



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, 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 May, 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]		NAAQMS
			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)	
POC-1	04.05.2015 to 06.05.2015	14:00 to 22:00	172		33		13	12.9	14	14.3	6	6.8	
		22:00 to 06:00					13		14		9		
		06:00 to 14:00					12		15		6		
POC-2	07.05.2015 to 08.05.2015	14:00 to 22:00	124		24		16	15.4	19	18.8	8	9.2	
		22:00 to 06:00					15		19		9		
		06:00 to 14:00					15		19		11		
POC-3	11.05.2015 to 12.05.2015	14:00 to 22:00	123		18		15	14.9	23	18.1	6	6.0	
		22:00 to 06:00					13		13		6		
		06:00 to 14:00					16		18		6		
POC-4	14.05.2015 to 15.05.2015	14:00 to 22:00	144		25		7	9.9	17	17.4	35	34.3	
		22:00 to 06:00					9		17		35		
		06:00 to 14:00					13		18		33		
POC-5	18.05.2015 to 19.05.2015	14:00 to 22:00	88		21		13	9.9	15	14.8	20	18.0	
		22:00 to 06:00					7		15		18		
		06:00 to 14:00					9		15		16		
POC-6	21.05.2015 to 22.05.2015	14:00 to 22:00	73		25		16	18.3	21	21.6	9	9.2	
		22:00 to 06:00					18		21		9		
		06:00 to 14:00					21		23		10		
POC-7	25.05.2015 to 26.05.2015	14:00 to 22:00	74		23		15	14.9	21	18.9	4	5.0	
		22:00 to 06:00					16		18		5		
		06:00 to 14:00					13		17		7		
POC-8	28.05.2015 to 27.03.2015	14:00 to 22:00	87		19		25	22.8	26	24.8	5	4.9	
		22:00 to 06:00					22		24		5		
		06:00 to 14:00					21		24		5		
Average			111	24	24			14.9		18.6		11.7	
Standard Dev			36	5	5			4.3		3.4		10.1	

Table 2: Results of Air Pollutant Concentration at POC Station																		
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	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	Grab Sampling	Grab Sampling	Grab Sampling	Grab Sampling
POC-1	04.05.2015 to 06.05.2015	14:00 to 22:00																
		22:00 to 06:00	23		0.12		<1		<1		3.1		<0.5		2.4		284	
		06:00 to 14:00																
POC-2	07.05.2015 to 08.05.2015	14:00 to 22:00																
		22:00 to 06:00	29		0.1		<1		<1		3.2		<0.5		2.1		286	
		06:00 to 14:00																
POC-3	11.05.2015 to 12.05.2015	14:00 to 22:00																
		22:00 to 06:00	31		0.09		<1		<1		2.4		<0.5		2.1		291	
		06:00 to 14:00																
POC-4	14.05.2015 to 15.05.2015	14:00 to 22:00																
		22:00 to 06:00	25		0.1		<1		<1		2.6		<0.5		2.6		279	
		06:00 to 14:00																
POC-5	18.05.2015 to 19.05.2015	14:00 to 22:00																
		22:00 to 06:00	23		0.06		<1		<1		3		<0.5		2.5		284	
		06:00 to 14:00																
POC-6	21.05.2015 to 22.05.2015	14:00 to 22:00																
		22:00 to 06:00	31		0.04		<1		<1		3.5		<0.5		2.4		284	
		06:00 to 14:00																
POC-7	25.05.2015 to 26.05.2015	14:00 to 22:00																
		22:00 to 06:00	27		0.06		<1		<1		2.8		<0.5		2.0		287	
		06:00 to 14:00																
POC-8	28.05.2015 to 27.03.2015	14:00 to 22:00																
		22:00 to 06:00	48		0.08		<1		<1		2.4		<0.5		2.5		290	
		06:00 to 14:00																
Average																		
Standard Dev																		

Table 3: Results of Air Pollutant Concentration at IMC Station

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	100 µg/m ³ 60 µg/m ³	24 hr	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)
NAAQMS													
IMC-1	04.05.2015 to 06.05.2015	15:00 to 23:00			21	15	14	23	17.9	5	5.8		
		23:00 to 07:00	157		13		14	14		5			
		07:00 to 15:00			15			17		7			
IMC-2	07.05.2015 to 08.05.2015	15:05 to 23:05			21	12		15		1	0.6		
		23:05 to 07:05	148		13	11	14	14.6	1				
		07:05 to 15:05			7		15		1				
IMC-3	11.05.2015 to 12.05.2015	15:10 to 23:10			21	13		15		6			
		23:10 to 07:10	151		22	20	26	22.3	6		6.0		
		07:10 to 15:10			25		26		6				
IMC-4	14.05.2015 to 15.05.2015	14:50 to 22:50			41	9		13		19	17.8		
		22:50 to 06:50	196		7	9	14	13.9	18				
		06:50 to 14:50			10		14		17				
IMC-5	18.05.2015 to 19.05.2015	15:00 to 23:00			20	10		13		18			
		23:00 to 07:00	122		9	10	13	13.1	20		18.9		
		07:00 to 15:00			12		13		19				
IMC-6	21.05.2015 to 22.05.2015	15:00 to 23:00			15	16		18		5			
		23:00 to 07:00	75		15	14.9	15	23.8	6		5.5		
		07:00 to 15:00			13		16		6				
IMC-7	25.05.2015 to 26.05.2015	15:00 to 23:00			20	22		16		5			
		23:00 to 07:00	75		25	25.3	27	23.8	5		6.2		
		07:00 to 15:00			28		29		8				
IMC-8	28.05.2015 to 27.03.2015	15:00 to 23:00			25	18		16		7			
		23:00 to 07:00	117		21	19.3	25	21.6	6		5.5		
		07:00 to 15:00			19		23		4				
Average			130	23	8		15.6		18.9		8.3		
Standard Dev			42	8			5.7		4.6		6.5		

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]	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	8 hr	24 hr	24 hr	Grab Sampling	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	4 ng/m ³	-						
NAAQMS																
IMC-1	04.05.2015 to 06.05.2015	15:00 to 23:00														
		23:00 to 07:00	31	0.13	<1	<1	<1	<0.5	2.4	284						
		07:00 to 15:00														
IMC-2	07.05.2015 to 08.05.2015	15:05 to 23:05														
		23:05 to 07:05	41	0.11	<1	<1	<0.5	2.5	286							
		07:05 to 15:05														
IMC-3	11.05.2015 to 12.05.2015	15:10 to 23:10														
		23:10 to 07:10	25	0.12	<1	<1	<0.5	3.1	281							
		07:10 to 15:10														
IMC-4	14.05.2015 to 15.05.2015	14:50 to 22:50														
		22:50 to 06:50	27	0.15	<1	<1	<0.5	2.4	281							
		06:50 to 14:50														
IMC-5	18.05.2015 to 19.05.2015	15:00 to 23:00														
		23:00 to 07:00	21	0.09	<1	<1	<0.5	2.0	284							
		07:00 to 15:00														
IMC-6	21.05.2015 to 22.05.2015	15:00 to 23:00														
		23:00 to 07:00	17	0.06	<1	<1	<0.5	2.3	290							
		07:00 to 15:00														
IMC-7	25.05.2015 to 26.05.2015	15:00 to 23:00														
		23:00 to 07:00	29	0.05	<1	<1	<0.5	2.6	282							
		07:00 to 15:00														
IMC-8	28.05.2015 to 27.03.2015	15:00 to 23:00														
		23:00 to 07:00	30	0.09	<1	<1	<0.5	2.4	286							
		07:00 to 15:00														
Average			28	0.10						2.5	284					
Standard Dev			7	0.03						0.3	3					

Table 4: Results of Air Pollutant Concentration at RC School 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	24 hr	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)		
			100 µg/m ³		60 µg/m ³		-	80 µg/m ³	-	80 µg/m ³	-	80 µg/m ³	-	400 µg/m ³
NAAQMS	RC-1	04.05.2015 to 06.05.2015	15:20 to 23:20	129	34	13	15	15	15	14.6	5	7	7.0	
		07:20 to 15:20			16	10	10	10	10		9			
RC-2		07.05.2015 to 08.05.2015	15:30 to 23:30	224	73	7	10	10	15	14.6	5	6	5.5	
	23:30 to 07:30			13	16	19	10	10		6				
	07:30 to 15:30			12	23	10	10	10		6				
RC-3	11.05.2015 to 12.05.2015	15:35 to 23:35	295	69	16	13	14	23	24.4	4	4	4.3		
	23:35 to 07:35			12	13	25	12	25		5				
	07:35 to 15:35			10	16	12	11	12	11.5	16	30	25.0		
RC-4	14.05.2015 to 15.05.2015	15:30 to 23:30	237	55	13	12	12	11	11.5	12	12	29		
	23:30 to 07:30			9	10	16	9	16	16.6	12	11	11.5		
	07:30 to 15:30			7	17	17	15	15	15.0	5	5	4.4		
RC-5	18.05.2015 to 19.05.2015	15:30 to 23:30	211	47	13	15	14	29	30.2	6	5	5.2		
	23:30 to 07:30			15	19	28	25	31	30.2	5	5	5		
	07:30 to 15:30			7	17	31	24	24	25.1	5	5	4.9		
RC-6	21.05.2015 to 22.05.2015	15:30 to 23:30	250	83	19	27	21	26	25.1	5	5	8.5		
	23:30 to 07:30			15	24	21	21	25	25.1	5	5	7.1		
	07:30 to 15:30			15	27	18	15.0	19.0	6.6					
RC-7	25.05.2015 to 26.05.2015	15:30 to 23:30	227	66	19	28	25	26	25.1	5	5	4.9		
	23:30 to 07:30			28	31	27	24	25	25.1	5	5	4.9		
	07:30 to 15:30			27	31	18	15.0	19.0	6.6					
RC-8	28.05.2015 to 27.03.2015	15:30 to 23:30	146	49	24	21	21	26	25.1	5	5	4.9		
	23:30 to 07:30			18	24	24	25	24	25.1	5	5	4.9		
	07:30 to 15:30			215	60		15.0	19.0	6.6					
Average				215	60		15.0	19.0	6.6			8.5		
Standard Dev				54	16		5.3	6.6				7.1		

Table 4: Results of Air Pollutant Concentration at RC School 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	24 hr	24 hr	24 hr	8 hr	24 hr	Grab Sampling	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	4 mg/m ³	4 mg/m ³	-				
NAAQMS	RC-1	04.05.2015 to 06.05.2015	15:20 to 23:20	34	0.08	<1	<1	2.4	<0.5	2.3	284				
			23:20 to 07:20												
			07:20 to 15:20												
	RC-2	07.05.2015 to 08.05.2015	15:30 to 23:30	23	0.19	<1	<1	2.2	<0.5	2.4	282				
			23:30 to 07:30												
			07:30 to 15:30												
	RC-3	11.05.2015 to 12.05.2015	15:35 to 23:35	29	0.2	<1	<1	2.1	<0.5	2.5	281				
			23:35 to 07:35												
			07:35 to 15:35												
	RC-4	14.05.2015 to 15.05.2015	15:30 to 23:30	41	0.18	<1	<1	2.6	<0.5	2.1	286				
			23:30 to 07:30												
			07:30 to 15:30												
	RC-5	18.05.2015 to 19.05.2015	15:30 to 23:30	28	0.12	<1	<1	3.2	<0.5	2.4	291				
			23:30 to 07:30												
			07:30 to 15:30												
	RC-6	21.05.2015 to 22.05.2015	15:30 to 23:30	29	0.23	<1	<1	3.3	<0.5	2.9	286				
			23:30 to 07:30												
			07:30 to 15:30												
	RC-7	25.05.2015 to 26.05.2015	15:30 to 23:30	37	0.2	<1	<1	3.1	<0.5	2.1	291				
			23:30 to 07:30												
			07:30 to 15:30												
	RC-8	28.05.2015 to 27.03.2015	15:30 to 23:30	24	0.11	<1	<1	2.1	<0.5	2.3	286				
			23:30 to 07:30												
			07:30 to 15:30												
Average				31	0.16			2.6		286					
Standard Dev				6	0.05			0.5	0.3	4					

Table 5: Results of Air Pollutant Concentration at EC Station

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]
EC	04.05.2015	14:00 to 22:00	117	13	16	5
	to	22:00 to 06:00	19	15	17	7
	05.05.2015	06:00 to 14:00		16	18	9

Table 5: Results of Air Pollutant Concentration at EC Station

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]
EC	04.05.2015	14:00 to 22:00	29	0.04	<1	2.1	<0.5	1.5	271
	to	22:00 to 06:00							
	05.05.2015	06:00 to 14:00							

Table 6: Results of Air Pollutant Concentration at NGC 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	24 hr (Avg)	8 hr	24 hr (Avg)			
			100 µg/m ³	60 µg/m ³	-	80 µg/m ³	-	80 µg/m ³			
NAAQMS	NG-1	07.05.2015 to 08.05.2015	16:00 to 00:00		45	13	16	6			
			00:00 to 08:00	145		7	12.9	15.8	15	11.3	
			08:00 to 16:00			18			13		
	NG-2	14.05.2015 to 15.05.2015	15:50 to 23:50			12	23		16		
		23:50 to 07:50	204	56	10	10.4	23	24.4	7	9.2	
		07:50 to 15:50			9		27		5		
NG-3	21.05.2015 to 22.05.2015	15:40 to 23:40			16	21		4			
		23:40 to 07:40	81	30	18	20.8	24	22.2	6	4.7	
		07:40 to 15:40			28		22		4		
NG-4	28.05.2015 to 27.03.2015	15:40 to 23:40			25	27		5			
		23:40 to 07:40	164	52	22	22.3	24	23.8	5	5.4	
		07:40 to 15:40			19		21		6		
Average			149	46		16.6		21.6		7.6	
Standard Dev			51	11		5.8		3.9		3.1	

Sampling Period	Date	Time, [Hrs]	Results of Air Pollutant Concentration at NGC Station									
			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	8 hr	24 hr	24 hr	4 mg/m ³		
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				
NG-1	07.05.2015 to 08.05.2015	16:00 to 00:00										
		00:00 to 08:00	29	0.15	<1	<1	2.5	<0.5	2.3	291		
		08:00 to 16:00										
		15:50 to 23:50	51	0.2	<1	<1	2.4	<0.5	2.1	293		
NG-2	14.05.2015 to 15.05.2015	23:50 to 07:50										
		07:50 to 15:50										
		15:40 to 23:40	30	0.09	<1	<1	2.6	<0.5	2.4	294		
		23:40 to 07:40										
NG-3	22.05.2015 to 28.05.2015	07:40 to 15:40										
		15:40 to 23:40	40	0.17	<1	<1	3.1	<0.5	2.3	293		
		23:40 to 07:40										
		07:40 to 15:40	38	0.15			3		2.3	293		
NG-4	27.03.2015											
			10	0.05			0.3		0.1	1		
Average												
Standard Dev												

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]	
			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												
SG-1	04.05.2015 to 06.05.2015	16:30 to 00:30					13		15		5	
		00:30 to 08:30	209		54		13	12.4	20	17.4	5	4.8
SG-2	11.05.2015 to 12.05.2015	16:15 to 00:15	168		42		13		16		5	
		00:15 to 08:15					18	17.9	17	16.9	4	4.3
SG-3	18.05.2015 to 19.05.2015	16:15 to 00:15					22		18		4	
		00:15 to 08:15	210		56		12		11		12	
SG-4	25.05.2015 to 26.05.2015	16:15 to 00:15	146		35		10	9.9	11	11.4	13	13.1
		00:15 to 08:15					7		12		15	
Average							12		15		6	
							15	14.9	21	18.6	6	6.3
Standard Dev			183		47		18	13.8	20	16.1	7	7.1
			32		10			3.4		3.2		4.1

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]
			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	4 mg/m ³			
			100 µg/m ³											
NAAQMS														
SG-1	04.05.2015 to 06.05.2015	16:30 to 00:30												
		00:30 to 08:30	23		0.18	<1	<1	2.4	<0.5	2.3		294		
		08:30 to 16:30												
SG-2	11.05.2015 to 12.05.2015	16:15 to 00:15	33		0.1	<1	<1	2.9	<0.5	2.4		291		
		00:15 to 08:15												
		08:15 to 16:15												
SG-3	18.05.2015 to 19.05.2015	16:15 to 00:15	14		0.18	<1	<1	2.8	<0.5	2.5		293		
		00:15 to 08:15												
		08:15 to 16:15												
SG-4	25.05.2015 to 26.05.2015	16:15 to 00:15	30		0.12	<1	<1	3.2	<0.5	2.4		301		
		00:15 to 08:15												
		08:15 to 16:15												
Average			25		0.15			2.8		2.4		295		
Standard Dev			8		0.04			0.3		0.1		4		

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 May, 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 May, 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 May, 2015

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 , [$\mu\text{g}/\text{m}^3$]	Pb [$\mu\text{g}/\text{m}^3$]	C ₆ H ₆ , [$\mu\text{g}/\text{m}^3$]	CO, [mg/m ³]	CO ₂ , [ppm]
NAAQMS	100	60	80	80	400	100	1	5	4	-
INDUSTRIAL AREA										
POC	111 \pm 36	24 \pm 05	14.9 \pm 4.3	18.6 \pm 3.4	11.7 \pm 10.1	30 \pm 08	0.08 \pm 0.03	2.9 \pm 0.4	2.3 \pm 0.2	286 \pm 04
IMC	130 \pm 42	23 \pm 08	15.6 \pm 5.7	18.9 \pm 4.6	08.3 \pm 6.5	28 \pm 07	0.10 \pm 0.03	2.4 \pm 0.4	2.5 \pm 0.3	284 \pm 03
NG	149 \pm 51	46 \pm 11	16.6 \pm 5.8	21.6 \pm 3.9	07.6 \pm 3.1	38 \pm 10	0.15 \pm 0.05	3.0 \pm 0.3	2.3 \pm 0.1	293 \pm 01
SG	183 \pm 32	47 \pm 10	13.8 \pm 3.4	16.1 \pm 3.2	07.1 \pm 4.1	25 \pm 08	0.15 \pm 0.04	2.8 \pm 0.3	2.4 \pm 0.1	295 \pm 04
RESIDENTIAL AREA										
RC	215 \pm 54	60 \pm 16	15.0 \pm 5.3	19.0 \pm 6.6	8.5 \pm 7.1	31 \pm 06	0.16 \pm 0.05	2.6 \pm 0.5	2.4 \pm 0.3	286 \pm 04
ECO-SENSITIVE AREA										
EC	117	19	14.9	17.0	7.0	29	0.04	2.1	1.5	271

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 prescribed national standards. All remaining pollutants were recorded well below the prescribed limits. Monthly average values obtained for the month of May, 2015 were tabulated in **Table 8**.

All the monitoring stations have higher particulate (PM₁₀) levels i.e. above prescribed standards. Highest levels among port stations were at RC i.e. residential area which is currently under renovation. Followed by SGC and NGC i.e. port vehicle entry points have particulate concentrations above prescribed standards because of ongoing road maintenance and heavy vehicular movement.

Results for the air quality parameters at Elephanta Caves [EC] station during 04th May'14 to 05th May'14 were tabulated in **Table 5**. Particulate concentration was above standards 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 May, 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 May'15:

- ✓ 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.
- ✓ *Construction of 4th Container Terminal on South side of JNPT:* Land preparation work of 4th C.T. is underway.
- ✓ Solid waste was being disposed near CFS i.e. Karal village in haphazard manner.
- ✓ *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.
- ✓ 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 May'15.



School building renovation and land preparation at proposed 4th Container terminal

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

- ✓ Renovation work should be executed under controlled conditions; debris and earth filling material 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
- ✓ Increasing the plantations in and around the port area as well as developing and maintaining thick green cover on both sides of the roads and tank farms.
- ✓ Cleaning and maintaining of paved and unpaved roads regularly to remove spillage of earth/soil material during transportation.

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).

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.	04 th May, 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	04 th May, 2015
3.	W3	Identified by the green buoy no. <u>FG2 Green</u> of JNPT approach channel and lies near the landing jetty.	05 th May, 2015
4.	W4	Located at Uran Patch Beacon (lighthouse on concrete platform) near the Butcher Island filling platform.	05 th May, 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	04 th May, 2015
	W11 to W14		06 th May, 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.	04 th May, 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.	05 th May, 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	05 th May, 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.	05 th May, 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

2.3 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 May, 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	12.6	30.9	7.86	36.9	11	30420	74	30494
	SM		31.4	7.90	35.3	7	30454	65	30519
	SB		31.0	7.48	36.1	18	30512	108	30620
	NS	10.0	29.9	7.87	36.1	11	30360	69	30429
	NM		30.2	7.57	37.8	7	30282	48	30330
	NB		30.9	7.62	36.9	19	30344	83	30427
W2	SS	5.3	31.0	7.53	36.9	12	30480	174	30654
	SM		30.9	7.69	36.1	20	30426	127	30553
	SB		30.7	7.86	35.3	30	30390	126	30516
	NS	4.4	29.6	7.71	37.8	20	30364	139	30503
	NM		29.6	7.42	36.9	18	30324	114	30438
	NB		31.2	7.63	35.3	33	30424	112	30536
W3	SS	6.8	30.2	7.32	35.3	21	30534	166	30700
	SM		29.9	7.44	36.9	14	30510	108	30618
	SB		30.6	7.63	36.1	35	30422	122	30544
	NS	6.5	30.1	7.58	38.6	23	30292	179	30471
	NM		30.0	7.48	37.8	10	30334	97	30431
	NB		29.9	7.76	41.9	35	30372	103	30475
W4	SS	7.8	30.4	7.62	33.7	26	30344	149	30493
	SM		30.9	7.73	35.3	19	30292	110	30402
	SB		31.0	7.69	36.9	33	30268	165	30433
	NS	7.6	28.8	7.63	36.1	20	30348	187	30535
	NM		30.2	7.57	38.6	18	30342	140	30482
	NB		30.5	7.61	37.8	25	30360	147	30507
W5	SS	10.0	31.3	7.71	35.3	8	30258	91	30349
	SM		31.6	7.98	36.1	10	30240	90	30330
	SB		31.5	7.59	37.8	45	30324	209	30533
	NS	9.2	29.8	7.40	36.9	5	30272	78	30350
	NM		30.0	7.79	36.1	10	30262	80	30342
	NB		30.8	7.63	35.3	48	30348	306	30654

SS – SPRING
SURFACE

NS – NEAP SURFACE
NM – NEAP MIDDLE

SM – SPRING 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	10.1	31.6	7.46	35.3	11	30212	109	30321
	SM		31.7	7.67	36.9	8	30340	47	30387
	SB		31.7	7.47	36.1	12	30372	86	30458
	NS	9.3	30.1	7.57	38.6	11	30298	98	30396
	NM		29.8	7.96	35.3	16	30412	60	30472
	NB		31.7	7.81	36.9	20	30426	89	30515
W7	SS	5.4	30.8	7.71	34.5	52	30458	197	30655
	SM		30.9	7.67	36.1	43	30392	295	30687
	SB		30.7	7.17	34.5	25	30316	228	30544
	NS	5.2	30.4	7.59	36.1	37	30408	234	30642
	NM		30.3	7.42	33.7	41	30428	275	30703
	NB		30.1	7.51	35.3	63	30530	198	30728
W8	SS	12.9	30.5	7.61	34.5	5	30188	47	30235
	SM		30.4	7.73	34.5	8	30214	45	30259
	SB		30.7	7.45	35.3	1	30264	40	30304
	NS	12.3	29.9	7.67	36.9	1	30422	40	30462
	NM		30.2	7.66	35.3	2	30248	105	30353
	NB		29.9	7.69	36.1	2	30228	21	30249
W9	SS	3.4	30.7	7.13	38.6	16	30328	160	30488
	SM		30.8	7.84	36.1	20	30222	280	30502
	SB		30.6	7.31	35.3	30	30312	62	30374
	NS	2.9	30.4	7.60	34.5	42	30422	297	30719
	NM		30.8	7.31	37.8	38	30372	214	30586
	NB		30.9	7.43	34.5	39	30148	245	30393

SS – SPRING SURFACE
SM – SPRING MIDDLE
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 May, 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	46	8
	SS	6.4	40	<2	<0.1	<0.01			
	SM	6.4	44		-	-			
	SB	6.1	36	-	-	-			
	NS#	-		-	-	-	2	80	2
	NS	6.1	32	<2	<0.1	<0.01			
	NM	5.9	48	-	-	-			
	NB	5.7	28	-	-	-			
W2	SS#	-					1	55	2
	SS	5.9	28		<0.1	<0.01			
	SM	5.9	36						
	SB	5.9	44						
	NS#	-					<1	130	<2
	NS	6.0	52		<0.1	<0.01			
	NM	6.0	40						
	NB	6.0	32						
W3	SS#	-	-	-	-	-	2	88	9
	SS	6.1	48	<2	<0.1	<0.01			
	SM	6.1	32	-	-	-			
	SB	6.1	28	-	-	-			
	NS#	-		-	-	-	1	<30	<2
	NS	6.1	44	<2	<0.1	<0.01			
	NM	6.0	36	-	-	-			
	NB	6.0	40	-	-	-			
W4	SS#	-	-	-	-	-	2	43	4
	SS	6.1	40	<2	<0.1	<0.01			
	SM	6.1	32	-	-	-			
	SB	6.0	36	-	-	-			
	NS#	-		-	-	-	2	56	<2
	NS	6.2	44	<2	<0.1	<0.01			
	NM	6.1	48	-	-	-			
	NB	6.0	36	-	-	-			
W5	SS#	-	-	-	-	-	3	<30	17
	SS	5.9	44	<2	<0.1	<0.01			
	SM	5.9	36	-	-	-			
	SB	5.9	48	-	-	-			
	NS#	-	-	-	-	-	2	85	2
	NS	6.1	40	<2	<0.1	<0.01			
	NM	5.9	32	-	-	-			
	NB	5.9	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	102	26
	SS	5.9	45	<2	<0.1	<0.01	-	-	-
	SM	5.9	41	-	-	-	-	-	-
	SB	5.9	33	-	-	-	-	-	-
	NS [#]	-	-	-	-	-	1	48	8
	NS	6.1	37	<2	<0.1	<0.01	-	-	-
	NM	6.0	49	-	-	-	-	-	-
	NB	5.9	29	-	-	-	-	-	-
W7	SS [#]	-	-	-	-	-	2	154	30
	SS	6.2	49	<2	<0.1	<0.01	-	-	-
	SM	6.1	37	-	-	-	-	-	-
	SB	6.1	29	-	-	-	-	-	-
	NS [#]	-	-	-	-	-	<1	83	4
	NS	6.2	45	<2	<0.1	<0.01	-	-	-
	NM	6.0	33	-	-	-	-	-	-
	NB	5.9	31	-	-	-	-	-	-
W8	SS [#]	-	-	-	-	-	2	82	11
	SS	6.1	45	<2	<0.1	<0.01	-	-	-
	SM	6.1	41	-	-	-	-	-	-
	SB	6.1	33	-	-	-	-	-	-
	NS [#]	-	-	-	-	-	3	65	2
	NS	6.0	37	<2	<0.1	<0.01	-	-	-
	NM	5.9	49	-	-	-	-	-	-
	NB	5.9	54	-	-	-	-	-	-
W9	SS [#]	-	-	-	-	-	1	<30	2
	SS	6.2	49	<2	<0.1	<0.01	-	-	-
	SM	6.3	45	-	-	-	-	-	-
	SB	6.2	54	-	-	-	-	-	-
	NS [#]	-	-	-	-	-	1	<30	<2
	NS	6.2	37	<2	<0.1	<0.01	-	-	-
	NM	6.0	41	-	-	-	-	-	-
	NB	5.9	43	-	-	-	-	-	-

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 May, 2015

Station Name	Organic Matter		Total Carbon		Inorganic Phosphate mg/kg
	mg/g	%	mg/g	%	
W1	Sample Not Found				
W2	91.0	9.1	53.0	5.3	140
W3	135.0	13.5	78.3	7.8	101
W4	115.2	11.5	66.8	6.7	89
W5	147.5	14.8	85.6	8.6	91
W6	146.1	14.6	84.7	8.5	125
W7	150.0	15.0	87.0	8.7	90
W8	143.6	14.4	83.3	8.3	115
W9	Sample Not Found				

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	1.9	28.2	7.37	33.7	46	30140	194	30334
	SM		27.7	7.21	36.1	60	29948	253	30201
	SB		27.7	7.30	35.3	51	30416	194	30610
	NS	3.4	30.2	7.39	36.9	43	30312	236	30548
	NM		30.1	7.11	37.8	46	30210	304	30514
	NB		30.0	7.18	32.8	41	30224	213	30437
W12	SS	3.4	26.3	7.47	38.6	50	30332	134	30466
	SM		26.0	7.28	36.9	36	30260	184	30444
	SB		25.7	7.02	36.1	32	30282	238	30520
	NS	2.4	31.2	7.50	36.9	37	30312	305	30617
	NM		30.7	7.34	34.5	37	30324	256	30580
	NB		30.2	7.28	37.8	41	30278	219	30497
W13	SS	2.9	26.2	7.48	36.1	10	30414	267	30681
	SM		26.0	7.52	36.9	43	30362	237	30599
	SB		24.7	7.34	38.6	25	30374	266	30640
	NS	1.4	32.2	7.64	34.5	17	30360	238	30598
	NM		31.7	7.34	35.3	35	30312	193	30505
	NB		31.0	7.18	36.9	33	30284	172	30456
W14	SS	3.9	26.2	7.46	37.8	42	30510	241	30751
	SM		25.7	7.53	35.3	45	30362	269	30631
	SB		25.2	7.25	36.9	43	30342	262	30604
	NS	2.9	31.7	7.63	36.1	44	30422	264	30686
	NM		31.2	7.21	38.6	47	30384	275	30659
	NB		31.2	7.13	36.9	32	30262	199	30461

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	5.0	49	<2	<0.1	<0.01	1	87
	SM	4.7	41	-	-	-	-	-
	SB	4.9	45	-	-	-	-	-
	NS	5.9	37	<2	<0.1	<0.01	2	42
	NM	5.7	53	-	-	-	-	-
	NB	5.9	33	-	-	-	-	-
W12	SS	5.1	53	<2	0.1	<0.01	2	<30
	SM	4.5	37	-	-	-	-	-
	SB	4.4	33	-	-	-	-	-
	NS	5.6	48	<2	<0.1	<0.01	<1	51
	NM	5.6	49	-	-	-	-	-
	NB	5.7	45	-	-	-	-	-
W13	SS	5.0	45	<2	0.1	<0.01	1	64
	SM	5.0	37	-	-	-	-	-
	SB	5.5	49	-	-	-	-	-
	NS	5.6	41	<2	0.1	<0.01	1	<30
	NM	5.5	57	-	-	-	-	-
	NB	5.6	53	-	-	-	-	-
W14	SS	5.5	53	<2	<0.1	<0.01	2	<30
	SM	5.3	41	-	-	-	-	-
	SB	5.3	57	-	-	-	-	-
	NS	5.6	45	<2	<0.1	<0.01	2	47
	NM	6.0	49	-	-	-	-	-
	NB	5.7	37	-	-	-	-	-

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 May, 2015

Sample Name	Organic Matter		Total Carbon		Inorganic Phosphate
	mg/g	%	mg/g	%	mg/kg
W11	Sediment not found				
W12					
W13	177.6	17.8	103.0	10.3	107
W14	154.7	15.5	89.7	9.0	103

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	28.8 – 31.7	°C	-
2	pH	7.1 – 8.0	-	6.5 - 9.0
3	Salinity	33.7 – 41.9	ppth	-
4	Turbidity	1.0 – 63.0	NTU	-
5	TDS	30148 – 30534	mg/L	-
6	TSS	21 – 306	mg/L	-
7	TS	30235 – 30728	mg/L	-
8	DO	5.7 – 6.4	mg/L	3.0 mg/L or 40% of saturation value
9	COD	27.8 – 53.5	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 – 10	mg/L	10
14	Total Plate Count	43 – 154	CFU/ml	-
15	Fecal Coliforms	2 – 30	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	24.7 – 32.2	°C	-
2	pH	7.0 – 7.6	-	6.5 - 9.0
3	Salinity	32.8 – 38.6	Ppth	-
4	Turbidity	10.0 – 60.0	NTU	-
5	TDS	29948 – 30510	mg/L	-
6	TSS	134 – 305	mg/L	-
7	TS	30201 – 3751	mg/L	-
8	DO	4.4 – 6.0	mg/L	3.0 mg/L or 40% of saturation value
9	COD	33 – 57	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	42 – 87	CFU/ml	-
15	Fecal Coliforms	2 – 11	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 May, 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 May, 2015 are found to be well within prescribed limits.

Observed salinity values for Harbor and Creek water samples in the month of May, 2015 are ranges from 32.8 to 38.6 ppth. [Refer Tables 11 and 14]. The ranges observed for COD values in mg/L are 27.8 – 53.4 and 32.6 – 57.1 respectively for Harbor and Creek water samples. The DO levels are ranges between 4.4 to 6.4 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 May, 2015. The values obtained for Organic Matter, Total Organic Carbon and Inorganic Phosphate are ranges between 9.1 – 15.0%, 5.3% – 8.7% and 89 – 140 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 15.5 & 17.8%, 9.0 & 10.3% and 103– 107 mg/kg, respectively for sediment samples collected from Nhava Creek area during the month of May, 2015.

2.5 OBSERVATIONS AND CONCLUSIONS

Observations for the month of May:

- ✓ *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 May, 2015. The characteristic parameters for sediments are also showing normal variation in concentrations for JNP Harbor area and Nhava Creek area during May, 2015. Considering the activities in the Harbor area and the results obtained for the month of May, 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 Harbour Area			
1.	W1	625	575
2.	W2	475	350
3.	W3	415	375
4.	W4	675	515
5.	W5	375	215
6.	W6	215	175
7.	W7	375	215
8.	W8	475	310
9.	W9	315	275
Nhava Creek Area			
10.	W11	475	375
11.	W12	315	275
12.	W13	375	275
13.	W14	475	315

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	Chryso-phyceae
1	W1	Surface	521	40	30	30	-
		Bottom	430	50	20	10	20
2	W2	Surface	570	55	15	20	10
		Bottom	380	60	20	20	-
3	W3	Surface	320	40	20	20	20
		Bottom	210	50	30	10	10
4	W4	Surface	640	50	20	20	10
		Bottom	525	50	20	10	20
5	W5	Surface	510	45	30	15	10
		Bottom	370	50	20	10	20
6	W6	Surface	420	50	20	10	20
		Bottom	370	40	20	20	20
7	W7	Surface	650	50	10	20	20
		Bottom	520	50	20	10	20
8	W8	Surface	650	80	10	10	-
		Bottom	510	50	30	10	10
9	W9	Surface	420	52	18	20	10
		Bottom	270	50	10	20	20
Nhava Creek							
10	W11	Surface	520	50	20	20	10
		Bottom	415	40	20	20	20
11	W12	Surface	400	50	20	20	10
		Bottom	290	45	15	20	20
12	W13	Surface	530	40	10	20	30
		Bottom	410	50	20	10	20
13	W14	Surface	450	70	20	10	-
		Bottom	390	50	10	20	20

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

Sr.	Bacillariophyceae	Chlorophyceae	Cyanophyceae	Chrysophyceae
1.	<i>Navicula</i> sp.	<i>Closterium</i> sp.	<i>Gloeocapsa</i> sp.	<i>Coscinodiscus</i> sp.
2.	<i>Nitzschia</i> sp.	<i>Cosmarium</i> sp.	<i>Oscillatoria</i> sp.	-
3.	<i>Gyrosigma</i> sp.	<i>Scenedesmus</i> sp.	<i>Anabaena</i> sp.	-
4.	<i>Fragillaria</i> sp.	<i>Ulothrix</i> sp.	<i>Aphanocapsa</i> sp. sp.	-
5.	<i>Surirella</i> sp.	<i>Pandorina</i> sp.	<i>Merismopedia</i> sp.	-
6.	<i>Triceratium</i> sp.	-	-	-
7.	<i>Pleurosigma</i> sp.	-	-	-
8.	<i>Mastogloia</i> sp.	-	-	-
9.	<i>Coscinodiscus</i> sp.	-	-	-
10.	<i>Stephanodiscus</i> sp.	-	-	-
11.	<i>Gomphoneis</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
2.	W2	50
3.	W3	40
4.	W4	50
5.	W5	40
6.	W6	40
7.	W7	40
8.	W8	30
9.	W9	50
Nhava Creek Area		
10.	W11	50
11.	W12	50
12.	W13	40
13.	W14	50

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			
			Copepoda	Cladocera	Foraminifera	Rotifera
1.	W1-W2	340	40	20	20	20
2.	W2-W5	410	50	30	20	-
3.	W5-W1	460	50	10	20	20
4.	W5-W6	620	50	30	20	-
5.	W6-W2	320	65	15	10	10
6.	W4-W3	410	70	20	10	-
7.	W3-W7	370	40	20	20	20
8.	W7-W10	420	50	30	10	10
9.	W10-W3	290	60	30	10	-
10.	W9-W3	375	45	15	20	20
11.	W5-W11	340	45	30	15	10
12.	W11-W12	560	40	20	20	20
13.	W12-W13	510	65	20	15	-
14.	W13-W14	470	50	20	20	10

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>Rotalia</i> sp.
2.	<i>Diaptomus</i> sp.	<i>Brachionus</i> sp.	<i>Moina</i> sp.	<i>Taberina</i> sp.
3.	<i>Bryocamptus</i> sp.	<i>Asplanchna</i> sp.	<i>Alonella</i> sp.	<i>Globulina</i> sp.
4.	-	<i>Filinia</i> sp.	-	-
5.	-	<i>Philodina</i> sp.	-	-
6.	-	<i>Lecane</i> sp.	-	-

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 (mg/m ³)
		Surface	Bottom	Surface	Bottom	
JNP Harbour Area						
1.	W1	4.2	2.9	BDL	BDL	280
2.	W2	3.7	3.1	BDL	BDL	246
3.	W3	4.9	3.4	BDL	BDL	326
4.	W4	5.1	4.2	BBL	BDL	339
5.	W5	3.2	2.2	BDL	BDL	213
6.	W6	3.4	2.6	BDL	BDL	226
7.	W7	2.5	2.1	BDL	BDL	166
8.	W8	5.6	4.4	BDL	BDL	373
9.	W9	3.1	2.1	BDL	BDL	206
Nhava Creek Area						
10.	W11	4.2	3.1	BDL	BDL	280
11.	W12	3.6	2.3	BDL	BDL	240
12.	W13	4.3	2.9	BDL	BDL	286
13.	W14	3.9	2.1	BDL	BDL	260

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

Sr. No.	Station	POC, [mg/m ³]
Standard		10 - 100
JNP Harbor Area		
1.	W1	458
2.	W2	514
3.	W3	608
4.	W4	902
5.	W5	461
6.	W6	1035
7.	W7	461
8.	W8	407
9.	W9	640
Nhava Creek Area		
10.	W11	790
11.	W12	661
12.	W13	427
13.	W14	741

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

Sr. No.	Station	Macrobenthos [No/m ²]	Percent Composition of Macrobenthos			
			Foraminifera	Gastropods	Polychaeta	Chironomidae
1.	W1	370	40	20	20	20
2.	W2	460	60	20	10	10
3.	W3	360	55	25	20	-
4.	W4	350	65	15	20	-
5.	W6	290	45	25	20	10
6.	W7	390	60	20	20	-
7.	W8	410	50	30	20	-
8.	W13	415	65	20	15	-
9.	W14	210	55	25	15	5

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 ⁻ , [mg/L]	SO ₄ ²⁻ , [mg/L]
Standard	-	-	-	-	0.1 - 90	1.0 - 500	<125	10 - 5000	-
JNP HARBOUR AREA									
W1	481	1482	296	10500	118	315	<10	2519	2294
W2	521	1507	292	10800	119	540	<10	2075	3026
W3	561	1507	294	10400	149	270	<10	1784	3118
W4	561	1531	300	10700	178	415	<10	1781	3069
W5	521	1458	296	10400	118	360	<10	1823	2856
W6	481	1531	292	10300	125	420	<10	2071	3033
W7	521	1434	292	10600	120	405	<10	1970	3027
W8	441	1531	298	10500	118	540	<10	1757	2955
W9	561	1434	294	10400	126	480	<10	1973	2489
JNP NHAVA CREEK AREA									
W11	481	1531	302	10300	123	355	<10	2347	3348
W12	561	1531	300	10800	123	640	<10	2192	2800
W13	441	1604	296	10900	166	875	<10	2385	2935
W14	521	1531	298	11000	159	365	<10	2491	3137

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

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	Sample not found								
W2	3680	632	240	7240	187	49	0.33	192	4266
W3	3840	197	400	5360	129	38	0.40	176	5217
W4	7920	197	420	5040	128	52	0.36	129	7679
W5	3040	437	270	6480	134	43	0.29	116	7633
W6	6400	146	410	5520	178	45	0.26	156	5544
W7	4640	197	330	5800	125	53	0.24	120	7012
W8	4320	389	270	6320	152	46	0.43	131	6094
W9	Sample not found								
JNP NHAVA CREEK AREA									
W11	Sample not found								
W12	Sample not found								
W13	5120	197	210	5280	153	43	0.46	144	6978
W14	4320	243	380	7040	143	47	0.29	121	3439

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 675 and 575 mgC/m³/d at stations W4 and W1 [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 Trivadrum (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.

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.

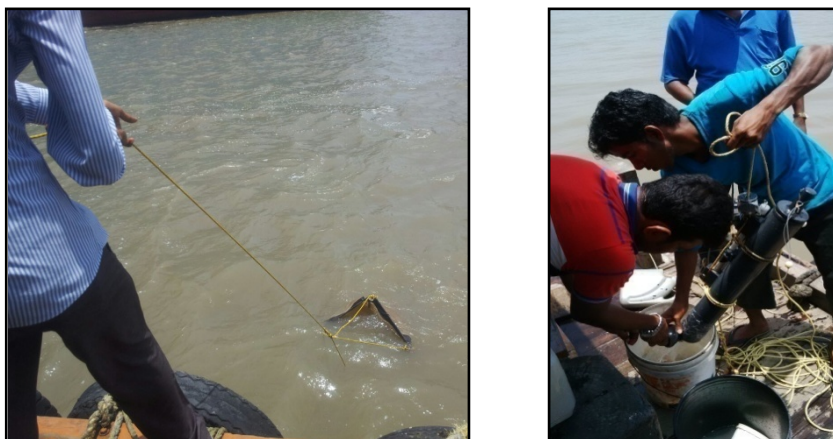


Plate 3.1: Collection of Plankton from JNP Harbour Area

A] Phytoplankton:

Count : Phytoplankton counts, recorded at different sampling stations, are presented in **Table 21**. Total algal population varied between 210 and 650 algal cells/ml. Samples collected at station W3(B) and W8(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 with twenty two different genera [**Table 22**]. The values also suggest low to medium impact of pollution or adverse factor. Some of the new genera like *Mastogloia*, *Stephanodiscus*, *Gomphoneis* etc. were observed. At station W8 Bacillariophyceae count was more which consumes silica might be a cause for less concentration of silica and high plankton count at this station.

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 30-50 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 290 and 620 N/m³ at stations W10-W3 and W5-W6. Total fifteen genera of zooplankton were recorded. Among zooplankton Copepoda and Cladocera group were dominant [**Table 25**]. Genera like *Philodina*, *Filinia* and *Lecane* were newly observed in the respective month. Some stations in JNP Harbour area and NHAVA creek represent the distribution of Hydromedusae species like *Blackfordia virginica* 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 166 and 373 mg/m³. The minimum algal biomass was (166 mg/m³) found at W7 and maximum (373 mg/m³) was found at W8 station. The lowest and highest chlorophyll *a* levels from surface water sample varied from 2.5 at station W7 to 5.6 mg/m³ at W8. High chlorophyll might be a cause of high plankton at respective station. Pheophytin concentrations of many samples were below detectable limit [Table 26]. Based on values of Chlorophyll-*a*, these waters can be classified as mesotrophic, that is of medium quality.

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 407 – 1035 mg/m³ with an average of 610 mg/m³. The minimum concentration of POC was found at W8 station and maximum concentration at W6 station. In Nhava creek the POC content was found to be between 427 – 790 mg/m³ with an average of 655 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* 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* and *Morula*. *Chironomous larva* from *Chironomidae* was also observed as benthic fauna. The highest count was 460 No/m² in sampling point W2. Benthos was absent at stations W9, W10, W11 and W12. The SWI values were observed to vary from 0.42 – 1.00 at stations W6 and W8.

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 118µg/L – 178µg/L. In JNP harbor region, the Phosphate value was found above prescribed standard range [0.1 – 90µg/L] at most of the stations. Nitrate was found to be between 270µg/L – 540µg/L. Minimum value of Nitrate was found at W3 station and maximum at W8 station. The average concentration of Nitrate was found to be 416µg/L and overall Nitrate was found within range [1.0 to 500µg/L] at all stations except W8 station. 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 1757 – 2519 µg/L with an average of 1972.6µg/L. The minimum concentration of silica was found at W8 station of JNP harbor region and the maximum concentration of silica was found at W1 station. The Sulphate was found between 2294 – 3118 mg/L. Minimum value recorded at W1 station and maximum at W3 station. The average concentration of Sulphate was found to be 2874 mg/L.

In Nhava Creek, Phosphate was found between 123µg/L – 166µg/L with an average 142.8µg/L which was above prescribed standard range [0.1-90µg/L]. Nitrate was found to be 355 – 875 µg/L with an average 558 µg/L. The silica content in Nhava creek was found to be 2192 – 2491 µg/L with an average of 2353 µg/L. The minimum silica content was found at station W12 station and maximum was found at W14 station. Sulphate was found between 2800 – 3348

mg/L with an average of 3055 mg/L. Minimum value for Sulphate was found at W12 station and maximum value at W11 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 125 – 187 mg/kg with an average of 147.6 mg/kg. The Nitrate was found minimum value at W3 station i.e. 38 mg/kg and maximum value at W7 station i.e. 53 mg/kg. The average concentration of Nitrate was found to be 46.4mg/kg. The Nitrite was found to be between 0.24 – 0.43 mg/kg with an average of 0.3 mg/kg. Silica in the form of silicate in JNP harbor sediments were found between 116 to 192 mg/kg with an average of 145.6 mg/kg. Minimum concentration of silica was found at W5 station and maximum value was found at W2 station. The Sulphate was found between 4266 to 7679 mg/kg, with minimum value at W2 station and maximum value at W4 station. The average concentration of Sulphate was found to be 6206.3 mg/kg.

In Nhava Creek region the sediment found at two locations out of four. Phosphate average level was 148 mg/kg. Nitrate was found to be 43 and 47 mg/kg. The average concentration of Nitrate was found to be 45 mg/kg. The Nitrite was found to be 0.46 and 0.29 mg/kg. Silica in the form of silicate in JNP harbor sediments was found to be 144 and 121 mg/kg with an average of 132.5 mg/kg. Sulphate was found to be 3439 and 6978 mg/kg. The average concentration of Sulphate was found to be 5208.5 mg/kg.

b. Cations:

In harbor region water, the Calcium was found between 441 to 561 mg/L with an average of 516.6 mg/L given in **Table 29**. The Magnesium was found to be 1434 – 1531 mg/L, with maximum value at W4 station. The average concentration of Magnesium was found to be 1490.4 mg/L. Potassium in JNP harbor water was found between 292 to 300 mg/L with an average of 294.9 mg/L. The minimum concentration of Potassium was found at W2, W6 and W7 stations and maximum value W4 station. The Sodium was found between 10300 to 10800 mg/L with an average of 10511.1 mg/L. Minimum concentration of sodium was found at W6 station and maximum value of at W2station.

In Nhava Creek, Calcium concentration was found with an average 501 mg/L given in **Table 29**. Magnesium concentration was found to be 1531 – 1604 mg/L with an average of 1549.1 mg/L. The minimum value of Magnesium was found at W11, W12 and W14 stations and maximum value was found at W13 stations. The Potassium content in Nhava creek was found to be 296 – 302 mg/L with an average of 299 mg/L. Sodium minimum concentration was found to be 10300 mg/L at W11 and maximum of 11000 mg/L at W14.

In harbor region sediments, the Calcium was found to be 30407920 to 8720 mg/Kg with an average of 4834.3 mg/Kg given in **Table 30**. The minimum Concentration of Calcium was found at W5 station and maximum concentration at W4 station. Magnesium was found to be 146 to 632 mg/Kg, with minimum value at W6 stations and maximum was recorded at W2 station. The

average concentration of Magnesium was found to be 313.6 mg/Kg. Potassium in JNP harbor sediment was found to be 240 to 420 mg/Kg with an average of 334.3 mg/Kg. The minimum concentration of Potassium was found at W2 station and maximum value at W4 station. Sodium was found to be 5040 to 7240 mg/Kg with an average of 5965.7 mg/Kg.

In Nhava Creek sediments, Calcium was found to be 4320 and 5120 mg/Kg with an average 4720 mg/Kg given in **Table 30**. Average magnesium was found to be 220.1 mg/Kg. Average potassium content in Nhava creek was found to be 295 mg/Kg. The minimum sodium value was found at W13 station and maximum value at W14.

3.5OBSERVATIONS 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 – 575 mgC/m ³ /day	-	Within Range
2.	Chlorophyll- <i>a</i>	< 4 mg/m ³ [Oligotrophic class] 4-10 mg/m ³ [Mesotrophic class] >10 mg/m ³ [Eutrophic classter]	The observed values falls under 2.5 – 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 – 114 µg/L; Creek area – 101.8 µg/L	A nutrient that acts as a fertilizer. High level of nutrient causes excessive plant and algal growth in aquatic ecosystem	Exceeds the Range
4.	Nitrate	1.0- 500 µg/L	Harbour area – 350 µg/L; Creek area – 587.5 µg/L	A nutrient produced in natural water by decomposition of nitrogenous organic compounds. Moderate level of nitrate.	Exceeds the Range in Creek area
5.	Nitrite	<125 µg/L	Harbour area – 27.7 µg/L & Creek area – <10µg/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 – 841 mg/m ³ ; Creek area – 895 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 – 1631.3 µg/L; Creek area – 1456 µg/L	Nucleic acid synthesis and skeletal formation of Diatoms.	Within Range

Observations for the month of May:

- ✓ *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 May, 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 May 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 08th May, 2015.

The water samples are analyzed for various parameters Colour, Odour, pH, Turbidity, Total Dissolved Solids, Aluminium as Al, NH_4^+ - N, Barium as Ba, Boron, Calcium as Ca, Chloride as Cl, Copper as Cu, Fluoride, Free Residual Chlorine, Iron as Fe, Magnesium as Mg, Manganese as Mn, Oil & grease, Nitrate as NO_3^- , Phenolic compound, Selenium as Se, Silver as Ag, Sulphate as SO_4^{2-} , Total Alkalinity as CaCO_3 , Total Hardness as CaCO_3 , Zinc as Zn, Cyanide, Lead as Pb, Mercury as Hg, Molybdenum as Mo, Nickel as Ni, Pesticides, Total Arsenic as As, Total Chromium as Cr, Total Coliforms and *E coli*

4.2 RESULTS

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

Table 33: Results of Drinking Water Quality

Parameter	Unit of Measurement	Station Name						Standards*
		DW1	DW2	DW3	DW4	DW5	DW6	
Colour	Hazen	<5	<5	<5	<5	<5	<5	5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
pH	-	7.37	7.46	7.52	7.20	7.64	7.75	6.5 to 8.5
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Total Dissolved Solids	mg/L	87	81	85	82	89	83	500
Aluminium as Al	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.03
NH ₄ ⁺ - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5
Barium as Ba	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7
Boron	mg/L	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.5
Calcium as Ca	mg/L	11	11	12	11	11	12	75
Chloride as Cl	mg/L	10.1	11.1	10.6	10.6	9.6	10.6	250
Copper as Cu	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05
Fluoride	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.0
Free Residual Chlorine	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Iron as Fe	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.3
Magnesium as Mg	mg/L	4	4	3	3	1	3	30
Manganese as Mn	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
Oil and grease	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Nitrate as NO ₃ ⁻	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	45
Phenolic compound	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Selenium as Se	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Silver as Ag	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Sulphate as SO ₄ ⁻²	mg/L	5.5	4.1	3.2	7.4	5.9	5.6	200
Total Alkalinity as CaCO ₃	mg/L	40	40	42	42	43	43	200
Total Hardness as CaCO ₃	mg/L	45	43	42	41	33	42	200
Zinc as Zn	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	5
Cyanide	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Lead as Pb	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Mercury as Hg	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.001
Molybdenum as Mo	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07
Nickel as Ni	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02
Pesticides	mg/L	ND	ND	ND	ND	ND	ND	0.5
Total Arsenic as As	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.01
Total Chromium as Cr	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Total Coliforms	MPN/100ml	Nil	Nil	2	Nil	Nil	2	Nil
E coli	MPN/100ml	Nil	Nil	2	Nil	Nil	2	Nil

*: IS 10500:2012, Drinking Water - Specification

Table 33: Results of Drinking Water Quality

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
pH	-	8.09	7.83	7.51	7.34	7.37	7.59	6.5 to 8.5
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Total Dissolved Solids	mg/L	92	86	86	84	88	85	500
Aluminium as Al	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.03
NH ₄ ⁺ - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5
Barium as Ba	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7
Boron	mg/L	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.5
Calcium as Ca	mg/L	14	12	11	10	12	11	75
Chloride as Cl	mg/L	9.6	10.1	9.6	9.2	9.6	9.6	250
Copper as Cu	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05
Fluoride	mg/L	0.4	<0.1	<0.1	0.2	0.2	<0.1	1.0
Free Residual Chlorine	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Iron as Fe	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.3
Magnesium as Mg	mg/L	3	3	4	4	3	4	30
Manganese as Mn	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
Oil and grease	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Nitrate as NO ₃ ⁻	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	45
Phenolic compound	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Selenium as Se	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Silver as Ag	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Sulphate as SO ₄ ⁻²	mg/L	4.7	4.0	5.5	5.5	5.7	5.5	200
Total Alkalinity as CaCO ₃	mg/L	47	44	42	42	41	42	200
Total Hardness as CaCO ₃	mg/L	46	43	43	42	42	43	200
Zinc as Zn	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	5
Cyanide	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Lead as Pb	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Mercury as Hg	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.001
Molybdenum as Mo	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07
Nickel as Ni	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02
Pesticides	mg/L	ND	ND	ND	ND	ND	ND	0.5
Total Arsenic as As	mg/L		<0.002	<0.002	<0.002	<0.002	<0.002	0.01
Total Chromium as Cr	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Total Coliforms	MPN/100ml	Nil	Nil	Nil	Nil	Nil	2	Nil
E coli	MPN/100ml	Nil	Nil	Nil	Nil	Nil	2	Nil

*: IS 10500:2012, Drinking Water - Specification

Table 33: Results of Drinking Water Quality

Parameter	Unit of Measurement	Station Name						Standards*
		DW13	DW14	DW15	DW16	DW17	DW18	
Colour	Hazen	<5	<5	<5	<5	<5	<5	5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
pH	-	7.41	7.83	7.79	7.39	8.12	7.40	6.5 to 8.5
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Total Dissolved Solids	mg/L	90	85	85	84	94	87	500
Aluminium as Al	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.03
NH ₄ ⁺ - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5
Barium as Ba	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7
Boron	mg/L	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.5
Calcium as Ca	mg/L	11	11	11	11	13	11	75
Chloride as Cl ⁻	mg/L	11.1	10.1	11.1	11.6	11.1	10.6	250
Copper as Cu	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05
Fluoride	mg/L	0.4	0.2	<0.1	<0.1	<0.1	0.5	1.0
Free Residual Chlorine	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Iron as Fe	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.3
Magnesium as Mg	mg/L	3	3	3	3	4	3	30
Manganese as Mn	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
Oil and grease	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Nitrate as NO ₃ ⁻	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	45
Phenolic compound	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Selenium as Se	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Silver as Ag	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Sulphate as SO ₄ ²⁻	mg/L	5.7	5.7	5.9	6.8	5.9	4.0	200
Total Alkalinity as CaCO ₃	mg/L	42	43	43	42	50	43	200
Total Hardness as CaCO ₃	mg/L	42	41	42	42	48	41	200
Zinc as Zn	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	5
Cyanide	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Lead as Pb	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Mercury as Hg	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.001
Molybdenum as Mo	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07
Nickel as Ni	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02
Pesticides	mg/L	ND	ND	ND	ND	ND	ND	0.5
Total Arsenic as As	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.01
Total Chromium as Cr	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Total Coliforms	MPN/100ml	Nil	2	Nil	Nil	Nil	Nil	Nil
E coli	MPN/100ml	Nil	2	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 9.2 to 11.6 mg/L; calcium 10.4 to 13.6 mg/L; magnesium 1.2 to 4.4 mg/L and sulphates 3.2 to 7.4 mg/L. The concentration of total dissolved solids is found to be between 81.0 to 94.0 mg/L and concentration of total hardness as CaCO_3 is found to be 33.0 to 48.0 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 acceptable range for pH is 6.5 to 8.5, while the observed pH range is 7.2 to 8.1. The iron content and other parameters were found to be well within the acceptable limit.

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 **May'15** reported NIL.

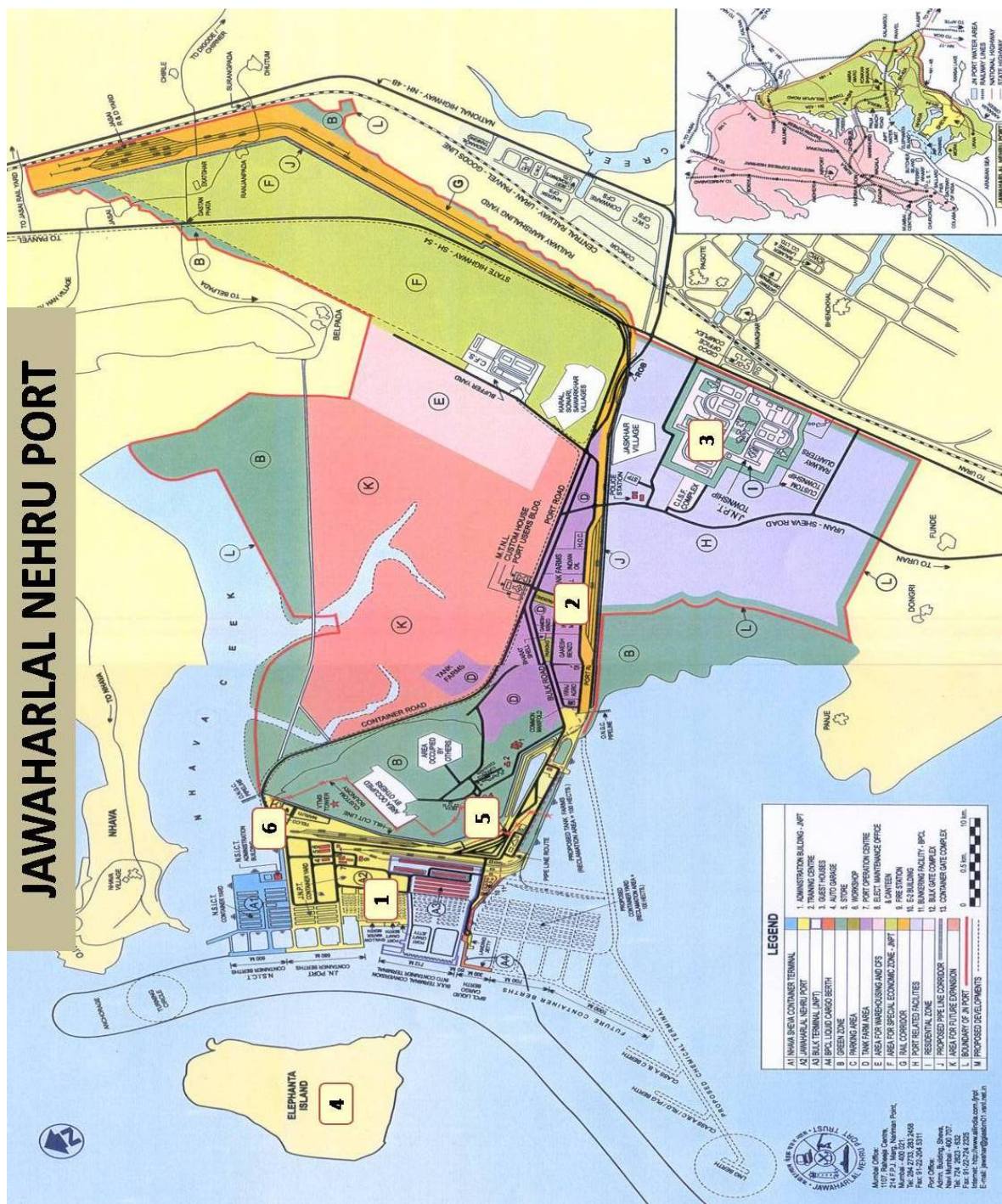
4.4 CONCLUSIONS

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 Todar, 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

JAWAHARLAL NEHRU PORT



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

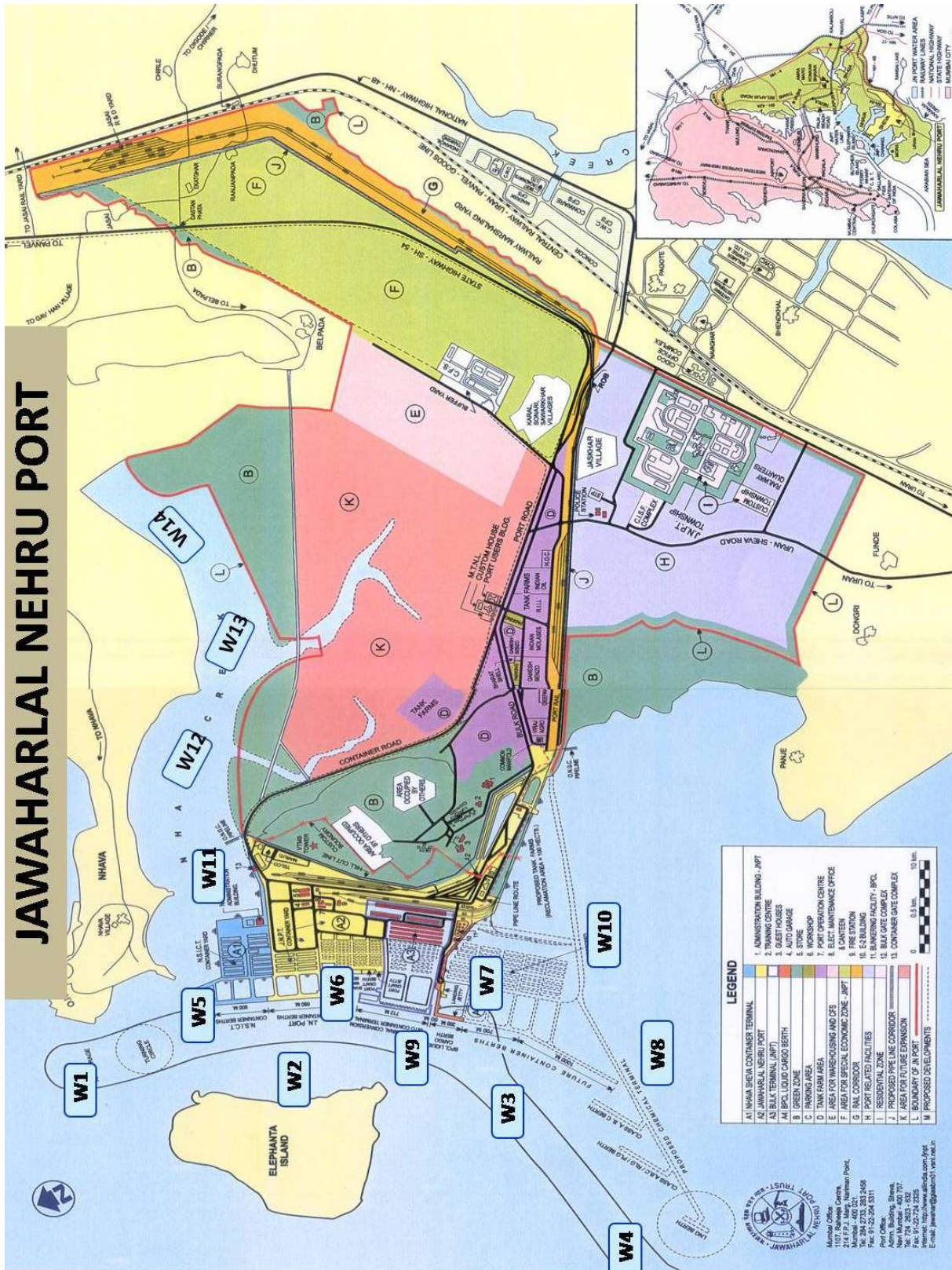
* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals

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

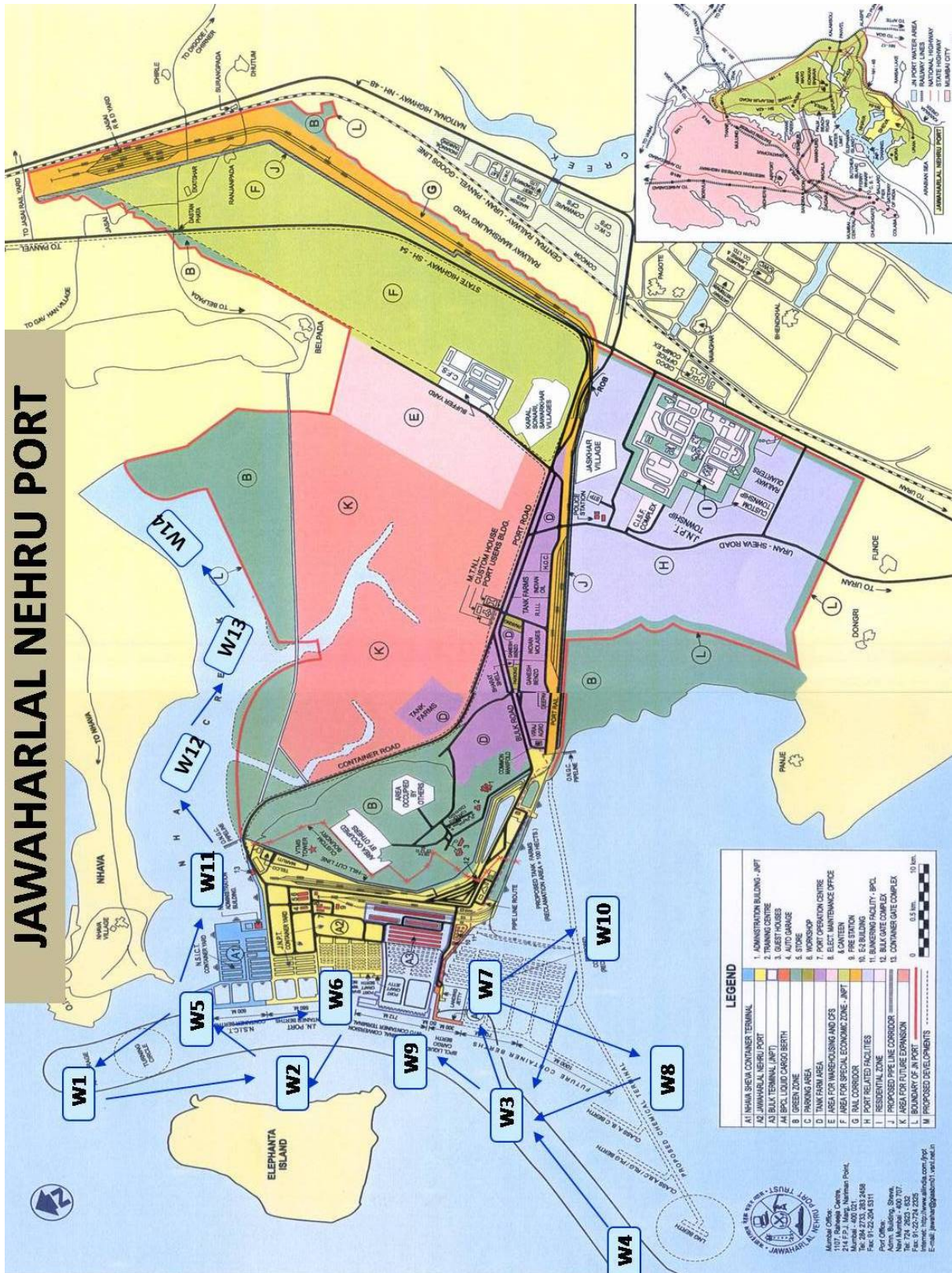
2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

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