

## PART-A

### Chapter-1: Air Quality Monitoring and Micro-Meteorology

#### 1.1 Introduction

Jawaharlal Nehru Port (JN Port) is one of the thirteen major ports of India, located on the east side of Mumbai Harbour adjoining the main land of the West Coast of India.

As per the Environmental Management Plan Air Monitoring has been done at three fixed stations in Port area and one moving station at Elephanta Caves.

The main objectives of air quality monitoring survey are:

- To determine the status of existing ambient air quality levels in the port and to compare it with CPCB specified standards as well as earlier surveys.
- To identify possible mitigation measures, as appropriate, based on the findings of current month survey.

The air quality parameters which are relevant to the port activity and mentioned in the National Ambient Air Quality Standards (NAAQS) are monitored. Sampling frequency is twice a week at the three stations and once a month at the moving station (EC). Seven major pollutants viz., Total Suspended Particulates (TSP), Respirable Particulate Matter (PM<sub>10</sub>), and Oxides of Nitrogen, Sulfur Dioxide, Ammonia, Carbon Monoxide and Carbon Dioxide are monitored at four monitoring stations viz., Liquid Chemical Terminal / Indian Molasses Company (IMC), POC Building (POC), Residential Colony of JNPT (RC) and Elephanta Caves (EC) for the month of October, 2013 Table A.1 gives the station name and its location with respect to prominent structures for the purpose of identification. The locations of all the stations for air quality monitoring are shown in MAP 1.

**Table A.1**  
**Description of Air Quality Monitoring Stations**

Stations	Location
RC	At JNPT residential township
IMC	At IMC compound in Liquid Chemical Terminal area
POC	Near Port Operation Centre (POC)
EC	At the Elephanta at MTDC Chalukya restaurant terrace (facing BARC)

## 1.2 Air Quality Monitoring Methodology for Stations

Frequency of monitoring in RC, IMC and POC is twice in a week and at EC was once in a month. Duration of monitoring at RC, IMC, POC and EC was of 8 hours each in 24-hour sampling period for gaseous monitoring and continuous 24 hour sampling for TSP and RSPM samples. After a continuous operation of eight hours of the sampler, the reagents (for the gaseous samples) were replaced to obtain three samples per day for each gaseous parameter. The filter paper and cyclone cup was used for a period of 24 hrs to obtain one sample of TSP and RSPM per day.

## 1.3 Results and Discussion

Tables A.2, A.3 and A.4 provide the results for the parameters sampled at RC, IMC and POC stations for October, 2013 respectively. Table A.5 shows results of air pollutant concentration at Elephanta Island during 10<sup>th</sup> to 11<sup>th</sup> October, 2013.

The results of air monitoring at RC station are as follows.

**Table A.2:**  
**Maximum and Minimum concentration of various parameters at RC station.**

Parameters	Maximum	October, 2013	Minimum	October, 2013	CPCB Prescribed Limits
	$\mu\text{g}/\text{m}^3$		$\mu\text{g}/\text{m}^3$		$\mu\text{g}/\text{m}^3$
<b>TSP</b>	82	28 <sup>th</sup> to 29 <sup>th</sup>	64	10 <sup>th</sup> to 11 <sup>th</sup> & 21 <sup>st</sup> to 22 <sup>nd</sup>	200
<b>PM<sub>10</sub></b>	45	28 <sup>th</sup> to 29 <sup>th</sup>	35	21 <sup>st</sup> to 22 <sup>nd</sup>	100
<b>NO<sub>x</sub></b>	11.1	24 <sup>th</sup> to 25 <sup>th</sup>	5.4	3 <sup>rd</sup> to 4 <sup>th</sup>	80
<b>SO<sub>2</sub></b>	5.2	14 <sup>th</sup> to 15 <sup>th</sup>	1.3	10 <sup>th</sup> to 11 <sup>th</sup> & 17 <sup>th</sup> to 18 <sup>th</sup>	80
<b>NH<sub>3</sub></b>	46.3	7 <sup>th</sup> to 8 <sup>th</sup>	20.1	21 <sup>st</sup> to 22 <sup>nd</sup>	400
<b>CO</b>	1.77 mg/m <sup>3</sup>	14 <sup>th</sup> to 15 <sup>th</sup>	1.60 mg/m <sup>3</sup>	7 <sup>th</sup> to 8 <sup>th</sup>	2mg/m <sup>3</sup>
<b>CO<sub>2</sub></b>	307 ppm	7 <sup>th</sup> to 8 <sup>th</sup>	303 ppm	3 <sup>rd</sup> to 4 <sup>th</sup>	-

The values for TSP and PM<sub>10</sub> were below the prescribed limit during whole sampling period in the month of October, 2013.

The results of air monitoring at IMC station are as follows:

**Table A.3:**  
**Maximum & Minimum concentration of various parameters at IMC station.**

Parameters	Maximum	October, 2013	Minimum	October, 2013	CPCB Prescribed Limits
	$\mu\text{g}/\text{m}^3$		$\mu\text{g}/\text{m}^3$		$\mu\text{g}/\text{m}^3$
<b>TSP</b>	186	28 <sup>th</sup> to 29 <sup>th</sup>	106	17 <sup>th</sup> to 18 <sup>th</sup>	200
<b>PM<sub>10</sub></b>	98	28 <sup>th</sup> to 29 <sup>th</sup>	56	17 <sup>th</sup> to 18 <sup>th</sup>	100
<b>NO<sub>x</sub></b>	20.0	10 <sup>th</sup> to 11 <sup>th</sup>	9.2	21 <sup>st</sup> to 22 <sup>nd</sup>	80
<b>SO<sub>2</sub></b>	5.7	28 <sup>th</sup> to 29 <sup>th</sup>	2.5	7 <sup>th</sup> to 8 <sup>th</sup> , 14 <sup>th</sup> to 15 <sup>th</sup> & 17 <sup>th</sup> to 18 <sup>th</sup>	80
<b>NH<sub>3</sub></b>	68.2	7 <sup>th</sup> to 8 <sup>th</sup>	29.6	21 <sup>st</sup> to 22 <sup>nd</sup>	400
<b>CO</b>	1.88 mg/m <sup>3</sup>	7 <sup>th</sup> to 8 <sup>th</sup>	1.68 mg/m <sup>3</sup>	7 <sup>th</sup> to 8 <sup>th</sup>	2mg/m <sup>3</sup>
<b>CO<sub>2</sub></b>	317 ppm	14 <sup>th</sup> to 15 <sup>th</sup>	307 ppm	7 <sup>th</sup> to 8 <sup>th</sup>	-

The values for TSP and PM<sub>10</sub> were below the prescribed limit during whole sampling period in the month of October, 2013.

The results of air monitoring at POC station are as follows.

**Table A.4:**  
**Maximum & Minimum concentration of various parameters at POC station.**

Parameters	Maximum	October, 2013	Minimum	October, 2013	CPCB Prescribed Limits
	$\mu\text{g}/\text{m}^3$		$\mu\text{g}/\text{m}^3$		$\mu\text{g}/\text{m}^3$
<b>TSP</b>	110	24 <sup>th</sup> to 25 <sup>th</sup>	66	10 <sup>th</sup> to 11 <sup>th</sup>	200
<b>PM<sub>10</sub></b>	56	24 <sup>th</sup> to 25 <sup>th</sup>	30	10 <sup>th</sup> to 11 <sup>th</sup>	100
<b>NO<sub>x</sub></b>	20.2	10 <sup>th</sup> to 11 <sup>th</sup>	5.8	28 <sup>th</sup> to 29 <sup>th</sup>	80
<b>SO<sub>2</sub></b>	3.9	17 <sup>th</sup> to 18 <sup>th</sup>	1.1	3 <sup>rd</sup> to 4 <sup>th</sup>	80
<b>NH<sub>3</sub></b>	52.2	21 <sup>st</sup> to 22 <sup>nd</sup>	24.8	10 <sup>th</sup> to 11 <sup>th</sup>	400
<b>CO</b>	1.86 mg/m <sup>3</sup>	10 <sup>th</sup> to 11 <sup>th</sup>	1.64 mg/m <sup>3</sup>	21 <sup>st</sup> to 22 <sup>nd</sup>	2mg/m <sup>3</sup>
<b>CO<sub>2</sub></b>	316 ppm	14 <sup>th</sup> to 15 <sup>th</sup>	305 ppm	7 <sup>th</sup> to 8 <sup>th</sup>	-

The values for TSP and PM<sub>10</sub> were below the prescribed limit during the whole month of October, 2013.

Table A.5 provides the results of the air quality parameters at Elephanta Island station during 10<sup>th</sup> to 11<sup>th</sup> October, 2013. The concentration of TSP and PM<sub>10</sub> was found to be 54µg/m<sup>3</sup> and 26µg/m<sup>3</sup> respectively. The concentration range of NO<sub>x</sub>, SO<sub>2</sub>, NH<sub>3</sub>, CO & CO<sub>2</sub> was found to be in the range of 3.7 to 4.2 µg/m<sup>3</sup>, 1.3 to 2.6 µg/m<sup>3</sup>, 19.9µg/m<sup>3</sup> to 27.3µg/m<sup>3</sup>, 1.63 mg/m<sup>3</sup> to 1.67 mg/m<sup>3</sup> and 302 ppm to 305 ppm respectively. The concentration of TSP, PM<sub>10</sub> and all gaseous pollutants were found to be below than the prescribed CPCB standard at EC station for the month of October, 2013.

**Table A.5**  
**Results of Air Pollutant Concentration at Elephanta Island During**  
**10<sup>th</sup> to 11<sup>th</sup> October, 2013**

STATION	DATE	TIME (Hrs)	TSP µg/m <sup>3</sup>	PM <sub>10</sub> µg/m <sup>3</sup>	NO <sub>x</sub> µg/m <sup>3</sup>	SO <sub>2</sub> µg/m <sup>3</sup>	NH <sub>3</sub> µg/m <sup>3</sup>	CO mg/m <sup>3</sup>	CO <sub>2</sub> ppm
STANDARD →			100 µg/m <sup>3</sup>	100 µg/m <sup>3</sup>	80 µg/m <sup>3</sup>	80 µg/m <sup>3</sup>	400 µg/m <sup>3</sup>	2.0 mg/m <sup>3</sup>	-
EC	10/10/13	2:00-8:00	54	26	3.7	1.3	25.3	1.65	304
	11/10/13	8:10-6:10			4.0	2.6	19.9	1.67	302
	11/10/13	6:15-2:15			4.2	2.5	27.3	1.63	305

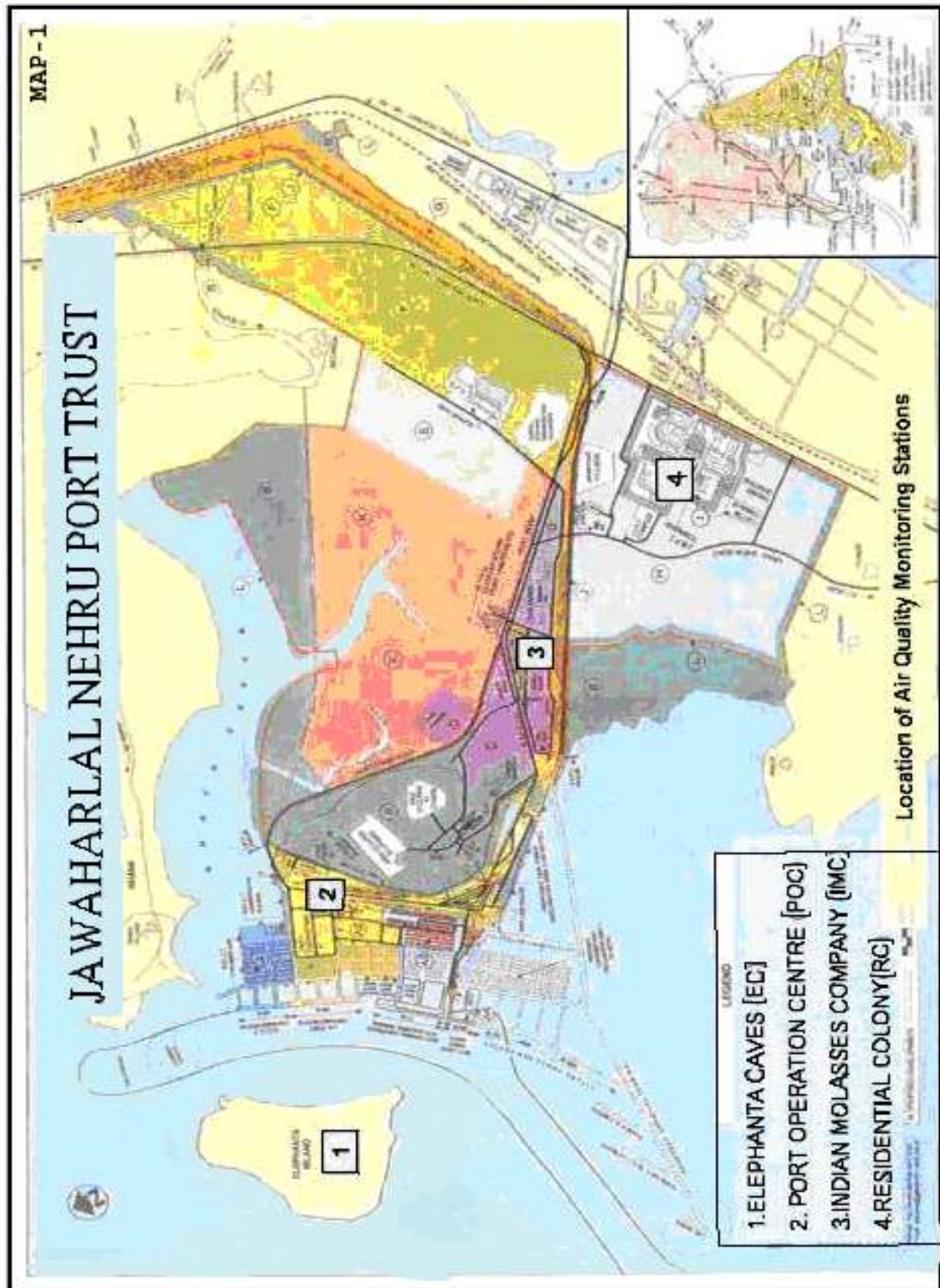
EC-ELEPHANTA CAVES

(\*) indicates the value is above the prescribed CPCB Standard

**Table A.6**  
**Monthly Average Values of Air Pollutant Concentration at Various Stations of JNP**  
**Area during the Month of October, 2013 and their Respective CPCB Standards**

STATION	TSP µg/m <sup>3</sup>	PM <sub>10</sub> µg/m <sup>3</sup>	NO <sub>x</sub> µg/m <sup>3</sup>	SO <sub>2</sub> µg/m <sup>3</sup>	NH <sub>3</sub> µg/m <sup>3</sup>	CO mg/m <sup>3</sup>
<b>Industrial areas</b>						
<b>NAAQ STDS.</b>	<b>200</b>	<b>100</b>	<b>80</b>	<b>80</b>	<b>400</b>	<b>2.0</b>
IMC	126±25.4	73±13	12.8±3.0	3.9±1.1	46.3 ±9.8	1.80±0.05
POC	83±14	40±9	9.7±3.2	2.5±0.7	34.8 ±6.4	1.75±0.07
<b>Residential and Rural Areas</b>						
<b>NAAQ STDS.</b>	<b>200</b>	<b>100</b>	<b>80</b>	<b>80</b>	<b>400</b>	<b>2.0</b>
RC	72±8	39±4	8.0±1.3	3.0±1.0	30.6±7.1	1.69±0.05
<b>Sensitive Areas</b>						
<b>NAAQ STDS.</b>	<b>100</b>	<b>100</b>	<b>80</b>	<b>80</b>	<b>400</b>	<b>2.0</b>
EC	54	26	4.0	2.1	24.2	1.65

Values as mean ± std deviation



**Table A.7**  
**Results of Air Pollutant Concentration at RC Station of JNP Area during the Month of October, 2013**

SR. NO	STATION	DATE	TIME (Hrs)	TSP ( $\mu\text{g}/\text{m}^3$ )	PM <sub>10</sub> $\mu\text{g}/\text{m}^3$	NO <sub>x</sub> $\mu\text{g}/\text{m}^3$		SO <sub>2</sub> $\mu\text{g}/\text{m}^3$		NH <sub>3</sub> $\mu\text{g}/\text{m}^3$		CO $\text{mg}/\text{m}^3$	CO <sub>2</sub> ppm
						8 hr	24 hr Avg	8 hr	24 hr Avg	8 hr	24 hr Avg		
	<b>STANDARD</b>			200 $\mu\text{g}/\text{m}^3$	100 $\mu\text{g}/\text{m}^3$	80 $\mu\text{g}/\text{m}^3$		80 $\mu\text{g}/\text{m}^3$		400 $\mu\text{g}/\text{m}^3$		2.0 $\text{mg}/\text{m}^3$	-
1	RC-I	03/10/13	03:30-11:30			8.2		2.4		46.1		1.65	
		04/10/13	11:30-07:30	80	42	8.2	7.3	2.6	2.9	30.1	38.0	1.68	303
		04/10/13	07:30-03:30			5.4		3.8		37.8		1.67	
2	RC-II	07/10/13	03:30-11:30			8.2		2.6		30.1		1.60	
		08/10/13	11:30-07:30	70	39	8.8	8.0	4.2	3.2	33.5	36.6	1.69	307
		08/10/13	07:30-03:30			7.1		2.8		46.3		1.73	
3	RC-III	10/10/13	03:30-11:30			9.8		2.9		32.6		1.76	
		11/10/13	11:30-07:30	64	36	9.0	8.8	2.6	2.2	27.6	29.2	1.67	304
		11/10/13	07:30-03:30			7.5		1.3		27.3		1.65	
4	RC-IV	14/10/13	03:30-11:30			6.0		5.2		26.2		1.68	
		15/10/13	11:30-07:30	70	38	9.0	7.3	2.5	3.9	27.0	25.0	1.61	306
		15/10/13	07:30-03:30			6.9		3.9		21.9		1.77	
5	RC-V	17/10/13	03:30-11:30			8.8		2.8		27.1		1.70	
		18/10/13	11:30-07:30	66	36	8.7	8.3	1.4	1.8	41.8	34.2	1.73	305
		18/10/13	07:30-03:30			7.4		1.3		33.8		1.65	
6	RC-VI	21/10/13	03:30-11:30			6.5		2.6		20.1		1.69	
		22/10/13	11:30-07:30	64	35	6.3	7.4	3.5	3.3	24.8	24.0	1.72	305
		22/10/13	07:30-03:30			9.6		3.8		27.0		1.64	
7	RC-VII	22/10/13	03:30-11:30			7.7		5.1		35.7		1.65	
		24/10/13	11:30-07:30	80	44	7.6	8.8	2.3	3.3	30.1	30.2	1.71	306
		25/10/13	07:30-03:30			11.1		2.6		24.8		1.72	
8	RC-VIII	28/10/13	03:30-11:30			7.9		3.9		25.1		1.76	
		29/10/13	11:30-07:30	82	45	7.5	8.2	2.9	3.1	22.3	27.6	1.68	304
		29/10/13	07:30-03:30			9.2		2.5		35.5		1.64	
9													

**Table A.8**  
**Results of Air Pollutant Concentration at IMC Station of JNP Area during the Month of October, 2013**

SR. NO	STATION	DATE	TIME (Hrs)	TSP ( $\mu\text{g}/\text{m}^3$ )	PM <sub>10</sub> $\mu\text{g}/\text{m}^3$	NO <sub>x</sub> $\mu\text{g}/\text{m}^3$		SO <sub>2</sub> $\mu\text{g}/\text{m}^3$		NH <sub>3</sub> $\mu\text{g}/\text{m}^3$		CO mg/m <sup>3</sup>	CO <sub>2</sub> ppm
						8 hr	24 hr Avg	8 hr	24 hr Avg	8 hr	24 hr Avg		
1	IMC-I	03/10/13	03:00-11:00	200	100	10.6	80	5.2	80	63.4	400	2.0	-
		04/10/13	11:00-07:00	116	64	11.1	10.8	4.3	4.4	50.9	55.3	1.69	311
		04/10/13	07:00-03:00			10.6		3.8		51.6		1.78	
2	IMC-II	07/10/13	03:00-11:00	118	70	9.9	11.3	3.9	4.0	55.8	60.0	1.68	307
		08/10/13	11:00-07:00			10.5		5.6		68.2		1.88	
		08/10/13	07:00-03:00			13.4		2.5		56.0		1.81	
3	IMC-III	10/10/13	03:00-11:00	125	76	15.4	15.5	2.6	3.2	37.6	39.4	1.82	312
		11/10/13	11:00-07:00			20.2		2.9		36.9		1.76	
		11/10/13	07:00-03:00			10.9		4.2		43.8		1.78	
4	IMC-IV	14/10/13	03:00-11:00	124	74	12.2	15.1	5.2	4.7	34.5	43.2	1.70	317
		15/10/13	11:00-07:00			14.7		2.5		44.6		1.71	
		15/10/13	07:00-03:00			18.5		3.9		50.7		1.83	
5	IMC-V	17/10/13	03:00-11:00	106	56	11.0	13.8	3.9	3.1	43.9	45.3	1.86	316
		18/10/13	11:00-07:00			12.2		2.9		50.2		1.77	
		18/10/13	07:00-03:00			18.3		2.5		41.9		1.72	
6	IMC-VI	21/10/13	03:00-11:00	112	60	9.2	11.9	2.6	3.4	29.6	37.0	1.81	308
		22/10/13	11:00-07:00			12.2		3.9		43.9		1.75	
		22/10/13	07:00-03:00			14.2		3.8		37.6		1.73	
7	IMC-VII	22/10/13	03:00-11:00	140	82	11.1	11.4	5.2	5.0	57.1	46.8	1.82	312
		24/10/13	11:00-07:00			12.3		5.2		43.9		1.77	
		25/10/13	07:00-03:00			11.0		4.6		39.3		1.80	
8	IMC-VIII	28/10/13	03:00-11:00	186	98	9.9	12.9	2.8	4.5	37.2	42.9	1.74	310
		29/10/13	11:00-07:00			12.4		5.1		35.7		1.82	
		29/10/13	07:00-03:00			16.2		5.7		55.7		1.85	
9													

**Table A.9**  
**Results of Air Pollutant Concentration at POC Station of JNP Area during the Month of October, 2013**

SR. NO	STATION	DATE	TIME (Hrs)	TSP ( $\mu\text{g}/\text{m}^3$ )	PM <sub>10</sub> ( $\mu\text{g}/\text{m}^3$ )	NO <sub>x</sub> $\mu\text{g}/\text{m}^3$		SO <sub>2</sub> $\mu\text{g}/\text{m}^3$		NH <sub>3</sub> $\mu\text{g}/\text{m}^3$		CO mg/m <sup>3</sup>	CO <sub>2</sub> ppm
STANDARD				200 $\mu\text{g}/\text{m}^3$	100 $\mu\text{g}/\text{m}^3$	8 hr	24 hr Avg	8 hr	24 hr Avg	8 hr	24 hr Avg	2.0 mg/m <sup>3</sup>	-
1	POC-I	03/10/13	02:30-10:30	72	32	6.3	7.3	2.6	2.1	38.8	41.7	1.65	308
		04/10/13	10:30-06:30			8.1		2.6		45.5		1.67	
		04/10/13	06:30-02:30			7.5		1.1		40.9		1.76	
2	POC-II	07/10/13	02:30-10:30	80	36	9.9	8.4	1.4	2.3	35.8	32.5	1.81	305
		08/10/13	10:30-06:30			10.5		2.9		32.6		1.77	
		08/10/13	06:30-02:30			13.4		2.5		29.2		1.67	
3	POC-III	10/10/13	02:30-10:30	66	30	15.4	10.2	2.3	2.8	24.8	31.6	1.65	310
		11/10/13	10:30-06:30			20.2		3.8		35.5		1.77	
		11/10/13	06:30-02:30			10.9		2.3		34.5		1.86	
4	POC-IV	14/10/13	02:30-10:30	74	34	9.5	8.4	2.6	1.7	33.0	30.2	1.81	316
		15/10/13	10:30-06:30			9.8		1.3		30.7		1.78	
		15/10/13	06:30-02:30			6.0		1.3		27.0		1.69	
5	POC-V	17/10/13	02:30-10:30	92	46	8.0	9.2	3.9	3.0	30.1	36.6	1.75	312
		18/10/13	10:30-06:30			9.7		2.5		35.6		1.73	
		18/10/13	06:30-02:30			10.0		2.6		44.1		1.83	
6	POC-VI	21/10/13	02:30-10:30	88	42	9.7	10.2	2.6	2.8	31.7	37.3	1.81	315
		22/10/13	10:30-06:30			11.9		2.8		52.2		1.69	
		22/10/13	06:30-02:30			9.0		2.9		28.0		1.64	
7	POC-VII	22/10/13	02:30-10:30	110	56	9.8	9.1	2.4	2.9	36.6	34.5	1.77	308
		24/10/13	10:30-06:30			9.0		3.8		30.0		1.83	
		25/10/13	06:30-02:30			8.6		2.5		36.8		1.72	
8	POC-VIII	28/10/13	02:30-10:30	82	40	6.6	6.1	2.3	2.7	39.0	32.5	1.77	311
		29/10/13	10:30-06:30			5.8		2.6		34.5		1.80	
		29/10/13	06:30-02:30			6.0		2.8		28.2		1.84	
9													

## 1.4 Conclusions and Mitigations Measures

Table A.6 shows the overall average values of TSP, PM<sub>10</sub> and all gaseous pollutants at all three sampling stations.

CPCB standards for ambient air quality for different areas are given in Table A. 6. All pollutants were found within prescribed limits at EC station for October 2013.

The following mitigation measures can be taken to reduce high TSP and PM<sub>10</sub> levels in and around the port area during construction time:

- Cleaning of paved and unpaved roads regularly to remove spillage of earth/soil material during transportation.
- Maintaining road pavement at IMC area regularly or using paver blocks as far as possible wherever heavy loads movement occurs.
- Spraying water on dusty road surfaces on regular intervals with more frequency in noon hours at various locations and all construction areas to avoid re-suspension.
- Good housekeeping during road cleaning to avoid dust resuspension by transportation of heavy 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.
- Regular PUC check up and maintenance of vehicles plying in the port.

**PART-A****Chapter-2: Marine Water Quality Monitoring****2.1 HARBOUR AREA****2.1.1 Introduction**

Nine sites are identified for water sampling as per the Environment Management plan. Water samples are collected from harbour region in and around JNP area.

The **Objectives** of Marine water Quality Monitoring are as follows,

- Indicate the state of health of marine waters;
- Assess compliance with the statutory Water Quality Objectives (WQOs);
- Reveal long-term changes in water quality;
- Provide a basis for the planning of pollution control strategies.

**Method of 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 cycles. The samples were collected after 1<sup>st</sup>, 3<sup>rd</sup> and 5<sup>th</sup> hour of flood and ebb tide and composite. In all 54 samples will be collected from eight fixed and one moving station every month. In addition the Sediment samples will be collected from all these stations to estimate total organic matter, organic carbon and inorganic phosphate. Table W.1 provides the Description of Water Quality Monitoring stations (Harbour Region).

**Table: W.1**  
**Description of Water Quality Monitoring stations (Harbour Region)**

Station Name	Location/Landmark	Date of Water Sampling
<b>W1</b>	Near ONGC	<b>10<sup>th</sup> October, 2013</b>
<b>W2</b>	Elephanta Jetty	<b>10<sup>th</sup> October, 2013</b>
<b>W3</b>	In-between Vessel channel	<b>11<sup>th</sup> October, 2013</b>
<b>W4</b>	Near Butcher Island	<b>11<sup>th</sup> October, 2013</b>
<b>W5</b>	Near NSICT	<b>10<sup>th</sup> October, 2013</b>
<b>W6</b>	JNPT Shallow Berth	<b>10<sup>th</sup> October, 2013</b>
<b>W7</b>	Towards Landing Jetty	<b>11<sup>th</sup> October, 2013</b>
<b>W9</b>	Near GTI Warf	<b>11<sup>th</sup> October, 2013</b>
<b>W10</b>	Near Mora village	<b>11<sup>h</sup> October, 2013</b>

Table W. 3 & W.4 provides the results for each of the water quality parameters sampled at various water quality monitoring stations of Harbour area of JNP from 10<sup>th</sup> & 11<sup>th</sup> October, 2013.

## 2.1.2 Results and Discussion

Following parameters are checked for the samples collected at the nine stations for pH, temperature, salinity, turbidity, TDS, SS, TS, DO, COD, BOD, and NH<sub>4</sub><sup>+</sup>-N, SPC, Coliform count, Phenol and Oil & Grease during the sampling period.

**Table: W. 2**

### **Minimum & Maximum concentrations of various parameters for Harbour region**

Sr. No	Parameter	Observed Range	CPCB Limits	Method Used	Reference
1	pH	7.4- 8.1	6.5-9.0	pH meter	IS 3025 (Part 11)
2	Temperature	26.9- 29.7°C	-	Thermometer	APHA 2550-B
3	Salinity	31.6- 42.4 ppt	-	Argentometric Titration	IS 3025 (Part 32)
4	Turbidity	69- 321 NTU	-	Nephelometer	IS 3025 (Part 10)
5	TDS	31250- 41672 mg/L	-	Gravimetry	IS 3025 (Part 16)
6	SS	251- 356 mg/L	-	Gravimetry	IS 3025 (Part 16)
7	TS	31504- 41997 mg/L	-	-	-
8	DO	5.4- 6.5 mg/L	3.0 mg/L or 40% of the higher saturation value	DO meter	-
9	COD	58- 138 mg/L	-	Potassium Dichromate	IS 3025 (Part 58)
10	BOD	<5- 5.5 mg/ L	5 mg/L	DO consumption on in 5days at 20°C	IS 3025 (Part 44)
11	NH <sub>4</sub> <sup>+</sup> -N	0.09- 0.23 mg/L	-	Colorimetry	IS 3025 (Part 34)
12	SPC	94- 378 / ml	-	Pour plate	IS 1622 1981
13	Coliform	<2- 19 CFU/ 100 ml	500/100 ml	Membrane Filtration	IS 1622- 1981
14	Phenol	BDL- 0.04 mg/ L	-	Titrimetric	IS 3025 (Part 43)
15	Oil & Grease	5- 14 mg/ L	10 mg/L	Solvent Extraction	IS 3025 (Part 39)



The maximum concentration of oil and grease (14 mg/L) was found at W3 station during neap tide, the minimum concentration (5 mg/L) was found during spring tide of W2 station.

The values of various water quality parameters such as pH, dissolved oxygen, oil and grease, CFU and BOD obtained during the month of October, 2013 are compared with the primary water quality criteria for class IV waters (Harbour waters) given by Central Pollution Control Board (CPCB) in Table S.2. They were found to be within the range for these parameters except BOD & Oil and Grease. The concentration of BOD was below the CPCB standard at all the stations except during neap tide of W2 & W3 stations. The concentration of oil and grease was below the CPCB standard at all the stations except at neap tide of W1, W3 & W10 stations.

**Table W. 3**  
**Results of Physico- Chemical Analysis of Water Samples Collected From JNP**  
**Harbor Area during October, 2013**

Water Quality during October, 2019									
Sample Name	Depth (m)	Temp. ( °C)	pH	Salinity (ppt)	Turbidity (NTU)	TDS (mg/L)	TSS (mg/L)	TS (mg/L)	
Standards	NA	NA	6.5-9.0	NA	NA	NA	NA	NA	
W1									
	SS	7.7	28.5	7.5	41.5	089	32465	259	32724
	SM		28.6	7.9	34.3	103	33659	356	34015
	SB		28.6	7.4	32.5	096	40598	341	40939
	NS	7.5	28.4	8.0	31.6	113	41214	289	41503
	NM		28.4	8.1	34.3	231	37894	274	38168
NB	28.4		8.0	35.2	198	36954	265	37219	
W2									
	SS	5.8	28.8	7.9	37.0	209	31250	254	31504
	SM		28.4	7.8	37.9	117	33245	299	33544
	SB		28.1	7.7	36.1	254	36987	309	37296
	NS	4.5	28.8	7.8	34.3	283	38452	313	38765
	NM		28.4	7.9	38.8	274	39524	352	39876
NB	28.1		7.6	39.7	069	40265	333	40598	
W3									
	SS	8.2	27.5	7.5	42.4	289	41000	310	41310
	SM		27.9	7.5	38.8	201	32699	300	32999
	SB		27.9	7.8	37.0	320	36985	251	37236
	NS	8.3	26.9	7.9	36.1	317	37415	283	37698
	NM		27.2	7.7	34.3	306	38555	344	38899
NB	27.3		7.9	35.2	269	39635	264	39899	
W4									
	SS	8.3	27.5	8.0	37.9	285	40269	274	40543
	SM		27.5	8.1	39.7	121	40998	285	41283
	SB		27.5	8.0	37.9	097	33897	299	34196
	NS	8.8	27.2	7.4	34.3	211	31253	290	31543
	NM		27.1	7.9	32.5	207	32554	301	32855
NB	27.1		7.5	41.5	116	41672	325	41997	
W5									
	SS	13.8	28.3	7.8	39.7	134	33457	346	33803
	SM		28.4	7.7	36.1	166	35698	347	36045
	SB		28.4	7.6	37.9	179	36954	322	37276
	NS	13.5	28.3	7.9	40.6	200	35896	255	36151
	NM		28.3	7.9	37.0	301	32658	274	32932
NB	28.3		8.0	37.9	319	36984	277	37261	

SS - SPRING SURFACE; SM - SPRING MIDDLE; SB - SPRING BOTTOM; NS-NEAP SURFACE  
 NM - NEAP MIDDLE; NB - NEAP BOTTOM  
 NS#- NEAP SAMPLE, SS #- SURFACE SAMPLE; BDL- BELOW DETECTABLE LIMIT  
 (\*) indicates the values exceeding the standard

Contd.....

Sample Name		Depth (m)	Temp. ( °C)	pH	Salinity (ppth)	Turbidity (NTU)	TDS (mg/L)	TSS (mg/L)	TS (mg/L)
Standards		NA	NA	6.5-9.0	NA	NA	NA	NA	NA
W6									
	SS	12.3	29.7	8.1	39.7	304	37451	296	37747
	SM		29.7	8.1	38.8	272	36894	306	37200
	SB		29.3	7.7	37.0	255	39325	316	39641
	NS	11.2	28.9	7.8	36.1	321	41230	346	41576
	NM		28.7	7.9	38.8	233	39658	328	39986
NB	28.5		7.9	37.9	264	40009	307	40316	
W7									
	SS	7.3	28.2	7.6	38.8	284	39546	351	39897
	SM		28.0	7.5	33.4	288	38551	322	38873
	SB		27.7	7.9	37.0	293	34856	310	35166
	NS	6.8	28.9	7.8	38.8	200	36998	296	37294
	NM		28.4	7.7	40.6	300	32445	258	32703
NB	28.0		7.9	41.5	307	31988	258	32246	
W9									
	SS	5.5	28.6	8.1	37.9	312	35684	269	35953
	SM		28.4	7.8	36.1	317	36548	271	36819
	SB		28.2	8.0	37.9	244	40896	289	41185
	NS	3.5	27.9	8.1	34.3	215	41007	266	41273
	NM		27.7	7.9	35.2	073	36989	349	37338
NB	27.5		7.7	36.1	089	34556	355	34911	
W10									
	SS	12.2	27.8	7.8	39.7	118	32859	341	33200
	SM		27.5	7.9	38.8	141	33597	308	33905
	SB		27.5	7.7	37.0	169	34784	312	35096
	NS	11.7	27.0	7.9	36.1	198	37784	300	38084
	NM		27.4	8.1	37.9	122	38454	327	38781
NB	27.1		8.0	37.0	109	39364	346	39710	

SS - SPRING SURFACE; SM -SPRING MIDDLE; SB - SPRING BOTTOM; NS – NEAP SURFACE NM - NEAP MIDDLE; NB - NEAP BOTTOM

NS#- NEAP SAMPLE, SS #- SURFACE SAMPLE; BDL- BELOW DETECTABLE LIMIT

(\*) indicates the values exceeding the standard

**Table W. 4**  
**Results of Bio-chemical Analysis of Water Samples Collected From JNP Harbor**  
**Area during October, 2013**

Sample Name	DO (mg/L)	COD (mg/L)	BOD (mg/L)	NH <sub>4</sub> <sup>+</sup> -N (mg/L)	Phenol (mg/L)	Oil & Grease (mg/L)	SPC (Per ml)	Coliform Count (per 100 ml)
<b>Standards</b>	3.0 or 40% of the saturation value	NA	5	NA	NA	10	NA	500 (MPN)
<b>W1</b>	SS#					10		
	SS	6.0	77	<5	0.11	BDL	119	<2
	SM	5.8	112					
	SB	5.6	99					
	NS#					11*		
	NS	5.8	93	<5	0.2	0.02	134	6
	NM	5.7	70					
	NB	5.6	58					
<b>W2</b>	SS#					05		
	SS	5.9	83	<5	0.21	BDL	378	<2
	SM	5.8	109					
	SB	5.8	122					
	NS#					09		
	NS	6.0	138	5.3*	0.09	0.03	284	<2
	NM	5.9	131					
	NB	5.8	115					
<b>W3</b>	SS#					06		
	SS	6.5	83	<5	0.1	0.02	263	11
	SM	6.5	99					
	SB	6.4	128					
	NS#					14*		
	NS	6.5	106	5.5*	0.16	0.04	247	<2
	NM	6.5	83					
	NB	6.4	86					
<b>W4</b>	SS#					07		
	SS	6.0	96	<5	0.19	BDL	222	<2
	SM	5.8	134					
	SB	5.8	112					
	NS#					06		
	NS	6.2	83	<5	0.23	BDL	155	18
	NM	5.8	102					
	NB	5.8	77					
<b>W5</b>	SS#					07		
	SS	6.0	90	<5	0.22	0.02	149	<2
	SM	5.9	86					
	SB	5.7	112					
	NS#					09		
	NS	5.8	128	<5	0.18	0.03	098	<2
	NM	5.8	115					
	NB	5.7	99					

(\*) indicates the values exceeding the standard

Contd.....

Sample Name		DO (mg/L)	COD (mg/L)	BOD (mg/L)	NH <sub>4</sub> <sup>+</sup> -N (mg/L)	Phenol (mg/L)	Oil & Grease (mg/L)	SPC (Per ml)	Coliform Count (per100 ml)
Standards		3.0 or 40% of the saturation value	NA	5	NA	NA	10	NA	500 (MPN)
W6	SS#						10		
	SS	5.8	122	<5	0.17	BDL		124	19
	SM	5.8	118						
	SB	5.8	83						
	NS#						10		
	NS	5.5	64	<5	0.1	0.04		094	10
	NM	5.4	70						
	NB	5.4	109						
W7	SS#						07		
	SS	6.2	77	<5	0.13	0.02		137	<2
	SM	6.1	83						
	SB	6.1	64						
	NS#						08		
	NS	5.8	90	<5	0.14	BDL		140	<2
	NM	5.8	109						
	NB	5.6	115						
W9	SS#						06		
	SS	6.2	128	<5	0.22	0.01		264	<2
	SM	6.5	131						
	SB	6.5	77						
	NS#						07		
	NS	5.8	64	<5	0.2	0.02		247	<2
	NM	5.8	77						
	NB	5.8	83						
W10	SS#						08		
	SS	5.8	131	<5	0.12	BDL		294	13
	SM	5.9	67						
	SB	6.2	70						
	NS#						12*		
	NS	6.2	74	<5	0.11	0.04		303	7
	NM	6.2	102						
	NB	6.3	106						

SS - SPRING SURFACE; SM -SPRING MIDDLE; SB - SPRING BOTTOM; NS – NEAP SURFACE NM - NEAP MIDDLE; NB - NEAP BOTTOM

NS#- NEAP SAMPLE, SS #- SURFACE SAMPLE; BDL- BELOW DETECTABLE LIMIT

(\*) indicates the values exceeding the standard

**Table W.5**  
**Results of Sediment Samples Collected From JNP Harbor Area during October, 2013**

Sediment Sample		Organic matter		Total carbon content		Inorganic phosphate µg/g
	Time, Hr	mg/g	%	mg/g	%	
Standards		N.A.	N.A.	N.A.	N.A.	N.A.
W1	1 <sup>st</sup> S	12.2	1.2	07.1	0.7	29.0
	3 <sup>rd</sup> S	14.3	1.4	08.2	0.8	38.5
	5 <sup>th</sup> S	16.8	1.7	10.2	1.0	27.5
	1 <sup>st</sup> N	17.7	1.8	10.9	1.1	27.0
	3 <sup>rd</sup> N	26.9	2.7	15.8	1.6	28.0
	5 <sup>th</sup> N	20.1	2.0	11.7	1.2	31.0
W2	1 <sup>st</sup> S	29.3	2.9	16.6	1.7	31.5
	3 <sup>rd</sup> S	24.7	2.5	13.9	1.4	32.0
	5 <sup>th</sup> S	23.6	2.4	14.1	1.4	30.0
	1 <sup>st</sup> N	19.1	1.9	10.6	1.1	34.5
	3 <sup>rd</sup> N	22.3	2.2	13.2	1.3	35.0
	5 <sup>th</sup> N	17.8	1.8	11.1	1.1	37.5
W3	1 <sup>st</sup> S	10.2	1.0	06.2	0.6	37.0
	3 <sup>rd</sup> S	09.1	0.9	05.1	0.5	35.5
	5 <sup>th</sup> S	10.3	1.0	06.3	0.6	34.5
	1 <sup>st</sup> N	11.2	1.1	06.4	0.6	33.0
	3 <sup>rd</sup> N	22.6	2.3	13.2	1.3	22.0
	5 <sup>th</sup> N	19.8	2.0	11.7	1.2	24.5
W4	1 <sup>st</sup> S	17.7	1.8	10.1	1.0	32.0
	3 <sup>rd</sup> S	18.2	1.8	10.9	1.1	34.5
	5 <sup>th</sup> S	06.3	0.6	04.3	0.4	31.5
	1 <sup>st</sup> N	08.1	0.8	05.1	0.5	33.5
	3 <sup>rd</sup> N	07.2	0.7	04.3	0.4	35.0
	5 <sup>th</sup> N	21.3	2.1	11.9	1.2	36.5
W5	1 <sup>st</sup> S	08.4	0.8	05.4	0.5	33.5
	3 <sup>rd</sup> S	20.6	2.1	12.3	1.2	32.5
	5 <sup>th</sup> S	21.7	2.2	13.1	1.3	30.0
	1 <sup>st</sup> N	27.9	2.8	15.9	1.6	33.0
	3 <sup>rd</sup> N	28.6	2.9	16.7	1.7	35.0
	5 <sup>th</sup> N	23.9	2.4	13.8	1.4	37.0
W6	1 <sup>st</sup> S	21.7	2.2	12.6	1.3	34.0
	3 <sup>rd</sup> S	26.3	2.6	14.6	1.5	31.5
	5 <sup>th</sup> S	29.1	2.9	17.1	1.7	34.5
	1 <sup>st</sup> N	31.1	3.1	18.2	1.8	35.0
	3 <sup>rd</sup> N	34.1	3.4	19.2	1.9	36.0
	5 <sup>th</sup> N	35.9	3.6	20.3	2.1	35.5

S - SPRING, N - NEAP, 1ST - FIRST HOUR, 3RD - THIRD HOUR, 5TH - FIFTH HOUR.

(\*) indicates the values exceeding the standard

Sediment Sample		Organic matter		Total carbon content		Inorganic phosphate µg/g
	Time, Hr	mg/g	%	mg/g	%	
Standards		NA	NA	NA	NA	NA
W7	1 <sup>st</sup> S	17.8	1.8	10.9	1.1	37.0
	3 <sup>rd</sup> S	09.3	0.9	05.1	0.5	34.5
	5 <sup>th</sup> S	10.1	1.0	06.3	0.6	32.0
	1 <sup>st</sup> N	09.2	0.9	05.1	0.5	31.5
	3 <sup>rd</sup> N	26.7	2.7	14.8	1.5	30.5
	5 <sup>th</sup> N	32.9	3.3	18.9	1.9	30.0
W9	1 <sup>st</sup> S	28.7	2.9	16.7	1.7	29.0
	3 <sup>rd</sup> S	26.9	2.7	14.9	1.5	34.0
	5 <sup>th</sup> S	27.1	2.7	14.6	1.5	33.0
	1 <sup>st</sup> N	19.2	1.9	10.8	1.1	31.5
	3 <sup>rd</sup> N	23.3	2.3	12.6	1.3	35.0
	5 <sup>th</sup> N	27.1	2.7	14.1	1.5	37.0
W10	1 <sup>st</sup> S	24.1	2.4	14.3	1.4	35.5
	3 <sup>rd</sup> S	21.9	2.2	12.8	1.3	36.0
	5 <sup>th</sup> S	32.2	3.3	18.7	1.9	34.0
	1 <sup>st</sup> N	31.3	3.2	19.2	1.9	32.5
	3 <sup>rd</sup> N	21.9	2.2	13.4	1.3	31.5
	5 <sup>th</sup> N	24.8	2.5	14.3	1.4	30.0

S - SPRING, N - NEAP, 1ST - FIRST HOUR, 3RD - THIRD HOUR, 5TH - FIFTH HOUR.

(\*) indicates the values exceeding the standard

Table W.5 provides the results for each of the sediment quality parameters sampled at various water quality monitoring stations from JNP harbor area for the month of October, 2013. The organic matter, total carbon content and inorganic phosphate in the sediment samples collected during the month of September, 2012 were found to be in the range of 0.6- 3.6 %, 0.4- 2.1 %, and 22.0- 38.5 µg/g.

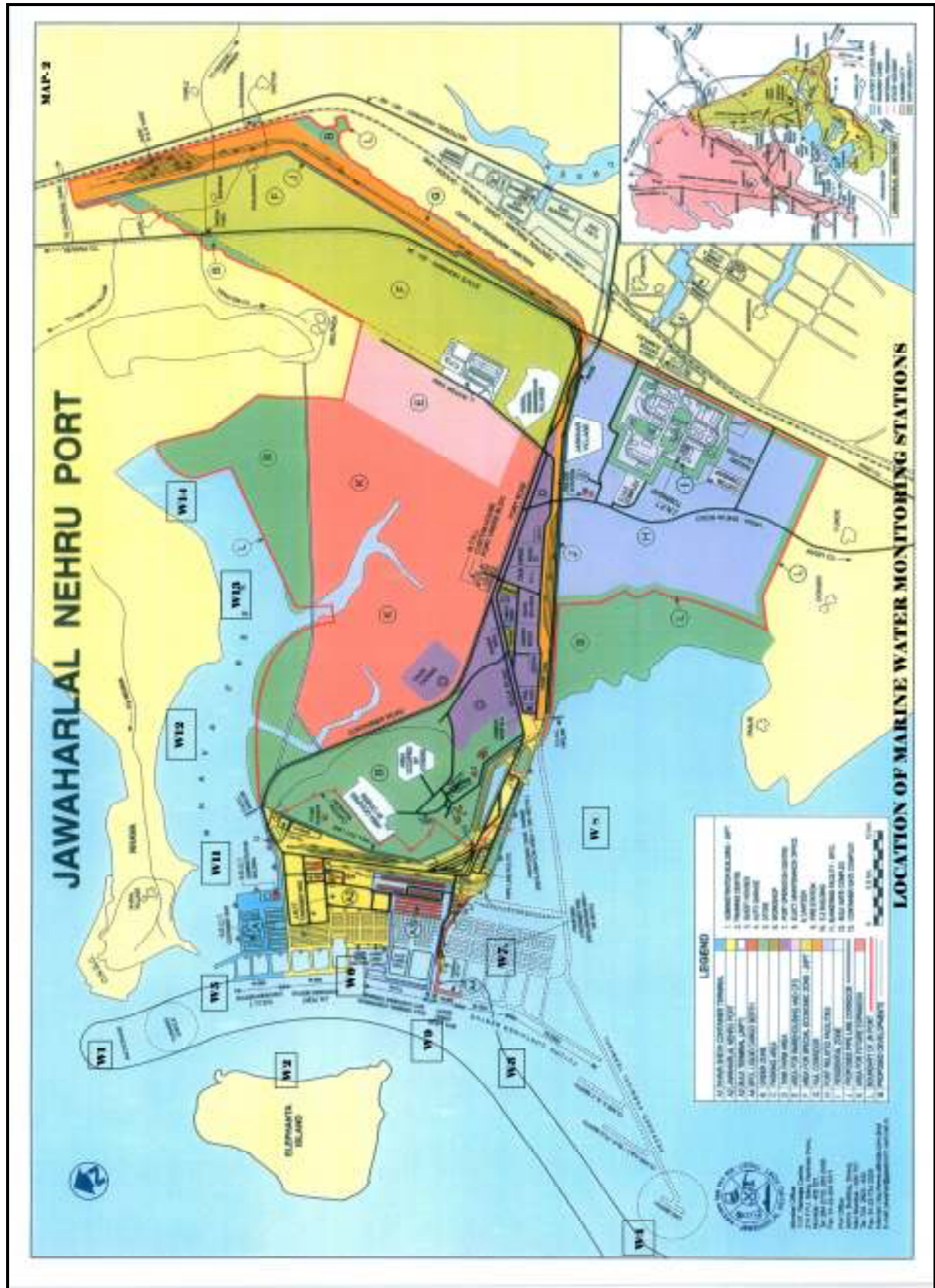
### 2.1.3 CONCLUSIONS

Definite correlation between turbidity and suspended solids could not be established. This could be due to presence of fine sediments in suspension also since turbidity depends upon the particle size and the refractive properties of the particles. Locations of various water quality monitoring stations are given in MAP 2. The standards for marine water quality are given in Table S.2.

Comparison with the standards (primary water quality criteria for class SW-IV waters (for harbour waters), observations and their mitigation measures are mentioned in the Table.W. 6

**Table W.6**  
**Conclusions and Mitigation Measures of Results for Water Samples Collected from Harbour During October, 2013**

Sr. No.	Parameter	Criteria	Observation (above/below) standard	Reasons	Mitigation measures
1	pH range	6.5 - 9.0	7.4- 8.1	-	-
2	Dissolved Oxygen	3.0 mg/L or 40 % of the saturation value, whichever is higher	5.4- 6.5 mg/L	-	-
3	Colour and Odour	No visible colour or offensive order	No visible colour or distinct odour was observed	-	-
4	Floating objects oil, grease and scum (including the petroleum products)	10 mg/L	5- 14 mg/ L Below at all stations except neap tide at W1, W3 & W10 stations.	This could be due to indiscriminate discharge of oil contaminated bilge water from launches moving from Gateway of India to Elephanta and JNP Jetty and from motorized fishing boats and vessels moving in the harbor waters of JNP and adjacent areas.	Strict management actions to be undertaken to avoid indiscriminate discharge of oil or oil contaminated water.
5	Fecal Coliform	500 per 100 ml (MPN)	<2 – 19 CFU /100 ml	-	-
6	Biochemical Oxygen Demand	5 mg/L	<5- 5.5 mg/L Below at all stations except neap tide at W2 W3 Stations.	Wastewater runoff from nearby areas, or waste dumping from launches and vessels.	Avoid indiscriminate drainage of waste or wastewater into sea water.



## 2.2 NHAVA CREEK

### 2.2.1 INTRODUCTION

Four sites are identified for water sampling as per the Environment Management plan. Water samples are collected from creek region in and around JNP area. Table W.7 provides the Description of Water Quality Monitoring stations (Creek Region).

#### Method of 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 cycles. The samples were collected after 1<sup>st</sup>, 3<sup>rd</sup> and 5<sup>th</sup> hour of flood and ebb tide and composite. In all 54 samples will be collected from eight fixed and one moving station every month. In addition the Sediment samples will be collected from all these stations to estimate total organic matter, organic carbon and inorganic phosphate.

**Table: W.7**

**Description of Water Quality Monitoring stations (Creek Region)**

Station Name	Location/Landmark	Date of Water Sampling
<b>W11</b>	At mouth of Nhava Creek	<b>9<sup>th</sup> October, 2013</b>
<b>W12</b>	Near Nhava Village	<b>9<sup>th</sup> October, 2013</b>
<b>W13</b>	Opposite North Gate	<b>9<sup>th</sup> October, 2013</b>
<b>W14</b>	Towards end of the Creek	<b>9<sup>th</sup> October, 2013</b>

Table W. 9 and W. 10 provides the results for each of the water quality parameters sampled at various water quality monitoring stations in the Nhava creek for the month of October, 2013.

### 2.2.2 RESULTS AND DISCUSSION

The range of values at nine stations for pH, temperature, salinity, turbidity, TDS, SS, TS, DO, COD, BOD, NH<sub>4</sub><sup>+</sup>-N, SPC, Coliform count, Phenol and Oil & Grease during the period as shown below,

**Table: W. 8**

**Minimum & Maximum concentrations of various parameters for Creek Region**

Sr. No.	Parameter	Observed Range	Prescribed Limits	Method Used	Reference
1	pH	7.6- 8.3	6.5-9.0	pH meter	IS 3025 (Part 11)
2	Temperature	29.1- 32.9 °C	-	Thermometer	APHA 2550-B
3	Salinity	33.4- 42.4 ppt	-	Argentometric Titration	IS 3025 (Part 32)
4	Turbidity	49- 288 NTU	-	Nephelometer	IS 3025 (Part 10)
5	TDS	32751- 42560 mg/L	-	Gravimetry	IS 3025 (Part 16)
6	SS	238- 374 mg/L	-	Gravimetry	IS 3025 (Part 16)
7	TS	33072- 42904 mg/L	-	-	-
8	DO	5.4- 5.9 mg/L	3.0 mg/L or 40% of the saturation value, whichever is higher	DO meter	-
9	COD	80- 147 mg/L	-	Potassium Dichromate	IS 3025 (Part 58)
10	BOD	<5- 6.0 mg/L	5 mg/L	DO consumption in 5 days at 20°C	IS 3025 (Part 44)
11	NH <sub>4</sub> <sup>+</sup> -N	0.05- 0.19 mg/L	-	Colorimetry	IS 3025 (Part 34)
12	SPC	111- 389 / ml	-	Pour plate	IS 1622 1981
13	Coliform	<2- 14 CFU/ 100 ml	500 per 100 ml	Membrane Filtration	IS 1622 1981
14	Phenol	BDL- 0.05 mg/ L	-	Titrimetric	IS 3025 (Part 43)
15	Oil and Grease	7- 15 mg/L	10 mg/L	Solvent Extraction	IS 3025 (Part 39)

The maximum concentration of oil and grease (15 mg/L) was found at W11 station during neap tide. The minimum concentration of oil and grease (7 mg/L) was found during neap tide of W12 station. The values of various water quality parameters such as pH, dissolved oxygen, oil and grease, CFU and BOD obtained during the month of October, 2013 were compared with the primary water quality criteria for class IV waters (Harbour waters) given by Central Pollution Control Board (CPCB) in the Table S.2. They were found to be within the range for these parameters except BOD & oil and grease. The concentration of BOD was below the CPCB standard at all the stations except during spring tide and neap tide W11 & W14, and spring tide of W13 station. The concentration of oil and grease was below the CPCB standard except during neap tide at W11 & W13 stations. This could be due to indiscriminate discharge of oil contaminated bilge water

from motorized fishing boats moving in the upstream of creek.

**Table W. 9**

**Results of Physico-Chemical Analysis of Water Samples Collected From JNP Creek Area during October, 2013**

Sample Name	Depth (m)	Temp. (°C)	pH	Salinity (ppt)	Turbidity (NTU)	TDS (mg/L)	TSS (mg/L)	TS (mg/L)	
Standards			6.5-9.0	N.A.	N.A.	N.A.	N.A.	N.A.	
W11									
	SS	4.0	30.1	7.8	33.4	067	33265	249	33514
	SM		29.9	7.9	37.0	088	34565	246	34811
	SB		29.6	8.0	42.4	288	36988	348	37336
	NS	3.5	32.3	7.7	34.3	245	40158	369	40527
	NM		31.8	8.3	36.1	287	42004	371	42375
NB	31.5		7.8	37.9	271	42457	238	42695	
W12									
	SS	3.0	32.0	7.9	41.5	263	38597	346	38943
	SM		31.7	8.0	41.5	165	37441	309	37750
	SB		31.4	7.9	37.0	199	36998	311	37309
	NS	3.5	32.3	8.2	37.9	175	37124	347	37471
	NM		32.1	8.1	38.8	132	39231	326	39557
NB	32.9		8.0	39.7	109	40568	328	40896	
W13									
	SS	3.0	29.8	8.2	36.1	141	32965	339	33304
	SM		29.6	7.6	36.1	111	41268	347	41615
	SB		29.3	7.7	37.0	099	39654	366	40020
	NS	2.5	31.5	8.2	35.2	049	38454	354	38808
	NM		30.9	7.9	34.3	056	32751	321	33072
NB	30.7		7.8	35.2	263	33569	325	33894	
W14									
	SS	2.5	29.4	7.8	36.1	255	33897	298	34195
	SM		29.1	7.7	35.2	247	40321	268	40589
	SB		29.8	7.9	34.3	232	41112	374	41486
	NS	2.0	32.5	8.1	37.0	222	37658	276	37934
	NM		32.0	8.0	37.9	200	39454	283	39737
NB	31.9		7.8	39.7	207	42560	344	42904	

SS - SPRING SURFACE; SM - SPRING MIDDLE; SB - SPRING BOTTOM; NS - NEAP SURFACE NM - NEAP MIDDLE; NB - NEAP BOTTOM

NS#- NEAP SAMPLE, SS #- SURFACE SAMPLE; BDL- BELOW DETECTABLE LIMIT

(\*) indicates the values exceeding the standard

**Table W. 10**  
**Results of Bio-chemical Analysis of Water Samples Collected From JNP Creek Area**  
**during October, 2013**

Sample Name	DO (mg/L)	COD (mg/L)	BOD (mg/L)	NH <sub>4</sub> <sup>+</sup> -N (mg/L)	Phenol (mg/L)	Oil & Grease (mg/L)	SPC (Per ml)	Coliform Count (per 100 ml)
<b>Standards</b>	<b>3.0 or 40% of the saturation value</b>	<b>N.A.</b>	<b>5</b>	<b>N.A.</b>	<b>N.A.</b>	<b>10</b>	<b>N.A.</b>	<b>500 (MPN)</b>
<b>W11</b>	SS#					9		
	SS	5.9	80	<5	0.08	BDL	127	09
	SM	5.7	109					
	SB	5.7	134					
	NS#					15*		
	NS	5.9	99	6*	0.09	BDL	264	13
	NM	5.9	83					
	NB	5.7	93					
<b>W12</b>	SS#					10		
	SS	5.5	96	<5	0.1	0.04	111	<2
	SM	5.4	122					
	SB	5.4	112					
	NS#					7		
	NS	5.9	130	<5	0.05	0.03	244	14
	NM	5.8	118					
	NB	5.7	102					
<b>W13</b>	SS#					8		
	SS	5.5	86	5.6*	0.16	0.01	209	10
	SM	5.5	106					
	SB	5.4	131					
	NS#					13*		
	NS	5.8	109	<5	0.19	BDL	389	<2
	NM	5.8	115					
	NB	5.7	102					
<b>W14</b>	SS#					9		
	SS	5.9	122	<5	0.17	BDL	356	<2
	SM	5.9	109					
	SB	5.8	147					
	NS#					10		
	NS	5.9	126	5.2*	0.16	0.05	374	12
	NM	5.9	109					
	NB	5.8	83					

SS - SPRING SURFACE; SM -SPRING MIDDLE; SB - SPRING BOTTOM; NS – NEAP SURFACE NM - NEAP MIDDLE; NB - NEAP BOTTOM

NS#- NEAP SAMPLE, SS #- SURFACE SAMPLE; BDL- BELOW DETECTABLE LIMIT

(\*) indicates the values exceeding the standard

**Table W. 11**  
**Results of Sediment Samples Collected From JNP Creek Area during October, 2013**

Sediment Sample		Organic matter		Total carbon content		Inorganic phosphate µg/g
	Time, Hr	mg/g	%	mg/g	%	
Standards		N.A.	N.A.	N.A.	N.A.	N.A.
W11	S	10.9	1.1	06.1	0.6	28.0
	N	18.7	1.9	10.8	1.1	23.5
W12	S	11.6	1.2	07.1	0.7	35.0
	N	21.1	2.1	11.9	1.2	34.0
W13	S	18.4	1.8	10.6	1.1	30.5
	N	12.3	1.2	07.2	0.7	36.0
W14	S	18.2	1.8	11.2	1.1	34.5
	N	14.2	1.4	08.3	0.8	31.0

S - SPRING, N - NEAP.

(-) SEDIMENT SAMPLES CONTAINED ONLY PEBBLES AND GRAVELS.

Table W.11 provides the detailed results for each of the sediment quality parameters sampled at various water quality monitoring stations in the Nhava creek for the month of October, 2013. The organic matter, total carbon content and inorganic phosphate in the sediment samples collected during the month of September, 2012 were found to be in the range of 1.1- 2.1 %, 0.6- 1.2 % and 23.5- 36.0 µg/g of sediments, respectively.

## 2.2.3 CONCLUSIONS

Definite correlation between turbidity and suspended solids could not be established. This could be due to presence of fine sediments in suspension also since turbidity depends upon the particle size and the refractive properties of the particles. Salinity varied between stations and between different water column depths.

Comparison with the standards (primary water quality criteria for class SW-IV waters (for harbour waters), observations and their mitigation measures are mentioned in the Table W.12

**Table W.12**  
**Conclusions and Mitigation Measures of Results for Water Samples Collected from Nhava Creek During October, 2013**

Sr. No.	Parameter	Criteria	Observation (above/below) standard	Reasons	Mitigation measures
1	pH range	6.5 - 9.0	7.6- 8.3	-	-
2	Dissolved Oxygen	3.0 mg/L or 40 % of the saturation value, whichever is higher	5.4- 5.9 mg/L	-	-
3	Colour and Odour	No visible colour or offensive order	No visible colour or distinct odour was observed	-	-
4	Floating objects oil, grease and scum (including the petroleum products)	10 mg/L	7- 15 mg/ L Below at all stations except neap tide of W11 & W13 stations.	This could be due to indiscriminate discharge of oil contaminated bilge water from motorized fishing boats, moving in the upstream of creek or accidental discharge of oil along with drainage water from vessels or nearby areas.	Strict management actions to be undertaken to avoid indiscriminate discharge of oil or oil contaminated water.
5	Fecal Coliform	500 per 100 ml (MPN)	<2- 14 CFU /100 ml	-	-
6	Biochemical Oxygen Demand (5 days at 20oC)	5 mg/L	<5- 6.0 mg/L Below at all stations except during spring of W13 station and neap tide of W11 & W14 stations.	Wastewater runoff from nearby areas, or waste dumping from launches and vessels.	Avoid indiscriminate drainage of waste or wastewater into sea water.

## **Chapter-3: Monitoring Of Marine Ecosystem**

---

### **3.1 Introduction**

Marine ecosystems are very important for the overall health of both marine and terrestrial environments and are largely the study of population numbers and the processes, which brings about fluctuation in these numbers. Each individual in a population interact with other members of that population, with other species and with the environment. Ecosystem comprises of two units viz., structure and function. The structure of any ecosystem includes nutrients, light, living organisms etc. and the function includes flow of energy to different tropic levels, mineral cycles etc.

The marine ecosystem of JNP was studied by collecting surface water samples from various water quality monitoring stations of harbour region and Nhava creek. The details of the study are given below:

### **3.2. Objectives**

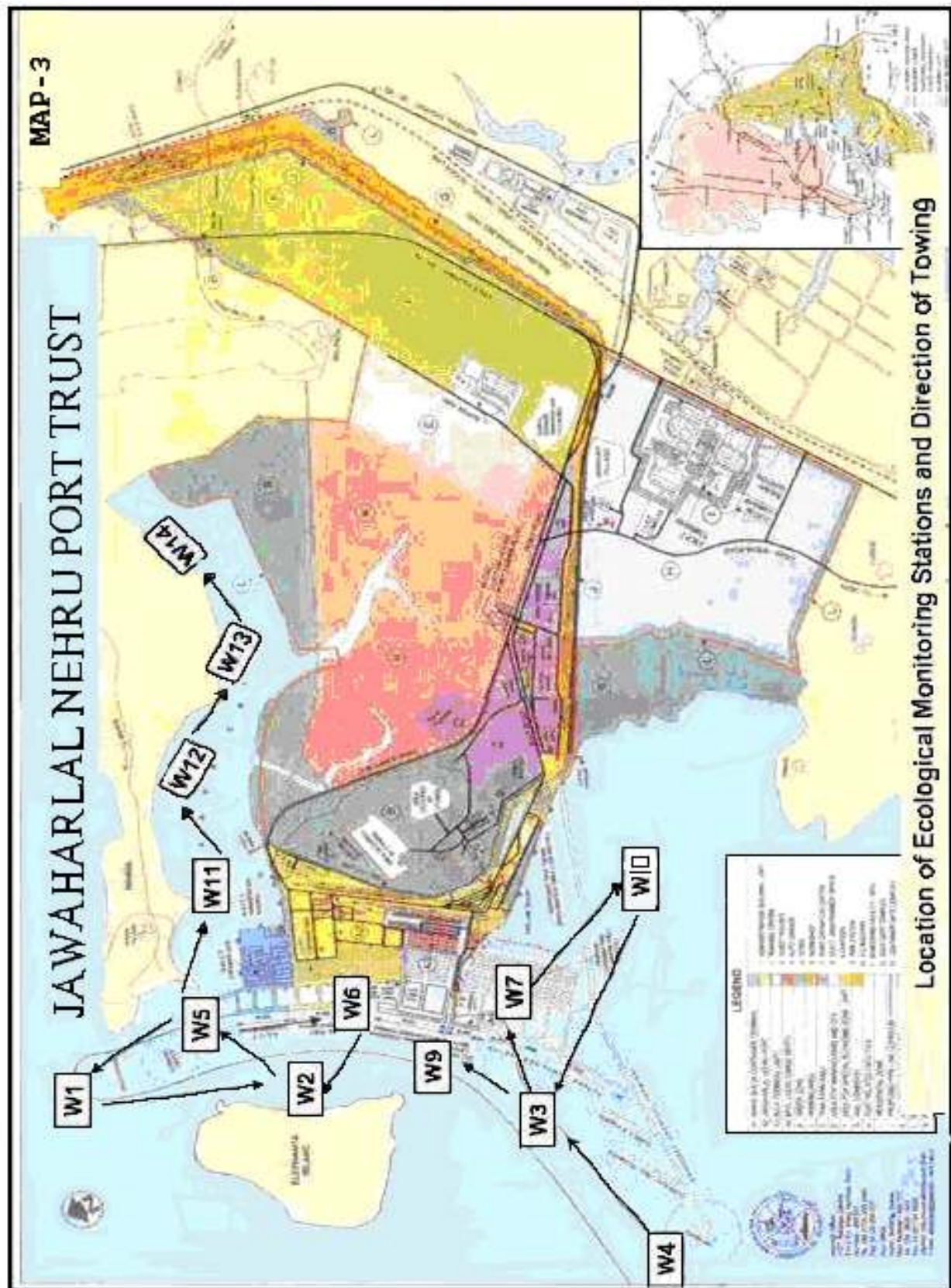
- a) Assessment of primary productivity;
- b) Analysis of phytoplankton and zooplankton diversity, density, relative abundance and biomass;
- c) Assessment of particulate oxidisable organic carbon (POC);
- d) Assessment of Secchi depth (light penetration); and
- e) Assessment of nutrients ( $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{SiO}_2$  and  $\text{PO}_4^{-3}$ )
- f) Sediment quality and their biological characteristics.

### **3.3. Materials and methods**

The monitoring of marine environment for the study of biological and ecological parameters was done on 9<sup>th</sup> October, 2013 in Nhava Creek regions and 10<sup>th</sup> and 11<sup>th</sup> October, 2013 in harbour of JNP, during flood tide. The surface water samples were collected by a water sampler from nine water quality monitoring stations of JNP harbour area (viz., W1, W2, W3, W4, W5, W6, W7, W9 and W10) and four stations (W11, W12, W13 and W14) in Nhava Creek for the estimation of primary productivity and analysis of phytoplankton, zooplanktons and nutrients. The primary productivity was estimated using light and dark bottle method and assessed for the changes in oxygen content by Winkler's Iodometric titration method after five hours of incubation in sunlight. For phytoplankton assay, the collected water samples were fixed using Lugol's solution fixative (Standard

Methods, APHA, 2005). The zooplankton was collected by transect survey towing the plankton net against tidal current at the towing rate of 1.5 meter/sec up to a certain distance. The direction of towing the plankton net and the thirteen marine water quality monitoring stations are shown in Figure 3. The collected zooplankton samples were then fixed using 5% formaldehyde solution. For quantitative study of phytoplankton, the collected water sample, after fixation, was subjected to sedimentation for three days and carefully decanting the supernatant, the sediment was taken in small volume of water. This was then taken in a Sedgwick-Rafter counting cell and examined under compound microscope to enumerate and identify the phytoplankton. The zooplankton sample was also taken in a counting cell and enumerated under dissecting and compound microscope. For the estimation of chlorophyll-a and pheophytin-a, a certain volume of water sample was filtered through glass fiber filter paper (GF/C-47 mm) 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 particulate oxidisable organic carbon (POC) of water sample was estimated by wet oxidation method with sulphuric acid-potassium dichromate oxidant followed by spectrophotometry at wavelength of 440 nm. The standing crop (Biomass) of phytoplankton was estimated by chlorophyll-a method while biomass of zooplankton was estimated by gravimetric method. The euphotic zone (light penetration) of JNP harbour and creek water was measured by Secchi disc. The NO<sub>3</sub>-nitrogen and PO<sub>4</sub><sup>3-</sup>-phosphorus were analyzed by brucine method and stannous-chloride method respectively while NO<sub>2</sub>-nitrogen was analyzed by NEDA method and silicate by molybdosilicate method (StandardMethods,APHA,2005).



### 3.4. Results and Discussion:

#### 3.4.1. PRIMARY PRODUCTIVITY

The phytoplankton mainly algae of aquatic ecosystem is responsible to fix radiant energy into organic carbon by the process of photosynthesis. The primary productivity depends upon light penetration, light intensity and duration of light.

The gross and net primary productivity of JNP harbour water was estimated in surface water taken from 1-meter depth of euphotic zone in terms of mg oxygen produced as well as mg carbon fixed in per unit volume of water per day. The producers (Phytoplankton) would release the oxygen in the process of photosynthesis, while a part of it would be utilized in the process of community respiration by phytoplankton as well as zooplankton over the period of incubation. The amount of oxygen increased in light bottle accounts for the net production while the depletion in oxygen in dark bottle accounts for the respiratory depletion. The sum of the amount of oxygen utilized in respiration during incubation period and the increased amount of oxygen from light bottle gives the gross production. From the Stoichiometric of photosynthetic reaction, the amount of oxygen liberated is related to the amount of glucose fixed in the process of photosynthesis. The net and gross primary productivity including community respiration rate of nine water quality monitoring stations of JNP harbour and four water quality monitoring stations of Nhava Creek is given in Table E.1. The range of net primary productivity (NPP) of JNP harbour water was found between 225 -375 mgC/m<sup>3</sup>/day with an average of 317 mgC/m<sup>3</sup>/day. minimum value (225 mgC/m<sup>3</sup>/day) was found at W7 station and maximum value of (375 mgC/m<sup>3</sup>/day) was found at W4 and W6 stations during monitoring period. In Nhava creek the net primary productivity was found 225-375 mgC/m<sup>3</sup>/ day with an average of 300 mgC/m<sup>3</sup>/ day minimum value 225 mgC/m<sup>3</sup>/ day was found at W14 station and maximum value (375 mgC/m<sup>3</sup>/ ) was found at W112 station during monitoring period as indicated in Table E.1. The light penetration measured by Secchi disc was found to be 0.5 – 1.0 ft, during monitoring period.

**Table E.1.**  
**Primary Productivity**

Sr. No.	Stations	Community Respiration rate (24hrs.) mg O <sub>2</sub> /m <sup>3</sup> /day	Gross Primary Productivity (10hrs.)		Net Primary Productivity (10hrs.)	
			mgO <sub>2</sub> /m <sup>3</sup> /day	mgC /m <sup>3</sup> /day	mgO <sub>2</sub> /m <sup>3</sup> /day	mgC /m <sup>3</sup> /day
Standard		NA	NA	NA	NA	<1500
JNP HARBOUR AREA						
1	W1	1440	1400	525	800	300
2	W2	960	1200	450	800	300
3	W3	960	1200	450	800	300
4	W4	960	1400	525	1000	375
5	W5	1920	1600	600	800	300
6	W6	960	1400	525	1000	375
7	W7	960	1000	375	600	225
8	W9	960	1200	450	800	300
9	W10	480	1200	450	1000	375
Average		1067	1289	483	844	317
NHAVA CREEK						
10	W11	960	1200	450	800	300
11	W12	1440	1600	600	1000	375
12	W13	1440	1400	525	800	300
13	W14	1440	1200	450	600	225
Average		1320	1350	506	800	300

### 3.4.2. POPULATION DENSITY AND ABUNDANCE OF PHYTOPLANKTON

Phytoplankton, being an autotrophic organism plays an important role to maintain the ecosystem of any aquatic community. They are primary producers and provide the energy to the heterotrophic herbivores. The growth of phytoplankton depends upon nutrients mainly nitrogen and phosphorous and intensity of light. The microscopic observation of water sample revealed phytoplankton of class Bacillariophyceae (Diatoms). The phytoplankton species **Skeletonema Bidulphia, Coscinodiscus, Pleurosigma, Naviculla, Triceratium** was observed in JNP Harbour and Creek water during sampling periods. The population density of phytoplankton in JNP harbour water and Nhava Creek is given in Table E.2. The average density of phytoplankton in JNP harbour water was found to be  $560 \times 10^3$  no's/L with minimum ( $413 \times 10^3$  no's/L) at W2 station and maximum ( $697 \times 10^3$  no's/L) at W4 station. In Nhava Creek the average phytoplankton density was found to be  $607 \times 10^3$  no's/L with minimum ( $573 \times 10^3$  no's/L) at W14 station and maximum ( $680 \times 10^3$  no's/L) at W12 station. The concentration of phytoplankton density depends on the grazing activity of zooplankton and nutrients dissolved in water. Relative abundance of phytoplankton in percentage is given in Table E.3.

### 3.4.3. PHOTOSYNTHETIC PIGMENTS AND ALGAL BIOMASS

The pigment distribution in aquatic ecosystem is useful tool for quantitative assessment of phytoplankton community composition and zooplankton grazing activity. Chlorophyll-a is the main photosynthetic pigment of primary producers and its concentration is widely used to assess the phytoplankton standing crop and growth. It can, therefore, also serve as an indirect measure of nutrient levels and eutrophication of water (class of water). The standard range of chlorophyll-a recorded as  $<4 \text{ mg/m}^3$  indicates oligotrophic class of water,  $4-10 \text{ mg/m}^3$  indicates mesotrophic and  $>10 \text{ mg/m}^3$  indicates eutrophic class of water. Pheophytin-a is an important degradation product of chlorophyll-a.

Chlorophyll-a constitutes approximately 1 to 2% (an average 1.5%) of dry weight of the phytoplankton and is extensively used to estimate the algal biomass. The estimated concentration of chlorophyll-a and pheophytin-a of JNP harbour water and Nhava Creek is given in Table E.4. The range of chlorophyll-a in JNP harbour water was found to be between  $3.9 - 9.0 \text{ mg/m}^3$  with an average of  $6.1 \text{ mg/m}^3$ . The minimum concentration of chlorophyll-a ( $3.9 \text{ mg/m}^3$ ) was found at W5 station and maximum value ( $9.0 \text{ mg/m}^3$ ) was found at W7 station as indicated in Table E4. In Nhava Creek the range of chlorophyll-a was found between  $7.3- 8.2 \text{ mg/m}^3$  with an average of  $7.8 \text{ mg/m}^3$ . Pheophytin-a is the

main degradation product of chlorophyll-a and it was found BDL(below detectable limit ) in Harbour water except W3,W4 and W5 stations where it was found 1.4, 0.6 and 1.8 mg/m<sup>3</sup> respectively and in Nhava creek water it was also found BDL during monitoring period.

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 E.5. In JNP harbour water, the range of algal biomass was found between 264 -601 mg/m<sup>3</sup>. The minimum algal biomass was (264 mg/m<sup>3</sup>) found at W5 station and maximum (601 mg/m<sup>3</sup>) was found at W7 station and average value of phytoplankton standing crop (Biomass) in JNP harbour water was found 410 mg/m<sup>3</sup>. In Nhava Creek it was found between 487-547 mg/m<sup>3</sup> with an average of 522 mg/m<sup>3</sup> during monitoring period. The minimum algal biomass was 487 mg/m<sup>3</sup> at W14 and maximum (547 mg/m<sup>3</sup>) was found at W11 station.

**Table E. 2.**  
**Population Density of Phytoplankton**

Sr.No.	Station	Density (no's / L)
<b>JNP HARBOUR AREA</b>		
1	W1	473 x 10 <sup>3</sup>
2	W2	413 X10 <sup>3</sup>
3	W3	510 x 10 <sup>3</sup>
4	W4	697 x 10 <sup>3</sup>
5	W5	520 x10 <sup>3</sup>
6	W6	640 X10 <sup>3</sup>
7	W7	573 X 10 <sup>3</sup>
8	W9	577 x 10 <sup>3</sup>
9	W10	640 x 10 <sup>3</sup>
<b>Average</b>		<b>560 x 10<sup>3</sup></b>
<b>NHAVA CREEK</b>		
10	W11	593 x 10 <sup>3</sup>
11	W12	680 x 10 <sup>3</sup>
12	W13	583 x 10 <sup>3</sup>
13	W14	573 x 10 <sup>3</sup>
<b>Average</b>		<b>607 x 10<sup>3</sup></b>

**Table E. 3.**  
**Abundance of Phytoplankton at Various Stations**

Sr. No		Species	PERCENTAGE OF PHYTOPLANKTON														
			JNP HARBOUR AREA										NHAVA CREEK				
			W1	W2	W3	W4	W5	W6	W7	W9	W10	Avg	W11	W12	W13	W14	Avg
1		<i>Cyclotella spp</i>	-	1.6	2.0	1.9	1.3	2.1	1.2	2.3	3.1	1.7	2.8	1.5	2.3	1.7	2.1
2		<i>Navicula spp</i>	2.8	4.0	3.3	1.9	1.3	2.6	2.3	3.5	2.1	2.6	1.7	1.0	2.3	2.3	1.8
3		<i>Skeletonema spp</i>	80.3	79.0	87.6	82.3	76.9	77.1	80.2	72.8	78.0	79.4	82.1	80.4	81.1	81.4	81.3
4		<i>Nitzcschia spp</i>	1.4	2.4	2.0	1.0	3.2	2.1	1.7	1.2	1.6	1.7	1.7	2.5	1.7	1.2	1.8
5		<i>Biddulphia spp</i>	2.1	1.6	1.3	-	1.9	-	1.2	3.5	2.1	1.5	1.7	1.0	1.1	1.2	1.3
6		<i>Gyrosigma spp.</i>	2.1	1.6	2.0	1.9	1.9	1.0	1.7	3.5	2.6	2.0	-	1.5	1.7	1.7	1.2
7		<i>Ceratium spp.</i>	-	1.6	2.0	1.4	1.9	1.6	2.3	1.7	-	1.4	1.1	1.5	1.7	-	1.1
8		<i>Tetraedron spp.</i>	1.4	-	-	-	-	-	-	-	-	0.2	-	-	-	-	-
9		<i>Thalassiosira spp.</i>	9.9	9.7	-	9.6	11.5	13.5	9.3	12.7	10.4	9.6	9.0	10.8	8.0	10.5	9.6
10		<i>Coscinodiscus spp.</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

**Table E.4.**  
**Photosynthetic Pigments**

Sr.No.	Station	Chlorophyll-a (mg/m <sup>3</sup> )	Pheophytin- a (mg/m <sup>3</sup> )
<b>JNP HARBOUR AREA</b>			
<b>1</b>	<b>W1</b>	5.7	BDL
<b>2</b>	<b>W2</b>	5.1	BDL
<b>3</b>	<b>W3</b>	4.5	1.4
<b>4</b>	<b>W4</b>	6.1	0.6
<b>5</b>	<b>W5</b>	3.9	1.8
<b>6</b>	<b>W6</b>	6.1	BDL
<b>7</b>	<b>W7</b>	9.0	BDL
<b>8</b>	<b>W9</b>	7.7	BDL
<b>9</b>	<b>W10</b>	7.0	BDL
<b>Average</b>		<b>6.1</b>	<b>0.4</b>
<b>NHAVA CREEK</b>			
<b>10</b>	<b>W11</b>	8.2	BDL
<b>11</b>	<b>W12</b>	7.9	BDL
<b>12</b>	<b>W13</b>	7.9	BDL
<b>13</b>	<b>W14</b>	7.3	BDL
<b>Average</b>		<b>7.8</b>	<b>BDL</b>

BDL: Below Detectable Limit

Parameter	Standard	Remarks
<b>Chlorophyll-a</b>	< 4	Oligotrophic class of water
	4-10	Mesotrophic class of water
	>10	Eutrophic class of water

**Table E.5.**  
**Algal Biomass (Chlorophyll-a Method)**

Sr.No.	Station	Algal Biomass (mg/m <sup>3</sup> )
<b>JNP HARBOUR AREA</b>		
1	W1	385
2	W2	345
3	W3	304
4	W4	408
5	W5	264
6	W6	405
7	W7	601
8	W9	515
9	W10	466
<b>Average</b>		<b>410</b>
<b>NHAVA CREEK</b>		
10	W11	547
11	W12	527
12	W13	527
13	W14	487
<b>Average</b>		<b>522</b>

#### **3.4.4. POPULATION DENSITY AND ABUNDANCE OF ZOOPLANKTON**

The most distinct parameter that could be used to analyze the biodiversity and or density or richness of marine community is the population density of zooplankton and its abundance. The population density of zooplankton and species diversity index (Shannon-Wiener's index) in the harbour water of JNP and Nhava Creek are given in Table E.6. Table E.7 gives the relative abundance of each species of zooplankton found at various stations. Since the size and exposure of the exoskeleton varies among the forms, only number would have given a false picture of abundance of zooplankton. Therefore, dry as well as ash free organic weight (biomass) constituted by zooplankton was used for the comparison of abundance of the same in marine ecosystem at various locations.

The zooplankton density collected by towing between various stations in JNP harbor water (as given in Table E.6) was found in the range of 216-267 no's/m<sup>3</sup>. The minimum population density of zooplankton (216 no's/m<sup>3</sup>) was found towing between

stations W1→W2 station and maximum of 267 no's/m<sup>3</sup> was found in between stations W10→W3. The zooplankton species **Copepods ,Decapods, Lucifers Gastrpods Decapods, Chaetognaths, medusa larva fish larva** was observed during sampling periods The average population density of zooplankton in JNP harbour water was 242 no's/m<sup>3</sup>. In Nhava creek population density of zooplankton was found in the range of 231 -473 no's/m<sup>3</sup> with an average of 305 no's/m<sup>3</sup>. The minimum density of zooplankton in creek water was 231 no's/m<sup>3</sup> found at towing between stations W5→W11 and maximum of 473 no's/m<sup>3</sup> at towing between stations W13→W14. The typical value of Shannon Wiener's index of species diversity of non-polluted sea water remains above 1 for moderate or more diversity. If the index value is obtained below 1, then it will represent less diversity. The Shannon Wiener's index of species diversity for JNP harbour was found between 0.30- 0.45 with an average of 0.37 and in Nhava creek it was found between 0.32 – 0.48 with an average of 0.39 shows less diversity. Over all diversity index of zooplankton in harbor region and Nhava creek region was found less it may due to disturbance of water body by water pollutants by surroundings areas during tidal current ald also due to the dredging activities int port region.

By the enumeration of zooplankton, the Copepods of crustacean group were found dominant in harbour region, 82.6 % of the total communities of JNP harbour water and 91.6 % were found to be dominant in creek region.

There was another representative (Barnacles) of subclass cirripedia of class crustacea seen to be attached on rocks, pilings, boats and other water retaining structures. These are economically important organisms. Zooplankton biomass crop was determined with reference to weight (dry wt as well as ash free wt). Table E.8 records the data of the same. In JNP harbour water, the minimum ash free biomass was 1.1 µg/L recorded between towing area of stations W3→W7 and maximum was 2.0 µg/L recorded between towing area of W2→W5, W6→W2 and W7→W10 stations. The average ash free zooplankton biomass of JNP harbour water was 1.6 µg/L. In Nhava creek the minimum ash free biomass was 1.4 µg/L found between towing area of stations W11→W12 and W13→W14 stations and maximum 2.4 µg/L was found between towing area of stations W12→W13 with an average of 1.8 µg/L.

The Particulate Oxidizable Carbon (POC) totally depends on the suspended dead remains of organisms like plant twigs, zooplankton or fish droppings, phytoplankton etc. The concentration of particulate oxidizable carbon (POC) is given in Table E.9. The concentration of particulate oxidizable carbon in JNP harbour was found between 444 –1144 mg/m<sup>3</sup> with an average of 905 mg/m<sup>3</sup>. The minimum concentration of POC (444 mg/m<sup>3</sup>) was found at W1 station and maximum (1144 mg/m<sup>3</sup>) at W3 station. In

Nhava creek the POC content was found to be between 833-944 mg/m<sup>3</sup> with an average of 889 mg/m<sup>3</sup>. The POC content in Nhava creek was found minimum as 833 mg/m<sup>3</sup> at W14 station and maximum at 944 mg/m<sup>3</sup> at W11 station. **The POC concentration was found very high at all stations in JNP harbour and creek both region as compared to prescribed standard range (10-100 mg/m<sup>3</sup>) it may due to suspended organic dead remains, discharge of organic wastes from nearby surroundings like towards Thane and Panvel creek during tidal current and it may disturb marine ecosystem of JNP areas .Copy of report studies by NIO is entered.**

**Table E.6.**  
**Population Density of Zooplankton**

Sr.No.	Towing between stations	Zooplankton Density ( no's/ m <sup>3</sup> )	Shannon Wiener's Diversity Index
<b>JNP HARBOUR AREA</b>			
1	<b>W1 → W2</b>	216	0.30
2	<b>W2 → W5</b>	241	0.31
3	<b>W5 → W1</b>	222	0.43
4	<b>W5 → W6</b>	238	0.35
5	<b>W6 → W2</b>	244	0.37
6	<b>W4 → W3</b>	243	0.38.
7	<b>W3 → W7</b>	251	0.35
8	<b>W7 → W8/10</b>	259	0.39
9	<b>W8/10 → W3</b>	267	0.39
10	<b>W3 → W9</b>	242	0.45
<b>Average</b>		<b>242</b>	<b>0.37</b>
<b>NHAVA CREEK</b>			
11	<b>W5 → W11</b>	231	0.48
12	<b>W11 → W12</b>	244	0.40
13	<b>W12 → W13</b>	272	0.35
14	<b>W13 → W14</b>	473	0.32
<b>Average</b>		<b>305</b>	<b>0.39</b>

**Table E.7.**  
**Abundance of Zooplankton at Various Towing Stations**

Sr. No	Species	PERCENTAGE OF PHYTOPLANKTON															
		JNP HARBOUR AREA										NHAVA CREEK					
		W1 → W2	W2 → W5	W5 → W1	W5 → W6	W6 → W2	W4 → W3	W3 → W7	W7 → W8/ 10	W8/ 10 → W3	W9 → - W3	Avg	W5 → W11	W11 → W12	W12 → W13	W13 → W14	Avg
1	Sagitta	0.8	0.7	1.0	0.9	1.1	1.1	1.1	1.1	0.8	1.1	1.0	1.2	0.7	0.4	1.2	0.9
2	Medusa larva	1.3	1.2	1.5	1.6	0.7	1.1	0.9	1.1	1.0	1.6	1.2	1.2	0.9	0.6	0.9	0.9
3	Mysids	2.1	1.8	3.8	1.6	3.0	3.0	2.7	3.9	3.1	3.4	2.8	6.0	3.0	4.1	2.3	3.9
4	Copepods	94.3	94.2	91.0	93.2	92.7	92.7	93.1	92.1	92.1	90.8	92.6	89.2	91.8	92.6	92.8	91.6
5	Fish larva	0.5	0.7	0.8	0.7	0.9	0.9	1.1	0.9	0.8	1.1	0.8	1.0	1.8	0.6	1.2	1.2
6	Zoea larva	1.0	1.4	2.0	1.9	1.6	1.1	1.1	1.1	2.1	1.8	1.5	1.4	1.8	1.6	1.6	1.6

**Table E.8. Zooplankton Biomass**

Sr.No	Towing between stations	Biomass	
		Dry wt. (µg/L)	Ash free wt. (µg/L)
JNP HARBOUR AREA			
1	W1 → W2	2.7	1.5
2	W2 → W5	2.3	2.0
3	W5 → W1	3.1	1.4
4	W5 → W6	2.9	1.3
5	W6 → W2	2.3	2.0
6	W4 → W3	2.5	1.6
7	W3 → W7	2.5	1.1
8	W7 → W8/10	3.2	2.0
9	W8/10→ W3	3.0	1.3
10	W3 → W9	2.5	1.3
Average		2.7	1.6
NHAVA CREEK			
11	W5 →W11	2.6	1.8
12	W11 →W12	2.8	1.4
13	W12 →W13	2.9	2.4
14	W13 →W14	3.0	1.4
Average		2.8	1.8

**Table E.9. Concentration of Particulate Oxidisable Organic Carbon**

Sr. No.	Stations	Concentration of POC (mg/m <sup>3</sup> )
<b>Standards</b>		<b>10 - 100</b>
<b>JNP HARBOUR AREA</b>		
1	W1	444
2	W2	1000
3	W3	1144
4	W4	911
5	W5	1056
6	W6	1022
7	W7	978
8	W9	789
9	W10	800
Average		905
<b>NHAVA CREEK</b>		
10	W11	944
11	W12	922
12	W13	856
13	W14	833
Average		889

### 3.4.5. BENTHIC FAUNA

Benthic fauna are organisms that live in the bottom of a water body (or in the sediment) and they are mostly invertebrates i.e., they have no backbone. They range from microscopic (e.g. micro invertebrates, <10 microns) to macroscopic (i.e., a few tens of centimeters or more in length, e.g. macro invertebrates, >50 cm). Benthic invertebrates live either on the surface of bedforms (e.g. rock, coral or sediment - epibenthos) or within sedimentary deposits (infauna), and comprise several types of feeding groups e.g. deposit-feeders, filter-feeders, grazers and predators. The abundance, biomass and species composition of benthic invertebrates can be used as indicators of changing environmental conditions.

In JNP harbour water, there was no macrobenthos was found during monitoring period as indicated in Table E.10. Overall in JNP harbour region macro fauna was found absent or less due to clayey sediment while in the creek water, some species of gastropods and pelecypods are found. The population density of benthic fauna in JNP harbour was found to be in the range of 1700 - 2100 no's/100gm with an average of 1900 no's/100 gm given in Table E.10. The minimum value of 1700 no's/m<sup>2</sup> was found at W4 station while the maximum value of 2100 no's/gm at W9 station. In Nhava creek region it was found to be in the range of 2004 -2208 no's/gm with an average of 2081 no's/100gm. The minimum value of 2004 no's/100 gm was found at W13 and the maximum value of 2208 no's/ gm was found at W11 station.

In the month of October -2013, the number of benthic faunal (generic) was in the range of one to three types of genera in each station, as given in Table E.10. The most common group of genera identified are, Foraminiferans group (**Triloculina sp. Quinqueloculina, Spiroloculina sp. Ammonia sp. Lagena sp. Discorbis sp. Florilus sp. Operculina Sorites Elphidium sp.**) Gastropods, Pelecypods etc.

**Table E.10**  
**Results of averages of biomass and population density of faunal groups at various stations**

Sr. No.	Station	Nos.of macrobenthos wet wt (g/100gm)	Population density of total faunal group (no's/ 100gm)	Total no. faunal group identified	Major group
1	W1	-	1800	1	Foraminiferans
2	W2	-	1800	1	Foraminiferans
3	W3	-	2000	1	Foraminiferans
4	W4	-	1700	1	Foraminiferans
5	W5	-	1800	1	Foraminiferans
6	W6	-	1900	1	Foraminiferans
7	W7	-	2000	1	Foraminiferans
8	W9	-	2100	1	Foraminiferans
9	W10	-	2000	1	Foraminiferans
<b>Average</b>			<b>1900</b>		
<b>NHAVA CREEK</b>					
11	W11	8	2208	3	Pelecypods,gastropods,foraminifera
12	W12	6	2106	3	Pelecypods,gastropods,foraminifera
13	W13	4	2004	3	Pelecypods,gastropods,foraminifera
14	W14	5	2005	3	Pelecypods,gastropods,foraminifera
			<b>2081</b>		

### 3.4.6. Nutrients

#### 3.4.6.A Anions:

The important micronutrients (viz., nitrate, nitrite, silica and phosphate) have received particular attention for any aquatic ecosystem because they are limiting factors for population of aquatic plants, algae and other vegetation and they are also important in relation to primary productivity. Levels of nitrogen and phosphorus in sea water include not only dissolved nutrients, but also the amount that are bound in plankton and suspended organic particulate matter. The level of nitrogen and phosphorus vary widely throughout the year. Nitrate is the most highly oxidized form of nitrogen commonly present in natural water and produced by the aerobic decomposition of nitrogenous compounds by nitrifying bacteria. The general range of nitrate in seawater has been recorded between 1-500 µg/L.

Phosphorus occurs in natural waters and wastewater almost solely as phosphate. These are classified as orthophosphate, condensed phosphate and organically bound phosphate. They occur in solution, particle or detritus, or in bodies of aquatic organisms. The condensed phosphates are the most abundant form of phosphate in natural water. Phosphates enter in lakes, ponds, rivers, estuaries and ocean from various primary sources such as inorganic fertilizers, wastewater treatment from municipal sources, soaps and detergents and industrial processes.

The nutrients at various stations in JNP harbour water and Nhava Creek are given in Table E.11. In harbour region the Phosphate was found between 79- 84 µg/L with an average of 81 µg/L. The minimum concentration of 79 µg/L of Phosphate was found at W1 station and maximum concentration of 84 µg/L at W7 station. Overall in JNP harbour region the Phosphate value was found under the standard range (0.1-90 µg/L) . The Nitrate was found between 321-339 µg/L, with minimum value as 321 µg/L at W1 and maximum as 339 µg/L at W9 station. The average concentration of Nitrate was found to be 330 µg/L and overall Nitrate was found within range (1.0-500 µg/L) at all stations. The Nitrite was found to be between 104-105 µg/L with an average of 104 µg/L. The minimum concentration of nitrite (104 µg/L) was found at all the stations except W10 station where it was found maximum 105 µg/L Overall in JNP harbour region the Nitrite value was found under standard range (<125 µg/L). Silica is another important nutrient in seawater. The requirement of silica by diatoms is however, entirely limited to skeletal formation and has particular importance in coastal upwelling region where diatoms form a dominant part of phytoplankton. Silica in the form of silicate in JNP harbour water was found between 1608 – 1678 µg/L with an average of 1635 µg/L. The minimum concentration of silica of 1608µg/L was found at W2,W6 and W10 stations and maximum was found 1678 µg/L at

W3 station. The Sulphate was found between 2103 - 2295 mg/L, with minimum value as 2103 mg/L at W1, W4 and W6 stations and maximum as 2295 mg/L at W9 station. The average concentration of Sulphate was found to be 2181 mg/L.

In Nhava Creek, Phosphate was found between 81-85  $\mu\text{g/L}$  with an average 83  $\mu\text{g/L}$  which was under standard range (0.1-90  $\mu\text{g/L}$ ). Nitrate was found between 330 - 339  $\mu\text{g/L}$  with an average 334  $\mu\text{g/L}$ . The minimum Nitrate (330  $\mu\text{g/L}$ ) was found at W11 and W13 stations and maximum (339  $\mu\text{g/L}$ ) at W12 station and Nitrite was found between 105  $\mu\text{g/L}$  at all stations. The silica content in Nhava creek was found between 1608  $\mu\text{g/L}$ - 1678  $\mu\text{g/L}$  with an average of 1643  $\mu\text{g/L}$ . The minimum silica content of 1608  $\mu\text{g/L}$  was found at stations W11 and maximum as 1678  $\mu\text{g/L}$  at W12 station. Sulphate was found between 2231- 2295 mg/L with an average of 2263 mg/L. The minimum Sulphate (2231 mg/L) was found at W11 and W14 station and maximum (2295mg/L) at W12 and W13 stations. Overall in JNP harbour and creek region the values of all the nutrients were found to be within the recommended ranges, which are given in Table 3.

The nutrients at various stations in JNP harbour area and Nhava Creek sediments are given in Table E.12. In harbour region the Phosphate was found between 25.7–30.8  $\mu\text{g/g}$  with an average of 28.2  $\mu\text{g/g}$ . The minimum concentration of Phosphate (25.7 $\mu\text{g/g}$ ) was found at W3 & W7 station and maximum concentration (30.8  $\mu\text{g/g}$ ) at W1 and W5 stations. The Nitrate was found between 0.24 – 0.31  $\mu\text{g/g}$ , with minimum value (0.24  $\mu\text{g/g}$ ) at W4 and W7 stations and maximum (0.31  $\mu\text{g/g}$ ) at W3 and W9 stations. The average concentration of Nitrate was found to be 0.27  $\mu\text{g/g}$ . The Nitrite was found to be between 1.40–1.99  $\mu\text{g/g}$  with an average of 1.86  $\mu\text{g/g}$ . The minimum concentration of nitrite (1.40  $\mu\text{g/g}$ ) was found at W3 station and maximum (1.99  $\mu\text{g/g}$ ) at W1 station. Silica in the form of silicate in JNP harbour sediments were found between 0.034  $\mu\text{g/g}$  at all stations. The Sulphate was found between 2422- 2613  $\mu\text{g/g}$ , with minimum value of 2422  $\mu\text{g/g}$  at W7 station and maximum of 2613  $\mu\text{g/g}$  at W1 and W6 stations. The average concentration of Sulphate was found to be 2543 $\mu\text{g/g}$ .

In Nhava Creek, Phosphate was found between 25.7- 28.2  $\mu\text{g/L}$  with an average 26.9  $\mu\text{g/L}$  which was under standard range (0.1-90  $\mu\text{g/L}$ ). Nitrate was found between 0.24 – 0.27  $\mu\text{g/L}$  with an average 0.26  $\mu\text{g/L}$ . The minimum Nitrate (0.24  $\mu\text{g/L}$ ) was found at W11 station and maximum (0.27  $\mu\text{g/L}$ ) at W12, W13 and W14 stations and Nitrite was found between 1.99- 2.03  $\mu\text{g/L}$  with an average of 2.00  $\mu\text{g/L}$ . The minimum Nitrite (1.99  $\mu\text{g/L}$ ) was found at W11, W13 and W14 stations and maximum (2.03  $\mu\text{g/L}$ ) at W12 station. The silica content in Nhava creek was found between 0.034  $\mu\text{g/L}$  at all stations. Sulphate was found between 2422- 2613 mg/L with an average of 2518 mg/L.

The minimum Sulphate (2422 mg/L) was found at W14 station and maximum (2613 mg/L) at W12 station. Overall in JNP harbour and creek region the values of all the nutrients were found to be within the recommended ranges.

#### 3.4.6. B Cations:

JNP harbour and creek water is indeed a complex solution of mineral salts like sodium, potassium, magnesium and calcium compounds and of decayed biologic matter. The concentration of some metals ions is given in Table.E.13. Most of the ocean's salts are derived by the gradual processes of weathering and erosion, the wearing down of mountains, and the dissolving action of rains and streams which transport their mineral washings to the sea. Dissolution of minerals from the rocks and sediments in the ocean floor also contribute to dissolved ions in the sea.

Mollusks (oysters, clams, and mussels) extract calcium from the sea to build their shells and skeletons. Foraminifers (unicellular sea animals) and crustaceans (crabs, shrimp, lobsters, and barnacles) likewise take out large amounts of calcium salts to build their bodies. When these organisms die their shells dissolve or degrade to again contribute to calcium concentration in sea water.

In harbour region water the Calcium was found between 834- 836 mg/L with an average of 835 mg/L. The minimum concentration (834 mg/L) of Calcium was Found at W1,W2 and W6 stations and maximum concentration (836 mg/L) at W4 and W10 station. Potassium in JNP harbour water was found between 551 -561 mg/L with an average of 558 mg/L. The minimum concentration of Potassium (551 mg/L) was found at W6 station and maximum (561 mg/L) at W1 station. The Magnesium was found between 851- 856 mg/L, with minimum value (851 mg/L) at W1 stations and maximum (856 mg/L) at W5 station. The average concentration of Magnesium was found to be 854 mg/L. The Sodium was found between 12517 - 12519 mg/L with an average of 12518 mg/L. The minimum concentration of sodium (12517 mg/L) was found at W10 station and maximum (12519 mg/L) at W1,W3 and W7 stations.

In Nhava Creek, Calcium concentration was found between 833 - 835 mg/L with an average 834 mg/L. The minimum value of Calcium (833 mg/L) was found at W11 station and maximum (835 mg/L) at W12 station. The Potassium content in Nhava creek was found between 555 -557 mg/L with an average of 556 mg/L. The minimum potassium value (555 mg/L) was found at W11 and W13 stations and maximum (557 mg/L) at W14 Station. Magnesium concentration was found between 846 – 848 mg/L with an average of 847 mg/L. The minimum value of Magnesium (846mg/L) was found at W14 station and



maximum (848 mg/L) was found at W11 and W13 stations. Sodium concentration was found between 12518-12519 mg/L with an average of 12519 mg/L. The minimum sodium value (12518 mg/L) was found at W12 and W14 stations and maximum (12519 mg/L) at W11 and W13 station.

In harbour region sediments, the Calcium was found between 238- 241 mg/Kg with an average of 239 mg/Kg given in Table E.14. The minimum Concentration of 238 mg/Kg of Calcium was found at W4 and W10 stations and maximum concentration of 241 mg/Kg at W1 and W5 stations. Potassium in JNP harbour sediment was found between 537- 539 mg/Kg with an average of 538 mg/Kg. The minimum concentration of Potassium of 537 mg/Kg was found at W1, W3, W4 and W7 stations and maximum of 539 mg/Kg at W5 and W10 station. Magnesium was found between 1736- 1739 mg/Kg, with minimum value as 1736 mg/Kg at W3 station and maximum as 1739 mg/Kg at W5, W6 and W10 stations. The average concentration of Magnesium was found to be 1738 mg/Kg. Sodium was found to be between 2938 - 3038 mg/Kg with an average of 3026 mg/Kg. The minimum concentration of sodium (2938 mg/Kg) was found at W6 station and maximum of 3038 mg/Kg at W2, W4, W9 and W10 stations.

In Nhava Creek sediments, Calcium was found between 238- 241 mg/Kg with an average 240 mg/Kg given in Table E. 14. The minimum value of calcium (238 mg/Kg) was found at W11 and maximum (241 mg/Kg) was found at W12 and W14 stations. The Potassium content in Nhava creek was found between 537- 539 mg/Kg with an average of 538 mg/Kg. The minimum Potassium content (537 mg/Kg) was found at station W14 station and maximum (539 mg/Kg) at W11 station. Magnesium was found between 1734 – 1736 mg/Kg with an average of 1735 mg/Kg. The minimum Magnesium value (1734 mg/Kg) was found at W11 and W14 stations and maximum (1736 mg/Kg) at W12 station. Sodium was found between 3022- 3025 mg/Kg with an average of 3023 mg/Kg. The minimum sodium value (3022 mg/Kg) was found at W12 station and maximum (3025 mg/Kg) at W14 station.

The depth of light penetration decreased by particles suspended in water, including any algal cells that are growing there. Coastal waters with high sediment content, or water in which an algal bloom is occurring, have less light penetration than clear open ocean water. The light penetration (Euphotic zone) in harbour of JNP and Nhava creek is given in Table E.16. It was measured by Secchi disc. The average visibility of Secchi disc was found to be 0.7 feet in JNP harbor water and 1.0 feet in Nhava creek. region.

**Table E.11. Concentration of Nutrients: Anions in Water**

Sr. No.	Stations	PO <sub>4</sub> <sup>-3</sup> -P (µg/L)	NO <sub>3</sub> <sup>-</sup> -N (µg/L)	NO <sub>2</sub> <sup>-</sup> -N (µg/L)	SiO <sub>2</sub> <sup>-</sup> (µg/L)	SO <sub>4</sub> <sup>2-</sup> (mg/L)
<b>Standards</b>		<b>0.1 - 90</b>	<b>1.0 - 500</b>	<b>&lt; 125</b>	<b>10-5000</b>	<b>NA</b>
<b>JNP HARBOUR AREA</b>						
<b>1</b>	<b>W1</b>	79	321	104	1643	2103
<b>2</b>	<b>W2</b>	81	335	104	1608	2167
<b>3</b>	<b>W3</b>	81	326	104	1678	2231
<b>4</b>	<b>W4</b>	82	330	104	1643	2103
<b>5</b>	<b>W5</b>	81	330	104	1643	2231
<b>6</b>	<b>W6</b>	82	330	104	1608	2103
<b>7</b>	<b>W7</b>	84	335	104	1643	2167
<b>8</b>	<b>W9</b>	81	326	105	1643	2231
<b>9</b>	<b>W10</b>	82	339	104	1608	2295
<b>Average</b>		<b>81</b>	<b>330</b>	<b>104</b>	<b>1635</b>	<b>2181</b>
<b>NHAVA CREEK</b>						
<b>10</b>	<b>W11</b>	81	330	105	1608	2231
<b>11</b>	<b>W12</b>	84	339	105	1678	2295
<b>12</b>	<b>W13</b>	85	330	105	1643	2295
<b>13</b>	<b>W14</b>	82	335	105	1643	2231
<b>Average</b>		<b>83</b>	<b>334</b>	<b>105</b>	<b>1643</b>	<b>2263</b>

**Table E.12. Concentration of Nutrients: Anions in Sediment**

Sr. No.	Stations	PO <sub>4</sub> <sup>3-</sup> -P (µg/g)	NO <sub>3</sub> <sup>-</sup> -N (µg/g)	NO <sub>2</sub> <sup>-</sup> -N (µg/g)	SiO <sub>2</sub> <sup>-</sup> (µg/g)	SO <sub>4</sub> <sup>2-</sup> (µg/g)
<b>Standards</b>		<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
<b>JNP HARBOUR AREA</b>						
<b>1</b>	<b>W1</b>	30.8	0.27	1.99	0.034	2613
<b>2</b>	<b>W2</b>	28.2	0.27	1.92	0.034	2550
<b>3</b>	<b>W3</b>	25.7	0.31	1.40	0.034	2486
<b>4</b>	<b>W4</b>	28.2	0.24	1.89	0.034	2550
<b>5</b>	<b>W5</b>	30.8	0.27	1.92	0.034	2613
<b>6</b>	<b>W6</b>	28.2	0.27	1.85	0.034	2613
<b>7</b>	<b>W7</b>	25.7	0.24	1.89	0.034	2422
<b>8</b>	<b>W9</b>	28.2	0.31	1.96	0.034	2486
<b>9</b>	<b>W10</b>	28.2	0.27	1.92	0.034	2550
<b>Average</b>		<b>28.2</b>	<b>0.27</b>	<b>1.86</b>	<b>0.034</b>	<b>2543</b>
<b>NHAVA CREEK</b>						
<b>10</b>	<b>W11</b>	25.7	0.24	1.99	0.034	2486
<b>11</b>	<b>W12</b>	28.2	0.27	2.03	0.034	2613
<b>12</b>	<b>W13</b>	28.2	0.27	1.99	0.034	2550
<b>13</b>	<b>W14</b>	25.7	0.27	1.99	0.034	2422
<b>Average</b>		<b>26.9</b>	<b>0.26</b>	<b>2.00</b>	<b>0.034</b>	<b>2518</b>

**Table E.13. Concentration of Nutrients: Cations in water**

Sr. No.	Stations	Ca <sup>++</sup> (mg/L)	K <sup>+</sup> (mg/L)	Mg <sup>++</sup> (mg/L)	Na <sup>+</sup> (mg/L)
<b>Standards</b>		<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
<b>JNP HARBOUR AREA</b>					
<b>1</b>	<b>W1</b>	834	561	851	12519
<b>2</b>	<b>W2</b>	834	560	852	12518
<b>3</b>	<b>W3</b>	835	560	853	12519
<b>4</b>	<b>W4</b>	836	559	854	12518
<b>5</b>	<b>W5</b>	835	556	856	12518
<b>6</b>	<b>W6</b>	834	551	854	12518
<b>7</b>	<b>W7</b>	835	557	855	12519
<b>8</b>	<b>W9</b>	835	557	855	12518
<b>9</b>	<b>W10</b>	836	558	854	12517
<b>Average</b>		<b>835</b>	<b>558</b>	<b>854</b>	<b>12518</b>
<b>NHAVA CREEK</b>					
<b>10</b>	<b>W11</b>	833	555	848	12519
<b>11</b>	<b>W12</b>	835	556	847	12518
<b>12</b>	<b>W13</b>	834	555	848	12519
<b>13</b>	<b>W14</b>	834	557	846	12518
<b>Average</b>		<b>834</b>	<b>556</b>	<b>847</b>	<b>12519</b>

**Table E.14. Concentration of Nutrients: Cations in sediment**

Sr. No.	Stations	Ca <sup>++</sup> (mg/kg)	K <sup>+</sup> (mg/kg)	Mg <sup>++</sup> (mg/kg)	Na <sup>+</sup> (mg/kg)
<b>Standards</b>		<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
<b>JNP HARBOUR AREA</b>					
<b>1</b>	<b>W1</b>	241	537	1738	3037
<b>2</b>	<b>W2</b>	239	538	1737	3038
<b>3</b>	<b>W3</b>	240	537	1736	3036
<b>4</b>	<b>W4</b>	238	537	1738	3038
<b>5</b>	<b>W5</b>	241	539	1739	3037
<b>6</b>	<b>W6</b>	239	538	1739	2938
<b>7</b>	<b>W7</b>	239	537	1738	3036
<b>8</b>	<b>W9</b>	240	538	1737	3038
<b>9</b>	<b>W10</b>	238	539	1739	3038
<b>Average</b>		<b>239</b>	<b>538</b>	<b>1738</b>	<b>3026</b>
<b>NHAVA CREEK</b>					
<b>10</b>	<b>W11</b>	238	539	1734	3023
<b>11</b>	<b>W12</b>	241	538	1736	3022
<b>12</b>	<b>W13</b>	240	538	1735	3023
<b>13</b>	<b>W14</b>	241	537	1734	3025
<b>Average</b>		<b>240</b>	<b>538</b>	<b>1735</b>	<b>3023</b>

**Table E.15. Results of Moisture Content**

Sr. No.	Stations	Moisture (%)
<b>JNP HARBOUR AREA</b>		
<b>1</b>	<b>W1</b>	0.35
<b>2</b>	<b>W2</b>	0.35
<b>3</b>	<b>W3</b>	0.34
<b>4</b>	<b>W4</b>	0.35
<b>5</b>	<b>W5</b>	0.34
<b>6</b>	<b>W6</b>	0.35
<b>7</b>	<b>W7</b>	0.35
<b>8</b>	<b>W9</b>	0.35
<b>9</b>	<b>W10</b>	0.35
<b>Average</b>		<b>0.35</b>
<b>NHAVA CREEK</b>		
<b>10</b>	<b>W11</b>	0.34
<b>11</b>	<b>W12</b>	0.35
<b>12</b>	<b>W13</b>	0.35
<b>13</b>	<b>W14</b>	0.34
<b>Average</b>		<b>0.35</b>

**Table E.16. Results of Secchi Depth**

Sr. No.	Stations	Secchi depth (ft)
<b>JNP HARBOUR AREA</b>		
<b>1</b>	<b>W1</b>	1.0
<b>2</b>	<b>W2</b>	1.0
<b>3</b>	<b>W3</b>	0.5
<b>4</b>	<b>W4</b>	1.0
<b>5</b>	<b>W5</b>	0.5
<b>6</b>	<b>W6</b>	0.5
<b>7</b>	<b>W7</b>	1.0
<b>8</b>	<b>W9</b>	1.0
<b>9</b>	<b>W10</b>	1.0
<b>Average</b>		<b>0.8</b>
<b>NHAVA CREEK</b>		
<b>10</b>	<b>W11</b>	1.0
<b>11</b>	<b>W12</b>	1.0
<b>12</b>	<b>W13</b>	1.0
<b>13</b>	<b>W14</b>	1.0
<b>Average</b>		<b>1.0</b>

### 3.5 Conclusions

The net primary productivity in month of October, 2013 in JNP harbour and creek region was found 225 to 375 mgC/m<sup>3</sup>/day. The visibility of Secchi disc (light penetration) in the JNP harbour water and Nhava creek was found to be between 0.5 – 1.0 feet. Low visibility could be due to the dredging activity in JNP area and surface runoff water from nearby areas. The overall average value of chlorophyll-a in JNP harbour water was found 6.1 mg/m<sup>3</sup> and in creek water was found to be 7.8 mg/m<sup>3</sup> represent mesotrophic class of water in harbor region and in creek region. The phytoplankton species observed belong to the diatoms group. The marine community of JNP harbour represents pelagic invertebrates and some other zooplankton. Copepods were found to be the dominant species in harbour region and Nhava creek region. The average value of Shannon Wiener Index of species diversity was found to be 0.37 in JNP harbour water and 0.41 in creek water. These values represent less species diversity in JNP harbour and in creek region.

In JNP harbour and creek region the benthic production in terms of biomass and population suggested organic pollution induced productivity at different trophic levels. To reduce the organic loading, effluent releases to inner creek or marine zone should be discouraged. For existing effluent discharges detailed site survey for assimilative capacity for receiving water body should be conducted and also if needed based on the study the effluent release sites should be shifted downstream or additional treatment should be provided to the effluent based on model studies.

Comparison with the standards (of some ecological parameters for Arabian Sea and other parts of Indian Ocean given by Raymont, 1980), of observations and mitigation measures are mentioned in Table E.17.

The standard ranges of some ecological parameters for Arabian Sea and other parts of Indian Ocean given by Raymont (1980) are given in Table S. 3.

**Table E.17.  
Conclusions and Mitigation Measures for Ecological Parameters During October, 2013**

Parameter	Range	Observation (above/below than standard)	Reasons	Mitigation measures
Net primary productivity	<1500 mgC/m <sup>3</sup> /day at surface	Harbour 317 mgC/m <sup>3</sup> /day Creek- 300 mgC/m <sup>3</sup> /day	--	Within range
Chlorophyll-a	-	Harbour 6.1 mg/m <sup>3</sup> Creek 7.8 mg/m <sup>3</sup>	Low phytoplankton density in harbour regions than creek region due to high turbidity.	-
Phosphate	0.1- 90 µg/L	Harbour –81.0 µg/L Creek –83.0 µg/L	-	-
Nitrate	1.0-500 µg/L	Harbour – 330.0 µg/L Creek -334.0 µg/L	-	Within range
Nitrite	<125 µg/L	Harbour – 104.0 µg/L Creek – 105.0 µg/L	-	Within range
Particulate Organic Carbon (POC)	10-100 mg/m <sup>3</sup>	Harbour – 905 mg/m <sup>3</sup> Creek -889 mg/m <sup>3</sup> High concentration at all stations	Dead organisms droppings of zooplankton. may be due to discharge of pollutants like waste water effluents from cities nearby areas towards Thane and Pavnvel creek etc.	Discharge of wastes in marine water should be discourage
Silicate (SiO <sub>2</sub> )	10-5000 µg/L	Harbour –1636µg/L Creek - 1643 µg/L	This is a natural phenomena.	Within range

Sr. No.	1	2	3	4	5	6	7
---------	---	---	---	---	---	---	---

### Literature Cited

1. Barnes, R. S. K. and Hughes, R. N., **“An Introduction to Marine Ecology “**, Blackwell Scientific Publications, Oxford, 1988.
2. Cushing D.H and Walsh J.J, **“The Ecology of the Seas”**, W.B. Saunders Co., Philadelphia, 1976.
3. Jenkins, D. and Medsker, L., **“Brucine Method for the Determination of Nitrate in Ocean, Estuarine and Fresh Water”**, Analytical Chemistry, 1964.
4. Odum Eugene P., **“Fundamentals of Ecology”**, W.B. Saunders, Philadelphia, 1971.
5. Parsons, T. R. and Strickland, J.D.H., **“Proximate analysis of marine standing crops”**, Nature, London, 1959.
6. Paul A. Meglitsch, **“Invertebrate Zoology”**, Oxford University Press, 1975.
7. Raymont, J.E.G., **“Plankton and Productivity in the Oceans Vol. I Phytoplankton”**, Pergamon Press, Oxford, 1980.
8. Standard Method for the Examination of Water and Waste Water (**APHA**), 2005.
9. Steele, J. H. and Baird, I. E., **“Relation between primary production, chlorophyll and particulate carbon”**, Limnology and Oceanography, 1961.

**Table S.1**

**CPCB standards of ambient air quality for different areas**

Sr. No.	Parameter	CPCB 24-Hours Standard		
		Industrial and Mixed areas	Residential and Rural areas	Sensitive areas
1.	TSP, $\mu\text{g}/\text{m}^3$	500	200	100
2.	PM <sub>10</sub> , $\mu\text{g}/\text{m}^3$	100	100	100
3.	NO <sub>x</sub> , $\mu\text{g}/\text{m}^3$	80	80	80
4.	SO <sub>2</sub> , $\mu\text{g}/\text{m}^3$	80	80	80
5.	NH <sub>3</sub> , $\mu\text{g}/\text{m}^3$	400	400	400

**Table S.2**

**Primary water quality criteria for class SW-IV waters (For Harbour Waters)**

Sr. No	Parameter	Criteria	Rationale/Remarks
1.	pH range	6.5 - 9.0	To minimize the corrosive and scaling effects.
2.	Dissolved Oxygen	3.0 mg/L or 40 % of the saturation value, whichever if higher	Considering bio-degradation of oil and inhibition to oxygen production through photosynthesis.
3.	Colour and Odour	No visible colour 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.

**Table S.3**

**Recommended ranges of the ecological parameters for Arabian sea**

Parameter	Range	Remark
<b>Net primary productivity</b>	<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.
<b>Chlorophyll-a</b>	< 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
<b>Phosphate</b>	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
<b>Nitrate</b>	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.
<b>Nitrite</b>	<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.
<b>Particulate Organic Carbon (POC)</b>	10-100 mg/m <sup>3</sup>	POC is directly related to primary productivity. High concentration of POC represents the region of high productivity.
<b>Silicate (SiO<sub>2</sub>)</b>	10-5000 µg/L	Nucleic acid synthesis and skeletal formation of Diatoms.

## Chapter-4: Drinking Water Quality Monitoring

### 4.1 Introduction

Assessment of drinking water quality was carried out for the month of October, 2013 to determine the present status of drinking water quality of JNPT area and to compare it with the prescribed standards. As per requirement samples were collected and analyzed from eighteen stations from outside and inside the port area of JNPT. Ten stations were outside the port area and eight stations were inside the port area. All the water samples were collected from the port area of JNPT on 11<sup>th</sup> October, 2013. Table D. 1 shows the description of the eighteen water quality- monitoring stations outside and inside the port area of JNPT. These water samples were analyzed for various physical, chemical and biological parameters viz., colour, odour, turbidity, conductivity, pH, total dissolved solids, chlorides, hardness, total iron, sulfate, NH<sub>4</sub><sup>+</sup>-N, PO<sub>4</sub><sup>3-</sup>-P and bacterial count .

**Table D.1**  
**Description of Drinking Water Quality Monitoring Stations Outside and Inside the Port Area of JNPT**

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

Table D.2 provides the value for each of the parameters sampled at various drinking water quality monitoring stations in the month of September, 2012 and also shows the acceptable standard for various parameters of drinking water as prescribed by Ministry of Urban Development, 1999 (CPHEEO). The results show that all the eighteen samples were colourless and odourless. Conductivity of all the samples was found to be in the range of 62 - 91  $\mu\text{Mhos/cm}$ . pH of all eighteen samples was in the range of 7.1 - 7.4 which is within the acceptable limits to the permissible standard of 7.0- 8.5. Concentration of chlorides was 5.3- 9.1 mg/L and was well within the acceptable limit (200 mg/L). TDS of all the eighteen samples was in the range of 61- 88 mg/L and was within the acceptable range (500 mg/L). Hardness of all the eighteen samples was found to be in the range of 39- 60 mg/L as  $\text{CaCO}_3$  and was within the acceptable limit (200 mg/L). Concentration of total iron was found to be in the range of 0.01- 0.05 mg/L and was within the acceptable limit (0.1 mg/L). Sulphate content of all the eighteen samples was in the range of 3.3- 6.4 mg/L and was within the acceptable limit of 200 mg/L in drinking water. Concentration of  $\text{NH}_4^+\text{-N}$  was in the range of 0.03- 0.07 mg/L. Concentration of  $\text{PO}_4^{3-}\text{-P}$  at all the eighteen stations, was found to be in the range of 0.05- 0.13 mg/L. Analysis of the bacteriological parameter showed that all the drinking water samples were safe in terms of bacteriological quality.

The results show that as per ISO: 10500 the water at all the eighteen stations is suitable for drinking purpose.

**Table D. 2**  
**Results of Drinking Water Quality Monitoring, 11<sup>th</sup> October, 2013**

Parameters	DW1	DW2	DW3	DW4	DW5	DW6	Standards
Colour	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	-
Odour	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Unobjectionable
Turbidity (NTU)	0.49	0.61	0.72	0.79	0.57	0.41	1.0
Conductivity [µMhos/cm]	74	82	90	64	69	70	-
pH	7.4	7.3	7.3	7.2	7.3	7.2	7.0 to 8.5
Chlorides (mg/l)	6.1	5.3	6.9	7.4	8.9	8.1	200
TDS (mg/l)	81	73	72	79	61	69	500
Total Hardness (mg/l as CaCO <sub>3</sub> )	41	58	39	60	57	52	200
Iron (mg/l)	0.01	0.02	0.02	0.03	0.04	0.04	0.1
Sulphate (mg/l)	4.5	3.7	3.4	3.3	6.2	5.5	200
NH <sub>4</sub> <sup>+</sup> -N (mg/l)	0.03	0.04	0.04	0.06	0.05	0.07	-----
PO <sub>4</sub> <sup>-3</sup> -P (mg/l)	0.05	0.09	0.1	0.08	0.06	0.11	-----
CFU (Per 100 ml)	Nil	Nil	Nil	Nil	Nil	Nil	Nil

: Below Detection Limit, \*Ref: Manual on Water supply and Treatment- (CPHEEO), Ministry of Urban Development, 1999.

### Results of Drinking Water Quality Monitoring, 11<sup>th</sup> October, 2013

Parameters	DW7	DW8	DW9	DW10	DW11	DW12	*Standards
Colour	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	-
Odour	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Unobjectionable
Turbidity (NTU)	0.66	0.62	0.59	0.51	0.64	0.58	1
Conductivity [µMhos/cm]	78	81	91	87	88	82	-
pH	7.1	7.2	7.2	7.1	7.3	7.3	7.0 to 8.5
Chlorides (mg/l)	6.5	6.3	9.1	8.9	9	5.5	200
TDS (mg/l)	75	84	88	80	74	70	500
Total Hardness (mg/l as CaCO <sub>3</sub> )	47	43	41	40	59	54	200
Iron (mg/l)	0.04	0.02	0.03	0.02	0.03	0.05	0.1
Sulphate (mg/l)	4.9	4	4.2	4.9	5.2	5.7	200
NH <sub>4</sub> <sup>+</sup> -N (mg/l)	0.05	0.06	0.07	0.04	0.05	0.06	----
PO <sub>4</sub> <sup>3-</sup> -P (mg/l)	0.13	0.09	0.08	0.06	0.07	0.13	-----
CFU (Per 100 ml)	Nil	Nil	Nil	Nil	Nil	Nil	Nil

: Below Detection Limit, \*Ref: Manual on Water supply and Treatment- (CPHEEO), Ministry of Urban Development, 1999.

### Results of Drinking Water Quality Monitoring, 11<sup>th</sup> October, 2013

Parameters	DW13	DW14	DW15	DW16	DW17	DW18	*Standards
Colour	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	-
Odour	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Unobjectionable
Turbidity (NTU)	0.63	0.77	0.70	0.62	0.58	0.55	1
Conductivity [µMhos/cm]	65	83	62	77	89	63	-
pH	7.2	7.4	7.3	7.2	7.1	7.2	7.0 to 8.5
Chlorides (mg/l)	5.7	6.4	6.9	5.5	6.3	8.7	200
TDS (mg/l)	66	62	78	84	87	79	500
Total Hardness (mg/l as CaCO <sub>3</sub> )	42	60	45	56	52	59	200
Iron (mg/l)	0.02	0.03	0.02	0.03	0.04	0.04	0.1
Sulphate (mg/l)	6.3	6.4	5.8	5.3	4.1	3.8	200
NH <sub>4</sub> <sup>+</sup> -N (mg/l)	0.04	0.05	0.05	0.05	0.04	0.06	----
PO <sub>4</sub> <sup>-3</sup> -P (mg/l)	0.06	0.12	0.08	0.06	0.07	0.12	-----
CFU (Per 100 ml)	Nil	Nil	Nil	Nil	Nil	Nil	Nil

: Below Detection Limit, \*Ref: Manual on Water supply and Treatment- (CPHEEO), Ministry of Urban Development, 1999.