

## Physio-chemical analysis of industrial effluents in Thane region of Maharashtra, India

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### ABSTRACT

Thane district is one of the most industrialized districts in the state. The heavy industrialization and the increasing urbanization are responsible for the rapidly increasing stress on the water environment of the area. Therefore an attempt has been made to study the physico chemical properties of effluents and to know the pollution load on the environment. Effluent Samples were obtained from various industries such as bulk drug chemicals, textile, and rubber chemicals, vitamin products, agrochemicals, dairy, dye manufacturing, textile processing, polymer, jewelry, construction chemicals, insecticides, paper products and fine chemicals. The effluent samples were analyzed and it is found that, electrical conductivity and T.D.S. varies from 0.43 to 46.5 millisimens  $\text{cm}^{-1}$  and 280 to 30,225 mg/lit. High T.D.S., low D.O. content, high C.O.D. and conductivity values with high  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$  content indicates highly polluted condition of effluent. Heavy metal analyses were analyzed by Inductively Coupled Plasma (ICPE-9000) Atomic Emission Spectroscopy. It is found that AS, Cu, Cd, CO, Fe, Ni, Zn, Pb and Cr are within the limit prescribed by I.S.I., Hg is beyond the prescribed limit.

**Key words:** Effluents, industries, heavy metals, I.S.I., Thane region.

### INTRODUCTION

Water is the most vital resource for all kinds of life on this planet, but it is being adversely affected both quantitatively and qualitatively by all kinds of life human activities on Land, Air and Water.

Today most of the rivers of world receive millions of litre sewage domestic waste and industrial effluents containing varying in characteristics from simple nutrients to highly toxic substances. Urban pollution increases rapidly by industrial developments. Industrialization and urbanization lead to generation of large volumes of wastewater from domestic, commercial, industrial and other sources.

Industrial waste waters discharged into natural water bodies like river, creeks have created new pollution problems. Toxic chemical compounds have killed aquatic biota in many water bodies and have rendered waters useless. As industrial pollution is found in large amount in specific geographic areas, collection and treatment of these materials should be easy to accomplish, unfortunately, only small percentage of factories treats their contaminated water adequately prior to its release.

The data generated by the studies on the surface water, ground waters and creek waters by MPCB<sup>1</sup> in Thane region of Maharashtra reveals that, the waste water generated from the cities located in the region along with industrial effluent are finally

disposed in the creeks. The untreated domestic waste waters from cities like Kalyan, Dombivali, Sarvali, Thane, Ulhasnagar, Ambernath etc. deteriorating the quality of creek water. Therefore an attempt has been made to study the physico-chemical characteristics of effluents of various industries located in Thane, Dombivali, Sarvali, Ulhasnagar and Ambernath of Thane region of Maharashtra India. The pollution level of each effluent is compared with the guidelines as prescribed by Indian Standard Institution <sup>2</sup>.

### Study area

Thane, the northern most district of Kokan, lies adjoins to Arabian Sea in North West of Maharashtra state. It extends between 20°20' north latitude 73°45' east longitudes. Thane district is one of the most industrialized districts in the state. The district is blessed with abundant natural resources in the form of perennial rivers extensive seashore and high mountainous range. Thane region is also marked with long coast line and rapidly growing residential areas of Thane, Dombivali, Ambernath, Mira, Bhayander, Vasai etc. As per the record of MPCB there are about 5449 industries in Thane region the various industries includes textile industries, dye manufacturing industries, match box factories, canning factories of various food stuff, fruit juice and slices as well as Beverage factories, pharmaceutical and chemical factories, paper mill, Jewelry industry, paint industry, insecticide industries etc. The waste from these industries, directly or indirectly find their way into the surface water, ground water and creek.

### MATERIAL AND METHODS

Industrial effluent samples were obtained from various types of industries is presented in Table No.1. Effluents obtained from industries situated in Thane and its suburbans Rabale, Dombivali, Kalyan and Ambernath Industrial area. Effluent samples were obtained from the particular industry on request as part of academic study and were analyzed as sample received. Effluent Samples were collected in 5 lit. Plastic container previously washed with 6 N Nitric acid and high purity water. The reagents used were of AR grade while double distilled water was used to prepare all solutions.

The physico- chemical parameters considered for the examination are temperature, color, electrical conductivity, oil and grease, total dissolved solids, total hardness, total alkalinity, dissolved oxygen, chemical oxygen demand, chlorides, Sulphates, nitrates and metal ions like calcium, magnesium, sodium, potassium. These parameters have been determined by standard methods <sup>3</sup>. Sodium and potassium ions have been determined by flame photometer (Model Elico CAL-178). Out of 16 industrial effluent samples 10 effluent samples were analyzed for heavy metal ions like arsenic, cadmium, cobalt, copper, iron, mercury, nickel, zinc, lead and chromium. Heavy metal ions were analyzed by Inductively Coupled Plasma-Atomic Emission Spectroscopy (Model ICPE-9000 Shimadzu, Japan.) Effluent samples were digested by adding con. HNO<sub>3</sub> for half an hour, cooled, filtered by using Whatman filter paper no. 41. The metals were estimated in the sample by aspirating the filtered sample solution directly into the plasma of the instrument. The instrument was standardized for the individual elements. Calibration curve was obtained for every metal ion using standard solution. Standard solutions were prepared from 1000 mg/lit. stock solution of different metals of interest. Minimum concentration of metal which could be detected by the instrument was 10 ppb. The results of all the above experimental findings are summarized in Table 1, 2 & 3.

### RESULT AND DISCUSSION

The values reported in Table 1, 2 and 3 are the average of triplicate analysis performed for every sample collected. It can be seen that the PH of the industrial effluents ranges from 3.50 to 9.15. Sample E<sub>3</sub>, E<sub>4</sub>, E<sub>5</sub>, E<sub>8</sub> and E<sub>11</sub> are found to acidic in nature. PH of the dairy effluent is acidic in nature this may be due to formation of lactic acid by decomposition of lactose <sup>4</sup>. Use of organic and inorganic acids in the manufacturing processes causes decline in pH values. Sample No. E<sub>2</sub>, E<sub>10</sub> are found to be more basic in nature this may be due to use of caustic soda, sodium silicate in the textile processes like Kiering, bleaching, mercerizing etc. <sup>5</sup> pH values of all the samples are found to be within the limit as per the standard prescribed by

Table 1: Physico-Chemical Characteristics of Effluents

Samples	Type of Industry	Temp	Color	pH	Elect. cond.	TDS	DO	COD	TH	TA
E1	Bulk drug chemicals	28.0	Pale yellow	8.7	3.09	1993	5.47	177	560	213
E2	Textile	28.5	Color less	8.20	1.041	677	6.49	100	146	241
E3	Vitamin Products	29.0	Light orange	6.59	3.11	2021	Nil	4368	4400	1778
E4	Rubber chemicals	31.0	Color less	6.76	17.25	11212	0.20	822	1020	500
E5	Dairy	30.0	White	6.53	0.75	488	Nil	560	216	377
E6	Agrochemicals	30.0	Color less	7.96	1.225	796	3.16	1236	488	209
E7	Polymer	29.5	Color less	8.20	0.57	371	4.26	179	520	262
E8	Chemical	30	Brown	3.50	7.2	4680	Nil	1238	1150	Nil
E9	Dye manufacturing	29.8	Light brown	9.15	16.34	10621	Nil	2382	700	2960
E10	Textile process	31.6	Blue	7.69	46.5	30225	Nil	2540	90000	27750
E11	Laboratory chemicals	30	Color less	5.20	1.09	709	0.40	1482	200	55
E12	Jewellery	30	Color less	6.82	0.43	280	3.85	267	100	170
E13	Paper products	30.0	Pale green	7.05	0.50	325	1.63	478	50	306
E14	Construction chem.	30.2	Color less	7.09	2.3	1495	0.40	502	450	540
E15	Insecticides	30.6	Color less	6.84	8.05	5233	Nil	5676	230	68
E16	Fine chemicals	30.4	Color less	7.35	6.90	4485	1.83	5284	1143	510

All parameters are expressed in mg/lit except P.H. Conductivity in millimens cm<sup>-1</sup>

Indian Standard Institution. Except sample no. E<sub>8</sub>, pH values of all the samples are found to be within the limit as per the standard prescribed by Indian Standard Institution.

#### Electrical conductivity

The range of electrical conductivity observed for different samples lies between 0.43 to 46.5 millisimens/cm the samples no. E<sub>4</sub>, E<sub>8</sub>, E<sub>9</sub>, E<sub>10</sub>, E<sub>15</sub> and E<sub>16</sub> show high conductivity mainly due to higher dissolved solids.

#### Total dissolved solids

The total dissolved solids of all the collected effluents range from 325 to 30,225 mg/lit. The maximum permissible limit as per ISI standard is 2100 mg/lit. It has been observed that sample E<sub>3</sub>, E<sub>4</sub>, E<sub>8</sub>, E<sub>9</sub>, E<sub>10</sub>, E<sub>15</sub> and E<sub>16</sub> show high value of total dissolved solids which is beyond the tolerance limit as set by ISI; high values of total dissolved solids indicating that these effluents contain various types of mineral species in the water.

#### Total hardness

The hardness value of effluents range from 50 to 90,000mg/lit. Sample no. E<sub>3</sub> shows hardness 4400 mg/lit. This industry manufactures vitamin product containing calcium and magnesium. The increase in hardness of sample E<sub>3</sub> and E<sub>10</sub> may be due to the presence of calcium hypochlorite use in the textile processes like Bleaching.

#### Total alkalinity

The total alkalinity of effluents ranges from 0 to 27750 mg/lit. The highest alkalinity is observed in the sample no. 10. This is thought to be due to the appreciable amount of caustic soda used in the kiering and mercerizing process of textile mill.

#### Dissolved oxygen

It has been observed that the sample nos. E<sub>3</sub>, E<sub>5</sub>, E<sub>8</sub>, E<sub>9</sub>, E<sub>10</sub> and E<sub>15</sub> show negligible amount of dissolved oxygen. This is due to large amount of biodegradable matter present in the sample. The remaining samples shows low values of dissolved oxygen due to inadequate amount of organic matter present in these effluents.

#### Chemical oxygen demand

Chemical oxygen demand is extremely

useful in finding out the pollution strength of industrial effluents. In the present study, most of the effluents show appreciable amount of COD. The sample No., E<sub>3</sub>, E<sub>4</sub>, E<sub>6</sub>, E<sub>7</sub>, E<sub>8</sub>, E<sub>9</sub>, E<sub>10</sub>, E<sub>14</sub>, and E<sub>16</sub> shows high value of COD due to vitamin waste, dyes, auxiliaries organ phosphorus compound etc., COD values of these sample exceeds the limit as prescribed by ISI standards. The results shows that industries which manufactures vitamin products agrochemicals, dye, auxiliaries, textile processing industries, rubber releasing large amount of oxygen demanding chemicals<sup>6</sup>.

#### Oil and Grease

It has been found that all the effluent samples shows oils and grease. Oils and Grease is used as the raw materials in the process or lubricants applied for machineries. Oils and grease are very high within the range of ISI values. The high values of grease are responsible to disturb the vegetation and effected the marine environment and its creatures.

#### Chlorides

The concentration of chlorides was found in the range of 103 to 69580 mg/lit. It has been found that, effluent sample no. E<sub>4</sub>, E<sub>8</sub>, E<sub>9</sub>, E<sub>10</sub>, E<sub>15</sub> and E<sub>16</sub>. Contain high amount of chlorides with the range of ISI values. High amount of chlorides may be due to chlorinated compounds used in rubber chemicals chlorinated pesticides and insecticides. Use of acid and salts in many process, use of chlorine and calcium hypochlorite in textile processing etc. high amount of chlorides may show deleterious effect on metallic pipes<sup>7</sup>.

#### Sulphates

The concentration of sulphate ranges from 26 to 2656 mg/lit. Effluent samples E<sub>3</sub>, E<sub>4</sub>, E<sub>9</sub>, E<sub>11</sub>, E<sub>14</sub>, E<sub>15</sub> and E<sub>16</sub> contains high amount of sulphate which is beyond the permissible limit as prescribed by ISI. High value of sulphate in the effluent samples is due to use of sulphuric acid, sodium sulphate, aluminium sulphate as the raw materials.

#### Phosphates and nitrates

It has been observed that phosphates and nitrates concentration in all the effluents is very low.

Table 2: Physico-Chemical characteristics of effluents

Samples	Cl <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	Oil & Grease	ISI
E1	564	93	20	124	467	42.6	2826	+0.63
E2	103	42	11	30	218	5.0	50	+0.65
E3	136	1599	160	975	171	40	540	+0.41
E4	2440	2656	30	231	2246	7.0	680	+0.87
E5	87	50	8.0	12	98	5.0	715	+0.90
E6	249	68	17	109	113	2.0	105	+1.62
E7	156	26	20	115	22	2.0	300	+0.37
E8	1863	91	40	221	933	655	290	+0.23
E9	5368	1258	120	98	2070	7.0	85	+0.45
E10	69580	63	400	21684	4011	22.0	35	+0.85
E11	229	1051	28	32	30	13.0	50	+03
E12	149	78	17	17	42	2.0	55	+1.1
E13	99	42	8.0	7.3	80	2.0	25	+1.22
E14	348	1080	92	54.0	188	16	15	-1.38
E15	1838	1046	61	20.0	470	3.0	20	+2.72
E16	1143	1056	40	12	104	5.0	210	+2.21

All parameters are expressed in mg/lit . L.S.I -Langlier Saturation Index

### Calcium and magnesium

Calcium and Magnesium content in the effluents are low except sample no E<sub>3</sub> and E<sub>10</sub>. In samples No. E<sub>3</sub>, Ca<sup>2+</sup> and Mg<sup>2+</sup> contents are 160 mg/lit and 975 mg/lit respectively. This is due to use of calcium and magnesium compounds in preparation of vitamins. Samples no E<sub>10</sub> contain 400 mg/lit and 21684 mg/lit of calcium and magnesium.

### Sodium and potassium

Most of the effluents show less amounts of Na<sup>+</sup> and K<sup>+</sup> except sample no E<sub>4</sub>, E<sub>9</sub> and E<sub>11</sub>. In these samples Na<sup>+</sup> contains are 2246 mg/lit 2070 mg /lit and 4011 mg/lit respectively. This is due to use of sodium and potassium salts during neutralization, bleaching and mercerizing.

### Heavy metals

Heavy metals are a major source of pollution in India due to industrial waste disposal and considered highly toxic to aquatic organisms. The compounds of these elements are non-biodegradable and hence remains suspended or partially dissolved in water column and get accumulated in many aquatic organisms.

### Arsenic

Arsenic forms a variety of inorganic and organic compounds of different toxicity reflecting the physico-chemical properties of arsenicals of different valency. It was found that effluent samples E<sub>1</sub>, E<sub>6</sub>, E<sub>8</sub> and E<sub>10</sub> contains 0.0059, 0.0057, 0.0128 and 0.0018 mg/lit of arsenic which is well below the permissible limit. These industries are chemicals, dye staff, agrochemicals and textile and bulk drug chemicals. Arsenic was not detected in the effluent samples E<sub>3</sub>, E<sub>4</sub>, E<sub>9</sub>, E<sub>11</sub>, E<sub>15</sub> and E<sub>16</sub>.

### Copper

Copper ion concentration in the effluents E<sub>1</sub>, E<sub>3</sub>, E<sub>4</sub>, E<sub>6</sub>, and E<sub>8</sub> are found to be within the limits as prescribed by ISI. Copper ion was not detected in the sample no E<sub>9</sub>, E<sub>10</sub>, E<sub>11</sub>, E<sub>15</sub>, E<sub>16</sub>. The toxicity of copper to aquatic life is depending on the alkalinity of water as copper is generally more toxic to aquatic fauna at lower alkalinities. B. Patel and et al.<sup>8</sup> reported dissolved copper 0.02 to 1.30 mg/lit in Bombay harbor which receives large amounts of industrial and municipal waste

### Cadmium

Cadmium ion concentration in the industrial effluents Nos. E<sub>3</sub>, E<sub>4</sub>, E<sub>8</sub>, E<sub>10</sub> are 0.101, 0.015, 0.0058, 0.0025 mg/lit. Cadmium ion was not detected in the remaining samples. Train<sup>9</sup> reported that, biologically, cadmium is non essential, non beneficial element, recognized to be highly toxic to fishes even at low levels in water that metal concentration at certain stations were relatively low. Mahapatra<sup>10</sup> analyzed the sediments of polluted Thane creek at 20 stations for 9 heavy metal ions. He found that cadmium in uncontaminated freshwater sediments is generally detected at 0.1 to 1.0 mg/lit dry weight, increasing to 4 to 10 mg/kg in contaminated areas.

### Cobalt

Cobalt ion concentration in the effluent sample no E<sub>3</sub> and E<sub>10</sub> are 0.133 mg/lit and 0.0036 mg/lit where as in other sample cobalt ion was not detected. Sample E3 contain cobalt ion because of use of cobalt compounds in vitamin products. Cobalt often is undetectable in drinking water, reflecting its low concentration in surface waters. When present, concentrations are generally < 0.005 mg/lit<sup>11</sup>.

### Iron

Iron concentrations in the effluents was found in the range of 0.792 mg/lit to 12.10 mg/lit. Effluent samples no E<sub>3</sub> and E<sub>8</sub> contain maximum iron concentration 12.10 mg/lit and 5.45 mg/lit. Effluent sample no E<sub>3</sub> contain maximum iron concentration 12.10 mg/lit, this is due to the use of iron compounds in the vitamins preparation. Iron concentration in the effluents may be due to the interaction of machinery components, with many acids, chlorides and sulphate due to which iron releases in the form of corrosion product<sup>7,12</sup>.

### Mercury

Almost all effluents are mercury rich and exceeding the limit prescribed by ISI. Mercury concentration in the effluents found to be in range 0.0191 mg/lit to 0.219 mg/lit high concentration of mercury in the effluents because of use of mercury compounds in various processes. Tejam and Halder<sup>13</sup> reported that fishes from Mumbai and Thane region had 35.56 mg of mercury per gm of fresh weight tissue.

Table 3: Heavy Metal concentrations in effluents

Samples	Copper (Cu)	Arsenic (As)	Cadmium (Cd)	Cobalt (Co)	Iron (Fe)	Mercury (Hg)	Nickel (Ni)	Zinc (Zn)	Lead (Pb)	Chromium (Cr)
E1	0.0979	0.0059	ND	ND	0.792	0.0578	ND	0.0695	0.088	0.56
E3	0.375	ND	0.101	0.133	12.10	0.219	0.0184	42.2	0.19	0.2
E4	0.0667	ND	0.015	ND	1.87	0.079	ND	15.6	0.11	0.064
E6	0.301	0.0057	ND	ND	1.24	0.0635	ND	0.426	0.091	0.078
E8	0.0007	0.0128	0.0058	ND	5.45	0.0626	0.0016	0.163	0.11	0.21
E9	ND	ND	ND	ND	2.17	0.0544	ND	0.0753	0.12	0.074
E10	ND	0.0018	0.0025	0.0036	1.23	0.117	ND	0.0938	0.14	0.078
E11	ND	ND	ND	ND	1.88	0.0191	ND	0.213	0.099	0.084
E15	ND	ND	ND	ND	1.29	0.0411	ND	0.197	0.075	0.027
E16	ND	ND	ND	ND	0.828	0.0633	ND	0.0997	0.091	0.067

All quantities are in mg/lit. N.D. – Not Detected.

Shaw<sup>14</sup> reported the effect of Chloro-alkali factory effluent in Orissa on plant and animal life has found mercury as the main pollutant. The most dangerous phenomenon of mercury is its methylation in the environment to form highly soluble, toxic species. These compounds are readily absorbed and concentrated by aquatic plants and animals.

#### Nickel

Nickel ion concentration in the effluent sample no E3 was found 0.0184 mg/lit. and E8 shows 0.0016 mg/lit which is below the limit prescribed by ISI. In other effluents Nickel was detected.

#### Zinc

Zinc ion concentration in all effluent sample is below the limit as prescribed by ISI except, In sample no E<sub>3</sub> zinc ion concentration is 42.2 mg/lit. which exceeds the limit.

#### Lead and Chromium

Lead and Chromium ion concentration is lower than the limits prescribed ISI, except sample no E<sub>3</sub>, E<sub>9</sub> and E<sub>10</sub> shows high lead ion concentration which exceeds the limit. The values of these metals show significant variation depending upon the nature of effluent suggesting that the respective metal salts have pronounced industrial activities.

### CONCLUSION

From the result of physico chemical analysis of effluents, it has been concluded that oil and grease, TDS, COD, chlorides, sulphates are very high in comparison to the standard Prescribed by ISI. The effluent samples showed appreciable concentration of all heavy metals. Concentration of mercury in all effluent samples is high in comparison to the standard prescribed by ISI. Concentration of other heavy metal is low, though the concentration levels are not high but more or less every industry discharges the heavy metals through their effluents and ultimately contaminates the water and soil in the Thane region.

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