



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 February, 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 of JNP Area during the month of February, 2015															
Sampling Period NAAQMS	Date	Time, [Hrs]	PM ₁₀ , [µg/m ³]		PM _{2.5} , [µg/m ³]		SO ₂ , [µg/m ³]		NO _x , [µg/m ³]		NH ₃ , [µg/m ³]				
			24 hr 100 µg/m ³	24 hr 60 µg/m ³	24 hr 60 µg/m ³	8 hr -	24 hr (Avg) 80 µg/m ³	8 hr -	24 hr (Avg) 80 µg/m ³	8 hr -	24 hr (Avg) 400 µg/m ³				
POC-1	02.02.2015 to 03.02.2015	14:00 to 22:00					15		23		4				
		22:00 to 06:00	109	46		13	13.4		27	24.1	7	6.6			
		06:00 to 14:00				12			22		8				
POC-2	05.02.2015 to 06.02.2015	14:00 to 22:00					15		25		8				
		22:00 to 06:00	121	67		13	14.9		26	27.1	7	7.1			
		06:00 to 14:00				16			30		6				
POC-3	09.02.2015 to 10.02.2015	14:00 to 22:00					16		30		9				
		22:00 to 06:00	138	60		13	14.4		29	28.5	10	7.8			
		06:00 to 14:00				13			26		5				
POC-4	12.02.2015 to 13.02.2015	14:00 to 22:00					10		28		6				
		22:00 to 06:00	118	53		13	13.4		23	27.9	19	10.9			
		06:00 to 14:00				16			33		7				
POC-5	16.02.2015 to 17.02.2015	14:00 to 22:00					18		16		13				
		22:00 to 06:00	117	46		12	13.4		27	19.9	7	9.3			
		06:00 to 14:00				10			17		8				
POC-6	19.02.2015 to 20.02.2015	14:00 to 22:00					13		40		1				
		22:00 to 06:00	98	35		15	14.9		24	28.1	11	6.9			
		06:00 to 14:00				16			21		9				
POC-7	23.02.2015 to 24.02.2015	14:00 to 22:00					18		21		4				
		22:00 to 06:00	122	68		16	16.4		23	21.5	6	5.5			
		06:00 to 14:00				15			21		7				
POC-8	26.02.2015 to 27.02.2015	14:00 to 22:00					16		18		6				
		22:00 to 06:00	139	50		13	14.4		16	16.6	6	8.4			
		06:00 to 14:00				13			16		13				
Average			120	53				14.4		24.2		7.8			
Standard Dev			14	11				1.0		4.5		1.7			

Table 2: Results of Air Pollutant Concentration at POC Station of JNP Area during the month of February, 2015

Sampling Period NAAQMS	Date	Time, [Hrs]	O ₃ , [$\mu\text{g}/\text{m}^3$] Pb, [$\mu\text{g}/\text{m}^3$] As, [$\mu\text{g}/\text{m}^3$] Ni, [$\mu\text{g}/\text{m}^3$] BaP, [$\mu\text{g}/\text{m}^3$] C ₆ H ₆ , [$\mu\text{g}/\text{m}^3$]		24 hr		8 hr		24 hr		24 hr		CO, [mg/m^3]		CO ₂ , [ppm]	
			8 hr	24 hr	24 hr	24 hr	24 hr	24 hr	24 hr	24 hr	24 hr	24 hr	Grab Sampling	Grab Sampling	Grab Sampling	Grab Sampling
			100 $\mu\text{g}/\text{m}^3$	1.0 $\mu\text{g}/\text{m}^3$	6 ng/m^3	20 ng/m^3	5 $\mu\text{g}/\text{m}^3$	1 ng/m^3	4 mg/m^3	-	-	-	-	-	-	-
POC-1	02.02.2015 to 03.02.2015	14:00 to 22:00	30	0.19	<1	<1	2.5	<0.5	3.2	298						
		22:00 to 06:00														
POC-2	05.02.2015 to 06.02.2015	06:00 to 14:00	28	0.18	<1	<1	2.4	<0.5	3.1	297						
		14:00 to 22:00														
POC-3	09.02.2015 to 10.02.2015	06:00 to 14:00	35	0.23	<1	<1	2.1	<0.5	3.3	301						
		14:00 to 22:00														
POC-4	12.02.2015 to 13.02.2015	06:00 to 14:00	22	0.21	<1	<1	3.5	<0.5	3.4	289						
		14:00 to 22:00														
POC-5	16.02.2015 to 17.02.2015	06:00 to 14:00	30	0.22	<1	<1	3.6	<0.5	2.9	296						
		14:00 to 22:00														
POC-6	19.02.2015 to 20.02.2015	06:00 to 14:00	32	0.1	<1	<1	4.6	<0.5	2.7	297						
		14:00 to 22:00														
POC-7	23.02.2015 to 24.02.2015	06:00 to 14:00	26	0.08	<1	<1	2.1	<0.5	3.3	294						
		14:00 to 22:00														
POC-8	26.02.2015 to 27.02.2015	06:00 to 14:00	45	0.1	<1	<1	4.6	<0.5	3.1	302						
		14:00 to 22:00														
Average			31	0.16			3.2						3.1	297		
Standard Dev			7	0.05			1.0						0.2	4		

Table 3: Results of Air Pollutant Concentration at IMC Station of JNP Area during the month of February, 2015													
Sampling Period	Date	Time (Hrs)	PM ₁₀ [$\mu\text{g}/\text{m}^3$]	PM _{2.5} [$\mu\text{g}/\text{m}^3$]	SO ₂ [$\mu\text{g}/\text{m}^3$]	NO _x [$\mu\text{g}/\text{m}^3$]	NH ₃ [$\mu\text{g}/\text{m}^3$]	24 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)
NAAQMS			100 $\mu\text{g}/\text{m}^3$	60 $\mu\text{g}/\text{m}^3$	-	80 $\mu\text{g}/\text{m}^3$	-	80 $\mu\text{g}/\text{m}^3$	-	80 $\mu\text{g}/\text{m}^3$	-	400 $\mu\text{g}/\text{m}^3$	-
IMC-1	02.02.2015 to 03.02.2015	15:00 to 23:00			13					28		5	
		23:00 to 07:00	128	62	12	13				24	25.8	5	5.7
		07:00 to 15:00			15					25		7	
IMC-2	05.02.2015 to 06.02.2015	15:05 to 23:05			13					25		9	
		23:05 to 07:05	122	56	12	13				23	24.1	10	9.7
		07:05 to 15:05			13					24		11	
IMC-3	09.02.2015 to 10.02.2015	15:10 to 23:10			10					25		6	
		23:10 to 07:10	144	58	16	14				31	27.4	6	8.5
		07:10 to 15:10			15					26		13	
IMC-4	12.02.2015 to 13.02.2015	14:50 to 22:50			22					35		5	
		22:50 to 06:50	140	66	18	18				29	36.4	5	7.5
		06:50 to 14:50			15					45		13	
IMC-5	16.02.2015 to 17.02.2015	15:00 to 23:00			13					21		7	
		23:00 to 07:00	152	68	12	12				33	22.8	7	8.0
		07:00 to 15:00			10					14		10	
IMC-6	19.02.2015 to 20.02.2015	15:00 to 23:00			12					33		5	
		23:00 to 07:00	107	58	10	12.4				24	20.7	6	5.7
		07:00 to 15:00			15					22		7	
IMC-7	23.02.2015 to 24.02.2015	15:00 to 23:00			12					26		5	
		23:00 to 07:00	122	64	13	11.9				19	20.7	5	5.2
		07:00 to 15:00			10					18		6	
IMC-8	26.02.2015 to 27.02.2015	15:00 to 23:00			12					29		14	
		23:00 to 07:00	117	60	13	13.4				28	25.4	5	7.5
		07:00 to 15:00			15					20		5	
Average			129	61		13.5					25.4		7.2
Standard Dev			15	4		2.1					5.0		1.6

Table 3: Results of Air Pollutant Concentration at IMC Station of JNP Area during the month of February, 2015														
Sampling Period	Date	Time, [Hrs]	O ₃ , [µg/m ³] Pb, [µg/m ³] As, [ng/m ³] Ni, [ng/m ³] BaP, [ng/m ³] C ₆ H ₆ , [µg/m ³] 24 hr								CO, [mg/m ³] Grab Sampling		CO ₂ , [ppm] Grab Sampling	
			8 hr	24 hr	24 hr	6 ng/m ³	20 ng/m ³	5 µg/m ³	1 ng/m ³	4 mg/m ³	-			
NAAQMS	02.02.2015 to 03.02.2015	15:00 to 23:00												
		23:00 to 07:00	38	0.13	<1	<1	<1	<0.5	<0.5	3.3	305			
IMC-1	03.02.2015 to 05.02.2015	07:00 to 15:00												
		15:05 to 23:05	54	0.13	<1	<1	<1	<0.5	<0.5	3.4	301			
IMC-2	06.02.2015 to 09.02.2015	23:05 to 07:05												
		07:05 to 15:05												
IMC-3	09.02.2015 to 10.02.2015	15:10 to 23:10												
		23:10 to 07:10	32	0.12	<1	<1	<1	<0.5	<0.5	2.8	289			
IMC-4	10.02.2015 to 13.02.2015	07:10 to 15:10												
		14:50 to 22:50												
IMC-5	13.02.2015 to 16.02.2015	22:50 to 06:50	32	0.16	<1	<1	<1	<0.5	<0.5	2.5	286			
		06:50 to 14:50												
IMC-6	16.02.2015 to 17.02.2015	15:00 to 23:00	36	0.14	<1	<1	<1	<0.5	<0.5	2.8	294			
		23:00 to 07:00												
IMC-7	17.02.2015 to 19.02.2015	07:00 to 15:00												
		15:00 to 23:00	22	0.08	<1	<1	<1	<0.5	<0.5	2.9	297			
IMC-8	20.02.2015 to 23.02.2015	23:00 to 07:00												
		07:00 to 15:00												
Average	23.02.2015 to 24.02.2015	15:00 to 23:00	29	0.1	<1	<1	<1	<0.5	<0.5	3.1	302			
		23:00 to 07:00												
Standard Dev	24.02.2015 to 26.02.2015	07:00 to 15:00												
		15:00 to 23:00	33	0.09	<1	<1	<1	<0.5	<0.5	3.3	305			
Standard Dev	26.02.2015 to 27.02.2015	23:00 to 07:00												
		07:00 to 15:00	35	0.12										
Standard Dev			9	0.03										

Table 4: Results of Air Pollutant Concentration at RC Station of JNP Area during the month of February, 2015														
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 [$\mu\text{g}/\text{m}^3$]		8 hr	24 hr (Avg)
			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)		
RC-1	02.02.2015 to 03.02.2015	15:20 to 23:20					13		31		4			
		23:20 to 07:20	126		54		15	15	28	28.1	9			8.6
		07:20 to 15:20					16		26		13			
RC-2	05.02.2015 to 06.02.2015	15:30 to 23:30					13		28		4			
		23:30 to 07:30	88		48		10	12	24	26.5	13			10.2
		07:30 to 15:30					12		27		13			
RC-3	09.02.2015 to 10.02.2015	15:35 to 23:35					13		27		4			
		23:35 to 07:35	152		69		15	15	25	26.7	6			5.8
		07:35 to 15:35					16		28		7			
RC-4	12.02.2015 to 13.02.2015	15:30 to 23:30					16		19		7			
		23:30 to 07:30	140		57		15	14	21	21.9	6			7.8
		07:30 to 15:30					10		26		11			
RC-5	16.02.2015 to 17.02.2015	15:30 to 23:30					9		16		7			
		23:30 to 07:30	132		39		12	10	21	19.2	5			6.2
		07:30 to 15:30					9		21		7			
RC-6	19.02.2015 to 20.02.2015	15:30 to 23:30					13		35		5			
		23:30 to 07:30	107		47		12	13	19	24.3	4			4.4
		07:30 to 15:30					13		19		5			
RC-7	23.02.2015 to 24.02.2015	15:30 to 23:30					13		17		5			
		23:30 to 07:30	124		39		15	15	14	17.7	4			4.9
		07:30 to 15:30					16		21		6			
RC-8	26.02.2015 to 27.02.2015	15:30 to 23:30					15		23		7			
		23:30 to 07:30	109		45		15	15	18	22.2	6			6.3
		07:30 to 15:30					16		25		6			
Average Standard Dev			122	50				13.6		23.3				6.8
			20	10				1.9		3.7				1.9

Table 4: Results of Air Pollutant Concentration at RC Station of JNP Area during the month of February, 2015												
Sampling Period	Date	Time, [Hrs]	C 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] Grab		CO ₂ , [ppm] Grab	
			8 hr	24 hr	1.0 µg/m ³	24 hr	6 ng/m ³	24 hr	20 ng/m ³	5 µg/m ³	1 ng/m ³	4 mg/m ³
NAAQMS			100 µg/m ³									
RC-1	02.02.2015 to 03.02.2015	15:20 to 23:20										
		23:20 to 07:20	33	0.24		<1	<1	<1	<1	2.8	<0.5	3.1
		07:20 to 15:20										301
RC-2	05.02.2015 to 06.02.2015	15:30 to 23:30										
		23:30 to 07:30	41	0.01		<1	<1	<1	<1	2.4	<0.5	2.9
		07:30 to 15:30										294
RC-3	09.02.2015 to 10.02.2015	15:35 to 23:35										
		23:35 to 07:35	29	0.25		<1	<1	<1	<1	2.5	<0.5	3.3
		07:35 to 15:35										296
RC-4	12.02.2015 to 13.02.2015	15:30 to 23:30										
		23:30 to 07:30	53	0.21		<1	<1	<1	<1	2.1	<0.5	3.2
		07:30 to 15:30										297
RC-5	16.02.2015 to 17.02.2015	15:30 to 23:30										
		23:30 to 07:30	32	0.17		<1	<1	<1	<1	1.8	<0.5	2.9
		07:30 to 15:30										305
RC-6	19.02.2015 to 20.02.2015	15:30 to 23:30										
		23:30 to 07:30	35	0.02		<1	<1	<1	<1	3.2	<0.5	3.1
		07:30 to 15:30										308
RC-7	23.02.2015 to 24.02.2015	15:30 to 23:30										
		23:30 to 07:30	41	0.06		<1	<1	<1	<1	3.1	<0.5	3.2
		07:30 to 15:30										306
RC-8	26.02.2015 to 27.02.2015	15:30 to 23:30										
		23:30 to 07:30	33	0.04		<1	<1	<1	<1	1.8	<0.5	2.8
		07:30 to 15:30										301
Average			37	0.13						2.5		3.1
Standard Dev			8	0.10						0.5		0.2
												5

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	05.02.2015 to 06.02.2015	24 hr 100 µg/m ³	24 hr 60 µg/m ³	8 hr -	8 hr -	24 hr -
				24 hr (Avg) 80	24 hr (Avg) 80	24 hr (Avg) 400
				15	24	9
EC	05.02.2015 to 06.02.2015	24 hr 97	24 hr 50	8 hr 15	8 hr 25	8 hr 25.5
				24 hr 15	24 hr 28	24 hr 8
				15	28	4

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	05.02.2015 to 06.02.2015	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	24 hr 4 mg/m ³	Grab Sampling

Sampling Period		Date	Time, [Hrs]	PM ₁₀ , [µg/m³]	PM _{2.5} , [µg/m³]	SO ₂ , [µg/m³]	NO _x , [µg/m³]	NH ₃ , [µg/m³]
NAAQMS				24 hr 100 µg/m³	24 hr 60 µg/m³	8 hr -	8 hr 80 µg/m³	8 hr -
NG-1		05.02.2015 to 06.02.2015	16:00 to 00:00	117	55	18	32	5
			00:00 to 08:00			15	20	4
			08:00 to 16:00			13	22	6
NG-2		12.02.2015 to 13.02.2015	15:50 to 23:50	120	65	13	29	2
			23:50 to 07:50			16	27	13
			07:50 to 15:50			18	29	11
NG-3		19.02.2015 to 20.02.2015	15:40 to 23:40	121	55	13	26	4
			23:40 to 07:40			12	27	8
			07:40 to 15:40			12	16	7
NG-4		23.02.2015 to 24.02.2015	15:40 to 23:40	113	63	7	16	5
			23:40 to 07:40			13	19	7
			07:40 to 15:40			15	19	6
Average				118	59		23.5	6.4
Standard Dev				4	5		4.2	1.4

Sampling Period NAAQMS	Date	Time, [Hrs]										CO ₂ [ppm]	
		U ₃ [μg/m ³]		Pb ₁ [μg/m ³]		As ₁ [ng/m ³]		Ni ₁ [ng/m ³]		BaP ₁ [ng/m ³]			CO ₁ [mg/m ³]
NG-1	05.02.2015 to 06.02.2015	8 hr	24 hr	24 hr	24 hr	8 hr	24 hr	24 hr	24 hr	1 ng/m ³	4 mg/m ³	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	2.8	3.1	<1	<0.5	2.3	305
		00:00 to 08:00	08:00 to 16:00										
NG-2	12.02.2015 to 13.02.2015	8 hr	24 hr	24 hr	24 hr	8 hr	24 hr	24 hr	24 hr	1 ng/m ³	4 mg/m ³	Grab Sampling	Grab Sampling
		55	0.11	<1	<1	3.1	<0.5	2.9	3.1	<1	<0.5	2.9	306
		15:50 to 23:50	23:50 to 07:50	07:50 to 15:50									
NG-3	19.02.2015 to 20.02.2015	8 hr	24 hr	24 hr	24 hr	8 hr	24 hr	24 hr	24 hr	1 ng/m ³	4 mg/m ³	Grab Sampling	Grab Sampling
		38	0.04	<1	<1	2.8	<0.5	2.5	2.8	<1	<0.5	2.5	301
		15:40 to 23:40	23:40 to 07:40	07:40 to 15:40									
NG-4	23.02.2015 to 24.02.2015	8 hr	24 hr	24 hr	24 hr	8 hr	24 hr	24 hr	24 hr	1 ng/m ³	4 mg/m ³	Grab Sampling	Grab Sampling
		34	0.13	<1	<1	2.3	<0.5	3.1	2.3	<1	<0.5	3.1	298
		15:40 to 23:40	23:40 to 07:40	07:40 to 15:40									
Average		47	0.10			2.8						2.8	303
Standard Dev		13	0.04			0.4						0.3	4

Table 7: Results of Air Pollutant Concentration at SGC Station

Sampling Period	Date	Time [Hrs]	PM ₁₀ [$\mu\text{g}/\text{m}^3$]	PM _{2.5} [$\mu\text{g}/\text{m}^3$]	SO ₂ [$\mu\text{g}/\text{m}^3$]	NO _x [$\mu\text{g}/\text{m}^3$]	NH ₃ [$\mu\text{g}/\text{m}^3$]
NAAQMS			24 hr 100 $\mu\text{g}/\text{m}^3$	24 hr 60 $\mu\text{g}/\text{m}^3$	8 hr 80 $\mu\text{g}/\text{m}^3$	24 hr (Avg) 80 $\mu\text{g}/\text{m}^3$	24 hr (Avg) 400 $\mu\text{g}/\text{m}^3$
SG-1	02.02.2015 to 03.02.2015	16:30 to 00:30			18	25	5
		00:30 to 08:30	130	51	16	26	4
		08:30 to 16:30			13	28	6
SG-2	09.02.2015 to 10.02.2015	16:15 to 00:15			13	31	2
		00:15 to 08:15	117	66	16	29	13
		08:15 to 16:15			10	26	11
SG-3	16.02.2015 to 17.02.2015	16:15 to 00:15			13	29	4
		00:15 to 08:15	132	49	13	30	0
		08:15 to 16:15			12	25	7
SG-4	26.02.2015 to 27.02.2015	16:15 to 00:15			10	10	5
		00:15 to 08:15	128	52	13	18	7
		08:15 to 16:15			15	16	6
Average			127	54		14.4	25.8
Standard Dev			7	0		1.7	5.7
							6.4
							1.4

Table 7: Results of Air Pollutant Concentration at SGC Station

Sampling Period	Date	Time [Hrs]	O ₃ [$\mu\text{g}/\text{m}^3$]	Pb [$\mu\text{g}/\text{m}^3$]	As [$\mu\text{g}/\text{m}^3$]	Ni [$\mu\text{g}/\text{m}^3$]	Cd [$\mu\text{g}/\text{m}^3$]	BaP [$\mu\text{g}/\text{m}^3$]	CO [$\mu\text{g}/\text{m}^3$]	CO ₂ [ppm]
NAAQMS			100 $\mu\text{g}/\text{m}^3$	1.0 $\mu\text{g}/\text{m}^3$	6 ng/ m^3	20 ng/ m^3	5 $\mu\text{g}/\text{m}^3$	1 ng/ m^3	4 ng/ m^3	Grab Sampling
SG-1	02.02.2015 to 03.02.2015	16:30 to 00:30								305
		00:30 to 08:30	26	0.16	<1	<1	2.4	<0.5	2.8	306
		08:30 to 16:30								
SG-2	09.02.2015 to 10.02.2015	16:15 to 00:15								
		00:15 to 08:15	33	0.19	<1	<1	2.6	<0.5	2.9	304
		08:15 to 16:15								
SG-3	16.02.2015 to 17.02.2015	16:15 to 00:15								
		00:15 to 08:15	29	0.17	<1	<1	2.8	<0.5	3.1	302
		08:15 to 16:15								
SG-4	26.02.2015 to 27.02.2015	16:15 to 00:15								
		00:15 to 08:15	28	0.14	<1	<1	3.1	<0.5	3.1	304
		08:15 to 16:15								
Average			29	0.17			2.7		3.0	304
Standard Dev			3	0.02			0.3		0.2	2

1.4 DISCUSSION

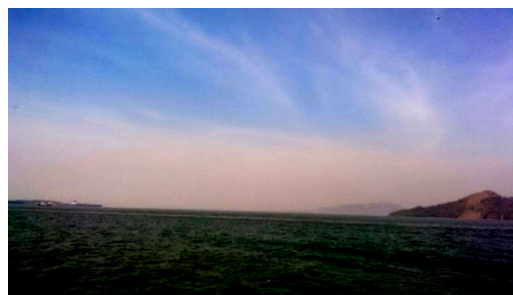
In Table 8, the average concentration values of air pollutants are provided at various stations of JNP area for the month of February, 2015. The values obtained are compared with respective CPCB standards described for Industrial, Residential, Rural and ecologically sensitive areas. The values obtained for Pb, As, Ni and Benzo(α)Pyrene [BaP] are below detection limits of measurements at all air monitoring stations for the month February, 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 February, 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	120 ± 14	53 ± 11	14.4 ± 1.0	24.2 ± 4.5	7.8 ± 1.7	31 ± 07	0.16 ± 0.06	3.2 ± 1.0	3.1 ± 0.2	297 ± 04
IMC	129 ± 15	61 ± 04	13.5 ± 2.1	25.4 ± 5.0	7.2 ± 1.6	35 ± 09	0.12 ± 0.03	3.3 ± 0.6	3.0 ± 0.3	297 ± 07
NG	118 ± 04	59 ± 05	13.9 ± 2.0	23.5 ± 4.2	6.4 ± 1.4	47 ± 13	0.10 ± 0.04	2.8 ± 0.4	2.8 ± 0.3	303 ± 04
SG	127 ± 07	54 ± 08	14.4 ± 1.7	25.8 ± 5.7	6.4 ± 1.4	29 ± 03	0.17 ± 0.02	2.7 ± 0.3	3.0 ± 0.2	304 ± 02
RESIDENTIAL AREA										
RC	122 ± 20	50 ± 10	13.6 ± 1.9	23.3 ± 3.7	6.8 ± 1.9	37 ± 08	0.13 ± 0.10	2.5 ± 0.5	3.1 ± 0.2	301 ± 05
ECO-SENSITIVE AREA										
EC	97	50	14.9	25.5	7.0	28	0.18	1.8	2.5	302

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 February, 2015 were tabulated in **Table 8**.

Micro-meteorology and atmospheric phenomenon studies explains the air pollutant levels finest; the atmospheric boundary level (ABL) is very close to ground and acts as virtual cutoff over earth. ABL traps the pollutants (figure along). ABL rises with increase in ambient temperature and allows more space for pollutants to get dispersed. Being winter season, the temperature is well below regular levels. Highest level of PM₁₀ was recorded at IMC i.e. major industrial activity area handling liquid chemical and also most congested road. Followed by SGC i.e. port vehicle entry point and RC i.e. location representing residential area have particulate concentrations above prescribed standards because of ongoing road maintenance and building renovation work.



Results for the air quality parameters at Elephanta Caves [EC] station during 05th February'14 to 06th February'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 February, 2015, the gaseous pollutants are well within the prescribed limits set for Industrial area.

1.5 OBSERVATIONS AND CONCLUSIONS

Shipping is less polluting than any other mode of transport and responsible for only 12% of marine pollution. However, public attitude remains highly negative towards shipping as substantial transportation is carried out through ships. A study conducted by International Maritime Organization (IMO) reveals that shipping contributes 3% of the world's GHG, 14% of world's NO_x emission and 5% of world's SO_x emission.

JN Port terminals have container handling capacity of about 86 thousand TEU's and 5.5 million tons of liquid cargo. Port is an interface between sea and hinterland, environmental implications by the shipping activities gets extended at the ports.

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.

Observations for the month of February'14:

- ✓ Construction of security check post and road maintenance at south gate complex was observed during the month. Along with concretization of port roads along the railway line was also observed.
- ✓ Development of centralized parking facility, construction of mooring jetty and 330mtr jetty got completed.
- ✓ Road connecting tank farm and township is being updated with construction of over bridge on the railway crossing. Land preparation and foundation work continued during the month of February'15.
- ✓ *Vehicular Traffic at three gates:* The monitoring of ambient air Quality at South gate and North gate complexes are done once a week. The particulate matter concentrations exceed the CPCB limits. Huge vehicular movement of container trailers, shift buses and passenger cars travel through these gates account for elevated pollutant levels. The location is covered by large control sections and dense tree cover accounting as pollutant trap. The initiative taken by the port in terms of maintenance of port vehicles, PUC checking of vehicles visiting port and enough green cover provided in and around the area contributes significantly to

reduce overall pollution.

- ✓ All the public and community buildings in residential complex / township are under renovation. These account for partially elevated particulate concentrations. This is being temporary activity, it will not affect in ambient concentrations over longer time.
- ✓ Open fire with solid waste, dried leaves and plant residue burning was significantly observed at Elephanta Island.



Open fire at Elephanta Island



Cement paving at maruti yard



Renovation of commercial complex at Residential Complex



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

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

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

2.1 INTRODUCTION

For study of Marine ecology, Total 8 fixed harbor stations [W1 to W7 and W9] and 1 movable station [W10] are identified. At Nhava creek 4 fixed stations [W11 to W14] are identified. All above mentioned stations are selected for studying aquatic flora and fauna as well as benthic fauna. The description of stations is depicted in **Table 9**. The location map of various Marine ecology monitoring stations along with direction of towing are described in **Annexure-IV**.

2.2 MARINE WATER QUALITY MONITORING METHODOLOGY

The objective of Marine water quality monitoring is to assess compliance with statutory water quality objectives, to reveal long term changes in water quality and to provide a basis for the planning of pollution control strategies.

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

Creek Water Quality Monitoring– Three samples from the surface, mid depth and bottom are collected and composite from four water quality monitoring stations in the Nhava Creek during spring and 3rd hour of neap tide only because of very low water depth available (mud flat) at these stations. In all 24 samples are collected from four Nhava creek stations.

Study of Sediment Characteristics – Sediment samples are collected from all 13 stations. The list of parameters analyzed to assess the Marine Water Quality is depicted in **Table 10** along with parameters to be monitored for sediment characterization. Annexure-V describes Primary Water Quality Criterion for **Class SW-IV** Waters (For Harbor Waters).



Water sampling with Niskinson Sampler Sediment sampling with Grab Sampler

Table 9: Description of Marine Water Quality Monitoring Stations

Sr. No.	Station	Description	Date of Sampling
1.	W1	Between Elephanta and Nhava Islands, and can be identified at the last green buoy no. <u>F1Green</u> of JNPT approach channel and just opposite to ONGC Depot at the Nhava Island.	05 th February, 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	05 th February, 2015
3.	W3	Identified by the green buoy no. <u>FG2 Green</u> of JNPT approach channel and lies near the landing jetty.	06 th February, 2015
4.	W4	Located at Uran Patch Beacon (lighthouse on concrete platform) near the Butcher Island filling platform.	06 th February, 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	05 th February, 2015
	W11 to W14		07 th February, 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.	05 th February, 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.	06 th February, 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	06 th February, 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.	06 th February, 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 February, 2015

Sample Name		Depth, [m]	Temp., [°C]	pH	Salinity, [ppth]	Turbidity, [NTU]	TDS, [mg/L]	TSS, [mg/L]	TS, [mg/L]
Standard		-	-	6.5 - 9.0	-	-	-	-	-
W1	SS	8.0	24.1	7.41	35.3	9	31808	58	31866
	SM		23.9	7.51	34.5	14	30142	74	30216
	SB		23.6	7.69	31.2	16	31312	160	31472
	NS	7.3	23.2	7.65	33.7	11	30200	122	30322
	NM		23.2	7.62	34.5	21	30004	80	30084
	NB		23.2	7.67	34.5	22	29870	88	29958
W2	SS	5.2	24.9	7.68	35.3	25	31324	142	31466
	SM		24.3	7.59	35.3	25	30256	164	30420
	SB		24.1	7.65	34.5	22	30148	211	30359
	NS	4.9	24.1	7.72	36.1	25	30092	235	30327
	NM		23.6	7.57	33.7	24	29946	176	30122
	NB		23.5	7.59	32.8	25	29888	231	30119
W3	SS	8.2	23.5	7.68	32.8	7	30132	42	30174
	SM		23.5	7.80	33.7	7	29786	136	29922
	SB		23.4	7.69	35.3	12	29872	152	30024
	NS	7.5	23.1	7.79	34.5	5	29840	21	29861
	NM		23	7.55	32.8	5	30076	38	30114
	NB		23	7.66	33.7	10	30462	24	30486
W4	SS	7.2	23.9	7.59	34.5	6	30954	101	31055
	SM		23.6	7.66	32.8	8	30730	45	30775
	SB		23.5	7.57	35.3	10	30180	97	30277
	NS	6.7	23.1	7.71	34.5	7	29952	85	30037
	NM		23.2	7.65	33.7	6	29874	94	29968
	NB		23	7.70	32.8	11	30136	132	30268
W5	SS	13.5	23.9	7.63	33.7	9	28886	147	29033
	SM		24.1	7.67	34.5	8	29460	104	29564
	SB		23.8	7.65	32.0	9	29388	140	29528
	NS	12.2	23.3	7.55	34.5	9	29840	104	29944
	NM		23.3	7.84	35.3	8	29940	95	30035
	NB		23.2	7.65	33.7	9	30086	95	30181

SS - SPRING

SURFACE

SM - SPRING MIDDLE

NS - NEAP SURFACE

NM - NEAP MIDDLE

NB - NEAP BOTTOM

Sample Name	Depth, [m]	Temp., [°C]	pH	Salinity, [ppt]	Turbidity, [NTU]	TDS, [mg/L]	TSS, [mg/L]	TS, [mg/L]
Standard	-	-	6.5 - 9.0	-	-	-	-	-
W6	SS	14.2	24.5	7.76	34.5	11	30340	135
	SM		24.5	7.71	34.5	9	30272	131
	SB		24.2	7.71	33.7	6	29940	96
	NS	12.0	24.2	7.74	33.7	6	29952	117
	NM		24	7.71	35.3	7	30008	151
	NB		23.8	7.76	32.0	9	30150	119
W7	SS	5.8	24.3	7.70	33.7	6	30042	118
	SM		23.9	7.65	34.5	9	30570	106
	SB		23.7	7.81	35.3	7	30280	117
	NS	5.2	23	7.66	34.5	6	30412	96
	NM		23.2	7.66	35.3	5	30980	121
	NB		23.3	7.84	33.7	6	30112	86
W9	SS	19.3	23.7	7.39	35.3	1	30162	89
	SM		23.5	7.46	34.5	2	30220	60
	SB		23.4	7.79	33.7	4	30484	55
	NS	16.7	23.5	7.56	35.3	1	29980	40
	NM		23.3	7.57	34.5	2	30142	58
	NB		23.3	7.54	36.1	3	29924	74
W10	SS	7.4	23.5	7.72	35.3	2	29880	53
	SM		23.6	7.58	34.5	3	30142	27
	SB		23.4	7.85	35.3	5	30186	43
	NS	6.2	23.1	7.64	33.7	2	29952	51
	NM		23.2	7.79	32.8	3	30180	32
	NB		23	7.62	34.5	3	30240	100

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 February, 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	38	2
	SS	6.4	41	<2	<0.1	<0.01	-	-
	SM	6.5	53	-	-	-	-	-
	SB	6.5	49	-	-	-	-	-
	NS#	-	-	-	-	1	<30	2
	NS	6.9	37	<2	<0.1	<0.01	-	-
	NM	6.8	45	-	-	-	-	-
	NB	6.8	33	-	-	-	-	-
W2	SS#	-	-	-	-	1	71	<2
	SS	6.6	45	<2	<0.1	<0.01	-	-
	SM	6.4	37	-	-	-	-	-
	SB	6.5	53	-	-	-	-	-
	NS#	-	-	-	-	1	59	2
	NS	6.6	41	<2	<0.1	<0.01	-	-
	NM	6.4	33	-	-	-	-	-
	NB	6.3	49	-	-	-	-	-
W3	SS#	-	-	-	-	2	171	12
	SS	5.9	41	<2	<0.1	<0.01	-	-
	SM	5.9	37	-	-	-	-	-
	SB	5.8	49	-	-	-	-	-
	NS#	-	-	-	-	1	85	4
	NS	5.5	45	<2	<0.1	<0.01	-	-
	NM	5.4	53	-	-	-	-	-
	NB	5.5	33	-	-	-	-	-
W4	SS#	-	-	-	-	1	79	2
	SS	5.4	53	<2	<0.1	<0.01	-	-
	SM	5.6	37	-	-	-	-	-
	SB	5.7	45	-	-	-	-	-
	NS#	-	-	-	-	2	52	<2
	NS	5.6	33	<2	<0.1	<0.01	-	-
	NM	5.6	49	-	-	-	-	-
	NB	5.6	41	-	-	-	-	-
W5	SS#	-	-	-	-	<1	72	2
	SS	6.6	45	<2	<0.1	<0.01	-	-
	SM	6.5	49	-	-	-	-	-
	SB	6.6	37	-	-	-	-	-
	NS#	-	-	-	-	1	<30	2
	NS	6.8	33	<2	<0.1	<0.01	-	-
	NM	6.8	41	-	-	-	-	-
	NB	6.8	53	-	-	-	-	-

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	195	2
	SS	6.6	41	<2	<0.1	<0.01	-	-
	SM	6.6	33	-	-	-	-	-
	SB	6.6	49	-	-	-	-	-
	NS [#]	-	-	-	-	1	62	<2
	NS	6.3	45	<2	<0.1	<0.01	-	-
	NM	6.2	29	-	-	-	-	-
	NB	6.2	37	-	-	-	-	-
W7	SS [#]	-	-	-	-	2	<30	<2
	SS	5.9	37	<2	<0.1	<0.01	-	-
	SM	5.7	45	-	-	-	-	-
	SB	5.6	29	-	-	-	-	-
	NS [#]	-	-	-	-	1	75	2
	NS	6.0	54	<2	<0.1	<0.01	-	-
	NM	5.8	33	-	-	-	-	-
	NB	5.8	41	-	-	-	-	-
W9	SS [#]	-	-	-	-	2	82	<2
	SS	5.9	41	<2	<0.1	<0.01	-	-
	SM	6.0	54	-	-	-	-	-
	SB	5.9	33	-	-	-	-	-
	NS [#]	-	-	-	-	1	40	4
	NS	5.6	45	<2	<0.1	<0.01	-	-
	NM	5.7	37	-	-	-	-	-
	NB	5.6	29	-	-	-	-	-
W10	SS [#]	-	-	-	-	3	98	4
	SS	6.4	37	<2	<0.1	<0.01	-	-
	SM	5.7	45	-	-	-	-	-
	SB	5.5	29	-	-	-	-	-
	NS [#]	-	-	-	-	2	75	<2
	NS	5.9	33	<2	<0.1	<0.01	-	-
	NM	5.6	41	-	-	-	-	-
	NB	5.3	54	-	-	-	-	-

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 February, 2015

Station Name	Organic Matter		Total Carbon		Inorganic Phosphate
	mg/g	%	mg/g	%	mg/kg
W1	107.0	10.7	62.1	6.2	79
W2	96.0	9.6	55.7	5.6	96
W3	133.0	13.3	77.1	7.7	69
W4	67.0	6.7	38.9	3.9	88
W5	Sediment not found				
W6	144.8	14.5	84.0	8.4	74
W7	101.0	10.1	58.6	5.9	93
W8	110.0	11.0	63.8	6.4	82
W9	130.0	13.0	75.4	7.5	86
Average	111.1	11.1	64.4	6.4	83.4

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

Sample Name	Depth, [m]	Temp., [°C]	pH	Salinity, [ppt]	Turbidity, [NTU]	TDS, [mg/L]	TSS, [mg/L]	TS, [mg/L]
Standard	-	-	6.5 - 9.0	-	-	-	-	-
W11	SS	3.5	24.6	7.69	33.7	26	30378	254
	SM		24.3	7.63	32.0	34	29930	331
	SB		24.1	7.69	34.5	33	30142	317
	NS	2.5	26.2	7.65	33.7	39	30228	250
	NM		26	7.74	32.8	17	29870	322
	NB		26	7.57	36.1	53	29910	281
W12	SS	3.5	24.8	7.60	32.8	29	29862	249
	SM		24.5	7.68	34.5	30	30240	303
	SB		24.2	7.66	32.0	51	30188	294
	NS	2.0	26.5	7.72	33.7	42	30360	319
	NM		26.3	7.64	32.0	29	30270	263
	NB		26.2	7.64	35.3	44	30242	276
W13	SS	3.5	24.1	7.63	39.4	47	30422	260
	SM		24.2	7.61	34.5	31	30380	197
	SB		24.1	7.69	32.8	48	29980	197
	NS	2.5	26.3	7.71	35.3	49	30140	290
	NM		26.1	7.62	41.9	46	30320	158
	NB		26	7.75	36.9	44	29932	202
W14	SS	3.0	24.8	7.62	35.3	32	30230	324
	SM		24.9	7.67	33.7	37	30512	331
	SB		24.4	7.69	34.5	34	30468	401
	NS	1.5	26.4	7.69	36.1	71	29922	234
	NM		26.2	7.63	34.5	52	30352	271
	NB		26.2	7.73	35.3	19	30240	140

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

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

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

Sample Name	DO, [mg/L]	COD, [mg/L]	BOD, [mg/L]	NH ₄ ⁺ -N, [mg/L]	Phenol, [mg/L]	O&G, [mg/L]	TPC, [CFU/mL]	Fecal Coliforms, [MPN/100 mL]
Standard	3.0 mg/L or 40% of saturation value	-	5	-	-	10	-	500
W11	SS	6.0	49	<2	<0.1	<0.01	1	48
	SM	5.6	41	-	-	-	-	-
	SB	5.7	33	-	-	-	-	-
	NS	6.0	37	<2	<0.1	<0.01	2	112
	NM	6.0	29	-	-	-	-	-
	NB	6.0	45	-	-	-	-	-
W12	SS	6.2	44	<2	0.1	<0.01	1	62
	SM	6.2	36	-	-	-	-	-
	SB	6.0	40	-	-	-	-	-
	NS	6.1	48	<2	<0.1	<0.01	1	<30
	NM	5.9	56	-	-	-	-	-
	NB	5.8	52	-	-	-	-	-
W13	SS	6.0	48	<2	0.1	<0.01	1	51
	SM	6.0	52	-	-	-	-	-
	SB	5.9	44	-	-	-	-	-
	NS	6.2	36	<2	0.1	<0.01	2	78
	NM	6.0	56	-	-	-	-	-
	NB	6.0	40	-	-	-	-	-
W14	SS	5.6	32	<2	<0.1	<0.01	1	170
	SM	5.5	34	-	-	-	-	-
	SB	5.6	56	-	-	-	-	-
	NS	6.0	48	<2	<0.1	<0.01	2	85
	NM	6.0	52	-	-	-	-	-
	NB	6.0	40	-	-	-	-	-

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 February, 2015

Sample Name	Organic Matter		Total Carbon		Inorganic Phosphate
	mg/g	%	mg/g	%	
W11	Sediment not found				
W12					
W13	90.0	9.0	52.2	5.2	75
W14	99.0	9.9	57.4	5.7	69

2.4DISCUSSION

In **Table 17**, the observed concentration range for various parameters for Harbor region is collected while in **Table 18**, the observed concentration range for various parameters for Nhava creek region is collected. The observed values are compared with Primary Water Quality Criteria for **Class IV Waters** [Harbor Waters] given by CPCB [refer **Annexure V**].

Table 17: Observed Concentration Ranges of Various Parameters for JNP Harbor Area

Sr. No.	Parameter	Observed Range	Unit	Prescribed Limits
1	Temperature	23.0 – 24.9	°C	-
2	pH	7.4 - 7.9	-	6.5 - 9.0
3	Salinity	31.2 – 36.1	ppth	-
4	Turbidity	1.2 – 25.2	NTU	-
5	TDS	28886 – 31808	mg/L	-
6	TSS	21 – 235	mg/L	-
7	TS	29033 – 31866	mg/L	-
8	DO	5.3 – 6.9	mg/L	3.0 mg/L or 40% of saturation value
9	COD	28.8 – 53.6	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	38 – 195	CFU/ml	-
15	Fecal Coliforms	2 – 500	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	24.1 – 26.5	°C	-
2	pH	7.6 – 7.8	-	6.5 - 9.0
3	Salinity	32.0 – 41.9	Ppth	-
4	Turbidity	17.0 – 70.7	NTU	-
5	TDS	29862 – 30512	mg/L	-
6	TSS	140 – 401	mg/L	-
7	TS	30111 – 30869	mg/L	-
8	DO	5.5 – 6.2	mg/L	3.0 mg/L or 40% of saturation value
9	COD	28.8 – 56.0	mg/L	-
10	BOD	< 2.0	mg/L	5
11	NH ⁴⁺ -N	< 1.0	mg/L	-
12	Phenol	< 0.01	mg/L	-
13	Oil & Grease	< 1.0	mg/L	10
14	Total Plate Count	48 – 170	CFU/ml	-
15	Fecal Coliforms	2 – 9	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 February, 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 February, 2015 are found to be well within prescribed limits.

The values obtained for turbidity February is due to variation in suspended solids, but exact relationship could not be established based on observed values. Approximately 3 to 4 % solids are present in water and the observed salinity values for Harbor and Creek water samples in the month of February, 2015 are ranges from 31.2 to 41.9 ppt. [Refer Tables 11 and 14]. The ranges observed for COD values in mg/L are 28.8 – 53.6 and 28.8 – 56.0 respectively for Harbor and Creek water samples. The DO levels are ranges between 5.3 to 6.9 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 February, 2015. The values obtained for Organic Matter, Total Organic Carbon and Inorganic Phosphate are ranges between 6.7 – 14.5%, 3.9 – 8.4% and 74 – 96 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 9.0 & 9.9%, 5.2 & 5.7% and 75 – 69 mg/kg, respectively for sediment samples collected from Nhava Creek area during the month of February, 2015.

2.5 OBSERVATIONS AND CONCLUSIONS

Observations for the month of February:

- ✓ *The Construction of 330 m Jetty at North Side of the JNP:* North Approach Bridge was completed.
- ✓ *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 February, 2015. The characteristic parameters for sediments are also showing normal variation in concentrations for JNP Harbor area and Nhava Creek area during February, 2015. Considering the activities in the Harbor area and the results obtained for the month of February, 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 [W10] water quality monitoring stations.

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

Table 19: List of Parameters to Monitor Marine Ecology

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

3.3 RESULTS

The net and gross primary productivity 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.	W1	425	375
2.	W2	315	275
3.	W3	315	215
4.	W4	215	175
5.	W5	375	310
6.	W6	475	215
7.	W7	415	315
8.	W9	315	275
9.	W10	375	275
NHAVA Creek Area			
10.	W11	275	215
11.	W12	415	315
12.	W13	275	215
13.	W14	315	275

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				SWI	PPI
				Bacillario-phyceae	Chloro-phyceae	Cyano-phyceae	Crypto-phyceae		
JNP Harbor Area									
1	W1	Surface	450	75	20	5	-	1.63	15
		Bottom	390	45	35	10	10	0.69	18
2	W2	Surface	520	50	30	10	10	1.10	16
		Bottom	425	65	25	10	-	0.85	15
3	W3	Surface	315	70	25	5	-	0.73	12

		Bottom	220	50	30	10	10	0.50	19
4	W4	Surface	345	45	30	20	5	1.50	18
		Bottom	290	60	20	10	10	1.25	21
5	W5	Surface	370	65	25	5	5	0.95	21
		Bottom	175	50	30	10	10	0.82	13
6	W6	Surface	370	65	25	10	-	1.22	21
		Bottom	210	55	25	10	10	0.70	17
7	W7	Surface	550	60	20	10	10	0.93	21
		Bottom	485	50	30	20	-	1.30	18
8	W9	Surface	575	55	30	15	-	1.45	15
		Bottom	410	65	25	10	-	0.52	16
9	W10	Surface	510	50	30	10	10	1.62	21
		Bottom	425	45	25	20	10	1.12	18
NHAVA Creek									
10	W11	Surface	530	56	24	10	10	1.12	21
		Bottom	425	65	25	10	5	0.96	17
11	W12	Surface	470	60	25	15	-	1.36	19
		Bottom	390	72	18	10	-	1.60	13
12	W13	Surface	420	65	25	10	-	0.96	18
		Bottom	375	75	20	5	-	0.35	21
13	W14	Surface	410	60	20	10	10	1.92	22
		Bottom	375	65	20	5	10	1.36	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 sp.</i>	<i>Closterium sp.</i>	<i>Gloeocapsa sp.</i>	<i>Cryptomonas sp.</i>
2.	<i>Nitzschia sp.</i>	<i>Cosmarium sp.</i>	<i>Oscillatoria sp.</i>	-
3.	<i>Gyrosigma sp.</i>	<i>Crucigenia sp.</i>	<i>Anabaena sp.</i>	-
4.	<i>Surirella sp.</i>	<i>Scenedesmus sp.</i>	<i>Aphanocapsa sp.</i>	-
5.	<i>Fragillaria sp.</i>	-	-	-
6.	<i>Skeletonema sp.</i>	-	-	-
7.	<i>Pleurosigma sp.</i>	-	-	-

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

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

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

Sr. No.	Towing between Stations	Zoo- plankton, [No/m ³]	Percent Composition of Zooplankton Groups				SWI
			Copepoda	Cladocera	Foraminifera	Rotifera	
JNP Harbor Area							
1.	W1 – W2	250	50	20	20	10	1.10
2.	W2 – W5	325	45	25	20	10	1.25
3.	W5 – W1	410	55	25	10	10	1.20
4.	W5 – W6	375	55	25	20	-	1.35
5.	W6 – W2	215	50	30	10	10	1.23
6.	W4 – W3	320	50	25	15	10	1.56
7.	W3 – W7	290	50	30	10	10	0.95
8.	W7 – W10	325	60	20	10	10	1.75
9.	W10 – W3	210	45	15	20	20	1.30
10.	W9 – W3	230	65	25	10	-	0.85
NHAVA Creek							
11.	W5 – W11	250	50	20	20	10	1.52
12.	W11 – W12	285	65	25	10	-	0.52
13.	W12 – W13	290	45	30	15	10	1.50
14.	W13 – W14	175	55	35	10	-	1.63
SWI : Ranges of Shannon Wiener Diversity Index <1 : Indicate maximum impact of pollution or adverse factor. 1 to <3 : Indicate medium impact of pollution or adverse factor. 3 & above : Indicate lowest or minimum impact of pollution or adverse factor.							

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

Sr. No.	Copepoda	Rotifera	Cladocera	Foraminifera
1.	<i>Cyclops</i> sp.	<i>Keratella</i> sp.	<i>Daphnia</i> sp.	<i>Rotaliasp.</i>
2.	-	<i>Brachionus</i> sp.	-	<i>Triloculina</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	4.2	3.5	BDL	BDL	280
2.	W2	3.6	2.5	BDL	BDL	240
3.	W3	2.7	1.6	BDL	BDL	180
4.	W4	2.1	1.5	0.8	BDL	140
5.	W5	3.5	2.6	BDL	BDL	233
6.	W6	3.2	2.5	BDL	BDL	213
7.	W7	2.5	1.7	BDL	BDL	166
8.	W9	3.9	2.4	BDL	BDL	260
9.	W10	2.1	1.9	BDL	BDL	140
Nhava Creek Area						
10.	W11	2.8	1.3	BDL	BDL	186
11.	W12	1.5	1.0	0.5	BDL	100
12.	W13	3.2	2.4	BDL	BDL	213
13.	W14	2.4	1.8	BDL	BDL	160

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

Sr. No.	Station	POC, [mg/m ³]
Standard		10 - 100
JNP Harbor Area		
1.	W1	912
2.	W2	757
3.	W3	989
4.	W4	963
5.	W5	860
6.	W6	1067
7.	W7	1041
8.	W8	895
9.	W9	1049
Nhava Creek Area		
10.	W11	981
11.	W12	946
12.	W13	886
13.	W14	963

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

Sr. No.	Station	Macrobenthos [No/m ³]	Percent Composition of Macrobenthos				SWI
			Foraminifera	Gastropods	Polychaeta	Chironomidae	
JNP Harbor Area							
1.	W1	230	50	20	20	10	1.21
2.	W2	320	60	30	10	-	1.32
3.	W3	215	50	30	20	-	0.56
4.	W4	195	30	30	20	20	1.69
5.	W6	250	50	20	20	10	0.82
6.	W7	150	40	20	20	20	0.90
7.	W9	175	55	30	15	-	1.63
Nhava Creek Area							
8.	W13	215	50	20	20	10	1.42
9.	W14	170	40	20	30	10	1.20
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	712	1349	258	11000	132	285	<10	1771	2992		
W2	534	1403	258	12800	142	775	<10	1614	3458		
W3	712	1268	216	8600	96	965	<10	1890	1470		
W4	489	1484	258	11500	109	810	17	2493	3039		
W5	801	1511	256	10500	103	292	<10	1640	2433		
W6	534	1726	254	10900	143	785	<10	1205	2341		
W7	667	1267	258	11500	109	820	15	1951	2666		
W9	489	1511	252	11500	141	1060	<10	1680	2844		
W10	489	1403	258	11100	171	935	16	2457	2849		
JNP NHAVA CREEK AREA											
W11	534	1511	248	11000	110	585	15	1656	3054		
W12	489	1511	260	10500	144	525	17	1982	2501		
W13	623	1484	258	11000	148	930	<10	1876	2775		
W14	489	1484	258	11600	141	1070	13	2128	3163		

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	1814	1102	310	5440	141	43	0.22	101	5479	
W2	8986	674	380	7360	167	51	0.37	174	4049	
W3	5184	157	340	6400	133	38	0.27	114	4895	
W4	4320	157	260	4640	130	60	0.31	121	4308	
W5	Sediment not found									
W6	4011	159	380	6600	155	41	0.29	111	4700	
W7	6134	105	380	7040	133	34	0.41	124	4108	
W9	5962	787	340	4200	168	62	0.33	108	2384	
W10	4320	157	350	6400	161	54	0.43	142	5137	
JNP NHAVA CREEK AREA										
W11	Sediment not found									
W12	Sediment not found									
W13	4406	420	180	2600	154	55	0.23	118	2856	
W14	5270	315	240	4720	142	38	0.26	151	3573	

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 475 and 375 mgC/m³/d at stations W6 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 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 W6 might be cause of high POC 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 175 and 575 algal cells/ml. Samples collected at station W5(B) and W9(S) showed lowest and highest counts respectively. The effluent discharges coming from Thane creek might be cause of high count in the respective station. Bacillariophyceae dominated all samples followed by Chlorophyceae. The phytoplankton population comprised of fifteen genera with 4 major groups, namely Bacillariophyceae, Chlorophyceae, Cyanophyceae and Chrysophyceae [Table 22]. High count of phytoplankton at station W9 might be cause of high phosphate count in the respective station.

Palmer Index: Palmer (1969) made the first major attempt to identify and prepare a list of genera and species of algae tolerant to organic pollution. Pollution-tolerant genera and species of four groups of algae from all stations were encountered as depicted in Table 20.

Shannon - Wiener Diversity Index (SWI): During the survey, the SWI values varied between 0.30 and 1.92 at stations W7B and W14S. The values also suggest low to medium impact of pollution or adverse factor.

Secchi Disk Transparency: Secchi disk transparency refers to the depth to which the black and white Secchi disk can be seen in the water. Water clarity, as determined by a Secchi disk, is affected by two primary factors: algae and suspended particulate matter. Light penetration was measured in the JNP Harbour Area and Nhava creek with the help of Secchi Disk (**Table 23**). Transparency varied between 30-50 cm. Maximum algal count might be cause for low transparency at station W9.

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 175 and 410 N/m³ at stations W13-W14 and W5-W1. Total six genera of zooplankton were recorded. Among zooplankton Copepoda and Cladocera group were dominant [**Table 25**]. As the genera indicating clean water quality.

Shannon - Wiener Diversity Index (SWI): The average SWI, observed to vary from 0.52 to 1.75 at stations W11-W12 & W7-W10 respectively indicated low to medium load of organic pollution or adverse factors. Generally “Shannon Wiener index” values between 1 and 3 are believed to indicate semi productivity of the water body, while the values above 3 are considered to represent lowest or minimum impact of pollution.

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 40C 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 100 and 260 mg/m³. The minimum algal biomass was (100 mg/m³) found at W12 and maximum (260 mg/m³) was found at W9 station. The lowest and highest chlorophyll a levels from surface water sample varied from 1.0 at station W12 (B) to 3.9 mg/m³ at W9(S). Phytoplankton count was high at W9 station resulted in increased chlorophyll

count in this station. However, Pheophytin concentrations of many samples were below detectable limit [Table 26].

3.4.1.d Particulate Organic Carbon [POC]:

The concentration of particulate oxidizable carbon [POC] is given in Table 27. In JNP harbor POC content was found to be between 757 – 1067mg/m³ with an average of 948 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 886 – 981 mg/m³ with an average of 944 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, Lagenella and Florilus 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. Chironomid larva from Chironomidae was also observed as benthic fauna. The highest count was 350 No/m³ in sampling point W2 (Table 28). Benthos was absent at stations W5, W11 and W12. The SWI values were observed to vary from 0.56 – 1.42 at stations W3 and W13. Presence of maximum macrobenthos around sampling stations might be because of high count of calcium found in this region.

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 31**), 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 96µg/L – 171µg/L. In JNP harbor region, the Phosphate value was found above prescribed standard range [0.1 – 90µg/L]. The Nitrate was found to be between 285µg/L – 1060µg/L. The minimum value of Nitrate was found at W1

station and maximum at W9 station. The average concentration of Nitrate was found to be 747µg/L and overall Nitrate was found within range [1.0 to 500µg/L] at all stations. Silica is another important nutrient in seawater. The requirement of silica by diatoms is however, entirely limited to skeletal formation and has particular importance in coastal upwelling region where diatoms form a dominant part of phytoplankton. Silica in the form of silicate in JNP harbor water was found between 1205 – 2493 µg/L with an average of 1856µg/L. The minimum concentration of silica was found at W6 station of JNP harbor region and the maximum concentration of silica was found at W4 station. The Sulphate was found between 1470 – 3458 mg/L, the minimum value recorded at W3 station and maximum at W2 station. The average concentration of Sulphate was found to be 2677 mg/L.

In Nhava Creek, Phosphate was found between 110µg/L – 148µg/L with an average 136µg/L which was above prescribed standard range [0.1-90µg/L]. Nitrate was found to be 525 – 1070 µg/L with an average 778 µg/L. The silica content in Nhava creek was found to be 1656 – 2128 µg/L with an average of 1910 µg/L. The minimum silica content was found at station W11 station and maximum was found at W14 station. Sulphate was found between 2501 – 3163 mg/L with an average of 2873 mg/L. The minimum value for Sulphate was found at W12 station and maximum value at W14 station.

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

The nutrients in sediments at various stations in JNP harbor area and Nhava Creek area are given in **Table 30**. In harbor region the sediment found at eight locations out of nine. Phosphate was found between 130 – 168 mg/kg with an average of 148 mg/kg. The Nitrate was found minimum value at W7 i.e. 34 mg/kg and maximum value at W9 station i.e. 62 mg/kg. The average concentration of Nitrate was found to be 48 mg/kg. The Nitrite was found to be between 0.22 – 0.43 mg/kg with an average of 0.33 mg/kg. The minimum concentration of nitrite was found at W1 station and maximum value at W10 station. Silica in the form of silicate in JNP harbor sediments were found between 101 to 174 mg/kg with an average of 125 mg/kg. The minimum concentration of silica was found at W1 station and maximum value was found at W2 station. The Sulphate was found between 2384 to 5479 mg/kg, with minimum value at W9 station and maximum value at W1 station. The average concentration of Sulphate was found to be 4383 mg/kg.

In Nhava Creek region the sediment found at two locations out of four. Phosphate levels were 142 and 154 mg/kg with an average of 148 mg/kg. Nitrate was found to be 38 and 55 mg/kg. The average concentration of Nitrate was found to be 47 mg/kg. The Nitrite was found to be 0.23 and 0.26 mg/kg. Silica in the form of silicate in JNP harbor sediments were found to be 118 to 151mg/kg with an average of 135 mg/kg. The Sulphate was found to be 2856 and 3573mg/kg. The average concentration of Sulphate was found to be 3215 mg/kg.

b. Cations:

In harbor region water, the Calcium was found between 489 to 801 mg/L with an average of 603 mg/L given in **Table 29**. The Magnesium was found to be 1267 – 1726 mg/L, with

maximum value at W6 station. The average concentration of Magnesium was found to be 1436 mg/L. Potassium in JNP harbor water was found between 216 to 258 mg/L with an average of 252 mg/L. The minimum concentration of Potassium was found at W3 station and maximum value at W1, W2, W4, W7 & W10 stations. The Sodium was found between 8600 to 12800 mg/L with an average of 11044 mg/L. The minimum concentration of sodium was found at W3 station and maximum value of at W2 station.

In Nhava Creek, Calcium concentration was found with an average 534 mg/L given in **Table 29**. Magnesium concentration was found to be 1484 – 1511 mg/L with an average of 1497 mg/L. The minimum value of Magnesium was found at W13 & W14 stations and maximum value was found at W11 & W12 stations. The Potassium content in Nhava creek was found to be 248 – 260 mg/L with an average of 256 mg/L. Sodium minimum concentration was found to be 10500 mg/L at W12 and maximum of 11600 mg/L at W14.

In harbor region sediments, the Calcium was found to be 1814 to 8986 mg/Kg with an average of 5091 mg/Kg given in **Table 30**. The minimum Concentration of Calcium was found at W1 station and maximum concentration at W2 station. Magnesium was found to be 105 to 1102 mg/Kg, with minimum value at W7 station and maximum was recorded at W1 station. The average concentration of Magnesium was found to be 412 mg/Kg. Potassium in JNP harbor sediment was found to be 260 to 380 mg/Kg with an average of 343 mg/Kg. The minimum concentration of Potassium was found at W4 station and maximum value at W2, W6 & W7 station. Sodium was found to be 4200 to 7360 mg/Kg with an average of 6010 mg/Kg. The minimum concentration of sodium was found at W9 station and maximum value at W2 station.

In Nhava Creek sediments, Calcium was found to be 4406 to 5270 mg/Kg with an average 4838 mg/Kg given in **Table 30**. Magnesium was found to be 315 to 420 mg/Kg. Average potassium content in Nhava creek was found to be 367 mg/Kg. The minimum sodium value was found at W13 station and maximum value at W14.

3.5 OBSERVATIONS AND CONCLUSIONS

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

Sr. No.	Parameter	Criteria	Observations	Remarks	Mitigation Measures
1.	Net primary productivity	<1500 mgC/m ³ /day at surface	The observed values falls under 175 – 375 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 1.0 – 4.2 mg/m ³	All stations follow Oligotrophic class of water	-
3.	Phosphate	0.1- 90 µg/L	Harbour area – 127 µg/L; Creek area – 136 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 – 747 µg/L; Creek area – 778 µg/L	A nutrient produced in natural water by decomposition of nitrogenous organic compounds. Moderate level of nitrate.	Exceeds the Range
5.	Nitrite	<125 µg/L	Harbour area – 16 µg/L & Creek area – 15 µg/L	A nutrient produced in natural water by decomposition of nitrogenous organic compounds. Moderate level of nitrite.	Exceeds the Range
6.	Particulate Organic Carbon	10 – 100 mg/m ³	Harbour area – 948 mg/m ³ ; Creek area – 944 mg/m ³	This may be due to detritus material originate from Mangrove swamps or detritus planktons	Awareness about the pollution of sea water
7.	Silicate (SiO ₂)	10-5000 µg/L	Harbour area – 1856 µg/L; Creek area – 1910 µg/L	Nucleic acid synthesis and skeletal formation of Diatoms.	Within Range

Observations for the month of February:

- ✓ *The Construction of 330 m Jetty at North Side of the JNP is underway:* North Approach Bridge was completed.
- ✓ *Construction of Mooring Dolphin Jetty in front of Liquid cargo jetty:* construction of slab and walkway was completed.
- ✓ *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 February, 2015 except Particulate Organic Carbon.

During the analysis of samples collected in February 2015, we have noticed higher level of above parameters than the typical ones. The main reason being the dilution of water near the coastal areas due to monsoon where in fresh flood water coming from Sahyadri terrine is getting mixed. The fresh water which mixes with coastal water has higher levels of Silicates (More than 40 mg/L), phosphates as well as nitrites. This has been seen in the analysis of above parameters. The water samples collected had lower salinity than the normal sea water which is a proof of mixing two different waters.

According to Tulaskar et al., the high values for POC may be due to detritus material originating from Mangrove swamps by tidal effects or February 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	DW10	Sector III
8	DW13	CISF Canteen
9	DW14	Custom Canteen
10	DW15	JNPT Guest House
Inside the Port Area		
11	DW6	NSICT Canteen
12	DW7	GTI Canteen
13	DW8	POC Canteen
14	DW11	JNPT Workshop
15	DW12	C.T. Canteen
16	DW16	PPD Site Office
17	DW17	GTI -2
18	DW18	GTI CGC

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

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

4.2 RESULTS

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

Table 33: Results of Drinking water quality monitoring

Parameter	Unit of Measurement	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	120	140	121	115	115	133	-
pH	-	7.32	7.49	7.29	7.30	7.31	7.30	6.5 to 8.5
Chloride as Cl	mg/L	9.5	8.6	9.0	9.5	9.5	9.0	250
Total Dissolved Solids	mg/L	76	90	77	74	75	85	500
Total Hardness as CaCO ₃	mg/L	42	47	49	48	47	47	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	<1	<1	<1	<1	<1	1.7	200
NH ₄ ⁺ - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5
PO ₄ ⁻³ - P	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Total Coliforms	MPN/100ml	Nil	Nil	Nil	Nil	Nil	2	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	211	128	150	127	125	178	-
pH	-	7.20	7.40	7.46	7.27	7.38	7.41	6.5 to 8.5
Chloride as Cl	mg/L	9.9	10.5	9.9	9.5	9.5	9.9	250
Total Dissolved Solids	mg/L	130	83	97	82	80	114	500
Total Hardness as CaCO ₃	mg/L	50	47	49	48	51	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	2.5	<1	1.7	1.4	2.7	2.5	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	4	Nil	Nil	2	Nil	Nil	Nil

*: IS 10500:2012, Drinking Water - Specification

Table 33: Results of Drinking water quality monitoring										
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	Agreeable	
Turbidity	NTU	<1	<1	<1	<1	<1	<1	<1	1	
Conductivity	mS/cm	125.8	180	123	131	117	135		.	
pH	-	7.29	7.42	7.22	7.54	7.21	7.50		6.5 to 8.5	
Chloride as Cl	mg/L	9.9	9.5	9.0	9.5	9.0	9.0		250	
Total Dissolved Solids	mg/L	81	116	80	84	75	86		500	
Total Hardness as CaCO ₃	mg/L	48	49	54	50	50	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	<1	1.4	<1	3.4	3.3	3.9		200	
NH ₄ ⁺ - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		0.5	
PO ₄ ⁻³ - P	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		.	
Total Coliforms	MPN/100ml	2	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 8.6 to 10.5 mg/L and sulphates 1.4 to 3.9 mg/L. The concentration of total dissolved solids is found to be between 74.0 to 130.0 mg/L and concentration of total hardness as CaCO₃ is found to be 42.2 to 54.0 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 114.7 to 211.0 μS/cm. The acceptable range for pH is 6.5 to 8.5, while the observed pH range is 7.2 to 7.5. The iron content and NH₄⁺ – N and PO₄⁻³ – 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 **February'15** reported higher coliform counts at DW6, DW7, DW10, DW13 and DW14.

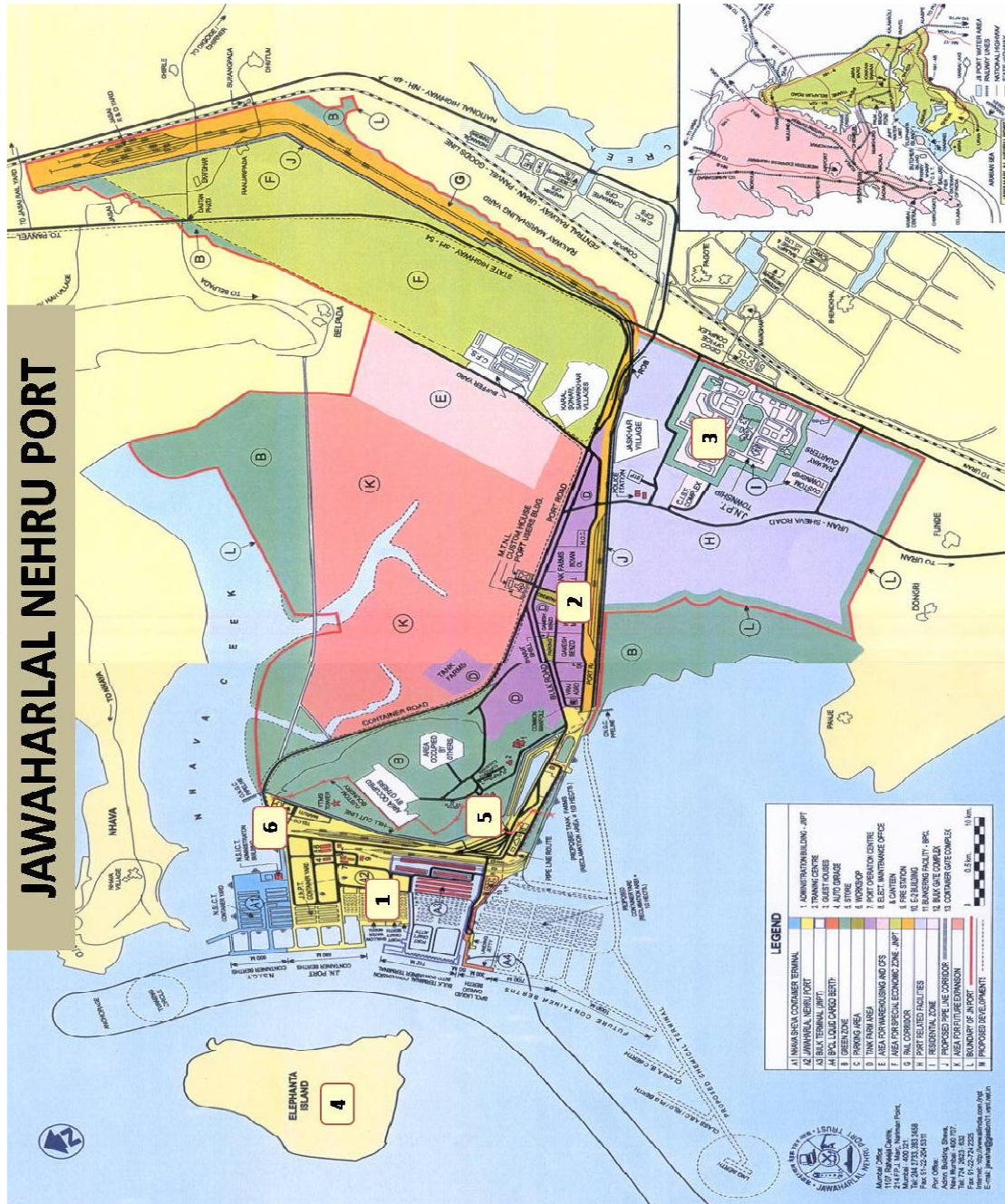
4.4 CONCLUSIONS

As per the drinking water specifications given in IS 10500:2012 and also on the basis of above described analysis parameters, the water is safe for drinking purpose at all drinking water monitoring stations around port area. Some stringent actions needed to be initiated to nullify coliform counts in side port operational area.

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

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

5. ANNEXURES



Annexure-I: Location map for Ambient Air Monitoring Stations

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

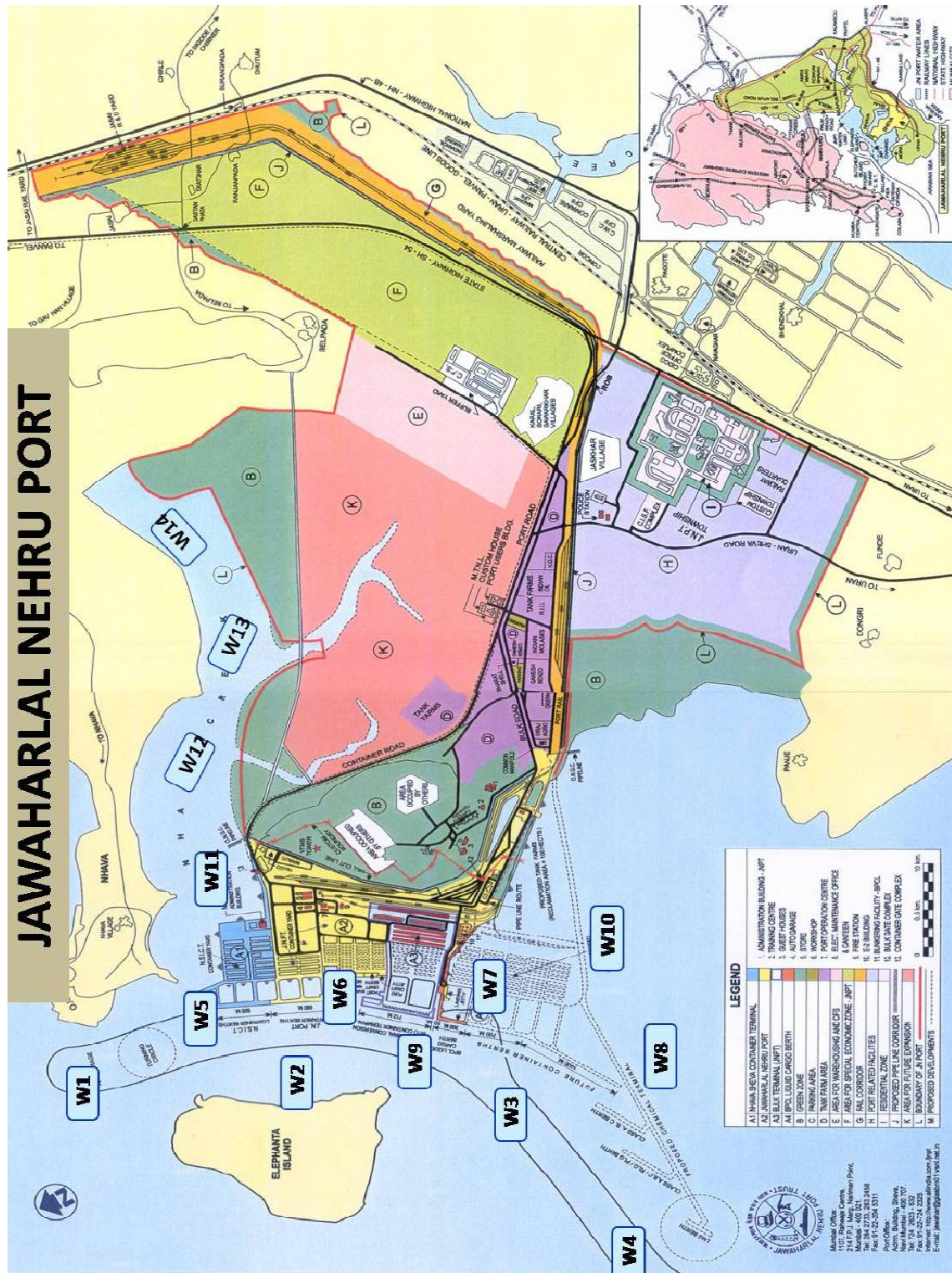
* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals

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

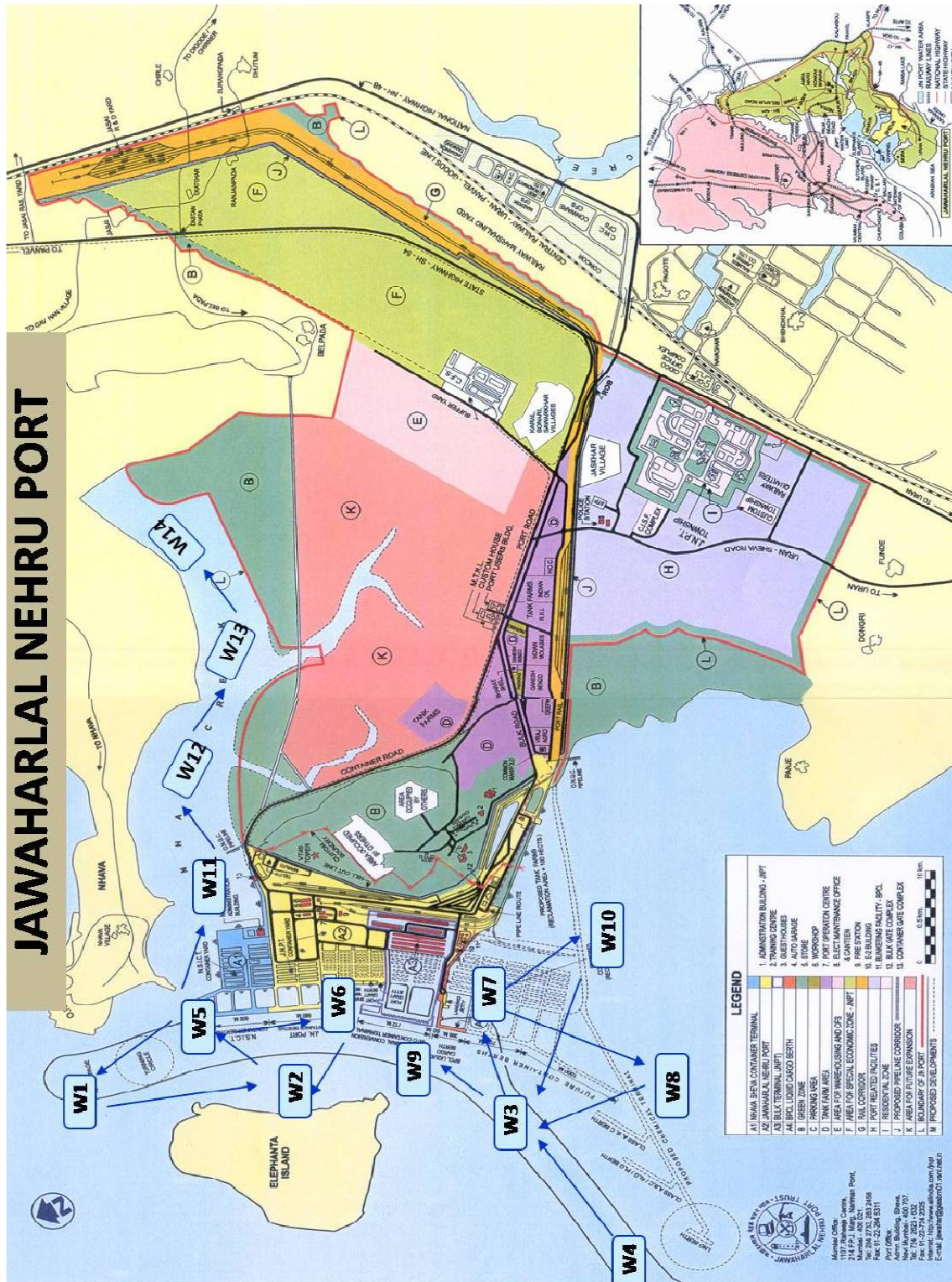
2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

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

Annexure-II: National Ambient Air Quality Monitoring Standard



Annexure-III: Location map for Marine Water Monitoring Stations



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

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

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

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

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