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Treatability Studies on Tannery Wastewater

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ABSTRACT
Tanning industry is one of the oldest industries releasing wastewater which is characterized by high BOD, COD, suspended solids, chloride and chromium. Coagulation process helps to reduce the suspended and colloidal materials responsible for turbidity of the wastewater. In the present study, an attempt has been made to evaluate the effectiveness of chemical coagulants such as Alum, Ferric Chloride, Ferrous Sulphate and Ferric Alum in the treatment of tannery wastewater. The treatment was carried on a magnetic stirrer. The optimum dosage and optimum pH of each of the coagulant were determined. The optimum dosages of Alum, $FeCl_3$, $FeSO_4$ and Ferric Alum were 1600mg, 1500mg, 2000mg and 2000mg per 650mL respectively and the optimum pH were 8,9,10.5 and 9.5 respectively. In case of Alum at an optimum dosage and optimum pH, the maximum reduction in COD, TSS, TDS, Total Chromium and BOD were found to be 41%, 51.7%, 26.8%, 69.4% and 55.7% respectively. In case of $FeCl_3$, the maximum reduction was found to be 64%, 58%, 28.7%, 73% and 63.6% respectively. In case of $FeSO_4$ and Ferric Alum the maximum reduction was found to be 71.7%, 62.5%, 32%, 76.8%, 66% and 74%, 62.2%, 35%, 77.3% and 71.5% respectively.
Keywords - Alum, Ferric Alum, Ferric Chloride, Ferrous Sulphate, Total Chromium.

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I. INTRODUCTION

Tanning is an ancient craft in India and with progress of time it has acquired the status of a mature industry playing an important role in the country's economy. Although tanning industry has been in existence for a long time, the problem of environmental pollution received serious considerations only in recent years [1]. Tanning industry is one of the major consumers of water and most of the water used is discharged as a waste. These wastes are characterized by high BOD, COD, suspended solids and strong color. Tannery wastes when discharged as such deplete the dissolved oxygen of the stream very rapidly, due to both chemical and biological oxidation of Sulphur and organic compounds. A secondary pollution of the stream may occur due to deposition of solids near the discharge point and its subsequent putrefaction. The chromium is toxic to aquatic life and inhibits the growth of fish in the stream. The vegetable tans are reddish tan in color and become inky blue when they come in contact with water. Presence of tannins in the raw water renders it unsuitable for use in certain industries. The various physico-chemical techniques have been studied for their applicability to treat the tannery wastewater. Among these are ozonation, reverse osmosis, ion exchange, activated carbon adsorption, coagulation and electrocoagulation [2]. Coagulation is by far the most widely used process to remove the substances producing turbidity in water. [3]

Coagulation and flocculation processes are intended to form particles large enough to be separated and removed by subsequent sedimentation, or alternative clarification processes. The coagulation stage occurs when a coagulant, such as alum, is added to the water to neutralize the charges on the colloidal particles in the raw water, thus bringing the particles closer together to allow a floc to begin to form. The flocculation process, following coagulation, allows smaller particles formed during the rapid coagulation stage to stick into larger particles to form settleable and/or filterable floc particles [4].

This paper describes experimental studies that were conducted on tannery wastewater in order to evaluate efficiencies of different coagulants in the removal of Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Total Chromium (TC) and Biochemical Oxygen Demand (BOD) at different doses of coagulants and at various pH of wastewater.

II. MATERIALS AND METHODOLOGY

2.1 Coagulants Used

The chemical coagulants such as Alum, Ferric Chloride, Ferrous Sulphate and Ferric Alum were used in the study.

2.2 Experimental Setup

650ml of sample was taken in each of the 4 beakers. Each beaker was placed separately on magnetic stirrer. The coagulants were added in varied dosage and were rapidly mixed for 1 minute at 100 rpm followed by slow mixing at 30 rpm for 29 minutes. After mixing the wastewater was allowed to settle for about 60 minutes. The supernatant was collected from the beaker with help of pipette without disturbing the sediment. Various tests such as BOD, COD, TSS, TDS, and Total Chromium were performed on the collected supernatant. The optimum dosage was determined by comparing the results obtained from different dosages. The dosage which gave the maximum reduced value of the above parameters was taken as optimum dosage. Using the optimum dosage, the optimum pH for the coagulant can be determined by varying the pH of the wastewater and keeping the optimum dosage of the coagulant as constant.

III. RESULTS AND DISCUSSION

3.1 Initial Characteristics of Tannery Wastewater

The physico chemical analysis test values for the tannery wastewater are shown in Table 1. The analysis of tannery wastewater was done as per APHA, Standard Methods for the Examination of Water and Wastewater, 20th Edition.

Table 1: Physico-Chemical Characteristics of Tannery Wastewater

Sl. No	Parameter	Results (Average)
1	Temperature	28 ^{0}C
2	Color	Bluish Grey
3	Odor	Obnoxious
4	pH	6.41
5	COD	3900 mg/L
6	BOD_3 @ 20°C	1650 mg/L
7	TDS	29906 mg/L
8	TSS	3146 mg/L
9	Total Chromium	540 mg/L
10	Electrical Conductivity	37700 S

3.2 Optimization of the coagulant dose

Alum dosage was varied in the range of 800-2000mg per 650mL at an interval of 400mg. Ferric Chloride was varied in the range of 500-2000mg per 650mL of wastewater at an interval of 500mg. Similarly, Ferrous Sulphate and Ferric Alum were varied in the range of 1000-4000mg per 650mL at an interval of 1000mg.

3.2.1 Reduction of COD

Fig.1 shows the influence of coagulant dose on the removal of COD. The maximum removal of COD with Alum as coagulant is 38.5% at a dosage of 1600mg per 650mL of wastewater, and the maximum removal of COD with $FeCl_3$ as coagulant is 53.8% at a dosage of 1500mg per 650mL of wastewater, with $FeSO_4$ is 69.2% at a dosage of 2000mg per 650mL of wastewater and with Ferric Alum is 71.7% at a dosage of 2000mg per 650mL

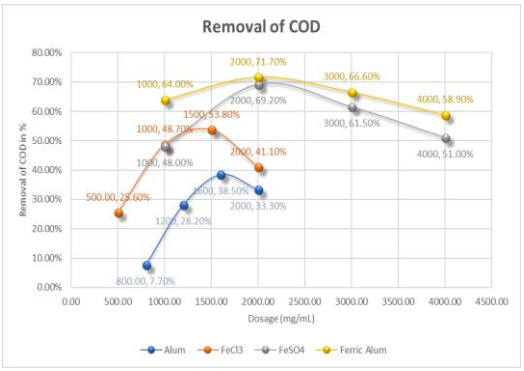

Fig.1. dosage vs removal of COD

3.3 Reduction of Total Suspended Solids

Fig. 2 shows the influence of coagulant dose on the removal of TSS. The maximum removal of TSS with alum as coagulant is 44.6% at a dosage of 1600mg per 650mL of wastewater, the maximum removal of TSS with FeCl3 as coagulant is 46.5% at a dosage of 1500mg per 650mL of wastewater, with FeSO4 is 50% at a dosage of 2000mg per 650mL of wastewater and with Ferric Alum is 53.6% at a dosage of 2000mg per 650mL.

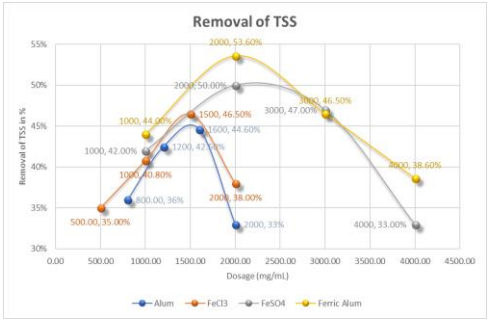

Fig.2. dosage vs removal of TSS

3.2.2 Reduction of Total Dissolved Solids

Fig.3 shows the influence of coagulant dose on removal of TDS. The maximum removal of TDS with alum as coagulant is 18.7% at a dosage of 1600mg per 650mL of wastewater, and the maximum removal of TDS with $FeCl_3$ as coagulant is 21% at a dosage of 1500mg per 650mL of wastewater, with $FeSO_4$ is 28% at a dosage of 2000mg per 650mL of wastewater and with Ferric Alum is 30.5% at a dosage of 2000mg per 650mL.

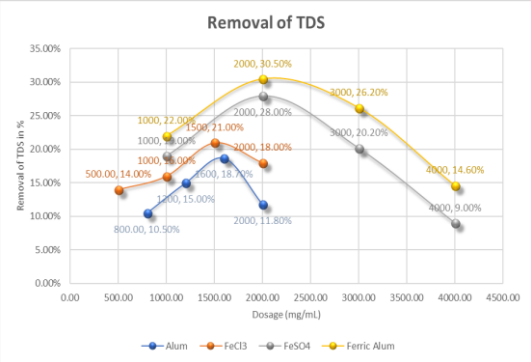

Fig.3. dosage vs removal of TDS

3.2.3 Reduction of Total Chromium

Fig.4 shows the influence of coagulant dose on the removal of Total Chromium. The maximum removal of Total Chromium with alum as coagulant is 67.4% at a dosage of 1600mg per 650mL of wastewater, and the maximum removal of Total Chromium with $FeCl_3$ as coagulant is 70% at a dosage of 1500mg per 650mL of wastewater, with $FeSO_4$ is 74.6% at a dosage of 2000mg per 650mL and with Ferric Alum is 76% at a dosage of 2000mg per 650mL.

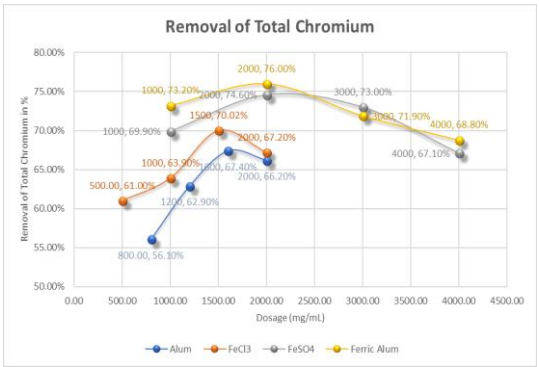

Fig.4. dosage vs removal of Total Chromium

3.2.4 Reduction of BOD

Fig.5 shows the influence of coagulant dose on the removal of BOD. The maximum percentage removal of BOD with alum as coagulant is 48.5% at a dosage of 1600mg per 650mL of wastewater, and the maximum percentage removal of BOD with FeCl3 as coagulant is 53.3% at a dosage of 1500mg per 650mL of wastewater, with FeSO4 is 62% at a dosage of 2000mg per 650mL of wastewater and with Ferric Alum is 69.6% at a dosage of 2000mg per 650mL.

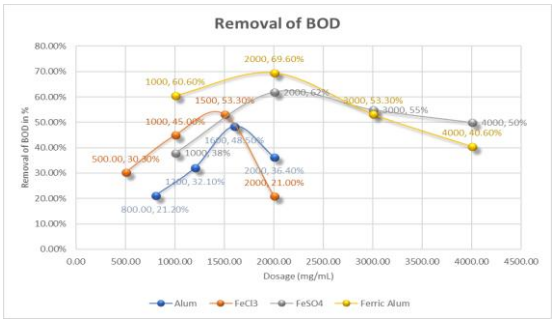

Fig.5. dosage vs removal of BOD

3.3 Optimization of the pH of wastewater

The pH of wastewater was varied for each of the coagulant to find the optimum pH in which the coagulant works efficiently. Each coagulant has a specific range of pH in which it works very efficiently. To find the optimum pH of alum, the pH of wastewater was varied as 4,6,8,10 and alum added at an optimum dosage of 1600mg per 650mL was kept constant for each pH variation. Similarly, the pH of wastewater was varied for Ferric Chloride, Ferrous Sulphate and Ferric Alum as 5,7,9,11 and 8.5,9.5,10.5,11.5 and 5.5,6.5,9.5,11.5 respectively by keeping their respective optimum dosage as constant.

3.3.1 Reduction of COD

Fig. 6, shows the influence of pH of wastewater on removal of COD. It can be seen that maximum removal of COD with alum as coagulant is 41% at pH of wastewater as 8, and the maximum removal of COD with $FeCl_3$ as coagulant is 64% at pH of wastewater as 9, with $FeSO_4$ is 64% at pH 10.5 and with Ferric Alum is 74% at pH 9.5

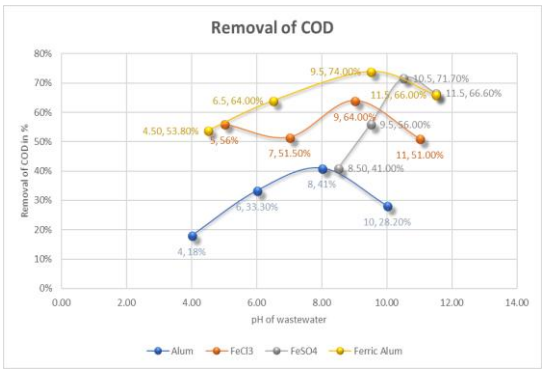

Fig.6. pH of wastewater vs removal of COD

3.3.2 Reduction of Total Suspended Solids

Fig. 7, shows the influence of pH of wastewater on removal of TSS. It is found that the

maximum removal of TSS with alum as coagulant is 51.7% at pH of wastewater as 8, and the maximum removal of TSS with $FeCl_3$ as coagulant is 58% at pH of wastewater as 9, with $FeSO_4$ is 61.2% at pH 10.5 and with Ferric Alum is 62% at pH 9.5.

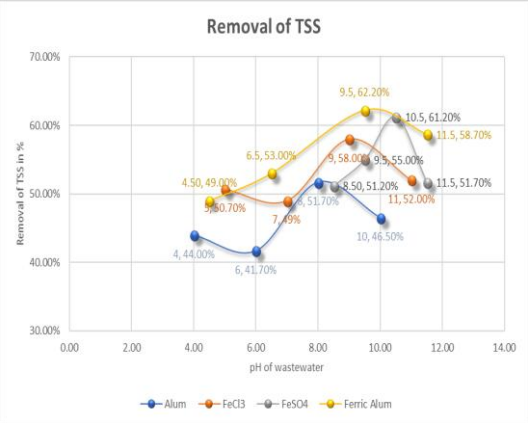

Fig.7. pH of wastewater vs removal of TSS

3.3.3 Reduction of Total Dissolved Solids

Fig. 8, shows the influence of pH of wastewater on removal of TDS. The maximum removal of TDS with alum as coagulant is 28.7% at pH of wastewater as 8, and the maximum removal of TDS with $FeCl_3$ as coagulant is 28.7% at pH of wastewater as 9, with $FeSO_4$ is 32% at pH 10.5 and with Ferric Alum is 35% at pH 9.5.

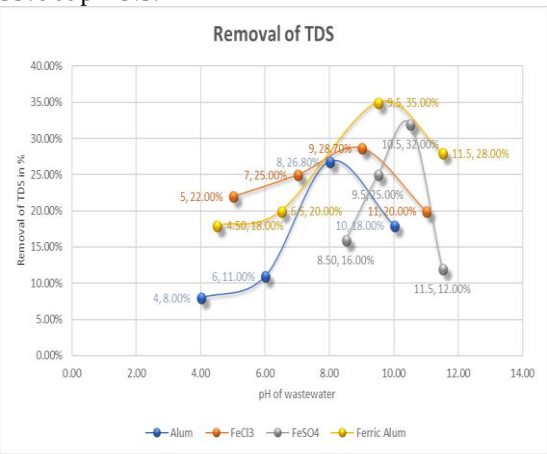

Fig.8. pH of wastewater vs removal of TDS

3.3.4 Reduction of Total Chromium

Fig. 9, shows the influence of pH of wastewater on removal of total Chromium. The maximum removal of Total Chromium with alum as coagulant is 69.4% at pH of wastewater as 8, and the maximum removal of Total Chromium with $FeCl_3$ as coagulant is 98.7 at pH of wastewater as 9, with $FeSO_4$ is 76.8% at pH 10.5 and with Ferric Alum is 77.3% at pH 9.5.

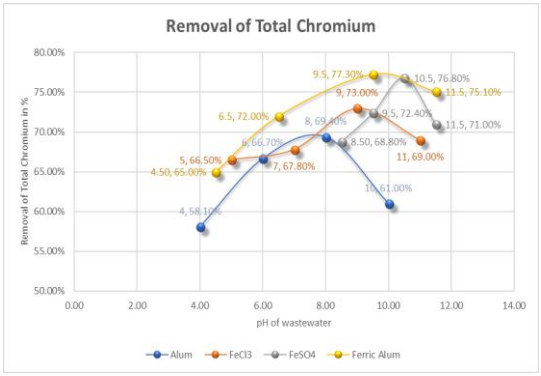

Fig.9. pH of wastewater vs removal of Total Chromium

3.3.5 Reduction of BOD

Fig. 10, shows the influence of pH of wastewater on removal of BOD. The maximum removal of BOD with alum as coagulant is 55.7% at pH of wastewater as 8, and the maximum removal of BOD with $FeCl_3$ as coagulant is 63.6% at pH of wastewater as 9, with $FeSO_4$ is 63.6% at pH as 10.5 and with Ferric Alum is 71.5% at pH 9.5.

Fig.10. pH of wastewater vs removal of BOD

IV. CONCLUSION

This investigation has demonstrated that Ferric Alum produced better results than Alum, Ferric Chloride and Ferrous Sulphate. The results showed a significant reduction of about 74% of COD, 62.2% of TSS, 30.5% TDS and 71.5% of BOD.

Chromium removal has been shown to be very effective with all four coagulants exhibiting a range from 69.4% to 77.3%. The efficiency of the coagulation of tannery wastewater is highly dependent on control of pH of wastewater within an optimum range.

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