

ENVIRONMENTAL MONITORING REPORT



DETOX GROUP



MONITORING OF ENVIRONMENTAL PLAN FOR JN PORT ENVIRONMENTAL MONITORING REPORT

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TABLE OF CONTENTS

SR. NO.	PARTICULARS	PAGE NO.
1.	AMBIENT AIR QUALITY MONITORING	<u>3-16</u>
1.1	Introduction	3
1.2	Methodology	3
1.3	Results	4-13
1.4	Discussion	14
1.5	Observations & Conclusions	15-16
2.	MARINE WATER QUALITY MONITORING [HARBOR& CREEK] INCLUDING STUDY OF SEDIMENT CHARACTERISTICS	<u>17-28</u>
2.1	Introduction	17
2.2	Methodology	17-18
2.3	Results	19-26
2.4	Discussion	27-28
2.5	Observations & Conclusions	28
3.	MARINE ECOSYSTEM MONITORING	<u>29-47</u>
3.1	Introduction – Marine Environment	29
3.2	Methodology- Zooplankton, Phytoplankton, Benthic Organisms	30-34
3.3	Results	34-43
	Aquatic Flora & Fauna	34-40
	Benthic Organisms	41
	Water Quality: Biotic	42
	Sediment Quality: Biotic	43
3.4	Nutrients	44-46
3.5	Observations & Conclusions	47
4.	DRINKING WATER QUALITY MONITORING	<u>48</u>
4.1	Introduction	48
4.2	Results	49-51
4.3	Discussion	52
4.4	Conclusions	52
5.	ANNEXURES	<u>53-60</u>
5.1	Annexure-I: Location map for Ambient Air Monitoring Stations	53
5.2	Annexure-II: National Ambient Air Quality Monitoring Standard	54
5.3	Annexure-III: Location map for Marine Water Monitoring Stations	55
5.4	Annexure-IV: Location map for Ecological monitoring Stations and Direction of Towing	56
5.5	Annexure-V: Primary Criterion for Class SW-IV Waters (For Harbor Waters)	57
5.6	Annexure-VI: Recommended Ranges of the Ecological Parameters for Arabian Sea	58
6.	BIBLIOGRAPHY	<u>59-60</u>

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 18th 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.

In all above stations, sampling duration is 24 hour for PM₁₀, PM_{2.5}, SO₂, NO_x, NH₃, Pb, As, Ni, Benzo(α) pyrene, 8 hour for Ozone & Benzene, and Grab-sampling for CO & CO₂ 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, SO₂, NO_x and NH₃. 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 PM₁₀ & PM_{2.5} respectively. After PM₁₀ 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 February, 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 February, 2016

Sampling Period	Date	Time [Hrs]	PM ₁₀ [$\mu\text{g}/\text{m}^3$]	PM _{2.5} [$\mu\text{g}/\text{m}^3$]	SO ₂ [$\mu\text{g}/\text{m}^3$]		NO _x [$\mu\text{g}/\text{m}^3$]		NH ₃ [$\mu\text{g}/\text{m}^3$]	
					24hr	8 hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 $\mu\text{g}/\text{m}^3$	60 $\mu\text{g}/\text{m}^3$		80 $\mu\text{g}/\text{m}^3$		80 $\mu\text{g}/\text{m}^3$		400 $\mu\text{g}/\text{m}^3$
POC-1	18.02.2016	7:00AM				5.61	51.42		26.67	
	to	3:00 PM	325.0	82.0		7.21	46.30	50.62	23.49	26.87
	19.02.2016	11:00 PM				8.81	54.14		30.47	
POC-2	20.02.2016	7:00AM				12.02	81.89		18.41	
	to	3:00 PM	215.0	71.0		16.03	85.45	82.37	19.68	19.89
	21.02.2016	11:00 PM				24.84	79.78		21.59	
POC-3	23.02.2016	7:00AM				20.42	84.77		25.40	
	to	3:00 PM	254.0	69.0		26.83	82.63	81.68	19.05	22.64
	24.02.2016	11:00 PM				28.85	77.65		23.49	
POC-4	26.02.2016	7:00AM				38.46	47.73		49.52	
	to	3:00 PM	184.0	76.0		39.62	44.17	47.49	51.43	49.10
	27.02.2016	11:00 PM				45.67	50.58		46.35	
Monthly Average			246.0	74.0		22.86		65.54		29.63
Standard Deviation			63.0	6.0		14.34		19.03		13.29

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

Sampling Period	Date	Time, [Hrs]	O ₃ [µg/m ³]	Pb [µg/m ³]	As [ng/m ³]	Ni [ng/m ³]	C ₆ H ₆ [µg/m ³]	B(a)P [ng/m ³]	CO [mg/m ³]	CO ₂ [ppm]
NAAQMS limit			8 hr	24hr	24hr (Avg)	24hr (Avg)	8 hr	24hr (Avg)	Grab Sampling	Grab Sampling
			100 µg/m ³	1.0 µg/m ³	6 ng/m ³	20 ng/m ³	5.0 µg/m ³	1.0 ng/m ³	4.0 mg/m ³	.
POC-1	18.02.2016	7:00AM								
		3:00 PM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	<1.0	225.0
		11:00 PM								
POC-2	20.02.2016	7:00AM								
		3:00 PM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	1.32	210.0
		11:00 PM								
POC-3	23.02.2016	7:00AM								
		3:00 PM	2237	<0.05	<5.0	<1.0	1.22	<0.5	1.41	232.0
		11:00 PM								
POC-4	26.02.2016	7:00AM								
		3:00 PM	2521	<0.05	<5.0	<1.0	1.29	<0.5	1.46	260.0
		11:00 PM								
Monthly Average			23.79	.	.	.	1.26	.	1.40	232.0
Standard Deviation			2.0	.	.	.	0.05	.	0.1	21.0

Table 3: Results of Air Pollutant Concentration at IMC Station of JNP Area during the month of February, 2016										
Sampling Period	Date	Time, [Hrs]	PM ₁₀ [µg/m ³]	PM _{2.5} [µg/m ³]	SO ₂ [µg/m ³]		NOx [µg/m ³]		NH ₃ [µg/m ³]	
NAAQMS limit			24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
			100 µg/m ³	60 µg/m ³		80 µg/m ³		80 µg/m ³		400 µg/m ³
IMC-1	22.02.2016	7:30 AM			30.45		24.22		10.16	
		3:30 PM			24.04		29.21		15.24	
		11:30 PM	176	78	27.24	27.24	25.64	26.36	12.7	12.7
IMC-2	23.02.2016	7:30 AM			36.86		57.7		21.59	
		3:30 PM			45.67		53.42		26.67	
		11:30 PM	194	92	39.26	40.59	61.26	57.46	18.41	22.2
IMC-3	25.02.2016	7:30 AM			17.63		77.64		29.2	
		3:30 PM			12.82		70.52		32.38	
		11:30 PM	255	112	8.81	11.63	69.81	72.65	26.67	29.42
IMC-4	26.02.2016	7:30 AM			21.63		43.45		41.9	
		3:30 PM			25.64		39.89		38.73	
		11:30 PM	216	98	32.85	26.7	46.3	43.21	45.08	41.9
Monthly Average			210	95		26.91		49.92		26.56
Standard Deviation			34	14		11.23		19.78		12.31

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

	Date	Time, [Hrs]	O ₃ [µg/m ³]	Pb [µg/m ³]	As [ng/m ³]	Ni [ng/m ³]	C ₆ H ₆ [µg/m ³]	B(a)P [ng/m ³]	CO [mg/m ³]	CO ₂ [ppm]
Sampling Period			8 hr	24hr	24hr (Avg.)	24hr (Avg.)	8 hr	24hr (Avg.)	Grab Sampling	Grab Sampling
NAAQMS limit			100 µg/m ³	1.0 µg/m ³	6 ng/m ³	20 ng/m ³	5.0 µg/m ³	1.0 ng/m ³	4.0 mg/m ³	-
IMC-1	22.02.2016	7:30 AM								
		3:30 PM								
		11:30 PM	27.96	<0.05	<5.0	<1.0	<1.0	<0.5	1.61	220
IMC-2	23.02.2016	7:30 AM								
		3:30 PM								
		11:30 PM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	1.74	237
IMC-3	25.02.2016	7:30 AM								
		3:30 PM								
		11:30 PM	<20.0	<0.05	<5.0	<1.0	1.73	<0.5	2.12	246
IMC-4	26.02.2016	7:30 AM								
		3:30 PM								
		11:30 PM	<20.0	<0.05	<5.0	<1.0	1.57	<0.5	1.83	228
Monthly Average			27.96	-		-	1.65	-	1.83	233
Standard Deviation			-	-		-	0.11	-	0.22	11

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

Sampling Period	Date	Time, [Hrs]	PM ₁₀ [µg/m ³]	PM _{2.5} [µg/m ³]	SO ₂ [µg/m ³]		NO _x [µg/m ³]		NH ₃ [µg/m ³]	
					8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit						80 µg/m ³		80 µg/m ³		400 µg/m ³
RC-1	18.02.2016	8:00 AM			15.22		40.6		33.01	
		4:00 PM	252	81	11.21	14.15	42.74	39.26	26.67	29.63
		12:00 AM			16.03		34.43		29.2	
RC-2	20.02.2016	8:00 AM			12.82		56.28		28.57	
		4:00 PM			17.63		58.41		20.95	
		12:00 AM	139	78	22.44	17.63	62.69	59.13	31.74	27.09
RC-3	23.02.2016	8:00 AM			38.46		14.95		19.68	
		4:00 PM			32.85		20.66		15.87	
		12:00 AM	341	95	41.67	37.66	27.07	20.89	13.33	16.29
RC-4	26.02.2016	8:00 AM			28.05		48.44		39.36	
		4:00 PM			23.24		57.7		35.24	
		12:00 AM	106	71	31.25	27.51	53.43	53.19	45.08	39.89
Monthly Average			209	81		24.23		43.12		28.23
Standard Deviation			108	10		10.59		17		9.69

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

	Date	Time, [Hrs]	O ₃ [µg/m ³]	Pb [µg/m ³]	As [ng/m ³]	Ni [ng/m ³]	C ₆ H ₆ [µg/m ³]	B(a)P [ng/m ³]	CO [mg/m ³]	CO ₂ [ppm]
Sampling Period			8 hr	24hr	24hr (Avg.)	24hr (Avg.)	8 hr	24hr (Avg.)	Grab Sampling	Grab Sampling
NAAQMS limit			100 µg/m ³	1.0 µg/m ³	6 ng/m ³	20 ng/m ³	5.0 µg/m ³	1.0 ng/m ³	4.0 mg/m ³	-
RC-1	18.02.2016	8:00 AM								
		4:00 PM								
		12:00 AM	22.07	<0.05	<5.0	<1.0	<1.0	<0.5	1.26	272
RC-2	20.02.2016	8:00 AM								
		4:00 PM								
		12:00 AM	<20.0	<0.05	<5.0	<1.0	1.27	<0.5	1.33	246
RC-3	23.02.2016	8:00 AM								
		4:00 PM								
		12:00 AM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	1.48	235
RC-4	26.02.2016	8:00 AM								
		4:00 PM								
		12:00 AM	21.48	<0.05	<5.0	<1.0	<1.0	<0.5	1.35	269
Monthly Average			21.78	-		-	1.27	-	1.35	255
Standard Deviation			0.42	-		-		-	0.09	18

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

Sampling Period	Date	Time, [Hrs]	PM ₁₀ [µg/m ³]	PM _{2.5} [µg/m ³]	SO ₂ [µg/m ³]		NO _x [µg/m ³]		NH ₃ [µg/m ³]	
					8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m ³	60 µg/m ³		80 µg/m ³		80 µg/m ³		400 µg/m ³
EC	26.02.2016	9:00 AM			12.65		34.19		11.43	
		5:00 PM			9.67		37.75		9.52	
		1:00 AM	148	22	11.9	11.41	20.92	33.95	13.97	11.64
Monthly Average			148	22		11.41		33.95		11.64
Standard Deviation			-	-		-		-		-

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

Sampling Period	Date	Time, [Hrs]	O ₃ [µg/m ³]	Pb [µg/m ³]	As [ng/m ³]	Ni [ng/m ³]	C ₆ H ₆ [µg/m ³]	B(a)P [ng/m ³]	CO [µg/m ³]	CO ₂ [ppm]
NAAQMS limit			100 µg/m ³	1.0 µg/m ³	6 ng/m ³	20 ng/m ³	5.0 µg/m ³	1.0 ng/m ³	4.0 mg/m ³	-
EC	26.02.2016	9:00 AM								
		5:00 PM								
		1:00 AM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	<1.0	226
Monthly Average			-	-	-	-	-	-	-	-
Standard Deviation			-	-	-	-	-	-	-	-

Table 6 : Results of Air Pollutant Concentration at NGC Station of JNP Area during the month of February ,2016

Table 6 : Results of Air Pollutant Concentration at NGC Station of JNP Area during the month of February ,2016										
	Date	Time , [Hrs]	PM ₁₀ [µg/m ³]	PM _{2.5} [µg/m ³]	SO ₂ [µg/m ³]		NOx [µg/m ³]		NH3 [µg/m ³]	
Sampling Period			24hr	24hr	8 hr	24hr (Avg)	8 hr	24hr (Avg)	8 hr	24hr (Avg)
NAAQMS limit			100 µg/m ³	60 µg/m ³		80 µg/m ³		80 µg/m ³		400 µg/m ³
NGC-1	20.02.2016	11:00 PM			23.24		89.04		14.6	
		7:00 AM	178	81	22.44	20.84	76.93	79.78	17.14	16.72
		3:00 PM			16.83		73.37		18.41	
NGC-2	25.02.2016	11:00 PM			49.68		52.71		15.87	
		7:00 AM	107	73	55.29	48.88	64.82	61.26	16.51	17.14
		3:00 PM			41.67		66.24		19.05	
Monthly Average			142	77		34.86		70.52		16.93
Standard Deviation			50	6		19.83		13.1		0.3

Table 6: Results of Air Pollutant Concentration at NGC Station of JNP Area during the month of February ,2016

Table 6: Results of Air Pollutant Concentration at NGC Station of JNP Area during the month of February ,2016										
	Date	Time , [Hrs]	O ₃ [µg/m ³]	Pb [µg/m ³]	As [ng/m ³]	Ni [ng/m ³]	C ₆ H ₆ [µg/m ³]	B(a)P [ng/m ³]	CO [mg/m ³]	CO ₂ [ppm]
Sampling Period			8 hr	24hr	24hr (Avg.)	24hr (Avg.)	8 hr	24hr (Avg.)	Grab Sampling	Grab Sampling
NAAQMS limit			100 µg/m ³	1.0 µg/m ³	6 ng/m ³	20 ng/m ³	5.0 µg/m ³	1.0 ng/m ³	4.0 mg/m ³	-
NGC-1	20.02.2016	11:00 PM								218
		7:00 AM	24.13	<0.05	<5.0	<1.0	<1.0	<0.5	1.57	
		3:00 PM								
NGC-2	25.02.2016	11:00 PM								242
		7:00 AM	<20.0	<0.05	<5.0	<1.0	<1.0	<0.5	1.45	
		3:00 PM								
Monthly Average			24.13	-		-		-	1.51	230
Standard Deviation			-	-		-		-	0.08	17

Table 7: Results of Air Pollutant Concentration at SGC Station of JNP Area during the month of February, 2016

	Date	Time, [Hrs]	PM ₁₀ [µg/m ³]	PM _{2.5} [µg/m ³]	SO ₂ [µg/m ³]	NOx [µg/m ³]	NH ₃	[µg/m ³]
Sampling Period			24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m ³	60 µg/m ³	80 µg/m ³	80 µg/m ³		100 µg/m ³
SGC-1	19.02.2016	11:00 PM			31.25	23.51	17.78	
		7:00 AM			42.47	19.95	20.32	
		3:00 PM	236	91	36.86	21.37	15.24	17.78
		7:00 AM			40.06	48.43	38.73	
SGC-2	23.02.2016	3:00 PM	186	72	34.46	41.32	41.27	
					32.05	39.18	46.35	42.12
Monthly Average			211	81	36.19			29.95
Standard Deviation			35	13	0.95	15.11		17.21

Table 7: Results of Air Pollutant Concentration at SGC Station of JNP Area during the month of February, 2016

	Date	Time, [Hrs]	O ₃ [µg/m ³]	Pb [µg/m ³]	As [ng/m ³]	Ni [ng/m ³]	Cd/Hg [µg/m ³]	B(a)P [ng/m ³]	CO [mg/m ³]	CO ₂ [ppm]
Sampling Period			8 hr	24hr	24hr (Avg.)	24hr (Avg.)	8 hr	24hr (Avg.)	Grab Sampling	Grab Sampling
NAAQMS limit			100 µg/m ³	1.0 µg/m ³	6 ng/m ³	20 ng/m ³	5.0 µg/m ³	1.0 ng/m ³	4.0 mg/m ³	-
SGC-1	19.02.2016	11:00 PM								
		7:00 AM								
		3:00 PM	23.74	<0.05	<5.0	<1.0	1.53	<0.5	1.72	226
		7:00 AM								
SGC-2	23.02.2016	3:00 PM	<20.0	<0.05	<5.0	<1.0	1.62	<0.5	1.86	212
			23.74	-	-	-	1.57	-	1.79	219
Monthly Average			-	-	-	-	0.06	-	0.1	10
Standard Deviation										

1.4 DISCUSSION

In **Table 8**, the average values of air pollutants are provided at various stations of JNP area for February, 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 February, 2016

STATION	PM ₁₀ , [µg/m ³]	PM _{2.5} , [µg/m ³]	SO ₂ , [µg/m ³]	NO _x , [µg/m ³]	NH ₃ , [µg/m ³]	O ₃ , [µg/m ³]	Pb, [µg/m ³]	C ₆ H ₆ , [µg/m ³]	CO, [mg/m ³]	CO ₂ , [ppm]
NAAQMS	100	60	80	80	400	100	1	5	4	-
INDUSTRIAL AREA										
POC	246±63	74 ± 6	22.86±14.34	65.54±19.08	29.63±13.29	23.29±2.0	<0.01	1.26±0.05	1.4±0.1	232±21
IMC	210±34	95±14	26.91±11.23	49.92±19.78	26.56±12.31	17 ± 07	<0.01	1.65±0.11	1.83±0.22	233±11
NG	142±50	77 ± 6	34.86±19.83	70.52±13.10	16.93 ± 0.30	24.13	<0.01	1.51±0.08	1.0 ± 0.5	230± 17
SG	211± 35	81 ± 13	36.19±0.95	32.29±15.11	29.95±17.21	14 ± 4	<0.01	23.74	1.79±0.10	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	255± 18
ECO-SENSITIVE AREA										
EC	148	22	11.41	33.95	11.64	<20.0	<0.01	<1.0	<1.0	226

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 PM₁₀ and PM_{2.5} at all stations were found to be exceeding the prescribed CPCB limits of 100µg/m³ and 60µg/m³, respectively. All other pollutants were recorded well below the prescribed limits.

Results for the air quality parameters at Elephanta Caves [EC] station during 25th February'16 to 26th February'16 are represented in **Table 5**. **Tables 6 & 7** provide the results for NGC and SGC air monitoring stations respectively.

In February, 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 February 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 PM₁₀ and PM_{2.5} viz, 100µg/m³ and 60µg/m³, respectively, which are higher than the prescribed CPCB standards.
- ✓ *Construction of 4th Container Terminal on South side of JNPT:* Land preparation work of 4th 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 PM₁₀ and PM_{2.5} Concentration at South Gate may be attributed due to the earth filling activity of 4th 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 PM₁₀ and PM_{2.5} 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 PM₁₀ and PM_{2.5} 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 PM₁₀ and PM_{2.5}.

The following measures can be taken to reduce further the PM₁₀ and PM_{2.5} 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 4th Container Terminal is required to be done, as significant amount of dust is generated due to earth filling activities at the site.

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

Conclusion:

From the results obtained for the month of February 2016, it can be concluded that overall Ambient Air quality of the JN Port is within CPCB limits, except the levels of PM₁₀ and PM_{2.5}, 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 each during spring and neap tidal cycle. The samples are taken after 1st, 3rd and 5th hour of the tide from eight fixed and one moving stations and composited from 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 composited from four water quality monitoring stations in the Nhava Creek during spring and 3rd hour of neap tide only because of very low water depth available (mud flat) at these stations. In all 24 samples are collected from four 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.	25.02.2016
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	25.02.2016
3.	W3	Identified by the green buoy no. <u>FG2 Green</u> of JNPT approach channel and lies near the landing jetty.	26.02.2016
4.	W4	Located at Uran Patch Beacon (lighthouse on concrete platform) near the Butcher Island filling platform.	26.02.2016
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.	25.02.2016
	W11 to W14		27.02.2016
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.	25.02.2016
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.	26.02.2016
8.	W9	Located in between GTI and Liquid Cargo Jetty. This station is selected to examine the impact of terminal activities on water qualities	26.02.2016
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.	26.02.2016

Table 10: List of Parameters Monitored for Marine Water Quality

Marine Water Quality Parameters [Harbor Area & Creek Area]
<p>A] Physical parameters of Water: 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] Bio-chemical Analysis of Water: Dissolved Oxygen, COD [Chemical Oxygen Demand], BOD [Biochemical Oxygen Demand], NH₃-N, Phenol, Oil & Grease, SPC [Standard Plate Count], Bacteriological count [MPN], Fecal Coliform</p> <p>C] Sediment Analysis: 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 February 2016

Sample Name		Depth, [m]	Temp., [°C]	pH	Salinity, [ppt]	Turbidity, [NTU]	TDS, [mg/L]	TSS, [mg/L]	TS, [mg/L]
Standard		-	-	6.5 - 9.0	-	-	-	-	-
W1	SS	13.6	25.8	8.05	30.2	6	30410	139	40404
	SM		25.6	8.06	31.2	10	30510	97	41412
	SB		25.2	8.08	32.5	15	30240	140	42592
	NS	12.5	28.6	8.05	26.1	12	30360	125	40348
	NM		27.4	8.08	32.5	12	30280	124	42644
	NB		27.2	8.07	30.9	24	31120	100	49592
W2	SS	8.5	24.6	8.1	31.8	18	31020	89	41628
	SM		23.2	7.8	30.9	22	31140	91	42356
	SB		22.8	7.71	31.1	23	30080	137	44792
	NS	8.0	27.9	8.02	32.8	21	31180	95	41308
	NM		26.8	8.07	31.1	26	31190	100	43480
	NB		26.5	7.61	31.3	24	31220	114	45212
W3	SS	9.5	25.4	8.05	31.9	9	30360	95	41540
	SM		25.2	8.03	32.8	27	30250	92	42636
	SB		23.9	7.8	30.5	31	30080	100	46160
	NS	8.5	30.1	7.65	30.6	6	30140	104	42572
	NM		29.8	7.43	30.2	18	30270	121	43836
	NB		29.4	7.41	29.6	29	30480	97	50660
W4	SS	11.8	27.1	8.1	30.4	14	30520	93	43828
	SM		26.8	8.0	31.2	21	30430	117	43896
	SB		24.5	7.79	32.3	36	30720	124	49780
	NS	10.5	26.7	8.02	32.2	9	30840	106	50024
	NM		26.5	8.03	30.0	25	30530	136	54628
	NB		26.1	7.49	32.6	31	30280	117	48848
W5	SS	13.6	28.6	7.72	32.0	11	30240	107	44308
	SM		27.4	7.94	32.1	6	30550	139	49776
	SB		27.1	7.81	29.6	5	31080	113	53516
	NS	12.2	29.5	8.1	32.8	10	31140	137	45048
	NM		28.3	8.3	31.9	15	31210	107	62760
	NB		28.1	8.0	28.6	9	30980	118	43408

SS# - SPRING SAMPLE
 SS - SPRING SURFACE
 SM - SPRING MIDDLE
 SB - SPRING BOTTOM

NS# - NEAP SAMPLE
 NS - NEAP SURFACE
 NM - NEAP MIDDLE
 NB - NEAP BOTTOM

Sample Name		Depth, [m]	Temp., [°C]	pH	Salinity, [ppt]	Turbidity, [NTU]	TDS, [mg/L]	TSS, [mg/L]	TS, [mg/L]
Standard		-	-	6.5 - 9.0	-	-	-	-	-
W6	SS	13.1	26.7	8.03	31.4	8	30750	100	46460
	SM		26.4	7.91	29.6	20	30380	155	44860
	SB		26	8.01	30.6	13	30460	137	50532
	NS	11.9	28	8.11	31.0	25	30670	91	50332
	NM		27.5	7.94	31.1	14	30280	128	45332
	NB		27.2	7.87	28.6	9	30840	95	41412
W7	SS	8.2	27.6	8.03	30.6	19	31147	104	46431
	SM		27.2	7.77	28.9	6	30293	102	44491
	SB		25.8	7.80	31.3	8	30209	96	46121
	NS	7.5	29.4	8.02	30.2	25	30437	95	50838
	NM		26.4	8.01	32.3	22	30298	95	48138
	NB		26.2	7.93	30.8	14	30325	116	45730
W9	SS	15.8	28.9	8.08	32.7	17	31476	118	47656
	SM		28.5	7.86	30.6	5	30254	116	45305
	SB		27.3	7.92	32.6	9	30155	110	45677
	NS	13.6	30.5	7.74	31.3	3	30153	96	48787
	NM		30.2	8.01	30.2	10	30473	125	47486
	NB		29.4	7.78	32.9	23	30373	117	44446
W10	SS	8.5	27.8	7.89	32.1	23	30469	101	49325
	SM		27.5	8.02	30.8	6	30275	115	46153
	SB		27.2	7.73	31.2	19	31457	125	46199
	NS	8.0	29.6	8.03	30.0	12	30320	111	48459
	NM		27.5	7.84	29.9	15	31408	121	49381
	NB		27.2	7.81	29.5	14	31223	103	47683

SS# - SPRING SAMPLE
 SS - SPRING SURFACE
 SM - SPRING MIDDLE
 SB - SPRING BOTTOM

NS# - NEAP SAMPLE
 NS - NEAP SURFACE
 NM - NEAP MIDDLE
 NB - NEAP BOTTOM

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

Sample Name		DO, [mg/L]	COD, [mg/L]	BOD, [mg/L]	NH ₃ -N, [mg/L]	Phenol, [mg/L]	O&G, [mg/L]	TPC, [CFU/mL]	Fecal Coliforms, [MPN/100 mL]
Standard		3.0 mg/L or 40% of saturation value	-	5	-	-	10	-	500
W1	SS#		-	-	-	-	<4.0	76	7
	SS	4.9	46	<2.0	<1.0	<0.001			
	SM	4.0	44	-	-	-			
	SB	4.1	33	-	-	-			
	NS#			-	-	-	<4.0	77	<2
	NS	5.4	46	<2.0	<1.0	<0.001			
	NM	4.3	37	-	-	-			
	NB	4.4	29	-	-	-			
W2	SS#						<4.0	42	9
	SS	4.5	32	<2.0	<1.0	<0.001			
	SM	4.4	29	-					
	SB	3.9	36	-					
	NS#						<4.0	77	2
	NS	4.8	44	<2.0	<1.0	<0.001			
	NM	4.5	47	-					
	NB	4.3	42	-					
W3	SS#			-	-	-	<4.0	42	60
	SS	4.4	46	<2.0	<1.0	<0.001			
	SM	4.3	44	-	-	-			
	SB	4.2	40	-	-	-			
	NS#			-	-	-	<4.0	82	8
	NS	4.5	40	<2.0	<1.0	<0.001			
	NM	4.4	45	-	-	-			
	NB	3.7	42	-	-	-			
W4	SS#			-	-	-	<4.0	73	7
	SS	5.2	41	<2.0	<1.0	<0.001			
	SM	4.5	33	-	-	-			
	SB	4.4	41	-	-	-			
	NS#			-	-	-	<4.0	56	<2
	NS	4.4	29	<2.0	<1.0	<0.001			
	NM	5.3	29	-	-	-			
	NB	4.5	32	-	-	-			
W5	SS#			-	-	-	<4.0	83	22
	SS	4.4	31	<2.0	<1.0	<0.001			
	SM	6.3	39	-	-	-			
	SB	4.1	45	-	-	-			
	NS#			-	-	-	<4.0	67	4
	NS	4.8	28	<2.0	<1.0	<0.001			
	NM	4.5	32	-	-	-			
	NB	3.6	35	-	-	-			

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NS - NEAP SURFACE
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Sample Name		DO, [mg/L]	COD, [mg/L]	BOD, [mg/L]	NH ₃ -N, [mg/L]	Phenol, [mg/L]	O&G, [mg/L]	TPC, [CFU/mL]	Fecal Coliforms, [MPN/100 mL]
Standard		3.0 mg/L or 40% of saturation value	-	5	-	-	10	-	500
W6	SS#		-	-	-	-	<4.0	81	20
	SS	4.5	44	<2.0	<1.0	<0.001			-
	SM	4.3	48	-	-	-			-
	SB	3.7	41	-	-	-			-
	NS#			-	-	-	<4.0	37	6
	NS	4.2	43	<2.0	<1.0	<0.001			-
	NM	4.0	39	-	-	-			-
	NB	3.6	45	-	-	-			-
W7	SS#						<4.0	70	3
	SS	4.3	45	<2.0	<1.0	<0.001		-	-
	SM	4.1	42	-				-	-
	SB	3.9	38	-				-	-
	NS#						<4.0	63	5
	NS	4.8	31	<2.0	<1.0	<0.001		-	-
	NM	4.9	35	-				-	-
	NB	4.6	46	-				-	-
W9	SS#			-	-	-	<4.0	57	10
	SS	4.6	33	<2.0	<1.0	<0.001		-	-
	SM	4.3	34	-	-	-		-	-
	SB	4.1	28	-	-	-		-	-
	NS#			-	-	-	<4.0	46	12
	NS	4.7	34	<2.0	<1.0	<0.001		-	-
	NM	4.5	47	-	-	-		-	-
	NB	4.3	33	-	-	-		-	-
W10	SS#			-	-	-	<4.0	84	4
	SS	4.4	37	<2.0	<1.0	<0.001		-	-
	SM	4.1	41	-	-	-		-	-
	SB	3.9	35	-	-	-		-	-
	NS#			-	-	-	<4.0	78	8
	NS	4.6	47	<2.0	<1.0	<0.001		-	-
	NM	4.5	39	-	-	-		-	-
	NB	4.0	45	-	-	-		-	-

SS# - SPRING SAMPLE
SS - SPRING SURFACE
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NS# - NEAP SAMPLE
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NM - NEAP MIDDLE
NB - NEAP BOTTOM

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

Station Name	Organic Matter		Total Carbon		Inorganic Phosphate
	mg/g	%	mg/g	%	
W1	152.8	15.28	86.9	8.69	262
W2	65.6	6.56	38.2	3.82	211
W3	129.3	12.93	81.5	8.15	252
W4	108.7	10.87	63.1	6.31	183
W5	86.4	8.64	44.8	4.48	316
W6	151.8	15.18	93.6	9.36	237
W9	163.2	16.32	87.3	8.73	284
W10	168.5	16.85	98.9	9.89	235

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

Sample Name		Depth, [m]	Temp., [°C]	pH	Salinity, [ppt]	Turbidity, [NTU]	TDS, [mg/L]	TSS, [mg/L]	TS, [mg/L]
Standard		-	-	6.5 - 9.0	-	-	-	-	-
W11	SS	3.5	25.5	7.77	31.5	15	31102	78	45404
	SM		25.4	7.75	36.8	12	32212	96	39920
	SB		25.3	7.63	31.7	16	30224	119	38760
	NS	3.0	30.0	7.73	32.6	13	32270	116	40236
	NM		29.9	7.66	35.5	14	31135	112	38696
	NB		29.5	7.67	36.9	20	30780	116	39184
W12	SS	3.0	27.5	7.72	30.2	11	32223	82	30950
	SM		27.4	7.2	35.4	12	32407	109	32477
	SB		27.2	7.82	33.8	15	30210	123	32234
	NS	2.5	29.8	7.76	34.2	13	32397	118	31950
	NM		29.7	7.62	34.9	10	3234	98	31197
	NB		29.4	7.68	35.4	9	31161	107	32295
W13	SS	3.0	26.3	7.53	31.8	12	30469	142	32447
	SM		26.4	7.49	32.4	14	32387	138	32332
	SB		26.0	7.62	35.1	13	32262	126	30108
	NS	2.5	29.7	7.6	33.6	13	31200	115	31161
	NM		29.1	7.59	31.5	9	30341	128	32118
	NB		28.9	7.58	32.9	11	31381	147	32349
W14	SS	2.5	26.7	7.87	31.4	13	32406	112	31570
	SM		26.5	7.76	32.1	10	32369	108	30129
	SB		26.5	7.62	35.6	12	32108	136	31381
	NS	2.0	29.8	7.71	30.7	11	31488	153	32195
	NM		29.7	7.52	31.3	12	32399	121	30630
	NB		27.8	7.63	33.4	12	31458	140	32110

SS# - SPRING SAMPLE
SS - SPRING SURFACE
SM - SPRING MIDDLE
SB - SPRING BOTTOM

NS# - NEAP SAMPLE
NS - NEAP SURFACE
NM - NEAP MIDDLE
NB - NEAP BOTTOM

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

Sample Name		DO, [mg/L]	COD, [mg/L]	BOD, [mg/L]	NH ₃ -N, [mg/L]	Phenol, [mg/L]	O&G, [mg/L]	TPC, [CFU/mL]	Fecal Coliforms, [MPN/100 mL]
Standard		3.0 mg/L or 40% of saturation value	-	5	-	-	10	-	500
W11	SS	4.6	51	<2.0	<1.0	<0.001	<4.0	66	66
	SM	4.3	39	-	-	-	-	-	-
	SB	4.0	41	-	-	-	-	-	-
	NS	4.6	35	<2.0	<1.0	<0.001	<4.0	87	10
	NM	4.3	38	-	-	-	-	-	-
	NB	4.1	46	-	-	-	-	-	-
W12	SS	5.2	47	<2.0	<1.0	<0.001	<4.0	59	18
	SM	4.9	44	-	-	-	-	-	-
	SB	4.6	34	-	-	-	-	-	-
	NS	4.6	35	<2.0	<1.0	<0.001	<4.0	52	6
	NM	4.2	47	-	-	-	-	-	-
	NB	4.1	32	-	-	-	-	-	-
W13	SS	4.3	34	<2.0	<1.0	<0.001	<4.0	77	8
	SM	4.1	48	-	-	-	-	-	-
	SB	3.9	41	-	-	-	-	-	-
	NS	4.6	38	<2.0	<1.0	<0.001	<4.0	62	4
	NM	4.3	48	-	-	-	-	-	-
	NB	4.1	45	-	-	-	-	-	-
W14	SS	4.5	33	<2.0	<1.0	<0.001	<4.0	63	30
	SM	4.4	47	-	-	-	-	-	-
	SB	4.2	40	-	-	-	-	-	-
	NS	4.4	36	<2.0	<1.0	<0.001	<4.0	58	6
	NM	4.2	36	-	-	-	-	-	-
	NB	3.9	50	-	-	-	-	-	-

SS# - SPRING SAMPLE
SS - SPRING SURFACE
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NS - NEAP SURFACE
NM - NEAP MIDDLE
NB - NEAP BOTTOM

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

Sample Name	Organic Matter		Total Carbon		Inorganic Phosphate
	mg/g	%	mg/g	%	mg/g
W11	104	8.1	55.4	4.6	219
W12	93	7.7	48.1	5.3	186
W13	86	9.8	53.9	6.2	257
W14	77	7.6	40.6	3.9	132

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	22.8 – 30.5	°C	-
2	pH	7.41 – 8.30	-	6.5 - 9.0
3	Salinity	26.1 – 32.5	ppt	-
4	Turbidity	3 – 36	NTU	-
5	TDS	30080 – 31220	mg/L	-
6	TSS	89 – 155	mg/L	-
7	TS	40348 – 62760	mg/L	-
8	DO	3.6 – 6.3	mg/L	3.0 mg/L(min.) or 40% of saturation value
9	COD	28 - 48	mg/L	-
10	BOD	<2.0	mg/L	5 (max.)
11	NH ₃ -N	<1.0	mg/L	-
12	Phenol	< 0.001	mg/L	-
13	Oil & Grease	<4.0	mg/L	10 (max.)
14	Total Plate Count	37 – 84	CFU/ml	-
15	Fecal Coliforms	<2- 60	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	25.3 – 30.0	°C	-
2	pH	7.20 – 7.87	-	6.5 - 9.0
3	Salinity	30.2 – 36.9	ppt	-
4	Turbidity	9 – 20	NTU	-
5	TDS	30780 – 32407	mg/L	-
6	TSS	78 – 153	mg/L	-
7	TS	30630 – 40236	mg/L	-
8	DO	3.9 – 5.2	mg/L	3.0 mg/L(min.) or 40% of saturation value
9	COD	32 – 50	mg/L	-
10	BOD	<2.0	mg/L	5 (max.)
11	NH ₃ -N	<1.0	mg/L	-
12	Phenol	< 0.001	mg/L	-
13	Oil & Grease	<4.0	mg/L	10 (max.)
14	Total Plate Count	52 – 87	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 February , 2016 are within the prescribed limits. Also, the concentration ranges observed for various parameters for water samples collected from Nhava Creek area during February, 2016 are also within prescribed limits.

Observed salinity values for Harbour and Creek water samples in the month of February, 2016 varied from 26.1 – 32.5 ppt and 30.2 – 36.9 ppt respectively [**Tables 11&14**]. The earth filling activity for the development of 4th 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 28 – 48 and 32 – 50 respectively for Harbour and Creek water samples. The DO levels were found between 3.6 & 6.3 mg/L and 3.9 & 5.2 mg/L for water samples collected from Harbour and Creek areas respectively. The concentrations of Phenol and NH₃ - 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 6.56 – 16.85 %, 3.82 – 9.89 % and 183 – 316 mg/kg, respectively. **Table 16** shows the values for Organic Matter, Total Organic Carbon and Inorganic Phosphate as 7.6 to 9.8 %, 3.9 to 6.2 % and 132 – 257 mg/kg, respectively in Nhava Creek sediments during February, 2016.

2.5 OBSERVATIONS AND CONCLUSION

- ✓ *Construction of 4th Container Terminal on South side of JNPT: Earth Filling work and dredging work of 4th 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 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.

Niksin 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 Niksin 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 Niksin 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 20 μ m 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 μ m) by using vacuum filtration assembly. After vacuum filtration the glass micro fiber filter paper was grinded 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.

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 20µm 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 μ 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 & PHEO PHTIN-A

The chlorophyll sample was collected from sub surface layer during st hour and #rd hour nad 5th 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 high, due the large representation by phytoplankton. In the sub surface water chlorophyll-a was varying from 1.11-3.43 mg/M³. Pheophytin -a level was below detectable limit in the all 13 sampling stations during sampling done in Feb 2016 (Table - 24b).

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, PO₄³⁻ - P, SO₄²⁻, NO₂⁻ - N, NO₃⁻ - N,
Cations: Ca²⁺, Mg²⁺, 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	92	15/15	100
	W2	104	12/15	80
	W3	94	14/15	93.3
	W4	114	15/15	100
	W5	94	13/15	86.6
	W6	112	14/15	93.3
	W7	95	14/15	93.3
	W9	104	13/15	86.6
	W10	62	12/15	80
NHAVA CREEK	W11	102	13/15	81.3
	W12	123	15/15	100
	W13	126	15/15	100
	W14	143	15/15	100

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	9	DIATOMS	44-82
			DINO FLAGELLATES	18-34
			TOTAL PHYTO PLANKTON	62-114
NHAVA CREEK	Sub surface	4	DIATOMS	74-93
			DINO FLAGELLATES	28-53
			TOTAL PHYTO PLANKTON	102-143

ZOOPLANKTON POPULATION:

Zooplankton sample was collected from the sub surface layer in 9 different sampling locations in JNP harbour area and four locations in Nhava Creek. Zooplankton community

was represented by four groups of plankton; Tintinids, Foraminifera, Copepods, and Arrow worms. Among these holoplankton of this region; Tintinids were the most dominant group followed by Copepods. 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 144-184 No./L In Harbour area and 180-208No/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	144	12/16	75
	W2	176	16/16	100
	W3	160	13/16	81.3
	W4	178	16/16	100
	W5	184	15/16	94
	W6	170	15/16	94
	W7	170	14/16	87.5
	W9	148	15/16	94
	W10	160	14/16	87.5
NHAVA CREEK	W11	206	13/16	81.3
	W12	206	16/16	100
	W13	180	16/16	100
	W14	208	16/16	100

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	9	Tintinids	56-96
			Copepods	48-66
			Arrow worms	0-4
			Larval forms	20-38
			TOTAL ZOOPLANKTON NO/L	144-184
NHAVA CREEK	Sub surface	4	Tintinids	90-108
			Copepods	52-68
			Arrow worms	0-6
			Larval forms	32-52
			TOTAL ZOOPLANKTON NO/L	180-206

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

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/ SPECIES	#
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	<i>Coscinodiscus marginatus</i>	D1
			Thalassiosirales	Skeletonemataceae	<i>Skeletonemaspa</i>	D2
			Thalassionematales	Thalassionemataceae	<i>Thalassionema</i>	D3
					<i>Thalassiothrix</i>	D4
			Naviculales	Naviculaceae	<i>Naviculaspa.</i>	D5
				Pleurosigmaaceae	<i>Pleurosigma sp.</i>	D6
			Fragilariales	Fragilariaceae	<i>Fragilaria sp.</i>	D7
					<i>Asterionellopsis</i>	D8
					<i>Synedra sp.</i>	D9
DINO FLAGELL ATES	Pyrrophyta	Desmophyceae	Dinophysiales	Dinophysiaceae	<i>Dinophysis sp.</i>	F1
			Gonyaulacales	Ceratiaceae	<i>Ceratium triops</i>	F2
					<i>Ceratium breve</i>	F3
					<i>Ceratium furca</i>	F4
			Gonyaulacales	Pyrophacaceae	<i>Pyrophacus sp.</i>	F5
			Peridinales	Protoperidiniaceae	<i>Protoperidinium sp.</i>	F6

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

Sr.No.	Station	Chlorophyll-a (mg/m ³)	Pheophytin- a (mg/m ³)	Algal Biomass (Chlorophyll method)mg/m ³
JNP HARBOUR AREA				
1	W1	3.43	BDL	229.8
2	W2	1.90	BDL	127.3
3	W3	1.46	BDL	97.82
4	W4	1.37	BDL	91.79
5	W5	1.48	BDL	99.16
6	W6	1.1	BDL	73.7
7	W7	1.90	BDL	127.3
8	W9	1.48	BDL	99.16

9	W10	2.18	BDL	146.06
NHAVA CREEK				
10	W11	1.26	BDL	84.42
11	W12	1.48	BDL	99.16
12	W13	1.38	BDL	92.46
13	W14	1.55	BDL	103.9

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 9	W 10	W 11	W 12	W 13	W14	
	DIATOMS														
D1	<i>Coscinodiscus marginatus</i>	14	18	10	16	12	14	20	16	8	10	12	10	18	
D2	<i>Skeletonema sp.</i>	8	12	10	8	16	4	2	2	0	4	8	12	10	
D3	<i>Thalassionema</i>	6	8	4	2	4	6	4	8	2	4	10	12	18	
D4	<i>Thalassiothrix</i>	14	16	20	18	14	12	20	18	14	22	18	16	13	
D5	<i>Naviculasp.</i>	4	6	8	10	2	12	4	6	2	10	7	8	6	
D6	<i>Pleurosigma sp.</i>	4	0	0	2	2	4	0	4	0	0	4	6	2	
D7	<i>Fragilariasp</i>	2	6	4	2	4	6	2	2	4	8	8	4	6	
D8	<i>Asterionellopsissp</i>	12	14	10	22	20	14	17	24	10	14	14	12	18	
D9	<i>Synedra</i>	4	2	6	2	4	6	8	2	4	2	4	6	2	
	DIATOMS TOTAL UNITS/L	68	82	72	82	78	78	77	82	44	74	85	86	93	
DINO FLAGELLATES															
F1	<i>Dinophysis sp.</i>	4	0	2	6	4	4	0	2	2	4	4	2	6	
F2	<i>Ceratiumtriops</i>	4	0	2	0	0	6	0	0	0	0	4	2	4	
F3	<i>Ceratium breve</i>	6	8	10	12	8	14	6	8	10	12	6	8	10	
F4	<i>Ceratiumfurca</i>	4	8	2	6	2	4	8	10	4	6	8	12	10	
F5	<i>Pyrophacus sp.</i>	4	0	0	4	0	0	0	0	0	0	8	10	10	
F6	<i>Protoperidiniumsp</i>	2	6	6	4	2	6	4	2	2	6	8	6	10	
	DINOFLAGELLATES TOTAL UNITS/ L	24	22	22	32	16	34	18	22	18	28	38	40	50	
	TOTAL PHYTOPLANKTON UNITS/L	92	104	94	114	94	112	95	104	62	102	123	126	143	

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)	SPIROTRICHEA	TINTINNIDA	Tintinnidiidae	<i>Leprotintinnus</i> sp.	T1
				Codonellidae	<i>Tintinnopsis tocantinensis</i>	T2
					<i>Tintinnopsis acuminata</i>	T3
					<i>Tintinnopsis baltica</i>	T4
					<i>Tintinnopsis radix</i>	T5
				Xystonellidae	<i>Favella</i> sp.	T6
COPEPODS	ARTHROPODA CRUSTACEA	SUB CLASS COPEPODA	CALANOIDA	Calanidae	<i>Canthocalanus</i> sp.	C1
				Centropagidae	<i>Centropages</i> sp.	C2
			CYCLOPOIDA	Oithonidae	<i>Oithona</i> sp.	C3
			HARPACTICOIDA	Euterpinae	<i>Euterpina</i> sp.	C4
UROCHORDATA	CHORDATA	APPENDICULARIA		Oikopleuridae	<i>Oikopleura</i> sp.	U1
	SUB PHYLUM UROCHORDATA			Fritillariidae	<i>Fritillaria</i> sp.	U2
ARROW WORMS	CHAETOGNATHA	SAGITTOIDEA	APHRAGMOPHORA	Sagittidae	<i>Sagitta</i> sp.	A1
(CRUSTACEAN LARVAE)	ARTHROPODA (CRUSTACEA)	COPEPODA	-	-	Nauplius larvae of Copepods	L1
(Brachyuran LARVAE)	ARTHROPODA CRUSTACEA	DECAPODA (BRACHYURA)	-	-	Zoea Larvae	L2
POLYCHAETE LARVAE			-	-	Trachophore larvae	L3

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 9	W 10	W 11	W 12	W 13	W 14	
TINTINIDS															
T1	Leprotintinnussp.	20	18	20	26	24	18	22	12	14	28	24	20	18	
T2	Tintinnopsistocantiniensis	16	24	10	20	12	22	18	14	16	24	20	32	20	
T3	Tintinnopsisacuminata	8	12	16	14	10	20	24	10	16	10	8	12	10	
T4	Tintinnopsisbaltica	4	8	6	2	12	10	8	6	12	10	14	10	16	
T5	Tintinnopsisradix	14	8	12	10	6	8	10	4	8	12	8	10	12	
T6	Favella sp.	12	26	10	16	14	16	12	10	18	24	16	10	14	
	TINTINIDS TOTAL NO/L	74	96	74	88	78	94	94	56	84	108	90	94	90	
COPEPODS															
C1	Canthocalanus	12	18	10	14	16	14	12	20	10	16	24	18	24	
C2	Centropages sp.	16	14	12	16	20	22	18	16	18	20	16	12	14	
C3	Oithona sp.	16	18	24	20	26	18	16	20	18	24	20	12	10	
C4	Euterpina sp.	4	2	2	6	4	2	6	4	2	4	8	10	12	
	COPEPODS Total NO/L	48	52	48	56	66	56	52	60	48	64	68	52	60	
ARROW WORMS															
A1	Sagitta sp.	0	4	0	2	4	0	2	2	0	2	4	0	6	
	ARROW WORMS Total No/L	0	4	0	2	4	0	2	2	0	2	4	0	6	
LARVAL FORMS															
L1	Nauplius larvae of Copepods	12	18	24	24	22	16	12	18	20	20	26	20	28	
L2	Zoea Larvae	6	4	8	6	10	2	8	10	6	8	10	8	12	
L3	Polychate larvae	4	2	6	2	4	2	2	2	2	4	8	6	12	
	Larval forms total no/l	22	24	38	32	36	20	22	30	28	32	44	34	52	
	TOTAL ZOOPLANKTON NO/L	144	176	160	178	184	170	170	148	160	206	206	180	208	
	Biomass by displacement ml/m3	0.07	0.09	0.08	0.08	0.10	0.09	0.08	0.07	0.07	0.11	0.12	0.10	0.18	

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/M² (**Table - 28**)

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

	ABUNDANCE IN NO/M ² DIFFERENT SAMPLING STATIONS											
	REPRESENTATION BY GROUP											
	W1	W2	W3	W4	W5	W6	W7	W9	W10	W11	W12	W13
POLYCHATES												
Family : Nephthydidae	40	60	70	80	160	60	80	40	50	60	90	110
<i>Nephtys sp.</i>												
Family : Nereidae	70	80	30	120	90	100	160	120	40	140	60	50
<i>Nereis sp.</i>												
Total Polychates N/m²	110	140	100	200	250	160	240	160	90	200	150	160
GASTROPODA(Molluscs)												
<i>Architectonica sp.</i>	0	0	10	0	40	0	0	10	20	0	40	0
<i>Total gastropods N/m²</i>	0	0	10	0	40	0	0	10	20	0	40	0
TOTAL macro Benthic Fauna NUMBER/ m²	110	140	100	200	290	160	240	170	110	200	190	160
BIOMASS gm/m²	7.67	9.4	9.37	14.28	24.28	10.26	16.32	13.6	12.67	13.52	13.6	10.35

WATER QUALITY NUTRIENTS (BIOTIC):

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

Station Name	Ca ²⁺ [mg/L]	Mg ⁺ [mg/L]	K ⁺ [mg/L]	Na ⁺ [mg/L]	PO ₄ ³⁻ -P [µg/L]	NO ₃ ¹⁻ -N [µg/L]	NO ₂ ¹⁻ -N [µg/L]	SiO ₂ ²⁻ [µg/L]	SO ₄ ²⁻ [µg/L]
Standard	-	-	-	-	0.1 - 90	1.0 - 500	<125	10 - 5000	-
JNP HARBOUR AREA									
W1	412	1159	218	10245	41	725	< 10	1289	3156
W2	512	1265	139	9895	60	820	< 10	1426	2648
W3	608	1162	175	10320	39	625	< 10	1505	2954
W4	535	1195	142	11025	40	508	< 10	1482	2348
W5	479	1305	155	9980	48	431	< 10	1535	2778
W6	564	1245	195	10624	62	915	< 10	1562	3152
W7	611	1148	172	10550	55	498	< 10	1488	2149
W9	468	1325	168	10295	47	716	< 10	1520	2462
W10	515	1205	208	10890	43	554	< 10	1495	3195
JNP NHAVA CREEK AREA									
W11	398	1330	137	11236	39	612	< 10	1502	2189
W12	472	1058	192	10582	51	710	< 10	1384	3156
W13	510	1152	184	11025	43	804	< 10	1496	2775
W14	415	1248	156	10350	79	870	< 10	1488	2462

SEDIMENT QUALITY NUTRIENTS (BIOTIC):

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

Station Name	Ca ²⁺ [mg/Kg]	Mg ⁺ [mg/Kg]	K ⁺ [mg/Kg]	Na ⁺ [mg/Kg]	PO ₄ ³⁻ -P [mg/Kg]	NO ₃ ¹⁻ -N [mg/Kg]	NO ₂ ¹⁻ -N [mg/Kg]	SiO ₂ ²⁻ [mg/Kg]	SO ₄ ²⁻ [mg/Kg]
Standard	-	-	-	-	-	-	-	-	-
JNP HARBOUR AREA									
W1	4952	215	214	5678	215	9	0.12	21	5924
W2	4658	167	222	5844	311	8	0.08	29	5126
W3	5248	375	315	5014	286	10	0.15	33	5008
W4	6221	366	298	5337	308	9	0.07	41	3892
W5	5062	243	315	4260	378	11	0.1	52	5160
W6	4921	248	308	4892	258	7	< 0.1	64	6082
W7	5260	327	244	5548	189	5	< 0.1	37	4652
W9	6287	281	401	4612	372	14	0.20	38	2985
W10	6915	411	329	4852	255	9	< 0.1	59	4615
JNP NHAVA CREEK AREA									
W11	4816	372	367	4962	243	11	0.11	37	4268
W12	5132	247	311	4829	291	9	0.09	58	4923
W13	5410	324	414	4436	362	15	0.14	66	4014
W14	6088	390	367	4218	311	20	0.16	73	5225

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 39µg/L – 62µg/L. The average concentration of Phosphate was found to be 48µg/L in JNP harbor region, the Phosphate values are within the prescribed standard range [0.1 – 90µg/L]. Nitrate was found to be between 431µg/L – 915µg/L. The minimum value of Nitrate 431µg/L was found at W5 station and maximum value 915µg/L at W6 station. The average concentration of Nitrate was found to be 676µg/L. At locations W1, W2, W3, W4, W6, W9, & W10 the Nitrate concentration was found to be above prescribed standard range [1.0 to 500 µg/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 1426 – 1496 µg/L with an average of 1562µg/L. The minimum concentration of silica was found at W2 station of JNP harbor region and the maximum concentration of silica was found at W6 station. The values of silica were observed to be well within the prescribed limits [10 to 5000 µg/L]. The Sulphate was found between 2149 – 3195 mg/L, the minimum value recorded at W7 station and maximum at W10 station. The average concentration of Sulphate was found to be 2760 mg/L.

In Nhava Creek, Phosphate was found between 39µg/L – 79µg/L with an average 53µg/L which is within the prescribed standard range [0.1 – 90 µg/L]. The minimum value was recorded at W11 and maximum at W14 location. Nitrate was found to be 612 (at W11) – 870 µg/L (at W14) with an average 749 µg/L. The silica content in Nhava creek was found to be 1488 – 1608 µg/L with an average of 1524 µg/L. The minimum silica content was found at station W14 station and maximum was found at W12 station. The values of silica were observed to be well within the prescribed limits. Sulphate was found between 2189 – 3156 mg/L with an average of 2646 mg/L. The minimum value for Sulphate was found at W11 station and maximum value at W12 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 189 – 378 mg/kg with an average of 286 mg/kg. The minimum value of 189 mg/kg was found at W7 location while maximum value (378 mg/kg) was found at W5. The Nitrate was found to be minimum at W7 station i.e. 5 mg/kg and maximum at W9 station i.e. 14mg/kg. The average concentration of Nitrate was found to be 9 mg/kg. The Nitrite was found to be between 0.05 – 0.20 mg/kg with an average of 0.12 mg/kg. The minimum concentration of nitrite was found at W5 station and maximum value at W9 station. Silica in the form of silicate in JNP harbor sediments were found between 21 and 64 mg/kg with an average of 42mg/kg. The minimum concentration of silica was found at W1 station i.e. 21mg/kg and maximum value was found at W6 station i.e. 64 mg/kg. The Sulphate was found between 2985 - 6082 mg/kg, with minimum value i.e. 2985 mg/kg at W9 station and maximum value i.e. 6082 mg/kg at W6 station. The average concentration of Sulphate was found to be 4827 mg/kg.

In Nhava Creek region the sediment found at four locations. Phosphate levels were 243 to 362 mg/kg with an average of 301 mg/kg. Nitrate was found to be 9 to 20 mg/kg. The average concentration of Nitrate was found to be 13.75 mg/kg. The Nitrite was found to be 0.09 and 0.16 mg/kg. The average concentration of Nitrite was found to be 0.12 mg/kg. Silica in the form of silicate in JNP creek sediments was found to be 37 to 73 mg/kg with an average of 58.5 mg/kg. The Sulphate was found to be 4014 to 5225 mg/kg. The average concentration of Sulphate was found to be 4607 mg/kg.

b. Cations:

In harbor region water, the Calcium was found between 412 to 611 mg/L with an average of 523 mg/L given in **Table 29**. The minimum value for Calcium i.e. 412 mg/L was found at W1 location whereas the maximum value i.e. 611 mg/L was found at W7 location. The Magnesium was found to be 1148 – 1325 mg/L, with minimum value i.e. 1148 mg/L at W7 location whereas maximum value i.e. 1325 was found at W9 stations. The average concentration of Magnesium was found to be 1223 mg/L. The minimum concentration of Potassium 139 mg/L was found at W2 location and maximum concentration 218 mg/L at W1 location with an average of 175 mg/L. The Sodium was found between 9895 to 11025 mg/L with an average of 10425 mg/L. The minimum concentration of sodium i.e. 9895 mg/L was found at W2 stations and maximum value i.e. 11025 mg/L of at W4 station.

In Nhava Creek, Calcium concentration was found with an average 449 mg/L given in **Table 29**. The minimum value 398 mg/L was found at W11 and maximum 510 mg/L at W13 station. Magnesium concentration was found to be 1058 – 1330 mg/L with an average of 1197 mg/L. The minimum value i.e. 1058 mg/L of Magnesium was found at W12 station and maximum value 1330 mg/L was found at W11 station. The Potassium

content in Nhava creek was found to be 137 mg/L at W11 – 192 mg/L at W12 station with an average of 167 mg/L. Sodium minimum concentration was found to be 10350 mg/L at W14 and maximum of 11236 mg/L at W11. The average concentration of sodium was found to be 10798 mg/L.

In harbor region sediments, the Calcium was found to be 4658 to 6915 mg/Kg with an average of 5503 mg/Kg given in **Table 30**. The minimum Concentration of Calcium 4658 mg/kg was found at W2 station and maximum concentration 6915 mg/kg at W10 station. Magnesium was found to be 167 to 411 mg/Kg, with minimum value 167 mg/kg at W2 station and maximum 411 mg/kg was recorded at W10 station. The average concentration of Magnesium was found to be 293 mg/Kg. Potassium in JNP harbor sediment was found to be 214 to 401 mg/Kg with an average of 294 mg/Kg. The minimum concentration of Potassium 214 mg/kg was found at W1 station and maximum value 401 mg/kg at W9 station. Sodium was found to be 4260 to 5844 mg/Kg with an average of 5115 mg/Kg. The minimum concentration of sodium 4260 mg/kg was found at W5 station and maximum value 5844 mg/kg at W2 station.

In Nhava Creek sediments, Calcium was found to be 5410 mg/kg at W13 and 6088 mg/Kg at W14 locations, with an average 5749 mg/Kg given in **Table 30**. Average magnesium was found to be 357 mg/Kg. The minimum concentration of magnesium was found at W13 location i.e. 324 mg/kg, whereas maximum concentration was observed at W14 location with value 390 mg/kg. The minimum concentration of potassium 367 mg/kg was observed at W14 and maximum concentration 414 mg/kg was observed at W13 station. Average potassium content in Nhava creek was found to be 391 mg/Kg. The minimum sodium value 4218 mg/kg was found at W14 station and maximum value 4436 mg/kg at W13. The average concentration of sodium was found to be 4327 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 4th Container Terminal on South side of JNPT:* Earth Filling work of 4thC.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
Outside the Port Area		
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	DW08	Sector III
8	DW13	CISF Canteen
9	DW14	Custom Canteen
10	DW15	JNPT Guest House
Inside the Port Area		
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 27th February, 2016.

The water samples are analyzed for various parameters, viz. Colour, Odour, pH, Turbidity, Total Dissolved Solids, Aluminium as Al, NH₃ - N, Barium as Ba, Boron, Calcium as Ca, Chloride as Cl⁻, Copper as Cu, Fluoride, Free Residual Chlorine, Iron as Fe, Magnesium as Mg, Manganese as Mn, Oil & grease, Nitrate as NO₃⁻, Phenolic compound, Selenium as Se, Silver as Ag, Sulphate as SO₄⁻², Total Alkalinity as CaCO₃, Total Hardness as CaCO₃, 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						
		DW1	DW2	DW3	DW4	DW5	DW6	Standard*
Color	Hazen	<1	<1	<1	<1	<1	<1	5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
pH	-	7.02	7.41	7.51	7.55	7.54	7.65	6.5 to 8.5
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Total Dissolved Solid	mg/l	139	102	124	116	120	98	500
Aluminium as Al	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03
NH ₃ -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	12.50	10.40	12.80	12.80	12.80	11.00	75
Chloride as Cl	mg/l	21.36	18.23	19.34	20.47	20.82	20.39	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	<0.01	<0.01	<0.01	0.3
Magnesium as Mg	mg/l	2.38	2.38	3.11	3.88	3.59	3.88	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 ₃	mg/l	1.34	1.26	1.29	0.96	1.39	0.75	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 ₄	mg/l	13.68	12.12	11.27	13.57	11.49	12.60	200
Total Alkalinity as CaCO ₃	mg/l	24	28	29	23	27	24	200
Total Hardness as CaCO ₃	mg/l	40.8	52	44.8	48	46.8	42	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	<0.01	<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						Standard*
		DW7	DW8	DW9	DW10	DW11	DW12	
Color	Hazen	<1	<1	<1	<1	<1	<1	5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
pH	-	7.65	7.73	7.67	7.61	7.27	7.25	6.5 to 8.5
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Total Dissolved Solid	mg/l	108	110	99	115	137	124	500
Aluminium as Al	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03
NH ₃ -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	11.2	12.02	12.02	12.18	10.42	12.02	75
Chloride as Cl	mg/l	18.32	19.08	19.49	18.23	19.34	18.16	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	<0.01	<0.01	<0.01	0.3
Magnesium as Mg	mg/l	4.86	4.37	5.24	6.51	8.50	7.05	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 ₃	mg/l	2.09	2.16	1.58	0.67	1.49	2.01	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 ₄	mg/l	10.37	9.84	10.26	11.38	10.49	12.12	200
Total Alkalinity as CaCO ₃	mg/l	27	26	23	19	22	24.0	200
Total Hardness as CaCO ₃	mg/l	48	48	52	42	48	44	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	<0.01	<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	-	7.06	6.98	6.93	7.06	7.11	7.21	6.5 to 8.5
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Total Dissolved Solid	mg/l	91	122	128	113	119	107	500
Aluminium as Al	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03
NH ₃ -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	11.86	12.50	11.38	11.70	11.22	10.42	75
Chloride as Cl	mg/l	18.27	17.36	19.40	18.03	18.43	19.24	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	<0.01	<0.01	<0.01	0.3
Magnesium as Mg	mg/l	7.58	8.84	6.27	7.14	2.91	3.4	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 ₃	mg/l	1.32	0.96	1.16	1.26	1.41	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 ₄	mg/l	11.44	12.52	13.19	12.37	11.26	13.44	200
Total Alkalinity as CaCO ₃	mg/l	28	26	27	22	18	22	200
Total Hardness as CaCO ₃	mg/l	46	52	40	44	40	40	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	<0.01	<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

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 February ,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, Iron as Fe and Ammonia as NH₃-N were observed to be below detection limits of measurement i.e. <1.0 NTU, <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 91 to 137 mg/L which are well below the acceptable standard limits (500 mg/L). pH values of all the samples were in the range of 6.93 to 7.65 which is within the permissible standard 6.5 to 8.5. Total Hardness as CaCO₃ values of all the eighteen samples were found to be in the range of 40 to 52 mg/L and found to be within the acceptable limit (200 mg/L).

Concentration levels observed for Chlorides as Cl⁻ and Sulphate as SO₄²⁻ were in the range of 17.36 to 21.36 mg/L, 9.84 to 13.14 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.

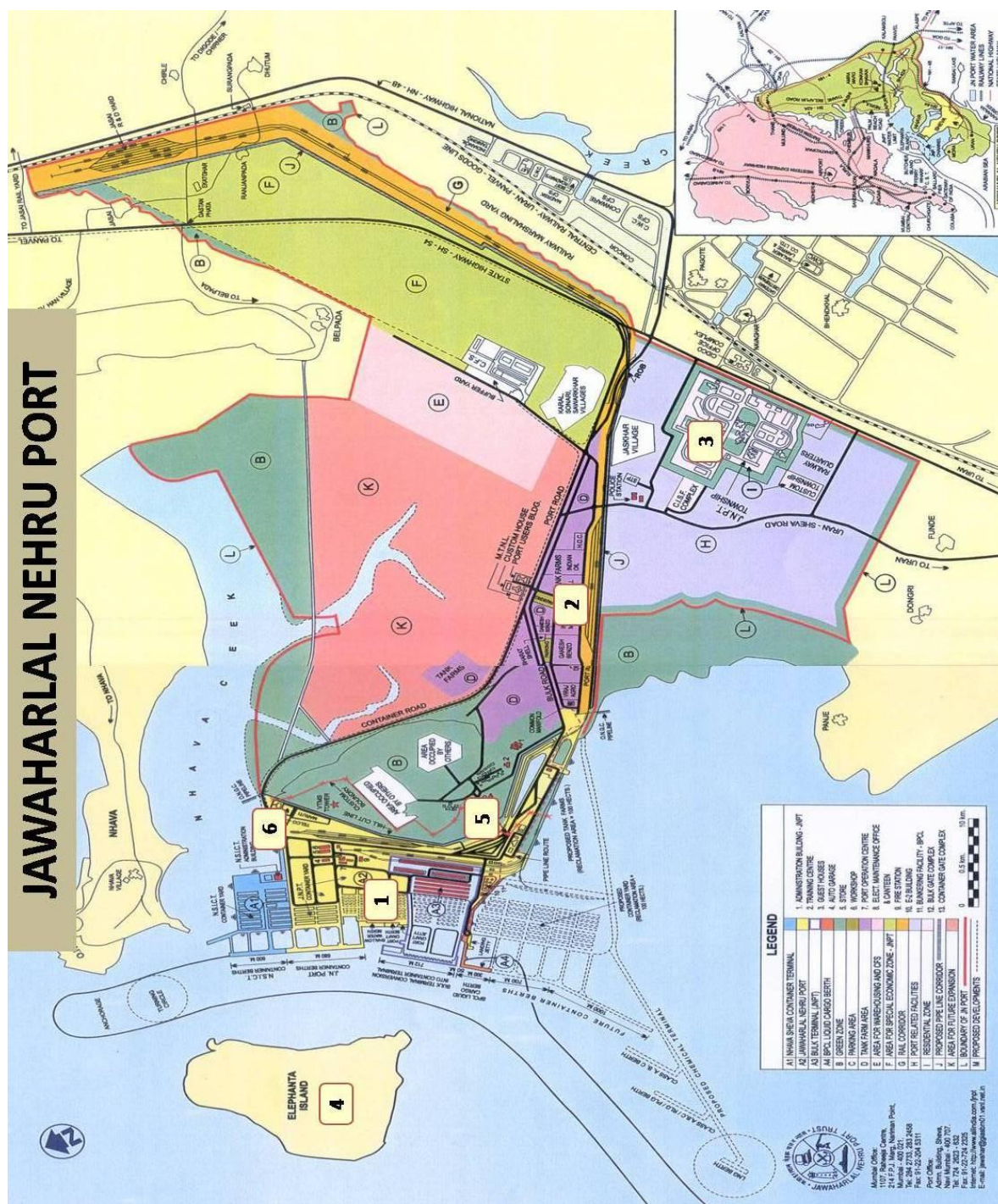
4.4 CONCLUSIONS AND MITIGATION MEASURES:

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

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

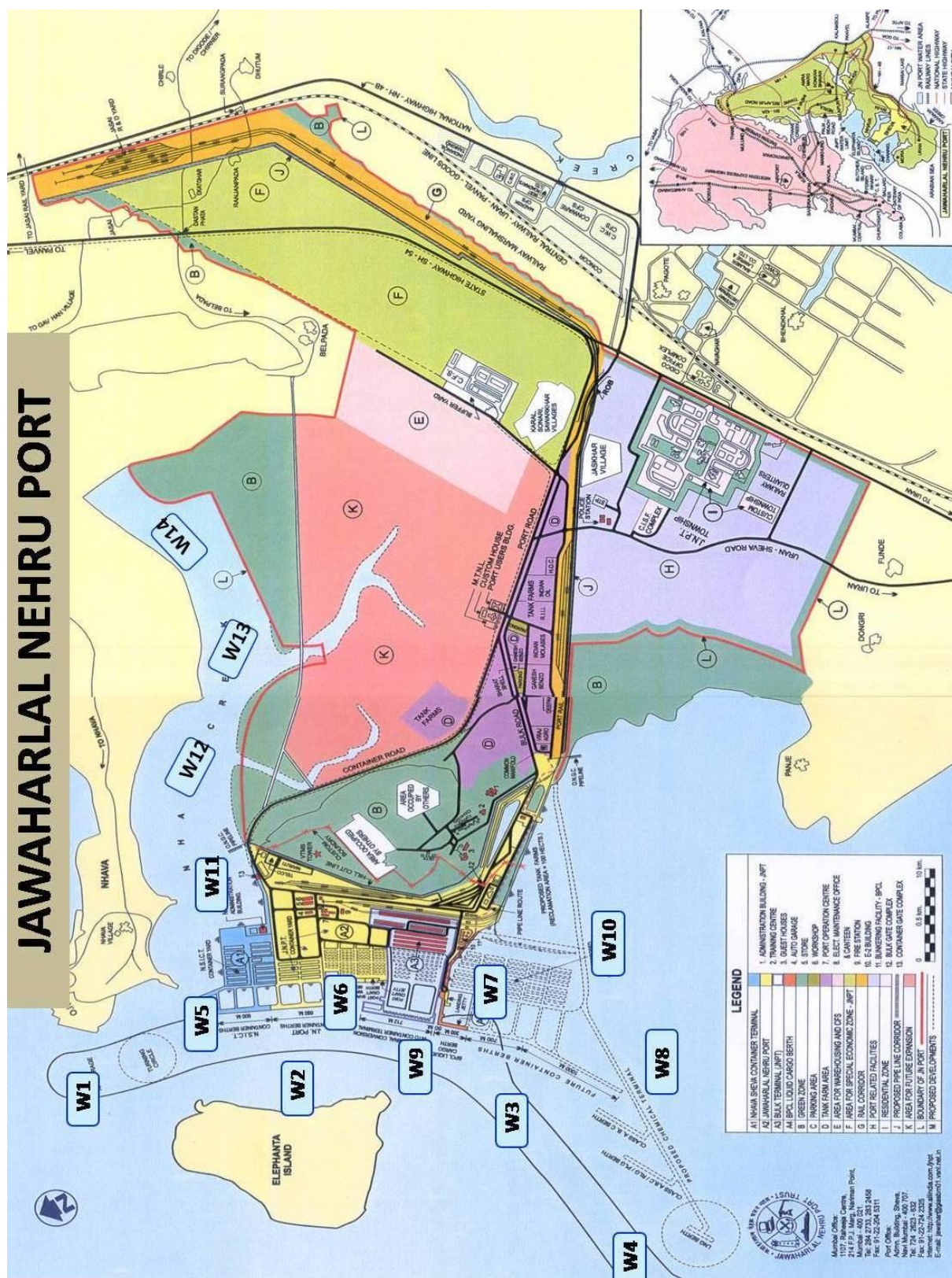
** 24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be compiled with 98% of the time in a year.

2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

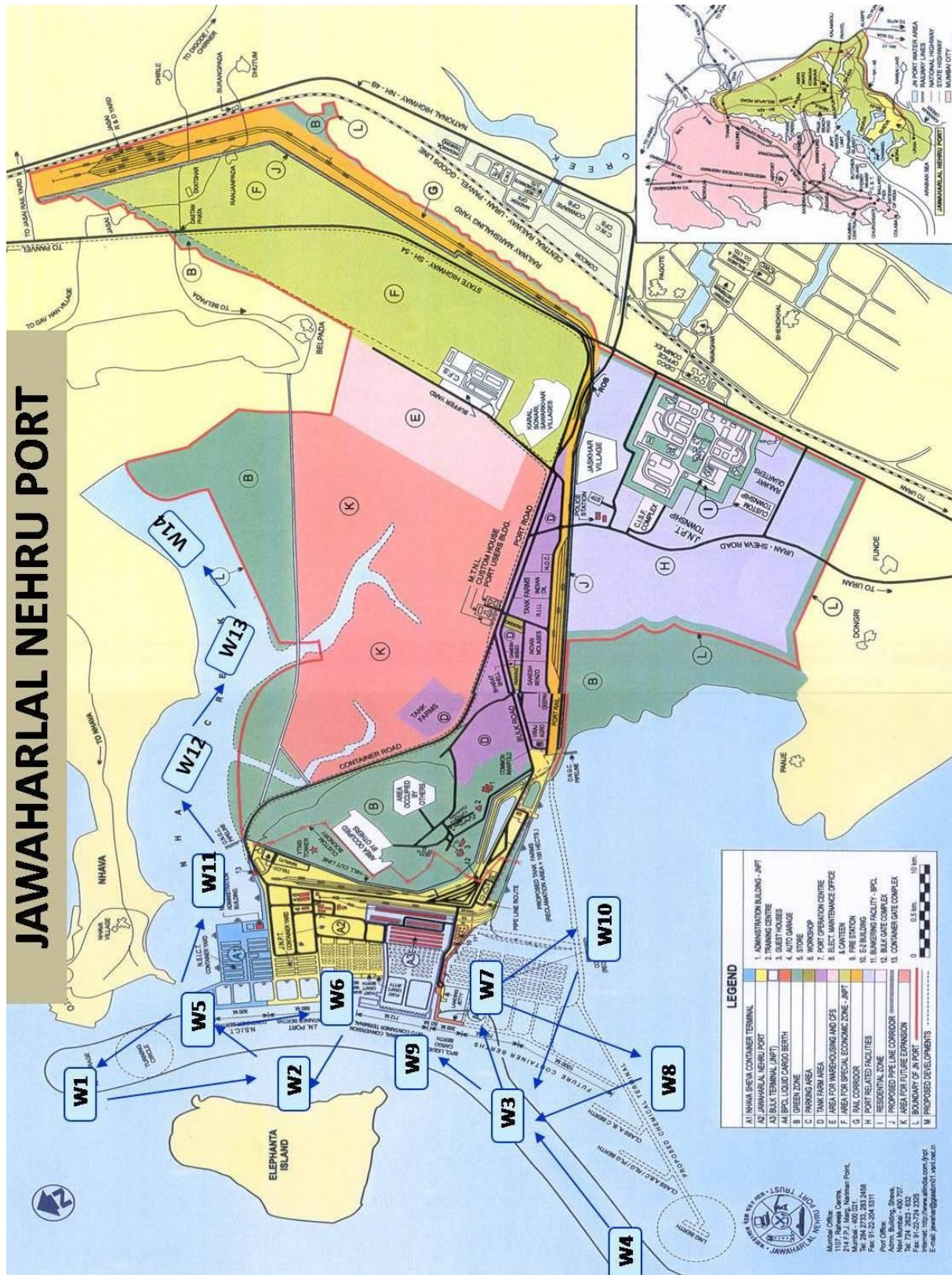
Note – Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigations.

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Annexure-III: Location map for Marine Water Monitoring Stations



Annexure-IV: Map for Ecological monitoring Stations and Towing Directions



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 ³ /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 ³ 4-10 mg/m ³ >10 mg/m ³	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 ³	POC is directly related to primary productivity. High concentration of POC represents the region of high productivity.
7.	Silicate (SiO ₂)	10-5000 µg/L	Nucleic acid synthesis and skeletal formation of Diatoms.

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Thank You