



MONITORING OF ENVIRONMENTAL PLAN FOR JN PORT

ENVIRONMENTAL MONITORING REPORT

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TABLE OF CONTENT		
SR. NO.	PARTICULARS	PAGE NO.
1.	AMBIENT AIR QUALITY MONITORING	2
1.1	INTRODUCTION	2
1.2	AIR QUALITY MONITORING METHODOLOGY	2
1.3	RESULTS	3
1.4	DISCUSSION	13
1.5	OBSERVATIONS & CONCLUSIONS	14
2.	MARINE WATER QUALITY MONITORING [HARBOR& CREEK] INCLUDING STUDY OF SEDIMENT CHARACTERISTICS	16
2.1	INTRODUCTION	16
2.2	MARINE WATER QUALITY MONITORING METHODOLOGY	16
2.3	RESULTS	17
2.4	DISCUSSION	24
2.5	OBSERVATIONS & CONCLUSIONS	25
3.	MARINE ECOSYSTEM MONITORING	26
3.1	INTRODUCTION	26
3.2	MARINE ECOSYSTEM MONITORING METHODOLOGY	26
3.3	RESULTS	27
3.4	DISCUSSION	34
3.4.1	Water Quality: Biotic	34
a	Primary Productivity	34
b	Plankton: Phytoplankton, Zooplankton	36-37
c	Photosynthetic pigments [Chlorophyll-a, Pheophytin-a]	37
d	Particulate Organic Carbon [POC]	37
3.4.2	Sediment Quality: Biotic	38
3.4.3	Nutrients	39
3.5	OBSERVATIONS & CONCLUSIONS	42
4.	DRINKING WATER QUALITY MONITORING	44
4.1	INTRODUCTION	44
4.2	RESULTS	44
4.3	DISCUSSION	48
4.4	CONCLUSIONS	48
5.	ANNEXURES	49
5.1	Annexure-I: Location map for Ambient Air Monitoring Stations	49
5.2	Annexure-II: National Ambient Air Quality Monitoring Standard	50
5.3	Annexure-III: Location map for Marine Water Monitoring Stations	51
5.4	Annexure-IV: Location map for Ecological monitoring Stations and Direction of Towing	52
5.5	Annexure-V: Primary Criterion for Class SW-IV Waters (For Harbor Waters)	53
5.6	Annexure-VI: Recommended Ranges of the Ecological Parameters for Arabian Sea	54

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 depicted in **Table 1**. The location map of various air quality monitoring stations at JNP is described 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 ambient air samples are carried out as per CPCB Guidelines for Ambient Air Quality Monitoring, Volume-I, 2012. The monitoring is carried-out for 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, at NGC and SGC is once in a week. The monitoring at Elephanta Caves is once in a month as per schedule directed by Engineer In-charge.

In all above station sampling duration was 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 is used for a period of 24 hours to obtain one sample of PM₁₀ & PM_{2.5}. 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 March, 2015 are given in **Table 2, Table 3 & Table 4** respectively. The ambient air quality monitoring data for EC and 2 movable stations, NGC&SGC are given in **Table 5, Table 6 & Table 7** respectively.

Table 2: Results of Air Pollutant Concentration at POC Station													
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]		
			24 hr	100 µg/m ³	24 hr	60 µg/m ³	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	
			100 µg/m ³										
NAAQMS													
POC-1	03.03.2015 to 04.03.2015	14:00 to 22:00					9		37		5		
		22:00 to 06:00	181		27		15	10.4	37	33.9	5	5.1	
		06:00 to 14:00					7		28		6		
POC-2	05.03.2015 to 06.03.2015	14:00 to 22:00					10		17		7		
		22:00 to 06:00	181		36		10	13.4	28	19.7	5	4.3	
		06:00 to 14:00					19		14		1		
POC-3	09.03.2015 to 10.03.2015	14:00 to 22:00					16		35		7		
		22:00 to 06:00	290		46		13	15.4	23	27.8	5	5.8	
		06:00 to 14:00					16		25		5		
POC-4	12.03.2015 to 13.03.2015	14:00 to 22:00					16		20		4		
		22:00 to 06:00	181		33		18	13.9	23	25.9	5	4.6	
		06:00 to 14:00					7		35		5		
POC-5	16.03.2015 to 17.03.2015	14:00 to 22:00					16		20		7		
		22:00 to 06:00	116		21		18	15.4	20	18.5	9	7.7	
		06:00 to 14:00					12		16		7		
POC-6	19.03.2015 to 20.03.2015	14:00 to 22:00					12		25		5		
		22:00 to 06:00	256		56		7	10.9	27	29.0	5	5.4	
		06:00 to 14:00					13		35		7		
POC-7	23.03.2015 to 24.03.2015	14:00 to 22:00					9		29		5		
		22:00 to 06:00	191		46		13	12.9	32	32.0	8	7.7	
		06:00 to 14:00					16		35		9		
POC-8	26.03.2015 to 27.03.2015	14:00 to 22:00					18		13		5		
		22:00 to 06:00	107		34		10	14.9	14	14.0	5	5.1	
		06:00 to 14:00					16		14		6		
POC-9	30.03.2015 to 31.03.2015	14:00 to 22:00					10		46		<1		
		22:00 to 06:00	172		35		40	24.0	6	18.3	<1	3.0	
		06:00 to 14:00					22		3		3		
Average			186		37			14.6		24.3		5.4	
Standard Dev			58		11			4.0		6.9		1.5	

Table 2: Results of Air Pollutant Concentration at POC Station																	
Sampling Period	Date	Time, [Hrs]	O ₃ , [µg/m ³]		Pb, [µg/m ³]		As, [ng/m ³]		Ni, [ng/m ³]		C ₈ H ₁₈ , [µg/m ³]		BaP, [ng/m ³]		Grab Sampling	CO ₂ , [ppm]	
			8 hr	100 µg/m ³	24 hr	1.0 µg/m ³	24 hr	6 ng/m ³	24 hr	20 ng/m ³	8 hr	5 µg/m ³	24 hr	1 ng/m ³			Grab Sampling
POC-1	03.03.2015 to 04.03.2015	14:00 to 22:00															
		22:00 to 06:00	25	0.13													
		06:00 to 14:00															
POC-2	05.03.2015 to 06.03.2015	14:00 to 22:00															
		22:00 to 06:00	39	0.07													
		06:00 to 14:00															
POC-3	09.03.2015 to 10.03.2015	14:00 to 22:00															
		22:00 to 06:00	33	0.1													
		06:00 to 14:00															
POC-4	12.03.2015 to 13.03.2015	14:00 to 22:00															
		22:00 to 06:00	29	0.13													
		06:00 to 14:00															
POC-5	16.03.2015 to 17.03.2015	14:00 to 22:00															
		22:00 to 06:00	28	0.08													
		06:00 to 14:00															
POC-6	19.03.2015 to 20.03.2015	14:00 to 22:00															
		22:00 to 06:00	33	0.2													
		06:00 to 14:00															
POC-7	23.03.2015 to 24.03.2015	14:00 to 22:00															
		22:00 to 06:00	51	0.12													
		06:00 to 14:00															
POC-8	26.03.2015 to 27.03.2015	14:00 to 22:00															
		22:00 to 06:00	40	0.1													
		06:00 to 14:00															
POC-9	30.03.2015 to 31.03.2015	14:00 to 22:00															
		22:00 to 06:00	34	0.1													
		06:00 to 14:00															
Average Standard Dev			35	0.11							2.9			3.1	293		
			8	0.04							0.6			0.2	12		

Table 3: Results of Air Pollutant Concentration at IMC Station													
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]		
			24 hr	24 hr	24 hr	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)
			100 µg/m ³	60 µg/m ³	60 µg/m ³	-	80 µg/m ³	-	80 µg/m ³	-	80 µg/m ³	-	400 µg/m ³
NAAQMS		15:00 to 23:00					7		28		6		
IMC-1	03.03.2015 to 04.03.2015	23:00 to 07:00	239	43			9	9	28	29.1	7	6.5	
		07:00 to 15:00				10			31		6		
		15:05 to 23:05				9			14		9		
IMC-2	05.03.2015 to 06.03.2015	23:05 to 07:05	313	64			13	12	11	20.3	6	6.8	
		07:05 to 15:05				13			35		5		
		15:10 to 23:10				18			25		4		
IMC-3	09.03.2015 to 10.03.2015	23:10 to 07:10	306	59			16	16	26	25.6	13	7.9	
		07:10 to 15:10				15			26		7		
		14:50 to 22:50				21			41		5		
IMC-4	12.03.2015 to 13.03.2015	22:50 to 06:50	176	73			19	19	37	31.8	5	4.6	
		06:50 to 14:50				16			17		4		
		15:00 to 23:00				15			23		4		
IMC-5	16.03.2015 to 17.03.2015	23:00 to 07:00	355	74			13	14	23	24.5	6	5.7	
		07:00 to 15:00				13			28		7		
		15:00 to 23:00				15			18		6		
IMC-6	19.03.2015 to 20.03.2015	23:00 to 07:00	413	115			13	15.9	18	24.7	8	6.8	
		07:00 to 15:00				19			33		7		
		15:00 to 23:00				12			19		3		
IMC-7	23.03.2015 to 24.03.2015	23:00 to 07:00	211	74			10	9.9	23	24.7	5	4.5	
		07:00 to 15:00				7			32		5		
		15:00 to 23:00				15			36		5		
IMC-8	26.03.2015 to 27.03.2015	23:00 to 07:00	215	43			7	11.4	36	28.2	7	6.3	
		07:00 to 15:00				12			13		8		
		15:00 to 23:00				16			35		<1		
IMC-9	30.03.2015 to 31.03.2015	23:00 to 07:00	298	178			18	13.7	4	14.3	<1	<1	
		07:00 to 15:00				7			4		.1		
			281	80			13.4		24.8		6.1		
Average				42			3.2		5.1		1.2		
Standard Dev			77										

Table 3: Results of Air Pollutant Concentration at IMC Station												
Sampling Period	Date	Time, [Hrs]	O ₃ , [µg/m ³]	Pb, [µg/m ³]	As, [ng/m ³]	24 hr 6 ng/m ³	24 hr 20 ng/m ³	Ni, [ng/m ³]	C ₆ H ₆ , [µg/m ³]	24 hr 1 ng/m ³	Grab Sampling 4 mg/m ³	CO ₂ , [ppm]
NAAQMS		0.5	8 hr 100 µg/m ³	1.0 µg/m ³	24 hr 6 ng/m ³	24 hr 20 ng/m ³	24 hr 20 ng/m ³	24 hr 20 ng/m ³	8 hr 5 µg/m ³	24 hr 1 ng/m ³	Grab Sampling 4 mg/m ³	CO ₂ , [ppm]
IMC-1	03.03.2015 to 04.03.2015	15:00 to 23:00										
		23:00 to 07:00	33	0.02	<1	<1	<1	<1	2.1	<0.5	3.3	299
		07:00 to 15:00										
IMC-2	05.03.2015 to 06.03.2015	15:05 to 23:05										
		23:05 to 07:05	42	0.13	<1	<1	<1	<1	3.0	<0.5	3.4	298
		07:05 to 15:05										
IMC-3	09.03.2015 to 10.03.2015	15:10 to 23:10										
		23:10 to 07:10	28	0.12	<1	<1	<1	<1	3.5	<0.5	2.8	287
		07:10 to 15:10										
IMC-4	12.03.2015 to 13.03.2015	14:50 to 22:50										
		22:50 to 06:50	30	0.12	<1	<1	<1	<1	3.5	<0.5	2.5	263
		06:50 to 14:50										
IMC-5	16.03.2015 to 17.03.2015	15:00 to 23:00										
		23:00 to 07:00	25	0.1	<1	<1	<1	<1	2.9	<0.5	2.8	297
		07:00 to 15:00										
IMC-6	19.03.2015 to 20.03.2015	15:00 to 23:00										
		23:00 to 07:00	20	0.09	<1	<1	<1	<1	3.0	<0.5	2.9	285
		07:00 to 15:00										
IMC-7	23.03.2015 to 24.03.2015	15:00 to 23:00										
		23:00 to 07:00	26	0.1	<1	<1	<1	<1	3.1	<0.5	3.1	302
		07:00 to 15:00										
IMC-8	26.03.2015 to 27.03.2015	15:00 to 23:00										
		23:00 to 07:00	30	0.09	<1	<1	<1	<1	2.7	<0.5	3.3	305
		07:00 to 15:00										
IMC-9	30.03.2015 to 31.03.2015	15:00 to 23:00										
		23:00 to 07:00	10	0.09	<1	<1	<1	<1	2.8	<0.5	3.3	305
		07:00 to 15:00										
Average Standard Dev			27	0.10					3.0		3.0	293
			9	0.03					0.4		0.3	13

Table 4: Results of Air Pollutant Concentration at RC Station												
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]	
			24 hr		24 hr		8 hr		8 hr		8 hr	
			100 µg/m ³	60 µg/m ³	60 µg/m ³	60 µg/m ³	80 µg/m ³	80 µg/m ³	80 µg/m ³	80 µg/m ³	400 µg/m ³	400 µg/m ³
RC-1	03.03.2015 to 04.03.2015	15:20 to 23:20					13		37		5	
		23:20 to 07:20	129	34			15	15	37		7	7.0
		07:20 to 15:20					16		28		9	
RC-2	05.03.2015 to 06.03.2015	15:30 to 23:30					9		12		7	
		23:30 to 07:30	224	73			10	10	11	15.3	6	7.0
		07:30 to 15:30					12		23		8	
RC-3	09.03.2015 to 10.03.2015	15:35 to 23:35					12		21		4	
		23:35 to 07:35	295	69			15	12	14	15.8	5	4.5
		07:35 to 15:35					10		13		5	
RC-4	12.03.2015 to 13.03.2015	15:30 to 23:30					9		15		7	
		23:30 to 07:30	237	55			15	11	17	20.5	8	7.1
		07:30 to 15:30					10		30		7	
RC-5	16.03.2015 to 17.03.2015	15:30 to 23:30					9		14		5	
		23:30 to 07:30	211	47			10	10	12	14.1	6	5.0
		07:30 to 15:30					12		16		4	
RC-6	19.03.2015 to 20.03.2015	15:30 to 23:30					10		13		3	
		23:30 to 07:30	250	83			10	11	12	15.0	5	4.4
		07:30 to 15:30					13		19		7	
RC-7	23.03.2015 to 24.03.2015	15:30 to 23:30					10		12		6	
		23:30 to 07:30	227	66			10	10	14	12.9	7	6.5
		07:30 to 15:30					10		13		7	
RC-8	26.03.2015 to 27.03.2015	15:30 to 23:30					9		14		6	
		23:30 to 07:30	146	49			10	10	14	15.0	7	6.2
		07:30 to 15:30					12		17		6	
RC-9	30.03.2015 to 31.03.2015	15:30 to 23:30					13		10		1	
		23:30 to 07:30	231	44			7	11	3	5.0	<1	1.0
		07:30 to 15:30					13		2		<1	
Average			217	58				11.3		16.4		5.4
Standard Dev			51	16				1.5		7.7		2.0

Table 4: Results of Air Pollutant Concentration at RC Station																
Sampling Period	Date	Time, [Hrs]	O ₃ , [µg/m ³]		Pb, [µg/m ³]		As, [ng/m ³]		NI, [ng/m ³]		CaH ₆ , [µg/m ³]		BaP, [ng/m ³]		CO ₂ , [ppm]	
			8 hr	24 hr	24 hr	1.0 µg/m ³	6 ng/m ³	20 ng/m ³	5 µg/m ³	1 ng/m ³	24 hr	Grab Sampling	24 hr	Grab Sampling	24 hr	Grab Sampling
NAAQMS			100 µg/m ³	100 µg/m ³	1.0 µg/m ³	1.0 µg/m ³	6 ng/m ³	20 ng/m ³	5 µg/m ³	1 ng/m ³	24 hr <td>Grab Sampling</td> <td>24 hr<td>Grab Sampling</td><td>24 hr<td>Grab Sampling</td></td></td>	Grab Sampling	24 hr <td>Grab Sampling</td> <td>24 hr<td>Grab Sampling</td></td>	Grab Sampling	24 hr <td>Grab Sampling</td>	Grab Sampling
RC-1	03.03.2015	15:20 to 23:20														
	to	23:20 to 07:20	31	0.01	<1	<1	<1	3.0	<0.5	3.1	311					
RC 2	04.03.2015	07:20 to 15:20														
	05.03.2015	15:30 to 23:30	16	0.11	<1	<1	<1	2.1	<0.5	2.9	294					
RC-3	06.03.2015	23:30 to 07:30														
	06.03.2015	07:30 to 15:30														
RC-3	09.03.2015	15:35 to 23:35	30	0.08	<1	<1	<1	2.9	<0.5	3.3	295					
	to	23:35 to 07:35														
RC-4	10.03.2015	07:35 to 15:35														
	12.03.2015	15:30 to 23:30	31	0.25	<1	<1	<1	2.7	<0.5	3.2	297					
RC-4	to	23:30 to 07:30														
	13.03.2015	07:30 to 15:30														
RC-5	16.03.2015	15:30 to 23:30	45	0.12	<1	<1	<1	1.3	<0.5	2.9	305					
	to	23:30 to 07:30														
RC-5	17.03.2015	07:30 to 15:30														
	19.03.2015	15:30 to 23:30	28	0.13	<1	<1	<1	3.2	<0.5	3.1	314					
RC-6	to	23:30 to 07:30														
	20.03.2015	07:30 to 15:30														
RC-6	23.03.2015	15:30 to 23:30	33	0.14	<1	<1	<1	3.1	<0.5	3.2	310					
	to	23:30 to 07:30														
RC-7	24.03.2015	07:30 to 15:30														
	26.03.2015	15:30 to 23:30	24	0.03	<1	<1	<1	1.8	<0.5	2.8	301					
RC-8	to	23:30 to 07:30														
	27.03.2015	07:30 to 15:30														
RC-8	30.03.2015	15:30 to 23:30	13	0.11	<1	<1	<1	1.8	<0.5	2.8	301					
	to	23:30 to 07:30														
RC-9	31.03.2015	07:30 to 15:30														
	31.03.2015	07:30 to 15:30														
Average			28	0.11					2.4		3.0	303				
			9	0.07					0.7		0.2	8				
Standard Dev																

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 , [$\mu\text{g}/\text{m}^3$]	
				24 hr	24 hr	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)
EC	07.03.2015 to 08.03.2015	16:30 to 00:30				15		24		9	
		00:30 to 08:30	229		57	15	14.9	25	25.5	8	7.0
		08:30 to 16:30				15		28		4	
			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 $\mu\text{g}/\text{m}^3$	

Sampling Period	Date	Time, [Hrs]	O ₃ , [$\mu\text{g}/\text{m}^3$]		Pb, [$\mu\text{g}/\text{m}^3$]		As, [$\mu\text{g}/\text{m}^3$]		Ni, [$\mu\text{g}/\text{m}^3$]		C ₆ H ₆ , [$\mu\text{g}/\text{m}^3$]		BaP, [$\mu\text{g}/\text{m}^3$]		CO, [mg/m^3]		CO ₂ , [ppm]	
			8 hr	100 $\mu\text{g}/\text{m}^3$	8 hr	1.0 $\mu\text{g}/\text{m}^3$	24 hr	6 ng/ m^3	24 hr	20 ng/ m^3	8 hr	5 $\mu\text{g}/\text{m}^3$	24 hr	1 ng/ m^3	Grab Sampling 4 ng/ m^3	Grab Sampling		
EC	07.03.2015 to 08.03.2015	16:30 to 00:30																
		00:30 to 08:30	26		0.15	<1	<1	<1	1.4	<0.5	2.7	309						
		08:30 to 16:30																

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]		
			24 hr	100 µg/m ³	24 hr	60 µg/m ³	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr
NAAQMS													
NG-1	05.03.2015 to 06.03.2015	16:00 to 00:00					10		32		5		
		00:00 to 08:00	210		64	15	15.4	20	24.7	4	5.0		
		08:00 to 16:00				13		22		6			
NG-2	12.03.2015 to 13.03.2015	15:50 to 23:50					12		33		6		
		23:50 to 07:50	225		43	13	13.3	22	26.7	6	6.0		
		07:50 to 15:50				15		25		6			
NG-3	19.03.2015 to 20.03.2015	15:40 to 23:40					13		26		4		
		23:40 to 07:40	320		40	12	12.4	27	23.0	8	6.2		
		07:40 to 15:40				12		16		7			
NG-4	26.03.2015 to 27.03.2015	15:40 to 23:40					31		11		6		
		23:40 to 07:40	142		43	30	29.3	10	10.3	5	6.0		
		07:40 to 15:40				27		10		7			
Average			224		40			17.6		21.2		5.0	
Standard Dev			73		11			7.9		7.4		0.5	

Table 6: Results of Air Pollutant Concentration at NGC Station										
Sampling Period	Date	Time, [Hrs]	O ₂ , [µg/m ³]	Pb, [µg/m ³]	As, [ng/m ³]	Ni, [ng/m ³]	C ₆ H ₆ , [µg/m ³]	BaP, [ng/m ³]	CO, [mg/m ³]	CO ₂ , [ppm]
			0 hr 100 µg/m ³	24 hr 1.0 µg/m ³	24 hr 6 ng/m ³	24 hr 20 ng/m ³	0 hr 5 µg/m ³	24 hr 1 ng/m ³	Grab Sampling 4 mg/m ³	Grab Sampling
NG-1	05.03.2015 to 06.03.2015	16:00 to 00:00								
		00:00 to 08:00	63	0.15	<1	<1	3.0	<0.5	2.8	310
		08:00 to 16:00								
NG-2	12.03.2015 to 13.03.2015	15:50 to 23:50								
		23:50 to 07:50	56	0.14	<1	<1	2.9	<0.5	3.1	304
		07:50 to 15:50								
NG-3	19.03.2015 to 20.03.2015	15:40 to 23:40								
		23:40 to 07:40	39	0.13	<1	<1	2.5	<0.5	2.5	309
		07:40 to 15:40								
NG-4	26.03.2015 to 27.03.2015	15:40 to 23:40								
		23:40 to 07:40	16	0.16	<1	<1	2.3	<0.5	3.1	298
		07:40 to 15:40								
Average			44							305
Standard Dev			21				2.7	2.9	0.3	6

Table 7: Results of Air Pollutant Concentration at SGC Station

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]
NAAQMS			24 hr	24 hr	8 hr	24 hr (Avg)	24 hr (Avg)
			100 µg/m ³	60 µg/m ³	-	80 µg/m ³	400 µg/m ³
SG-1	03.03.2015 to 04.03.2015	16:30 to 00:30			18	25	5
		00:30 to 08:30	233	50	16	15.9	26.3
		08:30 to 16:30			13	28	4
SG-2	09.03.2015 to 10.03.2015	16:15 to 00:15			22	43	2
		00:15 to 08:15	291	69	9	18.7	29.3
		08:15 to 16:15			25	25	13
SG-3	16.03.2015 to 17.03.2015	16:15 to 00:15			25	20	11
		00:15 to 08:15	160	40	10	21	8
		08:15 to 16:15			3	16.7	31.0
SG-4	23.03.2015 to 24.03.2015	16:15 to 00:15			37	50	5
		00:15 to 08:15	268	54	10	18	5
		08:15 to 16:15			13	12.9	17.6
SG-5	30.03.2015 to 31.03.2015	16:15 to 00:15			15	16	6
		00:15 to 08:15	225	84	6	8	<1
		08:15 to 16:15			37	16.7	9.7
Average			235	59	7	16.2	22.8
Standard Dev			50	17		2.1	9.0

Table 7: Results of Air Pollutant Concentration at SGC Station

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]	BaP, [ng/m ³]	CO, [mg/m ³]	CO ₂ , [ppm]
NAAQMS			0 hr	24 hr	24 hr	20 ng/m ³	5 µg/m ³	1 ng/m ³	Grab Sampling 4 mg/m ³	Grab Sampling
			100 µg/m ³	1.0 µg/m ³	6 ng/m ³	20 ng/m ³	5 µg/m ³	1 ng/m ³		
SG-1	03.03.2015 to 04.03.2015	16:30 to 00:30								
		00:30 to 08:30	23	0.13	<1	<1	2.9	<0.5	2.8	305
		08:30 to 16:30								
SG-2	09.03.2015 to 10.03.2015	16:15 to 00:15	33	0.09	<1	<1	3.1	<0.5	3.3	303
		00:15 to 08:15								
		08:15 to 16:15								
SG-3	16.03.2015 to 17.03.2015	16:15 to 00:15	14	0.11	<1	<1	3.2	<0.5	3.1	304
		00:15 to 08:15								
		08:15 to 16:15								
SG-4	23.03.2015 to 24.03.2015	16:15 to 00:15	30	0.13	<1	<1	3.1	<0.5	3.4	302
		00:15 to 08:15								
		08:15 to 16:15								
SG-5	30.03.2015 to 31.03.2015	16:15 to 00:15	32	0.14	<1	<1	3.1	<0.5	3.1	309
		00:15 to 08:15								
		08:15 to 16:15								
Average			26	0.12			3.1		3.1	305
Standard Dev			8	0.02			0.1		0.2	3

1.4 DISCUSSION

In Table 8, the average concentration values of air pollutants are provided at various stations of JNP area for the month of March, 2015. The values obtained are compared with respective CPCB standards described for Industrial, Residential, Rural and ecologically sensitive areas. The values obtained for Pb, As, Ni and Benzo(α)Pyrene [BaP] are below detection limits of measurements at all air monitoring stations for the month March, 2015 and hence these parameters are not included in **Table 8**.

Table 8: Monthly Average Values of Air Pollutant Concentration at Various Stations of JNP Area during the month of March, 2015

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	186 ± 58	37 ± 11	14.6 ± 4.0	24.3 ± 6.9	5.4 ± 1.5	35 ± 08	0.11 ± 0.04	2.9 ± 0.6	3.1 ± 0.2	293 ± 12
IMC	281 ± 77	74 ± 27	13.4 ± 3.2	24.8 ± 5.1	6.1 ± 1.2	27 ± 09	0.10 ± 0.03	3.0 ± 0.4	3.0 ± 0.3	293 ± 13
NG	224 ± 73	48 ± 11	17.6 ± 7.9	21.2 ± 7.4	5.8 ± 0.5	44 ± 21	0.15 ± 0.01	2.7 ± 0.3	2.9 ± 0.3	305 ± 06
SG	235 ± 50	59 ± 17	16.2 ± 2.1	22.8 ± 9.0	6.4 ± 1.4	26 ± 08	0.12 ± 0.02	3.1 ± 0.1	3.1 ± 0.2	305 ± 03
RESIDENTIAL AREA										
RC	217 ± 51	58 ± 16	11.3 ± 1.5	16.4 ± 7.7	5.4 ± 2.0	28 ± 09	0.11 ± 0.07	2.4 ± 0.7	3.0 ± 0.2	303 ± 08
ECO-SENSITIVE AREA										
EC	98	57	14.9	25.5	7.0	26	0.15	1.4	2.7	309

Daily average pollutant levels are depicted in **Table 2 to 7**. The concentrations obtained for particulate matter concentrations at all stations do not comply with the national standards. All remaining gaseous pollutants were found well below the prescribed limits. Monthly average values obtained for the month of March, 2015 were tabulated in **Table 8**.

Highest level of PM₁₀ was recorded at IMC i.e. major industrial activity area handling liquid chemical and also most congested road. Followed by SGC i.e. port vehicle entry point and RC i.e. location representing residential area have particulate concentrations above prescribed standards because of ongoing road maintenance and building renovation work.

Results for the air quality parameters at Elephanta Caves [EC] station during 07th March'14 to 08th March'14 were tabulated in **Table 5**. Particulate and gaseous pollutant concentrations were recorded below the prescribed standards for Ecologically Sensitive area. **Table 6 & Table 7** provide the results for NGC and SGC air monitoring stations respectively. These stations are the ultimate entry points for all the vehicular traffic i.e. container carrying heavy vehicles, light motor vehicles, buses and passenger cars moving in and out of port operation area. In March, 2015, the gaseous pollutants are well within the prescribed limits set for Industrial area.

1.5 OBSERVATIONS AND CONCLUSIONS

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

Observations for the month of March'14:

- ✓ Construction of security check post and road maintenance at south gate complex was observed during the month. Along with concretization of port roads along the railway line was also observed.
- ✓ *Construction of 4th Container Terminal on South side of JNPT:* Land preparation work of 4th C.T. is underway.
- ✓ 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 March'15.
- ✓ *Vehicular Traffic at three gates:* The monitoring of ambient air Quality at South gate and North gate complexes are done once a week. The particulate matter concentrations exceed the CPCB limits. Huge vehicular movement of container trailers, shift buses and passenger cars travel through these gates account for elevated pollutant levels. The location is covered by large control sections and dense tree cover accounting as pollutant trap. The initiative taken by the port in terms of maintenance of port vehicles, PUC checking of vehicles visiting port and enough green cover provided in and around the area contributes significantly to reduce overall pollution.
- ✓ All the public and community buildings in residential complex / township are under renovation. These account for partially elevated particulate concentrations. This is being temporary activity, it will not affect in ambient concentrations over longer time.



Land preparation at centralized parking plaza

The following measures can be taken to maintain controlled particulate levels of the port:

- ✓ 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.
- ✓ Strict actions should be taken against open burning of solid waste, biomass and trash.
- ✓ Cleaning and maintaining of paved and unpaved roads regularly to remove spillage of earth/soil material during transportation.
- ✓ Renovation work should be executed under controlled conditions and debris transportation must be in tarpaulin closed vehicles.
- ✓ Continue spraying of water on dusty surfaces on regular intervals. Frequency should be more around noon at impact locations at all construction, land preparation areas to avoid re-suspension.
- ✓ Endeavoring to reduce movements of port vehicles involved in the repositioning of cargoes within the port yards, and consider using electric-powered cranes instead of the more polluting diesel-powered cranes

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 [W08] 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 depicted in **Table 9**. The location map of various Marine ecology monitoring stations along with direction of towing are described in **Annexure-IV**.

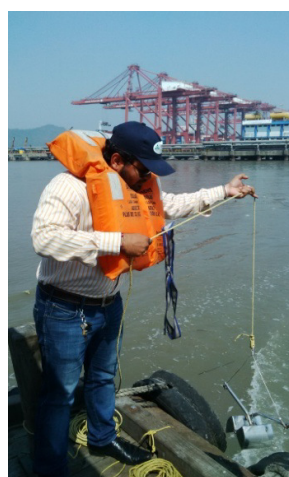
2.2 MARINE WATER QUALITY MONITORING METHODOLOGY

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 from the surface, mid depth and bottom are collected and composite from each harbor water quality monitoring station during spring and neap tidal cycle. The samples are after 1st, 3rd and 5th hour from eight fixed and one moving station every month. In all 54 samples are collected from nine stations.

Creek Water Quality Monitoring– Three samples from the surface, mid depth and bottom are collected and composite 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 depicted in **Table 10** along with parameters to be monitored for sediment characterization. Annexure-V describes Primary Water Quality Criterion for **Class SW-IV** Waters (For Harbor Waters).



Water sampling with Niskinson Sampler Sediment sampling with Grab Sampler

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.	07 th March, 2015
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	07 th March, 2015
3.	W3	Identified by the green buoy no. <u>FG2 Green</u> of JNPT approach channel and lies near the landing jetty.	08 th March, 2015
4.	W4	Located at Uran Patch Beacon (lighthouse on concrete platform) near the Butcher Island filling platform.	08 th March, 2015
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 Belpada to the creek water quality	07 th March, 2015
	W11 to W14		08 th March, 2015
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.	07 th March, 2015
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.	08 th March, 2015
8.	W9	Located in between GTI and Liquid Cargo Jetty. This station is selected to examine the impact of terminal activities on water qualities	08 th March, 2015
9.	W8	Located near proposed chemical berth. These stations are variable and selected to examine the impact of proposed chemical terminal and IV th Container terminal activities on water quality.	08 th March, 2015

Table 10: List of Parameters to Monitor Marine Water Quality

Marine Water Quality Parameters [Harbor Area & Creek Area]
A] Physico-chemical Analysis of Water: Depth, Temperature, pH, Salinity, Turbidity, Total Solids, Total Dissolved Solids, Total Suspended Solids,
B] Bio-chemical Analysis of Water: Dissolved Oxygen, COD [Chemical Oxygen Demand],BOD [Biochemical Oxygen Demand],NH ₃ - N, Phenol, Oil & Grease, SPC [Standard Plate Count],MPN [Most Probable Number],Fecal Coliform
C] Sediment Analysis: Total Organic Matter, Organic Carbon, Inorganic Phosphates

2.3RESULTS

The marine water quality data for nine Harbor water quality monitoring stations is depicted in **Table 11** for Physico-chemical parameter analysis, **Table 12** for Bio-chemical parameter analysis and **Table 13** for analysis of Sediment samples collected at these nine locations. The creek water quality data for four Nhava creek water quality monitoring stations is depicted in **Table 14** for Physico-chemical parameter analysis, **Table 15** for Bio-chemical parameter analysis and **Table 16** for analysis of Sediment samples collected at these four locations.

Table 11: Results of Physico-Chemical Analysis of Water Samples Collected from JNP Harbor Area during March, 2015

Sample Name		Depth, [m]	Temp., [°C]	pH	Salinity, [ppth]	Turbidity, [NTU]	TDS, [mg/L]	TSS, [mg/L]	TS, [mg/L]
Standard		-	-	6.5 - 9.0	-	-	-	-	-
W1	SS	8.5	24.6	7.17	39.4	12	33480	150	33630
	SM		24.4	7.39	35.3	26	32118	132	32250
	SB		24.3	7.38	32.8	32	32180	151	32331
	NS	8.0	23.9	7.20	33.7	12	32240	139	32379
	NM		23.8	7.39	32.8	26	32212	133	32345
	NB		23.8	7.40	32.8	19	32140	151	32291
W2	SS	3.5	24.7	7.47	33.7	7	31240	68	31308
	SM		24.5	7.14	35.3	9	31830	78	31908
	SB		24.4	7.96	32.8	18	31350	112	31462
	NS	2.8	24.3	7.63	34.5	9	31348	103	31451
	NM		23.9	7.55	33.7	9	31262	104	31366
	NB		23.9	7.50	32.8	10	31545	60	31605
W3	SS	8.6	23.8	7.94	34.5	10	32048	111	32159
	SM		23.5	7.30	36.9	4	32140	67	32207
	SB		23.4	7.54	37.8	12	32230	124	32354
	NS	7.7	23.7	7.57	32.8	12	31440	105	31545
	NM		23.5	7.32	32.8	6	31622	120	31742
	NB		23.6	7.55	33.7	12	31648	92	31740
W4	SS	7.6	24.0	7.59	34.5	11	32240	105	32345
	SM		23.8	7.87	33.7	12	31882	105	31987
	SB		23.7	7.60	32.8	12	31936	107	32043
	NS	7.0	23.6	7.94	34.5	11	32076	94	32170
	NM		23.5	7.64	33.7	14	31930	96	32026
	NB		23.6	7.58	32.8	11	31942	109	32051
W5	SS	12.6	24.5	7.42	35.3	13	31142	119	31261
	SM		24.2	7.50	34.5	17	31232	110	31342
	SB		24.2	7.49	33.7	17	31460	124	31584
	NS	12.0	24.3	7.50	32.8	17	30582	132	30714
	NM		24.3	7.47	32.8	18	30654	129	30783
	NB		24.2	7.78	34.5	20	30942	97	31039

SS - SPRING

SURFACE

SM - SPRING MIDDLE

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	14.6	24.8	7.53	32.8	18	32672	93	32765
	SM		24.7	7.57	33.7	17	32348	98	32446
	SB		24.7	7.53	34.5	18	31880	132	32012
	NS	12.8	24.3	7.42	32.8	29	31742	129	31871
	NM		24.2	7.51	33.7	23	31566	118	31684
	NB		23.8	7.49	36.1	22	30888	119	31007
W7	SS	5.5	24.4	7.99	32.8	19	31822	94	31916
	SM		23.9	7.58	32.8	16	30946	49	30995
	SB		23.8	7.55	34.5	16	31242	96	31338
	NS	5.0	23.8	7.31	33.7	15	30918	52	30970
	NM		23.6	7.49	35.3	15	31330	53	31383
	NB		23.5	7.53	34.5	10	30588	79	30667
W8	SS	7.6	23.9	7.57	32.8	20	31088	82	31170
	SM		23.8	7.51	33.7	12	31118	90	31208
	SB		23.6	7.95	32.8	17	32088	96	32184
	NS	6.0	23.9	7.55	32.8	13	31452	65	31517
	NM		23.7	7.33	34.5	10	31582	64	31646
	NB		23.6	7.54	36.9	13	30992	63	31055
W9	SS	16.5	24.5	7.16	32.8	2	31142	84	31226
	SM		24.4	7.27	33.7	7	30840	136	30976
	SB		24.4	7.34	34.5	10	31080	110	31190
	NS	15.8	23.8	7.41	35.3	11	30914	148	31062
	NM		23.7	7.33	35.3	10	30890	193	31083
	NB		23.6	7.38	34.5	12	30910	218	31128

SS – SPRING SURFACE
 NS – NEAP SURFACE
 SM – NEAP MIDDLE
 SB – NEAP BOTTOM

Table 12: Results of Bio-Chemical Analysis of Water Samples Collected from JNP Harbor Area during March, 2015

Sample Name	DO, [mg/L]	COD, [mg/L]	BOD, [mg/L]	NH ₄ ⁺ -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#	-	-	-	-	2	34	<2
	SS	6.3	40	<2	<0.1	<0.01		
	SM	6.2	48	-	-			
	SB	6.0	36	-	-			
	NS#		-	-	-	2	31	<2
	NS	6.5	44	<2	<0.1	<0.01		
	NM	6.3	32	-	-			
W2	NB	6.3	48	-	-			
	SS#					<1	49	<2
	SS	6.4	52	<0.1	<0.01			
	SM	6.4	44					
	SB	6.2	40					
	NS#					2	72	<2
	NS	6.6	46	<0.1	<0.01			
W3	NM	6.4	48					
	NB	6.3	32					
	SS#	-	-	-	-	1	178	4
	SS	6.0	36	<2	<0.1	<0.01		
	SM	5.9	44	-	-			
	SB	5.7	48	-	-			
	NS#		-	-	-	1	67	2
W4	NS	5.6	40	<2	<0.1	<0.01		
	NM	5.4	32	-	-			
	NB	5.5	52	-	-			
	SS#	-	-	-	-	2	97	2
	SS	5.8	40	<2	<0.1	<0.01		
	SM	5.6	48	-	-			
	SB	5.4	36	-	-			
W5	NS#		-	-	-	2	63	<2
	NS	5.8	52	<2	<0.1	<0.01		
	NM	5.6	32	-	-			
	NB	5.5	44	-	-			
	SS#	-	-	-	-	1	<30	2
	SS	6.5	44	<2	<0.1	<0.01		
	SM	6.0	36	-	-			
W5	SB	6.0	40	-	-			
	NS#	-	-	-	-	2	<30	<2
	NS	6.6	32	<2	<0.1	<0.01		
	NM	6.4	48	-	-			
	NB	6.2	52	-	-			

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	DO, [mg/L]	COD, [mg/L]	BOD, [mg/L]	NH ₄ ⁺ -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 [#]	-	-	-	-	<1	135	4
	SS	6.5	41	<2	<0.1	<0.01	-	-
	SM	6.2	37	-	-	-	-	-
	SB	6.0	45	-	-	-	-	-
	NS [#]	-	-	-	-	1	52	2
	NS	6.2	34	<2	<0.1	<0.01	-	-
	NM	6.0	33	-	-	-	-	-
	NB	6.2	25	-	-	-	-	-
W7	SS [#]	-	-	-	-	2	42	2
	SS	5.9	49	<2	<0.1	<0.01	-	-
	SM	6.0	34	-	-	-	-	-
	SB	5.8	33	-	-	-	-	-
	NS [#]	-	-	-	-	2	60	2
	NS	6.2	25	<2	<0.1	<0.01	-	-
	NM	5.8	37	-	-	-	-	-
	NB	5.6	41	-	-	-	-	-
W8	SS [#]	-	-	-	-	1	70	2
	SS	5.8	33	<2	<0.1	<0.01	-	-
	SM	6.1	45	-	-	-	-	-
	SB	5.9	41	-	-	-	-	-
	NS [#]	-	-	-	-	1	82	2
	NS	5.9	49	<2	<0.1	<0.01	-	-
	NM	5.7	29	-	-	-	-	-
	NB	5.6	37	-	-	-	-	-
W9	SS [#]	-	-	-	-	2	32	2
	SS	6.2	41	<2	<0.1	<0.01	-	-
	SM	5.9	29	-	-	-	-	-
	SB	5.6	33	-	-	-	-	-
	NS [#]	-	-	-	-	2	40	2
	NS	5.7	37	<2	<0.1	<0.01	-	-
	NM	5.5	45	-	-	-	-	-
	NB	5.4	49	-	-	-	-	-

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 13: Results of Sediment Samples Collected from JNP Harbor Area during March, 2015

Station Name	Organic Matter		Total Carbon		Inorganic Phosphate
	mg/g	%	mg/g	%	mg/kg
W1	198.0	19.8	114.8	11.5	113
W2	213.2	21.3	123.7	12.4	122
W3	154.1	15.4	89.4	8.9	130
W4	220.0	22.0	127.6	12.8	149
W5	Sediment not found				
W6	162.5	16.3	94.3	9.4	124
W7	159.6	16.0	92.6	9.3	141
W8	140.2	14.0	81.3	8.1	106
W9	174.8	17.5	101.4	10.1	69
Average	178	18	103	10	119

Table 14: Results of Physico-Chemical Analysis of Water Samples Collected 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	25.6	7.47	35.3	19	31140	108
	SM		25.4	7.48	35.3	18	31332	101
	SB		24.9	7.33	33.7	16	31262	111
	NS	2.5	26.0	7.42	34.5	19	31420	122
	NM		26.1	7.48	34.5	19	31182	106
	NB		26.0	7.47	32.8	20	31240	111
W12	SS	3.5	25.6	7.50	32.8	21	32140	198
	SM		25.5	7.53	34.5	20	31482	139
	SB		25.5	7.41	34.5	22	31562	217
	NS	2.0	25.7	7.46	33.7	25	30988	229
	NM		26.0	7.83	33.7	22	31140	288
	NB		26.0	7.44	32.8	20	31132	266
W13	SS	3.5	25.6	7.59	32.8	54	30810	124
	SM		25.4	7.48	34.5	25	30750	153
	SB		25.1	7.33	33.7	36	30642	120
	NS	2.5	26.0	7.44	32.0	43	30688	146
	NM		25.8	7.41	31.2	55	31140	110
	NB		26.0	7.16	32.8	30	31230	124
W14	SS	3.0	25.6	7.48	36.1	18	30842	138
	SM		25.4	7.48	35.3	16	31142	114
	SB		25.4	7.79	33.7	38	31088	217
	NS	1.5	25.8	7.56	32.0	51	31132	308
	NM		26.0	7.41	32.8	26	30438	135
	NB		26.0	7.51	33.7	32	31280	137

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

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

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

Sample Name	DO, [mg/L]	COD, [mg/L]	BOD, [mg/L]	NH ₄ ⁺ -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	6.2	40	<2	<0.1	<0.01	1	39
	SM	5.8	48	-	-	-	-	-
	SB	5.7	44	-	-	-	-	-
	NS	6.2	36	<2	<0.1	<0.01	1	95
	NM	6.0	28	-	-	-	-	-
	NB	6.1	40	-	-	-	-	-
W12	SS	6.4	52	<2	0.1	<0.01	2	85
	SM	6.0	36	-	-	-	-	-
	SB	6.2	48	-	-	-	-	-
	NS	6.1	40	<2	<0.1	<0.01	<1	<30
	NM	6.0	44	-	-	-	-	-
	NB	5.9	32	-	-	-	-	-
W13	SS	6.1	36	<2	0.1	<0.01	2	62
	SM	6.0	48	-	-	-	-	-
	SB	5.8	44	-	-	-	-	-
	NS	6.0	40	<2	0.1	<0.01	1	<30
	NM	5.8	28	-	-	-	-	-
	NB	6.0	36	-	-	-	-	-
W14	SS	5.8	44	<2	<0.1	<0.01	1	144
	SM	5.9	36	-	-	-	-	-
	SB	5.8	32	-	-	-	-	-
	NS	6.2	52	<2	<0.1	<0.01	1	61
	NM	6.1	40	-	-	-	-	-
	NB	6.1	44	-	-	-	-	-

SS – SPRING SURFACE
SM – SPRING MIDDLE
SB – SPRING BOTTOM

NS – NEAP SURFACE
NM – NEAP MIDDLE
NB – NEAP BOTTOM

Table 16: Results of Sediment Samples Collected from Nhava Creek Area during March, 2015

Sample Name	Organic Matter		Total Carbon		Inorganic Phosphate
	mg/g	%	mg/g	%	mg/kg
W11	Sediment not found				
W12					
W13	139.2	13.9	80.7	8.1	107
W14	169.4	16.9	98.3	9.8	121

2.4DISCUSSION

In **Table 17**, the observed concentration range for various parameters for Harbor region is collected while in **Table 18**, the observed concentration range for various parameters for Nhava creek region is collected. 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 Various Parameters for JNP Harbor Area

Sr. No.	Parameter	Observed Range	Unit	Prescribed Limits
1	Temperature	23.4 – 24.8	°C	-
2	pH	7.1 – 8.0	-	6.5 - 9.0
3	Salinity	32.8 – 39.4	ppth	-
4	Turbidity	2.0 – 32.0	NTU	-
5	TDS	30582 – 33480	mg/L	-
6	TSS	49 – 218	mg/L	-
7	TS	30667 – 33630	mg/L	-
8	DO	5.4 – 6.6	mg/L	3.0 mg/L or 40% of saturation value
9	COD	24.5 – 52.0	mg/L	-
10	BOD	< 2.0	mg/L	5
11	NH ⁴⁺ -N	< 1.0	mg/L	-
12	Phenol	< 0.01	mg/L	-
13	Oil & Grease	1 – 2	mg/L	10
14	Total Plate Count	31 – 178	CFU/ml	-
15	Fecal Coliforms	2 – 4	MPN/100 mL	500

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

Sr. No.	Parameter	Observed Range	Unit	Prescribed Limits
1	Temperature	24.9 – 26.1	°C	-
2	pH	7.2 – 7.8	-	6.5 - 9.0
3	Salinity	31.2 – 36.1	Ppth	-
4	Turbidity	16.0 – 55.0	NTU	-
5	TDS	30438 – 31140	mg/L	-
6	TSS	101 – 308	mg/L	-
7	TS	30573 – 31428	mg/L	-
8	DO	5.7 – 6.4	mg/L	3.0 mg/L or 40% of saturation value
9	COD	28 – 52	mg/L	-
10	BOD	< 2.0	mg/L	5
11	NH ⁴⁺ -N	< 1.0	mg/L	-
12	Phenol	< 0.01	mg/L	-
13	Oil & Grease	1 - 2	mg/L	10
14	Total Plate Count	39 – 144	CFU/ml	-
15	Fecal Coliforms	2 – 33	MPN/100 mL	500

It is seen from **Table 17** that, the values of various parameters such as pH, Dissolved Oxygen, BOD, Oil & Grease and Fecal *coliforms* obtained for water samples collected from JNP Harbor area during the month of March, 2015 are found to be well within the prescribed limits. Also,

the concentration ranges observed for various parameters for water samples collected from Nhava Creek area during March, 2015 are found to be well within prescribed limits.

Observed salinity values for Harbor and Creek water samples in the month of March, 2015 are ranges from 31.2 to 39.4 ppt. [Refer Tables 11 and 14]. The ranges observed for COD values in mg/L are 24.5 – 52 and 28.0 – 52.0 respectively for Harbor and Creek water samples. The DO levels are ranges between 5.4 to 6.6 for water samples collected from Harbor and Creek area. The concentration of Phenol and $\text{NH}_4^+ - \text{N}$ is found to be very less in JNP Harbor as well as Nhava Creek water samples. Bacteriological parameters are 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 sediment samples collected from JNP Harbor area during the month of March, 2015. The values obtained for Organic Matter, Total Organic Carbon and Inorganic Phosphate are ranges between 14 – 22%, 8.1% – 12.8% and 69 – 149 mg/kg, respectively. While, it is seen from **Table 16** that the values obtained for Organic Matter, Total Organic Carbon and Inorganic Phosphate are between 13.9 & 16.9%, 8.1 & 9.8% and 107– 121 mg/kg, respectively for sediment samples collected from Nhava Creek area during the month of March, 2015.

2.5OBSERVATIONS AND CONCLUSIONS

Observations for the month of March:

- ✓ *Construction of 4th Container Terminal on South side of JNPT:* Earth Filling work of 4th C.T. is underway.
- ✓ *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 reported in **Tables 11 to 18** and subsequently discussed in above paragraphs, all the parameters mentioned are complying with prescribed standard limits given in Primary Water Quality Criteria for **Class IV Waters** [Harbor Waters] given by CPCB for Physico-Chemical parameters and Bio-Chemical parameters collected from JNP Harbor area and Nhava Creek area during March, 2015. The characteristic parameters for sediments are also showing normal variation in concentrations for JNP Harbor area and Nhava Creek area during March, 2015. Considering the activities in the Harbor area and the results obtained for the month of March, it can be concluded that the overall Marine water Quality of the Port's Harbor and Creek waters is in good category.

3. MARINE ECOSYSTEM MONITORING

3.1 INTRODUCTION

For study of Marine ecology, Total 8 fixed harbor stations [W1 to W7 and W9] and 1 movable station [W08] 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 depicted in **Table 9**. The location map of various Marine ecology monitoring stations along with direction of towing are described in **Annexure-IV**.

3.2 MARINE ECOSYSTEM MONITORING METHODOLOGY

The objective of Marine ecology monitoring is to assess aquatic flora and fauna, to assess benthic flora and to assess nutrient content in water and sediments.

Marine Ecology Monitoring –Monitoring of marine ecology is carried out on the levels of high and low water of spring and neap tides at twelve fixed stations and one moving station in Port's water limit. Phytoplankton and Zooplankton samples are collected during spring tide and neap tide from all the 12 fixed [W1 to W7, W9 and W11 to W14] and one moving [W08] water quality monitoring stations.

The list of parameters analyzed to assess the Marine Ecology is depicted in **Table 19** along with parameters to be monitored for sediment characterization. **Annexure-VI** describes recommended ranges of the Ecological parameters for Arabian Sea.

Table 19: List of Parameters to Monitor 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, Particulate Organic Carbon, Chlorophyll-a, Pheophytin-a, Secchi Depth
B] Benthic Fauna: Species Identification & Density
C] Nutrients Analysis in Water: Anions: Silicates, PO_4^{3-} - P, SO_4^{2-} , NO_2^- - N, NO_3^- - N, Cations: Ca^{2+} , Mg^{2+} , Na^+ , K^+
D] Sediment Analysis: Anions: Silicates, PO_4^{3-} - P, SO_4^{2-} , NO_2^- - N, NO_3^- - N, Cations: Ca^{2+} , Mg^{2+} , Na^+ , K^+

3.3 RESULTS

The net and gross primary productivity of three water quality monitoring stations of JNP and one water quality monitoring station at Nhava creek were measured and values are presented in **Table 20**.

The enumeration of phytoplankton genera, observed in the JNP Harbor area and Nhava creek area are furnished in **Tables 21** and **Table 22**. The details of Secchi Depth of JNP Harbor and Nhava creek area are given in **Table 23**. The enumeration of zooplankton genera recorded in the JNP Harbor area and Nhava creek area are represented in **Tables 24** and **Table 25**. **Table 26** shows Chlorophyll-a contents in JNP Harbor and Nhava creek area.

Benthic fauna recorded in JNP Harbor area and Nhava were collected and the data are presented in **Table 28**. Concentrations of nutrients in water and sediments at JNP have been presented in **Tables 29** and **Table 30** respectively.

Table 20: Primary productivity of JNP Harbor area and Nhava Creek

Sr. No.	Station	Gross Primary Productivity [mgC/m ³ /d]	Net Primary Productivity [mgC/m ³ /d]
JNP Harbor Area			
1.	W01	375	315
2.	W02	515	425
3.	W03	215	275
4.	W04	315	215
5.	W05	415	375
6.	W06	315	275
7.	W07	275	175
8.	W09	415	315
9.	W08	310	275
NHAVA Creek Area			
10.	W11	315	275
11.	W12	375	275
12.	W13	415	315
13.	W14	475	415

Table 21: Enumeration of Phytoplankton in JNP Harbor area and Nhava Creek

Sr. No.	Sampling station	Sample Location	Phyto-plankton, [No/mL]	Percent Composition of Algal Groups Bacillario-phyceae	Chloro-phyceae	Cyano-phyceae	Crypto-phyceae	SWI	PPI
JNP Harbor Area									
1	W1	Surface	570	60	30	10	-	1.21	22
		Bottom	450	55	40	5	-	0.85	15
2	W2	Surface	720	55	30	5	10	1.56	21
		Bottom	570	50	20	10	20	1.35	14
3	W3	Surface	445	65	30	5	-	1.21	21
		Bottom	380	45	40	5	10	1.25	19
4	W4	Surface	420	50	20	20	10	0.98	15
		Bottom	390	50	30	10	10	1.10	18
5	W5	Surface	510	55	30	5	10	1.54	20
		Bottom	450	65	25	10	-	1.20	16
6	W6	Surface	550	45	20	15	20	0.96	24
		Bottom	480	60	20	20	10	1.82	20
7	W7	Surface	620	50	30	20	-	1.21	16
		Bottom	535	66	24	10	-	0.82	19
8	W9	Surface	615	50	40	10	-	1.69	22
		Bottom	520	50	30	20	-	1.22	23
9	W8	Surface	490	75	10	15	-	2.10	20
		Bottom	430	55	25	20	-	1.56	25
NHAVA Creek									
10	W11	Surface	615	65	20	15	-	1.20	23
		Bottom	550	50	20	20	10	2.10	20
11	W12	Surface	560	50	20	20	10	0.69	21
		Bottom	480	60	20	10	10	1.20	15
12	W13	Surface	650	70	20	10	-	0.90	13
		Bottom	540	60	25	15	-	0.80	22
13	W14	Surface	620	50	30	10	10	1.50	16
		Bottom	505	60	20	10	10	1.10	18
PPI : Ranges of Palmer's Pollution index <15 : Indicate absence of organic pollution. 15 to <20 : Indicate presence of organic pollution. >20 : Indicate presence of high organic pollution. SWI : Ranges of Shannon Wiener Diversity Index <1 : Indicate maximum impact of pollution or adverse factor. 1 to <3 : Indicate medium impact of pollution or adverse factor. 3 & above : Indicate lowest or minimum impact of pollution or adverse factor.									

Table 22: Phytoplankton Genera Observed in JNP Harbor Area and Nhava Creek Area

Sr.	Bacillariophyceae	Chlorophyceae	Cyanophyceae	Cryptophyceae
1.	<i>Navicula sp.</i>	<i>Closterium sp.</i>	<i>Gloeocapsa sp.</i>	<i>Cryptomonas sp.</i>
2.	<i>Nitzschia sp.</i>	<i>Cosmarium sp.</i>	<i>Oscillatoria sp.</i>	-
3.	<i>Fragillaria sp.</i>	<i>Crucigenia sp.</i>	<i>Anabaena sp.</i>	-
4.	<i>Surirella sp.</i>	<i>Scenedesmus sp.</i>	<i>Aphanocapsa sp.</i>	-
5.	<i>Gyrosigma sp.</i>	-	-	-

Table 23: Secchi Depth Details of JNP Harbor area and Nhava Creek

Sr. No.	Station	Secchi Depth, [cm]
JNP Harbor Area		
1.	W1	40
2.	W2	50
3.	W3	40
4.	W4	50
5.	W5	50
6.	W6	50
7.	W7	40
8.	W9	40
9.	W8	50
Nhava Creek Area		
10.	W11	50
11.	W12	40
12.	W13	50
13.	W14	40

Table 24: Enumeration of Zooplankton in JNP Harbor area and Nhava Creek

Sr. No.	Towing between Stations	Zoo-plankton, [No/m ³]	Percent Composition of Zooplankton Groups				SWI
			Copepoda	Cladocera	Foraminifera	Rotifera	
JNP Harbor Area							
1.	W1 – W2	370	55	25	10	10	1.15
2.	W2 – W5	410	50	20	30	-	0.95
3.	W5 – W1	520	40	20	20	20	1.56
4.	W5 – W6	450	50	20	20	10	1.10
5.	W6 – W2	350	60	20	20	-	0.90
6.	W4 – W3	420	55	20	15	10	1.60
7.	W3 – W7	350	45	40	15	-	1.20
8.	W7 – W8	410	50	20	20	10	1.54
9.	W8 – W3	350	50	20	20	10	1.39
10.	W9 – W3	410	45	30	15	10	1.10
NHAVA Creek							
11.	W5 – W11	300	40	30	20	10	0.60
12.	W11 – W12	420	60	20	10	10	1.20
13.	W12 – W13	370	60	20	20	-	1.80
14.	W13 – W14	250	50	30	20	-	1.11
SWI : Ranges of Shannon Wiener Diversity Index <1 : Indicate maximum impact of pollution or adverse factor. 1 to <3 : Indicate medium impact of pollution or adverse factor. 3 & above : Indicate lowest or minimum impact of pollution or adverse factor.							

Table 25: Zooplankton Genera Recorded in JNP Harbor Area and Nhava Creek Area

Sr. No.	Copepoda	Rotifera	Cladocera	Foraminifera
1.	<i>Cyclops sp.</i>	<i>Keratella sp.</i>	<i>Daphnia sp.</i>	<i>Rotaliasp.</i>
2.	<i>Diaptomus sp.</i>	<i>Brachionus sp.</i>	-	-

Table 26: Chlorophyll-a Content in JNP Harbor area and Nhava Creek

Sr. No.	Station	Chlorophyll- <i>a</i> [mg/m ³]		Pheophytin- <i>a</i> [mg/m ³]		Algal Biomass
		Surface	Bottom	Surface	Bottom	(mg/m ³)
JNP Harbor Area						
1.	W1	5.1	4.2	BDL	BDL	340
2.	W2	5.6	4.1	BDL	BDL	373
3.	W3	4.7	3.6	BDL	BDL	313
4.	W4	3.4	2.8	BBL	0.2	226
5.	W5	4.9	3.2	BDL	BDL	326
6.	W6	5.3	3.6	BDL	BDL	352
7.	W7	4.1	3.4	BDL	BDL	273
8.	W9	4.5	3.1	BDL	BDL	299
9.	W8	4.8	2.9	BDL	BDL	319
Nhava Creek Area						
10.	W11	5.2	4.5	BDL	BDL	346
11.	W12	3.5	2.1	BDL	BDL	233
12.	W13	4.1	3.5	BDL	BDL	273
13.	W14	4.3	3.1	BDL	BDL	286

Table 27: Concentration of Particulate Oxidisable Organic Carbon [POC]

Sr. No.	Station	POC, [mg/m ³]
Standard		10 - 100
JNP Harbor Area		
1.	W1	765
2.	W2	630
3.	W3	803
4.	W4	810
5.	W5	720
6.	W6	900
7.	W7	878
8.	W8	848
9.	W9	818
Nhava Creek Area		
10.	W11	788
11.	W12	758
12.	W13	728
13.	W14	825

Table 28: Benthic Fauna Recorded at JNP Harbor area and Nhava Creek

Sr. No.	Station	Macrobenthos [No/m ³]	Percent Composition of Macrobenthos				SWI
			Foraminifera	Gastropods	Polychaeta	Chironomidae	
JNP Harbor Area							
1.	W1	350	40	20	20	20	1.00
2.	W2	420	60	30	10	-	0.96
3.	W3	320	50	20	10	20	1.42
4.	W4	250	40	40	20	-	1.10
5.	W6	410	50	30	10	10	1.00
6.	W7	350	60	30	10	-	1.35
7.	W9	150	40	30	20	10	1.45
Nhava Creek Area							
8.	W13	350	60	30	10	-	0.63
9.	W14	320	65	15	10	10	0.89
Ranges of Shannon Wiener Diversity Index (SWI) <1: Indicate maximum impact of pollution or adverse factor. 1 - <3: Indicate medium impact of pollution or adverse factor. 3 & above: Indicate lowest or minimum impact of pollution or adverse factor.							

Table 29: Concentration of Nutrients in Water at JNP Harbours area and Nhava Creek

Station Name	Ca ²⁺ , [mg/L]	Mg ⁺ , [mg/L]	K ⁺ , [mg/L]	Na ⁺ , [mg/L]	PO ₄ ³⁻ -P, [mg/L]	NO ₃ ⁻ -N, [mg/L]	NO ₂ ⁻ -N, [mg/L]	SiO ₂ ²⁻ , [mg/L]	SO ₄ ²⁻ , [mg/L]
Standard	-	-	-	-	0.1 - 90	1.0 - 500	<125	10 - 5000	-
JNP HARBOUR AREA									
W1	556	1299	294	10400	94	327	<10	113	2570
W2	476	1419	292	10700	28	600	<10	29	2814
W3	476	1395	296	10100	92	345	<10	89	2471
W4	437	1492	296	10400	67	219	<10	175	2724
W5	497	1540	302	10500	120	475	31	12	2722
W6	476	1299	300	10700	102	421	<10	18	2832
W7	437	1419	304	10800	103	310	<10	16	2987
W8	437	1395	296	10800	98	650	<10	58	2798
W9	497	1492	294	10800	97	264	<10	14	2772
JNP NHAVA CREEK AREA									
W11	437	1347	296	10400	83	476	<10	195	2623
W12	476	1299	300	10500	125	381	<10	100	2928
W13	437	1371	292	10500	72	227	15	107	2794
W14	516	1443	300	11300	93	323	<10	55	3226

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 ⁻ -N, [mg/kg]	NO ₂ ⁻ -N, [mg/kg]	SiO ₂ ²⁻ , [mg/kg]	SO ₄ ²⁻ , [mg/kg]
Standard	-	-	-	-	-	-	-	-	-
JNP HARBOUR AREA									
W1	3508	248	290	5360	128	42	0.29	125	7665
W2	3264	99	490	6000	184	39	0.29	111	7733
W3	4651	545	210	6240	135	41	0.32	155	5099
W4	3264	644	440	6280	166	39	0.30	124	9651
W5	Sample not found								
W6	5304	347	310	7840	151	48	0.35	143	7372
W7	4733	198	420	7360	156	39	0.37	111	7895
W8	4570	198	500	5920	148	45	0.40	120	8448
W9	4243	297	210	6400	91	39	0.28	150	8966
JNP NHAVA CREEK AREA									
W11	Sample not found								
W12	Sample not found								
W13	5875	397	220	5880	165	39	0.37	148	7177
W14	9630	397	230	7160	171	44	0.48	130	6172

3.4 DISCUSSION

3.4.1 Water Quality: Biotic

In view of the need for conservation of environmental quality and biodiversity, study of biological environment is one of the most important components for ecological assessment. Ecological system shows inter relationship between biotic and abiotic components including dependence, competition and mutualism. Biotic component comprises of both plant and animal communities, which interact not only within and between them but also with the abiotic components viz., physical and chemical components of the environment.

Generally biological communities are the indicators of climatic conditions, dependent on environmental condition and resource of its distribution and survival. It may change if there is alteration in the environmental variables like temperature, humidity, rainfall, soil characteristics, topography etc., which are responsible for maintaining the homeostasis of the environment.

The species of flora and fauna in the environment are organized into natural communities with mutual dependencies and show various responses and sensitivities to anthropogenic influences. The changes in biotic community are studied in the pattern of distribution, abundance and diversity.

3.4.1.a Primary Productivity

Primary production in the surface water is dependent on the photosynthesis of green plants principally of phytoplankton with a possible, minor contribution from very few species of green photosynthetic bacteria. The level of primary production is associated with the concentration of nutrients. As primary production results conversion of inorganic carbon to organic carbon with release of oxygen, it is usually determined by measuring the changes in oxygen concentrations in the water body.

Production is generally defined as the total mass of tissue elaborated within a stated interval and includes material which does not endure to the end of the period. It is therefore, a measure of the dynamic state of the biomass, the rate at which material is being gained or lost within a given time, and thus it is usually expressed as the mass per unit time. Production may be gross, that is including all energy assimilated, or net, that is the amount which contributes to tissue growth, the difference being the energy which is used in the metabolic processes which maintain life, principally respiration. Algal production is usually expressed in gross terms i.e. net photosynthetic activity added to respiratory activity.

Water samples from three different sampling points of various depths were collected both in a transparent and completely opaque (dark) high quality glass bottle. From each sampling points two samples were collected in transparent bottles and the rest one was collected in dark bottle. Dark bottles were completely covered by a black cloth so as to avoid light penetration. The DO of one bottle was fixed on spot during the sample collection, while DO of other two light and dark bottles were fixed after a duration of six hours from sampling. DO of all the samples were analyzed using standard Sodium thiosulphate solution (*Standard Method, APHA 2005*).

The highest estimated gross and net primary productivity was measured as 515 and 425 mgC/m³/d at stations W2 and W14 [Table 20]. The values are within the lowest (95 mgC/m³/d) and highest (739 mgC/m³/d) productivity, as reported at near shore waters of Vizhinjam in Trivadrur (Rani Mary Jacob and Vasantha Kumar, 1984). Compared with other coastal ecosystems, primary productivity of JNP Harbour area and Nhava creek was at a moderate level. High production at W2 might be cause of high phytoplankton count in this area. Generally the production is high in summer than the other season.

3.4.1.b Plankton

Plankton are important component of ecosystem, which respond to ecosystem alterations rather rapidly. It is due to the fact that planktonic organisms, which react to different types of water pollution, play a key role in turnover of organic matter and energy through the ecosystem. This reaction is very rapid because of relatively short lifetime and high reproduction rates of the organisms. Since the phytoplankton play a key role of primary producer in aquatic environment, these are the first component in the trophic tier to be affected by pollution. Phytoplankton can grow rapidly and form massive blooms that can be regulated by environmental factors such as nutrients, availability of light and biotic interaction with grazers. Phytoplankton are passive drifters with the currents. Diatoms are a highly diverse and abundant group of phytoplankton in the aquatic environment. They are responsible for about 25% of global primary productivity and play a central role in the biogeochemical cycling of important nutrients such as carbon, nitrogen and silica. Most of the N is bound in organic compounds and its importance to phytoplankton bloom formation. If bloom formations take place in the water then it could significantly harm to these water bodies. Phytoplankton blooms decrease light penetration through the water column and can depress primary productivity. It may have diminished ecosystem integrity and the abundance and sustainability of living resources (e.g. fish and shrimp).

Similarly zooplankton, also a very important group in the aquatic ecosystem, act as the primary consumer and ultimately serve as the natural food source for many aquatic organisms, including fishes. Freshwater zooplankton show considerable variety comprising of members of almost every group from protozoa to chordate. Depending on seasons and environmental conditions, the plankton community shows pronounced variation in its character and composition.

Enumeration and Indices: Phytoplankton were enumerated from unfiltered water samples by Lackey Drop method (Lackey, 1983). For zooplankton, desired volume of waters were filtered through plankton net to represent all the available groups. The samples were fixed immediately with 5 % buffered formalin. The S-R cell is a device commonly used for zooplankton counting because it is easily manipulated. The parameters studied were numerical count of individual species, groups and indices, as described hereunder. In view of this, studies were carried out towards distribution, diversity and other ecological aspects of phytoplankton and zooplankton from different sampling locations of JNP Harbour area and Nhava creek.

Shannon Wiener Diversity Index:

Shannon Wiener Diversity Index (d) is a measure of diversity which takes into account the total count and individual count in water sample and is expressed as

$$\text{Shannon Wiener Diversity Index: } SWI = -\sum \frac{n_i}{N} \log_2 \frac{n_i}{N}$$

Where,

SWI = Shannon Wiener Diversity Index

N = Total number of individuals of species in a sample

n = number of individuals of species in a sample

A widely accepted ecological concept is that community with large number of species i.e. with high diversity will have stability and thus have the capability to resist adverse environment influences to certain extent. "The Shannon Wiener index" values in the range of 3 and above are generally considered to represent healthy conditions of water. The values between 1 and 3 are believed to indicate semi and poor productivity respectively.



Plate 3.1: Collection of Plankton from JNP Harbour Area

A] Phytoplankton:

Count : Phytoplankton counts, recorded at different sampling stations, are presented in Table 21. Total algal population varied between 390 and 720 algal cells/ml. Samples collected at station W4(B) and W2(S) showed lowest and highest counts respectively. *Bacillariophyceae* dominated all samples followed by Chlorophyceae. The phytoplankton population comprised of fifteen genera with 4 major groups, namely *Bacillariophyceae*, *Chlorophyceae*, *Cyanophyceae* and *Chrysophyceae* [Table 22]. PPI values varied from 13-24 indicate moderate organic pollution. Shannon - Wiener Diversity Index (SWI) varied between 0.69 and 2.10 at stations W12S and W10S. The values also suggest low to medium impact of pollution or adverse factor.

Secchi Disk Transparency: Secchi disk transparency refers to the depth to which the black and white Secchi disk can be seen in the water. Water clarity, as determined by a Secchi disk, is affected by two primary factors: algae and suspended particulate matter. Light penetration was

measured in the JNP Harbour Area and Nhava creek with the help of Secchi Disk (**Table 23**). Transparency varied between 40-50 cm.

B] Zooplankton:

Zooplankton counts, recorded at different sampling stations, are shown in Table 24. Since huge quantity of water was to be filtered through plankton net, middle and bottom samples could not be collected. Density of zooplankton varied between 300 and 520 N/m³ at stations W5-W11 and W5-W1. Total six genera of zooplankton were recorded. Among zooplankton Copepoda and Cladocera group were dominant [**Table 25**]. SWI vary from 0.60 to 1.80 at stations W5-W11 & W12-W13 respectively indicated low to medium load of organic pollution or adverse factors.

Distribution of Hydromedusae in JNP Harbour area and NHAVA creek: Often Hydromedusae contribute substantially to the total zooplankton standing stock in the estuarine and near shore waters. Occasionally these forms occur in dense swarms. Ecologically this group is important as they are exclusively carnivores and form an important link in the tropic estuaries experience only limited fluctuations of temperature. Some stations in JNP Harbour area and NHAVA creek represent the distribution of Hydromedusae species like Blackfordia virginica is an euryhaline species. This species is considered as backwater form but it may occasionally be found in coastal water also.

3.4.1.c Photosynthetic Pigments [Chlorophyll-a, Pheophytin-a]:

Chlorophyll is the green molecule in plant cells that carries out the bulk of energy fixation in the process of photosynthesis. Pheophytin (Pheo) is a chlorophyll derivative demodulated chlorophyll or simply chlorophyll without central Mg-atom. Pheophytin can be easily obtained during the extraction processes, due to the liability of magnesium in the chlorophyll molecule.

Standard method was followed to estimate chlorophyll-a and pheophytin of the water samples collected from different sampling points of JNP Harbour area and Nhava creek [**Table 26**]. For the estimation of chlorophyll-a and pheophytin-a, a certain volume of water sample was filtered through glass fiber filter paper and the filter paper was immersed in 5 ml of 90% acetone and grinded in tissue grinder and kept overnight at 4°C in dark for extraction of pigments. 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.

The algal biomass is the main source of food for the primary consumers and it was evaluated by chlorophyll-a method and its value is given in **Table 26**. In JNP harbor area, the range of algal biomass was found between 226 and 373 mg/m³. The minimum algal biomass was (226 mg/m³) found at W4 and maximum (373 mg/m³) was found at W2 station. The lowest and highest chlorophyll a levels from surface water sample varied from 2.1 at station W12 (B) to 5.6 mg/m³ at W2(S). Phytoplankton count was high at W2 station resulted in increased chlorophyll count in this station. However, Pheophytin concentrations of many samples were below detectable limit [**Table 26**].

3.4.1.d Particulate Organic Carbon [POC]:

The concentration of particulate oxidizable carbon [POC] is given in **Table 27**. In JNP harbor POC content was found to be between 630 – 900 mg/m³ with an average of 797 mg/m³. The minimum concentration of POC was found at W2 station and maximum concentration at W6 station. In Nhava creek the POC content was found to be between 728 – 825 mg/m³ with an average of 774 mg/m³. The POC concentration was found to be higher than the prescribed standard range i.e. 10- 100 mg/m³ at all stations in JNP Harbor region and Nhava Creek region. This may be due to detritus material originate from Mangrove swamps or detritus plankton. The higher values for POC were also reported in Tulaskar et al [Ind. J. Marine Sci., Vol. 21, 1992] for Rajapur and Vagothan estuaries (west coast of India).

3.4.2 Sediment Quality: Biotic

Benthos: The organisms which inhabit the bottom of aquatic body are called benthos. Many of them are sessile; some creep over or burrow in mud and base of water body. The quality and quantity of animals found at the bottom is not only related to the nature of substrata but also to depth, the kind and the quality of aquatic plants present in such environment. Their number and distribution also depend upon physico-chemical properties of water and biological complexes, such as food and other factors.

The bottom mud was collected from various sampling points of JNP Harbour area and NHAVA creek Van veen grab sampler having the area 0.02 m². The sediment was sieved through 500 μ mesh sieve and the organisms retained the sieve were preserved immediately with 5% buffered formalin. Subsequently, all the macrobenthic specimens were identified to the lowest possible level under a stereoscopic microscope. All unidentified specimens are referred to by their generic/family names and were considered in single taxonomic category.

A total of four macrobenthic groups were obtained from the 13 sediment samples. *Foraminifera* was the most diverse group. Species like *Triloculina*, *Ammonia* and *Lagena* were dominant. *Forams* are abundant all over the ocean. They either live on the sea bottom (benthic) or float in the upper water column (planktonic). The size of the *foraminiferal* test typically ranges from 0.05mm to 0.5mm although some *forams* may be as large as several centimeters with a recorded maximum of 18cm in diameter. They not only provide surface for respiration, but also perform feeding, locomotion, test building, metabolite release, adhering, etc. Foods of the *foraminifera* are variable: dissolved free amino acids, bacteria, unicellular algae, and even metazoans, such as copepods. It was followed by Gastropods. Among the Gastropods, the dominant species were *Litiopa sp.*, *Morula sp.* and *Oliva sp.* *Chironomous larva* from *Chironomidae* was also observed as benthic fauna. The highest count was 420 No/m² in sampling point W2. Benthos was absent at stations W5 and W10. The SWI values were observed to vary from 0.63 – 2.21 at stations W13 and W11.

Trophic level of JNP Harbor area and Nhava creek: In order to evaluate the trophic status of the lake the values of transparency, chlorophyll and phosphate were considered with available standards.. Since standards are not applicable to ecological parameters, Organization for Economic Co-Operation and Development (OECD) guidelines are recommended by US

Environmental Protection Agency (USEPA) for evaluating status of surface water qualities. Accordingly, the values of transparency, chlorophyll-a and phosphorus were considered for assessing trophic status of one each JNP Harbor and Nhava creek water.

These guidelines are based on blooming of algae due to excessive nutrients, particularly phosphorus in water body. Based on values of Chlorophyll-a (**Table 29**), these waters can be classified as Mesotrophic, that is of medium quality. It appears that transparency in these waters is less, not because of algal growth but due to turbidity. Further, phosphorus levels are also more due to discharge of wastes in creek and subsequent mixing with harbor water. Due to increase of turbidity, sunlight penetration is reduced, thereby hindering excessive growth of algae.

Table 31: Trophic Status of JNP Harbor Water and NHAVA Creek Water with Reference to OECD Guidelines

Status	Secchi Disk Depth (Transparency in m)	Chlorophyll-a (mg/m ³)	Total Phosphorus (mg/L)
Oligotrophic	> 4	< 2	<0.01
Mesotrophic	1.6 to 4	2 to 10	0.01-0.03
Eutrophic	0.7 to 1.6	10 to 30	0.03 – 0.06
Hypereutrophic	< 0.7	> 30	>0.06
JNP Harbor area	0.4	3.0	0.127
NHAVA creek	0.4	4.0	0.136

3.4.3 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 depicted in **Table 29**. In harbor region the Phosphate was found to be 28µg/L – 120µg/L. In JNP harbor region, the Phosphate value was found above prescribed standard range [0.1 – 90µg/L] at most of the stations. The Nitrate was found to be between 129µg/L – 650µg/L. The minimum value of Nitrate was found at W4 station and maximum at W8 station. The average concentration of Nitrate was found to be 401.2µg/L and overall Nitrate was found within range [1.0 to 500µg/L] at all stations except at W2 and W8 stations. 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 1302 – 2508 µg/L with an average of 1767µg/L. The minimum concentration of silica was found at W4 station of JNP harbor region and the maximum concentration of silica was found at W5 station. The Sulphate was found between 2471 – 2987 mg/L, the minimum value recorded at W3 station and maximum at W7 station. The average concentration of Sulphate was found to be 2743.3 mg/L.

In Nhava Creek, Phosphate was found between 72µg/L – 125µg/L with an average 93µg/L which was above prescribed standard range [0.1-90µg/L]. Nitrate was found to be 227 – 476 µg/L with an average 352 µg/L. The silica content in Nhava creek was found to be 1457 – 5939 µg/L with an average of 2743µg/L. The minimum silica content was found at station W12 station and maximum was found at W14 station. Sulphate was found between 2623 – 3226 mg/L with an average of 2893 mg/L. The minimum value for Sulphate was found at W11 station and maximum value at W14 station.

Overall in JNP harbor and creek region the values of all the nutrients were found to be within the recommended ranges, which are given in **Table 29**.

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 found at eight locations out of nine. Phosphate was found between 91 – 184 mg/kg with an average of 145 mg/kg. The Nitrate was found minimum value at W2, W4, W7, and W9 stations i.e. 39 mg/kg and maximum value at W2 station i.e. 48 mg/kg. The average concentration of Nitrate was found to be 41.5mg/kg. The Nitrite was found to be between 0.28 – 0.40 mg/kg with an average of 0.33 mg/kg. The minimum concentration of nitrite was found at W9 station and maximum value at W8 station. Silica in the form of silicate in JNP harbor sediments were found between 111 to 155 mg/kg with an average of 130 mg/kg. The minimum concentration of silica was found at W2 and W7 stations and maximum value was found at W3 station. The Sulphate was found between 5099 to 9651 mg/kg, with minimum value at W3 station and maximum value at W4 station. The average concentration of Sulphate was found to be 7854 mg/kg.

In Nhava Creek region the sediment found at two locations out of four. Phosphate levels were 165 and 171 mg/kg with an average of 168 mg/kg. Nitrate was found to be 39 and 44 mg/kg. The average concentration of Nitrate was found to be 41.4 mg/kg. The Nitrite was found to be 0.37 and 0.48 mg/kg. Silica in the form of silicate in JNP harbor sediments was found to be 130 to 148mg/kg with an average of 139 mg/kg. The Sulphate was found to be 6172 and 7177mg/kg. The average concentration of Sulphate was found to be 6674.5 mg/kg.

b. Cations:

In harbor region water, the Calcium was found between 437 to 556 mg/L with an average of 476.5 mg/L given in **Table 29**. The Magnesium was found to be 1299 – 1540 mg/L, with maximum value at W7 & W8 stations. The average concentration of Magnesium was found to be 1417 mg/L. Potassium in JNP harbor water was found between 292 to 304 mg/L with an average of 297 mg/L. The minimum concentration of Potassium was found at W2 station and

maximum value W7 station. The Sodium was found between 10100 to 10800 mg/L with an average of 10578 mg/L. The minimum concentration of sodium was found at W3 station and maximum value of at W7, W8 and W9 stations.

In Nhava Creek, Calcium concentration was found with an average 467 mg/L given in **Table 29**. Magnesium concentration was found to be 1299 – 1443 mg/L with an average of 1365 mg/L. The minimum value of Magnesium was found at W12 station and maximum value was found at W14 stations. The Potassium content in Nhava creek was found to be 292 – 300 mg/L with an average of 297 mg/L. Sodium minimum concentration was found to be 10400 mg/L at W11 and maximum of 11300 mg/L at W14.

In harbor region sediments, the Calcium was found to be 3264 to 5304 mg/Kg with an average of 4192 mg/Kg given in **Table 30**. The minimum Concentration of Calcium was found at W4 station and maximum concentration at W6 station. Magnesium was found to be 99 to 644 mg/Kg, with minimum value at W2 station and maximum was recorded at W4 station. The average concentration of Magnesium was found to be 322 mg/Kg. Potassium in JNP harbor sediment was found to be 210 to 500 mg/Kg with an average of 359 mg/Kg. The minimum concentration of Potassium was found at W3 & W9 stations and maximum value at W8 station. Sodium was found to be 5360 to 7840 mg/Kg with an average of 6425 mg/Kg. The minimum concentration of sodium was found at W1 station and maximum value at W6 station.

In Nhava Creek sediments, Calcium was found to be 5875 to 9630 mg/Kg with an average 7753 mg/Kg given in **Table 30**. Magnesium was found to be 397 mg/Kg. Average potassium content in Nhava creek was found to be 225 mg/Kg. The minimum sodium value was found at W13 station and maximum value at W14.

3.5 OBSERVATIONS AND CONCLUSIONS

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

Sr. No.	Parameter	Criteria	Observations	Remarks	Mitigation Measures
1.	Net primary productivity	<1500 mgC/m ³ /day at surface	The observed values falls under 175 – 425 mgC/m ³ /day	-	Within Range
2.	Chlorophyll-a	< 4 mg/m ³ [Oligotrophic class] 4-10 mg/m ³ [Mesotrophic class] >10 mg/m ³ [Eutrophic classter]	The observed values falls under 3.4 – 5.6 mg/m ³	All stations follow Oligotrophic class of water	Does not require since the values fall under Oligotrophic class of water
3.	Phosphate	0.1- 90 µg/L	Harbour area – 89 µg/L; Creek area – 93 µg/L	A nutrient that acts as a fertilizer. High level of this nutrient causes excessive plant and algal growth in aquatic ecosystem	Exceeds the Range
4.	Nitrate	1.0- 500 µg/L	Harbour area – 401 µg/L; Creek area – 352 µg/L	A nutrient produced in natural water by decomposition of nitrogenous organic compounds. Moderate level of nitrate.	Exceeds the Range
5.	Nitrite	<125 µg/L	Harbour area – <10 µg/L & Creek area – 0.42 µg/L	A nutrient produced in natural water by decomposition of nitrogenous organic compounds. Moderate level of nitrite.	Exceeds the Range
6.	Particulate Organic Carbon	10 – 100 mg/m ³	Harbour area – 797 mg/m ³ ; Creek area – 774 mg/m ³	This may be due to detritus material originate from Mangrove swamps or detritus planktons	Awareness about the pollution of sea water
7.	Silicate (SiO ₂)	10-5000 µg/L	Harbour area – 1856 µg/L; Creek area – 1910 µg/L	Nucleic acid synthesis and skeletal formation of Diatoms.	Within Range

Observations for the month of March:

- ✓ *Construction of 4th Container Terminal on South side of JNPT :* Earth Filling work of 4th C.T. is underway.
- ✓ *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 reported in **Tables 20 to 29** and subsequently discussed in above paragraphs, the relevant parameters mentioned in below given table are complying with recommended ranges of the ecological parameters for Arabian Sea during March, 2015 except Particulate Organic Carbon.

According to Tulaskar et al., the high values for POC may be due to detritus material originating from Mangrove swamps by tidal effects or March is due to detritus plankton. Based on other ecological parameters it is seen that, the marine ecosystem seems to be not disturbed due to port operational activities.

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 depicted 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	DW8	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 eighteen stations ten stations were outside the port and eight stations were inside the port. All samples were collected from the port area of JNP on 13th March, 2015.

The water samples are analyzed for various parameters Color, Odor, Turbidity, Conductivity, pH, Chlorides, TDS, Total hardness, Iron, Sulphate, NH₄⁺-N, PO₄³⁻-P, CFU Bacterial count.

4.2 RESULTS

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

Table 33: Results of Drinking water quality monitoring

Parameter	Unit of Measurement	DW1	DW2	DW3	DW4	DW5	DW6	Standards*
Colour	Hazen	<5	<5	<5	<5	<5	<5	5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Conductivity	mS/cm	99	111	101	115	98	112	-
pH	-	7.54	7.69	7.30	7.07	7.45	7.40	6.5 to 8.5
Chloride as Cl	mg/L	8.7	9.2	9.2	8.7	9.2	12.1	250
Total Dissolved Solids	mg/L	64	71	66	75	64	73	500
Total Hardness as CaCO ₃	mg/L	44	43	44	46	46	44	200
Iron as Fe	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.3
Sulphate as SO ₄ ²⁻	mg/L	4.5	1.8	4.3	9.3	1.7	4.9	200
NH ₄ ⁺ - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5
PO ₄ ³⁻ - P	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Total Coliforms	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil

*: IS 10500:2012, Drinking Water - Specification

Table 33: Results of Drinking water quality monitoring

Parameter	Unit of Measurement	Station Name						Standards*
		DW7	DW8	DW9	DW10	DW11	DW12	
Colour	Hazen	<5	<5	<5	<5	<5	<5	5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Conductivity	mS/cm	81	91	97	92	100	98	-
pH	-	7.10	7.53	7.51	7.53	7.55	7.62	6.5 to 8.5
Chloride as Cl	mg/L	4.9	8.7	10.2	8.3	9.7	8.7	250
Total Dissolved Solids	mg/L	52	58	63	60	65	63	500
Total Hardness as CaCO ₃	mg/L	30	43	44	42	43	43	200
Iron as Fe	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.3
Sulphate as SO ₄ ⁻²	mg/L	3.8	3.0	1.5	1.9	5.2	1.7	200
NH ₄ ⁺ - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5
PO ₄ ⁻³ - P	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Total Coliforms	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil

* IS 10500:2012, Drinking Water - Specification

*: IS 10500:2012, Drinking Water - Specification

Table 33: Results of Drinking water quality monitoring							
Parameter	Unit of Measurement	DW13	DW14	DW15	DW16	DW17	DW18
Colour	Hazen	<5	<5	<5	<5	<5	<5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
Turbidity	NTU	<1	<1	<1	<1	<1	<1
Conductivity	mS/cm	99.4	99.8	106	97	120	99
pH	-	7.49	7.60	8.03	7.55	7.70	7.68
Chloride as Cl	mg/L	8.7	8.7	8.7	9.2	10.7	8.7
Total Dissolved Solids	mg/L	65	66	69	63	78	64
Total Hardness as CaCO ₃	mg/L	46	44	51	46	52	44
Iron as Fe	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sulphate as SO ₄ ⁻²	mg/L	1.6	2.0	4.0	1.5	5.5	3.4
NH ₄ ⁺ - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
PO ₄ ⁻³ - P	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Coliforms	MFN/100ml	Nil	Nil	Nil	Nil	Nil	Nil
Standards*							
Colour	Hazen	<5	<5	<5	<5	<5	<5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
Turbidity	NTU	<1	<1	<1	<1	<1	<1
Conductivity	mS/cm	99.4	99.8	106	97	120	99
pH	-	7.49	7.60	8.03	7.55	7.70	7.68
Chloride as Cl	mg/L	8.7	8.7	8.7	9.2	10.7	8.7
Total Dissolved Solids	mg/L	65	66	69	63	78	64
Total Hardness as CaCO ₃	mg/L	46	44	51	46	52	44
Iron as Fe	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sulphate as SO ₄ ⁻²	mg/L	1.6	2.0	4.0	1.5	5.5	3.4
NH ₄ ⁺ - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
PO ₄ ⁻³ - P	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Coliforms	MFN/100ml	Nil	Nil	Nil	Nil	Nil	Nil

*: IS 10500:2012, Drinking Water - Specification

4.3 DISCUSSION

Table 33 provides the results for various parameters analyzed for drinking water collected at eighteen stations in and around the port's activity area. The observed results are compared with acceptable limits for various parameters of drinking water as prescribed in **IS 10500:2012** – Drinking Water Specification.

In collected drinking water, minimal variations of anion concentrations are found i.e. chlorides 4.9 to 12.1 mg/L and sulphates 1.5 to 9.3 mg/L. The concentration of total dissolved solids is found to be between 52.0 to 78.0 mg/L and concentration of total hardness as CaCO₃ is found to be 29.7 to 51.5 mg/L. All parameters including the above mentioned, are well within the prescribed limits.

The color of all drinking water samples is < 5 Hazen unit and Odor of the samples is also agreeable. The turbidity values are below acceptable limits i.e. 1 NTU. The values of conductivity are ranges between 80.6 to 119.7 μS/cm. The acceptable range for pH is 6.5 to 8.5, while the observed pH range is 7.1 to 8.0. The iron content and NH₄⁺ – N and PO₄³⁻ – P content is found to be well within the acceptable limit and observed levels are < 0.1 mg/L.

Monitoring for total coliforms was used, in conjunction with other indicators, as part of a multi-barrier approach to producing drinking water of an acceptable quality. Coliform bacteria are a commonly used bacterial indicator of sanitary quality of foods and water. Some coliforms can cause serious illness in humans. Infection symptoms and signs include bloody diarrhea, stomach cramps, vomiting and occasionally, fever. The bacteria can also cause pneumonia, other respiratory illnesses and urinary tract infections^{1,2}. Analysis of bacteriological parameter during **March'15** reported NIL.

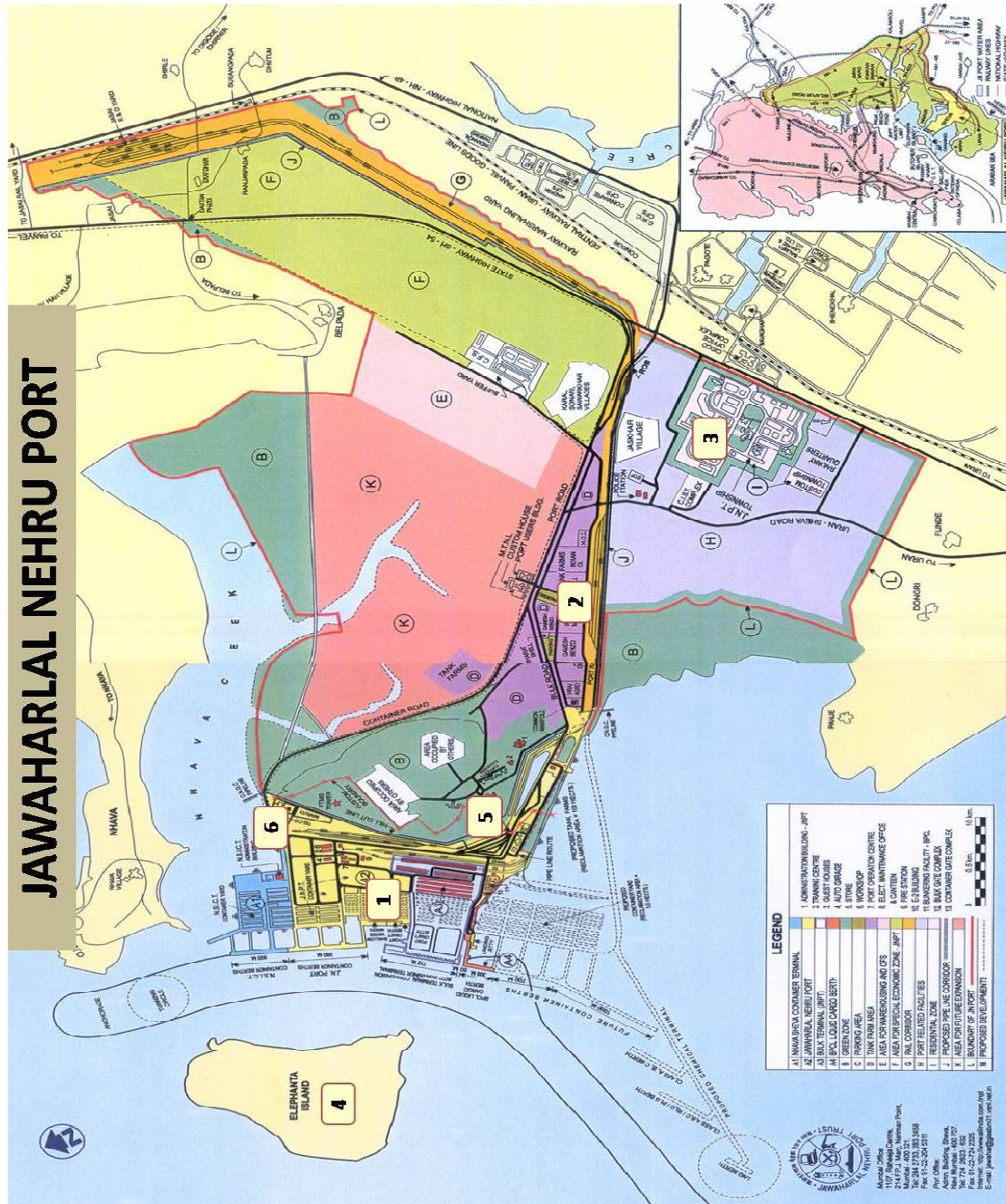
4.4 CONCLUSIONS

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. Some stringent actions needed to be initiated to nullify coliform counts in side port operational area.

¹ Todor, K. "Pathogenic *E. coli*". Online Textbook of Bacteriology. University of Wisconsin–Madison Department of Bacteriology. Retrieved 2007-11-30

² "Escherichia coli". CDC National Center for Emerging and Zoonotic Infectious Diseases. Retrieved 2012-10-02

5. ANNEXURES



Annexure-I: Location map for Ambient Air Monitoring Stations

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 Gaeke
		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) spectroscopy
		1 hour**	04	04	
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(α)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

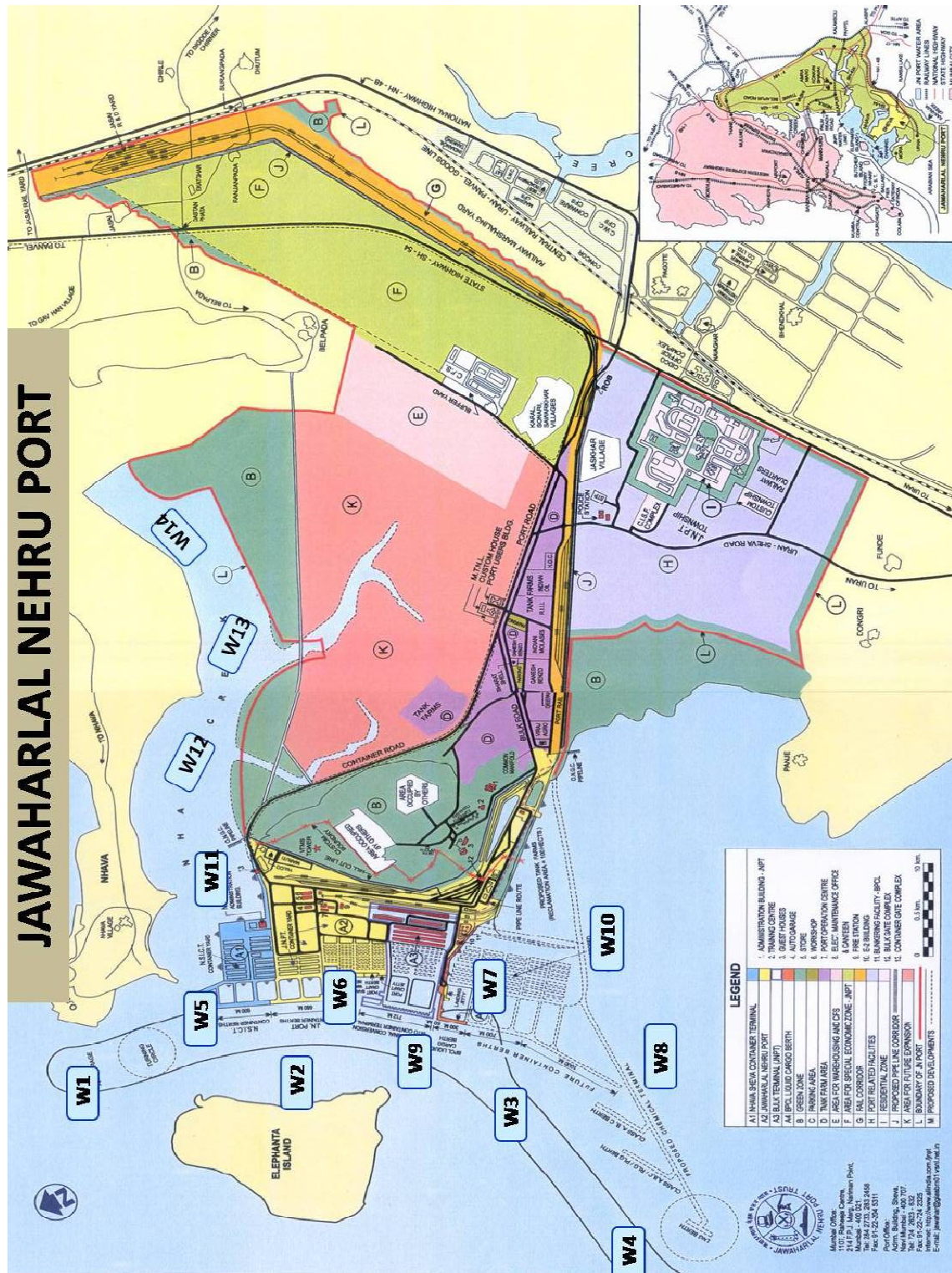
* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals

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

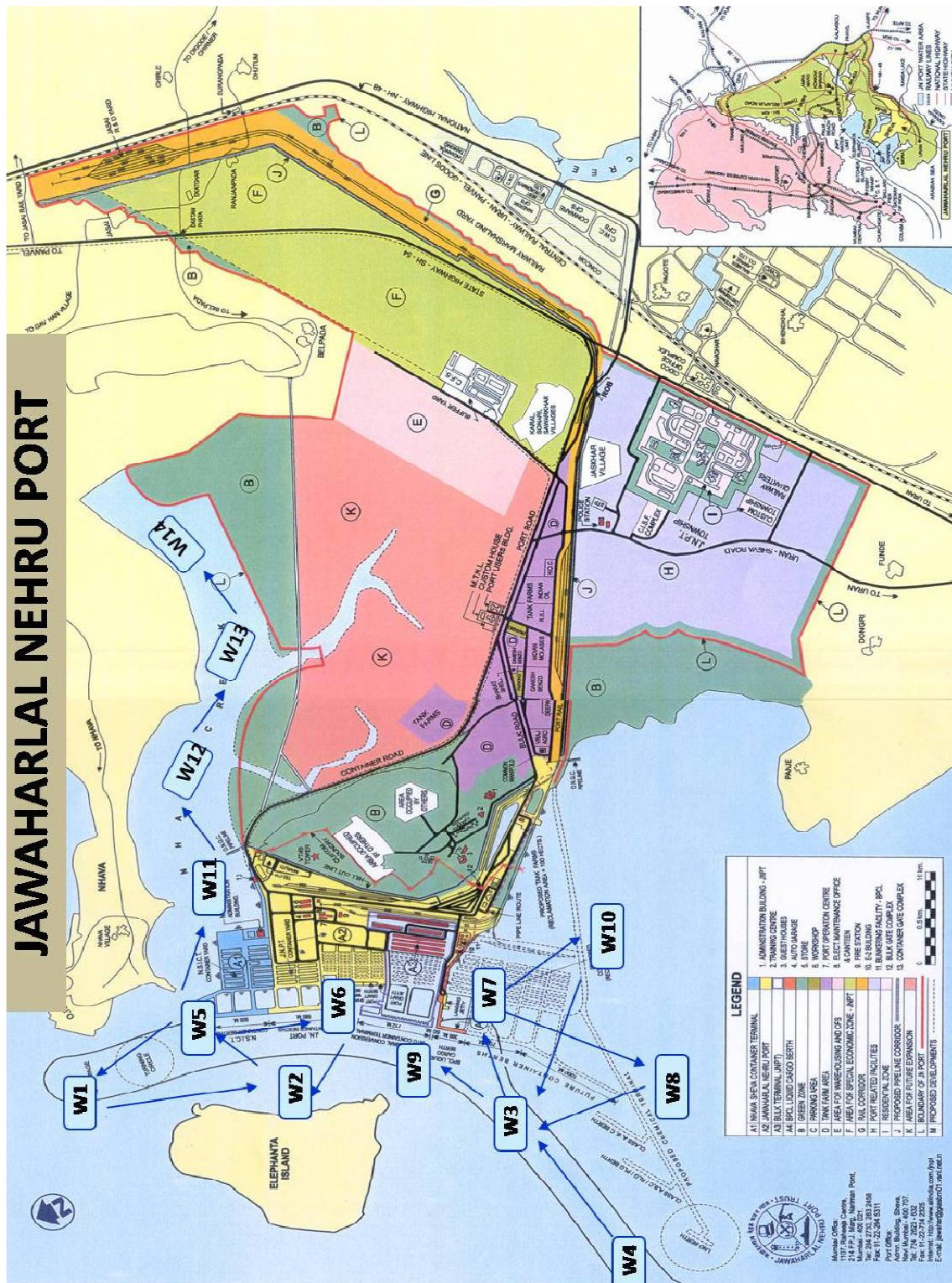
2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

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.

Annexure-II: National Ambient Air Quality Monitoring Standard



Annexure-III: Location map for Marine Water Monitoring Stations



Annexure-IV: Location map for Ecological monitoring Stations and Direction of Towing

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 (5 days at 20°C)	5 mg/L	To maintain water relatively free from the pollution caused by sewage and other decomposable wastes.

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

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.

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