2011 2nd International Conference on Chemical Engineering and Applications
IPCBEE vol. 23 (2011) © (2011) IACSIT Press, Singapore

Treatment of Cattle-Slaughterhouse Wastewater Using Tubular Electrocoagulator

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Abstract: Slaughtering animals and packaging processes generate large volume of wastewaters. This wastewater contains high amounts of organic matter such as proteins, blood, fat. In this study the slaughterhouse wastewater was treated by electrocoagulation method using iron rods. Experiments were conducted to examine the effects of the operating parameters, such as supporting electrolyte concentration and polyelectrolyte addition on COD removal in the electrocoagulation process. The energy consumptions were also analyzed. The COD removal efficiency of 72% was obtained with the addition of polyelectrolyte after 90 min electrocoagulation. It can be concluded that electrocoagulation is a relatively suitable process for removal of COD using iron electrodes to effectively treatment of slaughterhouse wastewater.

Keywords: Electrocoagulation; iron; abattoir wastewater, COD

1. Introduction

Slaughterhouses generate meat and products marketed for human consumption, pollutant solid waste and other by-products (skins, fats, and bones), as well as substantial volumes of wastewater as a result of cleaning operations [1]. Slaughterhouses generate wastewater mainly in the industrial slaughtering process, in the washing of equipment and facilities and in the production of by-products. The consumption of water per slaughtered animal varies according to the animal and the process employed in each industry, and ranges from 1 to 8.3m^3. Most of this amount is discarded as wastewater, with volumes from 0.4 to 3.1m^3 per slaughtered animal being reported in the literature [2].

Electrocoagulation is an alternative technology for wastewater treatment systems and most effective in removing inorganic and organic contaminants and pathogens. Compared with conventional chemical coagulation, electrocoagulation has many advantages such as simple equipment, easy operation and automation, a short retention time, low sludge production and no chemical requirement. The EC of poultry-slaughterhouse wastewater in a plexiglass reactor using four parallel monopolar aluminium and iron electrodes was studied by Kobya et al. [3] and in monopolar and bipolar electrolytic cells consisted of eight parallel pieces of metal plates by Asselin et.al [4]. Electrolysis of fowl-slaughterhouse wastewater using cast iron electrodes to minimize odors and organic matter was studied by Marconato et al. [5]. Electrocoagulation of cattle-slaughterhouse wastewater by aluminium and iron cylindrical anodes was also studied by Tezcan Un et.al [6]. In this study the cattle slaughterhouse wastewater was treated by using different designed iron electrodes. The purpose of this work was to investigate the performance of this reactor and also treating cattle-slaughterhouse wastewater by EC to achieve the required legal direct-discharge limit of COD which is 250mg/L in Turkey for the slaughterhouse industry effluents [6]. Fort this purpose experiments were conducted to examine the effects of the operating parameters, such as supporting electrolyte concentration

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and addition of polyelectrolyte on COD removal in the electrocoagulation process. The energy consumptions were also analyzed.

The most widely used electrode materials in electrocoagulation process are aluminium and iron. In the case of iron, two mechanisms proposed are as [6]

Mechanism 1

Anode

$$4Fe_{(s)} \rightarrow 4Fe^{2+}_{(aq)} + 8e^{-} \quad (1)$$

In the solution

$$4Fe^{2+}_{(aq)} + 10H_2O_{(l)} + O_{2(g)} \rightarrow 4Fe(OH)_{3(s)} + 8H^{+}_{(aq)} \quad (2)$$

Cathode

$$8H^{+}_{(aq)} + 8e- \rightarrow 4H_{2(g)} \quad (3)$$

Mechanism 2

Anode

$$Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^{-} \quad (4)$$

In the solution

$$Fe^{2+}_{(aq)} + 2OH^{-}_{(aq)} \rightarrow Fe(OH)_{2(s)} \quad (5)$$

Cathode

$$2H_2O_{(l)} + 2e- \rightarrow H_{2(g)} + 2OH^{-}_{(aq)} \quad (6)$$

2. Materials and Methods

The wastewater used in this work was taken from a local slaughterhouse plant located in the city of Eskisehir, Turkey. The wastewater was taken just before the entrance to the treatment facility and after the mixing with washing water. Although the quality of the effluent was variable, it was highly colored and typically had a pH of 7.1, COD of 840mg/L. A specific amount of supporting electrolyte (0.05M, 0.1M and 0.2M Na_2SO_4) was added to the wastewater to increase the conductivity.

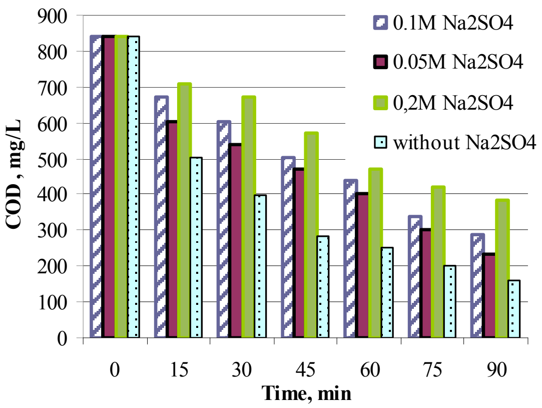
The iron electrocoagulator operated semi continuous mode was used to treat the 0,8 L of slaughterhouse wastewater. The cylindrical iron reactor with a height of 75 cm and diameter of 3.5 cm was made of iron and the three pairs of iron rods (o.d. = 1.1 cm) were used as anode and placed on a centre of the reactor as shown in Figure 1. Samples from the effluent were taken and centrifuged at 5000 rpm; after digestion of the resulting supernatant using the Hach COD Digestion Reagent, the solution was analyzed by titrimetric method.

Fig. 1: Experimental setup

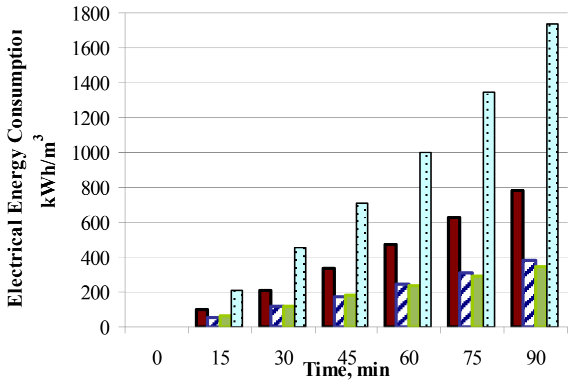
3. Results and Discussion

The efficiency of pollutant removal from wastewaters by EC process depends on several operating parameters such as supporting electrolyte concentration and polyelectrolyte addition. In this study, COD removal percentage was the primary criterion to assess the process performance. Electrical energy consumptions per cubic meter of wastewater also were taken into consideration.

Solution conductivity affects the cell voltage, current efficiency, and consumption of electrical energy in electrolytic cells. Therefore, the electrical conductivity of the solution is an important parameter for saving electric energy in an electrochemical cell. 0.05, 0.1 and 0.2M of Na_2SO_4 were used as supporting electrolyte in the experiments conducted to see the effect of supporting electrolyte concentration on the removal efficiency at 40mA/cm^2. As show from the Fig. 2 the concentration of the supporting electrolyte increased, the COD removal efficiency decreased which may be due to inhibition of SO_4^{2-} ions to the electrode surface and interaction of excess SO_4^{2-} ions with hydroxyl ions.



(a)



(b)

Fig. 2: Effect of supporting electrolyte concentration (a) on COD concentrations and (b) on electrical energy consumptions.

In order to enhance the removal efficiency polyelectrolyte was added to wastewater. It has enhanced surface activity and improved charge neutralizing capacity. The results obtained from processing at 40 mA/cm^2 are shown in Fig.3. When the electrocoagulation was conducted with coagulant-aid, the removal efficiency of 66.0% was increased to the 72.0% at current density of 40mA/cm^2 and 0.1M Na_2SO_4 concentration at the end of 90 min.

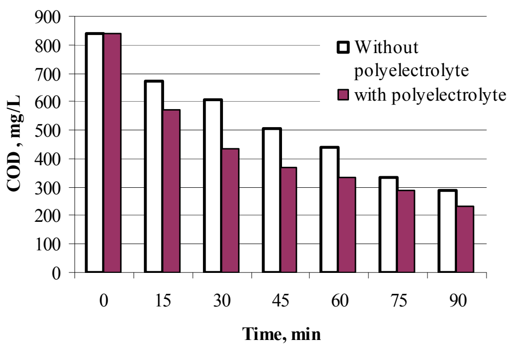


Fig.:3: Effect of polyelectrolyte addition on COD concentrations

4. Conclusion

In this study, the electrochemical treatment of cattle-slaughterhouse wastewater by EC using iron rod electrodes was investigated. Effects of supporting electrolyte concentration and polyelectrolyte addition on the electrocoagulation have been investigated. It can be concluded that our reactor operated in semi-continuous mode is effective for the treatment of wastewaters containing COD. According to the results obtained from the above experiments, an increase in supporting electrolyte concentration caused decrease electrical energy consumptions but higher concentration of Na2SO4 caused a reduction in the removal of COD from wastewater. The addition of polyelectrolyte also increases the removal efficiency of COD.

In conclusion, electrocoagulation is a relatively suitable process for removal of COD using iron electrodes to effectively treatment of slaughterhouse wastewater.

5. Acknowledgements

This research has been supported by Anadolu University Scientific Research Project.

6. References

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