



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 April, 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 NAAQMS	Date	Time, [Hrs]	PM ₁₀ , [µg/m³]		PM _{2.5} , [µg/m³]		SO ₂ , [µg/m³]		NO _x , [µg/m³]		NH ₃ , [µg/m³]			
			24 hr 100 µg/m³	24 hr 60 µg/m³	8 hr	24 hr (Avg) 80 µg/m³	8 hr	24 hr (Avg) 80 µg/m³	8 hr	24 hr (Avg) 80 µg/m³	8 hr	24 hr (Avg) 400 µg/m³		
POC-1	02.04.2015 to 03.04.2015	14:00 to 22:00	174	33	10	8.4	10	12.9	4	5.4				
		22:00 to 06:00			7		11		5					
		06:00 to 14:00			7		17		7					
POC-2	06.04.2015 to 07.04.2015	14:00 to 22:00	234	45	9	8.4	11	12.5	4	4.9				
		22:00 to 06:00			7		14		5					
		06:00 to 14:00			9		13		5					
POC-3	09.04.2015 to 10.04.2015	14:00 to 22:00	227	43	12	9.9	14	13.6	5	4.8				
		22:00 to 06:00			10		11		5					
		06:00 to 14:00			7		15		5					
POC-4	13.04.2015 to 14.04.2015	14:00 to 22:00	216	45	7	9.4	15	11.5	5	4.6				
		22:00 to 06:00			9		9		5					
		06:00 to 14:00			12		10		4					
POC-5	16.04.2015 to 17.04.2015	14:00 to 22:00	114	41	10	8.9	21	17.5	5	4.5				
		22:00 to 06:00			9		13		4					
		06:00 to 14:00			7		19		5					
POC-6	20.04.2015 to 21.04.2015	14:00 to 22:00	109	32	7	8.4	16	15.9	4	4.3				
		22:00 to 06:00			10		16		5					
		06:00 to 14:00			7		16		4					
POC-7	23.04.2015 to 24.04.2015	14:00 to 22:00	154	38	7	8.9	16	21.4	6	5.8				
		22:00 to 06:00			9		23		5					
		06:00 to 14:00			10		26		7					
POC-8	27.04.2015 to 28.04.2015	14:00 to 22:00	125	29	8	8.5	11	11.1	9	5.8				
		22:00 to 06:00			10		11		4					
		06:00 to 14:00			7		11		5					
POC-9	30.04.2015 to 01.05.2015	14:00 to 22:00	189	45	10	9.0	12	14.0	6	5.3				
		22:00 to 06:00			9		17		4					
		06:00 to 14:00			8		13		6					
Average Standard Dev			171	39		8.9		14.5		5.0				
			49	6		0.5		3.3		0.6				

Table 2: Results of Air Pollutant Concentration at POC Station																		
Sampling Period	Date	Time, [Hrs]	O ₃ , [µg/m ³]		Pb, [µg/m ³]		As, [ng/m ³]		Ni, [ng/m ³]		C 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	24 hr	6 ng/m ³	20 ng/m ³	24 hr	5 µg/m ³	1 ng/m ³	24 hr	4 ng/m ³	Grab Sampling	Grab Sampling		
NAAQMS																		
POC-1	02.04.2015	14:00 to 22:00			0.08	<1	<1	<1		2.8		<0.5		2.8		301		
	03.04.2015	06:00 to 14:00																
POC 2	06.04.2015	14:00 to 22:00			0.12	<1	<1	<1		3.1		<0.5		2.9		284		
	07.04.2015	06:00 to 14:00																
POC-3	09.04.2015	14:00 to 22:00			0.1	<1	<1	<1		2.4		<0.5		3.2		286		
	10.04.2015	06:00 to 14:00																
POC 4	13.04.2015	14:00 to 22:00			0.09	<1	<1	<1		3.4		<0.5		2.8		285		
	14.04.2015	06:00 to 14:00																
POC-5	16.04.2015	14:00 to 22:00			0.06	<1	<1	<1		3.2		<0.5		2.5		291		
	17.04.2015	06:00 to 14:00																
POC 6	20.04.2015	14:00 to 22:00			0.04	<1	<1	<1		2.8		<0.5		3.1		302		
	21.04.2015	06:00 to 14:00																
POC-7	23.04.2015	14:00 to 22:00			0.01	<1	<1	<1		2.9		<0.5		2.8		291		
	24.04.2015	06:00 to 14:00																
POC-8	27.04.2015	14:00 to 22:00			0.04	<1	<1	<1		2.4		<0.5		2.9		296		
	28.04.2015	06:00 to 14:00																
POC-9	30.04.2015	14:00 to 22:00			0.04	<1	<1	<1		3.1		<0.5		3.0		274		
	31.04.2015	06:00 to 14:00																
Average			29		0.06					2.9				2.9		290		
Standard Dev			6		0.04					0.3				0.2		9		

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]	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)
NAAQMS			100 µg/m ³	60 µg/m ³	-	-	-	-	-	-	-	-	-	-
IMC-1	02.04.2015 to 03.04.2015	15:00 to 23:00			16		35				5			
		23:00 to 07:00	257	68	7	12	13	20.2			4			4.0
		07:00 to 15:00			12		13				4			
IMC-2	06.04.2015 to 07.04.2015	15:05 to 23:05			10		15				6			
		23:05 to 07:05	345	50	7	8	12	12.2			5			5.2
		07:05 to 15:05			7		10				5			
IMC-3	09.04.2015 to 10.04.2015	15:10 to 23:10			7		10				5			
		23:10 to 07:10	248	47	7	8	14	12.7			5			5.0
		07:10 to 15:10			9		14				5			
IMC-4	13.04.2015 to 14.04.2015	14:50 to 22:50			9		9				5			
		22:50 to 06:50	274	30	9	9	11	10.9			5			5.2
		06:50 to 14:50			10		12				5			
IMC-5	16.04.2015 to 17.04.2015	15:00 to 23:00			13		17				6			
		23:00 to 07:00	153	28	15	15	19	19.2			5			4.8
		07:00 to 15:00			18		21				4			
IMC-6	20.04.2015 to 21.04.2015	15:00 to 23:00			16		17				5			
		23:00 to 07:00	127	25	16	16.4	17	26.5			4			4.1
		07:00 to 15:00			16		18				4			
IMC-7	23.04.2015 to 24.04.2015	15:00 to 23:00			18		28				5			
		23:00 to 07:00	201	32	21	17.4	30	26.5			0			6.0
		07:00 to 15:00			13		14				5			
IMC-8	27.04.2015 to 28.04.2015	15:00 to 23:00			15		23				6			
		23:00 to 07:00	109	33	13	12.9	14	16.6			5			5.5
		07:00 to 15:00			10		13				6			
IMC-9	30.04.2015 to 01.05.2015	15:00 to 23:00			10		14				6			
		23:00 to 07:00	240	56	12	10.3	16	15.0			6			6.3
		07:00 to 15:00			9		15				7			
Average			226	41		12.2		17.8						5.1
Standard Dev			66	15		3.5		5.8						0.8

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	100 µg/m ³	24 hr	1.0 µg/m ³	6 ng/m ³	20 ng/m ³	8 hr	5 µg/m ³	24 hr	1 ng/m ³	24 hr	4 mg/m ³	Grab Sampling	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS																		
IMC-1	02.04.2015 to 03.04.2015	15:00 to 23:00	28		<1	0.18	<1	<1	2.5	<1	<0.5	3.1	284					
		07:00 to 15:00	32		<1	0.16	<1	<1	2.4	<1	<0.5	2.9	285					
IMC-2	06.04.2015 to 07.04.2015	15:05 to 23:05	27		<1	0.09	<1	<1	2.1	<1	<0.5	3.2	294					
		23:05 to 07:05	31		<1	0.11	<1	<1	0.8	<1	<0.5	2.9	284					
IMC-3	09.04.2015 to 10.04.2015	15:10 to 23:10	26		<1	0.09	<1	<1	0.8	<1	<0.5	3.1	293					
		23:10 to 07:10	22		<1	0.06	<1	<1	1.3	<1	<0.5	2.6	301					
IMC-4	13.04.2015 to 14.04.2015	14:50 to 22:50	24		<1	0.12	<1	<1	2.4	<1	<0.5	3.1	304					
		22:50 to 06:50	28		<1	0.1	<1	<1	1.9	<1	<0.5	2.9	298					
IMC-5	16.04.2015 to 17.04.2015	15:00 to 23:00	33		<1	0.08	<1	<1	2.1	<1	<0.5	2.4	304					
		23:00 to 07:00	28		<1	0.1	<1	<1	1.9	<1	<0.5	2.9	298					
IMC-6	20.04.2015 to 21.04.2015	15:00 to 23:00	24		<1	0.12	<1	<1	2.4	<1	<0.5	3.1	304					
		23:00 to 07:00	28		<1	0.1	<1	<1	1.9	<1	<0.5	2.9	298					
IMC-7	23.04.2015 to 24.04.2015	15:00 to 23:00	33		<1	0.08	<1	<1	2.1	<1	<0.5	2.4	304					
		23:00 to 07:00	28		<1	0.1	<1	<1	1.9	<1	<0.5	2.9	298					
IMC-8	27.04.2015 to 28.04.2015	15:00 to 23:00	28		<1	0.1	<1	<1	1.9	<1	<0.5	2.9	298					
		23:00 to 07:00	33		<1	0.08	<1	<1	2.1	<1	<0.5	2.4	304					
IMC-9	30.04.2015 to 01.05.2015	15:00 to 23:00	28		<1	0.11	<1	<1	1.8	<1	<0.5	2.9	294					
		23:00 to 07:00	4		<1	0.04	<1	<1	0.7	<1	<0.5	0.3	8					
Average																		
Standard Dev																		

Table 4: Results of Air Pollutant Concentration at RC Station														
Sampling Period NAAQMS	Date	Time, [Hrs]	PM ₁₀ , [µg/m³]		PM _{2.5} , [µg/m³]		SO ₂ , [µg/m³]		NO _x , [µg/m³]		NH ₃ , [µg/m³]			
			24 hr 100 µg/m³	24 hr 60 µg/m³	24 hr 60 µg/m³	8 hr 80 µg/m³	8 hr 80 µg/m³	8 hr 80 µg/m³	8 hr 80 µg/m³	8 hr 80 µg/m³	24 hr (Avg) 400 µg/m³			
RC-1	02.04.2015 to 03.04.2015	15:20 to 23:20					7		10		7			
		23:20 to 07:20	153	31			7	7	11	12.2	5	5.4		
		07:20 to 15:20					7		15		5			
RC-2	06.04.2015 to 07.04.2015	15:30 to 23:30					9		9		4			
		23:30 to 07:30	289	46			10	10	11	11.9	4	4.3		
		07:30 to 15:30					12		15		5			
RC-3	09.04.2015 to 10.04.2015	15:35 to 23:35					10		11		4			
		23:35 to 07:35	290	32			7	10	10	12.0	5	4.8		
		07:35 to 15:35					12		14		5			
RC-4	13.04.2015 to 14.04.2015	15:30 to 23:30					10		9		4			
		23:30 to 07:30	266	48			9	9	9	9.5	5	4.7		
		07:30 to 15:30					9		10		5			
RC-5	16.04.2015 to 17.04.2015	15:30 to 23:30					10		14		5			
		23:30 to 07:30	161	33			12	11	14	14.1	4	4.4		
		07:30 to 15:30					10		14		4			
RC-6	20.04.2015 to 21.04.2015	15:30 to 23:30					9		10		4			
		23:30 to 07:30	142	15			9	9	11	10.5	5	4.4		
		07:30 to 15:30					9		11		5			
RC-7	23.04.2015 to 24.04.2015	15:30 to 23:30					10		12		5			
		23:30 to 07:30	287	45			11	10	13	12.3	6	6.0		
		07:30 to 15:30					9		12		7			
RC-8	27.04.2015 to 28.04.2015	15:30 to 23:30					15		26		5			
		23:30 to 07:30	234	34			13	15	14	20.8	5	5.3		
		07:30 to 15:30					18		23		6			
RC-9	30.04.2015 to 01.05.2015	15:30 to 23:30					9		12		5			
		23:30 to 07:30	216	31			12	11	16	14.0	8	6.7		
		07:30 to 15:30					11		14		7			
Average			226	35				10.3		13.0		5.1		
Standard Dev			61	10				2.2		3.3		0.8		

Sampling Period	Date	Time, [Hrs]	O ₃ , [µg/m ³]		Pb, [µg/m ³]		As, [ng/m ³]		Ni, [ng/m ³]		CdH ₁₆ , [µg/m ³]		BuP, [ng/m ³]		CO, [mg/m ³]		CO ₂ , [ppm]	
			8 hr	100 µg/m ³	24 hr	1.0 µg/m ³	24 hr	6 ng/m ³	20 ng/m ³	5 µg/m ³	24 hr	1 ng/m ³	4 mg/m ³	Grnh Sampling	Grnh Sampling	Grnh Sampling	Grnh Sampling	
RC-1	02.04.2015 to 03.04.2015	15:20 to 23:20	33		0.04		<1	<1	<1	2.8	<0.5		3.2		287			
		07:20 to 15:20																
RC-2	06.04.2015 to 07.04.2015	15:30 to 23:30	24		0.15		<1	<1	<1	2.4	<0.5		2.7		298			
		07:30 to 15:30																
RC-3	09.04.2015 to 10.04.2015	15:35 to 23:35	28		0.1		<1	<1	<1	2.1	<0.5		2.8		301			
		07:35 to 15:35																
RC-4	13.04.2015 to 14.04.2015	15:30 to 23:30	23		0.09		<1	<1	<1	2.6	<0.5		2.0		294			
		07:30 to 15:30																
RC-5	16.04.2015 to 17.04.2015	15:30 to 23:30	41		0.05		<1	<1	<1	1.2	<0.5		2.1		304			
		07:30 to 15:30																
RC-6	20.04.2015 to 21.04.2015	15:30 to 23:30	28		0.04		<1	<1	<1	1.6	<0.5		2.5		310			
		07:30 to 15:30																
RC-7	23.04.2015 to 24.04.2015	15:30 to 23:30	24		0.1		<1	<1	<1	2.1	<0.5		1.9		297			
		07:30 to 15:30																
RC-8	27.04.2015 to 28.04.2015	15:30 to 23:30	25		0.05		<1	<1	<1	2.1	<0.5		2.3		205			
		07:30 to 15:30																
RC-9	30.04.2015 to 01.05.2015	15:30 to 23:30	31		0.11		<1	<1	<1	2.3	<0.5		2.4		289			
		07:30 to 15:30																
Average Standard Dev			29		0.08					2.1			2.4		296			
			6		0.04					0.5			0.4		8			

Table 7: Results of Air Pollutant Concentration at SGC 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]	
		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)
EC	09.4.2015 to 10.04.2015	14:00 to 22:00				12		24		9	
		22:00 to 06:00	229	19		15	13.9	25	25.5	8	7.0
		06:00 to 14:00				15		28		4	

Table 7: Results of Air Pollutant Concentration at SGC 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]	
		8 hr	100 µg/m ³	24 hr	1.0 µg/m ³	24 hr	6 ng/m ³	24 hr	20 ng/m ³	8 hr	5 µg/m ³	24 hr	1 ng/m ³	Grab Sampling	4 mg/m ³	Grab Sampling	289
EC	09.4.2015 to 10.04.2015	14:00 to 22:00															
		22:00 to 06:00	26	0.08													
		06:00 to 14:00															

Table 6: Results of Air Pollutant Concentration at NGC Station

Sampling Period NAAQMS	Date	Time, [Hrs]	PM ₁₀ , [$\mu\text{g}/\text{m}^3$]		PM _{2.5} , [$\mu\text{g}/\text{m}^3$]		SO ₂ , [$\mu\text{g}/\text{m}^3$]		NO _x , [$\mu\text{g}/\text{m}^3$]		NH ₃ , [$\mu\text{g}/\text{m}^3$]	
			24 hr	100 $\mu\text{g}/\text{m}^3$	24 hr	60 $\mu\text{g}/\text{m}^3$	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)
NG-1	02.04.2015 to 03.04.2015	16:00 to 00:00					9		11		6	
		00:00 to 08:00	192	32		10	10.4		12	13.4	5	4.6
		08:00 to 16:00				12			17		4	
NG-2	09.04.2015 to 10.04.2015	15:50 to 23:50					10		11		5	
		23:50 to 07:50	248	31		7	8.9		11	10.5	4	4.5
		07:50 to 15:50				9			9		5	
NG-3	16.04.2015 to 17.04.2015	15:40 to 23:40					13		9		4	
		23:40 to 07:40	142	32		10	11.9		26	16.7	5	4.3
		07:40 to 15:40				12			15		4	
NG-4	23.04.2015 to 24.04.2015	15:40 to 23:40					7		11		7	
		23:40 to 07:40	201	36		10	9.9		10	10.4	9	8.4
		07:40 to 15:40				12			9		10	
NG-5	30.04.2015 to 01.05.2015	15:40 to 23:40					10		11		4	
		23:40 to 07:40	153	29		12	11.7		13	12.7	5	5.3
		07:40 to 15:40				13			14		7	
Average			187	32	3			10.6	12.7		5.4	1.7
Standard Dev			42	3				1.2	2.6			

Sampling Period NAAQMS	Date	Time, [Hrs]	O ₃ , [µg/m ³]		Pb, [µg/m ³]		As, [µg/m ³]		Ni, [µg/m ³]		Cd, [µg/m ³]		Cr, [µg/m ³]		Mn, [µg/m ³]		Cu, [µg/m ³]		Zn, [µg/m ³]		CO, [mg/m ³]		SO ₂ , [ppm]		
			8 hr	100 µg/m ³	24 hr	1.0 µg/m ³	24 hr	6 ng/m ³	24 hr	20 ng/m ³	24 hr	5 µg/m ³	8 hr	24 hr	1 ng/m ³	4 ng/m ³	4 ng/m ³	4 ng/m ³	4 ng/m ³	4 ng/m ³	4 ng/m ³	4 ng/m ³	4 ng/m ³	4 ng/m ³	4 ng/m ³
NG-1	02.04.2015 to 03.04.2015	16:00 to 00:00																							
		00:00 to 08:00	63		0.1	<1	<1	<1	<1	1.8															
		08:00 to 16:00																							
NG-2	09.04.2015 to 10.04.2015	15:50 to 23:50	56		0.13	<1	<1	<1	<1	2.1															
		23:50 to 07:50																							
		07:50 to 15:50																							
NG-3	16.04.2015 to 17.04.2015	15:40 to 23:40	23		0.06	<1	<1	<1	<1	2.4															
		23:40 to 07:40																							
		07:40 to 15:40																							
NG-4	23.04.2015 to 24.04.2015	15:40 to 23:40	41		0.07	<1	<1	<1	<1	2.1															
		23:40 to 07:40																							
		07:40 to 15:40																							
NG-5	30.04.2015 to 01.05.2015	15:40 to 23:40	10		0.1	<1	<1	<1	<1	2.3															
		23:40 to 07:40																							
		07:40 to 15:40																							
Average			40		0.09					2.1															
Standard Dev			20		0.03					0.2															

Sampling Period	Date	Time, [Hrs]	NAAQMS									
			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)	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
SG-1	06.04.2015 to 07.04.2015	16:30 to 00:30	242	58	7	13	5	14.0	5	4.5		
		00:30 to 08:30			7	15	5					
		08:30 to 16:30			13	14	4					
SG-2	13.04.2015 to 14.04.2015	16:15 to 00:15	227	45	7	11	5	10.2	5	4.6		
		00:15 to 08:15			7	10	5					
		08:15 to 16:15			9	9	4					
SG-3	20.04.2015 to 21.04.2015	16:15 to 00:15	181	32	7	16	4	15.7	4	4.3		
		00:15 to 08:15			9	16	5					
		08:15 to 16:15			10	16	4					
SG-4	27.04.2015 to 28.04.2015	16:15 to 00:15	202	42	15	23	4	20.8	4	5.3		
		00:15 to 08:15			18	26	5					
		08:15 to 16:15			12	14	7					
Average			213	44		10.3		15.2		4.7		
Standard Dev			27	11		3.1		4.4		0.4		

Table 7: Results of Air Pollutant Concentration at SGC Station												
Sampling Period	Date	Time, [Hrs]	NAAQMS									
			O ₃ , [µg/m ³]	Pb, [µg/m ³]	As, [ng/m ³]	Ni, [ng/m ³]	CdH ₁₆ , [µg/m ³]	BaP, [ng/m ³]	CO, [ng/m ³]	CO ₂ , [ppm]		
			8 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			
SG-1	06.04.2015 to 07.04.2015	16:30 to 00:30	21	0.13	<1	<1	1.9	<0.5	2.9	294		
		00:30 to 08:30										
SG-2	13.04.2015 to 14.04.2015	08:30 to 16:30	24	0.14	<1	<1	2.4	<0.5	3.1	310		
		16:15 to 00:15										
SG-3	20.04.2015 to 21.04.2015	00:15 to 08:15	15	0.1	<1	<1	2.1	<0.5	2.5	305		
		08:15 to 16:15										
SG-4	27.04.2015 to 28.04.2015	16:15 to 00:15	28	0.15	<1	<1	1.8	<0.5	2.4	312		
		00:15 to 08:15										
Average			22	0.13			2.1		2.7	305		
Standard Dev			5	0.02			0.3		0.3	8		

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 April, 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 April, 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 April, 2015

STATION	PM ₁₀ , [μg/m ³]	PM _{2.5} , [μg/m ³]	SO ₂ , [μg/m ³]	NO _x , [μg/m ³]	NH ₃ , [μg/m ³]	O ₃ , [μg/m ³]	Pb [μg/m ³]	C ₆ H ₆ , [μg/m ³]	CO, [mg/m ³]	CO ₂ , [ppm]
NAAQMS	100	60	80	80	400	100	1	5	4	-
INDUSTRIAL AREA										
POC	171 ± 49	39 ± 06	8.9 ± 0.5	14.5 ± 3.3	5.0 ± 0.6	29 ± 06	0.06 ± 0.04	2.9 ± 0.3	2.9 ± 0.2	290 ± 09
IMC	226 ± 66	41 ± 15	12.2 ± 3.5	17.8 ± 5.8	5.1 ± 0.8	28 ± 04	0.11 ± 0.04	1.8 ± 0.7	2.9 ± 0.3	294 ± 08
NG	187 ± 42	32 ± 03	10.6 ± 1.2	12.7 ± 2.6	5.4 ± 1.7	40 ± 20	0.09 ± 0.03	2.1 ± 0.2	2.8 ± 0.3	293 ± 06
SG	213 ± 27	44 ± 11	10.3 ± 3.1	15.2 ± 4.4	4.7 ± 0.4	22 ± 05	0.13 ± 0.02	2.1 ± 0.3	2.7 ± 0.3	305 ± 08
RESIDENTIAL AREA										
RC	226 ± 61	35 ± 10	10.3 ± 2.2	13.0 ± 3.3	5.1 ± 0.8	29 ± 06	0.08 ± 0.04	2.1 ± 0.5	2.4 ± 0.4	296 ± 08
ECO-SENSITIVE AREA										
EC	229	19	13.9	25.5	7.0	26	0.08	1.1	2.5	289

Daily average pollutant levels are depicted in **Table 2 to 7**. The concentrations obtained for particulate matter concentrations at all stations do not comply with the national standards. All remaining gaseous pollutants were found well below the prescribed limits. Monthly average values obtained for the month of April, 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 IMC i.e. major industrial activity area handling liquid chemical and also most congested road. Followed by SGC i.e. port vehicle entry point and RC i.e. location representing residential area have particulate concentrations above prescribed standards because of ongoing road maintenance and building renovation work.

Results for the air quality parameters at Elephanta Caves [EC] station during 09th April'14 to 10th April'14 were tabulated in **Table 5**. Particulate and gaseous pollutant concentrations were recorded below the prescribed standards for Ecologically Sensitive area. **Table 6 & Table 7** provide the results for NGC and SGC air monitoring stations respectively. These stations are the ultimate entry points for all the vehicular traffic i.e. container carrying heavy vehicles, light motor vehicles, buses and passenger cars moving in and out of port operation area. In April, 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 April'15:

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



Traffic movement 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.	08 th April, 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	08 th April, 2015
3.	W3	Identified by the green buoy no. <u>FG2 Green</u> of JNPT approach channel and lies near the landing jetty.	09 th April, 2015
4.	W4	Located at Uran Patch Beacon (lighthouse on concrete platform) near the Butcher Island filling platform.	09 th April, 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	08 th April, 2015
	W11 to W14		10 th April, 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.	08 th April, 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.	09 th April, 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	09 th April, 2015
9.	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.	09 th April, 2015

Table 10: List of Parameters to Monitor Marine Water Quality

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

2.3RESULTS

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

Table 11: Results of Physico-Chemical Analysis of Water Samples Collected from JNP Harbor Area during April, 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	9.5	25.3	7.00	34.5	26	30712	85	30797
	SM		25.1	7.63	33.7	42	30690	111	30801
	SB		25	7.38	35.3	33	30688	120	30808
	NS	9	24.6	7.67	34.5	44	30614	123	30737
	NM		24.5	7.69	34.5	30	30598	131	30729
	NB		24.5	7.64	35.3	23	30608	149	30757
W2	SS	4.5	25.4	7.57	33.7	47	30710	172	30882
	SM		25.2	7.82	34.5	43	30628	215	30843
	SB		25.1	7.80	35.3	26	30642	106	30748
	NS	3.8	25	7.51	34.5	20	30590	105	30695
	NM		24.6	7.49	36.1	57	30582	217	30799
	NB		24.6	7.87	41.9	15	30572	172	30744
W3	SS	9.6	24.5	7.89	36.9	18	30580	47	30627
	SM		24.2	7.74	36.9	20	30544	98	30642
	SB		24.1	7.87	36.1	21	30512	68	30580
	NS	8.7	24.4	7.62	37.8	10	30622	37	30659
	NM		24.2	7.90	34.8	12	30648	61	30709
	NB		24.3	7.72	35.3	14	30576	54	30630
W4	SS	8.6	24.7	7.77	34.5	17	30534	42	30576
	SM		24.5	7.74	35.3	18	30522	71	30593
	SB		24.4	7.73	36.1	46	30628	138	30766
	NS	8	24.3	7.87	33.7	11	30490	37	30527
	NM		24.2	7.77	33.7	13	30520	60	30580
	NB		24.3	7.79	35.3	12	30498	67	30565
W5	SS	13.6	25.2	7.67	37.8	29	30612	75	30687
	SM		24.9	7.70	36.1	34	30482	143	30625
	SB		24.9	7.93	32.8	43	30540	139	30679
	NS	13	25	7.87	36.9	38	30582	113	30695
	NM		25	7.89	35.3	33	30642	126	30768
	NB		24.9	7.81	35.3	41	30718	111	30829

SS - SPRING

SURFACE

SM - SPRING MIDDLE

NS - NEAP SURFACE

NM - NEAP MIDDLE

NB - NEAP BOTTOM

Sample Name	Depth, [m]	Temp., [°C]	pH	Salinity, [ppt]	Turbidity, [NTU]	TDS, [mg/L]	TSS, [mg/L]	TS, [mg/L]
Standard	-	-	6.5 - 9.0	-	-	-	-	-
W6	SS	15.6	25.5	7.40	34	30788	144	30932
	SM		25.4	7.65	55	30810	152	30962
	SB		25.4	7.67	45	30724	103	30827
	NS	13.8	25	7.80	62	30738	109	30847
	NM		24.9	7.81	53	30804	145	30949
	NB		24.5	7.70	47	30640	129	30769
W7	SS	6.5	25.1	7.96	38	30712	134	30846
	SM		24.6	7.69	46	30688	105	30793
	SB		24.5	7.53	41	30692	96	30788
	NS	6	24.5	7.91	27	30712	52	30764
	NM		24.3	7.84	25	30624	40	30664
	NB		24.2	7.68	29	30724	53	30777
W10	SS	8.6	24.6	7.72	39	30524	101	30625
	SM		24.5	7.92	42	30622	130	30752
	SB		24.3	7.87	47	30722	185	30907
	NS	7	24.6	7.82	25	30686	71	30757
	NM		24.4	7.91	32	30710	69	30779
	NB		24.3	7.77	26	30624	65	30689
W9	SS	17.5	25.2	7.60	19	30664	28	30692
	SM		25.1	7.69	29	30672	41	30713
	SB		25.1	7.90	30	30798	70	30868
	NS	16.8	24.5	7.71	21	30682	44	30726
	NM		24.4	7.67	20	30732	46	30778
	NB		24.3	7.72	19	30840	57	30897

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

Table 12: Results of Bio-Chemical Analysis of Water Samples Collected from JNP Harbor Area during April, 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#	-	-	-	-	1	122	2
	SS	5.1	38	<2	<0.1	<0.01		
	SM	5.0	42	-	-			
	SB	4.8	50	-	-	-		
	NS#		-	-	-	1	98	<2
	NS	5.3	46	<2	<0.1	<0.01		
	NM	5.1	54	-	-	-		
W2	NB	5.1	42	-	-	-		
	SS#					2	127	2
	SS	5.2	42	<0.1	<0.01			
	SM	5.2	54					
	SB	5.0	50					
	NS#					2	185	4
	NS	5.4	38	<0.1	<0.01			
W3	NM	5.2	46					
	NB	5.1	33					
	SS#	-	-	-	-	1	192	8
	SS	4.8	46	<2	<0.1	<0.01		
	SM	4.7	54	-	-	-		
	SB	4.5	50	-	-	-		
	NS#		-	-	-	2	50	<2
W4	NS	4.4	38	<2	<0.1	<0.01		
	NM	4.2	42	-	-	-		
	NB	4.3	46	-	-	-		
	SS#	-	-	-	-	1	112	<2
	SS	4.6	33	<2	<0.1	<0.01		
	SM	4.4	42	-	-	-		
	SB	4.2	50	-	-	-		
W5	NS#		-	-	-	<1	74	<2
	NS	4.6	54	<2	<0.1	<0.01		
	NM	4.4	46	-	-	-		
	NB	4.3	38	-	-	-		
	SS#	-	-	-	-	2	198	2
	SS	5.3	50	<2	<0.1	<0.01		
	SM	4.8	46	-	-	-		
W5	SB	4.8	42	-	-	-		
	NS#	-	-	-	-	4	105	2
	NS	5.4	38	<2	<0.1	<0.01		
	NM	5.2	54	-	-	-		
	NB	5.0	33	-	-	-		

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	<30	2
	SS	5.3	40	<2	<0.1	<0.01	-	-
	SM	5.0	44	-	-	-	-	-
	SB	4.8	36	-	-	-	-	-
	NS [#]	-	-	-	-	2	<30	<2
	NS	5.0	48	<2	<0.1	<0.01	-	-
	NM	4.8	32	-	-	-	-	-
	NB	5.0	28	-	-	-	-	-
W7	SS [#]	-	-	-	-	1	<30	4
	SS	4.7	28	<2	<0.1	<0.01	-	-
	SM	4.8	40	-	-	-	-	-
	SB	4.6	36	-	-	-	-	-
	NS [#]	-	-	-	-	2	<30	<2
	NS	5.0	44	<2	<0.1	<0.01	-	-
	NM	4.6	32	-	-	-	-	-
	NB	4.4	48	-	-	-	-	-
W10	SS [#]	-	-	-	-	2	78	<2
	SS	4.6	32	<2	<0.1	<0.01	-	-
	SM	4.9	48	-	-	-	-	-
	SB	4.7	44	-	-	-	-	-
	NS [#]	-	-	-	-	1	98	2
	NS	4.7	36	<2	<0.1	<0.01	-	-
	NM	4.5	52	-	-	-	-	-
	NB	4.4	28	-	-	-	-	-
W9	SS [#]	-	-	-	-	3	89	<2
	SS	5.0	44	<2	<0.1	<0.01	-	-
	SM	4.7	36	-	-	-	-	-
	SB	4.4	48	-	-	-	-	-
	NS [#]	-	-	-	-	2	<30	2
	NS	4.5	52	<2	<0.1	<0.01	-	-
	NM	4.3	28	-	-	-	-	-
	NB	4.2	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

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

Station Name	Organic Matter		Total Carbon		Inorganic Phosphate
	mg/g	%	mg/g	%	mg/kg
W1	146.0	14.6	84.6	8.5	132
W2	153.0	15.3	88.7	8.9	110
W3	136.2	13.6	79.0	7.9	118
W4	107.0	10.7	62.1	6.2	117
W5	148.3	14.8	86.0	8.6	122
W6	132.3	13.2	76.7	7.7	117
W7	148.3	14.8	86.0	8.6	121
W9	133.0	13.3	77.1	7.7	105
W10	166.0	16.6	96.3	9.6	131

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

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	-	-	-	-	-
W11	SS	4.5	26.3	7.72	35.3	30	30608	47	30655
	SM		26.1	7.74	37.8	36	30630	83	30713
	SB		25.6	7.86	34.5	35	30598	85	30683
	NS	3.5	26.7	7.70	35.3	31	30622	104	30726
	NM		26.8	7.86	35.3	34	30714	95	30809
	NB		26.7	7.91	36.9	28	30588	63	30651
W12	SS	4.5	26.3	7.71	41.1	42	30412	95	30507
	SM		26.2	7.81	35.3	34	30476	96	30572
	SB		26.2	7.71	37.8	32	30510	85	30595
	NS	3	26.4	7.70	34.5	30	30528	65	30593
	NM		26.7	7.69	36.1	38	30392	103	30495
	NB		26.7	7.72	36.9	26	30480	90	30570
W13	SS	4.5	26.3	7.77	35.3	37	30240	105	30345
	SM		26.1	7.80	34.5	27	30344	87	30431
	SB		25.8	7.69	33.7	36	30388	88	30476
	NS	3.5	26.7	7.70	36.9	29	30410	54	30464
	NM		26.5	7.74	34.5	31	30428	86	30514
	NB		26.7	7.76	37.8	26	30486	65	30551
W14	SS	4	26.3	7.67	36.1	29	30512	80	30592
	SM		26.1	7.78	36.9	35	30620	102	30722
	SB		26.1	7.87	36.1	32	30580	98	30678
	NS	2.5	26.5	7.90	35.3	33	30594	143	30737
	NM		26.7	7.70	36.1	40	30614	145	30759
	NB		26.7	7.66	34.5	41	30648	74	30722

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	40	<2	<0.1	<0.01	2	42
	SM	4.6	36	-	-	-	-	-
	SB	4.5	48	-	-	-	-	-
	NS	5.0	44	<2	<0.1	<0.01	2	82
	NM	4.8	28	-	-	-	-	-
	NB	4.9	32	-	-	-	-	-
W12	SS	5.2	28	<2	0.1	<0.01	1	95
	SM	4.8	32	-	-	-	-	-
	SB	5.0	36	-	-	-	-	-
	NS	4.9	48	<2	<0.1	<0.01	<1	41
	NM	4.8	40	-	-	-	-	-
	NB	4.7	44	-	-	-	-	-
W13	SS	4.9	40	<2	0.1	<0.01	2	45
	SM	4.8	36	-	-	-	-	-
	SB	4.6	44	-	-	-	-	-
	NS	4.8	32	<2	0.1	<0.01	2	<30
	NM	4.6	52	-	-	-	-	-
	NB	4.8	48	-	-	-	-	-
W14	SS	4.6	48	<2	<0.1	<0.01	2	178
	SM	4.7	32	-	-	-	-	-
	SB	4.6	52	-	-	-	-	-
	NS	5.0	36	<2	<0.1	<0.01	1	85
	NM	4.9	40	-	-	-	-	-
	NB	4.9		-	-	-	-	-

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 April, 2015

Sample Name	Organic Matter		Total Carbon		Inorganic Phosphate
	mg/g	%	mg/g	%	
W11	Sediment not found				mg/kg
W12					
W13	156.9	15.7	91.0	9.1	121
W14	145.2	14.5	84.2	8.4	150

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	24.1 – 25.5	°C	-
2	pH	7.0 – 8.0	-	6.5 - 9.0
3	Salinity	32.8 – 41.9	ppth	-
4	Turbidity	10.0 – 62.0	NTU	-
5	TDS	30482 – 30840	mg/L	-
6	TSS	28 – 217	mg/L	-
7	TS	30527 – 30962	mg/L	-
8	DO	4.2 – 5.4	mg/L	3.0 mg/L or 40% of saturation value
9	COD	28.0 – 54.2	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	50 – 198	CFU/ml	-
15	Fecal Coliforms	2 – 8	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	25.6 – 26.8	°C	-
2	pH	7.7 – 7.9	-	6.5 - 9.0
3	Salinity	33.7 – 41.1	Ppth	-
4	Turbidity	26.0 – 42.0	NTU	-
5	TDS	30240 – 30714	mg/L	-
6	TSS	47 – 145	mg/L	-
7	TS	30345 – 30809	mg/L	-
8	DO	4.5 – 5.2	mg/L	3.0 mg/L or 40% of saturation value
9	COD	28 – 52	mg/L	-
10	BOD	< 2.0	mg/L	5
11	NH ⁴⁺ -N	< 1.0	mg/L	-
12	Phenol	< 0.01	mg/L	-
13	Oil & Grease	1 - 2	mg/L	10
14	Total Plate Count	41 – 178	CFU/ml	-
15	Fecal Coliforms	2 – 26	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 April, 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 April, 2015 are found to be well within prescribed limits.

Observed salinity values for Harbor and Creek water samples in the month of April, 2015 are ranges from 32.8 to 41.9 ppt. [Refer Tables 11 and 14]. The ranges observed for COD values in mg/L are 28.0 – 54.2 and 28.0 – 52.0 respectively for Harbor and Creek water samples. The DO levels are ranges between 4.2 to 5.4 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 April, 2015. The values obtained for Organic Matter, Total Organic Carbon and Inorganic Phosphate are ranges between 10.7 – 16.6%, 6.21% – 9.63% and 105 – 131 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 14.5 & 16.7%, 8.4 & 9.1% and 121– 150 mg/kg, respectively for sediment samples collected from Nhava Creek area during the month of April, 2015.

2.5 OBSERVATIONS AND CONCLUSIONS

Observations for the month of April:

- ✓ *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 April, 2015. The characteristic parameters for sediments are also showing normal variation in concentrations for JNP Harbor area and Nhava Creek area during April, 2015. Considering the activities in the Harbor area and the results obtained for the month of April, it can be concluded that the overall Marine water Quality of the Port's Harbor and Creek waters is in good category.

3. MARINE ECOSYSTEM MONITORING

3.1 INTRODUCTION

For study of Marine ecology, Total 8 fixed harbor stations [W1 to W7 and W9] and 1 movable station [W08] are identified. At Nhava creek 4 fixed stations [W11 to W14] are identified. All above mentioned stations are selected for studying aquatic flora and fauna as well as benthic fauna. The description of stations is depicted in **Table 9**. The location map of various Marine ecology monitoring stations along with direction of towing are described in **Annexure-IV**.

3.2 MARINE ECOSYSTEM MONITORING METHODOLOGY

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

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

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

Table 19: List of Parameters to Monitor Marine Ecology

Marine Ecology Parameters [Harbor Area & Creek Area]
A] Aquatic Flora & Fauna: Primary Productivity (Net & Gross), Phytoplankton Diversity: Population Density, Species Identification, Relative Abundance, Zooplankton Diversity: Population Density, Species Identification, Relative Abundance, Particulate Organic Carbon, Chlorophyll-a, Pheophytin-a, Secchi Depth
B] Benthic Fauna: Species Identification & Density
C] Nutrients Analysis in Water: Anions: Silicates, PO_4^{3-} - P, SO_4^{2-} , NO_2^- - N, NO_3^- - N, Cations: Ca^{2+} , Mg^{2+} , Na^+ , K^+
D] Sediment Analysis: Anions: Silicates, PO_4^{3-} - P, SO_4^{2-} , NO_2^- - N, NO_3^- - N, Cations: Ca^{2+} , Mg^{2+} , Na^+ , K^+

3.3 RESULTS

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

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

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

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

Sr. No.	Station	Gross Primary Productivity [mgC/m ³ /d]	Net Primary Productivity [mgC/m ³ /d]
JNP Harbor Area			
1.	W01	450	375
2.	W02	550	475
3.	W03	315	275
4.	W04	615	425
5.	W05	515	415
6.	W06	515	475
7.	W07	315	210
8.	W09	515	420
9.	W10	475	315
NHAVA Creek Area			
10.	W11	515	375
11.	W12	415	315
12.	W13	575	415
13.	W14	515	425

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

Sr. No.	Sampling station	Sample Location	Phyto-plankton, [No/mL]	Percent Composition of Algal Groups Bacillario-phyceae	Chloro-phyceae	Cyano-phyceae	Crypto-phyceae	SWI	PPI
JNP Harbor Area									
1	W1	Surface	650	50	20	20	10	1.56	15
		Bottom	370	45	15	20	20	1.25	16
2	W2	Surface	690	50	20	10	20	1.10	15
		Bottom	460	60	30	-	10	0.56	15
3	W3	Surface	530	50	20	10	20	1.71	20
		Bottom	480	60	20	10	10	0.56	14
4	W4	Surface	710	55	15	10	20	1.63	16
		Bottom	520	45	15	20	20	1.22	14
5	W5	Surface	650	50	20	10	20	1.63	18
		Bottom	520	55	15	20	10	1.10	11
6	W6	Surface	630	40	30	20	10	1.46	19
		Bottom	510	50	25	15	10	1.80	15
7	W7	Surface	580	45	20	30	5	0.96	13
		Bottom	640	40	30	20	10	1.50	15
8	W9	Surface	560	50	20	20	10	1.90	16
		Bottom	480	40	20	20	20	2.30	20
9	W10	Surface	510	55	20	15	10	1.65	15
		Bottom	530	40	20	10	30	2.55	14
NHAVA Creek									
10	W11	Surface	730	40	30	20	10	1.56	12
		Bottom	610	40	30	10	20	2.23	15
11	W12	Surface	450	40	30	10	20	1.60	12
		Bottom	520	50	30	10	10	2.20	13
12	W13	Surface	710	40	30	20	10	1.62	16
		Bottom	480	50	20	20	10	2.30	15
13	W14	Surface	525	40	20	20	20	0.93	13
		Bottom	590	40	20	20	20	1.69	17
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>Closterium</i> sp.	<i>Gloeocapsa</i> sp.	<i>Coscinodiscus</i>
2.	<i>Nitzschia</i> sp.	<i>Cosmarium</i> sp.	<i>Oscillatoria</i> sp.	-
3.	<i>Fragillaria</i> sp.	<i>Scenedesmus</i> sp.	<i>Anabaena</i> sp.	-
4.	<i>Surirella</i> sp.	<i>Staurostrum</i> sp.	<i>Aphanocapsa</i>	-
5.	<i>Gyrosigma</i> sp.	<i>Tetrastrum</i> sp.	-	-
6.	-	<i>Ulothrix</i> sp.	-	-
7.	-	<i>Pandorina</i> sp.	-	-

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

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

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

Sr. No.	Towing between Stations	Zoo-plankton, [No/m³]	Percent Composition of Zooplankton Groups				SWI
			Copepoda	Cladocera	Foraminifera	Rotifera	
JNP Harbor Area							
1.	W1 – W2	520	50	20	20	10	1.25
2.	W2 – W5	370	45	15	20	20	1.65
3.	W5 – W1	410	60	20	20	-	0.98
4.	W5 – W6	550	60	25	15	-	1.25
5.	W6 – W2	240	50	30	20	-	0.90
6.	W4 – W3	510	40	30	20	10	1.62
7.	W3 – W7	450	55	35	10	-	1.52
8.	W7 – W10	530	45	25	10	20	1.36
9.	W10 – W3	450	44	26	20	10	1.15
10.	W9 – W3	520	50	20	20	10	0.63
NHAVA Creek							
11.	W5 – W11	220	51	29	-	20	1.15
12.	W11 – W12	450	50	30	20	-	1.56
13.	W12 – W13	475	65	15	10	10	1.45
14.	W13 – W14	350	66	24	10	-	0.85
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>Rotalia</i> sp.
2.	<i>Diaptomus</i> sp.	<i>Brachionus</i> sp.		<i>Taberina</i> sp.
3.	<i>Bryocamptus</i> sp.	<i>Asplanchna</i> sp.		<i>Globulina</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
		Surface	Bottom	Surface	Bottom	(mg/m ³)
JNP Harbor Area						
1.	W1	5.9	4.6	0.2	BDL	392
2.	W2	4.3	3.2	BDL	BDL	286
3.	W3	5.3	4.1	BDL	BDL	353
4.	W4	6.2	5.3	BBL	BDL	412
5.	W5	5.0	4.9	BDL	BDL	333
6.	W6	4.2	3.1	BDL	BDL	280
7.	W7	3.6	2.9	BDL	BDL	240
8.	W9	5.1	3.5	0.6	BDL	340
9.	W10	5.4	3.9	BDL	BDL	360
Nhava Creek Area						
10.	W11	5.6	4.1	BDL	BDL	372
11.	W12	4.3	3.5	BDL	BDL	286
12.	W13	5.2	4.2	BDL	BDL	346
13.	W14	5.6	3.6	BDL	BDL	372

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

Sr. No.	Station	POC, [mg/m ³]
Standard		10 - 100
JNP Harbor Area		
1.	W1	755
2.	W2	661
3.	W3	848
4.	W4	933
5.	W5	712
6.	W6	1052
7.	W7	890
8.	W9	780
9.	W10	941
Nhava Creek Area		
10.	W11	1035
11.	W12	958
12.	W13	797
13.	W14	789

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

Sr. No.	Station	Macrobenthos	Percent Composition of Macrobenthos				SWI
		[No/m ³]	Foraminifera	Gastropods	Polychaeta	Chironomidae	
JNP Harbor Area							
1.	W1	240	60	30	10	-	0.98
2.	W2	380	50	20	20	10	1.21
3.	W3	420	40	30	20	10	0.69
4.	W4	450	40	30	20	10	1.25
5.	W6	370	60	20	10	10	0.75
6.	W7	270	50	20	20	10	1.20
7.	W9	210	60	20	10	10	0.69
8.	W10	310	65	15	10	10	0.56
Nhava Creek Area							
9.	W13	280	50	20	20	10	1.30
10.	W14	420	50	20	10	20	0.62
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	476	1540	284	10300	105	335	<10	1503	3224
W2	397	1467	290	10500	94	457	<10	1345	3170
W3	397	1467	286	10200	154	440	<10	2204	3310
W4	397	1491	294	10600	61	380	<10	873	3139
W5	476	1467	296	10300	123	260	<10	1760	3135
W6	476	1491	300	10600	127	160	22	1817	3026
W7	516	1516	292	10700	81	210	<10	1159	3135
W10	516	1488	302	10600	156	520	12	2232	3140
W9	397	1467	294	10500	125	390	50	1789	3150
JNP NHAVA CREEK AREA									
W11	555	1371	296	10300	99	540	<10	1417	2894
W12	476	1515	298	10400	123	640	<10	1832	2898
W13	476	1515	286	10800	80	610	<10	1145	3268
W14	436	1540	300	11000	100	560	<10	1431	3143

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	6720	972	300	5520	159	34	0.22	95	6452
W2	6080	194	210	6280	126	57	0.42	124	5874
W3	3760	291	270	5440	161	60	0.39	141	6902
W4	8720	729	420	6880	144	39	0.26	163	5632
W5	4000	583	270	6600	161	45	0.24	178	7216
W6	5360	194	350	5680	174	56	0.33	132	7009
W7	6560	632	320	7200	213	52	0.26	110	7819
W9	4000	826	290	4640	152	46	0.41	156	6656
W10	5840	583	370	5880	166	53	0.30	154	6111
JNP NHAVA CREEK AREA									
W11	Sample not found								
W12	Sample not found								
W13	3520	243	410	6400	142	53	0.42	113	5282
W14	8320	389	430	5040	187	52	0.36	110	7315

3.4 DISCUSSION

3.4.1 Water Quality: Biotic

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

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

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

3.4.1.a Primary Productivity

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

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

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

The highest estimated gross and net primary productivity was measured as 615 and 475 mgC/m³/d at stations W4 and W2 [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 Trivandrum (Rani Mary Jacob and Vasantha Kumar, 1984). Compared with other coastal ecosystems, primary productivity of JNP Harbour area and Nhava creek was at a moderate level. High production at W4 might be cause of high phytoplankton as well as chlorophyll count in this area.

3.4.1.b Plankton

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

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

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

Shannon Wiener Diversity Index:

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

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

Where,

SWI = Shannon Wiener Diversity Index

N = Total number of individuals of species in a sample

n = number of individuals of species in a sample

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



Plate 3.1: Collection of Plankton from JNP Harbour Area

A] Phytoplankton:

Count : Phytoplankton counts, recorded at different sampling stations, are presented in **Table 21**. Total algal population varied between 370 and 710 algal cells/ml. Samples collected at station W1(B) and W4(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 seventeen different genera [**Table 22**]. PPI values varied from 11-20 indicate moderate organic pollution. Shannon - Wiener Diversity Index (SWI) varied between 0.56 and 2.55 at stations W2(B) and W10S. The values also suggest low to medium impact of pollution or adverse factor. High phytoplankton at station W4 might be a cause of less silica in the respective 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. Particulates may be introduced into the water by either runoff or sediments coming from the Thane creek be a cause for low transparency at station W3 and W13.

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 220 and 550 N/m³ at stations W5-W11 and W5-W6. Total six genera of zooplankton were recorded. Among zooplankton Copepoda and Cladocera group were dominant [Table 25]. SWI vary from 0.63 to 1.65 at stations W9-W3 & W2-W5 respectively indicated low to medium load of organic pollution or adverse factors.

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

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

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

Standard method was followed to estimate chlorophyll-a and pheophytin of the water samples collected from different sampling points of JNP Harbour area and Nhava creek [Table 26]. For the estimation of chlorophyll-a and pheophytin-a, a certain volume of water sample was filtered through glass fiber filter paper and the filter paper was immersed in 5 ml of 90% acetone and grinded in tissue grinder and kept overnight at 40°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 240 and 412 mg/m³. The minimum algal biomass was (240 mg/m³) found at W7 and maximum (412 mg/m³) was found at W4 station. The lowest and highest chlorophyll a levels from surface water sample varied from 2.9 at station W7 (B) to 6.2 mg/m³ at W4(S). High chlorophyll might be a cause of minimum phosphate at respective station. Phytoplankton count was high at W4 station resulted in increased chlorophyll count in this station. However, 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 661 – 1052 mg/m³ with an average of 841 mg/m³. The minimum concentration of POC was found at W2 station and maximum concentration at W6 station. In Nhava creek the POC content was found to be between 789 – 1035 mg/m³ with an average of 895 mg/m³. The POC concentration was found to be higher than the prescribed standard range i.e. 10- 100 mg/m³ at all stations in JNP Harbor region and Nhava Creek region. This may be due to detritus material originate from Mangrove swamps or detritus plankton. The higher values for POC were also reported in Tulaskar et al [Ind. J. Marine Sci., Vol. 21, 1992] for Rajapur and Vagothan estuaries (west coast of India).

3.4.2 Sediment Quality: Biotic

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

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

A total of four macrobenthic groups were obtained from the 13 sediment samples. *Foraminifera* was the most diverse group. Species like *Triloculina*, *Ammonia* and *Lagena* were dominant. *Forams* are abundant all over the ocean. They either live on the sea bottom (benthic) or float in the upper water column (planktonic). The size of the *foraminiferal* test typically ranges from 0.05mm to 0.5mm although some *forams* may be as large as several centimeters with a recorded maximum of 18cm in diameter. They not only provide surface for respiration, but also perform feeding, locomotion, test building, metabolite release, adhering, etc. Foods of the *foraminifera* are variable: dissolved free amino acids, bacteria, unicellular algae, and even metazoans, such as copepods. It was followed by Gastropods. Among the Gastropods, the dominant species were *Litiopa sp.*, *Morula sp.* and *Oliva sp.* *Chironomous larva* from *Chironomidae* was also observed as benthic fauna. The highest count was 450 No/m² in sampling point W4. Benthos was absent at stations W11 and W12. The SWI values were observed to vary from 0.56 – 1.25 at stations W10 and W4. As molluscs cell wall consumed the silica might be a cause for the minimum concentration of silica at this station.

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 61µg/L – 156µg/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 160µg/L – 520µg/L. The minimum value of Nitrate was found at W6 station and maximum at W10 station. The average concentration of Nitrate was found to be 350µg/L and overall Nitrate was found within range [1.0 to 500µg/L] at all stations except W10 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 873 – 2232 µg/L with an average of 1631µg/L. The minimum concentration of silica was found at W4 station of JNP harbor region and the maximum concentration of silica was found at W10 station. The Sulphate was found between 3026 – 3310 mg/L, the minimum value recorded at W6 station and maximum at W3 station. The average concentration of Sulphate was found to be 3159 mg/L.

In Nhava Creek, Phosphate was found between 80µg/L – 128µg/L with an average 102µg/L which was above prescribed standard range [0.1-90µg/L]. Nitrate was found to be 540 – 640 µg/L with an average 588 µg/L. The silica content in Nhava creek was found to be 1145 – 1832 µg/L with an average of 1456 µg/L. The minimum silica content was found at station W13 station and maximum was found at W12 station. Sulphate was found between 2894 – 3268 mg/L with an average of 3051 mg/L. The minimum value for Sulphate was found at W11 station and maximum value at W13 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 126 – 213 mg/kg with an average of 162 mg/kg. The Nitrate was found minimum value at W1 station i.e. 34 mg/kg and maximum value at W3 station i.e. 60 mg/kg. The average concentration of Nitrate was found to be 49mg/kg. The Nitrite was found to be between 0.22 – 0.42 mg/kg with an average of 0.31 mg/kg. The minimum concentration of nitrite was found at W1 station and maximum value at W2 station. Silica in the form of silicate in JNP harbor sediments were found between 95 to 178 mg/kg with an average of 139 mg/kg. The minimum concentration of silica was found at W1 station and maximum value was found at W5 station. The Sulphate was found between 5032 to 7819 mg/kg, with minimum value at W4 station and maximum value at W7 station. The average concentration of Sulphate was found to be 6630 mg/kg.

In Nhava Creek region the sediment found at two locations out of four. Phosphate levels were 142 and 187 mg/kg with an average of 165 mg/kg. Nitrate was found to be 53 and 52 mg/kg. The average concentration of Nitrate was found to be 52.5 mg/kg. The Nitrite was found to be 0.42 and 0.36 mg/kg. Silica in the form of silicate in JNP harbor sediments was found to be 110 to 113 mg/kg with an average of 112 mg/kg. The Sulphate was found to be 5282 and 7315mg/kg. The average concentration of Sulphate was found to be 6299 mg/kg.

b. Cations:

In harbor region water, the Calcium was found between 397 to 516 mg/L with an average of 450 mg/L given in **Table 29**. The Magnesium was found to be 1467 – 1540 mg/L, with maximum value at W1 station. The average concentration of Magnesium was found to be 1488.2 mg/L. Potassium in JNP harbor water was found between 284 to 302 mg/L with an average of 293.1 mg/L. The minimum concentration of Potassium was found at W1 station and maximum

value W10 station. The Sodium was found between 10200 to 10700 mg/L with an average of 10477 mg/L. The minimum concentration of sodium was found at W3 station and maximum value of at W7 station.

In Nhava Creek, Calcium concentration was found with an average 485.8 mg/L given in **Table 29**. Magnesium concentration was found to be 1371 – 1540 mg/L with an average of 1485.3 mg/L. The minimum value of Magnesium was found at W11 station and maximum value was found at W14 stations. The Potassium content in Nhava creek was found to be 9 – 300 mg/L with an average of 295 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 3760 to 8720 mg/Kg with an average of 4192 mg/Kg given in **Table 30**. The minimum Concentration of Calcium was found at W3 station and maximum concentration at W4 station. Magnesium was found to be 194 to 972 mg/Kg, with minimum value at W2 & W6 stations and maximum was recorded at W1 station. The average concentration of Magnesium was found to be 556.1 mg/Kg. Potassium in JNP harbor sediment was found to be 210 to 420 mg/Kg with an average of 311.1 mg/Kg. The minimum concentration of Potassium was found at W2 station and maximum value at W4 station. Sodium was found to be 4640 to 7200 mg/Kg with an average of 6013.3 mg/Kg. The minimum concentration of sodium was found at W9 station and maximum value at W7 station.

In Nhava Creek sediments, Calcium was found to be 3520 to 8320 mg/Kg with an average 5920 mg/Kg given in **Table 30**. Average magnesium was found to be 316 mg/Kg. Average potassium content in Nhava creek was found to be 420 mg/Kg. The minimum sodium value was found at W14 station and maximum value at W13.

3.5 OBSERVATIONS AND CONCLUSIONS

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

Sr. No.	Parameter	Criteria	Observations	Remarks	Mitigation Measures
1.	Net primary productivity	<1500 mgC/m ³ /day at surface	The observed values falls under 210 – 475 mgC/m ³ /day	-	Within Range
2.	Chlorophyll-a	< 4 mg/m ³ [Oligotrophic class] 4-10 mg/m ³ [Mesotrophic class] >10 mg/m ³ [Eutrophic classter]	The observed values falls under 2.9 – 6.2 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 this 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 April:

- ✓ *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 April, 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 April 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	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 17th April, 2015.

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

4.2 RESULTS

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

Table 33: Results of Drinking water quality monitoring

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
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Conductivity	mS/cm	173	121	121	144	131	140	-
pH	-	8.09	7.51	7.70	7.70	7.77	7.66	6.5 to 8.5
Chloride as Cl	mg/L	10.2	14.6	9.7	9.2	9.7	9.7	250
Total Dissolved Solids	mg/L	89	78	79	93	85	91	500
Total Hardness as CaCO ₃	mg/L	52	46	48	46	49	50	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	2.7	2.7	3.6	3.4	3.5	200
NH ₄ ⁺ - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5
PO ₄ ³⁻ - P	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Total Coliforms	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil

*, IS 10500:2012, Drinking Water - Specification

Table 33: Results of Drinking water quality monitoring

Parameter	Unit of Measurement	Station Name						Standards*	
		DW7	DW8	DW9	DW10	DW11	DW12		
Colour	Hazen	<5	<5	<5	<5	<5	<5	5	
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1	
Conductivity	mS/cm	134	138	151	147	146	136	-	
pH	-	7.69	7.71	7.81	7.59	7.57	7.74	6.5 to 8.5	
Chloride as Cl	mg/L	9.2	9.7	9.7	9.7	10.2	9.7	250	
Total Dissolved Solids	mg/L	87	90	98	95	95	88	500	
Total Hardness as CaCO ₃	mg/L	50	50	47	52	53	52	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	3.4	3.5	3.6	3.6	3.6	3.5	200	
NH ₄ ⁺ - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	
PO ₄ ³⁻ - P	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	
Total Coliforms	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
*: IS 10500:2012, Drinking Water - Specification									

Table 33: Results of Drinking water quality monitoring									
Parameter	Unit of Measurement	Station Name							
		DW13	DW14	DW15	DW16	DW17	DW18	Standards*	
Colour	Hazen	<5	<5	<5	<5	<5	<5	5	
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1	
Conductivity	mS/cm	129	142	135	135	151	148	-	
pH	-	7.87	7.71	7.76	7.81	7.56	7.66	6.5 to 8.5	
Chloride as Cl	mg/L	10.7	9.7	10.2	9.7	9.7	10.2	250	
Total Dissolved Solids	mg/L	84	92	88	89	98	96	500	
Total Hardness as CaCO ₃	mg/L	51	52	50	49	49	51	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	2.9	3.6	3.4	3.4	3.6	3.6	200	
NH ₄ ⁺ - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	
PO ₄ ⁻³ - P	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	
Total Coliforms	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil	

*, IS 10500:2012, Drinking Water - Specification

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 14.6 mg/L and sulphates 2.7 to 3.6 mg/L. The concentration of total dissolved solids is found to be between 78.0 to 98.0 mg/L and concentration of total hardness as CaCO_3 is found to be 46.7 to 53.0 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 values of conductivity are ranges between 121.0 to 173.0 $\mu\text{S}/\text{cm}$. The acceptable range for pH is 6.5 to 8.5, while the observed pH range is 7.5 to 8.1. The iron content and $\text{NH}_4^+ - \text{N}$ and $\text{PO}_4^{3-} - \text{P}$ content is found to be well within the acceptable limit and observed levels are < 0.1 mg/L.

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

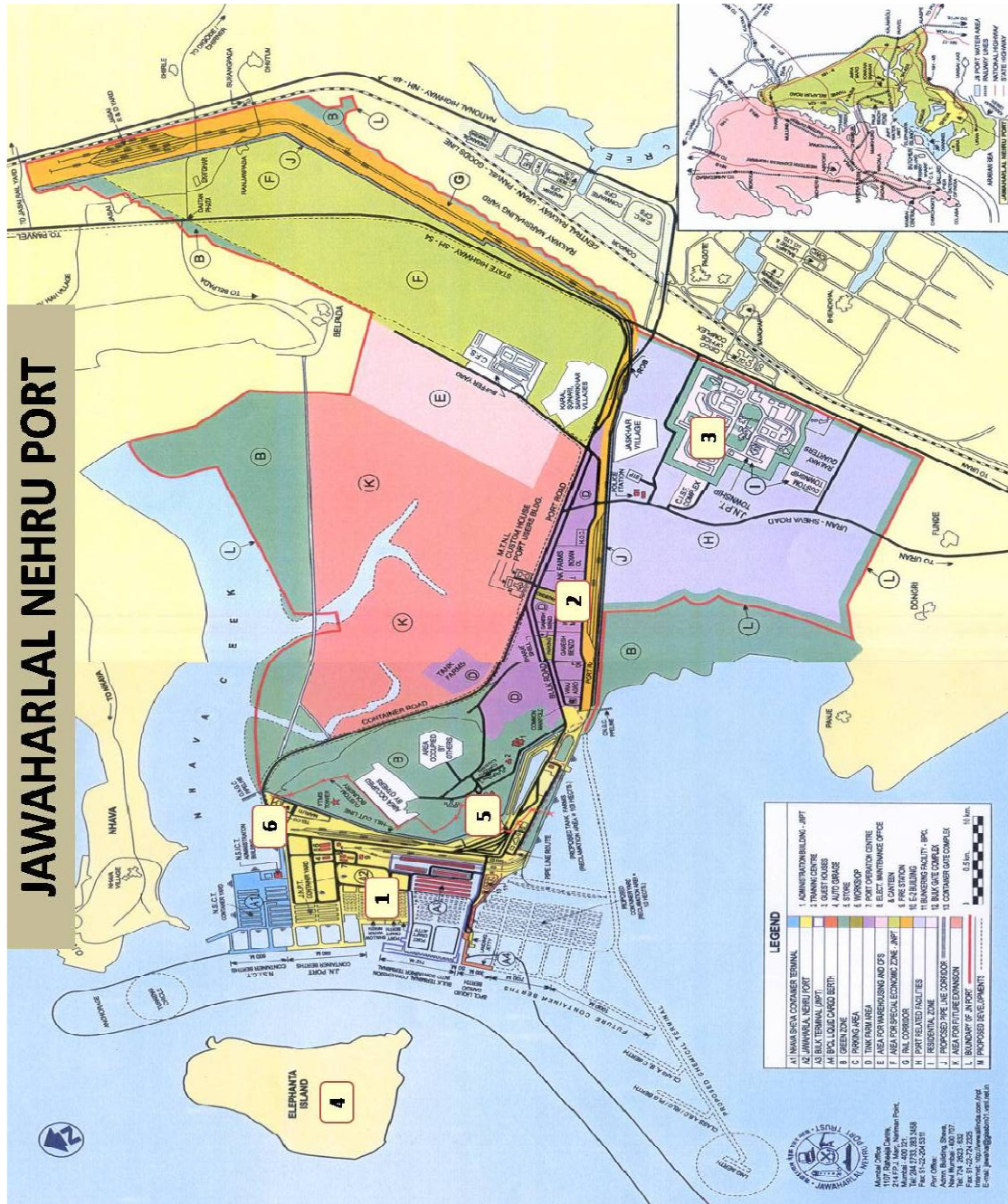
4.4 CONCLUSIONS

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

5. ANNEXURES



Annexure-I: Location map for Ambient Air Monitoring Stations

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

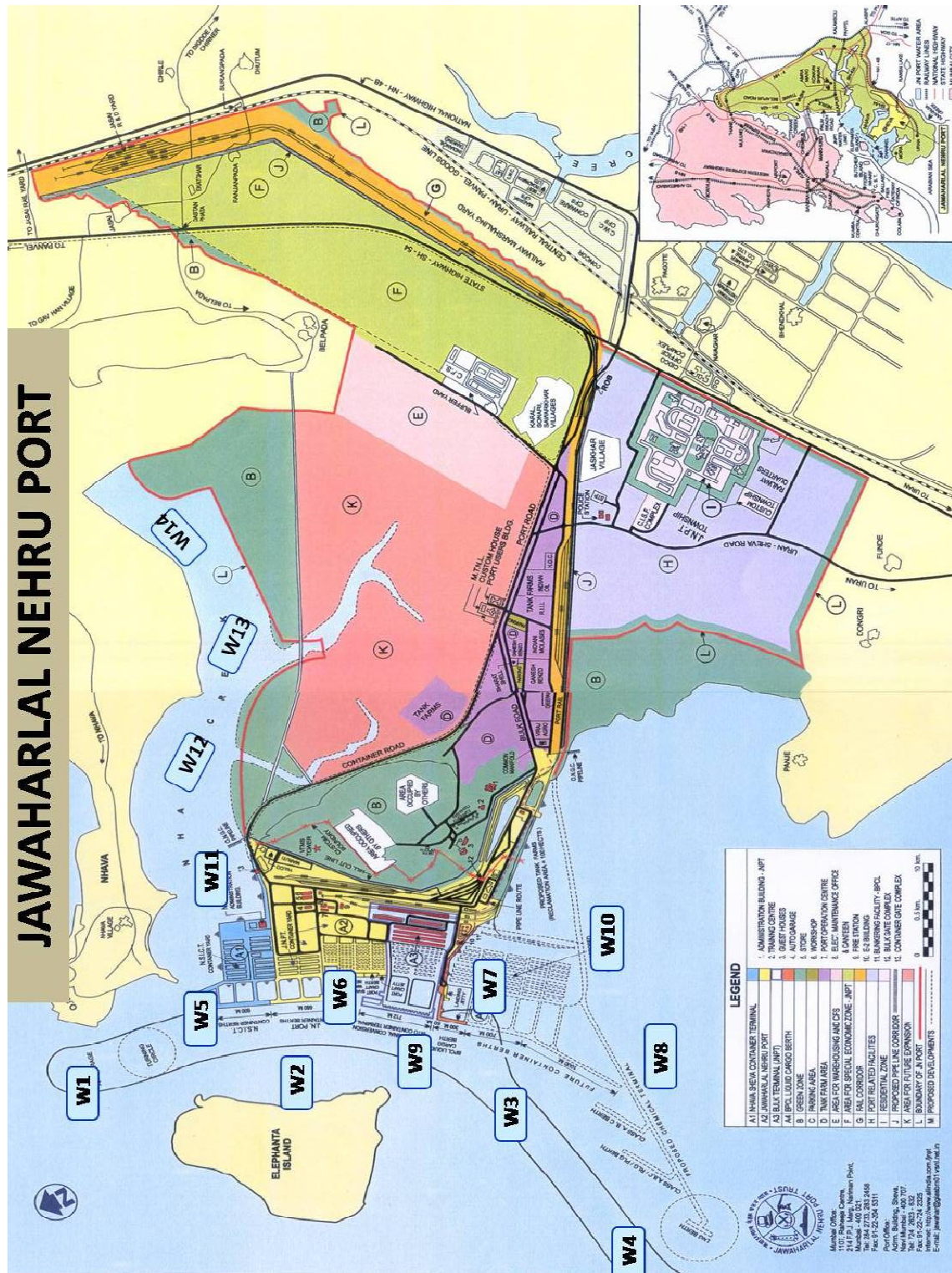
* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals

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

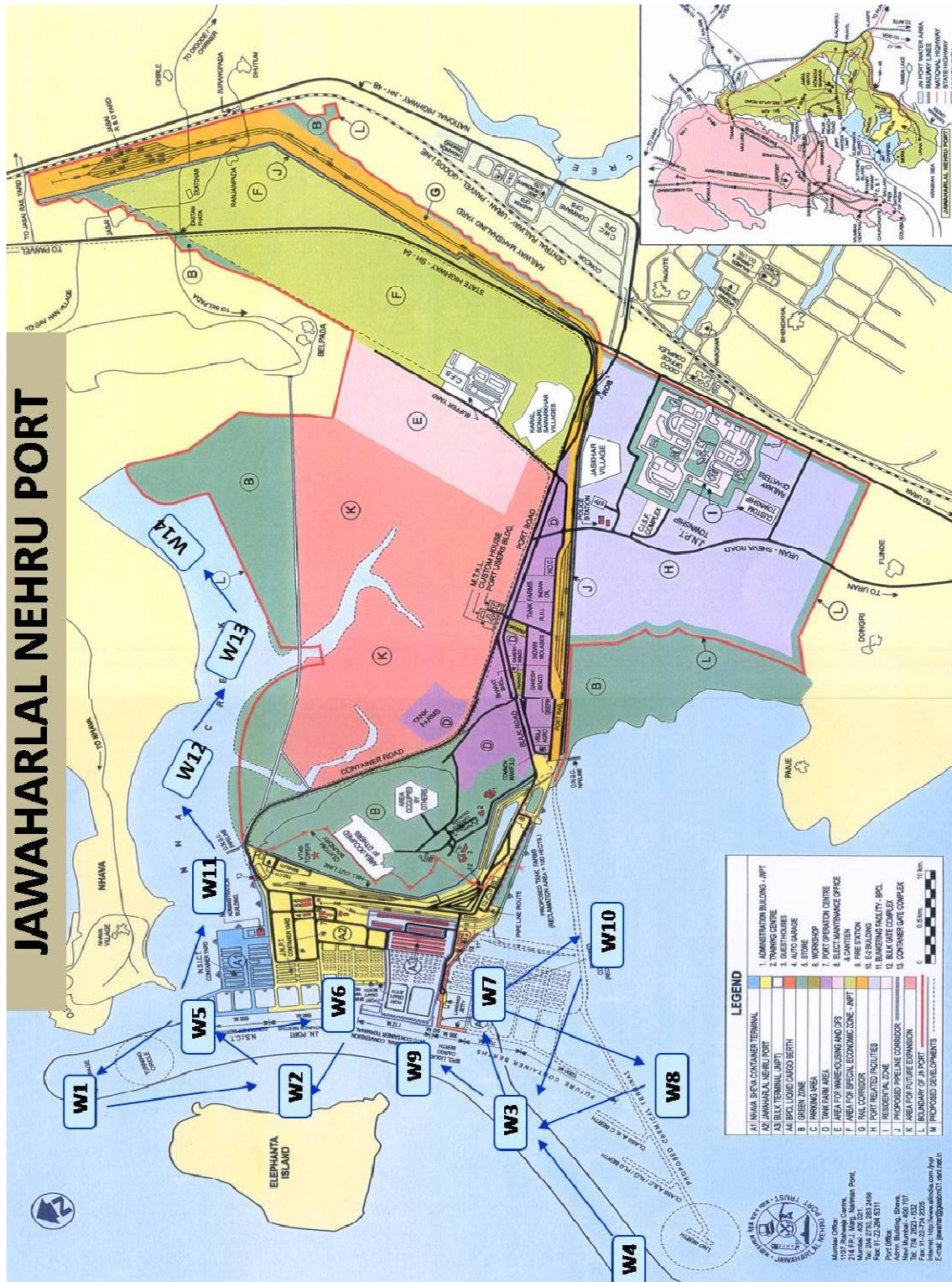
2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

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

Annexure-II: National Ambient Air Quality Monitoring Standard



Annexure-III: Location map for Marine Water Monitoring Stations



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

Sr. No.	Parameter	Criteria	Rationale/Remarks
1.	pH range	6.5 - 9.0	To minimize the corrosive and scaling effects.
2.	Dissolved Oxygen	3.0 mg/L or 40 % of the saturation value, whichever is higher	Considering bio-degradation of oil and inhibition to oxygen production through photosynthesis.
3.	Color and Odor	No visible color or offensive order	None from reactive chemicals which may corrode paints/metallic surfaces.
4.	Floating objects oil, grease and scum (including the petroleum products)	10 mg/L	Floating matter should be free from excessive living organisms which may clog or coat operative parts of marine vessels/equipment.
5.	Fecal Coliform	500/ 100 ml (MPN)	Not exceeding 1000/100 ml in 20 % of the samples in the year and in 3 consecutive samples in the monsoon months.
6.	Biochemical Oxygen Demand (5 days at 20°C)	5 mg/L	To maintain water relatively free from the pollution caused by sewage and other decomposable wastes.

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

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

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