Tannery Wastewater Treatment by Electrocoagulation Method Using Aluminium and Iron Electrodes

Malakangouda S P[1], Lokeshappa B[2], Krishnegowda K[3], Kiran Kumar H S[4]
[1, 2, 3, 4] Department of Civil Engineering
[1, 2, 3] UBDTCE, Davangere, Karnataka, India
[4] GMIT, Davangere, Karnataka, India

Abstract- *In this paper, treatment of tannery wastewater by Electro-Coagulation (EC) method using aluminum and iron electrodes has been investigated in a batch process. The tannery wastewater sample was collected from Ambur, Tamil Nadu. The effect of variables like voltage, time and distance were investigated on TDS, TSS, COD, BOD, Chloride and Chromium. The Electro-Coagulation process was carried out in a batch reactor of 1 liter capacity was taken out for batch at 10 and 15 voltages and corresponding times of 60, 90 and 120 min by keeping different distance between the electrodes viz., 2, 3 and 4cm. The results obtained showed that the highest removal efficiency of 92.75%, 97.5 %, 96.37 %, 85.74 %, 92.18% and 86.92 % of TDS, TSS, BOD, COD, Chloride and Chromium respectively is obtained at Distance 2cm, Volts 15V, 120 min duration and aluminium electrode configuration has Bi-polar electrodes and the highest removal efficiency of 94.36 %, 95.71 %, 95.91 %, 84.64%, 90.31% and 85.87 % of TDS, TSS, BOD, COD, Chloride and Chromium respectively is obtained at Distance 2cm, Volts 15V, 120 min duration and iron electrode configuration has Bi-polar electrodes. Comparison studies show that Aluminum electrode was found more advantageous in removing of all parameters compare to iron electrode except TDS.*

Keywords- Tannery wastewater, Aluminium, Iron, TDS, TSS, BOD, COD, Chloride, Chromium.

I. INTRODUCTION

Tanning is claimed as the second oldest profession in the world. In olden days, tanning was considered as a poisonous trade. Tanning is a procedure of changing animals skins (a characteristic renewable asset) to leather (a business sector material utilized in the manufacture of a wide range of products) [1]. The tanning industry is presently recognized as a major industry of incredible financial significance on a world wide scale producing a large group of products in one of the world's finest natural materials [2].

Treatment of tannery wastewater is troublesome and speaks to a genuine ecological and mechanical issue because of vicinity of a progression of chemicals with low biodegradability [3]. So the treatment of tannery wastewater is a matter of incredible concern in the nation having leather tanning industry.

The tannery industries are considered as polluting due to the inherent manufacturing processes as well as type of technology employed in the manufacture of hides and skin into leather. During the tanning process no less than 30 kg of chemicals are added per ton of hides [4]. Tannery wastewater when released into water bodies modify the physical, chemical and biological characteristics of water and reduces the dissolved oxygen, increases alkalinity, suspended solids and sulfides which are harmful to fish and other aquatic lives. Aside from natural materials which discharge significant nutrients for decay, tannery wastewater contains chromium and pathogens essentially of fecal origin and poisonous organic segments, all of which pose a serious threat to the environment [5].

Substantial metals in the tannery wastewater are one of the most dangerous environmental pollutants. Peoples, cattle's and plants are influenced when these poisonous metals like Cr, Cu, Zn, Pb and Cd are incorporated into the food chain [6]. Subsequently tannery wastewater with high contamination should be treated before its disposal. The treatment of industrial waste varies with its character, quantity and the nature of receiving media and the dilution available. The diverse systems are: Physical method, Chemical Method and Biological method [7].

An electrochemical technique called electrocoagulation has attracted significant attention for all main parameters in tannery wastewater process due to its operational simplicity [8]. This process doesn't require the addition of chemicals due to the oxidation and reduction reactions which takes place. this influences the reduction of COD and BOD, therefore the maintainance and operation of the system is simple [9]. The power consumptions also accepeted to be low. The present investigation is aimd at studying the effectiveness electrocoagulation techniques using different types of electrodes [10].

II. THEORY OF ELECTROCOAGULATION

Electrocoagulation is one of the Electro-chemical methods applied in the treatment of different types of waste water like textile dye waste water, tannery waste water, dairy waste water, domestic waste water [2]. This technique is characterized by simple equipment, easy operation and decrease amount of sludge [9].

Electrocoagulation is a treatment process of applying electric current in to an aqueous medium in an electrochemical cell using an electrode. The different types of electrodes used in this process are Aluminum, Zinc, Copper, Iron [10].

In instrument of Electro-Coagulation, an anode material experiences oxidation and henceforth, framed different monomeric and polymeric metal hydrolyzed species. This metal hydroxide expel organics from wastewater by breadth coagulation and by collecting with colloidal particles present in the wastewater to shape greater size rushes and evacuated by settling. Organics contained in wastewater are oxidized specifically at the surface of the anode or oxidizing specialist is electrochemically produced to do oxidation in electro-oxidation procedure of wastewater treatment [5].

Metal hydroxide are delivered amid the electrolytic procedure and go about as coagulants and Flocculants which is changed over into flocs obliged thickness to residue under gravity in the unit. Electromotive power is created from the electrical energy to deliver metal hydroxide.

The responses that occur on the anode surfaces amid electrocoagulation are:

Anode:

$$Al(s) \longrightarrow Al^{3+} + 3^{e-} \quad (1)$$

$$2H_2O \longrightarrow O_2 + 4H^+ + 4^{e-} \quad (2)$$

Cathode:

$$Al^{3+} + 3H_2O \longrightarrow Al(OH)_3 + 3H^+ \quad (3)$$

$$Al(OH)^{2+} + H_2O \longrightarrow Al(OH)_3 + H^+ \quad (4)$$

$$2H_2O \longrightarrow 4H^+ + 4^{e-} + O_2 \quad (5)$$

Separation of water by Electrocoagulation creates hydroxide particles, which of the most responsive species which oxidize the natural mixes, Polyhydroxides or Hydroxide have solid bond fascination; Suspended solids will happens in upward heading because of gas advanced at the anodes [3].

III. MATERIALS AND METHODOLOGY

A. Sample collection

The tannery wastewater sample was collected from Ambur, Tamil Nadu. Wastewater sample were collected from the effluent plant according to the standards and initial characteristics were carried for research facility.

B. Experimental Setup

The Bi-Polar Electrodes set up is showed in fig.1, which for the most part comprises of a measuring glass 1 liter Capacity of reactor to hold a specimen Aluminum/Iron plates of 3 mm thickness and 150 mm x 50 mm measurements was utilized as terminals. In Bi-Polar electrodes dipped in the reactor, DC power source was connected by anode and cathode with 2cm gap of electrode with magnetic stirrer at the bottom to mix the solution. Electrode spacing is maintained 2cm, 3cm and 4cm with direct current power supply (0-30V, 0-2A). All experiments were performed at a room temperature.

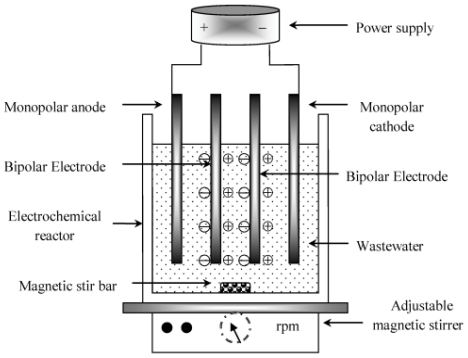

Fig.1 Laboratory Experimental setup

C. Experimental Procedure

The experimentation was carried out by using two electrodes i.e. Aluminum representing cathode and Copper representing anode. Both electrodes were dipped in a container containing leachate with defined spacing between electrodes (3, 4 and 5cm). The time maintained for the experiment was 15, 30 and 45 minutes. At the end of every run, the sludge formed at the top of container was removed and then the treated leachate sample was transferred to the beaker and kept undisturbed for certain periods for floc to settle. The treated leachate effluent is analyzed for several parameters like Chlorides, TDS, COD and TSS as per APHA.

IV. RESULTS AND DISCUSSION

The raw tannery wastewater which was collected from Ambur, Tamil Nadu were analysed for various physico-chemical properties to know its initial characteristics and shown in table 1.

Table 1 Tannery Wastewater Characteristics

Sl. No.	Parameters	Unit	Values
1	pH	-	3.5
2	Color	Pt Co	29400
3	TDS	ppm	6210
4	TSS	mg/L	11200
5	EC	µS	7280
6	Chloride	mg/L	3200
7	Chromium	mg/L	9.202
8	Temperature	^{0}C	30
9	BOD	mg/L	4560
10	Turbidity	NTU	302.7
11	COD	mg/L	11023

The Electrocoagulation process was influenced by variables such as applied cell voltage, distance between the electrodes and electrolysis time for the removal of various parameters by using Aluminium electrode.

A. Reduction of COD during EC Treatment

The effect of electrolysis time was investigated up to 120 min and the cell applied voltage of 10 to 15V by keeping a distance between electrodes of 2cm.

During the treatment the electrolysis time increases concentration of electrode ions and their hydroxide floc increases, also the rate of bubble generation increases. The removal efficiency of COD increases with the certain applied voltages, time and optimum distance between electrodes. Higher removal efficiency was observed at 10 and 15V, 120min of 93.55% and 96.37% respectively. The removal efficiency of COD is as shown in figure 2 and figure 3

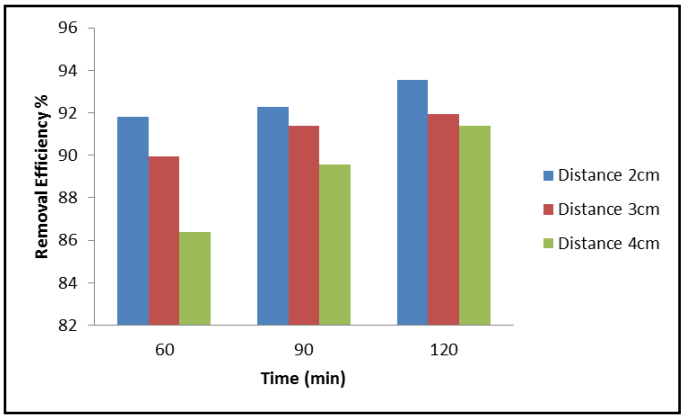

Fig.2 Variation of COD with Constant Voltage (10V) for Different Time (T) and Distance (D)

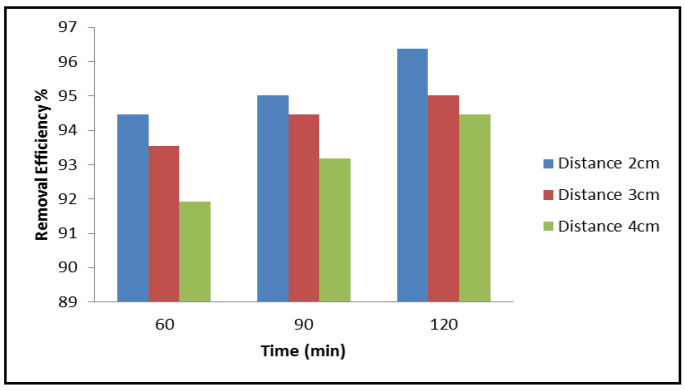

Fig.3 Variation of COD with Constant Voltage (15V) for Different Time (T) and Distance (D)

B. Reduction of Chromium during EC treatment

The removal efficiency of Chromium was studied for different time viz., 60, 90, 120 min and different distance viz., 2, 3 and 4cm.

Figure 4 and 5 shows reduction of Chromium with electro coagulation using aluminium electrodes. At 2cm distance, time 120 min, higher removal efficiency of TDS at 10V and 15V was found and the results was 82.06%, 86.92%.

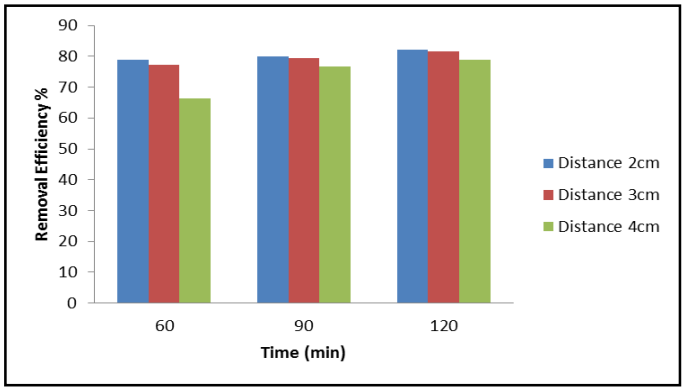

Fig.4 Variation of Chromium with Constant Voltage (10V) for Different Time (T) and Distance (D)

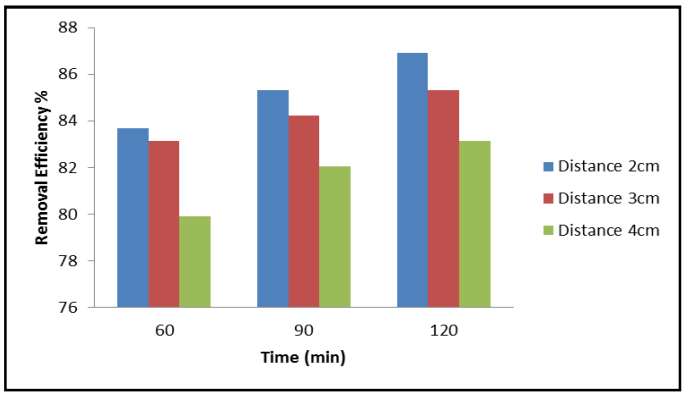

Fig.5 Variation of Chromium with Constant Voltage (15V) for Different Time (T) and Distance (D)

The Electrocoagulation process was influenced by variables such as applied cell voltage, distance between the electrodes and electrolysis time for the removal of various parameters by using Iron electrode.

C. Reduction of COD during EC treatment

The effect of electrolysis time (60, 90, 120 min) and applied voltage (10, 15 V) on the removal of COD by keeping distance of 2, 3 and 4cm between the electrodes is shown in fig 6 and fig 7.

During the treatment the electrolysis time increases concentration of electrode ions and their hydroxide floc increases, also the rate of bubble generation increases. The removal efficiency of COD increases with the certain applied voltages, time and optimum distance between electrodes. Higher removal efficiency was observed at 10 and 15V, 120min of 92.83% and 95.91% respectively.

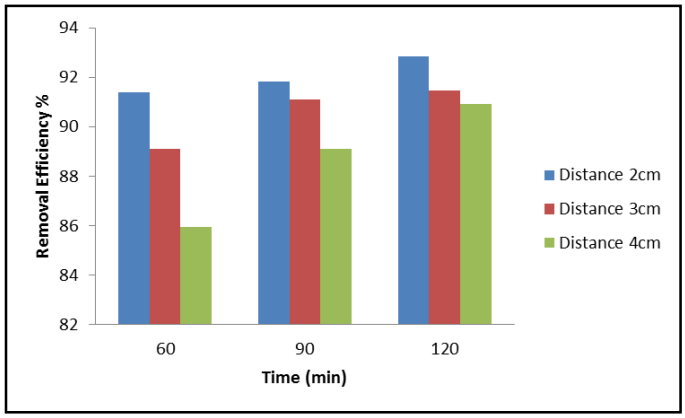

Fig.6 Variation of COD with Constant Voltage (10V) for Different Time (T) and Distance (D)

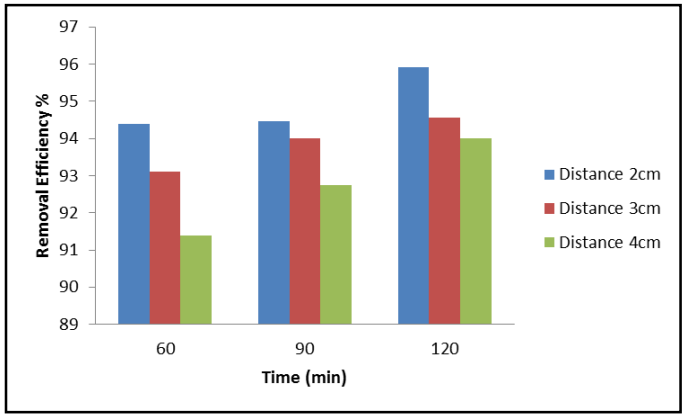

Fig.7 Variation of COD with Constant Voltage (15V) for Different Time (T) and Distance (D)

D. Reduction of Chromium during EC treatment

The removal efficiency of Chromium was studied for different time viz., 60, 90, 120 min and different distance viz., 2, 3 and 4cm.

Figure 8 and 9 shows reduction of Chromium with electro coagulation using iron electrodes. At 2cm distance, time 120 min, higher removal efficiency of TDS at 10V and 15V was found and the results was 79.89% and 85.87% respectively.

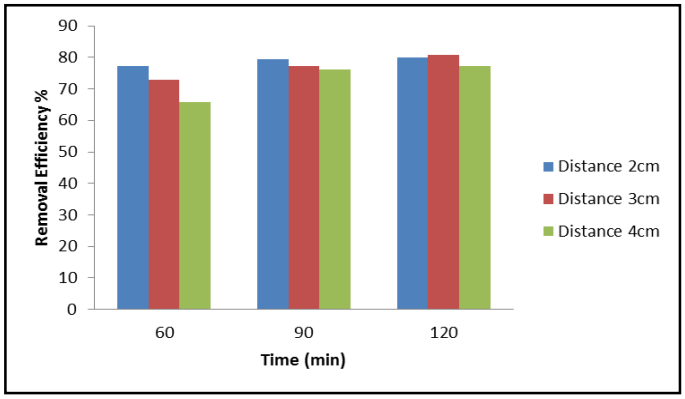

Fig.8 Variation of Chromium with Constant Voltage (10V) for Different Time (T) and Distance (D)

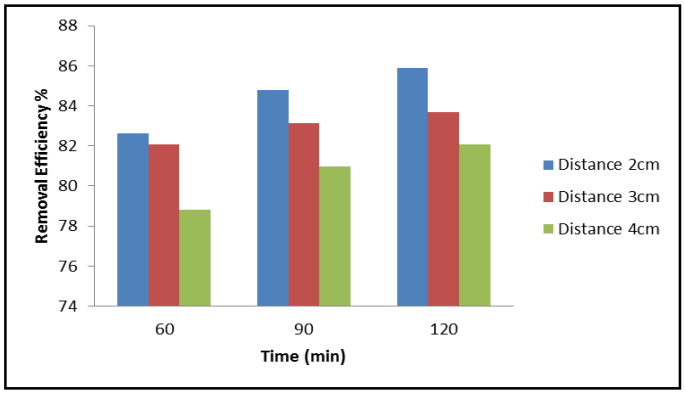

Fig.9 Variation of Chromium with Constant Voltage (15V) for Different Time (T) and Distance (D)

E. Comparison of Electrodes in Removal of Parameters with Constant Distance, Time and Voltage

Batch electro coagulation treatment of tannery wastewater sample was carried out using aluminium and iron electrodes in an electro-chemical reactor, the electrodes were placed 2cm apart for cell applied voltage of 15V. Samples were retrieved at 120 min. The higher removal efficiency of parameters was obtained for aluminium electrode compare to iron electrode.

The variations of parameters for different electrodes were drawn in the fig 10.

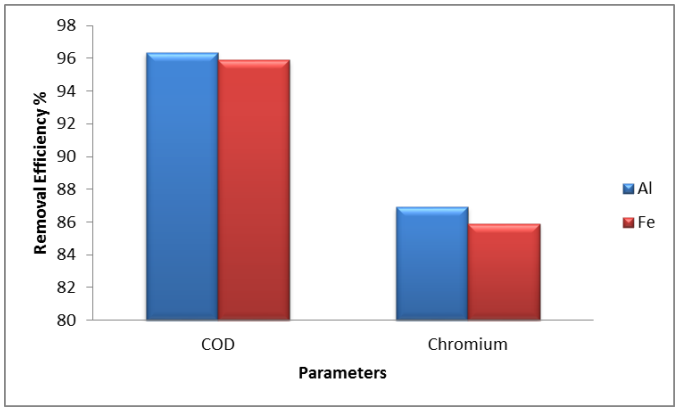

Fig.10 Comparison of Electrodes in Removal of Parameters with Constant Distance (D), Time (T) and Voltage (V)

VI. CONCLUSION

From the experimentation, it is concluded that the variables like Voltage, Contact time and Distance between the electrodes, the Bi-Polar Connections have higher removal efficiency. It is presumed that the removal of Chromium and COD show greater removal efficiency at Bi-polar connection. The highest removal efficiency of 85.74 % and 86.92 % of COD and Chromium respectively is obtained at Distance 2cm, Volts 15V, 120 min duration and aluminium electrode configuration has Bi-polar electrodes. The highest removal efficiency of 84.64% and 85.87 % of COD and Chromium respectively is obtained at Distance 2cm, Volts 15V and 120 min duration andiron electrode configuration has Bi-polar electrodes. It's presumed that during electrochemical process, the electrode distance which were placed a distance of 2 cm are more efficient in treating as compared to 3 and 4 cm. This study presumed that Electro-Coagulation is an effective treatment for tannery waste water, its more efficient compare to other treatment process.

ACKNOWLEDGMENT

Special thanks to all members of UBDTCE, Davangere for providing the research equipment's and internal foundations. I sincerely thank the faculty of the Department of Civil Engineering, who helped me to bring out this work successfully.

REFERENCES

[1] Debabrata Bera., Parimal Chattopadhyay. And Lalitagauri Ray, "Continuous removal of chromium from tannery wastewater using activated sludge process-Determination of kinetic parameters", Indian Journal of Chemical Technology, 2012, 19, pp 32-36.

[2] Saritha Banuraman. and Meikandaan T P, "Treatability study of tannery effluent by enhanced primary treatment", International Journal of Modern Engineering Research, 2013, 3(1), pp 119-122.

[3] Deepika, R. R., Gengadevi. and Saravanan K, "Effluent treatment of tannery industries: Optimization of experimental data using RSM", Journal of Chemical Engineering and Research, 2014, 2(1), pp 1-9.

[4] Shivayogimath C B. and Rashmi Jahagirdar,"Treatment of industrial waste water using electrocoagulation technique", International Journal of Research in Engineering and Technology, 2013, 8(2), pp 2321-7308.

[5] Malakootian. and Yousefi N, "The efficiency of electrocoagulation process using aluminum electrodes in removal of hardness from water", Iran. J. Environ. Health. Sci. Eng, 2009, 6(2), pp 131-136.

[6] Apaydin., Kurt U. and Gonullu M T, "An investigation on the treatment of tannery wastewater by electrocoagulation", Global NEST Journal, 2009, 11(4), pp 546-555.

[7] Giusy Lofrano., Sureyya Meric., Gulusum Emel Zengin. and Derin Orhon, "Chemical and biological treatment technologies for leather tannery chemical and waste waters", A Review, Science of the Total Environment, 2013, 8(2), pp 265-281.

[8] Tasneembano Kazi. and ArjunVirupakshi, "Treatment of tannery waste water using natural coagulants", International Journal of Innovative Research in Science, Engineering and Technology, 2013, 2(8), pp 216-220.

[9] Manjushree Chowdhury., Mostafa M G., Tapan Kumar Biswas. and Ananda Kumar Saha, "Treatment of leather industrial effluents by filtration and coagulation processes", Water Resources and Industry, 2013, 3(6), pp 11-22.