



MONITORING OF ENVIRONMENTAL PLAN FOR JN PORT

ENVIRONMENTAL MONITORING REPORT

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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, 2011. 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 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 October, 2014 are given in Table 2, 3 & 4 respectively. The ambient air quality monitoring data for EC and 2 movable stations, NGC & SGC are given in Table 5, 6 & 7 respectively.

Table 2: Results of Air Pollutant Concentration at POC Station of JNP Area during the month of October, 2014													
Sampling Period NAAQMS	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]		
			100 µg/m ³	24 hr	60 µg/m ³	24 hr	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	
POC-1	02.10.2014 to 03.10.2014	14:00 to 22:00		296	42		15		27		3		
		22:00 to 06:00					15	15.4	32	30.4	3	3.7	
		06:00 to 14:00					16		33		5		
POC-2	06.10.2014 to 07.10.2014	14:00 to 22:00		242	67		13		28		4		
		22:00 to 06:00					15	14.9	30	27.8	4	4.8	
		06:00 to 14:00					16		26		6		
POC-3	09.10.2014 to 10.10.2014	14:00 to 22:00		172	46		16		23		6		
		22:00 to 06:00					15	14.9	21	21.3	5	5.6	
		06:00 to 14:00					13		19		6		
POC-4	13.10.2014 to 14.10.2014	14:00 to 22:00		149	38		16		31		5		
		22:00 to 06:00					13	17.4	27	30.5	4	4.9	
		06:00 to 14:00					22		33		6		
POC-5	17.10.2014 to 18.10.2014	14:00 to 22:00		360	63		13		28		5		
		22:00 to 06:00					19	15.9	30	26.5	4	5.4	
		06:00 to 14:00					15		22		8		
POC-6	20.10.2014 to 21.10.2014	14:00 to 22:00		252	33		19		30		6		
		22:00 to 06:00					19	17.4	34	31.5	5	6.4	
		06:00 to 14:00					13		30		9		
POC-7	23.10.2014 to 24.10.2014	14:00 to 22:00		388	38		15		24		5		
		22:00 to 06:00					13	13.4	27	25.3	4	5.1	
		06:00 to 14:00					12		25		6		
POC-8	27.10.2014 to 28.10.2014	14:00 to 22:00		303	38		21		33		4		
		22:00 to 06:00					16	17.4	27	28.0	4	4.5	
		06:00 to 14:00					15		24		5		
Average			270		46			15.8		27.7		5.0	
Standard Dev			84		13			1.5		3.3		0.8	

Table 2: Results of Air Pollutant Concentration at POC Station of JNP Area during the month of October-2014																		
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]	
			8 hr	24 hr	24 hr	24 hr	24 hr	24 hr	8 hr	24 hr	24 hr	24 hr	24 hr	24 hr	24 hr	24 hr	24 hr	24 hr
			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	4 mg/m ³	-								
POC-1	02.10.2014 to 03.10.2014	14:00 to 22:00																
		22:00 to 06:00	25	<0.1	<1	<1	<1	2.6	<0.5	2.5	291							
POC-2	06.10.2014 to 07.10.2014	14:00 to 22:00																
		22:00 to 06:00	30	<0.1	<1	<1	<1	2.4	<0.5	2.9	294							
POC-3	09.10.2014 to 10.10.2014	06:00 to 14:00																
		14:00 to 22:00	28	<0.1	<1	<1	<1	2.8	<0.5	3.1	286							
POC-4	13.10.2014 to 14.10.2014	14:00 to 22:00																
		22:00 to 06:00	33	<0.1	<1	<1	<1	2.6	<0.5	2.8	287							
POC-5	17.10.2014 to 18.10.2014	06:00 to 14:00																
		14:00 to 22:00	28	<0.1	<1	<1	<1	2.3	<0.5	2.6	290							
POC-6	20.10.2014 to 21.10.2014	06:00 to 14:00																
		14:00 to 22:00	50	<0.1	<1	<1	<1	2.4	<0.5	2.1	289							
POC-7	23.10.2014 to 24.10.2014	14:00 to 22:00																
		22:00 to 06:00	29	<0.1	<1	<1	<1	2.5	<0.5	2.6	294							
POC-8	27.10.2014 to 28.10.2014	06:00 to 14:00																
		14:00 to 22:00	44	<0.1	<1	<1	<1	2.6	<0.5	2.3	293							
Average Standard Dev			33															
			9															

Table 3: Results of Air Pollutant Concentration at IMC Station of JNP Area during the month of October, 2014													
Sampling Period NAAQMS	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	24 hr 60 µg/m ³	24 hr 60 µg/m ³	8 hr	24 hr (Avg) 80 µg/m ³	8 hr	24 hr (Avg) 80 µg/m ³	8 hr	24 hr (Avg) 400 µg/m ³	
IMC-1	02.10.2014 to 03.10.2014	15:00 to 23:00					13		28		5		
		23:00 to 07:00	164		17		12	13.4	23	25.2	4	5.2	
		07:00 to 15:00					15		25		6		
IMC-2	06.10.2014 to 07.10.2014	15:05 to 23:05					13		27		3		
		23:05 to 07:05	245		63		19	17.4	32	30.8	7	6.0	
		07:05 to 15:05					19		33		8		
IMC-3	09.10.2014 to 10.10.2014	15:10 to 23:10					13		21		5		
		23:10 to 07:10	300		63		18	15.4	27	24.2	7	6.2	
		07:10 to 15:10					15		25		7		
IMC-4	13.10.2014 to 14.10.2014	14:50 to 22:50					13		34		7		
		22:50 to 06:50	236		54		15	13.4	28	30.1	5	5.7	
		06:50 to 14:50					12		29		5		
IMC-5	17.10.2014 to 18.10.2014	15:00 to 23:00					15		26		6		
		23:00 to 07:00	121		38		12	13.4	19	24.2	8	6.7	
		07:00 to 15:00					13		27		7		
IMC-6	20.10.2014 to 21.10.2014	15:00 to 23:00					16		31		5		
		23:00 to 07:00	309		33		15	14.9	29	29.6	4	4.6	
		07:00 to 15:00					13		29		5		
IMC-7	23.10.2014 to 24.10.2014	15:00 to 23:00					13		22		5		
		23:00 to 07:00	177		38		15	14.4	26	25.7	7	6.2	
		07:00 to 15:00					15		29		7		
IMC-8	27.10.2014 to 28.10.2014	15:00 to 23:00					13		19		5		
		23:00 to 07:00	264		58		13	12.4	21	23.4	6	5.8	
		07:00 to 15:00					10		30		6		
Average			227	46				14.3		26.7		5.8	
Standard Dev			67	17				1.6		3.0		0.6	

Table 3: Results of Air Pollutant Concentration at IMC Station of JNP Area during the month of October, 2014													
Sampling Period	Date	Time, [Hrs]	O ₃ , [µg/m ³]		Pb, [µg/m ³]		As, [ng/m ³]		C ₆ H ₆ , [µg/m ³]		BaP, [ng/m ³]	CO, [mg/m ³]	CO ₂ , [ppm]
			8 hr	24 hr	24 hr	24 hr	24 hr	24 hr	8 hr	24 hr	24 hr	Grab Sampling	Grab Sampling
NAAQMS			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	4 mg/m ³				
IMC-1	02.10.2014 to 03.10.2014	15:00 to 23:00											
		23:00 to 07:00	28	<0.1	<1	<1	<1	4.2	<0.5	2.4	301		
		07:00 to 15:00											
IMC-2	06.10.2014 to 07.10.2014	15:05 to 23:05											
		23:05 to 07:05	30	<0.1	<1	<1	<1	2.8	<0.5	2.6	291		
		07:05 to 15:05											
IMC-3	09.10.2014 to 10.10.2014	15:10 to 23:10											
		23:10 to 07:10	51	<0.1	<1	<1	<1	2.9	<0.5	2.8	297		
		07:10 to 15:10											
IMC-4	13.10.2014 to 14.10.2014	14:50 to 22:50											
		22:50 to 06:50	32	<0.1	<1	<1	<1	3.4	<0.5	2.7	298		
		06:50 to 14:50											
IMC-5	17.10.2014 to 18.10.2014	15:00 to 23:00											
		23:00 to 07:00	34	<0.1	<1	<1	<1	3.2	<0.5	2.5	296		
		07:00 to 15:00											
IMC-6	20.10.2014 to 21.10.2014	15:00 to 23:00											
		23:00 to 07:00	45	<0.1	<1	<1	<1	2.3	<0.5	2.6	297		
		07:00 to 15:00											
IMC-7	23.10.2014 to 24.10.2014	15:00 to 23:00											
		23:00 to 07:00	35	<0.1	<1	<1	<1	2.7	<0.5	2.4	298		
		07:00 to 15:00											
IMC-8	27.10.2014 to 28.10.2014	15:00 to 23:00											
		23:00 to 07:00	28	<0.1	<1	<1	<1	2.8	<0.5	2.6	299		
		07:00 to 15:00											
Average			35								2.6	297	
Standard Dev			8								0.1	3	

Table 4: Results of Air Pollutant Concentration at RC Station of JNP Area during the month of October, 2014													
Sampling Period NAAQMS	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	24 hr 50 µg/m ³	24 hr 30 µg/m ³	8 hr	24 hr (Avg) 80 µg/m ³	8 hr	24 hr (Avg) 80 µg/m ³	8 hr	24 hr (Avg) 400 µg/m ³	
RC-1	02.10.2014 to 03.10.2014	15:20 to 23:20					13		22		5		
		23:20 to 07:20	141	58			15	14.9	25	25.6	4	4.6	
		07:20 to 15:20					16		30		5		
RC-2	06.10.2014 to 07.10.2014	15:30 to 23:30					15		24		5		
		23:30 to 07:30	162	54			15	16.4	27	27.6	5	5.5	
		07:30 to 15:30					19		31		7		
RC-3	09.10.2014 to 10.10.2014	15:35 to 23:35					19		30		6		
		23:35 to 07:35	213	63			16	16.4	33	30.4	4	5.3	
		07:35 to 15:35					13		29		6		
RC-4	13.10.2014 to 14.10.2014	15:30 to 23:30					13		29		8		
		23:30 to 07:30	355	17			15	14.4	26	27.7	3	4.9	
		07:30 to 15:30					15		28		4		
RC-5	17.10.2014 to 18.10.2014	15:30 to 23:30					19		28		6		
		23:30 to 07:30	287	58			16	15.9	23	21.2	6	5.8	
		07:30 to 15:30					12		13		6		
RC-6	20.10.2014 to 21.10.2014	15:30 to 23:30					16		24		6		
		23:30 to 07:30	210	58			13	13.8	21	20.0	6	6.3	
		07:30 to 15:30					12		15		7		
RC-7	23.10.2014 to 24.10.2014	15:30 to 23:30					15		31		5		
		23:30 to 07:30	416	63			13	13.9	26	28.7	6	5.5	
		07:30 to 15:30					13		29		6		
RC-8	27.10.2014 to 28.10.2014	15:30 to 23:30					15		27		7		
		23:30 to 07:30	37	13			13	13.4	25	24.7	6	5.8	
		07:30 to 15:30					12		22		4		
Average Standard Dev			228	48				14.9		25.7		5.5	
			122	21				1.2		3.6		0.5	

Table 4: Results of Air Pollutant Concentration at RC Station of JNP Area during the month of October 2014													
Sampling Period	Date	Time, [Hrs]	O ₃ , [µg/m ³]	Pb, [µg/m ³]	As, [ng/m ³]	24 hr	24 hr	24 hr	C ₆ H ₆ , [µg/m ³]	BaP, [ng/m ³]	CO, [mg/m ³]	CO ₂ , [ppm]	
NAAQMS			8 hr	24 hr	6 ng/m ³	20 ng/m ³	5 µg/m ³	1 ng/m ³	4 mg/m ³	Grab Sampling	Grab Sampling	Grab Sampling	
			100 µg/m ³	1.0 µg/m ³									
RC-1	02.10.2014 to 03.10.2014	15:20 to 23:20											
		23:20 to 07:20	33	<0.1	<1	<1	2.1	<0.5	2.3			268	
RC-2	06.10.2014 to 07.10.2014	07:20 to 15:20											
		15:30 to 23:30	39	<0.1	<1	<1	2.3	<0.5	2.4			279	
RC-3	09.10.2014 to 10.10.2014	23:30 to 07:30											
		07:30 to 15:30											
RC-4	13.10.2014 to 14.10.2014	15:35 to 23:35	28	<0.1	<1	<1	2.4	<0.5	2.4			297	
		23:35 to 07:35											
RC-5	17.10.2014 to 18.10.2014	07:35 to 15:35											
		15:30 to 23:30	40	<0.1	<1	<1	2.3	<0.5	2.5			287	
RC-6	20.10.2014 to 21.10.2014	23:30 to 07:30											
		07:30 to 15:30	41	<0.1	<1	<1	2.2	<0.5	2.3			294	
RC-7	23.10.2014 to 24.10.2014	15:30 to 23:30											
		23:30 to 07:30	32	<0.1	<1	<1	2.3	<0.5	2.4			294	
RC-8	27.10.2014 to 28.10.2014	07:30 to 15:30											
		15:30 to 23:30	45	<0.1	<1	<1	2.1	<0.5	2.6			289	
Average		23:30 to 07:30	29	<0.1	<1	<1	2.3	<0.5	2.4			291	
		07:30 to 15:30	36				2.3		2.4			287	
Standard Dev			6				0.1		0.1			10	

Table 5: Results of Air Pollutant Concentration at EC 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)
NAAQMS	10.10.2014 to 11.10.2014	14:00 to 22:00 22:00 to 06:00 06:00 to 14:00	125	46	13	13.4	34	30.1	7	6	6	
EC												6.3

Table 5: Results of Air Pollutant Concentration at EC 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]		
			8 hr	24 hr	24 hr	1.0 µg/m ³	24 hr	24 hr	8 hr	24 hr	24 hr	24 hr	8 hr	24 hr	24 hr	Grab Sampling	Grab Sampling	4 mg/m ³	289
NAAQMS	10.10.2014 to 11.10.2014	14:00 to 22:00 22:00 to 06:00 06:00 to 14:00	33	<0.1	<1	<1	2.0	<0.5	2.4	289									

Table 6: Results of Air Pollutant Concentration at NGC Station of JNP Area during the month of October, 2014													
Sampling Period	Date	Time, [Hrs]	PM ₁₀ , [µg/m ³] 24 hr	PM _{2.5} , [µg/m ³] 24 hr	SO ₂ , [µg/m ³] 8 hr	NO _x , [µg/m ³] 24 hr (Avg)	NO _x , [µg/m ³] 8 hr	NH ₃ , [µg/m ³] 24 hr (Avg)	NH ₃ , [µg/m ³] 8 hr	CO ₂ , [ppm] Grab Sampling	CO ₂ , [ppm] 4 mg/m ³ Sampling	CO ₂ , [ppm] Grab Sampling	CO ₂ , [ppm] 4 mg/m ³ Sampling
NAAQMS	02.10.2014 to 03.10.2014	16:00 to 00:00 00:00 to 08:00 08:00 to 16:00	145	29	13	15.4	25	27.7	8	6	6	6	6.5
NG-1	09.10.2014 to 10.10.2014	15:50 to 23:50 23:50 to 07:50	340	71	13	14.9	21	23.9	5	7	6	6	6.1
NG-2	10.10.2014 to 17.10.2014	07:50 to 15:50 15:40 to 23:40	144	54	16	14.9	24	21.6	6	5	8	3	3.7
NG-3	17.10.2014 to 18.10.2014	07:50 to 15:50 23:40 to 07:40	169	42	15	14.4	35	30.1	5	3	3	3	3.7
NG-4	23.10.2014 to 24.10.2014	15:40 to 23:40 23:40 to 07:40	200	49	18	14.9	29	25.8	3	5.6	1.3	5.6	1.3
Average			94	18		0.4		3.8					
Standard Dev													

Table 6: Results of Air Pollutant Concentration at NGC Station of JNP Area during the month of October, 2014													
Sampling Period	Date	Time, [Hrs]	O ₃ , [µg/m ³] 8 hr	Pb, [µg/m ³] 24 hr	As, [ng/m ³] 24 hr	Ni, [ng/m ³] 24 hr	C ₆ H ₆ , [µg/m ³] 8 hr	BaP, [ng/m ³] 24 hr	CO, [mg/m ³] Grab Sampling	CO ₂ , [ppm] Grab Sampling	CO ₂ , [ppm] 4 mg/m ³ Sampling	CO ₂ , [ppm] Grab Sampling	CO ₂ , [ppm] 4 mg/m ³ Sampling
NAAQMS	02.10.2014 to 03.10.2014	16:00 to 00:00 00:00 to 08:00 08:00 to 16:00	22	<0.1	<1	<1	2.4	<0.5	2.6	297	2.6	2.6	297
NG-1	09.10.2014 to 10.10.2014	15:50 to 23:50 23:50 to 07:50	35	<0.1	<1	<1	2.3	<0.5	2.3	296	2.3	2.3	296
NG-2	10.10.2014 to 17.10.2014	07:50 to 15:50 15:40 to 23:40	28	<0.1	<1	<1	2.6	<0.5	2.4	287	2.4	2.4	287
NG-3	17.10.2014 to 18.10.2014	07:50 to 15:50 23:40 to 07:40	22	<0.1	<1	<1	2.5	<0.5	2.5	290	2.5	2.5	290
NG-4	23.10.2014 to 24.10.2014	15:40 to 23:40 23:40 to 07:40	27	<0.1	<1	<1	2.5	<0.5	2.5	293	2.5	2.5	293
Average			6				0.1		0.1	5	0.1	0.1	5
Standard Dev													

Table 7: Results of Air Pollutant Concentration at SGC Station of JNP Area during the month of October, 2014

Sampling Period NAAQMS	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	8 hr	24 hr 60 µg/m ³	8 hr	24 hr (Avg) 80 µg/m ³	8 hr	24 hr (Avg) 80 µg/m ³	8 hr	24 hr (Avg) 400 µg/m ³	8 hr
SG-1	06.10.2014 to 07.10.2014	16:30 to 00:30				14		21		6		
		00:30 to 08:30	61		25	13	13.5	22	21.4	4	4.9	
SG-2	13.10.2014 to 14.10.2014	08:30 to 16:30				13		21		5		
		16:15 to 00:15				13		18		5		
SG-3	20.10.2014 to 21.10.2014	00:15 to 08:15	386		83	13	13.9	16	18.1	5	4.6	
		08:15 to 16:15				15		21		4		
SG-4	27.10.2014 to 28.10.2014	16:15 to 00:15	195		50	11		16		5		
		00:15 to 08:15				11	11.8	17	16.7	3	3.7	
Average		08:15 to 16:15				13		18		3		
		16:15 to 00:15	155		54	17		26	20.6	4	4.7	
Standard Dev		00:15 to 08:15				14	14.7	18		5		
		08:15 to 16:15	199		53	13	13.5	18	19.2	5	4.5	
			137		24		1.2		2.2		0.5	

Table 7: Results of Air Pollutant Concentration at SGC Station of JNP Area during the month of October, 2014

Sampling Period NAAQMS	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]	
			8 hr	100 µg/m ³	24 hr	1.0 µg/m ³	6 ng/m ³	24 hr	20 ng/m ³	8 hr	5 µg/m ³	24 hr	1 ng/m ³	4 mg/m ³	Grab Sampling	4 mg/m ³	Grab Sampling	4 mg/m ³
SG-1	06.10.2014 to 07.10.2014	16:30 to 00:30																
		00:30 to 08:30	33		<0.1		<1		<1	2.1		<0.5		2.3	291			
SG-2	13.10.2014 to 14.10.2014	08:30 to 16:30																
		16:15 to 00:15	40		<0.1		<1		<1	2.2		<0.5		2.4	289			
SG-3	20.10.2014 to 21.10.2014	00:15 to 08:15																
		08:15 to 16:15	29		<0.1		<1		<1	2.2		<0.5		2.6	287			
SG-4	27.10.2014 to 28.10.2014	16:15 to 00:15																
		00:15 to 08:15	33		<0.1		<1		<1	2.3		<0.5		2.4	291			
Average		08:15 to 16:15																
			34							2.2		<0.5		2.4	290			
Standard Dev			5							0.1				0.1	2			

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 October, 2014. 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 October, 2014 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 October, 2014

STATION	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 , [$\mu\text{g}/\text{m}^3$]	O ₃ , [$\mu\text{g}/\text{m}^3$]	C ₆ H ₆ , [mg/m^3]	CO, [mg/m^3]	CO ₂ , [ppm]
NAAQMS	100	60	80	80	400	100	5	4	-
INDUSTRIAL AREA									
POC	270 \pm 84	46 \pm 13	15.8 \pm 1.5	27.7 \pm 3.3	5.0 \pm 0.8	33 \pm 09	2.5 \pm 0.2	2.6 \pm 0.3	291 \pm 03
IMC	227 \pm 67	46 \pm 17	14.3 \pm 1.6	26.7 \pm 3.0	5.8 \pm 0.6	35 \pm 08	3.0 \pm 0.6	2.6 \pm 0.1	297 \pm 03
NG	200 \pm 94	49 \pm 18	14.9 \pm 0.4	25.8 \pm 3.8	5.6 \pm 1.3	27 \pm 06	2.5 \pm 0.1	2.5 \pm 0.1	293 \pm 05
SG	199 \pm 137	53 \pm 24	13.5 \pm 1.2	19.2 \pm 2.2	4.5 \pm 0.5	34 \pm 05	2.2 \pm 0.1	2.4 \pm 0.1	290 \pm 02
RESIDENTIAL AREA									
RC	228 \pm 122	48 \pm 21	14.9 \pm 1.2	25.7 \pm 3.6	5.5 \pm 0.5	36 \pm 06	2.3 \pm 0.1	2.4 \pm 0.1	287 \pm 10
ECO-SENSITIVE AREA									
EC	125	46	13.4	30.1	6.3	33	2.0	2.4	289

It is seen from Table 2 & 8 that the results obtained for air pollutant concentrations at JN Port station for entire month of October, 2014 are below the prescribed limits mentioned in NAAQMS except PM₁₀. The monthly average value obtained for PM₁₀ as depicted in Table 8 is above the prescribed limit mentioned in the standard. Remaining all other gaseous pollutant concentrations and PM_{2.5} values are well within prescribed limits during the month of October, 2014.

RC Station comes under Residential area. It is seen from Table 4 & 8 that the results obtained for air pollutant concentrations at RC station for entire month of October, 2014 are well within the prescribed limits mentioned in NAAQMS except PM₁₀.

Table 5 provides the results obtained for the air quality parameters at Elephanta Caves [EC] station during 10th October'14 to 11th October'14. The concentrations of gaseous pollutants (except PM₁₀) are found to be below than the prescribed limits in NAAQMS for Ecologically Sensitive area.

Table 6 &7 provides the results for NGC and SGC air monitoring stations respectively. These stations are placed in the port activity area. In October, 2014, all the monitoring parameters (except PM₁₀) 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 are require to be taken into account before further developments are made within the region. 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.

Observations for the month of October'14:

- *Vehicular Traffic at North gate:* The monitoring of ambient air Quality is done at NG once a week. The results are well within the CPCB limits. Approx. 3000-4000 trailers enter or exit from this gate. The location is near the Nhava creek where large portion is covered by mangroves and Sheva hill which is having the full green cover and the wind blowing from the sea side helps the dispersion of pollutants, all this factors contributes to control the air quality of the area.
- *Vehicular Traffic at South gate and Central Gate:* Approximately 6000-7000 trailers pass through the point in 24hrs period. The Air quality monitored at South gate shows the results are well within the CPCB limits. Considering the huge vehicles movement it can be concluded that Ambient Air quality is good. 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.
- *Construction and Development Activities:*
 - i) Development of Centralized Parking Plaza
 - ii) *The Construction of 330 m Jetty at North Side of the JNP is underway:* The values of pollutants parameters at the nearest monitoring location i.e. North Gate is well within the prescribed CPCB limits. It is evident that construction of jetty does not affect the Ambient Air Quality.
- *Regular cleaning of roads at Port Operation Area:* Paver blocks are provided and necessary green cover is provided wherever needed all over the port area to prevent the suspension of dust. The overall Ambient air quality of the Port area is well within the prescribed CPCB limits.

The following measures can be taken to maintain controlled PM₁₀ and PM_{2.5} levels in and around the port area:

- 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.
- Minimize emissions from vehicle exhausts by improved design and regular monitoring of engine settings.
- Discourage indoor use of unflued oil and gasoline heating.
- Cleaning of paved and unpaved roads regularly to remove spillage of earth/soil material during transportation.
- Maintaining road pavement regularly or using paver blocks as far as possible wherever heavy loads movement occurs.
- Spraying water on dusty road surfaces on regular intervals with more frequency in noon hours at various locations and all construction areas to avoid re-suspension.
- Good housekeeping during road cleaning to avoid dust re-suspension by transportation of heavy vehicles.

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

2.1 INTRODUCTION

Marine water monitoring stations are selected in the harbor area including channel and near jetty areas and Nhava creek. As per EMP, Total 8 fixed harbor stations [W1 to W7 and W9] and 1 movable station [W10] are identified. At Nhava creek 4 fixed stations [W11 to W14] are identified. All above mentioned stations are also selected for studying sediment characteristics. The description of stations is depicted in Table 9. The location map of various Marine water quality monitoring stations are described in Annexure-III.

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).

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.	09 th October, 2014
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	09 th October, 2014
3.	W3	Identified by the green buoy no. <u>FG2 Green</u> of JNPT approach channel and lies near the landing jetty.	10 th October, 2014
4.	W4	Located at Uran Patch Beacon (lighthouse on concrete platform) near the Butcher Island filling platform.	10 th October, 2014
5.	W5	W5 is near to the guide bund and others are along Nhava creek uptoBelpada. These are selected to examine the impact of	09 th October, 2014
	W11 to W14	neighboring Nhava Villages and Belpada to the creek water quality	11 th October, 2014
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.	09 th October, 2014
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.	10 th October, 2014
8.	W10	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.	10 th October, 2014
9.	W9	Located in between GTI and Liquid Cargo Jetty. This station is selected to examine the impact of terminal activities on water qualities	10 th October, 2014

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

2.3 RESULTS

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 October, 2014

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	8.2	28.5	7.43	35.5	20	34186	224	34410
	SM		28.1	7.60	36.1	23	32094	216	32310
	SB		27.9	7.65	36.8	20	31186	181	31367
	NS	7.3	31.2	6.87	35.5	22	29824	144	29968
	NM		29.6	7.29	36.8	30	34482	197	34679
	NB		29.5	7.64	36.1	30	34480	282	34762
W2	SS	5.2	20.7	7.49	38.1	50	32828	215	33043
	SM		29	7.77	37.4	57	32742	356	33098
	SB		29	7.67	38.7	29	32680	328	33008
	NS	4.8	30	7.59	36.8	54	33084	241	33325
	NM		29.8	7.75	37.4	24	33008	324	33332
	NB		32.3	7.81	37.4	65	34002	370	34372
W3	SS	7.5	27.7	7.64	35.5	29	32840	203	33043
	SM		27.5	7.70	37.4	27	31188	287	31475
	SB		27.4	7.66	36.1	76	31242	484	31726
	NS	7	32.3	7.54	36.8	23	31268	178	31446
	NM		35.4	7.70	38.1	53	33182	320	33502
	NB		31.5	7.68	35.5	25	33162	730	33892
W4	SS	10.9	27.6	7.48	37.4	27	32462	235	32697
	SM		27.6	7.67	38.7	59	32142	322	32464
	SB		27.4	7.64	38.7	67	32228	605	32833
	NS	10	29.5	7.49	38.1	26	32262	204	32466
	NM		29	7.67	37.4	55	32330	329	32659
	NB		28.7	7.65	35.5	74	32190	690	32880
W5	SS	12.7	28	7.47	37.4	25	32140	174	32314
	SM		28	7.64	36.1	28	32088	206	32294
	SB		27.8	7.69	35.5	46	32080	219	32299
	NS	10	29.6	7.43	36.8	24	32114	195	32309
	NM		29.3	7.63	36.8	25	32124	210	32334
	NB		28.9	7.65	38.7	13	32106	179	32285

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

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

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	-	-	-	-	-
W6	SS	12.6	29.3	7.59	36.8	23	33154	259
	SM		29.4	7.68	38.1	24	33102	179
	SB		29.4	7.72	35.5	32	32942	250
	NS	10.2	30.2	7.74	37.4	31	33240	195
	NM		30.1	7.66	37.4	32	33254	180
	NB		29.9	7.68	36.1	31	33340	159
W7	SS	5.7	27.7	7.41	34.8	24	33488	136
	SM		27.6	7.65	36.1	32	33622	243
	SB		27.6	7.65	36.8	36	33728	242
	NS	5.4	30.4	7.45	35.5	21	33684	135
	NM		30.4	7.63	36.1	40	33824	218
	NB		30.4	7.59	35.5	33	33906	249
W10	SS	15.5	28	7.48	40.6	23	34080	127
	SM		27.9	7.64	36.1	23	34060	116
	SB		27.9	7.59	36.8	35	34112	239
	NS	15	31	7.63	35.5	20	34104	99
	NM		31.1	7.67	38.7	20	33988	119
	NB		31	7.53	38.1	30	33992	290
W9	SS	7	27.8	7.42	36.1	20	33742	209
	SM		27.9	7.69	35.5	43	34072	305
	SB		27.8	7.60	37.4	40	34050	294
	NS	7.5	30	7.48	37.4	22	33940	112
	NM		29.8	7.65	36.8	39	33970	264
	NB		29.7	7.65	36.1	39	33990	433

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

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 October, 2014

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#		-	-	-	-	<1	100	7
	SS	6.2	39.8	<2	<0.1	<0.01			
	SM	5.3	43.8		-	-			
	SB	5.4	35.9	-	-	-			
	NS#		-	-	-	-	<1	110	4
	NS	6.7	51.8	<2	<0.1	<0.01			
	NM	5.6	47.8	-	-	-			
	NB	5.7	39.8	-	-	-			
W2	SS#						6	120	4
	SS	5.8	31.9		<0.1	<0.01			
	SM	5.7	27.9						
	SB	5.3	39.8						
	NS#						2	80	4
	NS	6.1	47.8		<0.1	<0.01			
	NM	5.8	55.8						
	NB	5.6	51.8						
W3	SS#		-	-	-	-	1	140	12
	SS	5.7	43.8	<2	<0.1	<0.01			
	SM	5.7	35.9	-	-	-			
	SB	5.5	39.8	-	-	-			
	NS#		-	-	-	-	1	90	7
	NS	5.8	51.8	<2	<0.1	<0.01			
	NM	5.7	47.8	-	-	-			
	NB	5.5	51.8	-	-	-			
W4	SS#		-	-	-	-	<1	330	12
	SS	6.5	59.8	<2	<0.1	<0.01			
	SM	5.8	43.8	-	-	-			
	SB	5.7	35.9	-	-	-			
	NS#		-	-	-	-	<1	240	6
	NS	5.7	39.8	<2	<0.1	<0.01			
	NM	6	43.8	-	-	-			
	NB	5.8	51.8	-	-	-			
W5	SS#		-	-	-	-	<1	140	8
	SS	5.7	36	<2	<0.1	<0.01			
	SM	5.6	40	-	-	-			
	SB	5.4	28	-	-	-			
	NS#		-	-	-	-	<1	80	8
	NS	6.1	44	<2	<0.1	<0.01			
	NM	5.7	48	-	-	-			
	NB	5.4	32	-	-	-			

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 [#]		-	-	-	-	2	100	11
	SS	5.2	28	<2	<0.1	<0.01	-	-	-
	SM	5.2	40	-	-	-	-	-	-
	SB	5.2	36	-	-	-	-	-	-
	NS [#]		-	-	-	-	4	130	9
	NS	5.4	48	<2	<0.1	<0.01	-	-	-
	NM	5.6	44	-	-	-	-	-	-
W7	NB	5.2	56	-	-	-	-	-	-
	SS [#]		-	-	-	-	1	350	6
	SS	5.5	40	<2	<0.1	<0.01	-	-	-
	SM	5.6	52	-	-	-	-	-	-
	SB	5.8	36	-	-	-	-	-	-
	NS [#]		-	-	-	-	1	280	2
	NS	5.9	44	<2	<0.1	<0.01	-	-	-
W9	NM	6.1	36	-	-	-	-	-	-
	NB	6	32	-	-	-	-	-	-
	SS [#]		-	-	-	-	8	130	9
	SS	5.8	44	<2	<0.1	<0.01	-	-	-
	SM	5.7	36	-	-	-	-	-	-
	SB	5.6	52	-	-	-	-	-	-
	NS [#]		-	-	-	-	4	110	11
W10	NS	5.8	32	<2	<0.1	<0.01	-	-	-
	NM	5.6	40	-	-	-	-	-	-
	NB	5.7	52	-	-	-	-	-	-
	SS [#]			-	-	-	3	390	<2
	SS	5.6	40	<2	<0.1	<0.01	-	-	-
	SM	5.6	52	-	-	-	-	-	-
	SB	5.4	56	-	-	-	-	-	-
W10	NS [#]		-	-	-	-	2	240	4
	NS	5.8	36	<2	<0.1	<0.01	-	-	-
	NM	5.6	28	-	-	-	-	-	-
	NB	5.4	48	-	-	-	-	-	-

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 October, 2014

Station Name	Organic Matter		Total Carbon		Inorganic Phosphate
	mg/g	%	mg/g	%	mg/kg
W1	237.8	23.8	137.9	13.8	56.1
W2	252.8	25.3	146.6	14.7	18.3
W3	Sediment not found				
W4					
W5					
W6					
W7	187.3	18.7	108.6	10.9	17.3
W9	Sediment not found				
W10	214.9	21.5	124.6	12.5	176.2
Average	223.2	22.3	129.4	12.9	67.0

Table 14: Results of Physico-Chemical Analysis of Water Samples Collected from Nhava Creek Area during October, 2014

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	4.5	27.4	7.57	36.1	44	33140	410	33550
	SM		27.3	7.67	37.4	33	33188	316	33504
	SB		27.4	7.31	35.5	44	33240	441	33681
	NS	4	30.8	7.62	36.8	52	33262	463	33725
	NM		30.7	7.38	36.1	40	33104	363	33467
	NB		30.3	7.60	35.5	41	33420	346	33766
W12	SS	3.5	27.3	6.98	36.1	36	34132	596	34728
	SM		27.2	7.20	34.8	31	34040	357	34397
	SB		27.5	7.62	35.5	29	34052	353	34405
	NS	3	31.7	6.73	34.8	41	34168	473	34641
	NM		31.5	7.48	36.8	30	33980	234	34214
	NB		31.1	7.30	35.5	54	33976	460	34436
W13	SS	3.5	28.1	7.12	34.8	49	33268	511	33779
	SM		28.2	7.22	36.1	62	33420	377	33797
	SB		28	7.32	36.1	43	33526	462	33988
	NS	3	31.5	6.78	34.8	48	33534	311	33845
	NM		30.9	7.51	36.8	50	33672	281	33953
	NB		30.7	7.54	37.4	51	33584	296	33880
W14	SS	5	28.6	7.15	35.5	52	33308	371	33679
	SM		28.6	7.57	38.1	52	33426	263	33689
	SB		28.6	6.84	34.8	54	33338	348	33686
	NS	4	31.6	7.59	36.1	56	33362	404	33766
	NM		31.4	7.54	36.1	58	33422	424	33846
	NB		30.6	7.62	36.8	41	33346	281	33627

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 NhavaCreek Area during October, 2014

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	5.8	28	<2	<0.1	<0.01	<1	420
	SM	5.8	40	-	-	-	-	-
	SB	5.9	36	-	-	-	-	-
	NS	5.8	44	<2	<0.1	<0.01	<1	470
	NM	5.7	52	-	-	-	-	-
	NB	5.9	36	-	-	-	-	-
W12	SS	6.3	52	<2	0.1	<0.01	<1	450
	SM	6.4	56	-	-	-	-	-
	SB	6.3	40	-	-	-	-	-
	NS	5.7	36	<2	<0.1	<0.01	<1	270
	NM	5.9	32	-	-	-	-	-
	NB	5.9	44	-	-	-	-	-
W13	SS	5.7	28	<2	0.1	<0.01	<1	560
	SM	5.1	40	-	-	-	-	-
	SB	5.9	36	-	-	-	-	-
	NS	5.8	52	<2	0.1	<0.01	<1	210
	NM	5.7	56	-	-	-	-	-
	NB	5.9	32	-	-	-	-	-
W14	SS	5.8	47.8	<2	<0.1	<0.01	<1	830
	SM	5.7	39.8	-	-	-	-	-
	SB	5.6	31.9	-	-	-	-	-
	NS	5.9	51.8	<2	<0.1	<0.01	<1	410
	NM	5.8	27.9	-	-	-	-	-
	NB	5.6	55.8	-	-	-	-	-

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 October, 2014

Sample Name	Organic Matter		Total Carbon		Inorganic Phosphate
	mg/g	%	mg/g	%	mg/kg
W11	Sediment not Found				
W12					
W13	196.5	19.7	114.0	11.4	41.4
W14	245.8	24.6	142.6	14.3	34.3
Average	221.2	22.1	128.3	12.8	37.9

2.4 DISCUSSION

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	20.7- 35.4	°C	-
2	pH	6.87 - 7.81	-	6.5 - 9.0
3	Salinity	34.8 - 40.6	ppth	-
4	Turbidity	13 - 76	NTU	-
5	TDS	29824 - 34482	mg/L	-
6	TSS	99 - 730	mg/L	-
7	TS	29968 - 34762	mg/L	-
8	DO	5.2 - 6.7	mg/L	3.0 mg/L or 40% of
9	COD	27.9 - 59.8	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 - 8	mg/L	10
14	Total Plate Count	80 - 390	MPN/100 mL	-
15	Fecal Coliforms	2 - 12	MPN/100 mL	500

Table 18: Observed Concentration Ranges of Various Parameters for NhavaCreek Area

Sr. No.	Parameter	Observed Range	Unit	Prescribed Limits
1	Temperature	27.2- 31.7	°C	-
2	pH	6.73 - 7.67	-	6.5 - 9.0
3	Salinity	34.8 - 38.1	ppth	-
4	Turbidity	29 - 62	NTU	-
5	TDS	33104 - 34168	mg/L	-
6	TSS	234 - 596	mg/L	-
7	TS	33467 - 34728	mg/L	-
8	DO	5.1 - 6.4	mg/L	3.0 mg/L or 40% of
9	COD	27.9 - 56.0	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	2 - 3	mg/L	10
14	Total Plate Count	210 - 830	MPN/100 mL	-
15	Fecal Coliforms	2 - 12	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 October, 2014 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 October, 2014 are found to be well within prescribed limits.

The values obtained for turbidity Octoberis due to suspended solids, but exact relationship could not be established based on observed values. Approximately 3 to 4 % solids are present in water and the observed salinity values for Harbor and Creek water samples in the month of October, 2014 are ranges from 34.8 to 40.6ppt. [Refer Tables 11 and 14]. The ranges observed for COD values in mg/L are 27.9 to 59.8 and 27.9 to 56respectively for Harbor and Creek water samples. The DO levels are ranges between 5.1 to 6.7 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. Oil and grease values are ranges between 1 to 8 mg/L. 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 October, 2014. The values obtained for Organic Matter, Total Organic Carbon and Inorganic Phosphate are ranges between 18.7 – 25.3%, 10.9 – 14.7% and 17.3 – 176.2 mg/kg, respectively. While, it is seen from Table 16 that the values obtained for Organic Matter, Total Organic Carbon and Inorganic Phosphate are ranges between 19.7 – 24.6%, 11.4 – 14.3% and 34.3 – 41.4mg/kg, respectively for sediment samples collected from Nhava Creek area during the month of October, 2014.

2.5OBSERVATONS AND CONCLUSIONS

Observations for the month of October:

- *The Construction of 330 m Jetty at North Side of the JNP is underway:* Piling work was going on during the time of Sampling of marine water.
- *Dredging of JNPT Channel toward South End of Channel:* Dredging was being carried during the same time.
- *Construction of Mooring Dolphin Jetty in front of Liquid cargo jetty.*
- *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 October, 2014. The characteristic parameters for sediments are also showing normal variation in concentrations for JNP Harbor area and Nhava Creek area during October, 2014. Considering the activities in the Harbor area and the results obtained for the month of October, 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 [W10/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 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 [W10/W10] 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 at three water quality monitoring stations of JNP and at one water quality monitoring station in Nhava creek were measured and values are presented in Table 20.

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

Benthic fauna recorded in JNP Harbour 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 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.	W1	325	225
2.	W2	410	315
3.	W3	325	225
4.	W4	215	175
5.	W5	525	375
6.	W6	310	215
7.	W7	210	175
8.	W9	375	215
9.	W10	325	275
NHAVA Creek Area			
10.	W11	275	115
11.	W12	375	215
12.	W13	315	275
13.	W14	425	215

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 Bacillario-phyceae	Chloro-phyceae	Cyano-phyceae	SWI	PPI
JNP Harbor Area								
1	W1	Surface	315	45	20	25	10	0.95
		Bottom	210	55	10	35	-	0.21
2	W2	Surface	372	50	20	25	5	0.56
		Bottom	310	42	18	30	10	0.72
3	W3	Surface	470	40	10	50	-	0.36
		Bottom	345	40	10	40	10	1.25
4	W4	Surface	390	40	10	45	5	0.42
		Bottom	255	45	20	35	-	0.65
5	W5	Surface	475	58	12	25	5	0.82
		Bottom	360	41	20	29	10	1.30
6	W6	Surface	510	50	10	30	10	0.80
		Bottom	425	63	10	27	-	0.36
7	W7	Surface	460	35	25	40	-	0.75
		Bottom	421	42	18	40	-	0.63
8	W9	Surface	535	32	20	48	5	1.23
		Bottom	475	40	10	40	10	0.53
9	W10	Surface	436	55	25	20	-	0.63
		Bottom	318	60	10	20	10	0.87
NHAVA Creek								
10	W11	Surface	350	62	18	20	-	1.32
		Bottom	215	40	20	30	10	0.72
11	W12	Surface	585	55	20	25	-	0.62
		Bottom	425	54	16	25	5	0.86
12	W13	Surface	425	50	20	20	10	0.65
		Bottom	320	42	15	33	10	1.54
13	W14	Surface	570	55	25	20	-	0.85
		Bottom	485	40	20	30	10	0.69
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</i> sp.	<i>Cosmarium</i> sp.	<i>Gloeocapsa</i> sp.	<i>Cryptomonas</i> sp.
2.	<i>Nitzschia</i> sp.	<i>Ulothrix</i> sp.	<i>Oscillatoria</i> sp.	-
3.	<i>Gyrosigma</i> sp.	<i>Chlorococcum</i> sp.	<i>Anabaena</i> sp.	-
4.	<i>Surirella</i> sp.	-	<i>Aphanocapsa</i>	-
5.	<i>Fragillaria</i> sp.	-	<i>Spirulina</i> sp.	-
6.	<i>Skeletonema</i> sp.	-	-	-
7.	<i>Triceratium</i> sp.	-	-	-

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

Sr. No.	Station	Secchi Depth, [cm]
JNP Harbour Area		
1.	W1	40 cm
2.	W2	50 cm
3.	W3	40 cm
4.	W4	30 cm
5.	W5	40 cm
6.	W6	30 cm
7.	W7	50cm
8.	W9	30 cm
9.	W10	40 cm
NhavaCreek Area		
10.	W11	40 cm
11.	W12	40 cm
12.	W13	30 cm
13.	W14	50 cm

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 Harbour Area							
1.	W1-W2	415	50	20	10	20	0.65
2.	W2-W5	325	60	20	10	10	1.25
3.	W5-W1	354	45	25	10	20	0.85
4.	W5-W6	550	61	29	-	20	0.95
5.	W6-W2	370	55	20	-	25	0.64
6.	W4-W3	310	45	30	10	15	0.52
7.	W3-W7	510	50	20	10	20	1.20
8.	W7-W10	480	65	25	-	10	1.36
9.	W10-W3	390	40	30	-	30	0.82
10.	W9-W3	575	70	20	-	10	0.60
NHAVA Creek							
11.	W5-W11	380	50	20	-	30	0.75
12.	W11-W12	540	42	18	20	20	0.55
13.	W12-W13	512	50	30	10	10	1.26
14.	W13-W14	485	62	20	8	10	0.64
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</i> sp.	<i>Keratella</i> sp.	<i>Daphnia</i> sp.	<i>Rotaliasp.</i>
2.	<i>Diaptomus</i> sp.	<i>Brachionus</i> sp.	<i>Moinasp.</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]	
		Surface	Bottom	Surface	Bottom
JNP Harbour Area					
1.	W1	3.4	2.3	BDL	BDL
2.	W2	3.1	2.5	0.5	BDL
3.	W3	4.2	2.6	BDL	BDL
4.	W4	3.5	2.3	BDL	BDL
5.	W5	5.1	4.2	BDL	BDL
6.	W6	4.6	3.4	BDL	BDL
7.	W7	3.9	2.1	BDL	BDL
8.	W9	4.2	3.6	0.2	BDL
9.	W10	4.5	2.8	BDL	BDL
NhavaCreek Area					
10.	W11	3.7	2.7	BDL	BDL
11.	W12	3.6	3.2	0.4	BDL
12.	W13	4.3	2.5	BDL	BDL
13.	W14	3.2	2.0	0.7	BDL

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

Sr. No.	Station	POC, [mg/m ³]
Standard		10 - 100
JNP Harbor Area		
1.	W1	1015
2.	W2	834
3.	W3	1617
4.	W4	1239
5.	W5	1247
6.	W6	1351
7.	W7	1531
8.	W10	662
9.	W9	1772
Nhava Creek Area		
10.	W11	1652
11.	W12	1394
12.	W13	1084
13.	W14	1213

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 Harbour Area							
1.	W1	120	20	20	15	45	0.95
2.	W2	256	20	20	20	40	0.32
3.	W3	193	30	20	20	30	0.60
4.	W4	312	30	20	20	30	0.53
5.	W7	150	55	10	15	30	0.82
6.	W10	112					0.74
Nhava Creek Area							
7.	W11	90	50	20	20	10	0.70
8.	W13	106	60	10	20	10	1.0
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 Harbour 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	369	1207	268	10100	242	315	<10	1586	2374
W2	332	1207	272	9800	111	160	<10	1686	2477
W3	406	1274	262	9600	113	150	<10	1343	2773
W4	443	1230	272	10200	124	340	<10	1351	2899
W5	443	1140	264	10000	173	275	<10	1273	2827
W6	406	1163	272	9600	164	140	<10	1519	1904
W7	369	1230	268	10100	106	255	<10	1156	2820
W8	443	1207	270	9300	62	160	<10	1479	2857
W9	443	1118	270	9700	125	155	<10	1368	2711
Average	406	1197	269	9822	200	217		1418	2627
JNP NHAVA CREEK AREA									
W11	479	1163	268	9600	136	230	<10	2094	2477
W12	443	1185	268	9600	554	530	17	2281	2682
W13	406	1230	274	9000	421	715	<10	2047	2555
W14	479	1185	268	9500	246	385	<10	2403	2903
Average	452	1190	270	9425	339	465		2206	2654

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	1760	243	231	8433	113.5	52.4	0.09	313.8	8047
W2	2800	389	261	5354	115.8	38.8	0.04	250.2	8971
W3	Sediment not found								
W4	Sediment not found								
W5	Sediment not found								
W6	Sediment not found								
W7	4640	437	362	8358	129.7	42.4	0.03	321.2	9021
W8	2720	486	261	5591	250.7	41.6	0.02	260	7227
W9	Sample not collected								
Average	2980	389	279	6934	152.4	43.8	0.04	286.4	8317
JNP NHAVA CREEK AREA									
W11	Sediment not found								
W12	Sediment not found								
W13	3040	729	163	4125	143.9	38.4	0.04	296.1	8265
W14	2960	535	288	5875	100.4	39.5	0.03	256.6	5369
Average	3000	632	225	5000	122.2	38.9	0.04	276.3	6817

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.

Dark and light bottle technique (**Standard method 2005**) was employed to estimate primary productivity of JNP harbor area and NHAVA creek water. Waters from depths

were filled in the bottles and these were lowered at different depths for 6 hours. The depletion of oxygen, if any, in the dark bottles was measured by Winkler's method.

The highest estimated gross and net primary productivity was measured as 525 and 375 mgC/m³/d at stations W5 [Table 20]. The values are comparable to 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*).

3.4.1.b Plankton

Plankton is an important component of ecosystem, which responds 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 plays a key role of primary producer in aquatic environment, it is 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: The inhabitants of a particular ecosystem serve as biological indices and reflect the environmental conditions that are required for their optimum growth and survival. 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.

While phytoplankton were enumerated from unfiltered water samples, desired volume of waters were filtered through plankton net to represent all the available groups of zooplankton. The samples were fixed immediately with 5 % buffered formalin. The parameters studied were numerical count of individual species, groups and indices, as described hereunder.

Shannon Wiener Diversity Index: A biological community, whose composition is influenced by environmental conditions and availability of required resources, may undergo changes with respect to their number and types of species and their populations, depending upon changes in factors influencing their composition. For e.g. organic wastes eliminate the sensitive organisms and provide food for survival of tolerant forms. By natural purification, water quality improves and subsequently diversity increases. Thus, the nature and type of biological species present in particular environment is dependent on various chemical characteristics such as pH, conductivity, alkalinity, nutrients, DO etc. Additionally it is influenced by physical parameters like temperature, turbidity, colour, light penetration and flow of water. Usually diversity increases with decrease of pollution and vice versa.

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.

A] Phytoplankton:

Count: Phytoplankton counts, recorded at different sampling stations (**Plate 1**), are presented in Table 21. Total algal population varied between 210 and 585 algal cells/ml. Samples collected at station W1(B) and W12(S) showed lowest and highest counts respectively. Bacillariophyceae dominated all samples followed by Cyanophyceae. The phytoplankton population comprised of 4 major groups with 16

genera, namely Bacillariophyceae, Chlorophyceae, Cyanophyceae and Cryptophyceae [Table 22]. The most common genera found were *Gyrosigma*, *Aphanocapsa*, *Oscillatoria*, *Naviculla*, *Anabaena*, *Fragillaria*, *Ulothrix* etc. Light penetration was measured in the JNP Harbour Area and NHAVA creek with the help of Secchi disc [Table 23].

Palmer Index: According to Palmer (1969), a total score of 20 or more in a sample is an indicator of organic pollution. In the sampling stations, the scores of PPI at W2B, W3B, W4B, W7S, W7B, W9S, W10S, W12B and W14S varied within the range of 20 - 24, indicating probable organic pollution.

Shannon - Wiener Diversity Index (SWI): During the survey, the SWI values varied between 0.21 and 1.54. The values suggest low to medium impact of pollution or adverse factor.

B] Zooplankton:

Zooplankton counts, recorded at different sampling stations (Plate 1), are shown in Table 25. 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 310 and 575 N/m³. Total seven genera of zooplankton were recorded. A large number of zooplankton, recorded at W9-W3. Among zooplankton Copepoda and Cladocera group were dominant [Table 25].

Shannon - Wiener Diversity Index (SWI): The average SWI, observed to vary from 0.52 to 1.36 respectively indicated low to medium load of organic pollution or adverse factors. Generally "Shannon Wiener index" values between 1 and 3 are believed to indicate semi productivity of the water body, while the values above 3 are considered to represent lowest or minimum impact of pollution. Amongst the sites, W3, W4, W7 and W9 require special attention because of increased in Cyanophyceae counts. The water quality of JNP harbor area is deteriorated due to solid waste disposal (Plate 3.2).

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. Chlorophyll itself is actually not a single molecule but a family of related molecules, designated chlorophyll *a*, *b*, *c*, and *d*. Chlorophyll *a* is the molecule found in all plant cells and therefore its concentration is what is reported during chlorophyll analysis also it is used to indicate the state of fertilization of a water body. Chlorophyll *d* is found only in marine red algae, but chlorophylls *b* and *c* are common in fresh water. The molecular structure of chlorophylls *a* and *b* consists of a ring-like structure called a porphyrin and a long organic phytol "tail." In the center of the porphyrin ring is a magnesium molecule. The relative concentrations within the cell of these chlorophylls vary with the species of

algae, but chlorophyll *a* and other pigments are also present in algal cells. These are the carotenes and the xanthophylls. In the cyanobacteria, water-soluble phycobiliproteins are the predominant accessory pigment, giving the group their characteristic blue-green or red color. 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 and pheophytin of the water samples collected from different sampling points of JNP Harbour area and NHAVA creek. Each water sample was passed through filter paper and the resultant residue was processed with acetone in dark for spectrophotometric analysis. The lowest and highest chlorophyll *a* from surface water sample varied from 2.0 at station W14(B) to 5.1 mg/m³ at W5(S). However, Pheophytin concentrations of many samples were below detectable limit [Table 26].

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 *Blackfordiavirginica*, an euryhaline species. This species is considered as backwater form but it may occasionally be found in coastal water also.

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 662– 1772mg/m³ with an average of 1252 mg/m³. The minimum concentration of POC was found at W10 station and maximum concentration at W9 station. In Nhava creek the POC content was found to be between 1084–1652 mg/m³ with an average of 1335mg/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 Tulaskaret *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 (**Plate 3**) 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. Chironomideae and Foraminifera dominated the samples. Benthos was absent at stations W5, W6, W9, W12 and W14. The highest count was 312 No/m³ in sampling point W4 [**Table 28**]. The SWI values were observed to vary from 0.32 – 1.00.

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 flowthrough), 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 62 μ g/L to 242 μ g/L with an average of 678 μ g/L. JNP harbor region, the Phosphate value was found above prescribed standard range [0.1 – 90 μ g/L]. The Nitrate was found to be between 140 μ g/L to 340 μ g/L. The minimum value of 140 μ g/L of Nitrate was found at W6 station and maximum at W4 station. The average concentration of Nitrate was found to be 217 μ g/L and overall Nitrate was found within range [1.0 to 500 μ g/L] at all 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 1156– 1686 $\mu\text{g/L}$ with an average of 1418 $\mu\text{g/L}$. The minimum concentration of silica was found at W7 station of JNP harbor region and the maximum concentration of silica was found at W2 station. The Sulphate was found between 1904–2899 mg/L , the minimum value recorded at W6 station and maximum at W4 station. The average concentration of Sulphate was found to be 2627 mg/L .

In Nhava Creek, Phosphate was found between 136 $\mu\text{g/L}$ – 554 $\mu\text{g/L}$ with an average 339 $\mu\text{g/L}$ which was under prescribed standard range [0.1-90 $\mu\text{g/L}$]. Nitrate was found to be 230 – 715 $\mu\text{g/L}$ with an average 465 $\mu\text{g/L}$. The silica content in Nhava creek was found to be 2047 – 2403 $\mu\text{g/L}$ with an average of 2206 $\mu\text{g/L}$. The minimum silica content was found at station W13 station and maximum was found at W14 station. Sulphate was found between 2477 – 2903 mg/L with an average of 2654 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 Phosphate was found between 113.5 - 250.7 mg/kg with an average of 152.4 mg/kg . The minimum concentration of Phosphate was found at W1 station and maximum concentration at W10 station. The Nitrate was found to be 38.8 to 52.4 mg/kg with minimum value at W2 station and maximum value at W1 station. The average concentration of Nitrate was found to be 34.8 mg/kg . The Nitrite was found to be between 0.02 – 0.09 mg/kg with an average of 0.04 mg/kg . The minimum concentration of nitrite was found at W10 station and maximum value at W1 station. Silica in the form of silicate in JNP harbor sediments were found between 250.2 to 321.2 mg/kg with an average of 286.4 mg/kg . The minimum concentration of silica was found at W2 station and maximum value was found at W7 station. The Sulphate was found between 7227 to 9021 mg/kg , with minimum value at W10 station and maximum value at W7 station. The average concentration of Sulphate was found to be 8317 mg/kg .

In Nhava Creek region the Phosphate was found between 100.4 to 143.9 mg/kg with an average of 122.2 mg/kg . The minimum concentration of Phosphate was found at W14 station and maximum concentration at W13 station. The Nitrate was found between 38.4 to 39.5 mg/kg with minimum value at W13 station and maximum value of 39.5 mg/kg at W14 station. The average concentration of Nitrate was found to be 38.9 mg/kg . The Nitrite was found to be between 0.03 to 0.04 mg/kg with an average of

0.04mg/kg. The minimum concentration of nitrite was found at W14 station and maximum value at W13 station. Silica in the form of silicate in JNP harbor sediments were found between 256.6 to 296.1mg/kg with an average of 286.4 mg/kg. The minimum concentration of silica was found at W14 station and maximum value was found at W13 station. The Sulphate was found between 5369 to 8265 mg/kg, with minimum value at W14 station and maximum value at W13 station. The average concentration of Sulphate was found to be 6817mg/kg.

b. Cations:

In harbor region water, the Calcium was found between 332 to 443mg/L with an average of 406 mg/L given in Table 29. The Magnesium was found to be 1118–1274mg/L, with maximum value at W9 station. The average concentration of Magnesium was found to be 1197mg/L. Potassium in JNP harbor water was found between 262 to 272mg/L with an average of 269mg/L. The minimum concentration of Potassium was found at W3 station and maximum value at W2, W4 & W6station.The Sodium was found between 9300 to 10200 mg/L with an average of 9822 mg/L. The minimum concentration of sodium was found at W10 station and maximum value of at W4 station.

In Nhava Creek, Calcium concentration was found with an average 452 mg/L given in Table 29. Magnesium concentration was found to be 1163 – 1230 mg/L with an average of 1190 mg/L. The minimum value of Magnesium was found at W11 station and maximum value was found at W13station. The Potassium content in Nhava creek was found to be 268 – 274 mg/L with an average of 270 mg/L. The minimum potassium value was found at W12 station and maximum value at W13 stations. Sodium concentration was found to be 9000 to 9600mg/L with an average of 9425 mg/L. The minimum sodium value was recorded at W13 station and maximum value at W11 &W12 station.

In harbor region sediments, the Calcium was found to be 1760 to 4640mg/Kg with an average of 2980 mg/Kg given in Table 30. The minimum Concentration of Calcium was found at W1 station and maximum concentration at W7 station. Magnesium was found to be 243 to 486 mg/Kg, with minimum value at W1 station and maximum was recorded at W10 station. The average concentration of Magnesium was found to be 389mg/Kg. Potassium in JNP harbor sediment was found to be 231 to 362mg/Kg with an average of 279 mg/Kg. The minimum concentration of Potassium was found at W1 station and maximum value at W7 station. Sodium was found to be 5354 to 8433mg/Kg with an average of 6943 mg/Kg. The minimum concentration of sodiumwas found at W2 station and maximum value at W1 station.

In Nhava Creek sediments, Calcium was found to be 2960 to 3040 mg/Kg with an average 3000 mg/Kg given in Table 30. The minimum value of calcium was found at

W14 station and maximum value was found at W13 station. Magnesium was found between 535 to 729 mg/Kg with an average of 632 mg/Kg. The Potassium content in Nhava creek was found to be 163 to 288 mg/Kg with an average of 225 mg/Kg. The minimum Potassium content was found at W13 station and maximum value at W14 station. Sodium was found between 4125 to 5875 mg/Kg with an average of 5000 mg/Kg. The minimum sodium value was found at W13 station and maximum value at W14 station.

3.5 OBSERVATIONS AND CONCLUSIONS

Observations for the month of October:

- *The Construction of 330 m Jetty at North Side of the JNP is underway:* Pilling work was going on during the time of Sampling of marine water.
- *Dredging of JNPT Channel toward South End of Channel:* Dredging was being carried during the same time.
- *Construction of Mooring Dolphin Jetty in front of Liquid cargo jetty.*
- *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 prescribed recommended ranges of the ecological parameters for Arabian Sea during October, 2014 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 October be 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:

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	DW10	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 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 October, 2014.

The water samples are analyzed for various parameters Color, Odor, Turbidity, Conductivity, pH, Chlorides, TDS, Total hardness, Iron, Sulphate, NH_4^+-N , $\text{PO}_4^{3-}-\text{P}$, CFU Bacterial count.

4.2 RESULTS

The drinking water quality monitoring data for eighteen stations are given in Table 31.

Table 31: 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	$\mu\text{S}/\text{cm}$	106	102	109	111.7	114	107	-
pH	-	7.30	7.45	7.17	7.37	7.25	7.35	6.5 to 8.5
Chloride as Cl^-	mg/L	7.8	7.8	8.7	7.8	7.8	8.7	250
Total Dissolved Solids	mg/L	68	64	68	72	72	68	500
Total Hardness as CaCO_3	mg/L	41	39	44	42	42	42	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	3.5	3.0	4.5	4.0	3.7	3.5	200
$\text{NH}_4^+ \cdot \text{N}$	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5
$\text{PO}_4^{-3} \cdot \text{P}$	mg/L	<0.1	<0.1	<0.1	0.20	0.3	0.2	-
Total Coliforms	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil

*, IS 10500:2012, Drinking Water - Specification

Table 31: Results of Drinking water quality monitoring

Parameter	Unit of Measurement	DW7	DW8	DW9	DW10	DW11	DW12	Standard
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	$\mu\text{S}/\text{cm}$	107	113	109	109	113	106	-
pH	-	7.44	6.75	7.01	7.23	7.50	7.40	6.5 to 8.5
Chloride as Cl^-	mg/L	10	7.8	10.7	9.7	10.7	10.7	250
Total Dissolved Solids	mg/L	66	72	70	70	72	66	500
Total Hardness as CaCO_3	mg/L	41	41	44	48	48	39	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	5.2	4.7	7.19	5.13	6.15	5.23	200
$\text{NH}_4^+ \cdot \text{N}$	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5
$\text{PO}_4^{-3} \cdot \text{P}$	mg/L	0.2	0.1	0.30	0.2	0.2	<0.1	-
Total Coliforms	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil

*: IS 10500:2012, Drinking Water - Specification

Table 31: Results of Drinking water quality monitoring

Parameter	Unit of Measurement	Station Name							Standard
		DW13	DW14	DW15	DW16	DW17	DW18		
Colour	Hazen	<5	<5	<5	<5	<5	<5	Agreeable	5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
Turbidity	NTU	<1	<1	<1	<1	<1	<1	<1	1
Conductivity	$\mu\text{S}/\text{cm}$	107.4	107.9	106	107	107	107	107	-
pH	-	7.42	7.39	7.34	7.54	7.28	7.42	7.42	6.5 to 8.5
Chloride as Cl^-	mg/L	8.7	15.5	9.7	9.7	10.7	10.7	10.7	250
Total Dissolved Solids	mg/L	68	70	68	70	68	68	68	500
Total Hardness as CaCO_3	mg/L	42	39	41	37	42	41	41	200
Iron as Fe	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.3
Sulphate as SO_4^{2-}	mg/L	6.25	5.6	6.1	5.4	6.3	4.0	4.0	200
$\text{NH}_4^+ \cdot \text{N}$	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5
$\text{PO}_4^{3-} \cdot \text{P}$	mg/L	<0.1	<0.1	0.20	<0.1	<0.1	<0.1	<0.1	-
Total Coliforms	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

**: IS 10500:2012, Drinking Water - Specification*

4.3 DISCUSSION

Table 31 provides the results for various parameters analyzed for drinking water collected at 18 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, the variation of concentration levels of anions are found to be for chloride 7.8 to 15.5 mg/L, for sulphate 3.0 to 7.2 mg/L and for phosphate 0.1 to 0.3 mg/L. The concentration of total dissolved solids is found to be between 64.0 to 72.0 mg/L and concentration of total hardness is found to be 36.8 to 47.8 mg/L. All the above parameters are well within the acceptable limits.

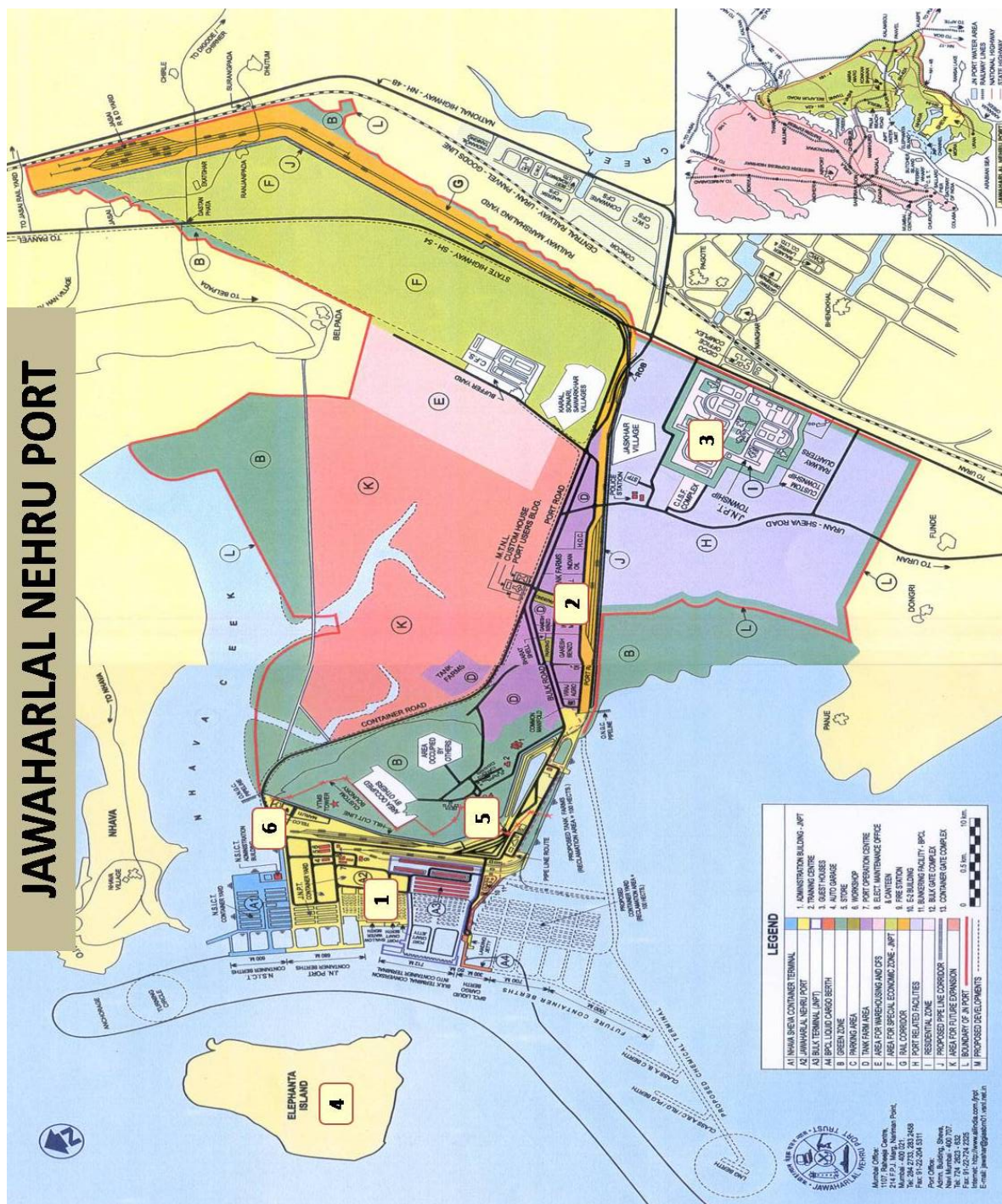
The color of all drinking water samples is < 5 Hazen unit and Odor of the samples is also agreeable. The turbidity values are below acceptable limits i.e. 1 NTU. The values of conductivity are ranges between 101.6 to 114.3 μ S/cm. The acceptable range for pH is 6.5 to 8.5, while the observed pH range is 6.8 to 7.5.

The iron content and $\text{NH}_4^+ - \text{N}$ content is found to be well within the acceptable limit and observed levels are < 0.01 mg/L and < 0.1 mg/L respectively. Analysis of bacteriological parameter shows that the water is free from bacterial contamination.

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 in and around the port.

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 -ED-XRF using Teflon filter
		24 hours**	1.0	1.0	
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

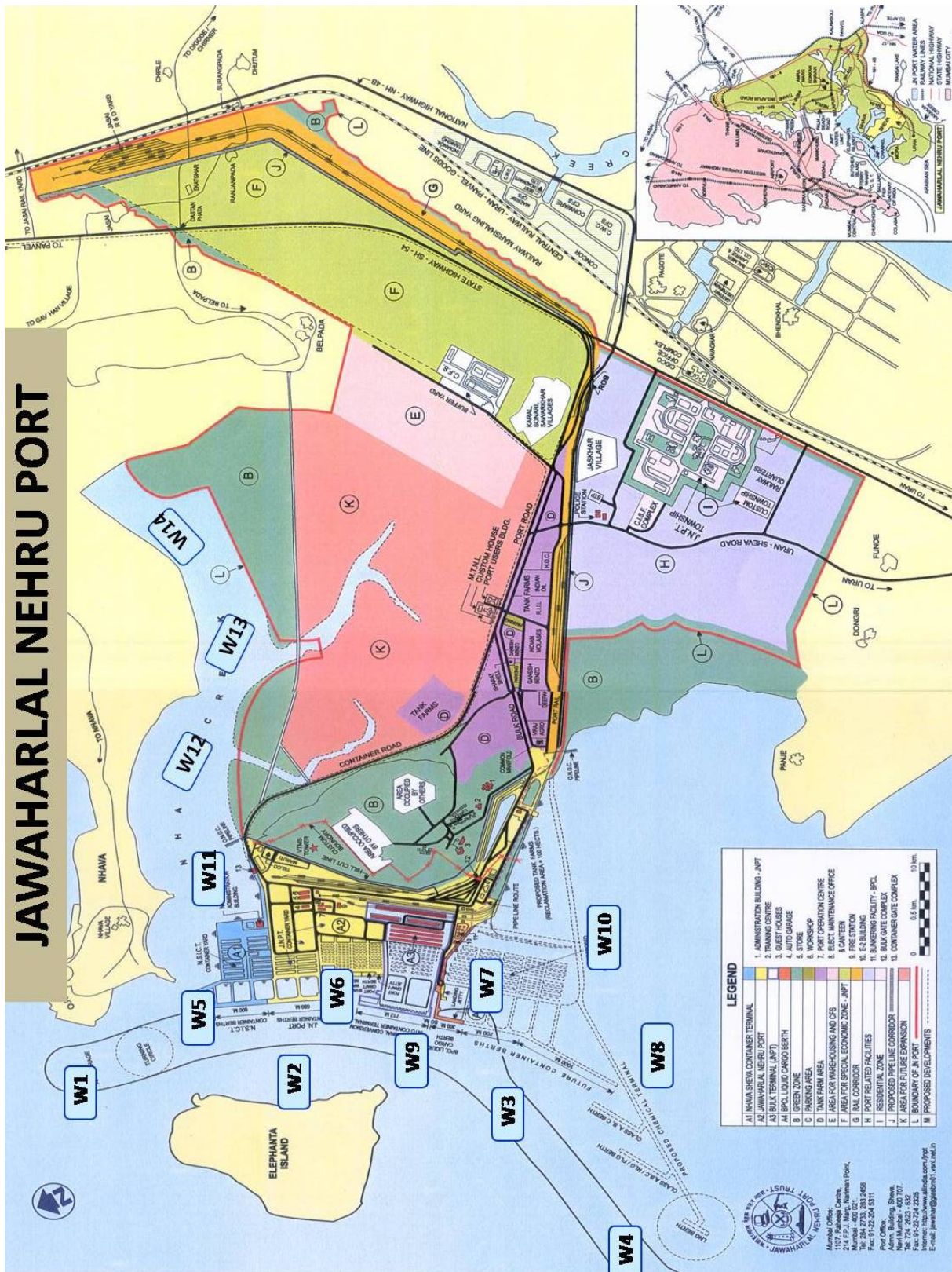
* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals

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

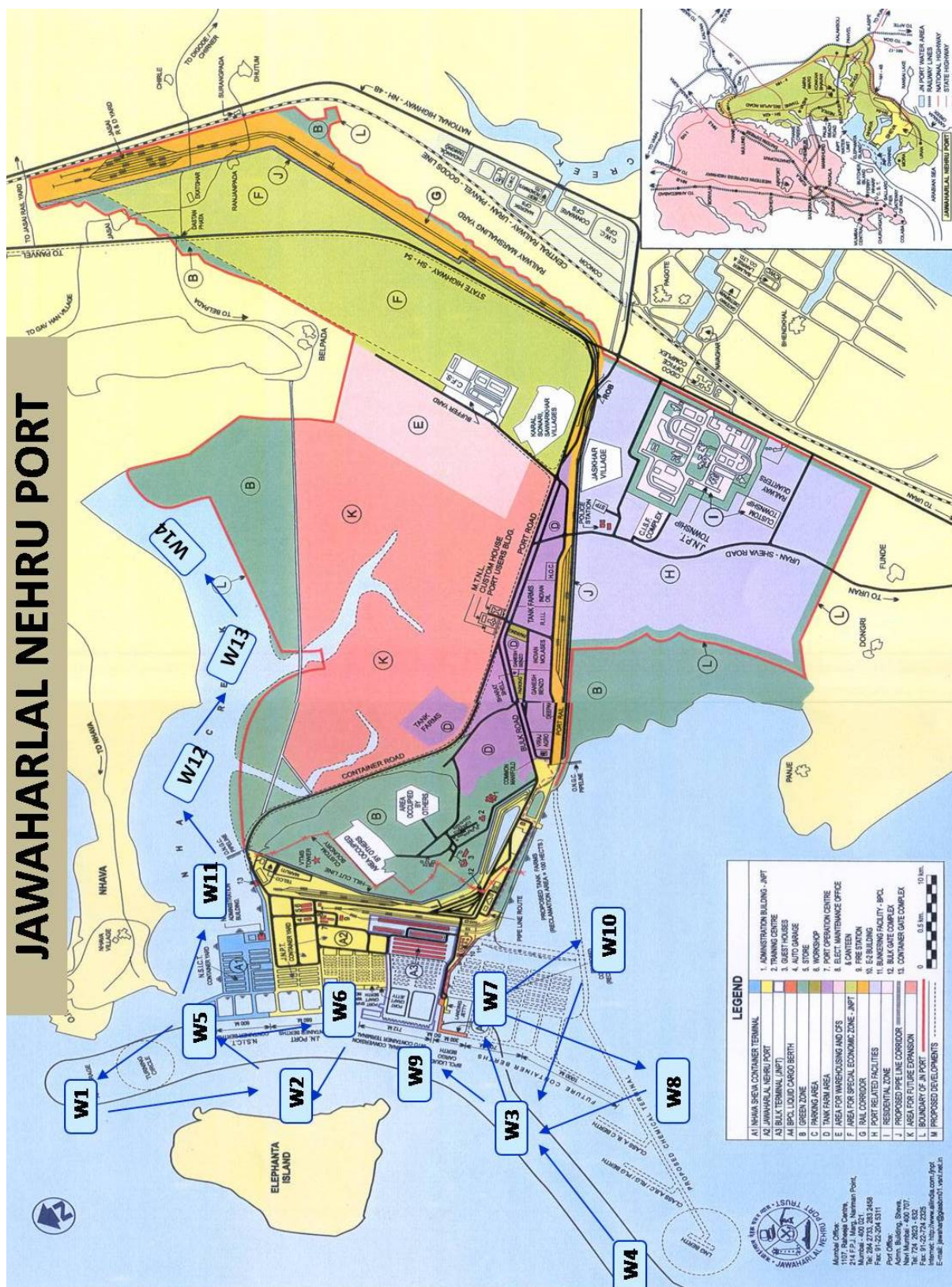
2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

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

Annexure-VII: Photo Plates



Plate 1: Collection of plankton samples from the JNP Harbor Area



Plate 2: Solid waste disposal in JNP Harbour Area



Plate 3: Collection of Benthos from JNP Harbour Area