

Treatment of Tannery Effluent Using Electrocoagulation

Dr C.B.Shivayogimath¹, Prashant Kurdekar²

¹Professor and Head, Department of Civil Engineering, Basaveshwar Engineering College, Bagalkot, Karnataka, India

²M.Tech Scholar, Department of Civil Engineering, Basaveshwar Engineering College, Bagalkot, Karnataka, India

ABSTRACT: In the present study, the treatment of tannery wastewater was performed by electrocoagulation method (EC) using aluminum electrodes in a bipolar connection. The removal of COD, Turbidity, TDS and Conductivity was experimentally investigated using direct current (DC) electrocoagulation (EC). In the EC of tannery wastewater, the effect of pH, electrolysis time and voltage were examined. The batch experimental results revealed that the removal efficiency of the overall COD, Turbidity, TDS, Conductivity, Total carbon, Chromium, Sulphate, Total solids and Chloride concentration, depend on the nature of the electrode material. The optimum operating range for each operating variable was experimentally determined. The highest COD and Turbidity removal efficiency were obtained with the use of aluminum electrode. The overall COD and Turbidity removal efficiencies reached 91% and 100%, respectively.

KEYWORDS: Electrocoagulation, tannery industry wastewater, electrolysis time, voltage, COD, turbidity.

I. INTRODUCTION

India is the third largest leather producer in the world, behind China and Italy. The Indian leather industry is a large player in the global market, and a major source of foreign exchange revenues [1]. The leather industry in India processes 3000 tons of hide and skins per annum and the total production capacity of India covers about 22% of the world market share [2]. On the other hand, tannery wastes are ranked as the highest pollutants among all other industrial wastes. There are two types of tanning processes namely, vegetable tanning and chrome tanning. The chrome tanning process results in toxic metals especially chromium passing to wastewater and are not easily eliminated by ordinary treatment process. Tannery effluents are mainly characterized by high salinity, high toxicity, high organic loading and specific pollutant such as chromium. Various chemicals used in tanning are lime, sodium carbonate, sodium bicarbonate, common salt, sodium sulphate, chrome sulphate, fat liquors, vegetable oils and dyes. Besides these, chemicals such as zinc chloride, mercuric chloride and formaldehyde are also used as disinfectants, sodium chloride in curing and as bleaching powder and sodium fluoride to prevent putrefaction. Hence the tannery effluent is always characterized by its strong color, high COD, high pH, and high dissolved solids [3]. Considering the large amount and the low biodegradability of chemicals present in the tannery productive cycle, tannery wastewater represents a serious environmental and technological problem [4]. Therefore, the improvement and development of treatment methods for these effluents is extremely necessary to protect the soil and human life. Tannery industry effluent is conventionally treated by adopting various physico-chemical and biological methods. These conventional processes are often inadequate for complete removal of pollutant in tannery industry [5]. Coagulants in addition to increasing the amount of sludge production increase the total solids in the effluents; adsorption process necessitates back-washing and use of membranes has the problem of scaling and frequent membrane fouling [6]. Hence electrochemical treatment of tannery industry wastewater may be considered as an economical alternative process when conventional treatment process fails to decrease the pollution load. The EC technique has been successfully used for the treatment of various wastewater such as sugar wastewater [6], hospital wastewater [7], textile wastewater [8] etc. Hence in the present study an attempt was made on the evaluation of the efficiency of the electrocoagulation process on treatment of tannery wastewater using aluminum electrodes.

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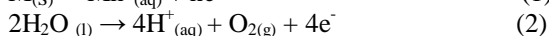
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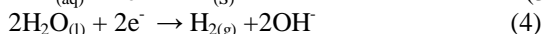
Theory of Electrocoagulation:

Electro coagulation (EC) is a process which depends on responses of water contaminants to strong electric fields and electrically induced oxidation and reduction reactions. EC technique utilizes direct current to cause sacrificial electrode ions to remove undesirable contaminants either by chemical reaction and precipitation or by causing colloidal materials to coalesce and then they are removed by electrolytic flotation [9]. During EC, coagulants are obtained *in situ* by the dissolution of the anode. In this process if M is considered as anode, the following reaction will occur

At the anode:



At the cathode:



Freshly formed amorphous $M(OH)_3$ has large surface areas that are beneficial for rapid adsorption of soluble organic compounds and trapping of colloidal particles.

II. MATERIALS AND METHODS

For the batch electrocoagulation, the reactor made up of acrylic material with the dimension of 15cm x 10cm x 15cm was used. The working volume of the reactor was 1L. The EC unit consists of six aluminum electrodes as bipolar system in the reactor and DC power supply. The dimensions of the electrodes were 10cm x 5cm x 1mm. The schematic representation of the experimental setup is shown in Fig 1. After initial characterization of wastewater, batch experimental studies were conducted to optimize the various parameters such as pH, electrolysis time and voltage. Experiments were performed with two electrodes connected to the DC power supply to determine optimum conditions. In the bipolar connection of electrodes, there is no electrical connection between inner electrodes; only the outer electrodes are connected to the power supply. The space between the six electrodes was maintained 1cm in all the experiments. In each run the voltage was varied between 10V to 20V. To maintain homogenous mixing of the reactor content, magnetic stirring unit was used. The wastewater concentration was reduced to ten times the strength throughout the study, as the effluent was highly concentrated with pollutants. The EC experiments were performed for 150 min and in each run samples were collected at 15min interval for necessary analysis.

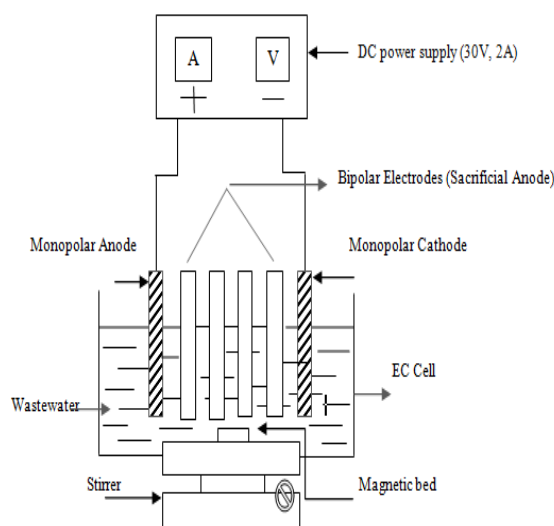


Fig 1: Schematic representation of experimental setup

III. RESULTS AND DISCUSSION

Wastewater sample was collected from the nearest tannery industry and was characterized for initial parameters as per Standard Methods. The various parameters of the wastewater are shown in Table I.

SI No	Parameters	Values
1.	pH	2.7
2.	Color	Black
3.	Turbidity	2550 NTU
4.	Total solids	2168 mg/L
5.	COD	56000 mg/L
6.	Total Dissolved Solids	8860 mg/L
7.	Total carbon	4378 mg/L
8.	Chloride	2460 mg/L
9.	Conductivity	20 mS/cm

The study was mainly focused on the electrocoagulation of the tannery wastewater for determining effects of operating parameters such as pH, voltage and electrolysis time on COD and Turbidity removal.

Initially, the experiments were carried out with adjusting pH of raw wastewater to pH 5 with varying voltages. The COD reduced from 5600 mg/L to 2720 mg/L, 1600 mg/L and 2720 mg/L thereby giving 51.4%, 74.4% and 51.4% COD removal efficiencies respectively for 10V, 15V and 20V at 150 min (Fig 2). However the COD removal efficiency remained same for 180 min of electrolysis time. The turbidity reduced from 255 NTU to 2.5, 81.5 and 0.0 NTU thereby being 99%, 68% and 100% efficient for 10V, 15V and 20V at 150 min (Fig 3). The turbidity removal efficiencies also did not change further for 180 min of electrolysis time.

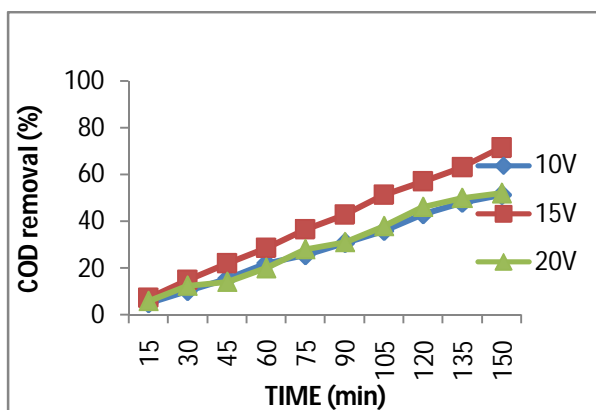


Fig 2: COD removal vs time at different voltages at pH 5

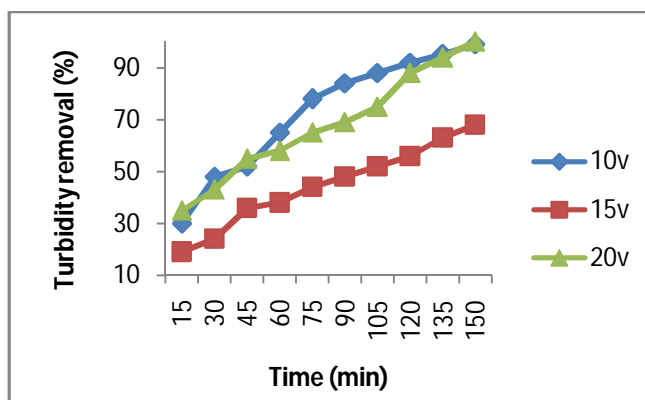


Fig 3: Turbidity removal vs time at different voltages at pH 5

Next the experiments were carried out by increasing pH to 6.0 with different voltages 10V, 15V and 20V. Maximum COD removal efficiencies of 57.14%, 85% and 91.0% respectively were obtained for 150 min (Fig 4) which remained constant for 180 min of electrolysis time. Similarly maximum turbidity removal efficiencies of 98.4%, 100% and 100% for 150 min (Fig 5) were obtained at these conditions.

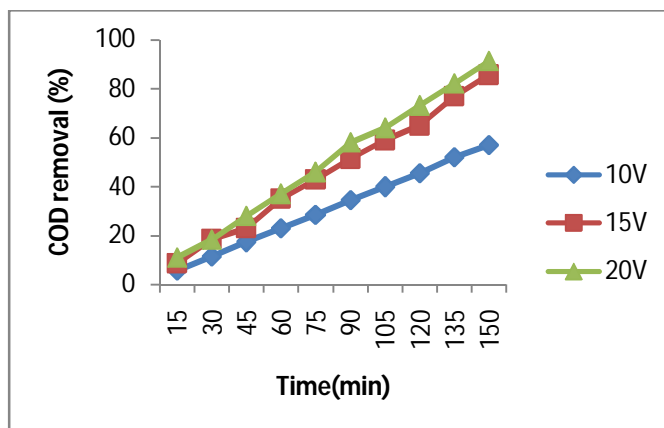


Fig 4: COD removal vs time at different voltages at pH 6

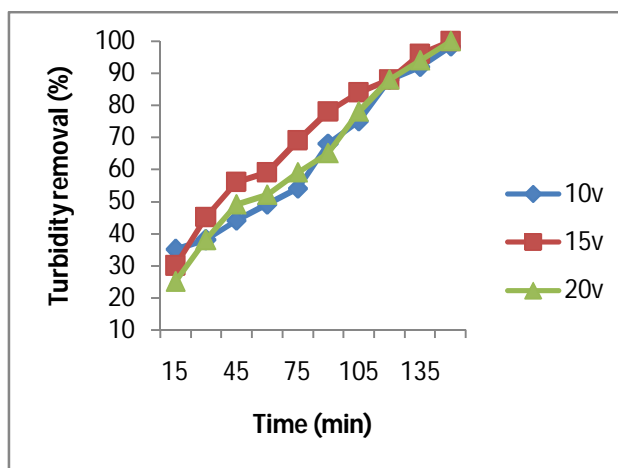


Fig 5: Turbidity removal vs time at different voltages at pH6

When experiments were carried out for pH 7.0 with varying voltages 10V, 15V and 20V, the maximum COD removal efficiencies were found to be 74%, 60% and 74% respectively for a electrolysis time of 150 min (Fig 6) and remained unchanged for 180 min of electrolysis time. Similarly, the maximum turbidity removal efficiencies obtained were 91.3%, 96.8% and 99.9% respectively for 150 min of electrolysis time (Fig 7).

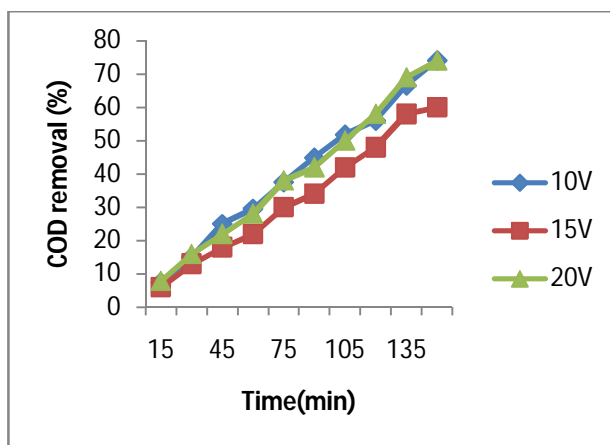


Fig 6: COD removal vs time at different voltages at pH 7

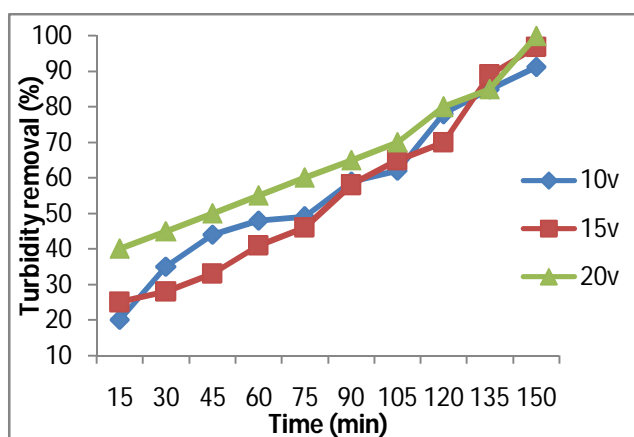


Fig 7: Turbidity removal vs time at different voltages at pH 7

From the experimental analysis, it was found that maximum COD removal efficiency 91.0% and turbidity removal of 100% were obtained at operating parameters of pH 6, 20V and 150 min of electrolysis time. At these operating conditions COD reduced from 5600 mg/L to 480 mg/L and turbidity reduced from 255 NTU to 0.0 NTU.

CONCLUSION

Based on the experimental observations, the electrolysis time of 150 min, pH 6.0 and 20V were found to be critical operating parameters for the treatment of wastewater using aluminum as electrode material. Maximum COD removal efficiency of 91.0% and turbidity removal of 100% were obtained at these optimum operating conditions. Hence, it can be concluded that the electrocoagulation technique using aluminum electrodes appears to be feasible alternative for the treatment of tannery industry wastewater. Thus electrocoagulation is an efficient process for the treatment of tannery wastewater which is quick, easy and economical and can be operated using less equipment and limited space.

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