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Research Article

CHEMICAL TREATMENT OF TEXTILE EFFLUENTS USING FERRIC CHLORIDE AS COAGULANT: AN ANALYSIS

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ABSTRACT
As countries around the world, including India, having introduced strict ecological standards and stringent controls expected to be implemented in the near future, it is essential that control measures be implemented / complied in totality to minimize the dangerous impact of effluent coming out for textile industries. Thus the use of conventional textile wastewater treatment processes becomes drastically challenged. Textile production processes not only consume large amounts of energy and water, but they also produce substantial waste water loaded with color, acidic and alkaline contaminants, high concentration of organic materials etc. Coagulation and Flocculation technique can be effectively used to treat this waste. The present research work was carried out to determine the scale of pollution due to textile effluents and understand the capability of Ferric chloride [$FeCl_3$] as coagulating agent to treat textile effluents. The results obtained showed significant decrease in all parameters viz. pH decreased in range of 22.02% to 25.21%, EC decreased in range of 50.39% to 54.48%, turbidity decreased in range of 50% to 55%, TSS decreased in range of 77.34% - 81.97%, TDS decreased in range of 77.52% to 80.50%, Hardness decreased in range of 50.63% - 55.45% COD decreased in range of 40.38% to 47.65%, Cl^- decreased in range of 53.94% - 58.25%, and SO_4^{-2} decreased in range of 47.50% - 56.65% respectively. Use of Ferric Chloride as coagulating agent in treating textile effluents will reduce water and soil pollution to a great extent and make industry sustainable in and around Jodhpur city.

Key Words: *Textile Effluents, Coagulation, Hardness, EC, TSS, TDS, COD, Chloride, and Sulphate*

INTRODUCTION
The quality of surface water within a region is governed by both natural processes (precipitation, weathering and soil erosion, lithology of basin, atmospheric inputs, and climatic conditions) and anthropogenic effects (urbanization, industrialization, agricultural activities, and human exploitation of water resource).

The input of textile waste effluents into surface water bodies has a negative impact not only on the aquatic life but also affects the self purification property or sustainability of the water body. The effluents from industries have a great deal of influence on pollution of water body by altering the physical, chemical and biological nature of receiving water body (Sangodoin, 1991). This further resulted in vast degradation of the surface waters making them worse in their use for agricultural, drinking, industrial, recreation and other purposes (Simeonov *et al.,* 2003). Considering both discharge volume and effluent composition, wastewater generated by the textile industry is rated as the most polluting among all industrial sectors (Vandevivere *et al.,* 1998). Textile industries play very important role in degrading the water quality by releasing their effluents in river, lakes and oceans. Jodhpur is hub of textile dyeing and printing industry.

Pollutants from textile dyeing and printing industries vary greatly and depend on the chemicals used in various dyeing and printing processes. Disposal of untreated / partially treated, or diluted textile industrial effluents on land surface, and on surface water bodies could transfer a large cost to society in terms of environmental pollution and related human health hazards. Broadly, industrial pollutants often alter the physicochemical characteristics, such as temperature, acidity, salinity, or turbidity of receiving water bodies, leading to ecosystem alterations. Thus receiving water thus becomes brackish. It was observed that high Sulphate (SO_4^{-2}) content in industrial effluents if discharged near drinking water supply can cause invigorating action (Agarwal, 1996). Besides this Chloride (Cl^-) content which has always been used as pollution indicator, may damage metallic pipes as well as agriculture crops (Kumar, 1989; Lalove *et al.,* 2000). The excellence of water quality can be assessed by chemical analyses using multiple parameters (Makia *et al.*, 1999), physiochemical treatment methods like adsorption (Ahmad and Ram, 1992), use of ozone (Lin and Lin, 1993), oxidation (Tan *et al.,* 2000), chemical precipitation (Duizbek and Kowal, 1983), and coagulation – flocculation (Bennett and Reeser, 1998; Belukear and Jekel, 1993).

MATERIALS AND METHODS

A. Sample Collection: Effluent samples were collected from different sampling sites in an around Jodhpur. From each sampling site five water samples were collected in one litre double cap acid washed polythene bottles. Prior to sampling each bottle was washed with diluted acid and double distilled water and before actual sampling these bottles were rinsed with waste water to be sampled.

B. Sample Analysis / Instrumentation: The collected samples were analyzed for pH using pH meter, Dissolved Oxygen (DO) was also measured by portable (Water and Soil Analysis Kit – Model 161 E (EI Make)), Hardness due to Calcium, Magnesium was measured by volumetric titration (EDTA Method), Turbidity was measured in NTU units (Rinker and Starent 1974) by Digital Turbidity Meter (Electronic India, Model 341), COD by using standard methods (Arnold *et al.,* 1992), Chlorides was measured by Argentometric method, Sulphates were measured by volumetric titration method (Rump and Krist, 1992), TSS was determined by the difference between the residue left after evaporation of unfiltered sample and of that of filtered sample in the laboratory.

The analytical results of all the water samples were thus evaluated in accordance with the norms prescribed under EPA standards.

C. Sample Treatment: All textile effluent samples were treated with coagulating agent $FeCl_3$ (Analytical Reagent Grade). Borosil beakers of 500 ml capacity were positioned on magnetic stirrers and 200 ml of untreated effluent was treated with specified 4 ml dose of coagulating agent $FeCl_3$. The sample was stirred rapidly for 90 seconds, and then stirred slowly for 20 minutes and finally without stirring for 30 minutes, so that flocks settled down. The solution was then filtered (Arnold *et al.,* 1992).

All these tests were performed at temperature (25ºC±2) because temperature is one of the effective parameters on density, viscosity and therefore retained volume of coagulant used. Temperature has a significant effect on pH measurement (APHA, 1989).

RESULTS AND DISCUSSION

To evaluate the pollution load due to textile effluents, the samples were analyzed for various physico-chemical parameters and the results were compared with values of EPA standards for industrial effluents. The effluent samples were analyzed for the above mentioned parameters before and after treating it with coagulating agent $FeCl_3$. The results obtained on characteristics of effluents and there is considerable fall in concentration of all the tested parameters.

1. pH of water samples usually has no direct impact on water consumers, it is one of the most important operational water-quality parameters in wastewater / effluents (Banerji, 1993).

As mentioned in Table 1 below, pH of textile effluents samples varied from 7.26 - 12.48 with a mean value of 8.90 suggesting that textile effluent samples were highly alkaline. pH of textile effluents decreased sharply after treating the samples with $FeCl_3$.

The reduction in pH was in range of 22.02 to 28.8 in percentage terms, suggesting that $FeCl_3$ as coagulating agent have high potential to reduce the pH at all the stages of water treatment.

Table 1: pH Measurement of Textile Effluents Samples

Sample No.	Before Treatment with $FeCl_3$	After Treatment with $FeCl_3$	Reduction/Decrease in [%]
1.	08.40	6.55	22.02%
2.	12.48	8.88	28.8%
3.	07.26	5.56	23.4%
4.	08.24	6.42	22.08%
5.	08.13	6.08	25.21%

2. The EC is total parameter for dissociated dissolved substances and it depends upon degree of dissociation of ions and their concentration, temperature, and migration of ions in the electric field but does not give idea about type of ions present (Rump and Krist, 1992). The electrical conductivity (EC) of textile effluent samples before and after treatment is given in Table 2. Before treatment, it ranged between 7.40×10^3 to 9.98×10^3 µ Siemens/cm, which is very high as per EPA standards permissible limits of 1000µ Siemens/cm, indicating high levels of pollution. Following treatment with $FeCl_3$, EC almost decreased from 50.39% to 54.48%.

Table 2: Electrical Conductivity (EC in Siemens/cm) of Textile Effluent Samples

Sample No.	Before Treatment with $FeCl_3$	After Treatment with $FeCl_3$	Decrease in [%]
1.	7.40×10^3	3.54×10^3	52.16%
2.	9.98×10^3	4.72×10^3	52.70%
3.	9.13×10^3	4.28×10^3	53.12%
4.	8.91×10^3	4.42×10^3	50.39%
5.	9.82×10^3	4.47×10^3	54.48%

3. Pure water is transparent in nature but as the concentration of different substance [ions, dyes and other materials] increases, turbidity of water increases. So turbidity is a good parameter to measure the degree of pollution of water. As shown in Table 3 below, the turbidity of textile wastewater was found to be in the range of 74 – 82 NTU before treatment with $FeCl_3$. However treatment with $FeCl_3$ resulted in decrease turbidity by nearly 50% to 55% in different textile effluent samples which is similar to findings of (Abdessemed *et al.*, 2002).

Table 3: Turbidity (NTU) of Textile Effluent Samples

Sample No.	Before Treatment with $FeCl_3$	After Treatment with $FeCl_3$	Decrease in [%]
1.	74	37	50%
2.	75	34	54.6%
3.	79	39	50.6%
4.	80	36	55%
5.	82	38	53.6%

4. As shown in Table 4 below, Total Suspended Solids (TSS mg/l) in different textile effluents samples was found to be in the range of 2726 - 3213 mg/l which was significantly higher than the permissible limit of TSS (150 mg/l) as per EPA standard in wastewater. After treatment it with $FeCl_3$, the decrease in TSS mg/l was significant and was found to decrease by nearly 77.34% - 81.97% in different effluent samples.

Table 4: Total Suspended Solids (TSS in mg/l) of Textile Effluent Samples

Sample No.	Before Treatment with $FeCl_3$	After Treatment with $FeCl_3$	Decrease in [%]
1.	2740	604	77.95%
2.	2485	563	77.34%
3.	2726	584	78.57%
4.	3106	650	79.00%
5.	3213	689	81.97%

5. As per Table No. 5 given below, the amount of Total Dissolved Solids (TDS in mg/l) in different textile effluent samples was found to be in the range of 2344 - 3025 mg/l. The highest level of TDS was found in effluent sample 5 and that of minimum in sample 1, which shows high level of pollution. After treatment the effluent samples with $FeCl_3$, the decrease in TDS level was found to be in the range of 77.52% - 80.50%. The range of TDS before treatment was found to be lower than the permissible limit of TDS (3500 mg/l) as per EPA standard in wastewater. The TDS in wastewater shows pollution strength which may result into alteration in taste or odours. TDS in wastewater to be used for agriculture activity may be as high as 1850 - 2000 mg/l, as but not more than this limit (Kumar, 1989).

Table 5: Total Dissolved Solids (TDS in mg/l) of Textile Effluent Samples

Sample No.	Before Treatment with $FeCl_3$	After Treatment with $FeCl_3$	Decrease in [%]
1.	2344	455	80.50%
2.	2410	520	78.40%
3.	2600	579	77.73%
4.	2808	623	77.80%
5.	3025	680	77.52%

6. Divalent metallic cations particularly Ca^{+2}, Mg^{+2}, Sr^{+2}, and Fe^{+2} are responsible for hardness in textile effluents (Abbasi, 1998). As per Table 6 given below, the total hardness in different textile effluent samples was found to be in the range of 550 - 678 mg/l. The highest level of hardness was observed in effluent sample 5 and the minimum in effluent sample 4. After treatment with $FeCl_3$, the total hardness reduced by 50.63% to 55.45% in different effluent samples. The amount of water pollution was found to be higher than the permissible limit (250 mg/l) as per EPA standard.

Table 6: Total Hardness (in mg/l) of Textile Effluent Samples

Sample No.	Before Treatment with $FeCl_3$	After Treatment with $FeCl_3$	Decrease in [%]
1.	550	245	55.45%
2.	630	311	50.63%
3.	745	367	50.73%
4.	466	223	52.14%
5.	678	327	51.76%

7. Chemical Oxygen Demand (COD) is a measure of all organic matter content in the effluent sample which includes both biodegradable fraction and non biodegradable fraction that survive bacterial attack but it can be oxidized by strong chemical oxidants (Abbasi, 1998; Tan *et al.,* 2000; Chiron *et al.,* 2000). As per Table 7 given below, the total COD in different textile effluent samples was found to be in the range of 490 - 870 mg/l showing high level of pollution. The degree of water pollution was found to be

higher than the permissible limit (150 mg/l) as per EPA standards. The highest level of COD was observed in effluent sample 3 and lowest in effluent sample 2. After treating the effluent sample with $FeCl_3$, the COD decrease by 40.38% to 47.65% in different effluent samples.

Table 7: Chemical Oxygen Demand (COD in mg/l) of Textile Effluent Samples

Sample No.	Before Treatment with $FeCl_3$	After Treatment with $FeCl_3$	Decrease in [%]
1.	640	335	47.65%
2.	490	267	45.50%
3.	870	467	46.32%
4.	756	442	41.53%
5.	577	344	40.38%

8. Almost all natural waters contain chloride and sulfate ions. The EPA standard recommends a maximum concentration of 250 mg/l for chloride ions. In small amounts they are not significant. In large concentrations they present problems. Usually chloride concentrations are low. The Table 8 given below shows that chloride contents of textile effluents are in rage 1301 - 1780 mg/l showing high level of pollution. After treating effluent with $FeCl_3$, the reduction in chloride contents was significant and in range of 53.94% to 58.25% for different effluent samples.

Table 8: Chlorides (Cl^- in mg/l) of Textile Effluent Samples

Sample No.	Before Treatment with $FeCl_3$	After Treatment with $FeCl_3$	Decrease in [%]
1.	1301	570	56.18%
2.	1645	689	58.11%
3.	1475	678	54.03%
4.	1570	723	53.94%
5.	1780	743	58.25%

9. Most natural water supplies contain Sulfates (SO_4^{-2}), which is a colorless and odorless compound of sulfur and oxygen and exists as a dissolved salt in water. Sulfates can be more troublesome because they generally occur in greater concentrations. The sulfate ion can be removed by anion resin in the chloride or hydroxide form. As per Table 9 given below, the amount of sulphate ions in different textile effluent samples was found to be in the range of 566 - 918 mg/l. The maximum amount of sulphate ions was found in sample 2 and that of minimum in sample no 3. After treating effluent samples with $FeCl_3$, there was significant decrease in sulphate ions concentration found in the range of 53.94% to 58.25%. As reported by (Agarwal, 1996) the industrial wastewater containing sulphate ions should not be discharged into any water body from where water is supplied for drinking, as higher concentration of sulphate ions cause taste change in water, have a laxative effect on livestock and humans, and are usually associated with high hardness levels.

Table 9: Sulphates (SO_4^{-2} mg/l) of Textile Effluent Samples

Sample No.	Before Treatment with $FeCl_3$	After Treatment with $FeCl_3$	Decrease in [%]
1.	634	312	50.78%
2.	918	434	52.72%
3.	566	248	56.18%
4.	802	421	47.50%
5.	789	342	56.65%

Conclusion

This investigation has demonstrated that coagulation with ferric chloride is an effective method to clarify textile effluents will lead to reduce treatment costs for industries. Pollutant removal efficiency was evaluated. Ferric chloride produced better results. The variation in the parameters studied among different samples is attributed to the differences in operations and the chemicals used in different industries. It was concluded that the industrial effluents should be treated before to be drained into the natural water bodies so that it may not cause water and soil pollution and $FeCl_3$ might be used for wastewater treatment on industrial scale. The results show a significant reduction of water pollution. Clarification process can be used in waste water treatment and reduces the operational cost too.

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