Jr. of Industrial Pollution Control 20 (1) (2004) pp. 137 -144

CHARACTERIZATION OF TEXTILE WASTEWATER

J. HUSSAIN, I. HUSSAIN* AND M. ARIF**

Dept. of Pure and Applied Chemistry
M.D.S. University, Ajmer- 305 009, Rajsthan, India.
*PHED Laboratory, Bhilwara- 311 001, Rajsthan, India.
**Dept. of Environmental Studies
M.D.S. University, Ajmer- 305 009, Rajsthan, India

Key words : Textile industry, wastewater, heavy metals, BOD, COD.

ABSTRACT

The wastewater generated from textile industries of Bhilwara city is studied for its characterization. Wastewater of textile industry was found to contains a high degree of pollutants with high TDS and suspended solids. The wastewater is highly colored and viscous due to dyestuff and suspended solids respectively. Sodium is only major cation due to high consumption of sodium salts in processing units. Chloride is major anion found in the wastewater but concentration of bicarbonate, sulphate and nitrate are also high (>100 mg/L). Sodium salts of these anions are most commonly used in the process. In heavy metal chromium is in higher concentration while other heavy metals iron, zinc, lead, copper and manganese are also present. The wastewater also have high BOD and COD indication its polluting nature.

INTRODUCTION

Since times immemorial, the three basic needs of mankind have been food, clothing and shelter. The units producing cloth by any mechanisms are called textile units. Textile industry is one of the oldest and largest industries of the India. Not going far back in the history of textile industry in India, the East India Company started its business by cotton industry. Now a days India is a major exporter of textile- finished material. The textile industry in India is a fast growing industry. As per the recent data published by the textile commissioner's office there are 1569 textile industries in India; of these 1294 are spinning industries while 275 are composite industries (CPCB, 2000; Hussain, 2001). The major textile industries are located in the large cities like Ahmedabad, Bombay, Bangalore, Baroda, Bhilwara, Kanpur, Madras etc. Rajasthan has about 150 textile industries including 35 cotton and 72 woolen industries.

Bhilwara city is known as Synthetic or Textile city not only in all over Rajsthan but also in India. In recent years the textile industries has undergone modernization to a large extent with the latest development in textile technology. The textile process requires volumes of water of high purity and generates equally large volumes of water, which are complex and highly variable both in regard to quantity and characteristics.

MATERIAL AND METHODS

Six major textile industries were marked for the study of characterization of textile wastewater. From these industries wastewater samples were collected in pre-cleaned poly-propylene bottles with necessary precautions (Brown *et. al.*, 1974). The pH and electrical conductivity (EC) were estimated at sampling sites, while total hardness (TH), nitrate (NO_3), Fluoride (F^-), sulfate ($SO4^{2-}$) chloride (Cl^-), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+) and total dissolved solids (TDS) were analyzed in the laboratory as per standard methods (APHA, 1991). For heavy metals analysis, the water samples were collected in pre-cleaned polypropylene bottles and acidified (to get pH 2.0) with concentrated ultra pure nitric acid for preservation soon after their collection. The samples were digested with nitric acid (concentrated) and metal were estimates with Atomic Absorption Spectrometer. (AAS)

RESULT AND DISCUSSION

For the study of characteristics of composite wastewater of textile industries wastewater samples from six major textile processing industries numbering from l_1 to l_6 were collected for their general characteristics. The results obtained from the examination are shown in Table 1.

In the textile processing units **pH** is very much important factor. It is regulated at various steps for better results. The pH is also important in the dyeing step as the solubility of the dyes depends on it. The pH also changes with type of cloth processed. Due to this the pH of the textile composite wastewater was found in a big range from 7.0 to 9.0. The minimum pH 7.0 is found in the wastewater of l_3 while maximum 9.0 pH is found in the wastewater of two industries l_5 and l_6. Thus the wastewater of textile industry is neutral to strong alkaline nature because in most of the steps caustic and other detergents of alkali nature are used in large quantity.

Electrical conductivity of wastewater from all industries was found to be in the range of 4430 to 8710 µs giving a mean value 6709.17 µs. The minimum electrical conductivity was recorded from the wastewater of industry l_1 while

maximum was recorded of 8710 µho/cm of industry l_6. However, the electrical conductivity of the wastewater depends on the quantity and type of cloth processes but it was found to be very much higher (more than 16 times) than that of water used. **Total dissolved solids** of the textile industries were found to vary from 3210 to 5290 mg/L. The minimum total dissolved solid was recorded from wastewater of industry l_1 while maximum recorded from industry l_6. This depends on the type of cloth processes and the total production.

The wastewater contains **suspended solids** in high quantity due to which the wastewater becomes viscous. The suspended solids of the textile industries were found between 830 to 1580 mg/L from industry l_1 and l_6 respectively. The suspended solids are due to undissolved solid particles removed from cloth. Some time the chemicals used also get precipitated due to change in pH, which increase the suspended particles. However the average suspended particles of all six industries was 1166 mg/L.

Chloride of two industries (I_3 and I_4) could not be determined due to highly colored wastewater. The chloride of four industries was found to show a discrepancy from 980 to 2185 mg/L. Minimum and maximum chloride concentration was recorded from industry I_1 and I_6 respectively. Chloride in textile wastewater also increases due to water softening process of when sodium chloride is used to recharge softeners. Moreover some chlorides containing compounds are also used in the wet processes of cloth.

Nitrate in the wastewater of all industries was to be found more than 100 mg/L. Its concentration fluctuates from 120 to 627 mg/L Minimum nitrate concentration was of industry l_1 and maximum l_2. The source of nitrate in the wastewaters is the impurities present in the chemicals used in various processes. Nitrate also increases due to the dyes used. Various dyes have this ion as functional group.

Total hardness of wastewater of 4 industries was found to be low. The wastewater values varied from 120 to 150 mg/L. **Calcium** and **magnesium** represent the hardness of water. Hardness is again a very important factor in dyeing process as most of the dyes get precipitated in the presence of calcium and magnesium ion. There fore, the water softening is carried out in all industries due to which the concentration decreases to a great extent. Calcium and magnesium concentration in the wastewater of all six industries was found to be very low. Calcium was recorded in the range of 13 to 29 mg/L while magnesium recorded in the range 1_3 to 29 mg/L. Minimum calcium concentration was recorded from industry l_6 and maximum from l_5. In case of magnesium minimum and maximum concentrations were recorded from industry l_5 and l_6 respectively. The magnesium concentration was recorded higher than that of calcium due to high solubility of magnesium than calcium. The reason for low concentration of both calcium and magnesium is the softening of water. In all the industries water softening is carried out in which calcium and magnesium are replace by sodium.

Sodium concentration of the wastewater of all industry was found at

TABLE - 1

Results of composite textile wastewater

S.No.	Particualr	11	12	13	14	15	16	Minimum	Maximum	Average
1.	pH	7.9	8.9	7.0	7.7	9.0	9.0	7.0	9.0	8.25
2.	EC (μmhos/cm)	4430	7685	4900	6470	8060	8710	4430	8710	6709.17
3.	Total dissoled solid	4040	6420	4520	5390	6560	7500	4040	7500	5738.33
4.	Suspended solid	830	1180	960	1130	1320	1580	830	1580	1166.67
5.	Dissolved solid	3210	5240	3560	4260	5240	5920	3210	5920	4571.67
6.	Total Hardness	150	120	NA	NA	125	150	120	150	136.25
7.	Carbonate	Nil	110	NA	NA	120	120	110	120	87.50
8.	Bicarbonate	1464	780	NA	NA	555	854	555	1464	913.25
9.	Chloride	980	1690	NA	NA	1935	2185	980	2185	1697.50
10.	Sulphate	307	NA	NA	NA	620	602	307	620	509.67
11.	Nitrate	120	442	313	627	248	378	120	627	354.67
12.	Fluoride	0.7	1.0	1.2	0.8	1	2.2	0.7	2.2	1.25
13.	Calcium	20	16	NA	NA	28	12	12	28	19.00
14.	Magnesium	24	19	NA	NA	13	29	13	29	21.25
15.	Sodium	975	1765	1174	1750	2185	2183	975	2185	1672.00
16.	Potassium	11	11	18	13	19	12	11	19	14.00
17.	Copper	0.015	0.017	0.311	NA	0.07	0.006	0.006	0.311	0.07
18.	Chromium	0.189	0.015	7.854	0.055	0.06	0.024	0.015	7.854	1.37
19.	Manganese	0.001	0.01	0.021	0.002	0.022	0.008	0.001	0.022	0.01
20.	Iron	0.163	0.038	0.153	0.017	0.041	0.067	0.017	0.163	0.018
21.	Lead	0.019	0.037	0.061	0.03	NA	0.011	0.011	0.061	0.03
22.	BOD	600	720	500	640	810	1010	500	1010	713.33
23.	COD	1630	2060	1600	1830	2430	3200	1600	3200	2125.00

NA= Not analyzed due to high colored sample, All values except pH in mg/l

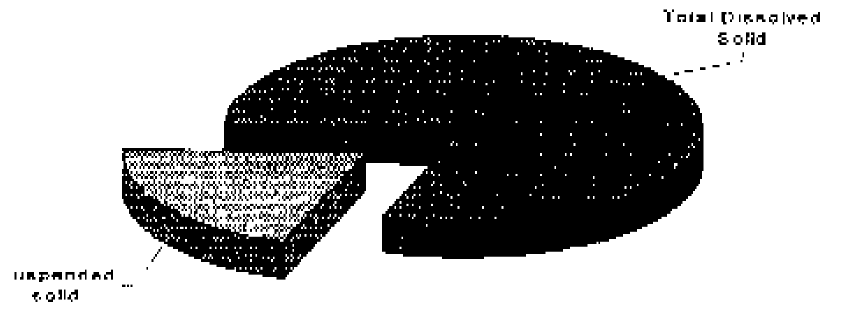

Fig 1. Solids in Composite Textile Wastewater

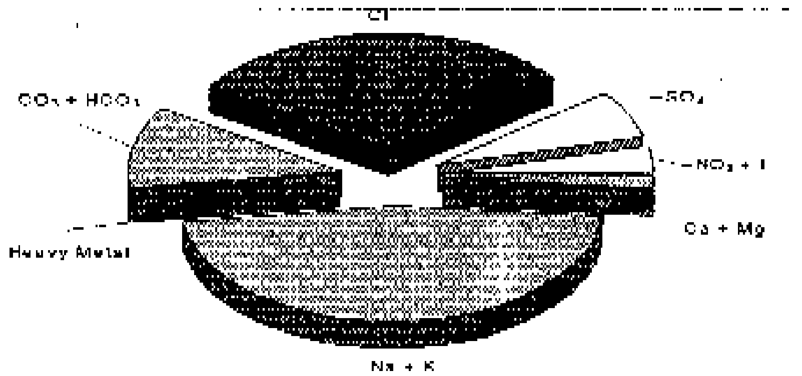

Fig 2. Composition of Textile Industrial Wastewater

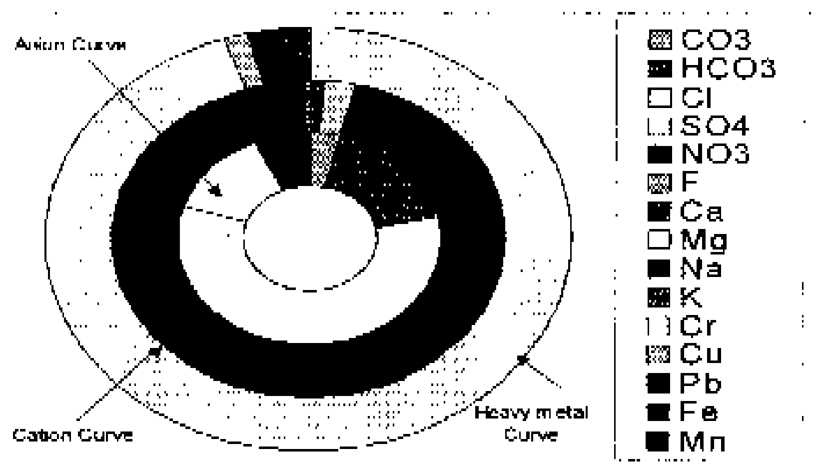

Fig 3. Ionic Composition of Textile Wastewater

a higher level. It ranged from 975 to 2330mg/l. Minimum and maximum sodium concentration was recorded from industry l_1 and l_5 respectively. The higher concentration of the sodium in wastewater was due to the sodium compounds, which are used in almost all steps of wet processes. Sodium chloride is extensively used in water softening also where it replaces calcium and magnesium. In all the processes the sodium compounds are preferred than that of potassium. There fore, the potassium in the industrial wastewater is in lower concentration. The potassium concentration of all six industrial wastewaters varied from 1 to 41 mg/l. Minimum potassium concentration was of industry l_1 and l_2 and maximum of l_5.

Sulphate wastewater of only two industries (l_3 and l_5) could be determined due to highly colored wastewater. Its concentration varied from 307 to 2267 mg/l in the remaining four industries. Minimum and maximum sulphate concentrations were recorded from industry l_1 and l_5 respectively. The change in sulphate concentration in a big range was due to the variety of cloths processes and the chemicals used in the process.

Bicarbonate in the wastewater was found in higher range due to the chemical (sodium bicarbonate) used in various steps of cloth process. The bicarbonate of the wastewater of four industries varied from 555 to 1464 g/l. Minimum and maximum bicarbonate concentration was recorded from industry l_5 and l_1 respectively. The **carbonate** was recorded in only three industries in a very low concentration in the range of nil to 120 mg/l in industry l_1 and l_5 and l_6, respectively. However, it is possible that the carbonate concentration of wastewater could be due to oxidation of bicarbonate in carbonate.

Zinc concentration present in the textile wastewater of six industries was found between 1 to 1535 μgm/l. In four industries it was found below 18 μgm/l indicating that the source of zinc in these industries was due to the impurities of chemicals used. In two industries l_3 and l_6, the zinc concentration is due to synthetic fibers, which is processes. The viscous rayon fibers contain zinc metal. Therefore, it may be possible that the zinc in the wastewater is due to process of viscous rayon fibers. De john. 1976 also concluded that the zinc concentration in the wastewater increases due to process of viscous rayon fibers.

Manganese in the textile wastewater is due to the impurities present in chemicals used in various steps. Therefore, its concentration in the wastewater was found to be low. It was recorded between 1 to 22 μgm/L. Minimum and maximum manganese concentration were recorded from industry l_1 and l_5 respectively.

Lead in the textile wastewater was found between 11 to 61 μg/mL. The reason for presence of lead in this range may be due to (1) chemical impurities present in chemical and or due to (2) lead linked iron pipes of the industry.

Copper concentration in the wastewaters of six industries varied from 6 to 311μgm/L. Only one industry l_3 had high copper concentration while remaining five industries had copper concentration below 18 μgm/L. A very small concentration in five industries may be due to impurities present in

chemicals used. The higher concentration of (31 μgm/L) in one unit is due to the use of copper complex dyes. Hitz, 1978 also recorded higher concentration of copper which copper complex dyes were used.

Chromium pollution problem is a general problem of textile industry, chromium complexed dyes are used where as chromium salts are also used in Khakhi dyeing. It is recorded that the chromium concentration increases 40 to 50 times if cloth is processes for khakhi dyeing. Therefore, the concentration of chromium fluctuates very much from industry to industry. The chromium concentration in the six industries ranged from 7 to 7854 μgm/L. The chromium concentration in three industries (l_4, l_5 and l_6) found below 60 μgm/L indicating no chromium complexed dye was used in the process. The reason for this concentration is the impurities present in chemicals used in various steps of cloth processes. In two industries (l_1 and l_2) the concentration of chromium was 150 and 189 μgm/L indicating no chromium complexed dye was used in the process. In only one industry l_3 it is 7854 μgm/L. From these results it is clear that cloth in this industry was dyed from khakhi colour.

Iron is also used in khakhi dyeing. It is also found in most compounds used in general industry. The small concentration if iron in wastewater is due to these impurities. In the six industries studies iron ranges from 17 to 163 μg-m/L. In three industries (I_2, I_4 and I_5) it was recorded below 50 μgm/L, which is due to chemical impurities as a source of iron in wastewater. Remaining three industries contain iron concentration between 67 to 163 μgm/L which was due to the use of iron complexed dyes. This is one more reason for the concentration of iron above 100 μgm/L in khakhi dyeing. In khakhi dyeing the iron compound are also used but it is been precipitated out after wards. Therefore, the concentration of iron dose not increase in the wastewater.

Biochemical Oxygen Demand (BOD) of all six industries was found to vary from 500 to 1010 mg/L. The minimum BOD was of industry. L3 while the maximum of industry I_6. BOD of the wastewater is due to the presence of unoxidized organic matter. Cotton is a natural plant fiber containing cellulose. It is processes in various steps where a part of cotton removed. In sizing and desizing steps cloth is treated with starch, gum and enzymes, which ultimately passes into wastewater. This is responsible for high biochemical oxygen demand .In case of process of synthetic fiber made cloths the biochemical oxygen demand values decreases.

Chemical Oxygen Demand (COD) of textile wastewater was recorded between 1600 to 3200 mg/L. Minimum and Maximum chemical oxygen demand concentration was recorded from industry I_3 and I_6 respectively. It is higher than that of Biological oxygen demand values. Higher chemical oxygen demand of the wastewater is due to presence of oxidisable compounds, which are used in various steps of process. higher chemical oxygen demand indicates the chemical pollution due to textile industry rather than biological pollution.

CONCLUSION

From all above discussion and figure 1 it is clear that the wastewater of the textile industry is highly viscous with high-suspended solids and high total dissolved solids. The total dissolved solids are high due to the use of chemical of high solubility and the suspended solids are due to the precipitation of salts and undissolved impurity separated by gray cloth. From figure 2 it is concluded that the textile wastewater is rich in chloride, sodium and bicarbonate. The concentration of sulphate was also recorded as high. The overall heavy metal concentration is quite low. From figure 3 it is clear that chromium is the major heavy metal which is due to use of chromium salts and chromium based dyes. The concentration of the manganese is very low. From cationic curve in figure 3 it is clear that sodium is major cation while the concentration of other cations is low. The sodium compounds are extensively used in the process as it helps to maintain pH. Sodium hydroxide is also used in the scouring the both. Sodium chloride is also used in the softening of water. In anions chloride is the major anion while the concentration of sulphate and bicarbonate are also high enough.

REFERENCE

APHA, 1991. *Standards methods for examination of water and wastewater*. American public health association, Washington DC.

Brown, E., Skougstad, M.W., and Fishman, M.J. 1974. *Method for collection and analysis of water samples for dissolved minerals and gases*. U.S. Department of interior, Book No.5

De John, P.B., and Hutchins, R.A. 1976. Treatment of dye wastes with granular activated carbon. *Textile chemist and colorist*. 8 (4) : 32.

Hitz, H.R., 1978. Adsoprtion of dyes on activated sludge. *Our. Soc. Dyers colourists* (G.B.) 94 : 71.

Hussain, J. 2001. Studies on the impact of industrial and domestic waste on groundwater quality, Ph.D. Thesis, MDS, University, Ajmer, Rajasthan.

Textile Industry, 2000. Central pollution control board India, comprehensive industrial documents, series : COINDS/59.