



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 given in **Table 1**. The location map of various air quality monitoring stations at JNP is depicted 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 of ambient air samples are carried out as per CPCB Guidelines for Ambient Air Quality Monitoring, Volume-I, 2012. The monitoring is carried-out as per air quality parameters mentioned in the National Ambient Air Quality Monitoring Standards (NAAQMS) CPCB Notification published on 18th December 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, while at NGC and SGC it is once a week. However, monitoring at Elephanta Caves is once a month as per schedule of EMP of JNPT.

In all above stations, 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 are used for a period of 24 hours to obtain one sample each 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 December, 2015 are given in **Tables 2, 3 & 4** respectively. The ambient air quality monitoring data for EC and two movable stations, NGC & SGC are given in **Tables 5, 6 & 7** respectively.

Table 2: Results of Air Pollutant Concentration at POC Station of JNP Area during the month of December, 2015													
Sampling Period	Date	Time, [Hrs]	PM ₁₀ , [µg/m ³]	PM _{2.5} , [µg/m ³]	SO ₂ , [µg/m ³]	24 hr (Avg)	8 hr	NO _x , [µg/m ³]	24 hr (Avg)	8 hr	NH ₃ , [µg/m ³]	24 hr (Avg)	8 hr
NAAQMS			100 µg/m ³	60 µg/m ³	-	80 µg/m ³	-	-	80 µg/m ³	-	-	400 µg/m ³	-
POC-1	01.12.2015 To 02.12.2015	14:00 to 22:00			28		53			26			
		22:00 to 06:00	241	105	30	28.2	58		54.7	28			27.3
		06:00 to 14:00			27		53			27			
POC-2	03.12.2015 To 04.12.2015	14:00 to 22:00			34		41			29			
		22:00 to 06:00	240	72	34	35.0	53		45.1	32			30.8
		06:00 to 14:00			38		42			31			
POC-3	07.12.2015 To 08.12.2015	14:00 to 22:00			39		62			41			
		22:00 to 06:00	248	93	41	40.1	69		70.8	44			41.8
		06:00 to 14:00			40		81			42			
POC-4	10.12.2015 To 11.12.2015	14:00 to 22:00			2		74			26			
		22:00 to 06:00	229	90	10	6.7	81		77.4	29			27.8
		06:00 to 14:00			9		77			28			
POC-5	14.12.2015 To 15.12.2015	14:00 to 22:00			77		61			22			
		22:00 to 06:00	305	100	84	83.7	64		62.2	19			21.2
		06:00 to 14:00			90		62			23			
POC-6	17.12.2015 To 18.12.2015	14:00 to 22:00			53		72			8			
		22:00 to 06:00	289	87	67	64.5	76		73.9	11			9.5
		06:00 to 14:00			73		74			10			
POC-7	21.12.2015 To 22.12.2015	14:00 to 22:00			78		65			13			
		22:00 to 06:00	242	100	85	81.5	68		66.1	12			13.4
		06:00 to 14:00			82		66			15			
POC-8	24.12.2015 To 25.12.2015	14:00 to 22:00			54		73			23			
		22:00 to 06:00	206	64	68	62.6	77		75.0	15			19.0
		06:00 to 14:00			65		75			19			
POC-9	28.12.2015 To 29.12.2015	14:00 to 22:00			50		34			11			
		22:00 to 06:00	207	52	22	37.4	60		37.0	12			12.0
		06:00 to 14:00			40		16			13			
Average			245	85		48.9			62.5				22.5
Standard Dev			33	18		25.8			14.2				10.4

Table 2: Results of Air Pollutant Concentration at POC Station of JNP Area during the month of December, 2015											
Sampling Period	Date	Time, [Hrs]	O ₃ , [µg/m ³]	Pb, [µg/m ³]	24 hr	As, [ng/m ³]	24 hr	Ni, [ng/m ³]	8 hr	24 hr	CO ₂ [ppm]
NAAQMS			100 µg/m ³	1.0 µg/m ³	6 ng/m ³	20 ng/m ³	5 µg/m ³	1 ng/m ³	4 mg/m ³	Grab Sampling	Grab Sampling
POC-1	01.12.2015	14:00 to 22:00	16	<0.01	<1	<1	<1	<0.5	2.3	248	
	To	22:00 to 06:00									
POC-2	02.12.2015	06:00 to 14:00									
	To	22:00 to 06:00	33	<0.01	<1	<1	12	<0.5	1.1	289	
POC-3	04.12.2015	06:00 to 14:00									
	To	22:00 to 06:00	20	<0.01	<1	<1	<1	<0.5	0.9	220	
POC-4	08.12.2015	06:00 to 14:00									
	To	22:00 to 06:00	9	<0.01	<1	<1	<1	<0.5	1.1	265	
POC-5	10.12.2015	14:00 to 22:00									
	To	22:00 to 06:00	14	<0.01	<1	<1	16	<0.5	1.1	220	
POC-6	14.12.2015	14:00 to 22:00									
	To	22:00 to 06:00	15	<0.01	<1	<1	<1	<0.5	1.3	274	
POC-7	15.12.2015	06:00 to 14:00									
	To	22:00 to 06:00	26	<0.01	<1	<1	<1	<0.5	1.6	201	
POC-8	17.12.2015	14:00 to 22:00									
	To	22:00 to 06:00	15	<0.01	<1	<1	<1	<0.5	1.1	266	
POC-9	22.12.2015	06:00 to 14:00									
	To	22:00 to 06:00	12	<0.01	<1	<1	15	<0.5	1.1	202	
Average			18				14		1.3	243	
Standard Dev			11				0.2		0.4	33	

Table 3: Results of Air Pollutant Concentration at IMC Station of JNP Area during the month of December, 2015

Sampling Period	Date	Time, [Hrs]	PM ₁₀ , [µg/m ³]		PM _{2.5} , [µg/m ³]		SO ₂ , [µg/m ³]		NO _x , [µg/m ³]		NH ₃ , [µg/m ³]	
			24 hr	100 µg/m ³	24 hr	60 µg/m ³	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)
NAAQMS												
IMC-1	01.12.2015 To 02.12.2015	15:00 to 23:00					24		35		17	
		23:00 to 07:00	297		145		26	25	39	37.4	18	172
		07:00 to 15:00					25		38		17	
IMC-2	03.12.2015 To 04.12.2015	15:05 to 23:05					32		20		15	
		23:05 to 07:05	233		172		36	34	25	22.4	18	16.5
		07:05 to 15:05					34		22		16	
IMC-3	07.12.2015 To 08.12.2015	15:10 to 23:10					27		23		43	
		23:10 to 07:10	283		195		32	26	97	48.9	47	46.3
		07:10 to 15:10					19		26		48	
IMC-4	10.12.2015 To 11.12.2015	14:50 to 22:50					30		60		41	
		22:50 to 06:50	275		142		33	31	67	64.3	43	41.8
		06:50 to 14:50					31		65		42	
IMC-5	14.12.2015 To 15.12.2015	15:00 to 23:00					76		40		25	
		23:00 to 07:00	179		114		82	79	44	42.3	29	27.8
		07:00 to 15:00					79		43		30	
IMC-6	17.12.2015 To 18.12.2015	15:00 to 23:00					71		60		22	
		23:00 to 07:00	188		89		78	73.8	64	61.7	25	23.5
		07:00 to 15:00					72		62		24	
IMC-7	21.12.2015 To 22.12.2015	15:00 to 23:00					77		43		15	
		23:00 to 07:00	102		84		82	79.2	45	43.7	22	16.9
		07:00 to 15:00					79		43		13	
IMC-8	24.12.2015 To 25.12.2015	15:00 to 23:00					72		64		25	
		23:00 to 07:00	137		67		79	74.8	67	65.2	28	24.9
		07:00 to 15:00					73		65		22	
IMC-9	28.12.2015 To 29.12.2015	15:00 to 23:00					61		34		22	
		23:00 to 07:00	140		62		46	48.4	44	38.4	13	16.0
		07:00 to 15:00					38		37		13	
Average Standard Dev			204		119			52.3		47.1		25.7
			71		47			24.1		14.4		11.3

Table 3: Results of Air Pollutant Concentration at IMC Station of JNP Area during the month of December, 2015																
Sampling Period	Date	Time, [Hrs]	O ₃ , [µg/m ³]	8 hr	Pb, [µg/m ³]	24 hr	As, [ng/m ³]	24 hr	Ni, [ng/m ³]	24 hr	C ₆ H ₆ , [µg/m ³]	BaP, [ng/m ³]	24 hr	CO, [mg/m ³]	Grab Sampling	CO ₂ , [ppm]
NAAQMS	01.12.2015	15:00 to 23:00														
IMC-1	To	23:00 to 07:00	28	<0.01	<1	<1	<1	<1	<0.5	0.8					288	
	02.12.2015	07:00 to 15:00														
IMC-2	To	15:05 to 23:05	18	<0.01	<1	<1	<1	<1	<0.5	1.6					237	
	04.12.2015	07:05 to 15:05														
IMC-3	To	15:10 to 23:10	14	<0.01	<1	<1	<1	<1	<0.5	2.0					245	
	08.12.2015	07:10 to 15:10														
IMC-4	To	14:50 to 22:50	13	<0.01	<1	<1	<1	<1	<0.5	1.6					212	
	11.12.2015	06:50 to 14:50														
IMC-5	To	15:00 to 23:00	12	<0.01	<1	<1	<1	<1	<0.5	2.0					233	
	15.12.2015	07:00 to 15:00														
IMC-6	To	15:00 to 23:00	13	<0.01	<1	<1	<1	<1	<0.5	1.1					214	
	18.12.2015	07:00 to 15:00														
IMC-7	To	15:00 to 23:00	13	<0.01	<1	<1	<1	<1	<0.5	0.8					298	
	21.12.2015	07:00 to 15:00														
IMC-8	To	15:00 to 23:00	17	<0.01	<1	<1	<1	<1	<0.5	1.3					212	
	25.12.2015	07:00 to 15:00														
IMC-9	To	15:00 to 23:00	10	<0.01	<1	<1	<1	<1	<0.5	0.9					233	
	29.12.2015	07:00 to 15:00														
Average			17							1.3				1.3	241	
Standard Dev			7							0.1				0.5	32	

Table 4: Results of Air Pollutant Concentration at RC School Station of JNP Area during the month of December, 2015

Sampling Period	Date	Time, [Hrs]	PM ₁₀ , [µg/m ³]		PM _{2.5} , [µg/m ³]		SO ₂ , [µg/m ³]		NO _x , [µg/m ³]		NH ₃ , [µg/m ³]	
			24 hr	100 µg/m ³	24 hr	60 µg/m ³	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)
NAAQMS												
RC-1	01.12.2015 To 02.12.2015	15:30 to 23:30					5		15		9	
		23:30 to 07:30	285		27		9	8	18	16.4	12	10.3
		07:30 to 15:30					10		16		10	
RC-2	03.12.2015 To 04.12.2015	15:30 to 23:30					6		15		27	
		23:30 to 07:30	241		168		10	8	21	18.0	31	28.9
		07:30 to 15:30					9		18		29	
RC-3	07.12.2015 To 08.12.2015	15:30 to 23:30					12		41		13	
		23:30 to 07:30	253		115		17	14	43	41.8	16	14.5
		07:30 to 15:30					14		41		14	
RC-4	10.12.2015 To 11.12.2015	15:30 to 23:30					13		29		8	
		23:30 to 07:30	102		58		18	16	36	32.3	10	9.0
		07:30 to 15:30					15		32		9	
RC-5	14.12.2015 To 15.12.2015	15:30 to 23:30					47		41		13	
		23:30 to 07:30	358		97		60	53	43	42.3	16	14.5
		07:30 to 15:30					52		43		14	
RC-6	17.12.2015 To 18.12.2015	15:30 to 23:30					44		32		11	
		23:30 to 07:30	391		98		57	50	36	33.2	9	10.2
		07:30 to 15:30					50		32		10	
RC-7	21.12.2015 To 22.12.2015	15:30 to 23:30					48		41		12	
		23:30 to 07:30	310		49		61	54	46	43.2	12	13.6
		07:30 to 15:30					53		43		17	
RC-8	24.12.2015 To 25.12.2015	15:30 to 23:30					45		35		31	
		23:30 to 07:30	337		22		58	51	39	36.5	17	17.9
		07:30 to 15:30					49		36		6	
RC-9	28.12.2015 To 29.12.2015	15:30 to 23:30					46		34		17	
		23:30 to 07:30	141		63		25	34	37	28.9	13	14.2
		07:30 to 15:30					32		16		12	
Average Standard Dev			269		77			32.0		32.5		14.8
			97		47			20.5		10.0		6.0

Table 4: Results of Air Pollutant Concentration at RC Station of JNP Area during the month of December, 2015														
Sampling Period	Date	Time, [Hrs]	O ₃ , [µg/m ³]	Ph, [µg/m ³]	As, [µg/m ³]	24 hr	24 hr	24 hr	Ni, [ng/m ³]	C ₆ H ₆ , [µg/m ³]	8 hr	24 hr	CO, [mg/m ³]	CO ₂ , [ppm]
			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	Grab Sampling	Grab Sampling			
NAAQMS														-
RC-1	01.12.2015	15:30 to 23:30												
	To	23:30 to 07:30	17	<0.01	<1	<1	<1	<0.5	0.5		<1	<0.5	0.5	222
RC-2	02.12.2015	07:30 to 15:30												
	To	15:30 to 23:30	20	<0.01	<1	<1	<1	<0.5	0.9		1.1	<0.5	0.9	248
RC-3	04.12.2015	07:30 to 15:30												
	To	15:30 to 23:30	12	<0.01	<1	<1	<1	<0.5	1.6		<1	<0.5	1.6	296
RC-4	08.12.2015	07:30 to 15:30												
	To	15:30 to 23:30	10	<0.01	<1	<1	<1	<0.5	1.0		1.2	<0.5	1.0	209
RC-5	10.12.2015	15:30 to 23:30												
	To	23:30 to 07:30	16	<0.01	<1	<1	<1	<0.5	1.5		<1	<0.5	1.5	222
RC-6	14.12.2015	15:30 to 23:30												
	To	23:30 to 07:30	17	<0.01	<1	<1	<1	<0.5	1.3		<1	<0.5	1.3	248
RC-7	17.12.2015	15:30 to 23:30												
	To	23:30 to 07:30	16	<0.01	<1	<1	<1	<0.5	0.8		1.4	<0.5	0.8	217
RC-8	18.12.2015	07:30 to 15:30												
	To	15:30 to 23:30	9	<0.01	<1	<1	<1	<0.5	1.2		<1	<0.5	1.2	203
RC-9	21.12.2015	15:30 to 23:30												
	To	23:30 to 07:30	12	<0.01	<1	<1	<1	<0.5	1.2		1.6	<0.5	1.2	225
Average	22.12.2015	07:30 to 15:30												
	To	15:30 to 23:30	13						1.1		1.3		1.1	232
Standard Dev			7						0.3		0.2		0.3	28

Table 5: Results of Air Pollutant Concentration at EC Station monitored during December, 2015

Sampling Period	Date	Time, [hrs]	PM ₁₀ , [µg/m ³]	PM _{2.5} , [µg/m ³]	SO ₂ , [µg/m ³]		NO _x , [µg/m ³]		NH ₃ , [µg/m ³]	
					8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)
NAAQMS			100 µg/m ³	60 µg/m ³	-	80 µg/m ³	-	80 µg/m ³	-	400 µg/m ³
EC	03.12.2015 To 04.12.2015	14:00 to 22:00	197	10	10	11	46	491	5	70
		22:00 to 06:00			13		53		10	
		06:00 to 14:00			11		48		6	

Table 5: Results of Air Pollutant Concentration at EC Station monitored during December,2015											
Sampling Period	Date	Time, [Hrs]	O ₃ , [µg/m ³]	Pb, [µg/m ³]	As, [µg/m ³]	Ni, [µg/m ³]	C ₄ H ₆ , [µg/m ³]	BaP, [ng/m ³]	CO, [mg/m ³]	CO ₂ , [ppm]	
NAAQMS			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	-	
	EC	03.12.2015	14:00 to 22:00	4	<0.01	<1	<1	<1	<0.5	0.9	212
		To	22:00 to 06:00								
04.12.2015		06:00 to 14:00									

Table 6: Results of Air Pollutant Concentration at NGC Station of JNP Area during the month of December, 2015

Sampling Period	Date	Time, [Hrs]	PM ₁₀ , [µg/m ³]	PM _{2.5} , [µg/m ³]	SO ₂ , [µg/m ³]	NO _x , [µg/m ³]	NH ₃ , [µg/m ³]
NAAQMS			24 hr	24 hr	8 hr	24 hr (Avg)	8 hr
			100 µg/m ³	60 µg/m ³	-	80 µg/m ³	-
NG-1	03.12.2015 To 04.12.2015	14:30 to 22:30			13	48	15
		22:30 to 06:30	220	20	13	53	17
		06:30 to 14:30			11	52	16
NG-2	10.12.2015 To 11.12.2015	14:30 to 22:30			15	96	22
		22:30 to 06:30	236	79	18	103	25
		06:30 to 14:30			16	101	24
NG-3	17.12.2015 To 18.12.2015	14:30 to 22:30			39	88	22
		22:30 to 06:30	247	80	49	94	24
		06:30 to 14:30			38	90	24
NG-4	24.12.2015 To 25.12.2015	14:30 to 22:30			41	88	13
		22:30 to 06:30	197	73	41	95	12
		06:30 to 14:30			39	90	17
Average			225	63		278	833
Standard Dev			22	29		15.7	218

Table 6: Results of Air Pollutant Concentration at NGC Station of JNP Area during the month of December, 2015

Sampling Period	Date	Time, [Hrs]	O ₃ , [µg/m ³]	Pb, [µg/m ³]	As, [ng/m ³]	24 hr	24 hr	Ni, [ng/m ³]	8 hr	C ₆ H ₆ , [µg/m ³]	BaP, [ng/m ³]	CO, [mg/m ³]	CO ₂ , [ppm]
NAAQMS			100 µg/m ³	1.0 µg/m ³	6 ng/m ³	20 ng/m ³	5 µg/m ³	1 ng/m ³	4 mg/m ³	Grab Sampling	Grab Sampling		
NG-1	03.12.2015 To 04.12.2015	14:30 to 22:30											
		22:30 to 06:30	9	<0.01	<1	<1	<1	<0.5	0.8			236	
		06:30 to 14:30											
NG-2	10.12.2015 To 11.12.2015	14:30 to 22:30											
		22:30 to 06:30	12	<0.01	<1	<1	<1	<0.5	1.3			215	
		06:30 to 14:30											
NG-3	17.12.2015 To 18.12.2015	14:30 to 22:30											
		22:30 to 06:30	18	<0.01	<1	<1	<1	<0.5	0.3			275	
		06:30 to 14:30											
NG-4	24.12.2015 To 25.12.2015	14:30 to 22:30											
		22:30 to 06:30	16	<0.01	<1	<1	<1	<0.5	1.5			215	
		06:30 to 14:30											
Average			20						1.1			1.0	235
Standard Dev			11						#DIV/0!			0.5	28

Table 7: Results of Air Pollutant Concentration at SGC Station of JNP Area during the month of December, 2015

Sampling Period	Date	Time, [Hrs]	PM ₁₀ , [µg/m ³]	PM _{2.5} , [µg/m ³]	SO ₂ , [µg/m ³]	NO _x , [µg/m ³]	NH ₃ , [µg/m ³]
NAAQMS			24 hr	24 hr	8 hr	24 hr (Avg)	8 hr
			100 µg/m ³	60 µg/m ³	-	80 µg/m ³	-
SG-1	01.12.2015	14:30 to 22:30			16	53	14
	To	22:30 to 06:30	244	74	18	59	17
	02.12.2015	06:30 to 14:30			15	52	16
SG-2	07.12.2015	14:30 to 22:30			8	81	7
	To	22:30 to 06:30	242	83	12	86	11
	08.12.2015	06:30 to 14:30			10	76	9
SG-3	14.12.2015	14:30 to 22:30			69	72	7
	to	22:30 to 06:30	350	99	75	79	10
	15.12.2015	06:30 to 14:30			72	74	8
SG-4	21.12.2015	14:30 to 22:30			69	76	13
	to	22:30 to 06:30	255	101	76	79	15
	22.12.2015	06:30 to 14:30			73	77	12
SG-5	28.12.2015	14:30 to 22:30			47	41	16
	to	22:30 to 06:30	136	65	32	26	12
	29.12.2015	06:30 to 14:30			52	48	11
Average			245	84		65.3	11.8
Standard Dev			76	16		18.1	3.0

Table 7: Results of Air Pollutant Concentration at SGC Station of JNP Area during the month of December, 2015

Sampling Period	Date	Time, [Hrs]	O ₃ , [µg/m ³]	Ph, [µg/m ³]	As, [µg/m ³]	Ni, [ng/m ³]	Cd, [µg/m ³]	CO, [mg/m ³]	CO ₂ , [ppm]
NAAQMS			8 hr	24 hr	24 hr	24 hr	24 hr	Grab Sampling	Grab Sampling
			100 µg/m ³	1.0 µg/m ³	6 ng/m ³	20 ng/m ³	1 ng/m ³	4 mg/m ³	-
SG-1	01.12.2015	14:30 to 22:30							
	To	22:30 to 06:30	13	<0.01	<1	<1	<0.5	0.8	225
SG-2	02.12.2015	06:30 to 14:30							
	To	22:30 to 06:30	13	<0.01	<1	<1	<0.5	1.6	239
SG-3	08.12.2015	06:30 to 14:30							
	to	22:30 to 06:30	18	<0.01	<1	<1	<0.5	1.2	249
SG-4	15.12.2015	06:30 to 14:30							
	to	22:30 to 06:30	12	<0.01	<1	<1	<0.5	0.9	215
SG-5	22.12.2015	06:30 to 14:30							
	to	22:30 to 06:30	13	<0.01	<1	<1	<0.5	1.1	229
	29.12.2015	06:30 to 14:30							
Average			14					1.1	231
Standard Dev			4					0.3	13

1.4 DISCUSSION

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

Table 8: Monthly Average Values of Air Pollutants at Various Stations in JNP Area during December, 2015

STATION	PM ₁₀ , [$\mu\text{g}/\text{m}^3$]	PM _{2.5} , [$\mu\text{g}/\text{m}^3$]	SO ₂ , [$\mu\text{g}/\text{m}^3$]	NO _x , [$\mu\text{g}/\text{m}^3$]	NH ₃ , [$\mu\text{g}/\text{m}^3$]	O ₃ , [$\mu\text{g}/\text{m}^3$]	Pb [$\mu\text{g}/\text{m}^3$]	C ₆ H ₆ , [$\mu\text{g}/\text{m}^3$]	CO, [mg/m ³]	CO ₂ , [ppm]
NAAQMS	100	60	80	80	400	100	1	5	4	-
INDUSTRIAL AREA										
POC	245 \pm 33	85 \pm 18	48.9 \pm 25.8	62.5 \pm 14.2	22.5 \pm 10.4	18 \pm 11	<0.01	1.4 \pm 0.2	1.3 \pm 0.4	243 \pm 33
IMC	204 \pm 71	119 \pm 47	52.3 \pm 24.1	47.1 \pm 14.4	25.7 \pm 11.3	17 \pm 07	<0.01	1.3 \pm 0.1	1.3 \pm 0.5	241 \pm 32
NG	225 \pm 22	63 \pm 29	27.8 \pm 15.7	83.3 \pm 21.8	19.2 \pm 4.9	20 \pm 11	<0.01	1.1	1.0 \pm 0.5	235 \pm 28
SG	245 \pm 76	84 \pm 16	43.0 \pm 29.8	65.3 \pm 18.1	11.8 \pm 3.0	14 \pm 4	<0.01	<1	1.1 \pm 0.3	231 \pm 13
RESIDENTIAL AREA										
RC	269 \pm 97	77 \pm 47	32.0 \pm 20.5	32.5 \pm 10.0	14.8 \pm 6.0	13 \pm 7	<0.01	1.3 \pm 0.2	1.1 \pm 0.3	232 \pm 28
ECO-SENSITIVE AREA										
EC	197	10	11	49.1	7.0	4	<0.01	<1	0.9	212

During the monitoring period, the overall Ambient Air Quality of the port area was found to be well within the desired levels for various pollutants. Daily average pollutant levels are presented in **Tables 2** through **7**. However, the concentrations obtained for particulate matter PM₁₀ and PM_{2.5} at all stations were found to be exceeding the prescribed CPCB limits. All other pollutants were recorded well below the prescribed limits.

Results for the air quality parameters at Elephanta Caves [EC] station during 02nd December'15 to 3rd December'15 are represented in **Table 5**. **Tables 6 & 7** provide the results for NGC and SGC air monitoring stations respectively.

In December '15, gaseous pollutants were well within the prescribed limits, set for industrial as well as sensitive areas.

1.5 OBSERVATIONS AND CONCLUSIONS

The environmental implications of a port and harbor operational activities must be considered prior to further developments. 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 December'15:

- ✓ All the public and community buildings in residential complex / township are under Renovation. Being temporary activity; it will not affect ambient air quality in long run. Existing Ambient air Quality of RC station is well within CPCB permissible limits except for PM₁₀ and PM_{2.5}, which are higher than the prescribed CPCB standard.
- ✓ *Construction of 4th Container Terminal on South side of JNPT:* Land preparation work of 4th C.T. is underway: The transportation of soil and earth shall be considered a vital part as it is potential source of particulates. The overall ambient air quality around the Port area shows no adverse effect. Increase in the PM₁₀ and PM_{2.5} Concentration at South Gate may be attributed to the earth filling activity of 4th C.T. where the Dumpers carrying earth filling materials were ferrying without any tarpaulin cover and heavy traffic movement at SGC.
- ✓ *Construction of NSIGT Yard is underway to the North side of JNPT:* The nearest Ambient Air Monitoring location is North gate Complex. The overall values of gaseous parameters are well within the CPCB limits except for PM₁₀ and PM_{2.5} Concentration which are found exceeding the CPCB limits. The development of yard for NSIGT and heavy vehicular movement causing the elevated values of PM₁₀ and PM_{2.5} Concentration at NGC.
- ✓ *Vehicular Traffic at three gates:* The monitoring of ambient air Quality at South and North gate complexes has been done once a week. The location is covered by large control sections and dense tree cover accounting as pollutant trap. The initiative taken by the port in terms of maintenance of port vehicles, PUC checking of vehicles visiting port and enough green cover provided in and around the area contributes significantly to reduce overall pollution.
- ✓ Road connecting tank farm and township is being updated with construction of over bridge on the railway crossing. Land preparation and foundation work continued during the month of December'15 for the Rail over bridge. Nearest location i.e. RC does not show any adverse impact due to this activity. All the AAQM parameters are well within the prescribed CPCB limits except the values of PM₁₀ and PM_{2.5}.

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

- ✓ Renovation work, being carried out at JNP Township, should be executed under controlled conditions.
- ✓ Debris and raw material carrying trucks must be covered with tarpaulin sheet during transportation.
- ✓ Minimizing emissions by regular maintenance and PUC checkup of vehicles.
- ✓ 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.

	
Civil Work at JNP Township	Land Preparation at 4th Container Terminal
	
Construction of yard near POC	NSIGT Yard filling work

Conclusion:

From the results obtained for the month of December, 2015 it can be concluded that overall Ambient Air quality of the JN Port is within CPCB limits, except the levels of PM₁₀ and PM_{2.5}, which are higher at all locations due to port development activities.

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 [W8/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 mentioned in **Table 9**. The location map of various Marine ecology monitoring stations along with direction of towing is depicted 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 during spring and neap tidal cycle. The samples are taken after 1st, 3rd and 5th hour of the tide from eight fixed and one moving stations and composited from each harbor water quality monitoring station. 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 composited 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 presented in **Table 10** along with parameters 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.	4 th December, 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	4 th December, 2015
3.	W3	Identified by the green buoy no. <u>FG2 Green</u> of JNPT approach channel and lies near the landing jetty.	5 th December, 2015
4.	W4	Located at Uran Patch Beacon (lighthouse on concrete platform) near the Butcher Island filling platform.	5 th December, 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 Belpadato the creek water quality.	4 th December, 2015
	W11 to W14		6 th December, 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.	4 th December, 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.	5 th December, 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	5 th December, 2015
9.	W8/W10	Located near proposed chemical berth. These stations are variable and selected to examine the impact of proposed chemical terminal and IVth Container terminal activities on water quality.	5 th December, 2015

Table 10: List of Parameters Monitored for Marine Water Quality

Marine Water Quality Parameters [Harbor Area & Creek Area]
A] Physical parameters 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], Bacteriological count [MPN], Fecal Coliform
C] Sediment Analysis: Total Organic Matter, Organic Carbon, Inorganic Phosphates

2.3 RESULTS

The marine water quality data for nine Harbor water quality monitoring stations are presented in **Table 11** for Physico-chemical parameters, **Table 12** for Bio-chemical parameters and **Table 13** for Sediment samples collected at these nine locations. The creek water quality data for four Nhava creek water quality monitoring stations are reported in **Table 14** for Physico-chemical parameters, **Table 15** for Bio-chemical parameters and **Table 16** for Sediment samples, collected at these locations.

Table 11: Results of Physical parameters of Water Samples Collected from JNP Harbor Area during December, 2015

Sample Name		Depth, [m]	Temp., [°C]	pH	Salinity, [ppt]	Turbidity, [NTU]	TDS, [mg/L]	TSS, [mg/L]	TS, [mg/L]
Standard		-	-	6.5 - 9.0	-	-	-	-	-
W1	SS	9.7	26.8	7.52	32.2	8	30410	76	30486
	SM		26.4	7.57	31.6	8	30510	92	30602
	SB		26.2	7.59	32.7	17	30240	132	30372
	NS	8.8	29.6	7.60	31.0	9	30360	110	30470
	NM		28.0	7.64	32.2	9	30280	79	30359
	NB		27.8	7.58	31.6	21	31120	109	31229
W2	SS	8.7	25.0	7.73	32.2	25	31020	64	31084
	SM		23.4	7.68	32.7	25	31140	92	31232
	SB		21.8	7.69	31.0	25	30080	135	30215
	NS	8.3	29.4	7.61	32.7	24	31180	144	31324
	NM		28.2	7.71	32.2	20	31190	145	31335
	NB		29.6	7.64	31.6	21	31220	181	31401
W3	SS	9.0	26.0	7.64	32.2	7	30360	98	30458
	SM		26.7	7.58	32.7	22	30250	153	30403
	SB		24.6	7.57	33.3	29	30080	180	30260
	NS	8.5	31.8	7.72	32.2	7	30140	86	30226
	NM		30.7	7.63	31.6	21	30270	160	30430
	NB		29.9	7.68	31.0	30	30480	152	30632
W4	SS	12.4	26.0	7.62	31.6	10	30520	109	30629
	SM		25.0	7.66	32.2	25	30430	148	30578
	SB		23.8	7.68	32.2	34	30720	140	30860
	NS	11.8	26.9	7.62	33.3	11	30840	62	30902
	NM		27.5	7.70	32.7	29	30530	105	30635
	NB		27.1	7.68	31.0	33	30280	168	30448
W5	SS	14.2	27.2	7.62	32.2	5	30240	141	30381
	SM		26.5	7.81	30.5	4	30550	135	30685
	SB		26.2	7.70	31.0	3	31080	122	31202
	NS	12.7	28.0	7.63	32.7	12	31140	141	31281
	NM		27.7	7.81	31.6	12	31210	177	31387
	NB		27.2	7.82	32.2	11	30980	148	31128

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		Depth, [m]	Temp., [°C]	pH	Salinity, [ppth]	Turbidity, [NTU]	TDS, [mg/L]	TSS, [mg/L]	TS, [mg/L]
Standard		-	-	6.5 - 9.0	-	-	-	-	-
W6	SS	14.1	27.8	7.66	31.6	11	30750	171	30921
	SM		27.6	7.88	32.2	13	30380	173	30553
	SB		27.4	7.66	32.7	15	30460	139	30599
	NS	12.7	30.5	7.67	33.3	8	30670	177	30847
	NM		30.4	7.94	31.0	16	30280	148	30428
	NB		29.2	8.05	30.5	29	30840	128	30968
W7	SS	9.2	28.1	7.75	33.9	20	30780	129	30909
	SM		28.0	7.84	32.7	16	31060	173	31233
	SB		27.0	7.80	33.3	12	31140	104	31244
	NS	8.9	30.0	7.85	31.0	7	30870	117	30987
	NM		28.8	7.89	32.2	23	30940	163	31103
	NB		27.0	7.88	31.6	10	30880	167	31047
W9	SS	16	27.6	7.88	32.7	6	30670	103	30773
	SM		26.3	7.91	33.3	13	30940	127	31067
	SB		26.2	7.94	31.6	16	30530	144	30674
	NS	14.6	29.5	7.95	31.0	8	30640	119	30759
	NM		30.4	7.96	32.2	20	30950	136	31086
	NB		29.7	7.94	33.3	14	30590	122	30712
W10	SS	10.7	28.1	7.95	32.2	17	30680	194	30874
	SM		28.0	7.99	31.0	17	31150	199	31349
	SB		28.0	7.84	33.3	26	30270	197	30467
	NS	10	29.1	7.94	31.6	17	30340	173	30513
	NM		28.2	7.91	32.7	22	31190	195	31385
	NB		28.0	7.96	30.5	22	31260	115	31375

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

Sample Name		DO, [mg/L]	COD, [mg/L]	BOD, [mg/L]	NH ₃ -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	145	27
	SS	4.9	40	<2	<0.1	<0.01			
	SM	4.0	48	-	-	-			
	SB	4.1	44	-	-	-			
	NS#			-	-	-	2	<30	<2
	NS	5.4	36	<2	<0.1	<0.01			
	NM	4.3	52	-	-	-			
W2	NB	4.4	32	-	-	-			
	SS#						2	<30	9
	SS	4.5	44	<2	<0.1	<0.01			
	SM	4.4	36	-					
	SB	4.0	48	-					
	NS#						1	55	2
	NS	4.8	40	<2	<0.1	<0.01			
W3	NM	4.5	32	-					
	NB	4.3	52	-					
	SS#		-	-	-	-	1	218	60
	SS	4.4	36	<2	<0.1	<0.01			
	SM	4.3	48	-	-	-			
	SB	4.2	40	-	-	-			
	NS#			-	-	-	1	48	8
W4	NS	4.5	44	<2	<0.1	<0.01			
	NM	4.4	52	-	-	-			
	NB	4.2	56	-	-	-			
	SS#		-	-	-	-	2	173	7
	SS	5.2	44	<2	<0.1	<0.01			
	SM	4.5	36	-	-	-			
	SB	4.4	52	-	-	-			
W5	NS#			-	-	-	2	<30	<2
	NS	4.4	48	<2	<0.1	<0.01			
	NM	5.3	56	-	-	-			
	NB	4.5	40	-	-	-			
	SS#		-	-	-	-	2	94	22
	SS	4.4	44	<2	<0.1	<0.01			
	SM	6.3	36	-	-	-			
W5	SB	5.1	40	-	-	-			
	NS#		-	-	-	-	1	<30	4
	NS	4.8	48	<2	<0.1	<0.01			
	NM	6.4	52	-	-	-			
	NB	5.1	32	-	-	-			

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

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

Sample Name	DO, [mg/L]	COD, [mg/L]	BOD, [mg/L]	NH ₃ -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#	-	-	-	-	3	<30	13
	SS	4.9	40	<2	<0.1	<0.01	-	-
	SM	4.8	52	-	-	-	-	-
	SB	3.9	32	-	-	-	-	-
	NS#	-	-	-	-	2	51	4
	NS	4.1	44	<2	<0.1	<0.01	-	-
	NM	4.3	36	-	-	-	-	-
	NB	3.8	48	-	-	-	-	-
W7	SS#	-	-	-	-	2	57	2
	SS	4.1	44	<2	<0.1	<0.01	-	-
	SM	4.2	36	-	-	-	-	-
	SB	4.4	40	-	-	-	-	-
	NS#	-	-	-	-	2	<30	8
	NS	4.6	48	<2	<0.1	<0.01	-	-
	NM	4.8	32	-	-	-	-	-
	NB	5.3	52	-	-	-	-	-
W9	SS#	-	-	-	-	1	<30	8
	SS	4.5	32	<2	<0.1	<0.01	-	-
	SM	4.4	52	-	-	-	-	-
	SB	4.3	40	-	-	-	-	-
	NS#	-	-	-	-	1	40	<2
	NS	4.5	36	<2	<0.1	<0.01	-	-
	NM	4.3	44	-	-	-	-	-
	NB	4.4	48	-	-	-	-	-
W10	SS#	-	-	-	-	2	115	6
	SS	4.3	40	2.1	<0.1	<0.01	-	-
	SM	4.3	48	-	-	-	-	-
	SB	4.1	32	-	-	-	-	-
	NS#	-	-	-	-	3	78	<2
	NS	4.5	52	<2	<0.1	<0.01	-	-
	NM	4.3	44	-	-	-	-	-
	NB	5.1	36	-	-	-	-	-

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 Dec., 2015

Station Name	Organic Matter		Total Carbon		Inorganic Phosphate
	mg/g	%	mg/g	%	mg/kg
W1	143.5	14.4	83.2	8.3	230
W2	70.1	7.0	40.7	4.1	200
W3	131.4	13.1	76.2	7.6	290
W4	101.5	10.2	58.9	5.9	160
W5	82.1	8.2	47.6	4.8	330
W6	156.5	15.7	90.8	9.1	240
W9	158.5	15.9	91.9	9.2	300
W10	163.7	16.4	95.0	9.5	220

Table 14: Results of Physico-Chemical Analysis of Water Samples 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	4.0	25.5	7.74	33.3	12	31350	48	31398
	SM		25.4	8.02	31.6	14	31220	70	31290
	SB		25.3	7.83	32.2	14	31110	77	31187
	NS	3.5	30.0	7.81	31.0	16	31080	86	31166
	NM		29.9	8.10	30.5	12	31060	68	31128
	NB		29.5	7.89	32.7	17	31170	128	31298
W12	SS	3.5	27.5	7.84	32.2	13	31530	112	31642
	SM		27.4	8.05	31.0	14	31280	104	31384
	SB		27.2	7.89	32.7	12	31350	107	31457
	NS	3.0	29.8	8.01	33.3	12	31220	153	31373
	NM		29.7	7.97	32.2	11	31190	144	31334
	NB		29.4	8.03	31.6	12	31420	81	31501
W13	SS	3.0	26.3	7.81	32.7	11	31470	118	31588
	SM		26.4	7.84	30.5	11	31120	127	31247
	SB		26.0	7.87	31.6	11	31090	126	31216
	NS	2.5	29.7	8.08	32.2	11	31110	119	31229
	NM		29.1	7.89	32.7	10	31140	109	31249
	NB		28.9	7.88	33.3	12	31080	64	31144
W14	SS	3.0	26.7	8.11	31.0	11	31510	78	31588
	SM		26.5	7.82	32.7	9	31270	60	31330
	SB		26.5	7.77	31.6	11	31340	68	31408
	NS	2.5	29.8	7.89	33.3	12	31060	59	31119
	NM		29.7	7.88	32.2	11	31140	66	31206
	NB		27.8	7.75	30.5	10	31170	65	31235

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

Sample Name	DO, [mg/L]	COD, [mg/L]	BOD, [mg/L]	NH ₃ -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	4.5	44	<2	<0.1	<0.01	2	128
	SM	4.4	36	-	-	-	-	-
	SB	4.6	40	-	-	-	-	-
	NS	4.5	48	<2	<0.1	<0.01	2	<30
	NM	4.4	52	-	-	-	-	-
	NB	4.6	32	-	-	-	-	-
W12	SS	5.0	48	<2	<0.1	<0.01	3	<30
	SM	5.1	32	-	-	-	-	-
	SB	5.0	52	-	-	-	-	-
	NS	4.4	44	<2	<0.1	<0.01	2	<30
	NM	4.6	40	-	-	-	-	-
	NB	4.6	36	-	-	-	-	-
W13	SS	4.4	48	<2	<0.1	<0.01	2	<30
	SM	3.8	36	-	-	-	-	-
	SB	4.5	44	-	-	-	-	-
	NS	4.4	40	<2	<0.1	<0.01	2	56
	NM	4.5	52	-	-	-	-	-
	NB	4.6	32	-	-	-	-	-
W14	SS	4.3	52	<2	<0.1	<0.01	2	98
	SM	4.5	32	-	-	-	-	-
	SB	4.6	48	-	-	-	-	-
	NS	4.6	40	<2	<0.1	<0.01	3	<30
	NM	4.5	36	-	-	-	-	-
	NB	4.3	44	-	-	-	-	-

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 16: Results of Sediment Samples Collected from Nhava Creek during Dec., 2015

Sample Name	Organic Matter		Total Carbon		Inorganic Phosphate
	mg/g	%	mg/g	%	
W11	Sample not found				
W12	Sample not found				
W13	93.0	9.3	53.9	5.4	240
W14	70.0	7.0	40.6	4.1	140

2.4 DISCUSSION

Tables 17 and 18 present concentration ranges of various parameters for Harbor and Nhava regions respectively. 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	21.8 – 31.8	°C	-
2	pH	7.52 – 8.05	-	6.5 - 9.0
3	Salinity	30.5 – 33.9	ppt	-
4	Turbidity	3 – 34	NTU	-
5	TDS	30080 – 31260	mg/L	-
6	TSS	62 – 199	mg/L	-
7	TS	30215 – 31401	mg/L	-
8	DO	4.0 – 6.4	mg/L	3.0 mg/L(min.) or 40% of saturation value
9	COD	32 – 56	mg/L	-
10	BOD	<2-2.1	mg/L	5 (max.)
11	NH ₃ -N	<0.1	mg/L	-
12	Phenol	< 0.01	mg/L	-
13	Oil & Grease	1– 3	mg/L	10 (max.)
14	Total Plate Count	<30 - 218	CFU/ml	-
15	Fecal Coliforms	<2- 60	MPN/100 mL	500 (max.)

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

Sr. No.	Parameter	Observed Range	Unit	Prescribed Limits
1	Temperature	25.2 – 30.0	°C	-
2	pH	7.74 – 8.11	-	6.5 - 9.0
3	Salinity	30.5 – 33.3	ppt	-
4	Turbidity	9 – 17	NTU	-
5	TDS	31060 – 31530	mg/L	-
6	TSS	48 – 153	mg/L	-
7	TS	31119 – 31642	mg/L	-
8	DO	3.8 – 5.1	mg/L	3.0 mg/L(min.) or 40% of saturation value
9	COD	32 – 52	mg/L	-
10	BOD	< 2.0	mg/L	5 (max.)
11	NH ₃ -N	< 0.1	mg/L	-
12	Phenol	< 0.01	mg/L	-
13	Oil & Grease	2 – 3	mg/L	10 (max.)
14	Total Plate Count	<30 - 128	CFU/ml	-
15	Fecal Coliforms	<2 -50	MPN/100 mL	500 (max.)

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 December, 2015 are within the prescribed limits. Also, the concentration ranges observed for various parameters for water samples collected from Nhava Creek area during December, 2015 are also within prescribed limits.

Observed salinity values for Harbor and Creek water samples in the month of December, 2015 varied from 30.5 - 33.9 ppt and 30.5 – 33.3 ppt respectively [**Tables 11&14**]. The earth filling activity for the development of 4th Container Terminal and Dredging works in the region does not seem to be affecting on Marine water Quality. The ranges observed for COD values in mg/L are 32 – 56 and 32-52 respectively for Harbor and Creek water samples. The DO levels were found between 4.0 & 6.4 mg/L and 4.5 & 5.0 mg/L for water samples collected from Harbor and Creek areas respectively. The concentrations of Phenol and NH₃ - N were found to be very less in both Harbor and Creek water samples. Bacteriological parameters were 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 JNP Harbor samples. The values obtained for Organic Matter, Total Organic Carbon and Inorganic Phosphate varied from 7.0 – 16.4 %, 4.1 – 9.5 % and 160 – 330 mg/kg, respectively. **Table 16** shows the values for Organic Matter, Total Organic Carbon and Inorganic Phosphate as 7.0 to 9.3 %, 4.1 to 5.4 % and 140– 240 mg/kg, respectively in Nhava Creek sediments during December, 2015.

2.5 OBSERVATIONS AND CONCLUSION

- ✓ *Construction of 4th Container Terminal on South side of JNPT:* Earth Filling work and dredging work of 4th C.T. is underway.
- ✓ *Construction of NSIGT Yard is underway to the North side of JNPT.*
- ✓ *Plying of Ferry Boats:* There were large numbers of ferry boats plying in the area from Gateway of India to Elephanta. The discharges from these boats were not monitored.

It is seen from the data as reported in **Tables 11** through **18** and subsequently discussed in above paragraphs; all the parameters mentioned comply with prescribed standard limits, as given in Primary Water Quality Criteria for **Class IV Waters** [Harbor Water by CPCB for Physico-Chemical parameters and Bio-Chemical parameters. The characteristic parameters for sediments also show normal variations.

Conclusion:

Considering the activities in the Harbor area and the results obtained for the month of December, 2015 it can be concluded that the Port's working does not affect the Quality of the Marine water. 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 [W8/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 presented in **Table 9**. The location map of various Marine ecology monitoring stations along with direction of towing are presented in **Annexure-IV**.

3.2 MARINE ECOSYSTEM MONITORING METHODOLOGY

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

Marine Ecology Monitoring –Monitoring of marine ecology was carried out on the levels of high & low water of spring and neap tides at twelve fixed stations and one moving station in Port's water limit. Phytoplankton and Zooplankton samples were collected during spring and neap tides from all the 12 fixed [W1 to W7, W9 and W11 to W14] and one moving [W8/W10] water quality monitoring stations.

The list of parameters analyzed to assess the Marine Ecology is presented in **Table 19** along with parameters 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 **22**. The details of Secchi Depth of JNP Harbor and Nhava creek areas are given in **Table 23**. The enumeration of zooplankton genera, recorded in the JNP Harbor area and Nhava creek areas, are represented in **Tables 24** and **25**. **Table 26** shows Chlorophyll-*a* contents in JNP Harbor and Nhava creek areas.

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

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

Sr. No.	Station	Gross Primary Productivity [mgC/m ³ /d]	Net Primary Productivity [mgC/m ³ /d]
JNP Harbour Area			
1.	W1	215	115
2.	W2	475	375
3.	W3	375	275
4.	W4	275	175
5.	W5	375	315
6.	W6	375	275
7.	W7	375	315
8.	W9	315	275
9.	W10	375	275
JNP Nhava Creek Area			
10.	W11	215	175
11.	W12	415	375
12.	W13	375	315
13.	W14	415	315

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

Sr. No.	Sampling station	Sample Location	Phyto-plankton [No/ml]	Percent Composition of Algal		
				Bacillario-phyceae	Chloro-phyceae	Cyano-phyceae
JNP Harbour Area						
1	W1	Surface	370	40	40	20
		Bottom	290	60	20	20
2	W2	Surface	520	60	20	20
		Bottom	375	70	20	10
3	W3	Surface	450	50	30	20
		Bottom	270	65	25	10
4	W4	Surface	390	65	25	10
		Bottom	315	50	30	20
5	W5	Surface	420	60	20	20
		Bottom	375	50	30	20
6	W6	Surface	290	50	20	30
		Bottom	215	60	30	10
7	W7	Surface	370	50	30	20
		Bottom	210	55	35	10
8	W9	Surface	450	45	30	25
		Bottom	390	75	25	-
9	W10	Surface	210	60	20	20
		Bottom	170	45	30	25
JNP Nhava Creek						
10	W11	Surface	370	50	30	20
		Bottom	290	40	30	30
11	W12	Surface	420	55	25	20
		Bottom	370	45	25	30
12	W13	Surface	395	65	25	10
		Bottom	210	60	30	10
13	W14	Surface	400	55	25	20
		Bottom	310	65	25	10

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

Sr. No.	Bacillariophyceae	Chlorophyceae	Cyanophyceae
1.	<i>Navicula</i> sp.	<i>Cosmarium</i> sp.	<i>Oscillatoria</i> sp.
2.	<i>Nitzschia</i> sp.	<i>Scenedesmus</i> sp.	<i>Anabaena</i> sp.
3.	<i>Fragillaria</i> sp.	<i>Ulothrix</i> sp.	<i>Aphanocapsa</i> sp.
4.	<i>Surirella</i> sp.	-	-
5.	<i>Gyrosigma</i> sp.	-	-
6.	<i>Skeletonema</i> sp.	-	-
7.	<i>Pleurosigma</i> sp.	-	-

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

Sr. No.	Station	Secchi Depth [cm]
JNP Harbour Area		
1.	W1	25
2.	W2	25
3.	W3	20
4.	W4	20
5.	W5	15
6.	W6	25
7.	W7	15
8.	W9	20
9.	W10	20
JNP Nhava Creek Area		
10.	W11	20
11.	W12	15
12.	W13	15
13.	W14	15

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

Sr. No.	Towing between Stations	Zoo-plankton, [No/m³]	Percent Composition of Zooplankton Groups			
			Copepoda	Cladocera	Foraminifera	Rotifera
JNP Harbour Area						
1.	W1-W2	270	50	20	20	10
2.	W2-W5	310	40	20	20	20
3.	W5-W1	420	40	20	25	15
4.	W5-W6	540	50	20	20	10
5.	W6-W2	225	50	15	30	5
6.	W4-W3	410	40	20	20	20
7.	W3-W7	225	50	20	10	20
8.	W7-W10	425	70	20	10	-
9.	W10-W3	410	60	20	20	-
10.	W9-W3	290	55	25	10	10
JNP Nhava Creek						
11.	W5-W11	320	55	25	20	-
12.	W11-W12	275	60	20	10	10
13.	W12-W13	290	55	20	15	10
14.	W13-W14	370	40	20	10	30

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>Brachionus</i> sp.	<i>Moina</i> sp.	-

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

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 Harbour Area						
1.	W1	4.1	2.9	BDL	BDL	273
2.	W2	3.5	2.1	BDL	BDL	233
3.	W3	3.1	1.9	BDL	BDL	206
4.	W4	2.5	3.6	BDL	BDL	166
5.	W5	4.1	2.7	0.5	BDL	273
6.	W6	2.3	1.5	BDL	BDL	153
7.	W7	4.0	2.9	BDL	BDL	266
8.	W9	3.5	2.7	BDL	BDL	233
9.	W10	4.0	3.2	BDL	BDL	266
Nhava Creek Area						
10.	W11	3.2	2.7	BDL	BDL	213
11.	W12	4.3	3.2	BDL	BDL	286
12.	W13	3.7	2.9	BDL	BDL	246
13.	W14	3.2	1.8	BDL	BDL	213

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

Sr. No.	Station	POC, [mg/m ³]
Standard		10 – 100
JNP Harbor Area		
1.	W1	677
2.	W2	857
3.	W3	891
4.	W4	1003
5.	W5	909
6.	W6	814
7.	W7	900
8.	W9	703
9.	W10	634
Nhava Creek Area		
10.	W11	994
11.	W12	1011
12.	W13	891
13.	W14	1054

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

Sr. No.	Station	Macrobenthos [No/m²]	Percent Composition of Macrobenthos			
			Gastropods	Polychaetes	Foraminifera	Chironomidae
JNP Harbour Area						
1.	W1	170	40	20	30	10
2.	W2	115	50	30	20	-
3.	W3	180	40	20	20	20
4.	W4	210	55	35	10	-
5.	W5	215	45	20	20	15
6.	W6	120	65	25	10	-
7.	W9	75	55	30	15	-
8.	W10	125	45	40	15	-
JNP Nhava Creek Area						
9.	W13	90	45	35	20	-
10.	W14	120	50	20	25	5

Note: No sediment was found at W7, W11 and W12

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	393	1310	178	10700	48	970	<10	1548	2661
W2	471	1381	148	10400	46	620	<10	1568	2960
W3	511	1286	156	10800	69	1105	<10	1527	2996
W4	629	1191	210	10500	35	460	<10	1555	2440
W5	511	1334	197	10000	63	320	<10	1532	2751
W6	629	1310	188	10400	69	590	<10	1595	2735
W7	471	1262	179	10700	46	670	<10	1542	2961
W9	550	1310	185	10600	65	1050	<10	1520	3014
W10	511	1286	192	11000	33	465	<10	1597	3002
JNP NHAVA CREEK AREA									
W11	432	1262	177	10800	68	410	<10	1541	2468
W12	550	1238	184	10900	47	940	<10	1556	2512
W13	511	1310	196	10300	88	1055	<10	1644	2942
W14	471	1357	199	10500	73	710	<10	1635	2532

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	5360	146	304	5210	300	11	0.06	34	6303
W2	5040	292	282	6177	250	6	0.09	44	4208
W3	5306	289	276	4634	340	11	0.12	65	4142
W4	8160	194	330	5180	230	7	0.15	34	5469
W5	4118	337	384	4628	380	5	0.06	30	5681
W6	4752	385	287	5323	280	9	0.05	46	6689
W7	Sample not found								
W9	8400	389	383	4917	330	20	0.11	72	1998
W10	7200	535	342	5073	300	6	0.16	23	6522
JNP NHAVA CREEK AREA									
W11	Sample not found								
W12	Sample not found								
W13	6960	535	342	4768	250	11	0.09	56	5431
W14	8400	291	379	4634	240	14	0.11	90	8432

3.4 DISCUSSION

3.4.1 Water Quality: Biotic

3.4.1.a Primary Productivity

The highest estimated gross and net primary productivity was measured as 475 and 375 mgC/m³/d at station W2 [Table 20]. Compared with other coastal ecosystems, primary productivity of JNP Harbour area and Nhava creek was at a moderate level. The dredging activity near W7 location does not seem to be affecting the primary productivity.

3.4.1.b Plankton

A] Phytoplankton:

Count : Phytoplankton counts, recorded at different sampling stations, are presented in Table 21. Total algal population varied between 170 and 520 algal cells/ml. Samples collected at stations W10(B) and W2(S) showed lowest and highest counts respectively. Bacillariophyceae dominated all samples followed by Chlorophyceae. The phytoplankton population comprised of thirteen genera with 3 major groups, namely Bacillariophyceae, Chlorophyceae and Cyanophyceae [Table 22]. As the dredging activities going on around W7, since it may not be affected on the plankton count, as the count at station W7 is not lowest compared to the other stations. Planktonic organisms respond quickly to environmental changes. Thus, the counts are quickly affected during dredging; they recover in a short time after dredging because the effects of dredging in the pelagic environment, although intensive, are generally short-lived.

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 15 and 25 cm.

B] Zooplankton:

Zooplankton counts, recorded at different sampling stations, are shown in Table 24. Since huge quantity of water was to be filtered through plankton net, middle and bottom samples could not be collected. Density of zooplankton varied between 225 and 540 N/m³ at stations W1-W2 & W3-W7 and W5-W6. Total six genera of zooplankton were recorded. Copepoda dominated all the samples [Table 25].

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

The algal biomass is the main source of food for the primary consumers and it was evaluated by chlorophyll-*a* method and its value is given in **Table 26**. In JNP harbor area, the range of algal biomass was found between 166 and 286 mg/m³. The minimum algal biomass was (166 mg/m³) found at W4 and maximum (286 mg/m³) was found at W12 station. The lowest and highest chlorophyll *a* levels from surface water sample varied from 2.5 mg/m³ at station W4(S) to 4.3 mg/m³ at W12(S). Pheophytin concentrations of many samples were below detectable limit [**Table 26**]. Based on values of Chlorophyll-*a*, these waters can be classified as mostly oligotrophic, that is of good quality.

3.4.1.d Particulate Organic Carbon [POC]:

The concentration of particulate oxidizable carbon [POC] is given in Table 27. In JNP harbour POC content was found to be between 634 and 1003 mg/m³ with an average of 829 mg/m³. The minimum concentration of POC i.e. 634 mg/m³ was found at W10 station and maximum concentration i.e. 1003 mg/m³ at W4 station. In Nhava creek the POC content was found to be from 891 - 1054 mg/m³ with an average of 988 mg/m³. The minimum concentration of POC i.e. 891 mg/m³ was found at W13 station and maximum concentration i.e. 923 mg/m³ was found at W14 station. The POC concentration was found to be higher than the prescribed standard range i.e. 10- 100 mg/m³ at all stations in JNP Harbour and Nhava Creek regions. This may be due to detritus material originated 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:

A total of four macrobenthic groups were obtained from the sediment samples. Gastropod are abundant. Among the Gastropods, the dominant genera were *Litiopa* sp., *Littorina* sp., *Morula* sp. and *Oliva* sp. The highest count was 215 No/m² at station W5 while lowest (75 No/m²) was found at station W9. No sediment was found at stations W7, W11 and W12. Presence of comparatively less number of macrobenthos around sampling stations W9 and W13 may be attributed to rocky bottom and abundance of predators in this region.

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 presented in **Table 29**. In harbor region the Phosphate was found to be in the range of 33 μ g/L – 69 μ g/L. The average concentration of Phosphate was found to be 53 μ g/L in JNP harbor region, the Phosphate values are within the prescribed standard range [0.1 – 90 μ g/L]. Nitrate was found to be between 320 μ g/L – 1105 μ g/L. The minimum value of Nitrate 320 μ g/L was found at W5 station and maximum value 1105 μ g/L at W3 station. The average concentration of Nitrate was found to be 694 μ g/L. At locations W1, W2, W3, W6, W7, & W9 the Nitrate concentration was found to be above prescribed standard range [1.0 to 500 μ g/L]. 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 1520 – 1597 μ g/L with an average of 1554 μ g/L. The minimum concentration of silica was found at W9 station of JNP harbor region and the maximum concentration of silica was found at W10 station. The values of silica were observed to be well within the prescribed limits [10 to 5000 μ g/L]. The Sulphate was found between 2440 – 3014 mg/L, the minimum value recorded at W4 station and maximum at W9 station. The average concentration of Sulphate was found to be 2836 mg/L.

In Nhava Creek, Phosphate was found between 47 μ g/L – 88 μ g/L with an average 69 μ g/L which is within the prescribed standard range [0.1-90 μ g/L]. The minimum value was recorded at W12 and maximum at W13 location. Nitrate was found to be 410 (at W11) – 1055 μ g/L (at W13) with an average 779 μ g/L. The silica content in Nhava creek was found to be 1541 – 1644 μ g/L with an average of 1594 μ g/L. The minimum silica content was found at station W11 station and maximum was found at W13 station. The values of silica were observed to be well within the prescribed limits. Sulphate was found between 2468 – 2942 mg/L with an average of 2614 mg/L. The minimum value for Sulphate was found at W11 station and maximum value at W13 station.

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 was found at eight out of nine locations. Phosphate was found between 230 – 380 mg/kg with an average of 301 mg/kg. The minimum value of 230mg/kg was found at W4 location while maximum value (380mg/kg) was found at W5. The Nitrate was found to be minimum at W5 station i.e. 5 mg/kg and maximum at W9 station i.e. 20mg/kg. The average concentration of Nitrate was found to be 9 mg/kg. The Nitrite was found to be between 0.05 – 0.16 mg/kg with an average of 0.12 mg/kg. The minimum concentration of nitrite was found at W6 station and maximum value at W10 station. Silica in the form of silicate in JNP harbor sediments were found between 23 and 72 mg/kg with an average of 43mg/kg. The minimum concentration of silica was found at W10 station i.e. 23mg/kg and maximum value was found at W9 station i.e. 72mg/kg. The Sulphate was found between 1998 - 6689 mg/kg, with minimum value i.e. 1998 mg/kg at W9 station and maximum value i.e. 6689 mg/kg at W6 station. The average concentration of Sulphate was found to be 5127 mg/kg.

In Nhava Creek region the sediment found at two locations out of four. Phosphate levels were 240 and 250 mg/kg with an average of 245 mg/kg. Nitrate was found to be 11 and 14 mg/kg. The average concentration of Nitrate was found to be 13 mg/kg. The Nitrite was found to be 0.09 and 0.11 mg/kg. The average concentration of Nitrite was found to be 0.10 mg/kg. Silica in the form of silicate in JNP harbor sediments was found to be 56 to 90 mg/kg with an average of 73 mg/kg. The Sulphate was found to be 5431 and 8432mg/kg. The average concentration of Sulphate was found to be 5332mg/kg.

b. Cations:

In harbor region water, the Calcium was found between 393 to 629 mg/L with an average of 520 mg/L given in **Table 29**. The minimum value for Calcium i.e. 393 mg/L was found at W1 location whereas the maximum value i.e. 629 mg/L was found at W4 and W6 locations. The Magnesium was found to be 1191 – 1381 mg/L, with minimum value i.e. 1191 mg/L at W4 location whereas maximum value i.e. 1381 was found at W2 stations. The average concentration of Magnesium was found to be 1297 mg/L. The minimum concentration of Potassium 148 mg/L was found at W2 location and maximum concentration 210 mg/L at W4 location with an average of 181 mg/L. The Sodium was found between 10000 to 11000 mg/L with an average of 10567 mg/L. The minimum concentration of sodium i.e. 10000 mg/L was found at W5 stations and maximum value i.e. 11000 mg/L of at W10 station.

In Nhava Creek, Calcium concentration was found with an average 491 mg/L given in **Table 29**. The minimum value 432 mg/L was found at W11 and maximum 550 mg/L at W12 station. Magnesium concentration was found to be 1238 – 1357 mg/L with an average of 1292 mg/L. The minimum value i.e. 1238 mg/L of Magnesium was found at W12 station and maximum value 1357 mg/L was found at W14 stations. The Potassium

content in Nhava creek was found to be 177 mg/L at W11 – 199 mg/L at W14 station with an average of 189 mg/L. Sodium minimum concentration was found to be 10300 mg/L at W13 and maximum of 10900 mg/L at W12. The average concentration of sodium was found to be 10625 mg/L.

In harbor region sediments, the Calcium was found to be 4118 to 8400 mg/Kg with an average of 6042 mg/Kg given in **Table 30**. The minimum Concentration of Calcium 4118 mg/kg was found at W5 station and maximum concentration 8400 mg/kg at W9 station. Magnesium was found to be 146 to 535 mg/Kg, with minimum value 146 mg/kg at W1 station and maximum 535 mg/kg was recorded at W10 station. The average concentration of Magnesium was found to be 321 mg/Kg. Potassium in JNP harbor sediment was found to be 276 to 384 mg/Kg with an average of 323 mg/Kg. The minimum concentration of Potassium 276 mg/kg was found at W3 station and maximum value 384 mg/kg at W5 station. Sodium was found to be 4628 to 6177 mg/Kg with an average of 5143 mg/Kg. The minimum concentration of sodium 4628 mg/kg was found at W5 station and maximum value 6177 mg/kg at W2 station.

In Nhava Creek sediments, Calcium was found to be 6960 mg/kg at W13 and 8400 mg/Kg at W14 locations, with an average 7680 mg/Kg given in **Table 30**. Average magnesium was found to be 413 mg/Kg. The minimum concentration of magnesium was found at W14 location i.e. 291 mg/kg, whereas maximum concentration was observed at W13 location with value 535 mg/kg. The minimum concentration of potassium 342 mg/kg was observed at W13 and maximum concentration 379 mg/kg was observed at W14 station. Average potassium content in Nhava creek was found to be 360 mg/Kg. The minimum sodium value 4634 mg/kg was found at W14 station and maximum value 4768 mg/kg at W13. The average concentration of sodium was found to be 4701 mg/kg.

3.5 OBSERVATIONS AND CONCLUSIONS

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

- ✓ *Construction of 4th Container Terminal on South side of JNPT:* Earth Filling work of 4thC.T. is underway.
- ✓ *Construction of NSIGT Yard is underway to the North side of JNPT.*
- ✓ *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, as reported in **Tables 20 to 29** and subsequently discussed in above paragraphs, the major parameters comply with recommended ranges of the ecological parameters for Arabian Sea during December, 2015 except parameters like Particulate Organic Carbon and Nitrate.

The increased levels of POC, Phosphate and Nitrate, although not at alarming state, might be attributed to:

- ❖ There are four lotic water bodies; viz. Thane creek, Ulhas river, Panvel creek and Patalganga river that join the sea in the vicinity of the sampling area. Amongst these four, most of the sampling points are either within or close to Thane and Panvel creek confluence, resulting in direct impact on harbor water
- ❖ The creek is narrow at Northern end, where it is fed partially by River Ulhas. Along the east and west sides of the creek, many industrial units have come up. Thane and Panvel creek is the ultimate recipient of all the liquid discharges from these industries and mostly untreated sewage discharges. The discharges into the creek on its western side are dominated by Mumbai city sewerage and wastes from petrochemical, fertilizer and thermal plants at Chembur, besides the pharmaceutical and chemical complexes at Vikhroli, Bhandup and Mulund.
- ❖ The comparatively high values for POC might be the offshoot of detritus materials originating from Mangrove swamps due to tidal effects or enriched by detritus plankton & other organisms, coming from the creeks located on the Northern side of the Port.
- ❖ It may be mentioned that JN Port is not handling any dry bulk cargo containing Phosphate

Based on observations of the overall ecological parameters in JNP Harbour and Nhava Creek area, it can be inferred that the marine ecosystem is not affected due to port operational activities. The undesirable levels of POC and Nitrate are the result of untreated discharges of sewage and industrial waste from the towns / villages around the area, like Navi-Mumbai, Thane, Panvel etc. Accordingly certain mitigation measures, corresponding to parameters, are recommended in **Table 31**.

Table 31: Suggested mitigating measures for the Ecological parameters

Sr. No.	Parameter	Criteria	Observations	Remarks	Mitigation Measures
1.	Net primary productivity	<1500 mgC/m ³ /day at surface	The observed values falls under 115 – 375 mgC/m ³ /day	-	Within Range
2.	Chlorophyll- <i>a</i>	< 4 mg/m ³ [Oligotrophic class] 4-10 mg/m ³ [Mesotrophic class] >10 mg/m ³ [Eutrophic class]	The observed values falls under 2.5 – 4.3 mg/m ³	Stations follow mostly 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 – 53 µg/L; Creek area – 69 µg/L	The nutrient acts as fertilizer. High level of nutrient from industrial waters from nearby mega cities may lead to excessive algal growth in aquatic ecosystem	Within Range
4.	Nitrate	1.0- 500 µg/L	Harbour area – 694 µg/L; Creek area – 779 µg/L	Besides wastes from sewage / industries, the nutrient is also produced in natural water by decomposition of nitrogenous organic compounds. Moderate level of nitrate in the area.	Proper treatment to Sewage and Industrial waste into the sea water by the concerned authorities like BMC, TMC, Panvel Municipal Corporation etc.
5.	Nitrite	<125 µg/L	Harbour area – <10 µg/L & Creek area – <10µg/L	A nutrient produced in natural water by decomposition of nitrogenous organic compounds. Moderate level of nitrite.	-----
6.	Particulate Organic Carbon	10 – 100 mg/m ³	Harbour area – 697 mg/m ³ ; Creek area – 875 mg/m ³	This may be due to detritus material originating from Mangrove swamps / detritus plankton, benthos, fish etc. / untreated sewage discharges from towns /villages around the area.	Natural Phenomenon regarding mangrove and other living organisms. Treatment of sewage and industrial wastes before discharging into the sea water by the concerned authorities.
7.	Silicate (SiO ₂)	10-5000 µg/L	Harbour area – 1554 µg/L; Creek area – 1594 µg/L	Nucleic acid synthesis and skeletal formation of Diatoms.	Within Range

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 presented 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 18 stations, 10 are in outside the port while 8 are inside the port. All samples were collected from the port area of JNP on 11th December, 2015.

The water samples are analyzed for various parameters, viz. Colour, Odour, pH, Turbidity, Total Dissolved Solids, Aluminium as Al, NH₃ - N, Barium as Ba, Boron, Calcium as Ca, Chloride as Cl⁻, Copper as Cu, Fluoride, Free Residual Chlorine, Iron as Fe, Magnesium as Mg, Manganese as Mn, Oil & grease, Nitrate as NO₃⁻, Phenolic compound, Selenium as Se, Silver as Ag, Sulphate as SO₄⁻², Total Alkalinity as CaCO₃, Total Hardness as CaCO₃, Zinc as Zn, Cyanide, Lead as Pb, Mercury as Hg, Molybdenum as Mo, Nickel as Ni, Pesticides, Total Arsenic as As, Total Chromium as Cr, Total Coliforms and *E. coli*.

4.2 RESULTS

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

Table 33: Results of Drinking water quality monitoring [Sample collected on December' 2015]								
Parameter	Unit of Measurement	Station Name						Standard*
		DW1	DW2	DW3	DW4	DW5	DW6	
Colour	Hazen	<5	<5	<5	<5	<5	<5	5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
pH	-	7.32	7.18	7.36	7.33	7.24	7.48	6.5 to 8.5
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Total Dissolved Solids	mg/L	104	96	137	148	116	120	500
Aluminium as Al	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.03
NH ₃ - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5
Barium as Ba	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7
Boron	mg/L	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.5
Calcium as Ca	mg/L	9	10	9	12	11	10	75
Chloride as Cl ⁻	mg/L	12	10	13	12	11	10	250
Copper as Cu	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05
Fluoride	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1
Free Residual Chlorine	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Iron as Fe	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.3
Magnesium as Mg	mg/L	6	6	6	7	6	5	30
Manganese as Mn	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
Oil and grease	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Nitrate as NO ₃	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	45
Phenolic compound	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Selenium as Se	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Silver as Ag	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Sulphate as SO ₄ ⁻²	mg/L	5	5	5	6	5	6	200
Total Alkalinity as CaCO ₃	mg/L	34	35	36	33	34	35	200
Total Hardness as CaCO ₃	mg/L	47	50	46	59	51	46	200
Zinc as Zn	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	5
Cyanide	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Lead as Pb	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Mercury as Hg	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.001
Molybdenum as Mo	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07
Nickel as Ni	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02
Pesticides	mg/L	ND	ND	ND	ND	ND	ND	0.5
Total Arsenic as As	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.01
Total Chromium as Cr	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Total Coliforms	MPN/100ml	<2	<2	<2	<2	2	2	Nil
E coli	-	Absent	Absent	Absent	Absent	Absent	Absent	Absent

*: IS 10500:2012, Drinking Water- Specification

Table 33: Results of Drinking water quality monitoring [Sample collected on December' 2015]

Parameter	Unit of Measurement	Station Name						Standard*
		DW7	DW8	DW9	DW10	DW11	DW12	
Colour	Hazen	<5	<5	<5	<5	<5	<5	5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
pH	-	7.42	7.32	7.46	7.32	7.16	7.21	6.5 to 8.5
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Total Dissolved Solids	mg/L	104	102	94	122	106	120	500
Aluminium as Al	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.03
NH ₃ - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5
Barium as Ba	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7
Boron	mg/L	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.5
Calcium as Ca	mg/L	9	9	10	11	8	9	75
Chlorides as Cl ⁻	mg/L	12	14	13	11	10	12	250
Copper as Cu	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05
Fluoride	mg/L	0.1	<0.1	<0.1	<0.1	<0.1	0.16	1
Free Residual Chlorine	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Iron as Fe	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.3
Magnesium as Mg	mg/L	5	5	6	6	5	8	30
Manganese as Mn	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
Oil and grease	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Nitrate as NO ₃ ⁻	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	0.8	45
Phenolic compound	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Selenium as Se	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Silver as Ag	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Sulphate as SO ₄ ²⁻	mg/L	6	5	5	5	5	7	200
Total Alkalinity as CaCO ₃	mg/L	38	36	35	36	38	36	200
Total Hardness as CaCO ₃	mg/L	44	45	50	52	41	55	200
Zinc as Zn	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	5
Cyanide	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Lead as Pb	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Mercury as Hg	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.001
Molybdenum as Mo	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07
Nickel as Ni	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02
Pesticides	mg/L	ND	ND	ND	ND	ND	ND	0.5
Total Arsenic as As	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.01
Total Chromium as Cr	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Total Coliforms	MPN/100ml	<2	<2	<2	4	<2	<2	Nil
E coli	-	Absent	Absent	Absent	Absent	Absent	Absent	Absent

*: IS 10500:2012, Drinking Water - Specification

Table 33: Results of Drinking water quality monitoring [Sample collected on December' 2015]

Parameter	Unit of Measurement	Station Name						Standard*
		DW13	DW14	DW15	DW16	DW17	DW18	
Colour	Hazen	<5	<5	<5	<5	<5	<5	5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
pH	-	7.22	7.23	7.42	7.28	7.36	7.32	6.5 to 8.5
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Total Dissolved Solids	mg/L	104	117	110	92	116	122	500
Aluminium as Al	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.03
NH ₃ -N	mg/l.	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5
Barium as Ba	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7
Boron	mg/L	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.5
Calcium as Ca	mg/L	8	8	10	11	11	10	75
Chloride as Cl	mg/L	11	10	12	13	13	11	250
Copper as Cu	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05
Fluoride	mg/L	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	1
Free Residual Chlorine	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Iron as Fe	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.3
Magnesium as Mg	mg/L	6	6	7	7	6	7	30
Manganese as Mn	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
Oil and grease	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Nitrate as NO ₃	mg/L	0.9	<0.2	<0.2	<0.2	<0.2	<0.2	45
Phenolic compound	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Selenium as Se	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Silver as Ag	mg/l.	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Sulphate as SO ₄ ⁻²	mg/L	6	6	5	5	5	5	200
Total Alkalinity as CaCO ₃	mg/L	34	33	35	34	33	36	200
Total Hardness as CaCO ₃	mg/L	43	45	52	56	53	55	200
Zinc as Zn	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	5
Cyanide	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Lead as Pb	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Mercury as Hg	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.001
Molybdenum as Mo	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07
Nickel as Ni	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02
Pesticides	mg/L	ND	ND	ND	ND	ND	ND	0.5
Total Arsenic as As	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.01
Total Chromium as Cr	mg/l.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Total Coliforms	MPN/100ml	<2	<2	<2	<2	<2	<2	Nil
E.coli	-	Absent	Absent	Absent	Absent	Absent	Absent	Absent

*: IS 10500:2012, Drinking Water - Specification

4.3 DISCUSSION

Table 33 provides the observed results for various parameters analyzed for drinking water samples collected from eighteen stations in and around the port's activity during the monitoring period of December, 2015 are compared with acceptable limits as prescribed in **IS 10500:2012** – Drinking Water Specification. It is seen from the analysis data that during the study period the water was safe for human consumption at all drinking water monitoring stations in and around the port.

The colour of all drinking water samples was < 5 Hazen unit and odour of the samples was also agreeable. The values of turbidity, Iron as Fe and Ammonia as $\text{NH}_3\text{-N}$ were observed to be below detection limits of measurement i.e. <0.1 NT, <0.03 mg/L and <0.1 mg/L respectively. Apparently these parameters are not at alarming levels.

Values observed for TDS for all the samples were in the range of 92 to 148 mg/L which are well below the acceptable standard limits (500 mg/L). pH values of all the samples were in the range of 7.16 to 7.48 which is within the permissible standard 6.5 to 8.5. Total Hardness as CaCO_3 values of all the eighteen samples were found to be in the range of 41 to 59 mg/L and found to be within the acceptable limit (200 mg/L).

Concentration levels observed for Chlorides as Cl^- and Sulphate as SO_4^{2-} were in the range of 8.0 to 13.5 mg/L, 5.0 to 16.0 mg/L respectively. The observed values for these parameters are well within the acceptable standard limits.

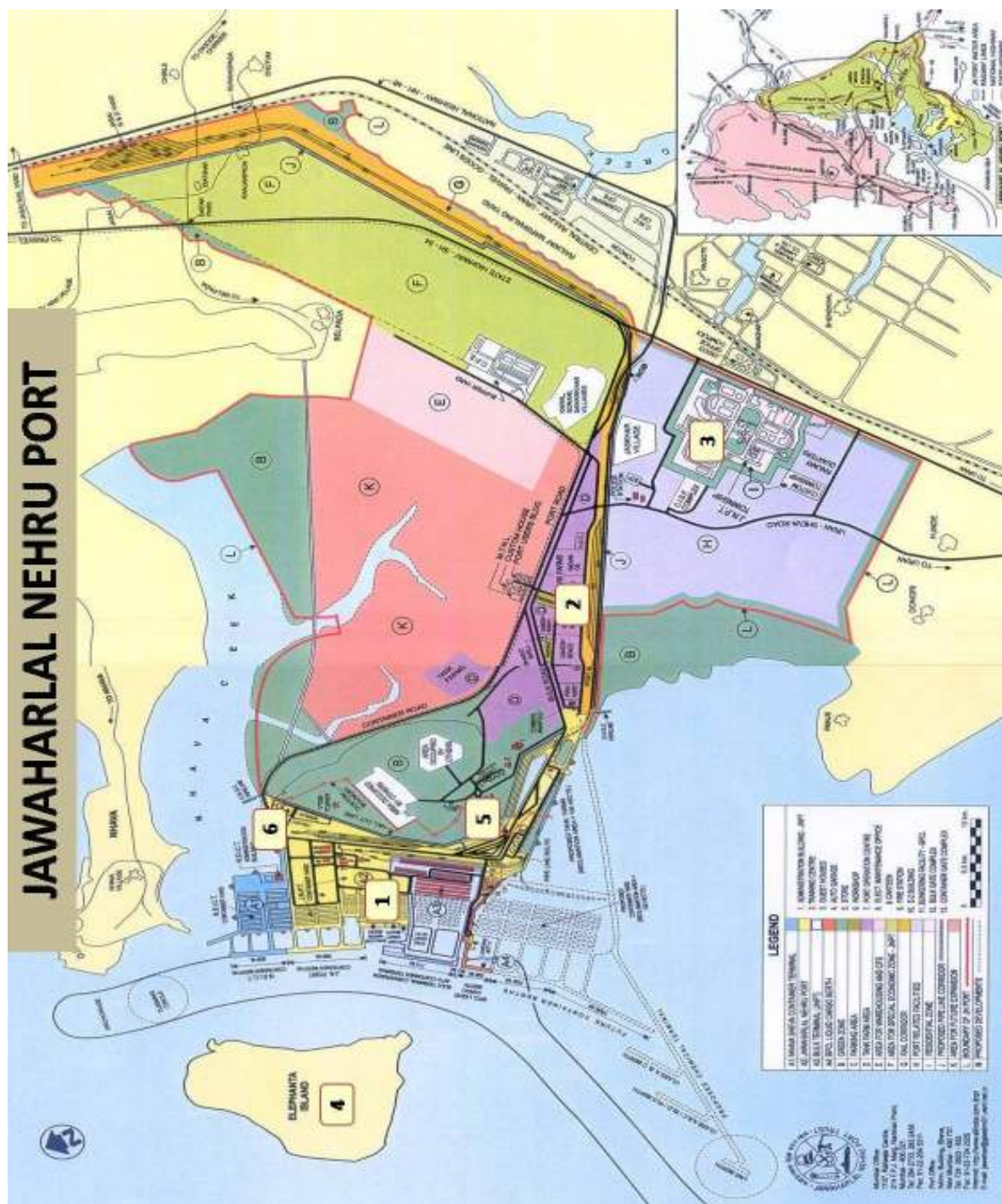
Analysis of the bacteriological parameter at all location DW5, DW6 & DW10 Total Coliform values is deviated from standard. Except at JNPT Inlet, NSICT canteen, and POC Canteen the Total Coliform and E-Coli values showed that all the other drinking water samples were safe from any bacteriological contamination.

4.4 CONCLUSIONS AND MITIGATION MEASURES:

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 except at NSICT canteen, and POC Canteen.

It is advisable that, utmost care has to be taken to keep drinking water premises clean and sanitized. Water Filters and purifiers have to be regularly cleaned.

Annexure-I: Location map for Ambient Air Monitoring Stations



Annexure-II: National Ambient Air Quality Monitoring Standard

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 Geake
		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)
		1 hour**	04	04	spectroscopy
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 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

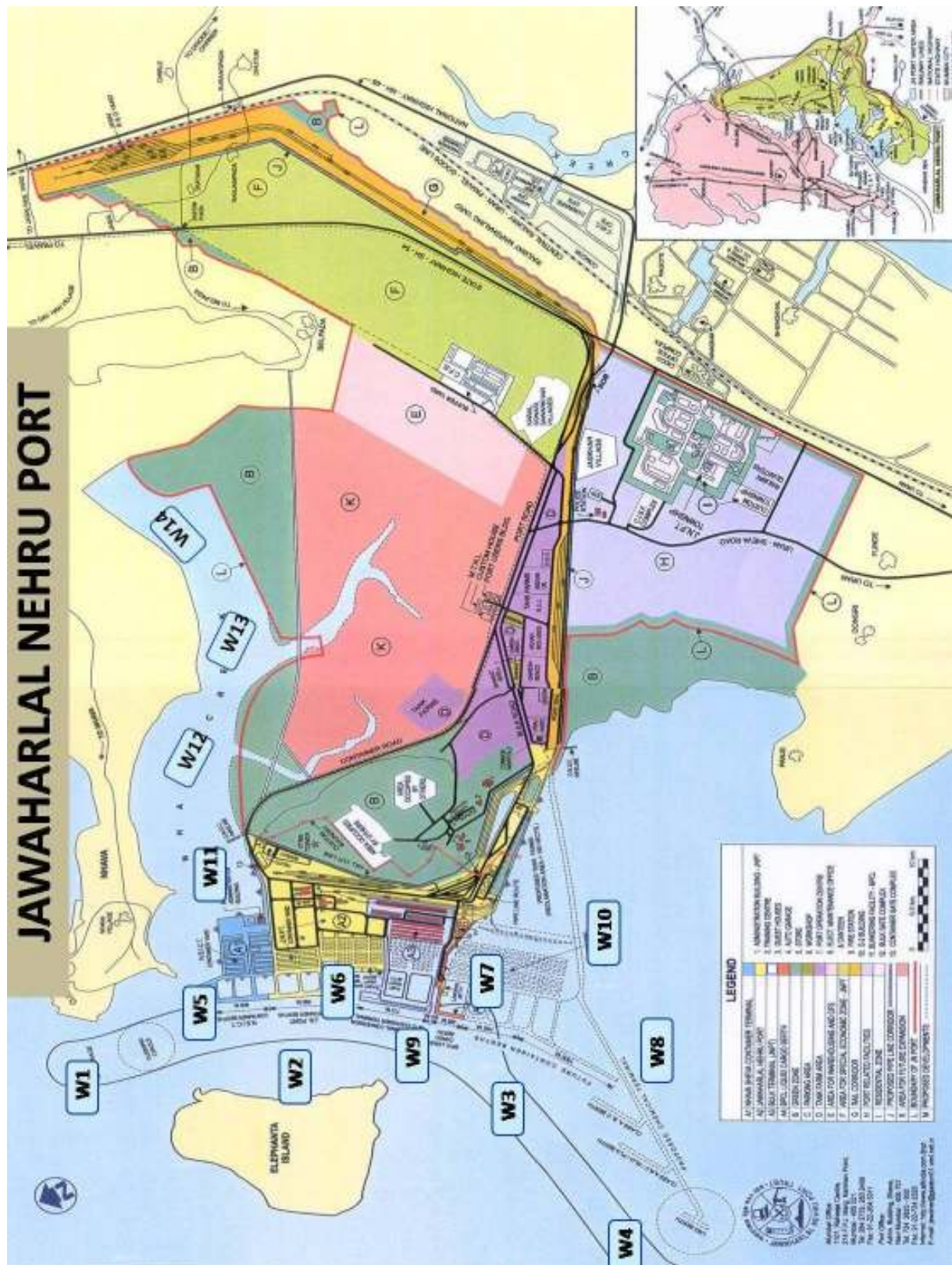
* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals

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

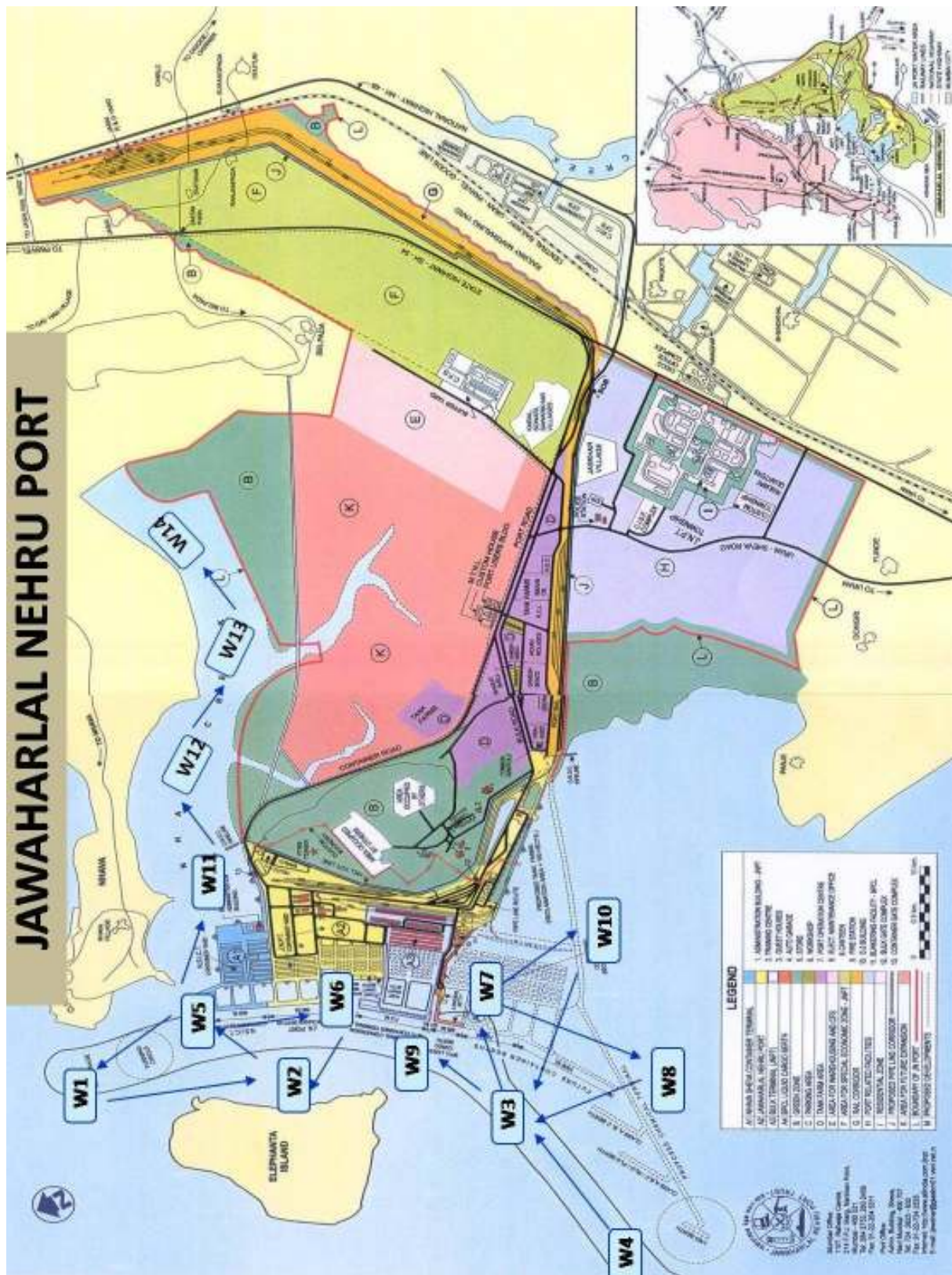
2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

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-III: Location map for Marine Water Monitoring Stations



Annexure-IV: Map for Ecological monitoring Stations and Towing Directions



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

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 (3 days at 27°C)	5 mg/L	To maintain water relatively free from the pollution caused by sewage and other decomposable wastes.

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

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.