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Report on

ENVIRONMENTAL POLLUTION MONITORING AT PARADIP PORT

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BY

INSTITUTE OF MINERALS & MATERIALS TECHNOLOGY
(Formerly known as Regional Research Laboratory)
(Council of Scientific & Industrial Research)
Bhubaneswar – 751 013
ODISHA

CONTENTS

SUMMARY

Regular pollution monitoring studies on Paradip Port is essential in view of its increasing activities to record the level of pollution from time to time and to implement the possible measures to bring down pollution level of the Port area. Environmental parameters have been assessed with respect to air, water, sediment, noise and biological studies during month of January-2015.

In air environment the pollutants like sulphur dioxide, nitrogen dioxide and ammonia were below the National Ambient Air Quality Standards whereas the Suspended Particulate Matters (SPM) were higher than that of the prescribed standard (Annexure-I) in certain areas like Administrative Building, Brundaban pump house, Iron ore handling berth, Tippler house, ADB-Coal handling plant, Electric Substation, Naya Bazaar Pump House and Atharabanki Gate inside and outside the port premises. The water samples collected from 12 different points including ADB-pond and Fishing harbor were analyzed for 35 parameters. In sediment environment all parameters like organic matter, trace and major elements analysed were within the prescribed limits. The trace and major elements exhibit wide variations both in bulk and fine fraction. Noise levels (Leq) have been recorded at 14 different locations inside as well as outside the port area. The noise level had exceeded the maximum permissible limit at some locations (i.e. Atharabanki gate, Brundaban Colony, Convent School and Market Complex (near Dipti Petrol Pump) during rush hours. Among biological parameters studied, phytoplankton population counted from 690 to 1442 and species diversity indicated that different species belonging to genera varied from 8 to 13 nos. The Shannon Diversity Index value ranging from 1.0751 to 1.4426 indicates that there may be some stressful conditions for phytoplankton growth. Bacterial analysis for TVC, TC and EC were also done for both water and sediment samples. TC and EC of the water samples were in satisfactory level.

The overall chemical analysis results indicate the quality of air, water; sediment and noise is within the normal range with a few exceptions. Although the port environment is not grossly modified sufficient care should be taken to minimize the SPM level within the port premises.

Pollution Monitoring at Paradip Port

INTRODUCTION

Paradip Port is the gateway of national and international coastal trades and thus invariably linked with the economic development of the country. Large quantities of various materials are exported or imported through Paradip Port. Materials exported through Paradip Port comprise of iron ore, manganese ore, coal, pig iron, steel, chrome ore and aluminium ingots, but the imported materials mostly consist of coking coal, scrap iron, petroleum products, ammonia, rock phosphate, phosphoric acid, sulphuric acid including different edible materials and machineries. A part from the finished products like aluminium from NALCO, steel products from RSP and TISCO, master alloys such as ferrochrome, ferromanganese, charge chrome, etc. are also exported. More than 600 small fishing trawlers and about seventy large fishing trawlers are engaged in coastal fishing and deep sea fishing through Paradip Port day in and day out. Presently, they are not directly operating through the Port but through the Fishing Harbour connected to the Bay of Bengal through the river Mahanadi. The transactions of the fishes allied marine food products, fuel for the trawlers, maintenance of trawlers and machineries, etc. are also major activities around Paradip Port.

The environmental impacts of various activities in port and harbour principally concern coastal and estuarine water quality, contamination of soil, degradation in sediment quality, air quality, noise and vibration generation beyond the permissible limits and generation of various types of wastes. There is always apprehension that the contaminants in both water and air affect marine and coastal life, crops, trees, wild animals and their habitats. Human health is also affected directly or indirectly.

Samples of different environment, i.e. Water, Sediment, Air and Noise have been collected to study the status of pollution arising due to various increased activities at Paradip Port. The samples are collected quarterly from twelve different identified points inside and outside of the harbour area to study the seasonal variations of the different parameters. ***In air environment***, the parameters like respirable suspended particulate matter (RSPM), total

suspended particulate matter, sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and ammonia (NH_3) were analysed***. In water environment,*** the parameters analysed were pH, conductivity, turbidity, temperature, salinity, chlorinity, dissolved oxygen (DO), biochemical oxygen demand (BOD), total suspended solids (TSS), total dissolved solids (TDS), total solids (TS), phenolphthalein alkalinity, total alkalinity, temporary hardness, permanent hardness, calcium hardness, magnesium hardness, total hardness, nitrate, nitrite, ammonia, phosphate, sulphate, soluble cations (calcium, magnesium, sodium, potassium) and heavy metal ions such as iron, manganese, copper, nickel, cobalt, zinc, lead, cadmium and chromium. ***In sediment environment***, pH, size analysis, mineralogy and the presence of metal ions such as copper, nickel, cobalt, zinc, manganese, lead, cadmium and chromium were analysed. ***In noise environment,*** the extents of noise intensities at various predetermined locations were measured with help of the Cygnet Precision Sound Level Meter of Type 2031. ***In respect of biological environment,*** the population of various phytoplankton species in harbor water were counted and reported. Various bacteriological studies of both water and sediment samples were done and mentioned. The overall chemical analysis results indicate that the quality of water, sediment, air and noise are within the normal range with a few exceptions. The analysis results of all the parameters are presented in different tables along with their standard values (Annexure-Tables).

AIR ENVIRONMENT

Air pollution studies at Paradip Port were carried out once in each quarter of the year. Thus, air sampling was done during 27th -29th January 2015. The duration of air sampling at a sampling point ranged from eight to twelve hours depending upon the observed concentration of SPM in the locality. In addition to the suspended particulate matter, the extent of sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and ammonia (NH_3) present in the air were absorbed in respective solutions and analysed colorimetrically with the help of a UV-Visible Spectrophotometer. From the quantum of pollutants and the volume of air treated, the concentration of the pollutants in air was calculated. The following sampling points at Paradip Port were considered for the collection of air samples.

Sl. No	Sampling points
1	Administrative Building
2	Madhuban Pump House
3	Brundaban pump House
4	IOHB
5	Tippler House
6	ADB Coal handling Plant
7	Electric Substation-1
8	Marine Site
9	Naya Bazaar Pump House
10	Atharabanki Gate

SAMPLE COLLECTION

High Volume Air Samplers were used for air sampling. For collection of airborne particulate matters, a known volume of air was sucked in and filtered through pre weight Whatman Glass Micro fiber Filter Paper No. GF/A (20.3 X 25.4 cm). The filter paper retains particles more than 0.1 μm size. Concentration of SPM in air was calculated by subtracting pre weight of filter paper from its final weight.

The concentration of gaseous pollutants like sulphur dioxide, nitrogen dioxide and ammonia in a particular volume of air were measured out by absorbing a known volume of air at

a regulated flow rate in the respective absorbing solutions followed by colorimetric analyses. Results of the air quality analysis of Paradip Port area during January-15 are presented in Table-1.

TOTAL SUSPENDED PARTICULATES MATTER (TSPM)

Particulate matter (PM) is a complex mixture of solid and liquid particles which remains suspended in air. These particles typically consist of a mixture of inorganic and organic chemicals, including carbon, sulfates, nitrates, metals, acids, and semi-volatile compounds. These particles come in many different size ranges such as coarse, fine and ultra fine. The size of PM in air ranged from approximately 0.005 to 100 micrometers (μm) in diameter, the size of just a few atoms to about the thickness of a human hair. They also vary in composition and origin. Particles are either directly emitted into the air by sources such as combustion processes and windblown dust, or formed in the atmosphere by transformation of emitted gases such as SO_2. The health effects of PM are likely to depend on several factors, including the size and composition of the particles, the level and duration of exposure, and age and sensitivity of the exposed person. Symptoms of exposure may include a sore throat, persistent cough, burning eyes, wheezing, shortness of breath, tightness of chest, and chest pain. PM may also trigger asthma and other respiratory disorders leading to premature death, particularly in the elderly who have preexisting cardiovascular and respiratory diseases.

Air samples were collected in the month of January 2015. The concentrations of TSPM at ten different points were within the range of 136.33-5295.13 μg/m^3, with the lowest and highest value being recorded at Marine Site and Trippler House respectively. The value of TSPM levels were exceeded the CPCB standard limit at all most all stations except Madhuban pump House and Marine Site.

RESPIRABLE SUSPENDED PARTICULATES MATTER (RSPM)

The concentrations of RSPM at ten designated points were in the range of 61.49 to 1520.84μg/m^3, with the lowest and highest value being recorded at Marine Site and Trippler House, respectively. The values of RSPM were exceeded the CPCB standard limit at all the stations except Marine Site.

SULPHUR DIOXIDE (SO_2)

Sulfur dioxide has a nasty, sharp smell. It reacts easily with other substances to form harmful compounds, such as sulfuric acid, sulfurous acid and sulfate particles. Sulfur dioxide is produced mainly from the combustion of fossil fuels that contain sulfur, such as coal and oil (for example, coal being burnt in a home fireplace for heating and diesel-powered vehicles). Sulfur dioxide is also produced from some industrial processes, such as fertilizer manufacturing, aluminium smelting and steel making. Natural sources of sulfur dioxide include geothermal activity. Sulfur dioxide is also present in motor vehicle emissions, as the result of fuel combustion. In the past, motor vehicle exhaust was an important, but not the main, source of sulfur dioxide in air. However, this is no longer the case.

Sulfur dioxide affects human health when it is breathed in. It irritates the nose, throat, and airways to cause coughing, wheezing, shortness of breath, or a tight feeling around the chest. The effects of sulfur dioxide are felt very quickly and most people would feel the worst symptoms in 10 to 15 minutes after breathing in. Those most at risk of developing problems if they are exposed to sulfur dioxide are people with asthma or similar conditions. Sulfur dioxide can cause respiratory problems, such as bronchitis, and it can irritate your nose, throat and lungs. It may cause coughing, wheezing, phlegm and asthma attacks. The effects are worse when you are exercising.

The concentrations of Sulfur Dioxide (SO_2) at ten different points were in the range of 0.487-57.120 $\mu g/m^3$ with the lowest value recorded at Naya Bazaar Pump House and highest value at IOHB. All Sulfur Dioxide (SO_2) values were under CPCB prescribed standard limit.

NITROGEN DIOXIDE (NO_2)

Nitrogen oxides or NOx, are the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Many of the nitrogen oxides are colorless and odorless. However, one common pollutant, nitrogen dioxide (NO_2) along with particles in the air can often be seen as a reddish-brown layer over many urban areas. Nitrogen oxides are generated when fuel is burned at high temperatures, as in a combustion process. The

primary manmade sources of NOx are motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels. NOx can also be formed naturally. In its pure state, nitrogen dioxide is a reddish-orange brown gas with a characteristic pungent odor. It is corrosive and a strong oxidizing agent. Nitrogen dioxide comprises about 10% of the oxides of nitrogen (NOx) that are formed when nitrogen in the air combines with oxygen during high temperature combustion. Most of the NOx emitted by combustion sources is nitric oxide (NO). However, during the day most of the NO is photo chemically transformed into NO_2. Thus, essentially all NOx emitted can be assumed too eventually become NO_2. Exposure to NO_2 affects the delicate structure of lung tissue. High levels cause lung irritation and potential lung damage. Lower levels have been associated with increased respiratory disease. Oxides of nitrogen can cause serious injury to vegetation, including bleaching or death of plant tissue, loss of leaves, and reduced growth rate. NO_X also deteriorates fabrics and fades fabric dyes. Nitrate salts formed from nitrogen oxides have been associated with the corrosion of metals. Nitrogen oxides can also reduce visibility.

The concentration of Nitrogen Dioxide (NO_2) at ten designated points was within the range 1.150-57.120 $\mu g/m^3$ with the lowest value recorded at ADB Coal handling Plant and highest value at IOHB respectively. All Nitrogen Dioxide (NO_2) values were under CPCB prescribed standard limit.

AMMONIA (NH_3)

Ammonia is a colorless gas with a very sharp odor. It is a chemical made both by humans and by nature. The odour of ammonia is familiar to most people because ammonia is used in smelling salts, household cleaners, and window cleaning products. Ammonia easily dissolves in water. Since ammonia occurs naturally in the environment, we are regularly exposed to low levels in air, soil, animals, and water. Ammonia does not last very long in the environment. Plants, bacteria, and animals rapidly take it up. Ammonia does not build up in the food chain, but serves as a nutrient for plants and bacteria. No health effects have been found in humans exposed to typical environmental concentrations of ammonia. Exposure to high levels of ammonia in air may be irritating to your skin, eyes, throat, and lungs and cause coughing and burns. Lung damage and death may occur after exposure to very high concentrations of ammonia. Some people with asthma may be more sensitive to breathing ammonia than others.

The concentrations of Ammonia (NH_3) at the ten designated points were within the range of 0.988-7.716 µg/m^3 with the lowest and highest value being recorded at Naya Bazar Pump House and IOHB respectively. All Ammonia (NH_3) values were under CPCB prescribed standard limit.

TABLE-1
AIR SAMPLING DATA FOR THE MONTH OF JANUARY-2015
(Date of sampling- 27th -29th January- 2015)

Sl.No.	Locations		[RSPM] µg/m^3	[TSPM] µg/m^3	[SO_2] µg/m^3	[NO_2] µg/m^3	[NH_3] µg/m^3
1	Administrative Building		109.23	211.61	1.729	8.667	1.083
2	Madhuban Pump House		114.93	188.62	1.791	14.099	1.545
3	Brundaban pump House		136.84	336.27	2.245	35.283	1.838
4	IOHB		202.08	737.85	5.973	57.120	7.716
5	Tippler House		1520.84	5295.13	5.133	21.280	5.351
6	ADB Coal handling Plant		438.74	1788.63	7.000	1.150	7.237
7	Electric Substation-1		972.22	2266.26	4.951	17.016	3.870
8	Marine Site		61.49	136.33	3.652	8.198	2.680
9	Naya Bazaar Pump House		152.03	217.88	0.487	5.841	0.988
10	Atharabanki Gate	Night	512.33	1242.91	3.165	39.930	3.672
		Day	556.18	1736.10	2.138	22.590	2.998

WATER ENVIRONMENT

Water samples were collected in the month of January-2015 from twelve different identified points inside harbour area including fishing harbour and analysed for various parameters along with bacterial and phytoplankton population. Most of the water quality parameters are within the prescribed limit and are presented in Table-2.1 to 2.5 for January-2015 samples.

SAMPLE COLLECTION

SURFACE WATER

Sampling of harbour surface water was carried out at the deck of a launch with the help of a bucket and rope. From the bucket of water, samples were collected for DO (dissolved oxygen) and BOD (biochemical oxygen demand) in specific bottles. One liter of this water was collected in a polyethylene bottle for analyzing the petroleum hydrocarbon (PHC). Another two liters of water samples were collected in two polyethylene bottles for analyzing other physical and chemical parameters.

BOTTOM WATER

For sampling of water from the bottom of harbour, a special kind of sampler made of synthetic materials procured from Mumbai was used to collect water samples. The specialty of this sampler is that it carries a weight along with it to withstand the turbulent conditions of harbour to sample conveniently from the vulnerable points like Approach Channel, Oil Jetty, etc. The sampler, which opens at both the ends, is lowered to the floor of the harbour at the sampling points to collect the bottom water. Like surface water collection specific samples were collected for specific parameters.

RESULTS

TEMPERATURE

Temperature is a measure of the hotness of a body. The measurement of temperature of a water body is important basically for its effect on the chemical and the biochemical reactions taking place within the living organism. During January-2015 the surface and bottom water temperatures were within the range of 23.3to 24.2 ^{0}C, whereas that of the ADB Pond and Fishing harbor registered as 25.6 and 24.2^{0}C.

pH

Since the seawater pH is normally alkaline the pH variations for surface and bottom water samples of harbour were observed within the range 8.13 to 8.26. IOHB (BW) showed highest pH 8.26, GCB (BW) showed pH 8.13, whereas the ADB Pond and Fishing harbour registered 8.47 and 7.91 pH respectively.

CONDUCTANCE

Conductivity denotes the capacity of a substance or a solution to conduct electrical current through it. This property in an aqueous solution is due to the presence of cations and anions in it. The observed conductance values of surface and bottom water were also within the range 42.8-44.7 mS/cm at EQ (SW) and EQ (BW) respectively .Whereas the ADB Pond and Fishing harbour registered 0.93 and 16.08 mS/cm of conductance respectively.

TURBIDITY

Turbidity arises due to the presence of various suspended matters such as slit, clay, partly miscible salt, organic matter, phytoplankton and other microscopic organism. During this quarter the surface and bottom water turbidity was within the range 2.29 - 31.7 NTU at NQ (BW) and MS (BW) respectively. The ADB Pond and Fishing harbor showed turbidity 13 NTU and 38.9 NTU respectively.

TOTAL DISSOLVED SOLIDS (TDS)

Total dissolved solids of the surface and bottom water samples were within the range 30.89 g/l (MS-SW) to 42.9(OJ-BW) g/l, whereas the observed TDS values in ADB Pond and Fishing Harbour were 3.35 g/l and 11.78 g/l, respectively.

TOTAL SUSPENDED SOLIDS (TSS)

Suspended solids in a water body are defined as the insoluble organic and inorganic substance in water. Total Suspended solids of the surface and bottom water were within the range of 0.0094 g/l (AC-SW) to 0.057 g/l (MS-SW), whereas the observed TSS value in ADB Pond and FH were 0.0475 g/l and 0.0252 g/l respectively.

TOTAL SOLIDS (TS)

The concentration of total solid (TS) in a water sample is the sum of concentrations of total suspended solids (TSS) and total dissolved solids (TDS) in a liter of water. The TS variations in the surface and bottom water samples were within the range 30.947 g/l (MS-SW) to 42.9121 g/l (OJ-BW). The observed TS values in ADB Pond and Fishing Harbour were 3.5975 g/l and 11.8052 g/l, respectively.

PETROLEUM HYDROCARBON (PHC)

The concentration of PHC was analysed in the surface water samples only because of its low density to float on the surface water. In surface water the PHC variations were from1.7 to 4.9 mg/l, showing the highest value at OJ and the lowest value at GCB. The observed PHC values in ADB Pond and Fishing Harbour were 1.3 mg/l and 6.8 mg/l, respectively.

DISSOLVED OXYGEN (DO)

Dissolved oxygen (DO) is the key substance in determining the extent and kind of life in a water body. Oxygen deficiency is fatal to most of the aquatic animals like fish. The presence of oxygen is also fatal to many kinds of anaerobic bacteria too. However, all the chemical and biochemical processes undergoing in a water body are largely dependent upon the presence of oxygen. The surface and bottom water of the harbour, DO were found to be within the range 4.28 mg/l (EQ-BW) to 6.73 mg/l (NQ-SW), whereas DO values of ADBP and FH are 9.18 and 6.73 mg/l respectively.

BIOLOGICAL OXYGEN DEMAND (BOD)

Biochemical Oxygen Demand (BOD) is another parameter for water quality, which refers to the amount of oxygen required to degrade the organic matter in a given volume of water by microorganisms. The BOD variations in harbour water were recorded within the range 0.31 mg/l

(EQ-BW) to 4.59 mg/l (NQ-SW). ADBP showed BOD value 6.43 mg/l, whereas FH registered 5.81 mg/l.

NUTRIENTS

Nutrients, like nitrogen and phosphorus, occur naturally in water. Just as the nitrogen and phosphorus in fertilizer aids the growth of agricultural crops, both nutrients are vital to the growth of plants within the Bay and rivers. The nitrogen bearing nutrients and phosphorus bearing nutrient were analysed in the harbour water samples of Paradip Port. Nitrite (NO_2^-) and Nitrate (NO_3^-) variation in surface and bottom water were within the range 0.0014 mg/l (AC-SW) to 0.0126 mg/l (IOHB-BW) and 0.0640 mg/l (AC-SW) to 0.1364 mg/l (IOHB-BW) respectively. Similarly, the concentration of ammonia varied from 0.0054 mg/l (AC-BW) to 0.0252 mg/l (FB-SW), both in surface and bottom water. Phosphate is generally considered as the critical nutrient for growth of algae in water. The enrichment of this nutrient leads to the process of eutrophication. The most important source of phosphate is the discharge of domestic sewage, detergents and agricultural run off. However, the surface and bottom water Phosphate values were within the range of 0.0072 mg/l (GCB-BW) to 0.1168 mg/l (MS-SW). The Nitrite, Nitrate, Ammonia, phosphate level at ADB and Fishing harbour were found to be 0.0004, 0.0416, 0.0142, 0.0520 mg/l and 0.0170, 0.1464, 0.0186, 2.2296 mg/l respectively.

SULPHATE

Sulphate is a naturally occurring anion found in almost all kinds of water bodies. It may undergo transformations to sulfur or hydrogen sulphide depending largely upon the redox potential of water. This is an important anion to impart hardness to water. The sulfate concentrations in surface and bottom water were found to be within the range of 1574.40 mg/l (AC, BW) to 2035.20 mg/l (GIOHB, SW). ADBP and FH showed the concentration of sulfate 115.20 and 576.00 mg/l respectively.

CHLORINITY & SALINITY

Chlorinity of the surface and bottom water of harbour was within the range 15.17 g/l (EQ-SW) to 15.94 g/l (EQ-BW), whereas 0.11 g/l was observed in ADB Pond water and 5.26 g/l in case of Fishing Harbour. Similarly, the observed salinity in surface and bottom water varied

from 27.4 ppt (EQ-SW) to 28.8 ppt (EQ-BW). Salinity observed at ADB Pond and at Fishing Harbour were 0.2 ppt. and 9.5 ppt. respectively.

ALKALINITY

Alkalinity values in water samples consisting of phenolphthalein alkalinity and total alkalinity were analysed. The phenolphthalein alkalinity (PA) is due to the carbonate content of the water body whereas total alkalinity (TA) is due to the bicarbonate, carbonate and hydroxide contents in a water sample taken together. The variations of Phenolphthalein Alkalinity in surface and bottom water observed to be within the range of 12(AC-SW) to 15.6 mg $CaCO_3$/l (IOHB SW) and alkalinities due to bicarbonate were within the range 85.4(IOHB-SW) to 98.82 mg $CaCO_3$/l (IOHB-BW).

HARDNESS

The hardness in water is due to the presence of bicarbonates, carbonates, chlorides and sulphates of inorganic salts in a water body. The total hardness of the samples were within the range of 5144.58(IOHB-SW) to 5364.78 mg $CaCO_3$/l (NQ,BW) in surface and bottom water and the analysed hardness in ADB Pond was 220.20 mg $CaCO_3$/l and at Fishing harbor was 1781.59 mg $CaCO_3$/l. The measured permanent hardness in surface and bottom water ranged from 4664.16 to 4764.25 mg CaCO3/l (NQ, BW). The observed permanent hardness values in ADB Pond and Fishing Harbour were 200.18 mg$CaCO_3$/l and 1581.41 mg $CaCO_3$/l, respectively. The temporary hardness varied from 420.37 to 600.54 mg $CaCO_3$/l (NQ- BW). ADB Pond and Fishing harbor registered 20.02 mg$CaCO_3$/l and 200.18 mg$CaCO_3$/l, respectively. Similarly the measured Calcium hardness in surface and bottom water ranged from 500.45 to 640.57 mg$CaCO_3$/l. Whereas the observed Calcium hardness values in ADB Pond and Fishing Harbour were 120.11 mg$CaCO_3$/l and 240.21 mg$CaCO_3$/l, respectively. The measured Magnesium hardness in surface and bottom water ranged from 4564.07 to 4724.21 mg $CaCO_3$/l (NQ, BW), whereas the observed Magnesium hardness values in ADB Pond and Fishing harbor were 100.09 mg $CaCO_3$/l and 1541.37 mg $CaCO_3$/l, respectively.

CALCIUM (Ca)

Calcium concentrations of the surface and bottom water were within the range 200.18 to 256.23 mg/l, whereas the observed Calcium concentration values in ADB Pond and Fishing Harbour were 48.04 mg/l and 96.09 mg/l, respectively.

MAGNESIUM (Mg)

Magnesium concentrations of the surface and bottom water were within the range 1109.07 to 1147.98 mg/l. However, the observed Magnesium concentration values in ADB Pond and Fishing Harbour were 24.32 mg/l and 374.55 mg/l, respectively.

SODIUM (Na) AND POTASSIUM (K)

Sodium and Potassium are the vital component of sea water, their concentrations in surface and bottom water were in the range of 7262 mg/l (FB-BW) to 9257 mg/l (OJ,SW) and 229 mg/l (MS-BW) to 377 mg/l (IOHB,BW) respectively. The concentration of "Na" at ADB Pond and Fishing Harbour were 60.88 mg/l and 2159 mg/l that of 'K' were 10.08 mg/l and 21 mg/l.

HEAVY METALS

Environmental pollution due to the presence of metal ions in water is a recent concern to the human beings as well as the entire ecosystem. The term Heavy metal is somewhat imprecise, which include most of the metals with atomic numbers more than 20 excluding the alkali metals, alkaline earth metals, lanthanides and actinides. They comprise 38 elements having specific gravity more than 5 excluding the lanthanides and actinides.

The inside port water analysis result predicted that the Iron concentrations were within the range 0.0167- 0.0251mg/l, the concentration levels of Manganese were within the range 0-0.00506. The observed values of Copper and Nickel were within the range 0.0001-0.0065 mg/l, 0-0.0045 mg/l respectively. The values of Cobalt were within the range 0.0001 to 0.0065 mg/l. Zinc concentrations were within the range 0.0061- 0.0471 mg/l and Lead concentrations were within 0.0102-0.0191 mg/l. Similarly, variation of Chromium concentrations were within the range 0.0076-0.0134 mg/l, and the concentrations level of Cadmium were within the range 0.00001-0.00011mg/l.

TABLE-2.1
WATER ANALYSIS DATA FOR THE MONTH OF JANUARY- 2015
(Date of sampling- 27th -29th January-2015)

Sampling point		Temp.°C	pH	Condu. mS/cm	Turb-idity NTU	TSS g/l	TDS g/l	TS g/l	PHC mg/l
AC	SW	23.4	8.17	44.2	2.91	0.0094	39.14	39.1494	2.9
	BW	233	8.19	44.4	7.72	0.0159	33.73	33.7459	
OJ	SW	23.6	8.25	44.0	2.63	0.013	41.28	41.2930	4.9
	BW	23.7	8.23	44.5	3.67	0.0121	42.9	42.9121	
IOHB	SW	24.2	8.21	44.0	9.33	0.0145	39.97	39.9845	4.3
	BW	23.7	8.26	44.5	6.95	0.0182	33.78	33.7982	
ADB	SW	23.7	8.24	44.2	5.3	0.0115	39.9	39.9115	3.7
	BW	23.7	8.22	44.5	8.48	0.0191	39.36	39.3791	
NQ	SW	23.8	8.21	44.2	8.57	0.0175	35.92	35.9375	2.2
	BW	23.8	8.2	44.6	2.29	0.0363	34.73	34.7663	
GCB	SW	23.9	8.17	44.2	3.97	0.0133	35.81	35.8233	1.7
	BW	23.8	8.13	44.5	6.17	0.0135	34.96	34.9735	
SQ	SW	23.8	8.19	44.3	6.68	0.0185	38.95	38.9685	3.2
	BW	23.9	8.21	44.4	9	0.0174	33.02	33.0374	
EQ	SW	23.7	8.21	42.8	15.6	0.0321	35.43	35.4621	2.4
	BW	23.6	8.16	44.7	25.3	0.0478	33.74	33.7878	
FB	SW	23.8	8.24	44.3	20.1	0.0371	32.85	32.8871	4.6
	BW	23.7	8.18	44.6	27.2	0.0412	31.19	31.2312	
MS	SW	23.8	8.19	44.0	27.7	0.057	30.89	30.9470	1.6
	BW	23.9	8.22	43.8	31.7	0.0552	39.71	39.7652	
ADBP	SW	25.6	8.47	0.93	13	0.0475	3.55	3.5975	1.3
FH	SW	24.2	7.91	16.08	38.9	0.0252	11.78	11.8052	6.8

TABLE-2.2
WATER ANALYSIS DATA FOR THE MONTH OF JANUARY-2015
(Date of sampling-27th -29th January 2015)

Sampling point		[DO] mg/l	[BOD] mg/l	[NO_2^-] mg/l	[NO_3^-] mg/l	[NH_3] mg/l	[PO_4^{3-}] mg/l	[SO_4^{2-}] mg/l
AC	SW	4.59	1.22	0.0014	0.0640	0.0106	0.0542	1766.40
	BW	6.43	2.14	0.0034	0.0938	0.0054	0.0260	1574.40
OJ	SW	6.43	2.75	0.0030	0.0672	0.0092	0.0466	1843.20
	BW	6.12	3.98	0.0088	0.0930	0.0108	0.0588	1958.40
IOHB	SW	6.43	2.14	0.0098	0.1070	0.0126	0.0648	2035.20
	BW	6.12	2.75	0.0126	0.1364	0.0138	0.0676	1958.40
ADB	SW	6.43	2.30	0.0084	0.1110	0.0152	0.0752	1920.00
	BW	6.43	2.45	0.0090	0.1148	0.012	0.0440	1862.40
NQ	SW	6.73	4.59	0.0080	0.1044	0.0104	0.0586	1862.40
	BW	6.37	2.39	0.0100	0.1254	0.0172	0.0834	1843.20
GCB	SW	6.43	2.30	0.0056	0.1136	0.0126	0.0598	1804.80
	BW	6.12	2.14	0.0086	0.1080	0.016	0.0072	1747.20
SQ	SW	6.12	3.06	0.0070	0.1016	0.0144	0.0730	1824.00
	BW	6.12	1.90	0.0122	0.1204	0.0158	0.0764	1766.40
EQ	SW	4.59	0.92	0.0070	0.0938	0.0192	0.0984	1804.80
	BW	4.28	0.31	0.0090	0.0818	0.0178	0.0876	1766.40
FB	SW	6.27	2.75	0.0106	0.0924	0.0252	0.1044	1881.60
	BW	5.81	1.84	0.0086	0.1040	0.0216	0.0906	1824.00
MS	SW	4.44	1.38	0.0052	0.1084	0.0196	0.0968	1900.80
	BW	4.28	1.13	0.0036	0.0972	0.0184	0.1168	1843.20
ADBP	SW	9.18	6.43	0.0004	0.0416	0.0142	0.0520	115.20
FH	SW	6.73	5.81	0.0170	0.1464	0.0186	2.2296	576.00

TABLE-2.3
WATER ANALYSIS DATA FOR THE MONTH OF JANUARY-2015
(Date of sampling 27-29 January, 2015)

Sampling point		Chlorinity, g/l	Salinity, ppt.	$[CO_3^{2-}]$, mg CaCO3/l	$[HCO_3^-]$ mg $CaCO_3$ /l	Total Hard. mg $CaCO_3$ /l	Perm. Hard. mg $CaCO_3$/l	Temp. Hard. mg $CaCO_3$/l
AC	SW	15.72	28.4	12	97.6	5204.64	4724.21	480.43
	BW	15.83	28.6	14.4	90.28	5284.71	4744.23	540.48
OJ	SW	15.67	28.3	14.4	91.5	5204.64	4704.19	500.45
	BW	15.83	28.6	14.4	91.5	5244.67	4744.23	500.45
IOHB	SW	15.67	28.3	15.6	85.4	5144.58	4684.17	460.41
	BW	15.89	28.7	12	98.82	5204.64	4724.21	480.43
ADB	SW	15.78	28.5	13.2	90.28	5164.60	4704.19	460.41
	BW	15.89	28.7	12	96.38	5204.64	4704.19	500.45
NQ	SW	15.78	28.5	13.2	95.16	5144.58	4664.16	480.43
	BW	15.94	28.8	13.2	96.38	5364.78	4764.25	600.54
GCB	SW	15.72	28.4	12	97.6	5164.60	4724.21	440.39
	BW	15.83	28.6	13.2	95.16	5144.58	4724.21	420.37
SQ	SW	15.78	28.5	12	92.72	5204.64	4744.23	460.41
	BW	15.83	28.6	14.4	91.5	5184.62	4724.21	460.41
EQ	SW	15.17	27.4	13.2	92.72	5144.58	4704.19	440.39
	BW	15.94	28.8	12	93.94	5204.64	4744.23	460.41
FB	SW	15.78	28.5	13.2	92.72	5184.62	4744.23	440.39
	BW	15.89	28.7	14.4	92.72	5204.64	4744.23	460.41
MS	SW	15.67	28.3	14.4	91.5	5164.60	4724.21	440.39
	BW	15.61	28.2	15.6	90.28	5184.62	4724.21	460.41
ADBP	SW	0.11	0.2	3.6	98.82	220.20	200.18	20.02
FH	SW	5.26	9.5	2.4	100.04	1781.59	1581.41	200.18

TABLE-2.4
WATER ANALYSIS DATA FOR THE MONTH OF JANUARY-2015
(Date of sampling- 27th -29 th January 2015)

Sampling point		Ca Hard. mg. $CaCO_3$ /l	Mg Hard. mg. $CaCO_3$ /l	[Ca], mg/l	[Mg], mg/l	[Na], mg/l	[K], mg/l
AC	SW	600.54	4604.10	240.21	1118.80	9080	362
	BW	580.52	4704.19	232.21	1143.12	9241	372
OJ	SW	600.54	4604.10	240.21	1118.80	9257	358
	BW	540.48	4704.19	216.19	1143.12	9233	374
IOHB	SW	540.48	4604.10	216.19	1118.80	8373	377
	BW	600.54	4604.10	240.21	1118.80	8257	354
ADB	SW	500.45	4664.16	200.18	1133.39	7949	346
	BW	580.52	4624.12	232.21	1123.66	8218	328
NQ	SW	560.50	4584.09	224.20	1113.93	7772	288
	BW	640.57	4724.21	256.23	1147.98	8042	299
GCB	SW	580.52	4584.09	232.21	1113.93	7633	302
	BW	580.52	4564.07	232.21	1109.07	7766	279
SQ	SW	600.54	4604.10	240.21	1118.80	7752	278
	BW	580.52	4604.10	232.21	1118.80	7717	282
EQ	SW	580.52	4564.07	232.21	1109.07	7427	250
	BW	600.54	4604.10	240.21	1118.80	7639	272
FB	SW	560.50	4624.12	224.20	1123.66	7481	265
	BW	600.54	4604.10	240.21	1118.80	7262	247
MS	SW	560.50	4604.10	224.20	1118.80	7263	248
	BW	580.52	4604.10	232.21	1118.80	7414	229
ADBP	SW	120.11	100.09	48.04	24.32	60.88	10.08
FH	SW	240.21	1541.37	96.09	374.55	2159	21

TABLE-2.5
WATER ANALYSIS DATA FOR THE MONTH OF JANUARY-2015
(Date of sampling- 27th 29 th January 2015)

Sampling point		[Fe] mg/l	[Mn], mg/l	[Cu], mg/l	[Ni], mg/l	[Co], mg/l	[Zn], mg/l	[Pb], mg/l	[Cr], mg/l	[Cd], mg/l
AC	SW	0.0219	0.00270	0.0051	0.0011	0.0051	0.0326	0.0153	0.0106	0.00005
	BW	0.0251	0.00034	0.0027	0.0001	0.0027	0.0104	0.0159	0.0076	0.00008
OJ	SW	0.0228	0.00000	0.0065	0.0001	0.0065	0.0290	0.0172	0.0079	0.00010
	BW	0.0216	0.00338	0.0020	0.0001	0.0020	0.0089	0.0121	0.0091	0.00011
IOHB	SW	0.0184	0.00293	0.0001	0.0000	0.0001	0.0129	0.0146	0.0088	0.00006
	BW	0.0224	0.00248	0.0034	0.0018	0.0034	0.0187	0.0102	0.0091	0.00007
ADB	SW	0.0191	0.00011	0.0016	0.0022	0.0016	0.0471	0.0108	0.0085	0.00011
	BW	0.0207	0.00506	0.0024	0.0021	0.0024	0.0074	0.0115	0.0076	0.00005
NQ	SW	0.0167	0.00158	0.0016	0.0021	0.0016	0.0079	0.0121	0.0085	0.00006
	BW	0.0198	0.00124	0.0042	0.0045	0.0042	0.0373	0.0108	0.0091	0.00001
GCB	SW	0.0177	0.00236	0.0001	0.0021	0.0001	0.0089	0.0115	0.0103	0.00003
	BW	0.0195	0.00090	0.0024	0.0027	0.0024	0.0095	0.0153	0.0082	0.00003
SQ	SW	0.0202	0.00495	0.0005	0.0019	0.0005	0.0197	0.0146	0.0091	0.00001
	BW	0.0172	0.00248	0.0019	0.0019	0.0019	0.0103	0.0166	0.0106	0.00001
EQ	SW	0.0179	0.00011	0.0002	0.0012	0.0002	0.0150	0.0159	0.0116	0.00006
	BW	0.0224	0.00079	0.0038	0.0027	0.0038	0.0061	0.0178	0.0125	0.00006
FB	SW	0.0188	0.00169	0.0003	0.0029	0.0003	0.0105	0.0153	0.0122	0.00001
	BW	0.0200	0.00225	0.0003	0.0037	0.0003	0.0219	0.0185	0.0106	0.00004
MS	SW	0.0226	0.00158	0.0007	0.0019	0.0007	0.0391	0.0191	0.0122	0.00005
	BW	0.0170	0.00034	0.0001	0.0026	0.0001	0.0123	0.0185	0.0134	0.00002
ADBP	SW	0.0212	0.00124	0.0017	0.0026	0.0017	0.0057	0.0204	0.0134	0.00006
FH	SW	0.0209	0.00135	0.0027	0.0019	0.0027	0.0936	0.0229	0.0116	0.00001

SEDIMENT ENVIRONMENT

The unconsolidated materials derived from pre-existing rocks or similar other sources by the process of denudation are deposited in water medium is known as sediment. For a system, like a port, where large varieties of raw materials and finished products are handled, expected sediment contamination is obvious. The materials or part of materials spilled over the water during loading and unloading operations lead to the deposition in the harbor water along with sediment and thus collected as harbour sediment sample. These loose materials serve as receptor of many trace elements, which are prone to environment impact. In this connection it is pertinent to study the concentration and distribution of environmentally sensitive elements in the harbor sediment.

SAMPLE COLLECTION

Samples were collected by means of a specially designed grab known as clamp-shell snapper from different sampling locations given below and these samples were subjected to study the different physical and chemical parameters and the observations are discussed below.

Serial no.	Locations
1	Approach channel (AC)
2	Oil jetty (OJ)
3	Iron ore handling berth (IOHB)
4	ADB coal handling plant (ADBCHP)
5	North quay (NQ)
6	General Cargo Berth(GCB)
7	South quay (SQ)
8	East quay (EQ)
9	Fertilizers Berth (FB)
10	Marine Site(MS)

RESULTS

SIZE ANALYSIS

This is a physical property of sediment it provides the texture and fine content of the sample. For size analysis the sediment sample is subjected to 63µm wet sieving. The size analysis data for sediment is given in Table-3.1. From wet sieving it was observed that during, January-2015, the samples collected at all stations are clay type except AC, GCB and EQ.

TABLE-3.1
PERCENTAGE OF ORGANIC MATTER, ORGANIC CARBON
&
SIZE ANALYSIS IN SEDIMENT

Sampling point	Organic Carbon		Organic Matter		Size Analysis (%)	
	Bulk	-63 µm	Bulk	-63 µm	+63µm	-63 µm
AC	7.564	20.485	1.304	3.532	70	30
OJ	13.788	17.255	2.377	2.975	5	95
IOHB	15.364	33.485	2.649	5.773	10	90
ADB	24.582	32.303	4.238	5.569	15	85
NQ	9.376	28.758	1.616	4.958	25	75
GCB	35.612	36.873	6.140	6.357	65	35
SQ	37.661	38.370	6.493	6.615	20	80
EQ	6.539	17.727	1.127	3.056	60	40
FB	20.839	26.709	3.593	4.605	10	90
MS	12.448	14.576	2.146	2.513	5	95

ORGANIC MATTER

Organic matter in sediment consists of carbon and nutrients in the form of carbohydrate, proteins, fats and nucleic acids. The presence of Organic matter in sediment is derived from plant and animal detritus, bacteria or plankton formed in situ or derived from natural and anthropogenic sources in catchments. The amount of Organic matter found in sediment is a function of various sources reaching the surface of sediment and the rates at which various types of organic matter are degraded by microbiological process during burial. The carbon content depends on eutrophication, prevailing pH condition, rates of sedimentation, grain size of the

sediment and the amount of fresh water flow through the system. Organic matter is also a source of food and energy and its nutritional balance plays an important role in material flow through ecosystem. Generally, in an undistributed sedimentation system, organic matter has a high affinity for fine-grained sediment because it absorbs onto mineral surface. The organic matter contents at the locations for different sampling points given in table-3. In January 2015 the organic matter in the bulk at different sampling points were within the range of 1.127-6.493 % in wt. Organic carbon at those points were within range 6.539-37.661 % in wt. Organic Matter and Organic Carbon in -63 μm were within the range 2.513-6.615 % and 14.576-38.370 % in wt respectively. The maximum wt% found at SQ and minimum at MS.

TRACE & MAJOR ELEMENTS

The concentration of trace and major elements were measured by AAS and are given in Table-3.2 and Table-3.3 for trace and major elements, respectively. The analysis report of bulk samples during January 2015 predicted that the trace elements like Cu, Ni, Co, Pb, Zn, Cr, Cd were found within the range of 26.95-98.35 mg/kg, 75.75-110.85 mg/kg, 13.75-42.6 mg/kg, 239.35-300.45 mg/kg, 123.8-287.45 mg/kg, 243.25-997.25 mg/kg,0.35-1.1 mg/kg respectively. The concentration of Cu was maximum at FB and minimum at GCB. For nickel the concentration was highest at GCB and the lowest concentration at MS. In case of cobalt the maximum concentration was found at NQ and minimum at MS. The concentration of zinc was maximum at IOHB and minimum at EQ. The maximum concentration of lead was found at FB and minimum concentration was at OJ. The maximum concentration of chromium was at GCB and minimum at EQ. The maximum concentration of cadmium was at SQ and minimum at GCB.

The elements like Fe, Mn, Ca, Mg, Na and K were found in bulk samples within the range 2.66-15.71%, 0.05-0.18%, 0.18-0.38%, 0.18-0.33 %, 4.68-7.28% and 0.58-1.48% by weight, respectively. Weight percentage of Fe, Mn, Ca, Mg, Na, K were found highest at IOHB, AC, OJ, GCB, ADB, SQ respectively.

TABLE-3.2
TRACE ELEMENTS IN SEDIMENT IN PPM (mg/kg)

Sampling point	Ni		Co		Pb		Cr		Zn		Cu		Cd	
	Bulk	-63µm	Bulk	-63µm	Bulk	-63µm	Bulk	-63µm	Bulk	-63µm	Bulk	-63µm	Bulk	-63µm
AC	98.8	130.6	34.35	45.35	244.40	280.05	291.90	321.05	154.85	177.95	31.3	80.2	0.65	1.6
OJ	100.95	136.1	37.1	35.7	239.35	315.70	328.35	360.00	203.80	204.60	78.3	90.85	0.55	0.55
IOHB	94.4	119.65	20.6	31.6	249.50	285.15	347.80	450.00	287.45	307.35	42	63.9	0.75	0.8
ADB	94.4	106.45	35.7	38.45	259.70	315.70	277.30	328.35	186.75	207.30	41.35	78.95	0.7	0.75
NQ	102.05	129.5	42.6	43.95	264.80	325.90	289.45	330.80	181.85	221.30	36.35	82.7	0.6	0.2
GCB	110.85	116.35	16.5	52.2	269.90	310.60	997.25	428.10	147.60	200.90	26.95	83.3	0.35	0.9
SQ	92.2	111.95	34.35	31.6	254.60	310.60	296.75	316.20	136.45	239.90	36.95	77.05	1.1	1
EQ	77.9	124	16.5	35.7	269.90	290.25	243.25	328.35	123.80	175.45	26.95	72.05	1.1	1.15
FB	106.45	117.45	22	33	300.45	315.70	291.90	321.05	173.60	612.70	98.35	90.2	0.6	0.9
MS	75.75	111.95	13.75	31.6	290.25	331.00	255.40	311.35	126.50	276.15	33.85	127.2	1	0.8

TABLE-3.3
PERCENTAGE OF MAJOR ELEMENTS IN SEDIMENT (Wt %)

Sampling Point	Fe		Mn		Ca		Mg		Na		K	
	Bulk	-63µm	Bulk	-63µm	Bulk	-63µm	Bulk	-63µm	Bulk	-63µm	Bulk	-63µm
AC	6.55	8.46	0.18	0.22	0.33	0.23	0.23	0.33	6.83	7.23	0.93	0.60
OJ	6.93	8.22	0.15	0.16	0.38	0.28	0.18	0.30	6.03	6.78	1.43	0.98
IOHB	15.71	17.68	0.18	0.15	0.25	0.20	0.25	0.35	5.43	7.15	0.90	1.05
ADB	6.60	8.40	0.14	0.15	0.23	0.18	0.30	0.38	7.28	7.40	1.10	1.43
NQ	5.57	9.09	0.12	0.17	0.18	0.13	0.23	0.28	5.15	6.60	0.58	1.03
GCB	5.34	8.63	0.13	0.15	0.20	0.18	0.33	0.38	5.53	6.93	0.78	0.70
SQ	5.82	8.77	0.12	0.16	0.18	0.18	0.20	0.28	4.68	6.18	1.48	1.78
EQ	4.34	7.86	0.08	0.14	0.23	0.23	0.28	0.30	5.80	6.88	1.20	1.48
FB	6.28	7.60	0.11	0.13	0.25	0.23	0.30	0.35	6.05	5.90	1.03	1.65
MS	2.66	8.28	0.05	0.13	0.30	0.25	0.23	0.33	4.90	5.70	0.93	1.35

NOISE ENVIRONMENT

Noise measurement is an important diagnostic tool which allows monitoring and comparing different noise levels for assessment of adverse impacts of noise and implementing suitable measures for noise reduction. The intensity of sound is measured in sound pressure levels (SPL) and common unit of measurement is decibel (dB). The community (ambient) noise levels are measured in the A - weighted SPL, abbreviated dB (A). This scale resembles the audible response of human ear. The sources of noise may vary according to daily activities. The sources may be domestic, natural (shores, birds/animal shouts, wind movement, sea tide movement, waterfalls etc.), commercial (automobiles, aeroplanes, machinery etc.), industrial (generator sets, boilers, plant operations, trolley movement, transport vehicles, pumps, motors etc.).

With a view to ascertain noise emitted by various activities in the Paradip port area, the noise measurements have been carried out once in each quarter. The noise evaluated for the month of January-2015 has been presented in the following tables. Noise level monitoring has been carried out both inside and outside the harbor premises during day time using Cygnet Precision Sound Level meter Type 2031, capable of measuring sound levels up to 0.1 dB(A). Noise level data were measured at 6 selected locations within the port area (Table-4.1) and at 8 locations outside the port area (Table-4.2) as identified.

Based on the measured values the noise data has been computed for quantification as L_{eq} and the data is presented in Tables-4.1 and 4.2. The prescribed noise limits has been incorporated in the last column. It is note that even though port activity is going on generally in full swing the noise emitted is well within the prescribed limits inside the port area. However, considering the noise limits in commercial, residential and silence zones outside port area, only at selected locations viz. Atharabanki gate, Brundaban Colony, Convent School and Market Complex (near Dipti Petrol Pump), where noise limits exceeded prescribed limits nominally during rush hours. Outside the port area the highest value recorded at Market Complex and Atharabanki gate.

TABLE-4.1
NOISE DATA COLLECTED IN JANUARY-2015
(Date of sampling- 27th -29th January 2015)

Inside Port Area

Sl. No	Location	Noise Range, dBA	L_{eq}, dBA	SPL Min, dBA	SPL Max, dBA	Prescribed Noise limit dBA
1	**Wagner Tippler**	59.1-70.7	62.0	59.5	62.2	75
2	**IOHB**	52.2-70.5	56.5	51.1	57.9	75
3	**Conveyer Belt**	66.7-71.4	71.4	68.8	75.1	75
4	**MCH plant**	66.3-77.9	71.7	66.5	71.9	75
5	**Marine site**	53.1-64.4	58.2	58.2	74.1	75
6	**Electrical Substation**	55.1- 70.7	62.5	59.8	68.4	75

TABLE-4.2
NOISE DATA COLLECTED IN JANUARY-2015
(Date of sampling- 27th -29th January 2015)

Outside Port Area

Sl. No	Location	Noise Range, dBA	L_{eq}, dBA	SPL Min, dBA	SPL Max, dBA	Prescribed Noise limit, dBA
1	**Atharabanki Gate**	57.5-79.2	66.3	63.1	79.3	65
2	**Madhuban Pump House**	20-68.9	49.6	44.5	56.4	55
3	**Brundaban Colony**	55.4-76.2	63.1	54.1	66.4	55
4	**Convent School**	47.5-77.9	57.3	56.8	72.0	50
5	**Administrative Building**	42.3-84.4	61.8	59.3	79.5	65
6	**Market Complex (Dipti Petrol Pump)**	56.7-99.1	66.6	59.3	75.7	65
7	**Power Plant (3MW) Outside**	57.0-82.9	65.2	53.7	68.6	75
8	**Fishing Harbour**	58.7-74.7	63.5	53.8	65.2	75

BIOLOGICAL ENVIRONMENT

PHYTOPLANKTON STUDY

Phytoplanktons are the microscopic algae that live free-floating and suspended in bodies of water. Phytoplankton obtains energy through a process called photosynthesis. Through photosynthesis, phytoplanktons are responsible for much of the oxygen present in the Earth's atmosphere – half of the total amount produced by all plant life. Their cumulative energy fixation in carbon compounds (primary production) is the basis for the vast majority of oceanic and also many freshwater food webs (chemosynthesis is a notable exception). Planktonic habitat, consisting of suspended but poorly motile forms, concentrates in the thin sunlit photic zone where radiant energy from the sun is utilized by photosynthetic microorganisms to produce organic matter. This soluble and particulate organic matter produced by the phytoplankton, which is moved up the food chain by Bacterioplankton, Protozooplankton, and Zooplankton, is the basis for virtually all life in the sea. Part of the organic matter released by the activities of the plankton is concentrated at the sea- air interface to form a thin skin or surface micro layer.

Water quality indicators include physical, chemical and biological parameters. The composition of a water body varies naturally over time and is significantly related to human activities. Phytoplankton is the food even utilized by the world’s largest and longest living aquatic animals and fishes. The abundance of phytoplankton population in a water body undergoes seasonal changes with variations in temperature, sunlight and availability of nutrients. It is advantageous for the phytoplankton species to remain in the surface water of the ocean where there is sunlight, abundance of food resources and good circulation of water mass. Changes in nutrient conditions (eutrophication) and light conditions (turbidity, mixing and cloudy sky) may shift the competitive balance between phytoplankton species. Analysis and interpretation of long-term data are essential to develop qualitative and quantitative relationship between the abundance of particular phytoplankton functional groups and other parameters. These analyses generate information, which can link the abundance of a phytoplankton functional group with a particular set of environmental conditions. Thus specific phytoplankton functional groups can be used as biological indicators of water quality.

Phytoplankton communities indicate the available nutrient levels. Abundance of nutrients usually results in dense algal blooms. These blooms reduce the penetration of

sunlight to subsurface water as a result of which the growth of submerged aquatic vegetation is hampered. This has also impact on dissolved oxygen levels. Extremely dense algal blooms produce high quantity of oxygen levels on sunny days while the algae are photosynthesizing. During night or on cloudy days, the large algal blooms use up all the oxygen from water column depriving the aquatic animals from available adequate oxygen levels. In lesser densities algal bloom burdens the system when they die. The decomposition of dead biomass can use up all the dissolved oxygen available in bottom waters. Excess available nutrients in a water body also change the level of phytoplankton community. Due to their short life cycles, phytoplankton respond quickly to environmental changes, so the phytoplankton community present in a water body can also provide valuable information about water quality.

LOCATION OF SAMPLING POINTS

The criteria for selection of sampling points inside the harbor area of Paradip port were on the basis of port activities and suitability for sample collection. The following sampling points were chosen for the study inside the harbor.

Sampling points

CODE	LOCATIONS
AC	Approach Channel
OJ	Oil jetty
IOHB	Iron Ore Handling Berth
ADB	ADB Coal Handling
NQ	North Quay
GCB	General Cargo Berth
SQ	South Quay
EQ	East Quay
FB	Fertilizer Berth
MS	Marine Site
FH	Fishing harbor

Sample collection and processing

Surface water from different points of Paradip Port harbor was collected in the month of January-2015. From each point 1.0 Liter of surface water sample was collected in polythene bottles and preserved immediately by adding 10 ml of Lugol's iodine solution. The samples were brought to the laboratory and were kept standing undisturbed in a separating funnel for at least 48 hours. This allowed the phytoplankton's present in the sample to settle down to the bottom of the funnel. The lower layer of water sample containing phytoplankton biomass was removed carefully leaving the upper layer of clear water. The samples were then used for phytoplankton estimation under light microscope.

Estimation of Phytoplankton

Each concentrated sample was shacked for uniform mixing and 1 ml of it was loaded in to the phytoplankton counting slide (Sedgewick- Rafter counting slide) with cover slip in position. It was allowed to stand for five minutes. Counting was done under a binocular research microscope. Various species present in a sample was identified and their number was counted. Calculation of species diversity of phytoplankton was done using Shannon-Weaver's Diversity index. Species diversity is the variety and abundance of different types of organisms, which inhabit in a particular area. Findings of the samples collected during post monsoon in the month of January-2015 are presented in the table-5.1 below.

RESULTS

From phytoplankton analysis presented in Table-5.1, it is evident that the total count of phytoplankton per liter of sea water observed varied between 690 and 1442. Maximum count was found at FH and minimum was at IOHB and SQ. Major Species belonged to genera *Coscinodiscus sp., Triceratium sp., Ceratium sp.* Number of species belonging to different genera was found between 8 and 13, the highest being at FH and lowest at IOHB and ADB. The Shannon weaver Diversity index value was ranged from 1.0751 to 1.4426, lowest index value was at GCB and highest was at EQ respectively.

Table-5.1: PHYTOPLANKTON STUDY

RESULTS OF PHYTOPLANKTON ESTIMATION				
Site Code	***Total count/l***	***No. of species***	***Major Species***	***Shannon's Diversity Index (H)***
AC	840	10	*Triceratium sp.*	1.3473
OJ	750	10	*Coscinodiscus sp.*	1.2903
IOHB	690	8	*Ceratium sp.*	1.3967
ADB	1230	8	*Triceratium sp.*	1.3034
NQ	1050	11	*Coscinodiscus sp.*	1.2376
GCB	960	11	*Triceratium sp.*	1.0751
SQ	690	10	*Triceratium sp.*	1.3302
EQ	840	10	*Coscinodiscus sp.*	1.4426
FB	840	11	*Coscinodiscus sp.*	1.2912
MS	1110	12	*Coscinodiscus sp.*	1.3507
FH	1442	13	*Coscinodiscus sp.*	1.3134

MICROBIAL ESTIMATION

WATER MICROBIOLOGY

Bacterial population in aquatic environment is a complex phenomenon due to their numerous sources in a given water body and the various fate and transport processes that control their behavior and distribution in aquatic ecosystems. Bacterial indicators such as total viable count, total coliform count and *Escherichia coli (E.coli)* count are used to identify the potential for the presence of other pathogenic organisms. These originate from human and non-human sources and they are released into water bodies via point source such as effluents and runoff from rainwater drainage as well as dispersed sources such as direct runoff from residential areas and streets, on-site sewage disposal by man, deposition from birds and animals and re-suspension of bacteria from stream sediments. Bacteria are present in water and sediment, and experience re-growth and death within a water body. Moreover, bacteria loads into a stream vary temporarily due to the change of flow within the stream and due to the different loads coming from various sources at different times into the stream. Bacteria are living organisms and do not behave like chemical water quality parameters. These factors and considerations, makes it a necessity to measure their population at frequent intervals.

Sample collection and Processing

For the estimation of bacterial population in water samples of Paradip port, samples were collected from approved sampling points in pre-sterilized bottles. Samples were brought to the laboratory under ice pack and processed for estimation of viable bacterial population following standard plate count method. Nutrient agar medium was used for estimation of total viable bacterial count, Levine- EMB Agar medium was used for total coliform and *E.coli* count. Sterile medium was poured into sterile disposable Petri plates and allowed to solidify, water samples (0.1ml) were inoculated into each plate. Inoculated plates were incubated at 37^0C for 24 to 48 hours. The bacterial colonies growing in the plates were examined and the colony forming units (CFU) were counted. Results obtained from the samples of January-2015, have been presented in Table-5.2.

SEDIMENT MICROBIOLOGY

Bottom sediments act both as a sink for contaminants and as a source of these contaminants to the overlying water mass and aquatic organisms. Land and agriculture runoff and atmospheric deposition, play an active role for increasing the concentration of bacteria, fungi and dissolved contaminants such as metal or xenobiotic compounds. In estuarine sediments the movement of contaminants associated with sediment is very dynamic. This is caused by several factors such as wave and wind action, seasonal or continuous mixing, slumping and sliding in slopes, deposition of river in material and human activity such as dredging and vessel movement.

Microbial activity in sediment is typically profound in comparison to the planktonic bacterial populations inhabiting the water column over the sediment due to availability of perfect substrate with sufficient nutrient source for their growth and proliferation. Therefore, the sediment bacterial populations have the most intense effect on redox reactions, nutrient cycling and the bioremediation processes.

Potential pathogenic bio indicators such as coliform bacteria were introduced in sediment from animal and human sources. Due to gravitational force and absence of locomotary organs these organisms settle in the sediments. So the study of sediment microbiology gives a clear depiction of deposition of contaminants by human activities.

Sample collection and Processing

For the estimation of bacterial population in sediment samples of Paradip port, samples were collected by a Grab sampler from approved sampling points in pre-sterilized bottles. Samples were brought to the laboratory under ice pack and processed for estimation of viable bacterial population following standard serial dilution method. For serial dilution approximately 1 gm wet sediment was taken and to it 9 ml of sterile water was added and shaken to make sediment water slurry. Then serial dilution of 10^{-1}, 10^{-2} and 10^{-3} were made by adding 1 ml of pre diluted sample to 9 ml of sterile water. Finally one ml aliquot of each dilution was added to a sterile Petri dish to which desired amount of sterile molten agar medium was added. Nutrient agar medium was used for estimation of total viable bacterial count, Levine- EMB agar medium was used for total coliform and *E.coli* count. The Petri dishes were incubated at

suitable temperature inside an incubator. After 24-48 hours incubation the number of colonies were counted. This number was then multiplied by the dilution factor to find the total number of cells per ml of the original sample. The bacterial colonies growing in the plates were examined and expressed as the colony forming units (CFU) per 1 gm dry sediment. Results obtained from the samples of January-2015, have been presented in Table-5.3.

RESULTS OF MICROBIOLOGICAL STUDY

The viable Bacterial counts of water samples (CFU/ml) are presented in Table-5.2. For surface water, it was observed (CFU/1ml) between 140 at GCB and 8550 at MS. In case of bottom water it was ranged between 30 at OJ and 690 at NQ. For total Coliform count (CFU/1ml), the number was found to vary between 9 (NQ) to 294 (OJ) in surface water and for bottom water it was from 17 (GCB) to 158 (MS). However, the number of *E.coli* in surface water was found 1 CFU/ml at AC, ADB, GCB, EQ and FB respectively. In bottom water the *E.coli* ranges from 1 to 3 CFU/ml and were detected at ADB, NQ, EQ and MS. Results of the bacterial estimation from sediment samples are presented in Table-5.3. Total viable bacterial count was expressed as CFU/1gm dry wt. and ranged from 51612 (EQ) to 3006631 (SQ). Similarly total Coliform (CFU/1gm dry wt.) was varied between 2580 (EQ) to 396356 (OJ). Both total viable and coliform bacterial count were found maximum at SQ and OJ. Highier bacterial count in the sediment samples was observed at station like AC, OJ and SQ. However, *E.coli* was not detected at any point in sediment samples collected in this month.

TABLE – 5.2: WATER MICROBIOLOGY

BACTERIA COUNT IN WATER SAMPLES						
Site Code	**Total Viable Count (TVC) in CFU/1ml**		**Total Coliform count(TC) in CFU/1ml**		***E. coli* count in CFU/1ml**	
	SW	**BW**	**SW**	**BW**	**SW**	**BW**
AC	900	250	241	28	1	ND*
OJ	1470	30	294	21	ND*	
IOHB	260	90	59	26		
ADB	580	40	47	30	1	2
NQ	220	690	9	41	ND*	1
GCB	140	130	19	17	1	ND*
SQ	1910	80	153	33	ND*	
EQ	670	180	250	57	1	1
FB	1500	60	278	45	1	ND*
MS	8550	540	146	158	ND*	3

*ND: Not Detected**.**

TABLE – 5.3: SEDIMENT MICROBIOLOGY

BACTERIA COUNT IN SEDIMENT SAMPLES			
Site Code	**Total Viable Count (TVC) in CFU/1 gm dry wt.**	**Total Coliform count(TC) in CFU/1 gm dry wt.**	***E. coli* count in CFU/1 gm dry wt.**
AC	1575578	27712	ND*
OJ	2683407	396356	
IOHB	187040	10688	
ADB	139737	17467	
NQ	436031	112729	
GCB	642021	126333	
SQ	3006631	324619	
EQ	51612	2580	
FB	1235343	219849	
MS	1003064	178322	

*ND: Not Detected**.**

DISCUSSION

Total Phytoplankton population was found higher at FH as compared to other points probably may due to availability of more nutrients, less contamination, TSS and TDS levels which allows light to enhance the Phytoplankton growth and other favorable conditions. Whereas numbers of individual species and Shannon's diversity index were found highest at FH and EQ respectively, due to less port effect and low pollution level at these points favoring more species diversification.

Some pollution indicating phytoplanktons such as *Prorocentrum species*, *protoperidinium* and *Dinophysis caudate* detected in all most all the points except IOHB and FH are less in number (30-90 cells/L), (30-60 cells/L) and (30-60 cells/L) respectively, as compared to total population. Hence, they had no serious impact on the sea water system as well as on other phytoplankton population.

As reported earlier, *Porocentrum micans* and *protoperidinium* species were known to be non toxic, but *Porocentrum* sp. are capable of forming extensive blooms and have been reported to inhibit growth of other diatoms (Tayler and Seliger, 1979, Anderson *et al*., 1985, Faust and Steidinger, 1998). *Protoperidinium* blooms can cause discoloration of the water (Balech, 1976; Inoue, 1990). *Dinophysis caudata* produce toxins (Dinophysistoxins and Okadaic acid) that cause diarrheic shelfish poisoning (DSP) and also involved in red tide (Okachi, 1967; Larsen and Moestrup, 1992).

The total Coliform counts of surface and bottom water were observed maximum at OJ and MS respectively. In bottom water higher *E. coli* bacteria were found at station MS may be due to more human activity at this point. Whether in sediment sample total coliform was found maximum at OJ, which may be due to more fecal contamination from the human sources at this point. Maximum *E. coli* detected (300 CFU/100ml) at point MS surface water and was within prescribed limit. The OJ and MS were showing more coliform bacterial load incase of both water and sediment environment may due to more shipping activity and human fecal contamination.

OBSERVATIONS AND RECOMMENDATIONS

1. "Good House Keeping" – the most important area of concern, should be attained by the available human resource through conducting routine in-house workshops on different activities for the betterment of the environment.

2. Coal and ore stack yards release a lot of dust to the atmosphere due to wind. The coal stack yards catch fire during summer season too. Mechanical sprinkling of water (although existing) at appropriate interval on the stack yards during the dry seasons can prevent this.

4. During loading of various kinds of materials such as ores, coal, etc. into the ship a lot of dust is released to the atmosphere. This can be minimized to a great extent if the distance between the loader boom and the hold of the ship is brought down with fixation of a flexible skirt between the loader boom and the hold of the ship.

5. Spillage of various materials into the harbour during the loading/unloading operation causes contamination of harbour water. This spillage into the harbour water can be prevented by use of properly designed screens.

6. Some ships after entering into the harbour discharge objectionable waste materials and remnant cargo into the harbour water to cause pollution. This can be controlled to a great extent through improved vigilance and appropriate punitive measures by the port authorities.

7. A lot of vehicles ply in the port premises to overload the roads with dust particles for which the SPM levels in the air increase drastically. If the level of the road is kept higher than the level of the surrounding area along with regular cleaning of road surface with dust scrubbing machines and regular sprinkling of water, the SPM level in the port atmosphere will definitely be brought down.

8. Coal handling facility at Paradip Port has the facilities for sprinkling of water over the coal but is not adequate. During wagon tippling lot of dust is generated. The dust collection

system is defunct and not in use. Conveyor system of coal handling also generates certain amount of suspended particulate matter (SPM). Worker engaged in this area must use dust mask.

9. All the heavy machines should be properly installed and maintained regularly to generate less noise. Personnel exposed to noise levels higher than 85 dBA at places like workshop, power plant, shunting of wagons, etc. are provided with the earmuffs.

10. Since trees minimize air pollution, noise pollution, temperature, etc. plantation of trees all around Paradip including the harbour premises would be of immense help in this direction. Plantation of trees by the side of all roads in the locality will be beneficial too. A lot of area lying vacant within the port boundary walls can be utilized for plantation of fast growing species to reduce air and noise pollution.

11. Since the activities in Paradip Port are increasing day by day with marching industrialisation of Orissa and the country as a whole, pollution level in port area is expected to increase with time. To record the level of pollution from time to time and to implement the possible measures to bring down the level of pollution for a normal life, it has become the necessary and essential on the part of the Paradip port to continue the regular pollution monitoring studies around the place.

12. In Paradip Port the spillage of phosphoric materials was observed into the dock waters. Sufficient care should be taken to avoid spillage of phosphatic rock, etc.

ANNEXURES

TABLE – 1

INDIAN STANDARD SPECIFICATIONS FOR COASTAL/HARBOUR WATER

	Substance or Characteristics	**Desirable limits**
1	Colour, Hazen Unit Max.	10
2	Odour	-
3	Taste	-
4	Turbidity, NTU, Max	10
5	pH value	6.5 to 8.5
6	DO, mg/l	>3.0
7	BOD, mg/l	<5.0
8	Total Hardness (as $CaCO_3$), mg/l, Max	300
9	Calcium (as Ca), mg/l, Max	0.05
10	Magnesium (as Mg), mg/l, Max	30
11	Copper (as Cu), mg/l, Max	0.05
12	Iron (as Fe), mg/l, Max	0.5
13	Manganese, (as Mn), mg/l, Max	0.5
14	Chloride, (as Cl), mg/l, Max	250
15	Sulphate, (as SO_4), mg/l, Max	250
16	Nitrate, (as NO_3), mg/l, Max	12
17	Cadmium, (as Cd), mg/l, Max	0.01
18	Lead, (as Pb), mg/l, Max	0.1
19	Zinc, (as Zn), mg/l, Max	5.0
20	Chromium, (as Cr^{6+}), mg/l, Max	0.05
21	PHC, mg/l	10.0
22	Ammonia, mg/l	0.4

TABLE – 2

AIR QUALITY CRITERIA – CENTRAL POLLUTION CONTROL BOARD

Category Of Area	Concentration, $\mu g/m^3$				Ammonia mg/m^3
	SPM	RSPM	SO_x	NO_x	
Industrial	500	120	120	120	0.4
Residential	200	60	80	80	0.4
Sensitive	100	50	30	30	0.4

TABLE - 3
NATIONAL AMBIENT AIR QUALITY STANDARDS
(CENTRAL POLLUTION CONTROL BOARD)

Notification dated 18.11.2009

Sl. No.	Pollutant	Time Weighted Average	Concentration in Ambient Air	
			Industrial, Residential, Rural and Other Area	Ecologically sensitive Area (Notified by central Government)
(1)	(2)	(3)	(4)	(5)
1	Particulate Matter (size less than 10µm) or PM_{10} $\mu g/m^3$	Annual*	60	60
		24 hours**	100	100
2	Particulate Matter (size less than 2.5µm) or $PM_{2.5}$ $\mu g/m^3$	Annual*	40	40
		24 hours**	60	60
3	Sulphur Dioxide (SO_2), $\mu g/m^3$	Annual*	50	20
		24 hours**	80	80
4	Nitrogen Dioxide (NO_2), $\mu g/m^3$	Annual*	40	30
		24 hours**	80	80
5	Ammonia (NH_3) $\mu g/m^3$	Annual*	100	100
		24 hours**	400	400

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

** 24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring

TABLE – 4

TOXICITY LIMITS OF DIFFERENT METALS IN SOIL

Elements	**Toxicity Threshold, mg/kg of Soil**
Copper	200 – 400
Zinc	500 – 5000
Cadmium	10 – 175
Nickel	200 – 2000
Lead	500 – 1500
Chromium	500 – 1500
Mercury	10 – 1000

TABLE – 5

RECOMMENDED AMBIENT NOISE LEVELS

Types of Residential Area	**Sound Level, Leq dBA**		
	Day (6 AM to 9 PM)	**Night**	**Evening and weekends**
Silence zones	50	45	-
Rural residential area	50	40	45
Sub-urban residential area	55	45	50
Urban residential area	60	50	55
Urban with nearly commercial or light industry	65	55	60
Predominantly industrial	70	60	65
Heavily industrial	75	65	70