND	1604
W8	468	1336	264	7929	ND	1193	< 10	ND	1612
W9	444	1306	281	7632	ND	1243	< 10	ND	1840
<b>JNP NHAVA CREEK AREA</b>									
W11	427	1323	348	5710	ND	893	< 10	ND	1684
W12	419	1370	181	8493	44	997	< 10	ND	1728
W13	438	1379	181	8807	ND	1567	< 10	1.6	1832
W14	430	1407	252	9464	22	1043	< 10	1.0	1904

## SEDIMENT QUALITY NUTRIENTS (BIOTIC):

**Table 30: Concentration of Nutrients in Sediments at JNP Harbour area and Nhava Creek**

Station Name	Ca <sup>2+</sup> [mg/Kg]	Mg <sup>+</sup> [mg/Kg]	K <sup>+</sup> [mg/Kg]	Na <sup>+</sup> [mg/Kg]	PO <sub>4</sub> <sup>3-</sup> -P [mg/Kg]	NO <sub>3</sub> <sup>1-</sup> -N [mg/Kg]	NO <sub>2</sub> <sup>1-</sup> -N [mg/Kg]	SiO <sub>2</sub> <sup>2-</sup> [mg/Kg]	SO <sub>4</sub> <sup>2-</sup> [mg/Kg]
Standard	-	-	-	-	-	-	-	-	-
<b>JNP HARBOUR AREA</b>									
W1	4366	252	360	5020	228	10	0.18	25	5273
W2	5123	201	254	5162	302	11	0.10	38	4929
W3	4951	324	284	5397	271	8	<0.1	44	4573
W4	6948	313	247	5944	326	10	<0.1	49	4219
W5	4319	264	287	3982	401	12	0.11	43	5396
W6	4167	215	321	5137	274	9	0.16	58	6944
W7	5582	285	263	5029	201	9	0.12	41	3806
W9	6590	116	338	4996	347	9	<0.1	32	2174
W10	6029	381	295	5295	216	11	0.11	65	4256
<b>JNP NHAVA CREEK AREA</b>									
W11	5183	285	411	4185	189	10	0.14	29	5317
W12	4756	204	335	5368	324	12	0.12	68	5748
W13	5939	198	362	3827	318	13	0.11	78	4526
W14	5261	228	450	5288	363	16	0.13	62	4589

### 3.4. Nutrients

Nutrients are measured using a variety of wet chemistry techniques, which generate a color reaction measurable with a colorimeter or spectrophotometer. The technique involves adding a reagent (or reagents) to the seawater sample, allowing a color to develop and then measuring the intensity of the color against blanks and standards. Manual methods usually allow the color to develop fully before measurement, whereas most automated methods (e.g. segmented flow analysis, flow injection analysis) provide partial color development with time controls. Concentrations of nutrients are measured in optical cells (static or flow through), using a spectrophotometer tuned to defined wavelengths.

#### a. Anions:

The nutrients at various stations in JNP harbor water and Nhava Creek are presented in **Table 29**. In harbor region the Phosphate was found to be in the range of 44 $\mu$ g/L – 87 $\mu$ g/L. The average concentration of Phosphate was found to be 66  $\mu$ g/L in JNP harbor region, the Phosphate values are within the prescribed standard range [0.1 – 90 $\mu$ g/L]. Nitrate was found to be between 1193  $\mu$ g/L – 1640  $\mu$ g/L. The minimum value of Nitrate 1193  $\mu$ g/L was found at W8 station and maximum value 1640  $\mu$ g/L at W6 station. The average concentration of Nitrate was found to be 1394  $\mu$ g/L. At locations W1, W2, W3, W4, W5, W6, W7, W8 & W9 the Nitrate concentration was found to be above prescribed standard range [1.0 to 500  $\mu$ g/L]. Silica is another important nutrient in seawater. The requirement of silica by diatoms is however, entirely limited to skeletal formation and has particular importance in coastal upwelling region where diatoms form a dominant part of phytoplankton. Silica in the form of silicate in JNP harbor water was found between 1000 – 1390  $\mu$ g/L with an average of 1212 $\mu$ g/L. The minimum concentration of silica was found at W2 station of JNP harbor region and the maximum concentration of silica was found at W1 station. The values of silica were observed to be well within the prescribed limits [10 to 5000  $\mu$ g/L]. The Sulphate was found between 1540 – 1884 mg/L, the minimum value recorded at W6 station and maximum at W1 station. The average concentration of Sulphate was found to be 1683 mg/L.

In Nhava Creek, Phosphate was found between 32  $\mu$ g/L – 63  $\mu$ g/L with an average 47  $\mu$ g/L which is within the prescribed standard range [0.1 – 90  $\mu$ g/L]. The minimum value was recorded at W14 and maximum at W11 location. Nitrate was found to be 893 (at W11) – 1567  $\mu$ g/L (at W13) with an average 1125  $\mu$ g/L. The silica content in Nhava creek was found to be 1047 – 1283  $\mu$ g/L with an average of 1185  $\mu$ g/L. The minimum silica content was found at station W13 station and maximum was found at W14 station. The values of silica were observed to be well within the prescribed limits. Sulphate was found between 1684 – 1904 mg/L with an average of 1787 mg/L. The minimum value for Sulphate was found at W11 station and maximum value at W14 station.

The nutrients in sediments at various stations in JNP harbor area and Nhava Creek area are given in **Table 30**. In harbor region, the sediment was found nine locations. Phosphate was found between 201 – 401 mg/kg with an average of 285 mg/kg. The minimum value of 201 mg/kg was found at W7 location while maximum value (401 mg/kg) was found at W5. The Nitrate was found to be minimum at W3 station i.e. 8 mg/kg and maximum at W5 station i.e. 12 mg/kg. The average concentration of Nitrate was found to be 10 mg/kg. The Nitrite was found to be between 0.10 – 0.18 mg/kg with an average of 0.13 mg/kg. The minimum concentration of nitrite was found at W2 station and maximum value at W1 station. Silica in the form of silicate in JNP harbor sediments were found between 25 and 65 mg/kg with an average of 44 mg/kg. The minimum concentration of silica was found at W1 station i.e. 25 mg/kg and maximum value was found at W9 station i.e. 65 mg/kg. The Sulphate was found between 2174 - 6944 mg/kg, with minimum value i.e. 2174 mg/kg at W8 station and maximum value i.e. 6944 mg/kg at W6 station. The average concentration of Sulphate was found to be 4619 mg/kg.

In Nhava Creek region the sediment found at four locations. Phosphate levels were 189 to 363 mg/kg with an average of 299 mg/kg. Nitrate was found to be 10 to 16 mg/kg. The average concentration of Nitrate was found to be 12.75 mg/kg. The Nitrite was found to be 0.11 and 0.14 mg/kg. The average concentration of Nitrite was found to be 0.13 mg/kg. Silica in the form of silicate in JNP creek sediments was found to be 29 to 78 mg/kg with an average of 59 mg/kg. The Sulphate was found to be 4526 to 5748 mg/kg. The average concentration of Sulphate was found to be 5045 mg/kg.

#### **b. Cations:**

In harbor region water, the Calcium was found between 427 to 481 mg/L with an average of 449 mg/L given in **Table 29**. The minimum value for Calcium i.e. 427 mg/L was found at W4 location whereas the maximum value i.e. 481 mg/L was found at W3 location. The Magnesium was found to be 1296 – 1377 mg/L, with minimum value i.e. 1296 mg/L at W2 location whereas maximum value i.e. 1377 was found at W4 stations. The average concentration of Magnesium was found to be 1333 mg/L. The minimum concentration of Potassium 264 mg/L was found at W8 location and maximum concentration 425 mg/L at W2 location with an average of 367 mg/L. The Sodium was found between 7507 to 8608 mg/L with an average of 8053 mg/L. The minimum concentration of sodium i.e. 7507 mg/L was found at W3 stations and maximum value i.e. 8608 mg/L of at W6 station.

In Nhava Creek, Calcium concentration was found with an average 429 mg/L given in **Table 29**. The minimum value 419 mg/L was found at W12 and maximum 438 mg/L at W13 station. Magnesium concentration was found to be 1323 – 1407 mg/L with an average of 1370 mg/L. The minimum value i.e. 1323 mg/L of Magnesium was found at W11 station and maximum value 1407 mg/L was found at W14 station. The Potassium content in Nhava creek was found to be 181 mg/L at W12 – 348 mg/L at W11 station

with an average of 241 mg/L. Sodium minimum concentration was found to be 5710 mg/L at W11 and maximum of 9464 mg/L at W14. The average concentration of sodium was found to be 8119 mg/L.

In harbour region sediments, the Calcium was found to be 4167 to 6948 mg/Kg with an average of 5342 mg/Kg given in **Table 30**. The minimum Concentration of Calcium 4167 mg/kg was found at W6 station and maximum concentration 6948 mg/kg at W4 station. Magnesium was found to be 116 to 381 mg/Kg, with minimum value 116 mg/kg at W8 station and maximum 381 mg/kg was recorded at W9 station. The average concentration of Magnesium was found to be 361 mg/Kg. Potassium in JNP harbor sediment was found to be 247 to 360 mg/Kg with an average of 294 mg/Kg. The minimum concentration of Potassium 247 mg/kg was found at W4 station and maximum value 360 mg/kg at W1 station. Sodium was found to be 3982 to 5944 mg/Kg with an average of 5107 mg/Kg. The minimum concentration of sodium 3982 mg/kg was found at W5 station and maximum value 5944 mg/kg at W4 station.

In Nhava Creek sediments, Calcium was found to be 4756 mg/kg at W12 and 5939 mg/Kg at W13 locations, with an average 5285 mg/Kg given in **Table 30**. Average magnesium was found to be 229 mg/Kg. The minimum concentration of magnesium was found at W13 location i.e. 198 mg/kg, whereas maximum concentration was observed at W11 location with value 285 mg/kg. The minimum concentration of potassium 335 mg/kg was observed at W12 and maximum concentration 450 mg/kg was observed at W14 station. Average potassium content in Nhava creek was found to be 390 mg/Kg. The minimum sodium value 3827 mg/kg was found at W13 station and maximum value 5368 mg/kg at W12. The average concentration of sodium was found to be 4667 mg/kg.

### 3.5 OBSERVATIONS AND CONCLUSIONS

Considering the various activities in JNP Harbour and NHAVA Creek area, it is seen from the following table that apparently the marine ecosystem is not adversely affected by following activities.

- ✓ *Construction of 4<sup>th</sup> Container Terminal on South side of JNPT:* Earth Filling work of 4<sup>th</sup>C.T. is underway.
- ✓ *Construction of NSIGT Yard is underway to the North side of JNPT.*
- ✓ *Plying of Ferry Boats:* There were large numbers of ferry boats plying in the area from Gateway of India to Elephanta.

It is seen from the data of Marine Ecology , as reported in **Tables 20 to 29** and subsequently discussed in above paragraphs, the major parameters comply with recommended ranges of the ecological parameters for Arabian Sea during February, 2016

Some Observations related to the impact on quality of marine water and ecology:

- ❖ There are four lotic water bodies; viz. Thane creek, Ulhas river, Panvel creek and Patalganga river that join the sea in the vicinity of the sampling area. Amongst these four, most of the sampling points are either within or close to Thane and Panvel creek confluence, resulting in direct impact on harbor water.
- ❖ The creek is narrow at Northern end, where it is fed partially by River Ulhas. Along the east and west sides of the creek, many industrial units have come up. Thane and Panvel creek is the ultimate recipient of all the liquid discharges from these industries and mostly untreated sewage discharges. The discharges into the creek on its western side are dominated by Mumbai city sewerage and wastes from petrochemical, fertilizer and thermal plants at Chembur, besides the pharmaceutical and chemical complexes at Vikhroli, Bhandup and Mulund.
- ❖ It may be mentioned that JN Port is not handling any dry bulk cargo containing Phosphate.

Based on observations of the overall ecological parameters in JNP Harbour and Nhava Creek area, it can be inferred that the marine ecosystem is not affected due to port operational activities. Untreated discharges of sewage and industrial waste from the towns / villages around the area, like Navi-Mumbai, Thane, and Panvel etc., may probably effect nitrate and phosphate levels.

4.

**DRINKING WATER QUALITY MONITORING**

**4.1 INTRODUCTION**

Drinking Water Quality Monitoring was carried out at eighteen stations in the port and port's township area. A list of locations for collecting the drinking water samples is presented below:

**Table 32: Description of Drinking Water Quality Monitoring Stations**

Sr. No.	Stations	Locations
<b>Outside the Port Area</b>		
1	DW1	Administration Building
2	DW2	Secondary School
3	DW3	PUB Canteen
4	DW4	Hospital Canteen
5	DW5	JNPT Inlet
6	DW9	Sector II
7	DW8	Sector III
8	DW13	CISF Canteen
9	DW14	Custom Canteen
10	DW15	JNPT Guest House
<b>Inside the Port Area</b>		
11	DW6	NSICT Canteen
12	DW7	GTI Canteen
13	DW10	POC Canteen
14	DW11	JNPT Workshop
15	DW12	C.T. Canteen
16	DW16	PPD Site Office
17	DW17	GTI -2
18	DW18	GTI CGC

Out of 18 stations, 10 are in outside the port while 8 are inside the port. All samples were collected from the port area of JNP on 31<sup>th</sup> March, 2016.

The water samples are analyzed for various parameters, viz. Colour, Odour, pH, Turbidity, Total Dissolved Solids, Aluminium as Al, NH<sub>3</sub> - N, Barium as Ba, Boron, Calcium as Ca, Chloride as Cl<sup>-</sup>, Copper as Cu, Fluoride, Free Residual Chlorine, Iron as Fe, Magnesium as Mg, Manganese as Mn, Oil & grease, Nitrate as NO<sub>3</sub><sup>-</sup>, Phenolic compound, Selenium as Se, Silver as Ag, Sulphate as SO<sub>4</sub><sup>-2</sup>, Total Alkalinity as CaCO<sub>3</sub>, Total Hardness as CaCO<sub>3</sub>, Zinc as Zn, Cyanide, Lead as Pb, Mercury as Hg, Molybdenum as Mo, Nickel as Ni, Pesticides, Total Arsenic as As, Total Chromium as Cr, Total Coliforms and *E. coli*.

## 4.2 RESULTS

The drinking water quality monitoring data for eighteen stations are given in **Table 33**.

Parameter	Unit of Measurement	Station Name						Standard*
		DW1	DW2	DW3	DW4	DW5	DW6	
Color	Hazen	<1	<1	<1	<1	<1	<1	5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
pH	-	6.60	6.70	6.80	6.80	7.01	7.10	6.5 to 8.5
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Total Dissolved Solid	mg/l	90	50	70	50	50	60	500
Aluminium as Al	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03
NH <sub>3</sub> -N	mg/l	<1	<1	<1	<1	<1	<1	0.5
Barium as Ba	mg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7
Boron	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.5
Calcium as Ca	mg/l	10.90	16.03	11.22	10.10	10.42	10.58	75
Chloride as Cl	mg/l	20.60	7.36	20.11	8.83	7.85	7.85	250
Copper as Cu	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05
Fluoride	mg/l	0.07	0.06	<0.05	<0.05	0.10	0.20	1.0
Free Residual Chlorine	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Iron as Fe	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.3
Magnesium as Mg	mg/l	3.11	1.46	2.92	4.08	3.60	3.69	30.0
Manganese as Mn	mg/l	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.1
Oil & Grease	mg/l	<4	<4	<4	<4	<4	<4	0.5
Nitrate as NO <sub>3</sub>	mg/l	2.46	1.67	7.08	2.98	2.23	1.12	45
Phenolic Compound	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Selenium as Se	mg/l	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.01
Silver as Ag	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
Sulphate as SO <sub>4</sub>	mg/l	13.20	2.52	11.76	1.56	1.80	3.96	200
Total Alkalinity as CaCO <sub>3</sub>	mg/l	56.0	64.0	72.0	86.0	82.0	74.0	200
Total Hardness as CaCO <sub>3</sub>	mg/l	40.0	46.0	40.0	42.0	40.8	41.6	200
Zinc as Zn	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	0.10	5
Cyanide	mg/l	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.05
Lead as Pb	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Molybdenum	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07
Nickel as Ni	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.02
Pesticides	mg/l	ND	ND	ND	ND	ND	ND	0.5
Total Arsenic as As	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Total Chromium as Cr	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05
Total Coli forms	MPN/100ml	Absent	Absent	Absent	Absent	Absent	Absent	Nil
E Coli	-	Absent	Absent	Absent	Absent	Absent	Absent	Absent

\*IS 10500:2012, Drinking Water Specification

Parameter	Unit of Measurement	Station Name						
		DW7	DW8	DW9	DW10	DW11	DW12	Standard*
Color	Hazen	<1	<1	<1	<1	<1	<1	5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
pH	-	7.17	7.20	7.25	7.20	7.25	7.20	6.5 to 8.5
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Total Dissolved Solid	mg/l	50	50	70	70	60	70	500
Aluminium as Al	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03
NH <sub>3</sub> -N	mg/l	<1	<1	<1	<1	<1	<1	0.5
Barium as Ba	mg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7
Boron	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.5
Calcium as Ca	mg/l	10.42	10.60	10.60	10.90	11.38	10.90	75
Chloride as Cl	mg/l	8.83	7.85	20.10	18.64	14.71	18.64	250
Copper as Cu	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05
Fluoride	mg/l	<0.05	<0.05	0.07	<0.05	<0.05	<0.05	1.0
Free Residual Chlorine	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Iron as Fe	mg/l	<0.01	<0.01	0.89	<0.01	<0.01	<0.01	0.3
Magnesium as Mg	mg/l	4.08	3.79	3.30	3.11	2.81	3.11	30.0
Manganese as Mn	mg/l	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.1
Oil & Grease	mg/l	<4	<4	<4	<4	<4	<4	0.5
Nitrate as NO <sub>3</sub>	mg/l	2.31	2.91	1.42	1.71	1.04	1.42	45
Phenolic Compound	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Selenium as Se	mg/l	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.01
Silver as Ag	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
Sulphate as SO <sub>4</sub>	mg/l	3.24	2.76	12.96	11.52	8.64	11.76	200
Total Alkalinity as CaCO <sub>3</sub>	mg/l	76.0	80.0	60.0	66.0	64.0	62.0	200
Total Hardness as CaCO <sub>3</sub>	mg/l	43.0	42.0	40.0	40.0	40.0	40.0	200
Zinc as Zn	mg/l	<0.1	<0.1	<0.1	0.10	<0.1	<0.1	5
Cyanide	mg/l	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.05
Lead as Pb	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Molybdenum	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07
Nickel as Ni	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
Pesticides	mg/l	ND	ND	ND	ND	ND	ND	0.5
Total Arsenic as As	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Total Chromium as Cr	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05
Total Coli forms	MPN/100ml	Absent	Absent	Absent	Absent	Absent	Absent	Nil
E Coli	-	Absent	Absent	Absent	Absent	Absent	Absent	Absent
*IS 10500:2012, Drinking Water Specification								

Parameter	Unit of Measurement	Station Name						
		DW13	DW14	DW15	DW16	DW17	DW18	Standard*
Color	Hazen	<1	<1	<1	<1	<1	<1	5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
pH	-	7.22	7.15	7.15	7.15	7.18	7.15	6.5 to 8.5
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Total Dissolved Solid	mg/l	80	80	70	70	70	70	500
Aluminium as Al	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03
NH <sub>3</sub> -N	mg/l	<1	<1	<1	<1	<1	<1	0.5
Barium as Ba	mg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7
Boron	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.5
Calcium as Ca	mg/l	11.22	10.90	11.38	11.38	11.22	10.90	75
Chloride as Cl	mg/l	19.13	18.64	19.62	18.64	18.15	18.15	250
Copper as Cu	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05
Fluoride	mg/l	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	1.0
Free Residual Chlorine	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.32	<0.01	<0.01	0.3
Magnesium as Mg	mg/l	2.92	3.11	2.81	2.81	2.92	3.11	30.0
Manganese as Mn	mg/l	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.1
Oil & Grease	mg/l	<4	<4	<4	<4	<4	<4	0.5
Nitrate as NO <sub>3</sub>	mg/l	2.31	1.79	1.27	2.39	1.12	1.27	45
Phenolic Compound	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Selenium as Se	mg/l	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.01
Silver as Ag	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
Sulphate as SO <sub>4</sub>	mg/l	12.60	11.04	12.12	11.16	12.12	12.48	200
Total Alkalinity as CaCO <sub>3</sub>	mg/l	62.0	64.0	74.0	84.0	70.0	70.0	200
Total Hardness as CaCO <sub>3</sub>	mg/l	40.0	40.0	40.0	40.0	40.0	40.0	200
Zinc as Zn	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5
Cyanide	mg/l	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.05
Lead as Pb	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Molybdenum	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07
Nickel as Ni	mg/l	0.03	0.03	0.03	<0.01	<0.01	<0.01	0.02
Pesticides	mg/l	ND	ND	ND	ND	ND	ND	0.5
Total Arsenic as As	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Total Chromium as Cr	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05
Total Coli forms	MPN/100ml	Absent	Absent	Absent	Absent	Absent	Absent	Nil
E Coli	-	Absent	Absent	Absent	Absent	Absent	Absent	Absent
*IS 10500:2012, Drinking Water Specification								

### 4.3 DISCUSSION

**Table 33** provides the observed results for various parameters analyzed for drinking water samples collected from eighteen stations in and around the port's activity during the monitoring period of March ,2016 are compared with acceptable limits as prescribed in **IS 10500:2012** – Drinking Water Specification. It is seen from the analysis data that during the study period the water was safe for human consumption at all drinking water monitoring stations in and around the port.

The colour of all drinking water samples was < 5 Hazen unit and odour of the samples was also agreeable. The values of Turbidity Aluminium as Al, Barium, Boron, and Ammonia as NH<sub>3</sub>-N were observed to be below detection limits of measurement i.e. <1.0 NTU, <0.01 mg/L, <0.5 mg/L, <0.01 mg/L and <1.0 mg/L respectively. Apparently these parameters are not at alarming levels.

Values observed for TDS for all the samples were in the range of 50 to 90 mg/L which are well below the acceptable standard limits (500 mg/L). pH values of all the samples were in the range of 6.6 to 7.25 which is within the permissible standard 6.5 to 8.5. Total Hardness as CaCO<sub>3</sub> values of all the eighteen samples were found to be in the range of 40 to 46 mg/L and found to be within the acceptable limit (200 mg/L).

Concentration levels observed for Chlorides as Cl<sup>-</sup> and Sulphate as SO<sub>4</sub><sup>2-</sup> were in the range of 7.36 to 20.60 mg/L, 1.56 to 13.20 mg/L respectively. The observed values for these parameters are well within the acceptable standard limits.

Analysis of the bacteriological parameter at all location and Total Coliform values is well within the prescribed standard limits. Hence the Total Coliform and E-Coli values showed that all the drinking water samples were safe from any bacteriological contamination.

### 4.4 CONCLUSIONS AND MITIGATION MEASURES:

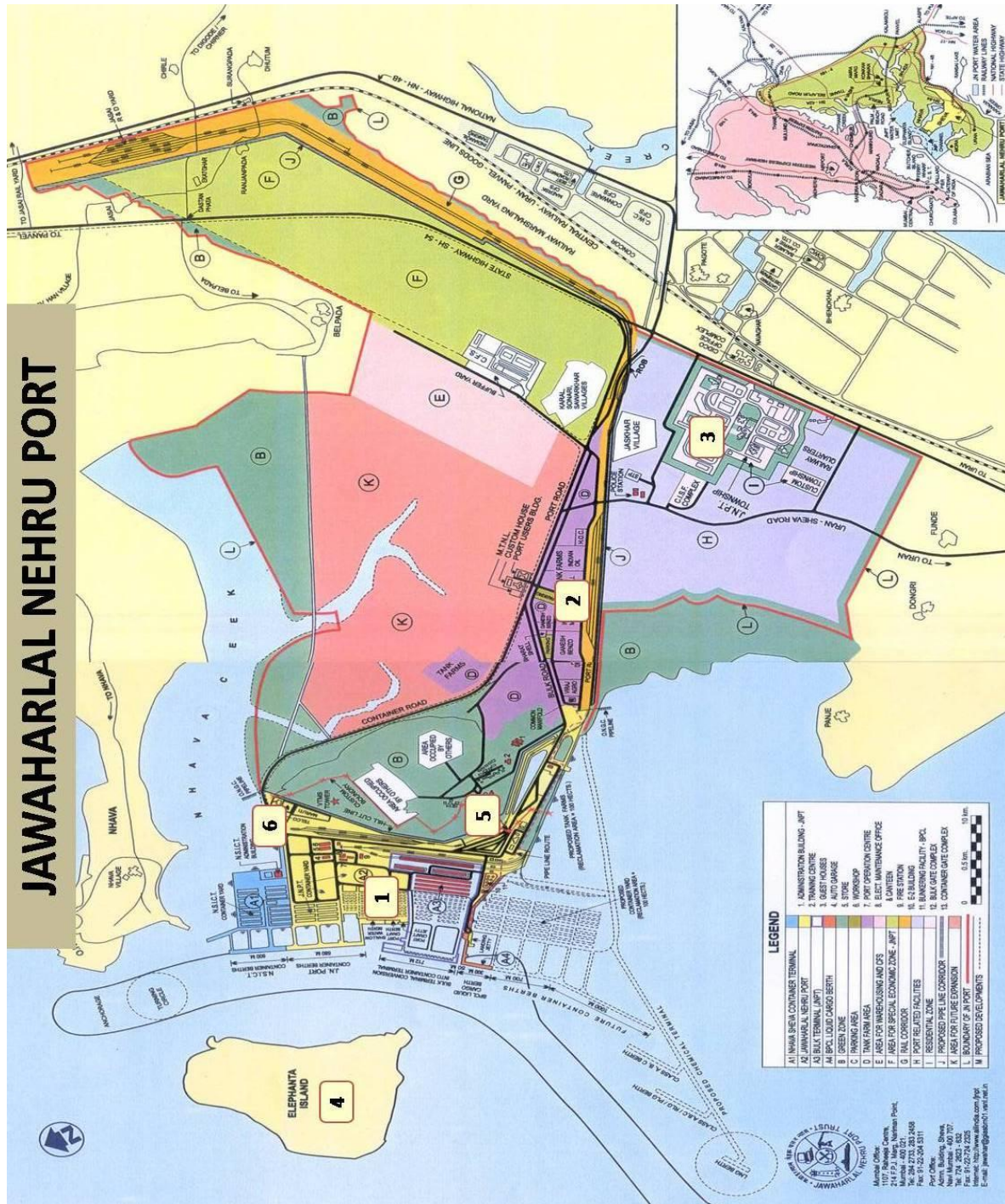
As per the drinking water specifications, given in IS 10500:2012 and also on the basis of above described analysis parameters, the water is safe for drinking purpose at all drinking water monitoring stations around port area.

It is advisable that, utmost care has to be taken to keep drinking water premises clean and sanitized. Water Filters and purifiers have to be regularly cleaned and should be covered under AMC.

5.

ANNEXURES

Annexure-I: Location map for Ambient Air Monitoring Stations



## Annexure-II: National Ambient Air Quality Monitoring Standard

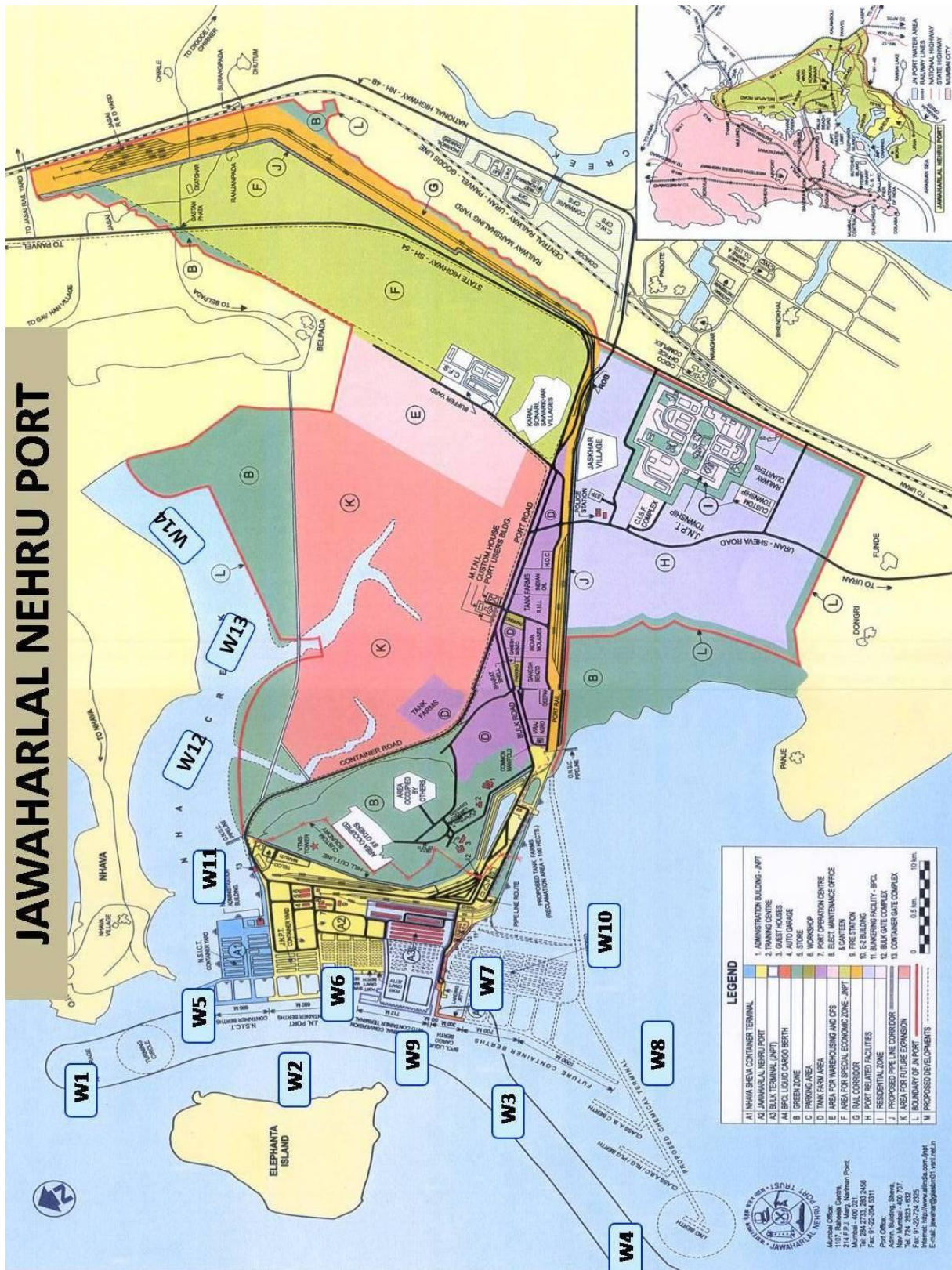
Sr. No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (notified by Central Government)	Methods of Measurement
1.	Sulphur Dioxide (SO <sub>2</sub> ), µg/m <sup>3</sup>	Annual* 24 hours**	50 80	20 80	-Improved West and Geake -Ultraviolet fluorescence
2.	Nitrogen Dioxide (NO <sub>2</sub> ), µg/m <sup>3</sup>	Annual* 24 hours**	40 80	30 80	-Modified Jacob & Hochheiser (Na-Arsenite) -Chemiluminescence
3.	Particulate Matter (size less than 10µm) or PM <sub>10</sub> , µg/m <sup>3</sup>	Annual* 24 hours**	60 100	60 100	-Gravimetric -TOEM -Beta attenuation
4.	Particulate Matter (size less than 2.5µm) or PM <sub>2.5</sub> , µg/m <sup>3</sup>	Annual* 24 hours**	40 60	40 60	-Gravimetric -TOEM -Beta attenuation
5.	Ozone (O <sub>3</sub> ), µg/m <sup>3</sup>	8 hours** 1 hour**	100 180	100 180	-UV photometric -Chemiluminescence -Chemical Method
6.	Lead (Pb), µg/m <sup>3</sup>	Annual* 24 hours**	0.5 1.0	0.5 1.0	-AAS/ICP method after sampling on EPM 2000 or equivalent filter paper -ED-XRF using Teflon filter
7.	Carbon Monoxide (CO), mg/m <sup>3</sup>	8 hours** 1 hour**	02 04	02 04	-Non Dispersive Infra-Red (NDIR) spectroscopy
8.	Ammonia (NH <sub>3</sub> ), µg/m <sup>3</sup>	Annual* 24 hours**	100 400	100 400	-Chemiluminescence -Indophenol blue method
9.	Benzene (C <sub>6</sub> H <sub>6</sub> ), µg/m <sup>3</sup>	Annual*	05	05	-Gas chromatography based continuous analyzer -Adsorption and Desorption followed by GC analysis
10.	Benzo Pyrene (BaP) – particulate phase only, ng/m <sup>3</sup>	Annual*	01	01	-Solvent extraction followed by HPLC/GC analysis
11.	Arsenic (As), ng/m <sup>3</sup>	Annual*	06	06	-AAS/ICP method after sampling on EPM 2000 or equivalent filter paper
12.	Nickel (Ni), ng/m <sup>3</sup>	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 compiled 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 investigations.

### Annexure-III: Location map for Marine Water Monitoring Stations



# JAWAHARLAL NEHRU PORT

### ***Annexure-V: Primary Criterion for Class SW-IV Waters (For Harbor Waters)***

Sr. No.	Parameter	Criteria	Rationale/Remarks
1.	pH range	6.5 - 9.0	To minimize the corrosive and scaling effects.
2.	Dissolved Oxygen	3.0 mg/L or 40 % of the saturation value, whichever is higher	Considering bio-degradation of oil and inhibition to oxygen production through photosynthesis.
3.	Color and Odor	No visible color or offensive order	None from reactive chemicals which may corrode paints/metallic surfaces.
4.	Floating objects oil, grease and scum (including the 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 (MPN)	Not exceeding 1000/100 ml in 20 % of the samples in the year and in 3 consecutive samples in the monsoon months.
6.	Biochemical Oxygen Demand (3 days at 27°C)	5 mg/L	To maintain water relatively free from the pollution caused by sewage and other decomposable wastes.

### ***Annexure-VI: Recommended Ranges of the Ecological Parameters for Arabian Sea***

Sr. No.	Parameter	Criteria	Rationale/Remarks
1.	Net primary productivity	<1500 mgC/m <sup>3</sup> /day at surface	High productivity indicates the abundance of phytoplankton crop available to primary producers this could lead to poor water quality.
2.	Chlorophyll-a	< 4 mg/m <sup>3</sup> 4-10 mg/m <sup>3</sup> >10 mg/m <sup>3</sup>	Oligotrophic class of water Mesotrophic class of water Eutrophic class of water
3.	Phosphate	0.1- 90 µg/L	A nutrient that acts as a fertilizer. High level of this nutrient causes excessive plant and algal growth in aquatic ecosystem
4.	Nitrate	1.0- 500 µg/L	This is also a nutrient produced in natural water by decomposition of nitrogenous organic compounds. High level of nitrate represents the presence of more nitrogenous compounds and resulting in to excessive growth of algae and other aquatic vegetation.
5.	Nitrite	<125 µg/L	Nitrite in water poisons the fish by binding to the hemoglobin in the blood preventing oxygen carrying capacity, in effect suffocating the fish .The gills of fish dying as a result of nitrite poisoning are characteristic brown color.
6.	Particulate Organic Carbon (POC)	10-100 mg/m <sup>3</sup>	POC is directly related to primary productivity. High concentration of POC represents the region of high productivity.
7.	Silicate (SiO <sub>2</sub> )	10-5000 µg/L	Nucleic acid synthesis and skeletal formation of Diatoms.

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***Thank You***