



## MONITORING OF ENVIRONMENTAL PLAN FOR JN PORT

### ENVIRONMENTAL MONITORING REPORT

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## TABLE OF CONTENT

SR. NO.	PARTICULARS	PAGE NO.
<b>1.</b>	<b>AMBIENT AIR QUALITY MONITORING</b>	<b>2</b>
1.1	INTRODUCTION	2
1.2	AIR QUALITY MONITORING METHODOLOGY	2
1.3	RESULTS	3
1.4	DISCUSSION	13
1.5	OBSERVATIONS & CONCLUSIONS	14
<b>2.</b>	<b>MARINE WATER QUALITY MONITORING [HARBOR&amp; CREEK] INCLUDING STUDY OF SEDIMENT CHARACTERISTICS</b>	<b>16</b>
2.1	INTRODUCTION	16
2.2	MARINE WATER QUALITY MONITORING METHODOLOGY	16
2.3	RESULTS	17
2.4	DISCUSSION	24
2.5	OBSERVATIONS & CONCLUSIONS	25
<b>3.</b>	<b>MARINE ECOSYSTEM MONITORING</b>	<b>26</b>
3.1	INTRODUCTION	26
3.2	MARINE ECOSYSTEM MONITORING METHODOLOGY	26
3.3	RESULTS	27
3.4	DISCUSSION	34
3.4.1	Water Quality: Biotic	34
a	Primary Productivity	34
b	Plankton: Phytoplankton, Zooplankton	35
c	Photosynthetic pigments [Chlorophyll-a, Pheophytin-a]	37
d	Particulate Organic Carbon [POC]	37
3.4.2	Sediment Quality: Biotic	38
3.4.3	Nutrients	39
3.5	OBSERVATIONS & CONCLUSIONS	41
<b>4.</b>	<b>DRINKING WATER QUALITY MONITORING</b>	<b>44</b>
4.1	INTRODUCTION	44
4.2	RESULTS	44
4.3	DISCUSSION	48
4.4	CONCLUSIONS	48
<b>5.</b>	<b>ANNEXURES</b>	<b>49</b>
5.1	Annexure-I: Location map for Ambient Air Monitoring Stations	49
5.2	Annexure-II: National Ambient Air Quality Monitoring Standard	50
5.3	Annexure-III: Location map for Marine Water Monitoring Stations	51
5.4	Annexure-IV: Location map for Ecological monitoring Stations and Direction of Towing	52
5.5	Annexure-V: Primary Criterion for Class SW-IV Waters (For Harbor Waters)	53
5.6	Annexure-VI: Recommended Ranges of the Ecological Parameters for Arabian Sea	54

## 1. AMBIENT AIR QUALITY MONITORING

### 1.1 INTRODUCTION

As per the Environmental Monitoring Plan of Jawaharlal Nehru Port (JNP), Air monitoring locations are selected in port and outside including nearby residential and eco-sensitive areas. Locations of stations are selected based on the significance of sources, receptors and to get representative data. Three fixed stations are identified namely Port Operational Centre (POC), Indian Molasses Company (IMC) and Residential Colony (RC). Three movable locations are also identified namely Elephanta Caves (EC), North Gate Complex (NGC) and South Gate Complex (SGC). The description of stations is depicted in **Table 1**. The location map of various air quality monitoring stations at JNP is described in **Annexure-I**.

*Table 1: Description of Ambient Air Monitoring Stations*

Station No.	Station	Location	Selection Criterion
1.	POC	At Port Operational Centre	Main Port Activity Location
2.	IMC	At IMC compound in Liquid Chemical Terminal Area	Major industrial activity centre
3.	RC	At JNP residential township	Impact on human population, receptor oriented
4.	EC	At Elephanta Caves	Impact on archeological site, receptor oriented
5.	NGC	Near North Gate Complex	Heavy traffic movement
6.	SGC	Near South Gate Complex	Heavy traffic movement

### 1.2 AIR QUALITY MONITORING METHODOLOGY

The objective behind Air Quality monitoring survey is to determine the status of existing ambient air quality in the port and to compare it with CPCB specified standards. Sampling and analysis ambient air samples are carried out as per CPCB Guidelines for Ambient Air Quality Monitoring, Volume-I, 2011. The monitoring is carried-out for air quality parameters mentioned in the National Ambient Air Quality Monitoring Standards (NAAQMS), CPCB Notification published on 18<sup>th</sup> 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 PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>x</sub>, NH<sub>3</sub>, Pb, As, Ni, Benzo(α)pyrene, 8 hour for Ozone & Benzene, and Grab-sampling for CO & CO<sub>2</sub> 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, SO<sub>2</sub>, NO<sub>x</sub> and NH<sub>3</sub>. The EPM 2000 filter paper and PTFE Membrane bound filter paper is used for a period of 24 hours to obtain one sample of PM<sub>10</sub>& PM<sub>2.5</sub>. After PM<sub>10</sub> 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, 2014 are given in Table 2, 3 & 4 respectively. The ambient air quality monitoring data for EC and 2 movable stations, NGC&SGC are given in Table 5, 6 & 7 respectively.

Table 2: Results of Air Pollutant Concentration at POC Station of JNP Area during the month of December, 2014														
Sampling Period	Date	Time, [Hrs]	PM <sub>10</sub> , [µg/m <sup>3</sup> ]	PM <sub>2.5</sub> , [µg/m <sup>3</sup> ]	SO <sub>2</sub> , [µg/m <sup>3</sup> ]	NO <sub>x</sub> , [µg/m <sup>3</sup> ]	NO <sub>x</sub> , [µg/m <sup>3</sup> ]	NO <sub>x</sub> , [µg/m <sup>3</sup> ]	NO <sub>x</sub> , [µg/m <sup>3</sup> ]	NO <sub>x</sub> , [µg/m <sup>3</sup> ]	NO <sub>x</sub> , [µg/m <sup>3</sup> ]	NO <sub>x</sub> , [µg/m <sup>3</sup> ]	NO <sub>x</sub> , [µg/m <sup>3</sup> ]	NO <sub>x</sub> , [µg/m <sup>3</sup> ]
NAAQMS	02.12.2014 to 03.12.2014	14:00 to 22:00	159	63	10	12.4	20	20	20	20	20	20	20	20
POC-1	03.12.2014 to 04.12.2014	22:00 to 06:00	159	63	15	12.4	21	21	21	21	21	21	21	21
	04.12.2014 to 05.12.2014	06:00 to 14:00	159	63	12	12.4	19	19	19	19	19	19	19	19
POC-2	05.12.2014 to 08.12.2014	14:00 to 22:00	282	97	13	13.9	23	23	23	23	23	23	23	23
	08.12.2014 to 09.12.2014	22:00 to 06:00	282	97	13	13.9	24	24	24	24	24	24	24	24
	09.12.2014 to 11.12.2014	06:00 to 14:00	282	97	15	13.9	22	22	22	22	22	22	22	22
POC-3	11.12.2014 to 12.12.2014	14:00 to 22:00	170	80	18	16.4	32	32	32	32	32	32	32	32
	12.12.2014 to 13.12.2014	22:00 to 06:00	170	80	15	16.4	28	28	28	28	28	28	28	28
	13.12.2014 to 15.12.2014	06:00 to 14:00	170	80	16	16.4	29	29	29	29	29	29	29	29
POC-4	15.12.2014 to 16.12.2014	14:00 to 22:00	71	40	18	15.9	33	33	33	33	33	33	33	33
	16.12.2014 to 18.12.2014	22:00 to 06:00	71	40	16	15.9	29	29	29	29	29	29	29	29
	18.12.2014 to 19.12.2014	06:00 to 14:00	71	40	13	15.9	26	26	26	26	26	26	26	26
POC-5	19.12.2014 to 22.12.2014	14:00 to 22:00	98	34	15	14.9	25	25	25	25	25	25	25	25
	22.12.2014 to 23.12.2014	22:00 to 06:00	98	34	16	14.9	30	30	30	30	30	30	30	30
	23.12.2014 to 24.12.2014	06:00 to 14:00	98	34	13	14.9	23	23	23	23	23	23	23	23
POC-6	24.12.2014 to 25.12.2014	14:00 to 22:00	114	50	13	14.3	32	32	32	32	32	32	32	32
	25.12.2014 to 29.12.2014	22:00 to 06:00	114	50	13	14.3	28	28	28	28	28	28	28	28
	29.12.2014 to 30.12.2014	06:00 to 14:00	114	50	16	14.3	29	29	29	29	29	29	29	29
POC-7	30.12.2014 to 31.12.2014	14:00 to 22:00	126	70	18	15.4	33	33	33	33	33	33	33	33
	31.12.2014 to 01.01.2015	22:00 to 06:00	126	70	12	15.4	29	29	29	29	29	29	29	29
	01.01.2015 to 02.01.2015	06:00 to 14:00	126	70	16	15.4	26	26	26	26	26	26	26	26
POC-8	02.01.2015 to 03.01.2015	14:00 to 22:00	117	66	16	14.0	32	32	32	32	32	32	32	32
	03.01.2015 to 04.01.2015	22:00 to 06:00	117	66	14	14.0	33	33	33	33	33	33	33	33
	04.01.2015 to 05.01.2015	06:00 to 14:00	117	66	12	14.0	28	28	28	28	28	28	28	28
POC-9	05.01.2015 to 06.01.2015	14:00 to 22:00	108	57	11	13.0	26	26	26	26	26	26	26	26
	06.01.2015 to 07.01.2015	22:00 to 06:00	108	57	15	13.0	29	29	29	29	29	29	29	29
	07.01.2015 to 08.01.2015	06:00 to 14:00	108	57	13	13.0	30	30	30	30	30	30	30	30
Average			138	62		14.4								
Standard Dev			61	20		1.3								

Table 2: Results of Air Pollutant Concentration at POC Station of JNP Area during the month of December 2014										
Sampling Period	Date	Time, [Hrs]	O <sub>3</sub> , [µg/m <sup>3</sup> ]	Pb, [µg/m <sup>3</sup> ]	As, [ng/m <sup>3</sup> ]	Ni, [ng/m <sup>3</sup> ]	C <sub>6</sub> H <sub>6</sub> , [µg/m <sup>3</sup> ]	BaP, [ng/m <sup>3</sup> ]	CO, [mg/m <sup>3</sup> ]	CO <sub>2</sub> , [ppm]
NAAQMS			8 hr	24 hr	24 hr	24 hr	8 hr	24 hr	Grab Sampling	Grab Sampling
			100 µg/m <sup>3</sup>	1.0 µg/m <sup>3</sup>	6 ng/m <sup>3</sup>	20 ng/m <sup>3</sup>	5 µg/m <sup>3</sup>	1 ng/m <sup>3</sup>	4 mg/m <sup>3</sup>	-
POC-1	02.12.2014 to 03.12.2014	14:00 to 22:00								
		22:00 to 06:00	27	<0.01	<1	<1	3	<0.5	3.4	304
POC-2	04.12.2014 to 05.12.2014	06:00 to 14:00								
		14:00 to 22:00	31	<0.01	<1	<1	3.1	<0.5	3.2	301
POC-3	08.12.2014 to 09.12.2014	06:00 to 14:00								
		14:00 to 22:00	27	<0.01	<1	<1	3.5	<0.5	3.1	256
POC-4	11.12.2014 to 12.12.2014	06:00 to 14:00								
		14:00 to 22:00	29	<0.01	<1	<1	3.3	<0.5	2.9	309
POC-5	15.12.2014 to 16.12.2014	06:00 to 14:00								
		14:00 to 22:00	30	<0.01	<1	<1	3.1	<0.5	2.8	314
POC-6	18.12.2014 to 19.12.2014	06:00 to 14:00								
		14:00 to 22:00	26	<0.01	<1	<1	2.8	<0.5	3.8	315
POC-7	22.12.2014 to 23.12.2014	06:00 to 14:00								
		14:00 to 22:00	25	<0.01	<1	<1	3.1	<0.5	3.8	320
POC-8	24.12.2014 to 25.12.2014	06:00 to 14:00								
		14:00 to 22:00	32	<0.01	<1	<1	3.8	<0.5	3.4	318
POC-9	29.12.2014 to 30.12.2014	06:00 to 14:00								
		14:00 to 22:00	39	<0.01	<1	<1	3.6	<0.5	3.7	321
Average			30				3.3		3.3	306
Standard Dev			4				0.3		0.4	20

Table 3: Results of Air Pollutant Concentration at IMC Station of JNP Area during the month of December, 2014

Sampling Period	Date	Time, [Hrs]	PM <sub>10</sub> , [µg/m <sup>3</sup> ] 24 hr 100 µg/m <sup>3</sup>	PM <sub>2.5</sub> , [µg/m <sup>3</sup> ] 24 hr 60 µg/m <sup>3</sup>	SO <sub>2</sub> , [µg/m <sup>3</sup> ] 8 hr -	NO <sub>x</sub> , [µg/m <sup>3</sup> ] 24 hr (Avg) 80 µg/m <sup>3</sup>	NO <sub>x</sub> , [µg/m <sup>3</sup> ] 8 hr -	NH <sub>3</sub> , [µg/m <sup>3</sup> ] 24 hr (Avg) 400 µg/m <sup>3</sup>
NAAQMS	02.12.2014 to 03.12.2014	15:00 to 23:00 23:00 to 07:00 07:00 to 15:00	165	76	13 15 13	14	19 21 20	7 5 5
IMC-1	04.12.2014 to 05.12.2014	15:05 to 23:05 23:05 to 07:05 07:05 to 15:05	140	67	16 15 16	16	18 27 21	4 5 6
IMC-2	08.12.2014 to 09.12.2014	15:10 to 23:10 23:10 to 07:10 07:10 to 15:10	174	89	15 16 15	15	23 31 26	5 5 7
IMC-3	11.12.2014 to 12.12.2014	14:50 to 22:50 22:50 to 06:50 06:50 to 14:50	27	28	15 16 15	15	19 21 20	4 5 5
IMC-4	15.12.2014 to 16.12.2014	15:00 to 23:00 23:00 to 07:00 07:00 to 15:00	201	46	12 15 10	12	18 27 21	6 5 5
IMC-5	18.12.2014 to 19.12.2014	15:00 to 23:00 23:00 to 07:00 07:00 to 15:00	217	36	12 10 11	11.0	24 26 30	5 6 7
IMC-6	22.12.2014 to 23.12.2014	15:00 to 23:00 23:00 to 07:00 07:00 to 15:00	248	76	14 16 13	14.3	31 25 26	5 4 5
IMC-7	24.12.2014 to 25.12.2014	15:00 to 23:00 23:00 to 07:00 07:00 to 15:00	204	46	12 14 13	13.0	25 26 21	6 4 5
IMC-8	29.12.2014 to 30.12.2014	15:00 to 23:00 23:00 to 07:00 07:00 to 15:00	105	54	11 15 13	13.0	22 30 29	6 5 4
Average			165	57		13.8		5.2
Standard Dev			67	21		1.6		0.4

**Table 3: Results of Air Pollutant Concentration at IMC Station of JNP Area during the month of December, 2014**

Sampling Period	Date	Time, [Hrs]	O <sub>3</sub> , [µg/m <sup>3</sup> ] Pb, [µg/m <sup>3</sup> ] As, [ng/m <sup>3</sup> ] Ni, [ng/m <sup>3</sup> ] C <sub>6</sub> H <sub>6</sub> , [µg/m <sup>3</sup> ] BaP, [ng/m <sup>3</sup> ] 24 hr										CO, [mg/m <sup>3</sup> ] Grab Sampling		CO <sub>2</sub> , [ppm] Grab Sampling	
			8 hr	24 hr	24 hr	24 hr	24 hr	24 hr	24 hr	24 hr	24 hr	24 hr	1 ng/m <sup>3</sup>	4 ng/m <sup>3</sup>	4 ng/m <sup>3</sup>	-
<b>NAAQMS</b>			100 µg/m <sup>3</sup>	1.0 µg/m <sup>3</sup>	6 ng/m <sup>3</sup>	20 ng/m <sup>3</sup>	5 µg/m <sup>3</sup>	<1	<1	<1	<1	<1	<0.5	<0.5	<0.5	<0.5
<b>IMC-1</b>	02.12.2014 to 03.12.2014	15:00 to 23:00 07:00 to 15:00	29	<0.01	<1	<1	<1	<1	<1	<1	<1	<1	<0.5	<0.5	3.3	256
<b>IMC-2</b>	04.12.2014 to 05.12.2014	15:05 to 23:05 07:05 to 15:05	32	<0.01	<1	<1	<1	<1	<1	<1	<1	<1	<0.5	<0.5	2.7	3.9
<b>IMC-3</b>	08.12.2014 to 09.12.2014	15:10 to 23:10 07:10 to 15:10	41	<0.01	<1	<1	<1	<1	<1	<1	<1	<1	<0.5	<0.5	2.8	259
<b>IMC-4</b>	11.12.2014 to 12.12.2014	14:50 to 22:50 06:50 to 14:50	35	<0.01	<1	<1	<1	<1	<1	<1	<1	<1	<0.5	<0.5	3.1	278
<b>IMC-5</b>	15.12.2014 to 16.12.2014	15:00 to 23:00 07:00 to 15:00	39	<0.01	<1	<1	<1	<1	<1	<1	<1	<1	<0.5	<0.5	3.2	291
<b>IMC-6</b>	18.12.2014 to 19.12.2014	15:00 to 23:00 07:00 to 15:00	30	<0.01	<1	<1	<1	<1	<1	<1	<1	<1	<0.5	<0.5	3.2	298
<b>IMC-7</b>	22.12.2014 to 23.12.2014	15:00 to 23:00 07:00 to 15:00	29	<0.01	<1	<1	<1	<1	<1	<1	<1	<1	<0.5	<0.5	3.6	301
<b>IMC-8</b>	24.12.2014 to 25.12.2014	15:00 to 23:00 07:00 to 15:00	29	<0.01	<1	<1	<1	<1	<1	<1	<1	<1	<0.5	<0.5	3.4	312
<b>IMC-9</b>	29.12.2014 to 30.12.2014	15:00 to 23:00 07:00 to 15:00	28	<0.01	<1	<1	<1	<1	<1	<1	<1	<1	<0.5	<0.5	3.1	308
<b>Average</b>			32												3.2	256
<b>Standard Dev</b>			5												0.3	97

Table 4: Results of Air Pollutant Concentration at RC Station of JNP Area during the month of December, 2014

Table 4: Results of Air Pollutant Concentration at RC Station of JNP Area during the month of December, 2014												
Sampling Period NAAQMS	Date	Time, [Hrs]	PM <sub>10</sub> , [µg/m <sup>3</sup> ]		PM <sub>2.5</sub> , [µg/m <sup>3</sup> ]		SO <sub>2</sub> , [µg/m <sup>3</sup> ]		NO <sub>x</sub> , [µg/m <sup>3</sup> ]		NH <sub>3</sub> , [µg/m <sup>3</sup> ]	
			24 hr 100 µg/m <sup>3</sup>	24 hr 60 µg/m <sup>3</sup>	24 hr 60 µg/m <sup>3</sup>	8 hr	24 hr (Avg) 80 µg/m <sup>3</sup>	8 hr	24 hr (Avg) 80 µg/m <sup>3</sup>	8 hr	24 hr (Avg) 80 µg/m <sup>3</sup>	8 hr
RC-1	02.12.2014 to 03.12.2014	15:20 to 23:20				15		24		6		
		23:20 to 07:20	70	42		15	14	31	25.7	6	5.5	
		07:20 to 15:20				13		22		4		
RC-2	04.12.2014 to 05.12.2014	15:30 to 23:30	43	26		16		28		6		
		23:30 to 07:30				13	15	29	26.2	6	6.0	
		07:30 to 15:30				15		22		6		
RC-3	08.12.2014 to 09.12.2014	15:35 to 23:35				13		21		5		
		23:35 to 07:35	171	82		18	15	30	25.4	5	5.0	
		07:35 to 15:35				15		25		5		
RC-4	11.12.2014 to 12.12.2014	15:30 to 23:30				15		24		5		
		23:30 to 07:30	143	63		16	15	31	25.7	5	4.8	
		07:30 to 15:30				15		22		5		
RC-5	15.12.2014 to 16.12.2014	15:30 to 23:30				15		28		5		
		23:30 to 07:30	120	49		16	15	29	26.2	5	5.6	
		07:30 to 15:30				15		22		6		
RC-6	18.12.2014 to 19.12.2014	15:30 to 23:30				13		18		4		
		23:30 to 07:30	135	75		16	14	21	21.1	6	4.4	
		07:30 to 15:30				12		24		5		
RC-7	22.12.2014 to 23.12.2014	15:30 to 23:30				16		20		5		
		23:30 to 07:30	139	110		18	15	21	20.0	5	5.2	
		07:30 to 15:30				12		19		6		
RC-8	24.12.2014 to 25.12.2014	15:30 to 23:30				13		22		5		
		23:30 to 07:30	140	88		15	13	18	19.8	5	5.1	
		07:30 to 15:30				12		19		5		
RC-9	29.12.2014 to 30.12.2014	15:30 to 23:30				11		22		8		
		23:30 to 07:30	180	78		12	12	21	22.3	6	6.4	
		07:30 to 15:30				13		24		5		
Average			127	68			14.4		23.6		5.3	
Standard Dev			44	26			1.2		2.8		0.6	

Table 4: Results of Air Pollutant Concentration at RC Station of JNP Area during the month of December 2014

Sampling Period	Date	Time, [Hrs]	O <sub>3</sub> , [ $\mu\text{g}/\text{m}^3$ ]		Pb, [ $\mu\text{g}/\text{m}^3$ ]		As, [ $\mu\text{g}/\text{m}^3$ ]		Ni, [ $\mu\text{g}/\text{m}^3$ ]		C <sub>6</sub> H <sub>6</sub> , [ $\mu\text{g}/\text{m}^3$ ]		BaP, [ $\mu\text{g}/\text{m}^3$ ]		CO, [ $\text{mg}/\text{m}^3$ ]		CO <sub>2</sub> , [ppm]	
			8 hr	24 hr	8 hr	24 hr	6 ng/m <sup>3</sup>	24 hr	20 ng/m <sup>3</sup>	24 hr	5 $\mu\text{g}/\text{m}^3$	1 ng/m <sup>3</sup>	1 ng/m <sup>3</sup>	24 hr	Grab Sampling 4 ng/m <sup>3</sup>	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS			100 $\mu\text{g}/\text{m}^3$	1.0 $\mu\text{g}/\text{m}^3$														
RC-1	02.12.2014 to 03.12.2014	15:20 to 23:20																
		23:20 to 07:20	25	<0.01	<1	<1	<1	<1	<1	<1	1.7	<0.5	<0.5	<0.5	2.6	303		
RC-2	04.12.2014 to 05.12.2014	07:20 to 15:20																
		15:30 to 23:30	32	<0.01	<1	<1	<1	<1	<1	<1	1.8	<0.5	<0.5	<0.5	2.8	309		
RC-3	08.12.2014 to 09.12.2014	15:35 to 23:35																
		23:35 to 07:35	22	<0.01	<1	<1	<1	<1	<1	<1	2.3	<0.5	<0.5	<0.5	2.4	256		
RC-4	11.12.2014 to 12.12.2014	15:30 to 23:30																
		23:30 to 07:30	31	<0.01	<1	<1	<1	<1	<1	<1	1.6	<0.5	<0.5	<0.5	2.9	297		
RC-5	15.12.2014 to 16.12.2014	15:30 to 23:30																
		23:30 to 07:30	43	<0.01	<1	<1	<1	<1	<1	<1	1.9	<0.5	<0.5	<0.5	2.5	301		
RC-6	18.12.2014 to 19.12.2014	15:30 to 23:30																
		23:30 to 07:30	43	<0.01	<1	<1	<1	<1	<1	<1	2.1	<0.5	<0.5	<0.5	2.7	308		
RC-7	22.12.2014 to 23.12.2014	15:30 to 23:30																
		23:30 to 07:30	33	<0.01	<1	<1	<1	<1	<1	<1	2.1	<0.5	<0.5	<0.5	2.5	305		
RC-8	24.12.2014 to 25.12.2014	15:30 to 23:30																
		23:30 to 07:30	29	<0.01	<1	<1	<1	<1	<1	<1	1.8	<0.5	<0.5	<0.5	2.5	308		
RC-9	29.12.2014 to 30.12.2014	15:30 to 23:30																
		23:30 to 07:30	30	<0.01	<1	<1	<1	<1	<1	<1	1.7	<0.5	<0.5	<0.5	2.6	310		
Average Standard Dev			32								1.9				2.6	300		
			7								0.2				0.2	17		

Table 5: Results of Air Pollutant Concentration at EC Station										
Sampling Period	Date	Time, [Hrs]	PM <sub>10</sub> , [µg/m <sup>3</sup> ]	PM <sub>2.5</sub> , [µg/m <sup>3</sup> ]	SO <sub>2</sub> , [µg/m <sup>3</sup> ]	NO <sub>x</sub> , [µg/m <sup>3</sup> ]	NH <sub>3</sub> , [µg/m <sup>3</sup> ]			
NAAQMS	04.12.2014 to 05.12.2014	24 hr	24 hr	24 hr	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)	8 hr	24 hr (Avg)
		100 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>	-	80 µg/m <sup>3</sup>	-	80 µg/m <sup>3</sup>	-	400 µg/m <sup>3</sup>	
		14:00 to 22:00	130	82	15	21	5			
		22:00 to 06:00			16	24	5			
EC		06:00 to 14:00			12	19	5			

**Table 5: Results of Air Pollutant Concentration at EC Station**

Sampling Period	Date	Time, [Hrs]	O <sub>3</sub> , [µg/m <sup>3</sup> ]	Pb, [µg/m <sup>3</sup> ]	As, [ng/m <sup>3</sup> ]	Ni, [ng/m <sup>3</sup> ]	C <sub>6</sub> H <sub>6</sub> , [µg/m <sup>3</sup> ]	BaP, [ng/m <sup>3</sup> ]	CO, [mg/m <sup>3</sup> ]	CO <sub>2</sub> , [ppm]
NAAQMS	04.12.2014 to 05.12.2014	8 hr	100 µg/m <sup>3</sup>	1.0 µg/m <sup>3</sup>	6 ng/m <sup>3</sup>	20 ng/m <sup>3</sup>	5 µg/m <sup>3</sup>	1 ng/m <sup>3</sup>	4 mg/m <sup>3</sup>	312
		14:00 to 22:00	34	<0.01	<1	<1	<0.5	<0.5	2.5	
		22:00 to 06:00								
EC		06:00 to 14:00								

**Table 6: Results of Air Pollutant Concentration at NGC Station of JNP Area during the month of December, 2014**

Sampling Period	Date	Time, [Hrs]	PM <sub>10</sub> , [µg/m <sup>3</sup> ]	PM <sub>2.5</sub> , [µg/m <sup>3</sup> ]	SO <sub>2</sub> , [µg/m <sup>3</sup> ]	NO <sub>x</sub> , [µg/m <sup>3</sup> ]	NH <sub>3</sub> , [µg/m <sup>3</sup> ]
NAAQMS			100 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>	24 hr	8 hr	24 hr (Avg)
NG-1	04.12.2014 to 05.12.2014	16:00 to 00:00	95	38	16	27	5
		00:00 to 08:00			15	22	7
		08:00 to 16:00			12	20	7
NG-2	11.12.2014 to 12.12.2014	15:50 to 23:50	78	42	15	25	5
		23:50 to 07:50			13	27	7
		07:50 to 15:50			12	31	6
NG-3	18.12.2014 to 19.12.2014	15:40 to 23:40	139	78	12	23	5
		23:40 to 07:40			13	22	7
		07:40 to 15:40			12	20	7
NG-4	24.12.2014 to 25.12.2014	15:40 to 23:40	137	96	15	29	5
		23:40 to 07:40			13	13	7
		07:40 to 15:40			15	25	6
Average			112	64		13.6	23.6
Standard Dev			30	28		0.9	2.8

**Table 6: Results of Air Pollutant Concentration at NGC Station of JNP Area during the month of December, 2014**

Sampling Period	Date	Time, [Hrs]	O <sub>3</sub> , [µg/m <sup>3</sup> ]	Pb, [µg/m <sup>3</sup> ]	As, [ng/m <sup>3</sup> ]	Ni, [ng/m <sup>3</sup> ]	C <sub>6</sub> H <sub>6</sub> , [µg/m <sup>3</sup> ]	BaP, [ng/m <sup>3</sup> ]	CO, [mg/m <sup>3</sup> ]	CO <sub>2</sub> , [ppm]
NAAQMS			8 hr	24 hr	24 hr	24 hr	8 hr	24 hr	Grab Sampling	Grab Sampling
NG-1	04.12.2014 to 05.12.2014	16:00 to 00:00	33	<0.01	<1	<1	3.1	<0.5	3.8	312
		00:00 to 08:00								
		08:00 to 16:00								
NG-2	11.12.2014 to 12.12.2014	15:50 to 23:50	25	<0.01	<1	<1	3.2	<0.5	3.6	318
		23:50 to 07:50								
		07:50 to 15:50								
NG-3	18.12.2014 to 19.12.2014	15:40 to 23:40	25	<0.01	<1	<1	3.2	<0.5	3.2	320
		23:40 to 07:40								
		07:40 to 15:40								
NG-4	24.12.2014 to 25.12.2014	15:40 to 23:40	23	<0.01	<1	<1	2.8	<0.5	3.4	318
		23:40 to 07:40								
		07:40 to 15:40								
Average			27				3.1		3.5	317
Standard Dev			4				0.2		0.3	3

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

Sampling Period	Date	Time, [Hrs]	PM <sub>10</sub> , [µg/m³]	PM <sub>2.5</sub> , [µg/m³]	SO <sub>2</sub> , [µg/m³]	NO <sub>x</sub> , [µg/m³]	NH <sub>3</sub> , [µg/m³]
NAAQMS			24 hr	24 hr	8 hr	24 hr (Avg)	8 hr
			100 µg/m³	60 µg/m³	80 µg/m³	80 µg/m³	400 µg/m³
SG-1	02.12.2014 to 03.12.2014	16:30 to 00:30	132	75	13	21	4
		00:30 to 08:30			15	27	5
		08:30 to 16:30			18	29	5
SG-2	08.12.2014 to 09.12.2014	16:15 to 00:15	149	80	16	27	4
		00:15 to 08:15			18	21	6
		08:15 to 16:15			10	19	5
SG-3	15.12.2014 to 16.12.2014	16:15 to 00:15	146	76	15	24	4
		00:15 to 08:15			16	30	5
		08:15 to 16:15			13	21	4
SG-4	22.12.2014 to 23.12.2014	16:15 to 00:15	161	88	12	24	6
		00:15 to 08:15			11	30	7
		08:15 to 16:15			10	25	5
SG-5	29.12.2014 to 30.12.2014	16:15 to 00:15	110	49	11	24	5
		00:15 to 08:15			12	30	6
		08:15 to 16:15			11	28	6
Average			140	74	13.5	25.4	5.2
Standard Dev			19	15	2.1	1.8	0.7

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

Sampling Period	Date	Time, [Hrs]	O <sub>3</sub> , [µg/m³]	Pb, [µg/m³]	As, [ng/m³]	Ni, [ng/m³]	C <sub>6</sub> H <sub>6</sub> , [µg/m³]	BaP, [ng/m³]	CO, [mg/m³]	CO <sub>2</sub> , [ppm]
NAAQMS			8 hr	24 hr	24 hr	24 hr	24 hr	24 hr	Grab Sampling	Grab Sampling
			100 µg/m³	1.0 µg/m³	6 ng/m³	20 ng/m³	5 µg/m³	1 ng/m³	4 mg/m³	-
SG-1	03.11.2014 to 04.11.2014	16:30 to 00:30								
		00:30 to 08:30	31	<0.01	<1	<1	<1	<0.5	3.3	315
		08:30 to 16:30								
SG-2	11.11.2014 to 12.11.2014	16:15 to 00:15	40	<0.01	<1	<1	<1	<0.5	3.1	309
		00:15 to 08:15								
		08:15 to 16:15								
SG-3	17.11.2014 to 18.11.2014	16:15 to 00:15	32	<0.01	<1	<1	<1	<0.5	3.3	315
		00:15 to 08:15								
		08:15 to 16:15								
SG-4	22.12.2014 to 23.12.2014	16:15 to 00:15	36	<0.01	<1	<1	<1	<0.5	3.1	302
		00:15 to 08:15								
		08:15 to 16:15								
SG-5	29.12.2014 to 30.12.2014	16:15 to 00:15	32	<0.01	<1	<1	<1	<0.5	3.5	315
		00:15 to 08:15								
		08:15 to 16:15								
Average			34						3.3	311
Standard Dev			4						0.2	6

## 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 December, 2014. The values obtained are compared with respective CPCB standards described for Industrial, Residential, Rural and ecologically sensitive areas. The values obtained for Pb, As, Ni and Benzo( $\alpha$ )Pyrene [BaP] are below detection limits of measurements at all air monitoring stations for the month December, 2014 and hence these parameters are not included in **Table 8**.

**Table 8:** Monthly Average Values of Air Pollutant Concentration at Various Stations of JNP Area during the month of December, 2014

STATION	PM <sub>10</sub> , [ $\mu\text{g}/\text{m}^3$ ]	PM <sub>2.5</sub> , [ $\mu\text{g}/\text{m}^3$ ]	SO <sub>2</sub> , [ $\mu\text{g}/\text{m}^3$ ]	NO <sub>x</sub> , [ $\mu\text{g}/\text{m}^3$ ]	NH <sub>3</sub> , [ $\mu\text{g}/\text{m}^3$ ]	O <sub>3</sub> , [ $\mu\text{g}/\text{m}^3$ ]	C <sub>6</sub> H <sub>6</sub> , [ $\mu\text{g}/\text{m}^3$ ]	CO, [mg/m <sup>3</sup> ]	CO <sub>2</sub> , [ppm]
NAAQMS	100	60	80	80	400	100	5	4	-
<b>INDUSTRIAL AREA</b>									
POC	138 $\pm$ 61	62 $\pm$ 20	14.4 $\pm$ 1.3	27.3 $\pm$ 3.6	5.7 $\pm$ 0.5	30 $\pm$ 04	3.3 $\pm$ 0.3	3.3 $\pm$ 0.4	306 $\pm$ 20
IMC	165 $\pm$ 67	57 $\pm$ 21	13.8 $\pm$ 1.6	24.0 $\pm$ 3.1	5.2 $\pm$ 0.4	32 $\pm$ 05	3.1 $\pm$ 0.2	3.2 $\pm$ 0.3	256 $\pm$ 97
NG	112 $\pm$ 30	64 $\pm$ 28	13.6 $\pm$ 0.9	23.6 $\pm$ 2.8	6.2 $\pm$ 0.2	27 $\pm$ 04	3.1 $\pm$ 0.2	3.5 $\pm$ 0.3	317 $\pm$ 03
SG	140 $\pm$ 19	74 $\pm$ 15	13.5 $\pm$ 2.1	25.4 $\pm$ 1.8	5.2 $\pm$ 0.7	34 $\pm$ 04	2.8 $\pm$ 0.6	3.3 $\pm$ 0.2	311 $\pm$ 06
<b>RESIDENTIAL AREA</b>									
RC	127 $\pm$ 44	68 $\pm$ 26	14.4 $\pm$ 1.2	23.6 $\pm$ 2.8	5.3 $\pm$ 0.6	32 $\pm$ 07	1.9 $\pm$ 0.2	2.6 $\pm$ 0.2	300 $\pm$ 17
<b>ECO-SENSITIVE AREA</b>									
EC	130	82	14.4	21.4	4.9	34	< 0.5	2.5	312

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 December, 2014 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. Hence more particulate pollutants are found along ground level. Highest level of PM<sub>10</sub> was recorded at IMC i.e. major industrial activity area handling liquid chemical and also most congested road. RC i.e. location representing Residential area have particulate concentrations slightly above national standards i.e. PM<sub>10</sub> and PM<sub>2.5</sub>.



Comparing with earlier month, December 2014 levels of PM<sub>10</sub> dropped significantly by 31% to 75%, whereas overall PM<sub>2.5</sub> levels recorded slight decrease at IMC and RC. Eco-sensitive zone i.e. Elephanta island recorded  $\frac{3}{4}$  fold rise in particulate matter levels. This increase is mainly because of seasonal weather phenomenon, along with contribution from biomass or litter burning to fight with cold and warming bathing water.

Results for the air quality parameters at Elephanta Caves [EC] station during 04<sup>th</sup> December'14 to 05<sup>th</sup> December'14 were tabulated in **Table 5**. The concentrations of gaseous pollutants were recorded below the limits prescribed in NAAQMS 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 December, 2014, 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<sub>x</sub> emission and 5% of world's SO<sub>x</sub> 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 December'14:***

- ✓ *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
- ✓ *Centralized parking facility:* is being developed along the road connecting north gate and CFS yard. Land preparation and vehicular movement during this account for elevated levels of particulate pollutants.
- ✓ *Construction of 330 m Jetty at the creek mouth:* Even though it is evident that construction of jetty does not affect the Ambient Air Quality. The values of pollutants parameters at the

nearest monitoring location i.e. North Gate cross prescribed limits.

- ✓ Paver blocks are provided and necessary green cover is provided all over the port area to prevent the re-suspension of road dust.



Development of Centralized Parking



Water sprinkling to avoid re-suspension



Vehicular traffic at Port entry gate



Community lit fire at Elephanta Island

The following measures can be taken to maintain controlled PM<sub>10</sub> and PM<sub>2.5</sub> levels in and around the port area:

- ✓ Renovation work at Township and other sites should be executed under controlled conditions; debris and earth filling material transportation must be in tarpaulin closed vehicles.
- ✓ Continue spraying of water on dusty surfaces on regular intervals. Frequency should be more around noon at impact locations at all construction, land preparation areas to avoid re-suspension.
- ✓ 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 during transportation.

### Conclusion:

From the results obtained for the month of November, 2014 it can be concluded that overall Ambient Air quality of the JN Port is within CPCB limits, except PM<sub>10</sub> where it is above the prescribed CPCB limits.

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

### 2.1 INTRODUCTION

Marine water monitoring stations are selected in the harbor area including channel and near jetty areas and Nhava creek. As per EMP, Total 8 fixed harbor stations [W1 to W7 and W9] and 1 movable station [W8] are identified. At Nhava creek 4 fixed stations [W11 to W14] are identified. All above mentioned stations are also selected for studying sediment characteristics. The description of stations is depicted in Table 9. The location map of various Marine water quality monitoring stations are described in Annexure-III.

### 2.2 MARINE WATER QUALITY MONITORING METHODOLOGY

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

**Harbor Water Quality Monitoring** – Three samples from the surface, mid depth and bottom are collected and composite from each harbor water quality monitoring station during spring and neap tidal cycle. The samples are after 1<sup>st</sup>, 3<sup>rd</sup> and 5<sup>th</sup> 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 3<sup>rd</sup> 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 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.	04 <sup>th</sup> December, 2014
2.	W2	Denoted by buoy no. <u>FG2 RED</u> of JNPT channel. It is near the Elephanta Island, and opposite to Port Craft Jetty	04 <sup>th</sup> December, 2014
3.	W3	Identified by the green buoy no. <u>FG2 Green</u> of JNPT approach channel and lies near the landing jetty.	05 <sup>th</sup> December, 2014
4.	W4	Located at Uran Patch Beacon (lighthouse on concrete platform) near the Butcher Island filling platform.	05 <sup>th</sup> December, 2014
5.	W5	W5 is near to the guide bund and others are along Nhava creek upto Belpada. These are selected to examine the impact of neighboring Nhava Villages and Belpada to the creek water quality	04 <sup>th</sup> December, 2014
	W11 to W14		06 <sup>th</sup> December, 2014
6.	W6	This is a mobile station and hence its location is changed during every visit. This sampling station was selected in order to examine the variation of water quality in the area not represented by the fixed stations.	04 <sup>th</sup> December, 2014
7.	W7	This station is located near landing jetty. This station was selected in order to examine the water quality due to liquid cargo jetty.	05 <sup>th</sup> December, 2014
8.	W9	Located in between GTI and Liquid Cargo Jetty. This station is selected to examine the impact of terminal activities on water qualities	05 <sup>th</sup> December, 2014
9.	W8	Located near proposed chemical berth. These stations are variable and selected to examine the impact of proposed chemical terminal and IV <sup>th</sup> Container terminal activities on water quality.	05 <sup>th</sup> December, 2014

**Table 10: List of Parameters to Monitor Marine Water Quality**

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

## 2.3 RESULTS

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

**Table 11:** Results of Physico-Chemical Analysis of Water Samples Collected from JNP Harbor Area during December, 2014

Sample Name		Depth, [m]	Temp., [°C]	pH	Salinity, [ppth]	Turbidity, [NTU]	TDS, [mg/L]	TSS, [mg/L]	TS, [mg/L]
Standard		-	-	6.5 - 9.0	-	-	-	-	-
W1	SS	9.7	26.9	7.27	40.3	4	28476	44	28520
	SM		26.5	7.39	33.7	4	26210	35	26245
	SB		26.3	7.30	34.9	4	27214	42	27256
	NS	8.8	29.6	7.58	34.9	4	28218	34	28252
	NM		28.0	7.44	33.7	5	28004	40	28044
	NB		27.9	7.41	34.3	6	28148	60	28208
W2	SS	8.7	25.1	7.42	34.3	4	29204	41	29245
	SM		23.5	7.47	34.9	4	28578	42	28620
	SB		21.9	7.56	36.1	5	29108	47	29155
	NS	8.3	29.4	7.76	34.9	3	27794	38	27832
	NM		28.2	7.51	35.5	6	28212	44	28256
	NB		29.7	7.47	33.7	17	27974	199	28173
W3	SS	9.0	26.1	7.50	33.7	10	26316	65	26381
	SM		26.9	7.48	34.9	8	26728	52	26780
	SB		24.8	7.54	34.3	10	27008	55	27063
	NS	8.5	31.7	7.50	36.1	7	26942	56	26998
	NM		30.8	7.54	34.9	9	26446	47	26493
	NB		29.9	7.55	35.5	10	27100	67	27167
W4	SS	12.4	26.0	7.54	34.3	6	26996	51	27047
	SM		25.0	7.61	33.7	8	24974	53	25027
	SB		23.8	7.51	35.5	11	27008	70	27078
	NS	11.8	26.9	7.56	34.9	9	26992	53	27045
	NM		27.5	7.49	34.3	8	27214	52	27266
	NB		27.1	7.41	38.5	7	26048	66	26114
W5	SS	14.2	27.2	7.27	35.5	12	28218	58	28276
	SM		26.5	7.44	36.7	12	26042	47	26089
	SB		26.2	7.71	34.9	15	27748	50	27798
	NS	12.7	28.0	7.35	34.3	11	28916	42	28958
	NM		27.7	7.45	36.1	13	26612	42	26654
	NB		27.3	7.46	35.5	13	26978	39	27017

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

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

Sample Name		Depth, [m]	Temp., [°C]	pH	Salinity, [ppt]	Turbidity, [NTU]	TDS, [mg/L]	TSS, [mg/L]	TS, [mg/L]
Standard		-	-	6.5 - 9.0	-	-	-	-	-
W6	SS	14.1	27.7	7.56	33.1	12	27416	36	27452
	SM		27.8	7.43	33.7	13	26878	54	26932
	SB		27.8	7.41	34.9	14	27102	67	27169
	NS	12.7	30.6	7.43	34.3	12	26884	32	26916
	NM		30.5	7.44	35.5	11	27218	44	27262
	NB		29.3	7.43	33.1	13	28046	55	28101
W7	SS	9.2	28.1	7.38	36.1	12	26784	72	26856
	SM		28.0	7.52	35.5	15	27416	68	27484
	SB		27.0	7.45	34.3	13	26148	67	26215
	NS	8.9	30.0	7.57	32.5	16	26244	56	26300
	NM		28.8	7.47	34.9	15	25996	49	26045
	NB		30.1	7.48	33.7	22	24918	71	24989
W8	SS	10.7	28.2	7.45	35.5	13	29212	82	29294
	SM		28.3	7.47	33.7	13	28786	64	28850
	SB		28.2	7.41	34.3	21	28594	80	28674
	NS	10	29.1	7.34	36.7	13	27216	66	27282
	NM		28.2	7.65	34.9	16	26884	64	26948
	NB		28.1	7.61	34.9	19	25418	65	25483
W9	SS	16	27.6	7.31	32.5	5	28214	36	28250
	SM		26.3	7.51	34.3	4	28146	51	28197
	SB		26.3	7.43	34.9	8	27146	61	27207
	NS	14.6	29.6	7.45	34.9	6	28248	40	28288
	NM		30.5	7.44	39.7	5	27976	62	28038
	NB		29.9	7.49	33.7	9	27998	66	28064

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

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

**Table 12: Results of Bio-Chemical Analysis of Water Samples Collected from JNP Harbor Area during December, 2014**

Sample Name	DO, [mg/L]	COD, [mg/L]	BOD, [mg/L]	NH <sub>4</sub> <sup>+</sup> -N, [mg/L]	Phenol, [mg/L]	O&G, [mg/L]	TPC, [CFU/mL]	Fecal Coliforms [MPN/100 mL]
<b>Standard</b>	3.0 mg/L or 40% of saturation value	-	5	-	-	10	-	500
W1	SS#	-	-	-	-	<1	<30	9
	SS	4.9	39.5	<2	<0.1	<0.01		
	SM	4.0	43.5		-			
	SB	4.1	31.6	-	-	-		
	NS#	-	-	-	-	<1	<30	4
	NS	5.4	43.5	<2	<0.1	<0.01		
	NM	4.3	27.7	-	-	-		
	NB	4.4	39.5	-	-	-		
W2	SS#					1	82	7
	SS	4.5	31.6		<0.1	<0.01		
	SM	4.4	43.5					
	SB	4.0	27.7					
	NS#					1	76	2
	NS	4.8	47.4		<0.1	<0.01		
	NM	4.5	35.6					
	NB	4.3	39.5					
W3	SS#	-	-	-	-	2	178	<2
	SS	4.4	39.5	<2	<0.1	<0.01		
	SM	4.4	31.6	-	-	-		
	SB	4.2	35.6	-	-	-		
	NS#	-	-	-	-	<1	97	4
	NS	4.5	23.7	<2	<0.1	<0.01		
	NM	4.4	43.5	-	-	-		
	NB	4.2	27.7	-	-	-		
W4	SS#	-	-	-	-	<1	120	9
	SS	5.2	35.6	<2	<0.1	<0.01		
	SM	4.5	23.7	-	-	-		
	SB	4.4	43.5	-	-	-		
	NS#		-	-	-	<1	95	6
	NS	4.4	27.7	<2	<0.1	<0.01		
	NM	5.3	35.6	-	-	-		
	NB	4.5	31.6	-	-	-		
W5	SS#	-	-	-	-	<1	<30	2
	SS	4.4	40	<2	<0.1	<0.01		
	SM	6.3	44	-	-	-		
	SB	5.1	32	-	-	-		
	NS#	-	-	-	-	<1	<30	4
	NS	4.8	36	<2	<0.1	<0.01		
	NM	6.4	48	-	-	-		
	NB	5.1	24	-	-	-		

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 <sub>4</sub> <sup>+</sup> -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 <sup>#</sup>		-	-	-	-	1	40	<2
	SS	4.9	52	<2	<0.1	<0.01	-	-	-
	SM	4.9	36	-	-	-	-	-	-
	SB	3.9	40	-	-	-	-	-	-
	NS <sup>#</sup>		-	-	-	-	<1	38	<2
	NS	4.1	48	<2	<0.1	<0.01	-	-	-
	NM	4.3	32	-	-	-	-	-	-
W7	NB	3.9	56	-	-	-	-	-	-
	SS <sup>#</sup>		-	-	-	-	2	197	9
	SS	4.2	40	<2	<0.1	<0.01	-	-	-
	SM	4.3	36	-	-	-	-	-	-
	SB	4.5	32	-	-	-	-	-	-
	NS <sup>#</sup>		-	-	-	-	1	152	2
	NS	4.6	48	<2	<0.1	<0.01	-	-	-
W8	NM	4.8	40	-	-	-	-	-	-
	NB	5.3	44	-	-	-	-	-	-
	SS <sup>#</sup>		-	-	-	-	2	110	2
	SS	4.3	32	<2	<0.1	<0.01	-	-	-
	SM	4.3	48	-	-	-	-	-	-
	SB	4.1	40	-	-	-	-	-	-
	NS <sup>#</sup>		-	-	-	-	<1	84	4
W9	NS	4.5	44	<2	<0.1	<0.01	-	-	-
	NM	4.3	36	-	-	-	-	-	-
	NB	5.1	32	-	-	-	-	-	-
	SS <sup>#</sup>			-	-	-	1	112	4
	SS	4.5	40.8	<2	<0.1	<0.01	-	-	-
	SM	4.4	32.6	-	-	-	-	-	-
	SB	4.3	36.7	-	-	-	-	-	-
	NS <sup>#</sup>		-	-	-	-	1	98	<2
	NS	4.5	44.9	<2	<0.1	<0.01	-	-	-
	NM	4.3	28.6	-	-	-	-	-	-
	NB	4.4	48.9	-	-	-	-	-	-

SS<sup>#</sup> - SPRING SAMPLE  
SS - SPRING SURFACE  
SM - SPRING MIDDLE  
SB - SPRING BOTTOM

NS<sup>#</sup> - NEAP SAMPLE  
NS - NEAP SURFACE  
NM - NEAP MIDDLE  
NB - NEAP BOTTOM

**Table 13: Results of Sediment Samples Collected from JNP Harbor Area during December, 2014**

Station Name	Organic Matter		Total Carbon		Inorganic Phosphate mg/kg
	mg/g	%	mg/g	%	
W1	145.8	14.58	84.6	8.5	103
W2	118.4	11.84	68.7	6.9	97
W3	152.5	15.25	88.4	8.8	94
W4	158.1	15.81	91.7	9.2	110
W5	Sample not found				
W6	176.7	17.67	102.5	10.3	100
W7	168.0	16.80	97.4	9.7	91
W9	Sample not collected				
W8					
Average	153.3	15.3	88.9	8.9	99.0

**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	6.9	25.6	7.53	35.5	28	27218	110	27328
	SM		25.5	7.64	34.9	51	26544	277	26821
	SB		25.6	7.61	35.5	49	25216	219	25435
	NS	6.4	30.0	7.60	33.7	25	26218	137	26355
	NM		29.9	7.64	34.3	48	24994	183	25177
	NB		29.5	7.67	34.9	48	24546	316	24862
W12	SS	6.0	27.5	7.58	35.5	23	26218	106	26324
	SM		27.4	7.62	40.3	45	26148	170	26318
	SB		27.7	7.58	36.7	50	26544	202	26746
	NS	5.5	29.9	7.63	34.9	30	27008	143	27151
	NM		29.7	7.60	34.3	48	27944	202	28146
	NB		29.3	7.67	34.9	49	26248	299	26547
W13	SS	7.0	26.3	7.59	33.7	26	27214	246	27460
	SM		26.4	7.68	33.1	56	28442	316	28758
	SB		26.0	7.55	36.7	35	28214	235	28449
	NS	6.4	29.7	7.62	34.3	22	26912	246	27158
	NM		29.1	7.51	34.3	41	26888	209	27097
	NB		28.9	7.63	35.5	33	27336	168	27504
W14	SS	6.8	26.8	7.57	34.3	23	27416	253	27669
	SM		26.8	7.64	34.9	23	27558	286	27844
	SB		26.8	7.57	35.5	34	26936	269	27205
	NS	6.2	29.8	7.62	32.5	25	27448	244	27692
	NM		29.6	7.58	33.7	35	27734	176	27910
	NB		27.8	7.60	36.1	25	26334	288	26622

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 <sub>4</sub> <sup>+</sup> -N, [mg/L]	Phenol, [mg/L]	O&G, [mg/L]	TPC, [CFU/mL]	Fecal Coliforms, [MPN/100 mL]
<b>Standard</b>	3.0 mg/L or 40% of saturation value	-	5	-	-	10	-	500
W11	SS	4.5	32.6	<2	<0.1	<0.01	1	158
	SM	4.5	36.7	-	-	-	-	-
	SB	4.6	40.8	-	-	-	-	-
	NS	4.5	28.6	<2	<0.1	<0.01	<1	121
	NM	4.4	48.9	-	-	-	-	-
	NB	4.6	44.9	-	-	-	-	-
W12	SS	5.0	40.8	<2	0.1	<0.01	2	67
	SM	5.1	36.7	-	-	-	-	-
	SB	5.0	32.6	-	-	-	-	-
	NS	4.4	44.9	<2	<0.1	<0.01	1	<30
	NM	4.6	28.6	-	-	-	-	-
	NB	4.6	36.7	-	-	-	-	-
W13	SS	4.4	32.6	<2	0.1	<0.01	2	52
	SM	3.8	36.7	-	-	-	-	-
	SB	4.6	28.6	-	-	-	-	-
	NS	4.5	40.8	<2	0.1	<0.01	2	72
	NM	4.4	44.9	-	-	-	-	-
	NB	4.6	24.5	-	-	-	-	-
W14	SS	4.5	32.6	<2	<0.1	<0.01	1	202
	SM	4.4	40.8	-	-	-	-	-
	SB	4.3	28.6	-	-	-	-	-
	NS	4.6	44.9	<2	<0.1	<0.01	2	142
	NM	4.5	48.9	-	-	-	-	-
	NB	4.3	36.7	-	-	-	-	-

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 December, 2014

Sample Name	Organic Matter		Total Carbon		Inorganic Phosphate
	mg/g	%	mg/g	%	
W11	151.3	15.13	87.8	8.8	88
W12	164.3	16.43	95.3	9.5	85
W13	133.0	13.30	77.1	7.7	82
W14	129.9	12.99	75.3	7.5	90
Average	144.6	14.5	83.9	8.4	86

## 2.4 DISCUSSION

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

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

Sr. No.	Parameter	Observed Range	Unit	Prescribed Limits
1	Temperature	21.9 - 31.7	°C	-
2	pH	7.3 - 7.8	-	6.5 - 9.0
3	Salinity	32.5 - 40.3	ppth	-
4	Turbidity	3 - 22	NTU	-
5	TDS	24918 - 29212	mg/L	-
6	TSS	32 - 199	mg/L	-
7	TS	24989 - 29294	mg/L	-
8	DO	3.9 - 6.4	mg/L	3.0 mg/L or 40% of saturation value
9	COD	23.7 - 56.0	mg/L	-
10	BOD	< 2.0	mg/L	5
11	NH <sub>4</sub> <sup>+</sup> -N	< 1.0	mg/L	-
12	Phenol	< 0.01	mg/L	-
13	Oil & Grease	1 - 2	mg/L	10
14	Total Plate Count	38 - 197	MPN/100 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	25.5 - 30.0	°C	-
2	pH	7.5 - 7.7	-	6.5 - 9.0
3	Salinity	32.5 - 40.3	Ppth	-
4	Turbidity	22 - 56	NTU	-
5	TDS	24546 - 28442	mg/L	-
6	TSS	106 - 316	mg/L	-
7	TS	24862 - 28758	mg/L	-
8	DO	3.8 - 5.1	mg/L	3.0 mg/L or 40% of saturation value
9	COD	24.5 - 48.9	mg/L	-
10	BOD	< 2.0	mg/L	5
11	NH <sub>4</sub> <sup>+</sup> -N	< 1.0	mg/L	-
12	Phenol	< 0.01	mg/L	-
13	Oil & Grease	< 1.0	mg/L	10
14	Total Plate Count	52 - 202	MPN/100 mL	-
15	Fecal Coliforms	4 - 33	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 December, 2014 are found to be well within the prescribed limits.

Also, the concentration ranges observed for various parameters for water samples collected from Nhava Creek area during December, 2014 are found to be well within prescribed limits.

The values obtained for turbidity December is due to suspended solids, but exact relationship could not be established based on observed values. Approximately 3 to 4 % solids are present in water and the observed salinity values for Harbor and Creek water samples in the month of December, 2014 are ranges from 32.5 to 40.3 ppt. [Refer Tables 11 and 14]. The ranges observed for COD values in mg/L are 23.7 – 56.0 and 24.5 – 48.9 respectively for Harbor and Creek water samples. The DO levels are ranges between 3.8 to 6.4 for water samples collected from Harbor and Creek area. The concentration of Phenol and  $\text{NH}_4^+ - \text{N}$  is found to be very less in JNP Harbor as well as Nhava Creek water samples. Bacteriological parameters are also found to be far below the prescribed limits set for Harbor region.

**Table 13** provides the results obtained for sediment quality parameters for the sediment samples collected from JNP Harbor area during the month of December, 2014. The values obtained for Organic Matter, Total Organic Carbon and Inorganic Phosphate are ranges between 11.8 – 17.7%, 6.9 – 10.3% and 91.0 – 109.7 mg/kg, respectively. While, it is seen from **Table 16** that the values obtained for Organic Matter, Total Organic Carbon and Inorganic Phosphate are ranges between 19.9 – 16.4%, 7.5 – 9.5% and 81.6 – 90.4 mg/kg, respectively for sediment samples collected from Nhava Creek area during the month of December, 2014.

## 2.5 OBSERVATIONS AND CONCLUSIONS

### *Observations for the month of December:*

- ✓ *The Construction of 330 m Jetty at North Side of the JNP is underway:* During the monitoring period North Approach Bridge is being carried out.
- ✓ *Construction of Mooring Dolphin Jetty in front of Liquid cargo jetty:* construction of slab and walkway is going on during the time of Sampling of marine water.
- ✓ *Construction of Yard at NSGT:* During monitoring period Earth filling work continued.
- ✓ *Plying of Ferry Boats:* There were large numbers of ferry boats plying in the area from Gateway of India to Elephanta. The emissions from these boats are not monitored. The discharge from these boats may cause pollution of marine water and these pollutants may carry away to JNP Waters by tidal currents.

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 December, 2014. The characteristic parameters for sediments are also showing normal variation in concentrations for JNP Harbor area and Nhava Creek area during December, 2014.

**Conclusion:** Considering the activities in the Harbor area and the results obtained for the month of December, 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/W8] are identified. At Nhava creek 4 fixed stations [W11 to W14] are identified. All above mentioned stations are selected for studying aquatic flora and fauna as well as benthic fauna. The description of stations is depicted in **Table 9**. The location map of various Marine ecology monitoring stations along with direction of towing are described in Annexure-IV.

#### 3.2 MARINE ECOSYSTEM MONITORING METHODOLOGY

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

**Marine Ecology Monitoring** –Monitoring of marine ecology is carried out on the levels of high and low water of spring and neap tides at twelve fixed stations and one moving station in Port's water limit. Phytoplankton and Zooplankton samples are collected during spring tide and neap tide from all the 12 fixed [W1 to W7, W9 and W11 to W14] and one moving [W08/W8] 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]
<b>A] Aquatic Flora &amp; Fauna:</b> 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>B] Benthic Fauna:</b> Species Identification & Density
<b>C] Nutrients Analysis in Water:</b> Anions: Silicates, $\text{PO}_4^{3-}$ - P, $\text{SO}_4^{2-}$ , $\text{NO}_2^-$ - N, $\text{NO}_3^-$ - N, Cations: $\text{Ca}^{2+}$ , $\text{Mg}^{2+}$ , $\text{Na}^+$ , $\text{K}^+$
<b>D] Sediment Analysis:</b> Anions: Silicates, $\text{PO}_4^{3-}$ - P, $\text{SO}_4^{2-}$ , $\text{NO}_2^-$ - N, $\text{NO}_3^-$ - N, Cations: $\text{Ca}^{2+}$ , $\text{Mg}^{2+}$ , $\text{Na}^+$ , $\text{K}^+$

### 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 <sup>3</sup> /d]	Net Primary Productivity [mgC/m <sup>3</sup> /d]
<b>JNP Harbor Area</b>			
1.	W1	175	150
2.	W2	215	175
3.	W3	400	225
4.	W4	275	150
5.	W5	315	275
6.	W6	150	110
7.	W7	275	215
8.	W9	225	175
9.	W8	175	115
<b>NHAVA Creek Area</b>			
10.	W11	175	110
11.	W12	215	175
12.	W13	375	210
13.	W14	215	115

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

Sr. No.	Sampling station	Sample Location	Phyto-plankton, [No/mL]	Percent Composition of Algal Groups			
				Bacillario-phyceae	Chloro-phyceae	Cyano-phyceae	Crypto-phyceae
JNP Harbor Area							
1	W1	Surface	325	50	20	10	20
		Bottom	220	40	20	20	20
2	W2	Surface	270	60	10	20	10
		Bottom	190	55	15	20	10
3	W3	Surface	521	40	20	30	10
		Bottom	315	40	30	10	20
4	W4	Surface	354	62	28	10	-
		Bottom	280	55	15	10	20
5	W5	Surface	390	50	20	10	20
		Bottom	250	40	10	30	20
6	W6	Surface	325	30	10	20	30
		Bottom	210	50	30	20	-
7	W7	Surface	210	40	20	10	30
		Bottom	115	65	15	10	10
8	W9	Surface	412	45	15	20	20
		Bottom	245	50	20	20	10
9	W8	Surface	420	66	14	10	10
		Bottom	310	40	20	20	20
NHAVA Creek							
10	W11	Surface	310	45	25	20	10
		Bottom	225	50	30	10	10
11	W12	Surface	430	72	18	10	-
		Bottom	375	60	20	20	-
12	W13	Surface	425	50	20	20	10
		Bottom	319	60	30	10	-
13	W14	Surface	360	50	20	20	10
		Bottom	225	45	20	15	20

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

Sr.	Bacillariophyceae	Chlorophyceae	Cyanophyceae	Cryptophyceae
1.	<i>Navicula sp.</i>	<i>Cosmarium sp.</i>	<i>Gloeocapsa sp.</i>	<i>Cryptomonas sp.</i>
2.	<i>Nitzschia sp.</i>	<i>Ulothrix sp.</i>	<i>Oscillatoria sp.</i>	-
3.	<i>Gyrosigma sp.</i>	<i>Scenedesmus sp.</i>	<i>Anabaena sp.</i>	-
4.	<i>Surirella sp.</i>	<i>Chlamadomonas</i>	<i>Aphanocapsa sp.</i>	-

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

Sr. No.	Station	Secchi Depth, [cm]
<b>JNP Harbor Area</b>		
1.	W1	50 cm
2.	W2	30 cm
3.	W3	30 cm
4.	W4	20 cm
5.	W5	50 cm
6.	W6	50 cm
7.	W7	60cm
8.	W9	50 cm
9.	W8	50 cm
<b>Nhava Creek Area</b>		
10.	W11	40 cm
11.	W12	50 cm
12.	W13	30 cm
13.	W14	40 cm

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

			Percent Composition of Zooplankton Groups			
Sr. No.	Towing between Stations	Zoo-plankton, [No/m³]	Copepoda	Cladocera	Foraminifera	Rotifera
JNP Harbor Area						
			30	35		15
1.	W1-W2	270	46	36	20	18
2.	W2-W5	420	45	20	15	20
3.	W5-W1	370	40	30	20	10
4.	W5-W6	520	55	30	15	-
5.	W6-W2	275	35	15	30	20
6.	W4-W3	175	45	30	25	-
7.	W3-W7	370	65	20	15	-
8.	W7-W8	250	40	35	10	15
9.	W8-W3	260	40	20	20	20
10.	W9-W3	390	30	40	20	10
NHAVA Creek						
11.	W5-W11	460	30	40	20	10
12.	W11-W12	130	40	20	10	30
13.	W12-W13	320	50	10	20	20
14.	W13-W14	190	40	20	20	20

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

Sr. No.	Copepoda	Rotifera	Cladocera	Foraminifera
1.	<i>Cyclops</i> sp.	<i>Keratella</i> sp.	<i>Daphnia</i> sp.	<i>Rotaliasp.</i>
2.	<i>Diaptomus</i> sp.	<i>Brachionus</i> sp.	-	-

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

Sr. No.	Station	Chlorophyll- <i>a</i> [mg/m <sup>3</sup> ]		Pheophytin- <i>a</i> [mg/m <sup>3</sup> ]	
		Surface	Bottom	Surface	Bottom
JNP Harbor Area					
1.	W1	2.4	1.6	BDL	BDL
2.	W2	1.5	1.1	BDL	BDL
3.	W3	1.7	1.2	BDL	BDL
4.	W4	3.1	1.7	0.3	BDL
5.	W5	2.5	1.6	BDL	BDL
6.	W6	4.0	2.3	BDL	BDL
7.	W7	2.4	1.5	BDL	BDL
8.	W9	1.9	1.0	0.9	BDL
9.	W8	3.2	2.4	BDL	BDL
Nhava Creek Area					
10.	W11	1.5	1.1	BDL	BDL
11.	W12	1.7	1.3	BDL	BDL
12.	W13	2.6	1.2	0.5	BDL
13.	W14	3.6	2.0	BDL	BDL

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

Sr. No.	Station	POC, [mg/m <sup>3</sup> ]
<b>Standard</b>		<b>10 - 100</b>
<b>JNP Harbor Area</b>		
1.	W1	904
2.	W2	847
3.	W3	1148
4.	W4	1186
5.	W5	1101
6.	W6	998
7.	W7	960
8.	W9	1271
9.	W8	781
<b>Nhava Creek Area</b>		
10.	W11	1242
11.	W12	1177
12.	W13	1280
13.	W14	1073

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

Sr. No.	Macrobenthos		Percent Composition of Macrobenthos			
	Station	[No/m <sup>3</sup> ]	Foraminifera	Gastropods	Polychaeta	Chironomidae
<b>JNP Harbor Area</b>						
1.	W1	150	20	30	30	20
2.	W2	230	35	15	30	20
3.	W4	270	45	35	20	-
<b>Nhava Creek Area</b>						
4.	W11	250	40	30	20	10
5.	W13	170	50	20	20	10

Table 29: Concentration of Nutrients in Water at JNP Harbour area and Nhava Creek									
Station Name	Ca <sup>2+</sup> , [mg/L]	Mg <sup>+</sup> , [mg/L]	K <sup>+</sup> , [mg/L]	Na <sup>+</sup> , [mg/L]	PO <sub>4</sub> <sup>3-</sup> -P, [mg/L]	NO <sub>3</sub> <sup>-</sup> -N, [mg/L]	NO <sub>2</sub> <sup>-</sup> -N, [mg/L]	SiO <sub>2</sub> <sup>2-</sup> , [mg/L]	SO <sub>4</sub> <sup>2-</sup> , [mg/L]
Standard	-	-	-	-	0.1 - 90	1.0 - 500	<125	10 - 5000	-
JNP HARBOUR AREA									
W1	283	1325	688	10900	104	96	11	2202	2697
W2	324	1301	704	10700	102	430	11	2457	2545
W3	324	1473	648	9800	104	495	14	1860	2535
W4	364	1399	764	11100	115	580	12	2579	3195
W5	405	1276	640	10000	110	675	<10	2437	2733
W6	364	1374	784	9900	114	570	<10	2175	2646
W7	405	1424	728	10400	97	805	<10	2876	2618
W9	405	1448	744	10600	90	530	10	3767	2745
W10	405	1473	660	11000	112	750	13	2564	2854
Average	364	1388	707	10489	105	548	12	2546	2730
JNP NHAVA CREEK AREA									
W11	405	1497	792	10300	113	405	<10	2538	2805
W12	324	1424	692	11100	101	650	<10	2859	2758
W13	405	1424	796	12600	108	1070	<10	2758	3137
W14	405	1374	632	11600	111	765	<10	3525	2895
Average	385	1430	728	11400	108	723	<10	2920	2899

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

Station Name	Ca <sup>2+</sup> , [mg/kg]	Mg <sup>+</sup> , [mg/kg]	K <sup>+</sup> , [mg/kg]	Na <sup>+</sup> , [mg/kg]	PO <sub>4</sub> <sup>3-</sup> -P, [mg/kg]	NO <sub>3</sub> <sup>-</sup> -N, [mg/kg]	NO <sub>2</sub> <sup>-</sup> -N, [mg/kg]	SiO <sub>2</sub> <sup>2-</sup> , [mg/kg]	SO <sub>4</sub> <sup>2-</sup> , [mg/kg]
Standard	-	-	-	-	-	-	-	-	-
<b>JNP HARBOUR AREA</b>									
W1	1921	348	275	7489	172	39	0.32	166	6957
W2	1948	366	306	7860	161	61	0.26	160	7442
W3	2129	209	345	8405	134	46	0.56	196	7019
W4	2126	134	347	8403	165	67	0.48	176	7218
W5	Sample not found								
W6	2141	212	363	7054	162	72	0.56	256	6767
W7	2184	345	280	6500	132	75	0.50	205	6436
W9	Sample not found								
W10	Sample not found								
Average	2075	269	319	7619	154	60	0.45	193	6973
<b>JNP NHAVA CREEK AREA</b>									
W11	2266	436	302	7359	149	51	0.45	176	6429
W12	1882	328	348	8017	156	44	0.52	153	6552
W13	1840	398	357	7248	159	55	0.35	182	6735
W14	2210	239	382	7642	139	58	0.42	158	6864
Average	2050	350	347	7567	151	52	0.43	167	6645

### 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.

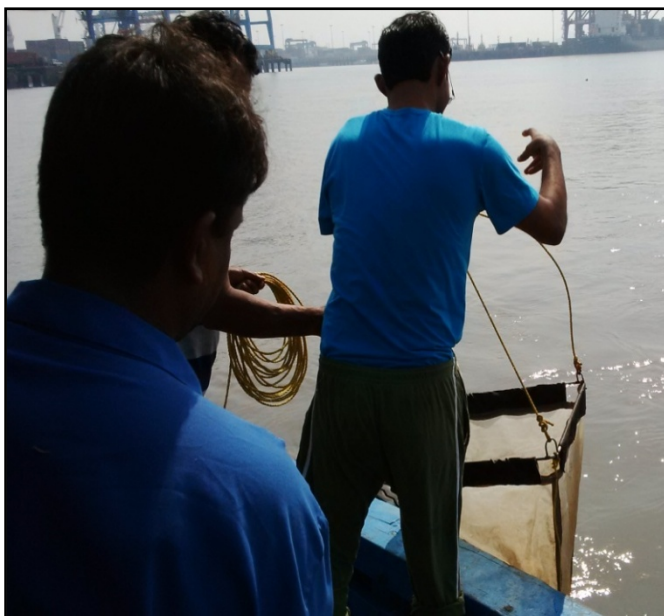
Water samples from three different sampling points of various depths were collected both in a transparent and completely opaque (dark) high quality glass bottle. From each sampling points two samples were collected in transparent bottles and the rest one was collected in dark bottle. Dark bottles were 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 increase in the oxygen concentration in the light bottle is measure of net production which, because of the concurrent use of oxygen in respiration, is somewhat less than the total (or gross production). The loss of oxygen in the dark bottle is used as an estimate of total plankton respiration. The highest estimated gross and net primary productivity was measured as 400 and 275 mgC/m<sup>3</sup>/d at stations W3 and W5 [Table 20]. The values are within the lowest (95 mgC/m<sup>3</sup>/d) and highest (739 mgC/m<sup>3</sup>/d) productivity, as reported at near shore waters of Vizhinjam in Trivadrum (Rani Mary Jacob and Vasantha Kumar, 1984). Primary productivity showed no significant upward or downward trend. Compared with other coastal ecosystems, primary productivity of JNP Harbor area and Nhava creek was at a moderate level. Change in the direction of sea currents and dredging activities might be the cause for increased turbidity and comparatively less primary productivity in December.

#### **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.



#### A] Phytoplankton:

**Count :** Phytoplankton counts, recorded at different sampling stations, are presented in Table 21. Total algal population varied between 117 and 521 algal cells/ml. Samples collected at station W7(B) and W3(S) showed lowest and highest counts respectively. Bacillariophyceae dominated all samples followed by Chlorophyceae. The phytoplankton population comprised of thirteen genera with 4 major groups, namely Bacillariophyceae, Chlorophyceae, Cyanophyceae and Cryptophyceae [Table 22]. The most common genera found were *Anabaena*, *Aphanocapsa*, *Oscillatoria*, *Gloeocapsa*, *Ulothrix*, etc.

**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 Harbor Area and Nhava creek with the help of Secchi Disk (Table 23). Transparency varied between 20-60 cm at W4 and W7 stations respectively. Particulates (soil or dead leaves) may be introduced into the water by either runoff or sediments coming from the Butcher Island might be a cause for low transparency at station W4. Also algal numbers was increased at station W4 produced high turbidity; also high benthos at W4 produces the water turbid and resulting a weak transparency in water.

#### 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 130 and 520 N/m<sup>3</sup> at stations W11-W12 and W5-W6. Total six genera of zooplankton were recorded. Among zooplankton Copepoda and Rotifera group were dominant [Table 25].

In view of uncontrolled anthropogenic activities, the water characteristics of JNP Harbor area and Nhava creek have been deteriorated substantially. Reduced inflows coupled with organic pollution and nutrient addition result in increased algal activity as noticed at stations W3, W9, W11 and W12. Station W5-W6 comprising of moderately high phytoplankton count might be a reason of high zooplankton observed in this station.

The survey surrounding the JNP Harbor area and Nhava creek revealed that there are ample possibilities of contamination from various sources viz., domestic wastewater at stations W2, W3, W4 and W9, solid waste disposal at stations W8, W8, W11 and W12 and Oil spill from launches to all stations causes fluctuations in the plankton counts.

#### **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 Harbor area and Nhava creek [Table 26]. For the estimation of chlorophyll-a and pheophytin-a, a certain volume of water sample was filtered through glass fiber filter paper and the filter paper was immersed in 5 ml of 90% acetone and grinded in tissue grinder and kept overnight at 4°C in dark for extraction of pigments. The extract of pigments was then measured by spectrophotometer at wavelength of 750 nm and 664 nm before acidification and at 665 nm after acidification by 0.1ml of 0.1N HCl.

The algal biomass is the main source of food for the primary consumers and it was evaluated by chlorophyll-a method and its value is given in Table 26. In JNP harbor area, the range of algal biomass was found between 100 and 266 mg/m<sup>3</sup>. The minimum algal biomass was (100 mg/m<sup>3</sup>) found at W2 & W11 stations and maximum (266 mg/m<sup>3</sup>) was found at W6 station. The lowest and highest chlorophyll a from surface water sample varied from 1.0 at station W9 (B) to 4.0 mg/m<sup>3</sup> at W6(S). Phytoplankton count was high at W6 station resulted in increased algal activity. This could be due to indiscriminate discharge of oil contaminated water from launches and from motorized fishing boats and vessels moving at this station. However, Pheophytin concentrations of many samples were below detectable limit [Table 26].

#### **3.4.1.d Particulate Organic Carbon [POC]:**

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 Harbor area and NHAVA creek Van veen grab sampler having the area 0.02 m<sup>2</sup>. The sediment was sieved through 500 μ

mesh sieve and the organisms retained the sieve were preserved immediately with 5% buffered formalin. Subsequently, all the macrobenthic specimens were identified to the lowest possible level under a stereoscopic microscope. All unidentified specimens are referred to by their generic/family names and were considered in single taxonomic category.

A total of four macrobenthic groups were obtained from the 13 sediment samples. Foraminifera was the most diverse group. Species like Triloculina and Florilus were dominant. Foraminifera 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 forms may be as large as several centimeters with a recorded maximum of 18 cm 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. Chironomous larva from Chironomidae was also observed as benthic fauna, which is indicator of pollution stress. The highest count was 270 No/m<sup>3</sup> in sampling point W4 [Table 28]. Benthos was absent at stations W3, W5, W6, W7, W9, W8 and W12. As the runoff or sediments coming from the Butcher Island and the drainage activities in and around nearby areas caused the high benthic fauna in this region.

### 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 Harbor area and NHAVA creek Van veen grab sampler having the area 0.02 m<sup>2</sup>. The sediment was sieved through 500  $\mu$  mesh sieve and the organisms retained the sieve were preserved immediately with 5% buffered formalin. Subsequently, all the macro-benthic 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.

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W3, W5, W6, W7, W9, W8 and W12. As the runoff or sediments coming from the Butcher Island and the drainage activities in and around nearby areas caused the high benthic fauna 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 29), these waters can be classified as Mesotrophic, which 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 <sup>3</sup> )	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	2.5	0.105
NHAVA creek	0.4	2.3	0.108

### 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 90 µg/L – 115 µg/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 96 µg/L – 805 µg/L. The minimum value of Nitrate was found at W1

station and maximum at W7 station. The average concentration of Nitrate was found to be 548µg/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 1860– 3767 µg/L with an average of 2546 µg/L. The minimum concentration of silica was found at W3 station of JNP harbor region and the maximum concentration of silica was found at W9 station. The Sulphate was found between 2535 – 3195 mg/L, the minimum value recorded at W3 station and maximum at W4 station. The average concentration of Sulphate was found to be 2730 mg/L.

In Nhava Creek, Phosphate was found between 101µg/L – 113µg/L with an average 108µg/L which was under prescribed standard range [0.1-90µg/L]. Nitrate was found to be 405 – 1070 µg/L with an average 723 µg/L. The silica content in Nhava creek was found to be 2538 – 3525 µg/L with an average of 2920 µg/L. The minimum silica content was found at station W11 station and maximum was found at W14 station. Sulphate was found between 2758 – 3137 mg/L with an average of 2899 mg/L. The minimum value for Sulphate was found at W12 station and maximum value at W13 station.

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

The nutrients in sediments at various stations in JNP harbor area and Nhava Creek area are given in **Table 30**. In harbor region the sediment found at five locations out of nine. Phosphate was found between 132 – 172 mg/kg with an average of 154 mg/kg. The Nitrate was found minimum value at W1 i.e. 39 mg/kg and 75 mg/kg i.e. maximum value at W7 station. The average concentration of Nitrate was found to be 60.0 mg/kg. The Nitrite was found to be between 0.26 – 0.56 mg/kg with an average of 0.45 mg/kg. The minimum concentration of nitrite was found at W2 station and maximum value at W3 and W6 station. Silica in the form of silicate in JNP harbor sediments were found between 160 to 256 mg/kg with an average of 193 mg/kg. The minimum concentration of silica was found at W2 station and maximum value was found at W6 station. The Sulphate was found between 6436 to 7442 mg/kg, with minimum value at W7 station and maximum value at W2 station. The average concentration of Sulphate was found to be 6973.2 mg/kg.

In Nhava Creek region the sediment found at two locations out of four. Phosphate levels were between 139 to 159 mg/kg with an average of 151 mg/kg. Nitrate was found between 44 to 58 mg/kg. The average concentration of Nitrate was found to be 52 mg/kg. The Nitrite was found to be between 0.35 to 0.52 mg/kg with an average of 0.43mg/kg. Silica in the form of silicate in JNP harbor sediments were found between 153 to 182 mg/kg with an average of 167 mg/kg. The Sulphate was found between 6429 to 6864 mg/kg. The average concentration of Sulphate was found to be 6645 mg/kg.

## b. Cations:

In harbor region water, the Calcium was found between 283 to 405 mg/L with an average of 364 mg/L given in **Table 29**. The Magnesium was found to be 1276 – 1473 mg/L, with maximum value at W8 station. The average concentration of Magnesium was found to be 1388 mg/L. Potassium in JNP harbor water was found between 640 to 784 mg/L with an average of 707 mg/L. The minimum concentration of Potassium was found at W5 station and maximum value at W6 station. The Sodium was found between 9800 to 11100 mg/L with an average of 10489 mg/L. The minimum concentration of sodium was found at W3 station and maximum value of at W4 station.

In Nhava Creek, Calcium concentration was found with an average 385 mg/L given in **Table 29**. Magnesium concentration was found to be 1374 – 1497 mg/L with an average of 1430 mg/L. The minimum value of Magnesium was found at W14 station and maximum value was found at W11 station. The Potassium content in Nhava creek was found to be 632 – 796 mg/L with an average of 728 mg/L. The minimum potassium value was found at W14 station and maximum value at W13 stations. Sodium concentration was found to be 10300 to 12600mg/L with an average of 11400 mg/L. The minimum sodium value was recorded at W11 station and maximum value at W13 station.

In harbor region sediments, the Calcium was found to be 1921 to 2184 mg/Kg with an average of 2077 mg/Kg given in **Table 30**. The minimum Concentration of Calcium was found at W1 station and maximum concentration at W7 station. Magnesium was found to be 134 to 366 mg/Kg, with minimum value at W4 station and maximum was recorded at W2 station. The average concentration of Magnesium was found to be 269 mg/Kg. Potassium in JNP harbor sediment was found to be 275 to 363 mg/Kg with an average of 319 mg/Kg. The minimum concentration of Potassium was found at W1 station and maximum value at W6 station. Sodium was found to be 6500 to 8405 mg/Kg with an average of 7619 mg/Kg. The minimum concentration of sodium was found at W7 station and maximum value at W3 station.

In Nhava Creek sediments, Calcium was found to be 1840 to 2266 mg/Kg with an average 2050 mg/Kg given in **Table 30**. Magnesium was found between 239 to 436 mg/Kg. Average potassium content in Nhava creek was found to be 350 mg/Kg. The minimum Potassium content was found at W11 station and maximum value at W14 station. Sodium was found between 7248 to 8017 mg/Kg with an average of 7567 mg/Kg. The minimum sodium value was found at W13 station and maximum value at W12.

## 3.5OBSERVATIONS AND CONCLUSIONS

### *Observations for the month of December:*

- ✓ *The Construction of 330 m Jetty at North Side of the JNP is underway:* During the monitoring period North Approach Bridge is being carried out.
- ✓ *Construction of Mooring Dolphin Jetty in front of Liquid cargo jetty:* construction of slab and walkway is going on during the time of Sampling of marine water.
- ✓ *Construction of Yard at NSGT:* During monitoring period Earth filling work continued.

- ✓ *Plying of Ferry Boats:* There were large numbers of ferry boats plying in the area from Gateway of India to Elephanta. The emissions from these boats are not monitored. The discharge from these boats may cause pollution of marine water and these pollutants may carry away to JNP Waters by tidal currents.

The maximum gross and net primary productivities were measured as 400 and 275 mgC/m<sup>3</sup>/d at stations W3 and W5. Change in the direction of sea currents and dredging activities might be the cause for increased turbidity and comparatively less primary productivity in December. Transparency varied from 20-60 cm at W4 and W7 stations respectively. Algal counts were increased at stations W4 and W6, resulting in low transparency. Based on values of Chlorophyll-*a*, these waters can be classified as Mesotrophic, that is of medium quality. Reduced inflows coupled with organic pollution and nutrient might have increased algal activity as noticed at stations W3, W9, W11 and W12. Stations W5-W6 comprising of moderately high phytoplankton count might be a reason of corresponding high zooplankton in this station. The survey surrounding the JNP Harbour area and Nhava creek revealed that there are ample possibilities of contamination from various sources viz., Thane creek, Ulhas river and Patalganga river causing fluctuations in the plankton counts. The highest count of benthos was found at sampling point W4.

The increased level of POC, phosphate and Nitrate may be attributed as follows:

There are four lentic water bodies; viz. Thane creek, Ulhas river, Khargar 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 creek confluence, resulting in direct impact on harbour waters. A brief note on Thane creek is furnished hereunder.

Thane Creek (TC) is adjacent to Mumbai harbour bay. It is a triangular mass of brackish water which widens out and opens to the Arabian Sea in the South. The creek is narrow at the 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 creek is the ultimate recipient of all the liquid discharges from these industries. The discharges into the creek on its Western side are dominated by Mumbai city sewerage and effluents from the industrial complexes, including the textile mills of South and Central Mumbai, the petrochemical, fertilizer and thermal plants at Chembur and the pharmaceutical and chemical complexes at Vikhroli, Bhandup and Mulund. The Trans-Thane Creek Industrial Area was developed as a chemical zone by the MIDC. Of the 1800 odd industries registered in the area, nearly 50 could be termed as major and the rest classified as small and medium scale. The effluent discharges both treated and untreated are let into the creek.

Sr. No.	Parameter	Criteria	Observations	Remarks	Mitigation Measures
1.	Net primary productivity	<1500 mgC/m <sup>3</sup> /day at surface	The observed values falls under 110-275 mgC/m <sup>3</sup> /day	-	Within Range
2.	Chlorophyll-a	< 4 mg/m <sup>3</sup> [Oligotrophic class] 4-10 mg/m <sup>3</sup> [Mesotrophic class] >10 mg/m <sup>3</sup> [Eutrophic classter]	The observed values falls under 1.0 – 4.0 mg/m <sup>3</sup>	Oligotrophic class of water at all stations except W4 station	-
3.	Phosphate	0.1- 90 µg/L	Harbour area – 105 µg/L; Creek area – 108µg/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 – 548 µg/L; Creek area – 723 µg/L	A nutrient produced in natural water by decomposition of nitrogenous compounds.	Exceeds the Range
5.	Nitrite	<125 µg/L	Harbour area – 12 µg/L; Creek area – <10 µg/L	-	-
6.	Particulate Organic Carbon	10 – 100 mg/m <sup>3</sup>	Harbour area – 1051 mg/m <sup>3</sup> ; Creek area – 1193 mg/m <sup>3</sup>	This may be due to detritus material originate from Mangrove swamps or detritus planktons	Awareness about the pollution of sea water
7.	Silicate (SiO <sub>2</sub> )	10-5000 µg/L	Harbour area – 2546 µg/L; Creek area – 2920 µg/L	Nucleic acid synthesis and skeletal formation of Diatoms.	Within Range

It is seen from the data reported in Tables 20 to 30 and subsequently discussed in above paragraphs, the relevant parameters mentioned in above given table are complying with prescribed recommended ranges of the ecological parameters for Arabian Sea during November, 2014 except POC, Phosphate and Nitrate.

### Conclusion:

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 much by these 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
<b>Outside the Port Area</b>		
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	DW8	Sector III
8	DW13	CISF Canteen
9	DW14	Custom Canteen
10	DW15	JNPT Guest House
<b>Inside the Port Area</b>		
11	DW6	NSICT Canteen
12	DW7	GTI Canteen
13	DW10	POC Canteen
14	DW11	JNPT Workshop
15	DW12	C.T. Canteen
16	DW16	PPD Site Office
17	DW17	GTI -2
18	DW18	GTI CGC

Out of eighteen stations ten stations were outside the port and eight stations were inside the port. All samples were collected from the port area of JNP on 20<sup>th</sup> December, 2014.

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

### 4.2 RESULTS

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

**Table 33: Results of Drinking water quality monitoring**

Parameter	Unit of Measurement	Station Name						Standards*
		DW1	DW2	DW3	DW4	DW5	DW6	
Colour	Hazen	<5	<5	<5	<5	<5	<5	5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
Turbidity	NTU	<1	<1	<1	<1	<1	<1	1
Conductivity	mS/cm	100	105	106	105.8	105	108	-
pH	-	7.29	7.21	7.21	7.32	7.18	7.44	6.5 to 8.5
Chloride as Cl <sup>-</sup>	mg/L	8.8	7.8	8.8	7.8	9.8	8.8	250
Total Dissolved Solids	mg/L	63	67	67	66	69	68	500
Total Hardness as CaCO <sub>3</sub>	mg/L	53	44	47	44	49	49	200
Iron as Fe	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.3
Sulphate as SO <sub>4</sub> <sup>-2</sup>	mg/L	3.5	2.7	3.7	2.6	3.2	<1	200
NH <sub>4</sub> <sup>+</sup> - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5
PO <sub>4</sub> <sup>-3</sup> - P	mg/L	0.2	<0.1	0.1	0.4	<0.1	<0.1	-
Total Coliforms	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil

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

Table 33: Results of Drinking water quality monitoring										
Parameter	Unit of Measurement	Station Name						Standard		
		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	108	109	106	105	116	108	-		
pH	-	7.02	7.34	7.36	7.43	6.99	7.54	6.5 to 8.5		
Chloride as Cl	mg/L	8	9.8	8.8	7.8	7.8	9.8	250		
Total Dissolved Solids	mg/L	67	66	66	64	70	68	500		
Total Hardness as CaCO <sub>3</sub>	mg/L	53	51	47	51	49	44	200		
Iron as Fe	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.3		
Sulphate as SO <sub>4</sub> <sup>-2</sup>	mg/L	2.3	2.5	1.45	<1	10.33	4.88	200		
NH <sub>4</sub> <sup>+</sup> - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5		
PO <sub>4</sub> <sup>-3</sup> - P	mg/L	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	-		
Total Coliforms	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil		
*: IS 10500:2012, Drinking Water - Specification										

Table 33: Results of Drinking water quality monitoring										
Parameter	Unit of Measurement	Station Name						Standard		
		DW13	DW14	DW15	DW16	DW17	DW18			
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	µS/cm	109.4	109.2	109	103	108	106	-		
pH	-	7.28	7.47	7.27	7.42	7.37	7.49	6.5 to 8.5		
Chloride as Cl	mg/L	8.8	9.8	7.8	8.8	9.8	9.8	250		
Total Dissolved Solids	mg/L	70	70	68	66	68	68	500		
Total Hardness as CaCO <sub>3</sub>	mg/L	44	49	44	47	47	49	200		
Iron as Fe	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.3		
Sulphate as SO <sub>4</sub> <sup>-2</sup>	mg/L	4.69	3.0	4.1	2.7	3.1	2.9	200		
NH <sub>4</sub> <sup>+</sup> - N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5		
PO <sub>4</sub> <sup>-3</sup> - P	mg/L	0.1	<0.1	<0.1	0.6	<0.1	<0.1	-		
Total Coliforms	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil		
*: IS 10500:2012, Drinking Water - Specification										

### 4.3 DISCUSSION

**Table 33** provides the results for various parameters analyzed for drinking water collected at eighteen stations in and around the port's activity area. The observed results are compared with acceptable limits for various parameters of drinking water as prescribed in *IS 10500:2012* – Drinking Water Specification.

In collected drinking water, the variation of concentration levels of anions are found to be for chloride 7.8 to 9.8 mg/L, for sulphate 1.5 to 10.3 mg/L and for phosphate 0.1 to 0.4 mg/L. The concentration of total dissolved solids is found to be between 63.0 to 70.0 mg/L and concentration of total hardness is found to be 44.4 to 52.5 mg/L. All the above parameters are well within the acceptable limits.

The color of all drinking water samples is < 5 Hazen unit and Odor of the samples is also agreeable. The turbidity values are below acceptable limits i.e. 1 NTU. The values of conductivity are ranges between 100.0 to 116.2 $\mu$ S/cm. The acceptable range for pH is 6.5 to 8.5, while the observed pH range is 7.0 to 7.5.

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

### 4.4 CONCLUSIONS

As per the drinking water specifications given in IS 10500:2012 and also on the basis of above described analysis parameters, the water is safe for drinking purpose at all drinking water monitoring stations in and around the port.

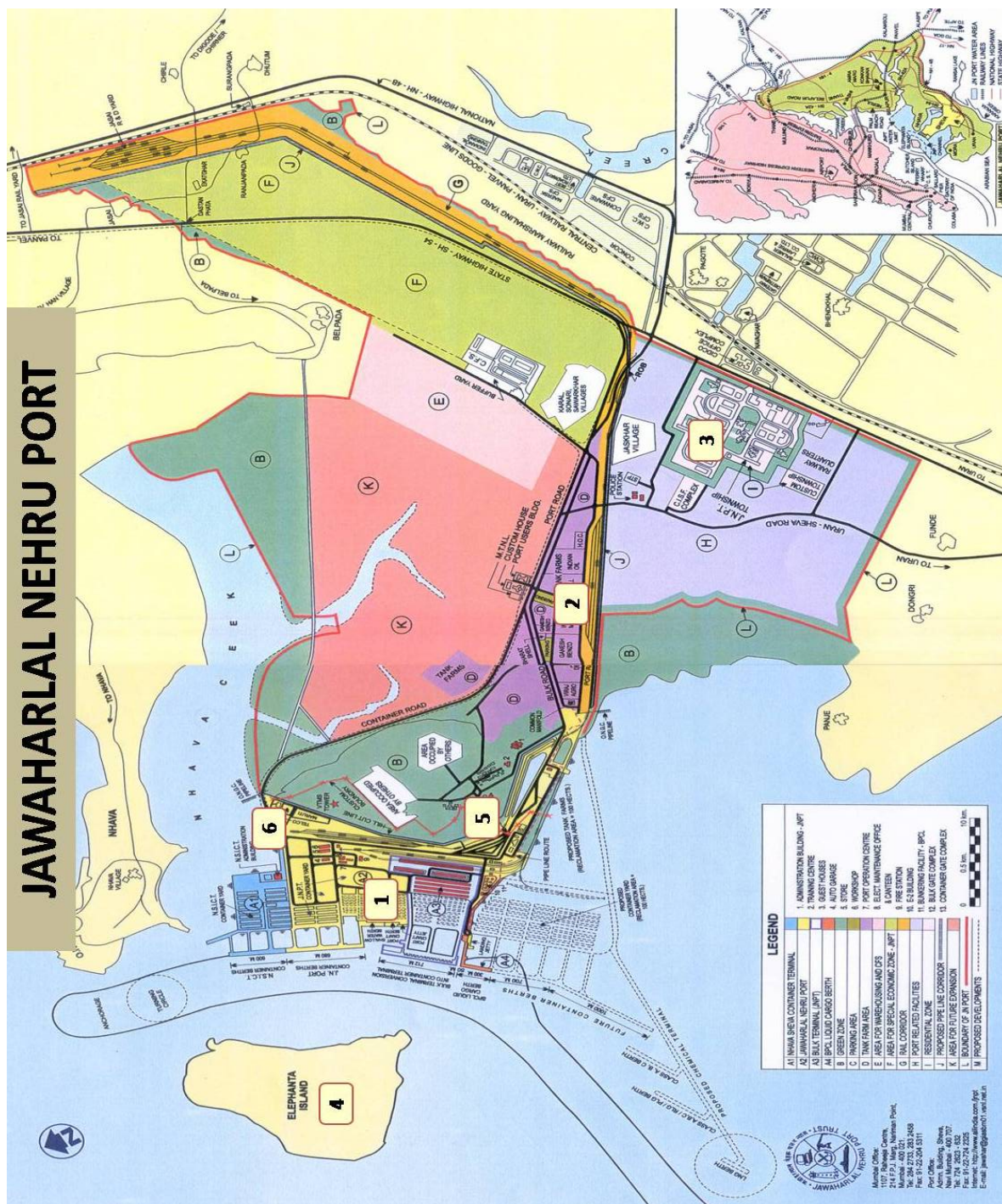


Drinking Water Collection in  
sterilized can



Sterilized Bottle for  
Microbial parameter

# JAWAHARLAL NEHRU PORT



***Annexure-I: Location map for Ambient Air Monitoring Stations***

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

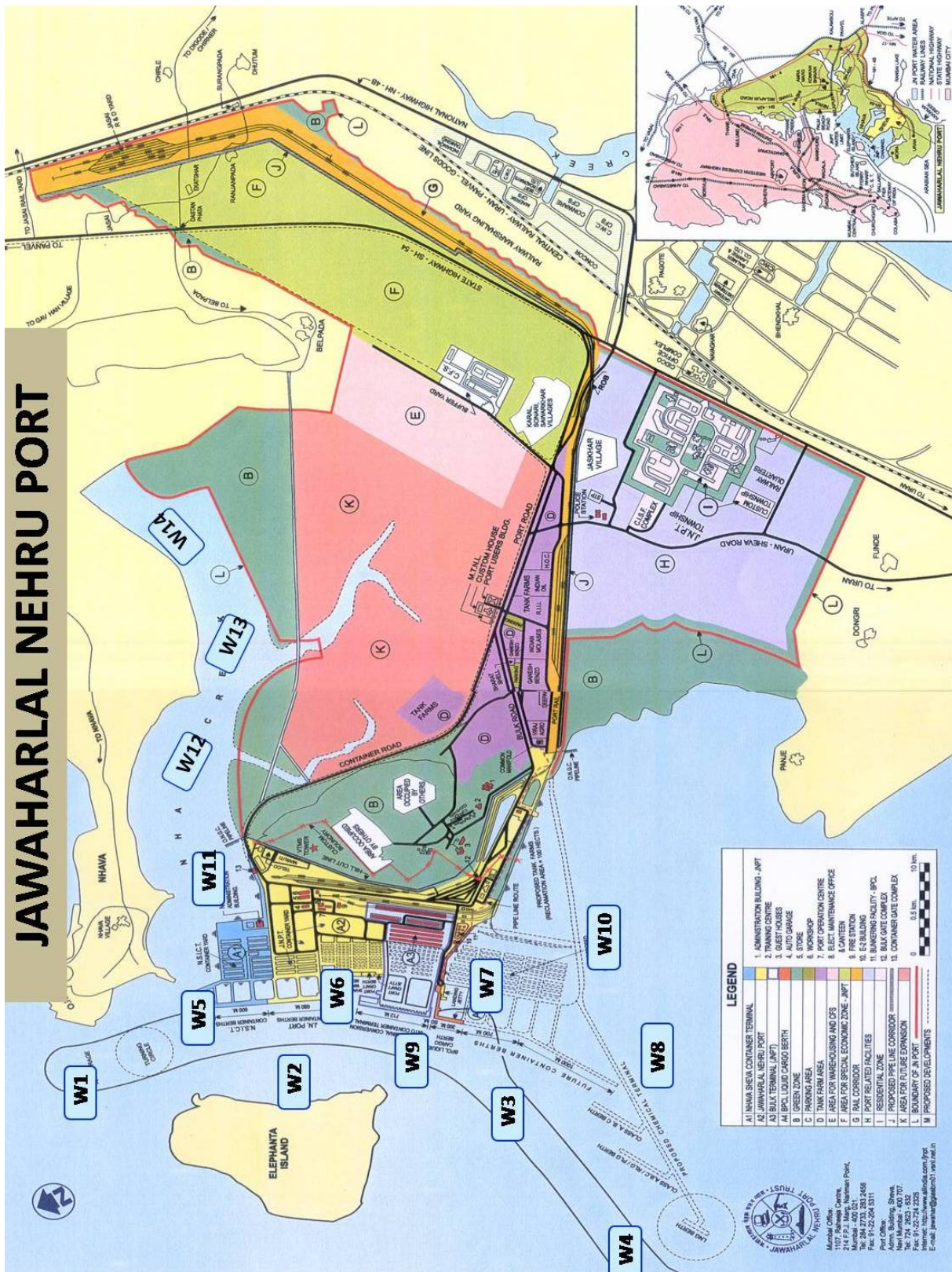
\* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals

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

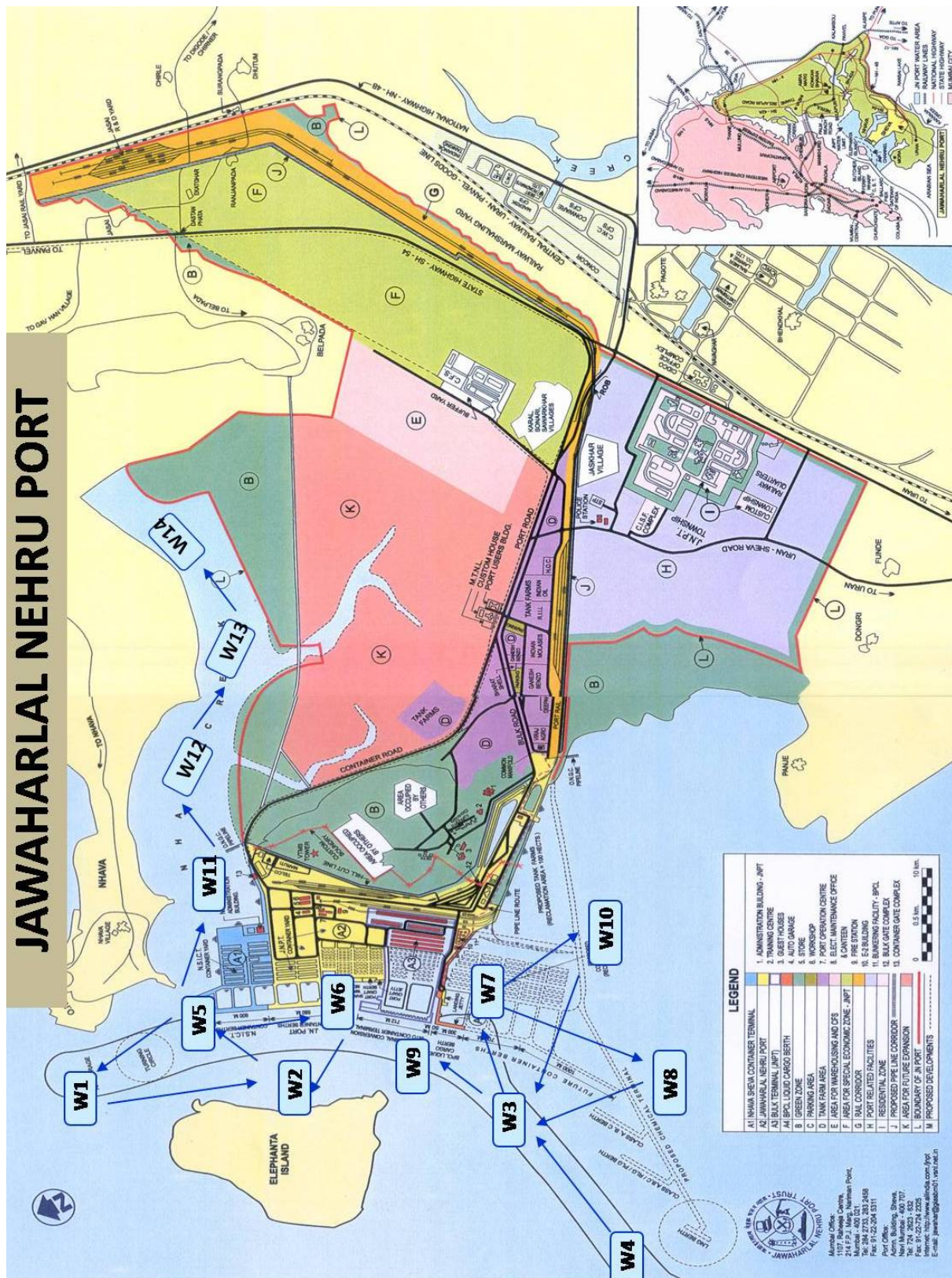
2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

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 <sup>3</sup> /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 <sup>3</sup> 4-10 mg/m <sup>3</sup> >10 mg/m <sup>3</sup>	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 <sup>3</sup>	POC is directly related to primary productivity. High concentration of POC represents the region of high productivity.
7.	Silicate (SiO <sub>2</sub> )	10-5000 µg/L	Nucleic acid synthesis and skeletal formation of Diatoms.

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