

TREATMENT OF SUGAR INDUSTRY WASTEWATER USING ELECTROCOAGULATION TECHNIQUE

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Abstract

The cost effective treatment of sugar industry wastewater is a challenging task. In the present work, an attempt was made for the treatment of sugar industry wastewater using electrocoagulation technique with iron electrodes as sacrificial anode in bipolar connection system. The effects of operating parameters such as pH, voltage and electrolysis duration on the removal of COD and turbidity were investigated. The optimum value for each operating variable was experimentally determined. The optimum values of voltage, initial pH and electrolysis time were found to be 12V, 6.0 and 4 hours respectively. The experiments revealed that COD and turbidity in aqueous phase was effectively removed. The analysis of the treated water showed that the maximum COD and turbidity removal efficiencies were 92.8% and 92.4% respectively at optimum conditions. The effluent was very clear and its quality meets the discharge standard. Consequently, the electrocoagulation process can be considered as a reliable, safe and cost effective method for the treatment of sugar industry wastewater.

Keywords: Electrocoagulation, sugar industry wastewater, electrolysis time, voltage, COD, turbidity.

1. INTRODUCTION

India is one of the largest producers and consumers of 22 million tones of sugar per annum in the world and about 1000L of wastewater is produced for every ton of cane crushed [1]. Because of high BOD content, sugar industry wastewater lead to the depletion of dissolved oxygen content in the water bodies resulting if discharged untreated, rendering the water bodies unfit for both aquatic and human uses [2]. If untreated wastewater is discharged on land, decaying organic solids present in the wastewater clog the soil pores [3].

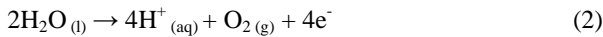
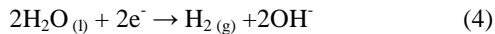
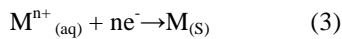
Rapid urbanization, industrialization and population growth have led to the severe contamination of most of the fresh water resources with untreated industrial and municipal wastes [4]. Treatment and reuse of wastewaters have become absolute necessity to avoid pollution of fresh water bodies [5]. Hence purification of sugar industry wastewater is a challenging task due to the stringent discharge standards for the protection of environment.

Sugar industry effluent is conventionally treated by adopting various physico-chemical and biological methods. These conventional processes suffer the disadvantage that the reagent costs are high and the soluble COD removal is low. Moreover, chemical treatments could induce a secondary pollution due to the fact that chemical additives may contaminate the treated water [6]. 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 [7]. Conventional biological treatment systems for sugar factory wastewaters may not be feasible due to large land space requirement as well as high capital and operational cost [8]. Hence electrochemical treatment of sugar industry wastewater may be considered as an economical alternative process when conventional treatment methods fail to reduce pollution. The EC technique has been successfully used for the treatment of various wastewaters such as domestic wastewater [9], cyanide containing wastewater [10], tannery wastewater [11], textile wastewater [12], slaughter-house wastewater [13] etc. Hence in the present study an attempt was made on the evaluation of the efficiency of the electrocoagulation process on treatment of sugar industry wastewater using iron electrodes.

1.1 Theory of Electrocoagulation:

Electro coagulation (EC) is a process in which the anode material undergoes oxidation with formation of various monomeric and polymeric metal hydrolyzed species. These metal hydroxides remove organics from wastewater by sweep coagulation and/or by aggregating with the colloidal particles present in the wastewater to form bigger size flocs which ultimately are removed by settling [14]. During EC, coagulants are obtained *in situ* by the dissolution of the anode. In this process if M is considered as anode, the following reactions will occur [15]:

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.

2. MATERIALS AND METHODS

For the batch electrocoagulation, the reactor made up of plastic material with the dimensions of 14cm x 9cm x 15cm was used. The working volume of the reactor was 1L. The EC unit consisted of four iron electrodes connected as bipolar system in the reactor and DC power supply. The dimensions of the electrodes were 5cm x 5cm x 1mm. The schematic representation of the experimental setup is shown in Fig 1.

After the initial characterization of wastewater, batch experimental studies were conducted to optimize the various parameters such as pH, electrolysis time (ET) 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 four electrodes was maintained 1cm in all the experiments. In each run the voltage was varied to a desired value of 8, 10 and 12V. To maintain homogenous mixing of the reactor content, magnetic stirring unit is used. The wastewater concentration was reduced to half the strength throughout the study to reduce the time and current consumption and to obtain better efficiency. The EC experiments were performed for 5 hours and in each run samples were collected at every one hour interval for necessary analysis.

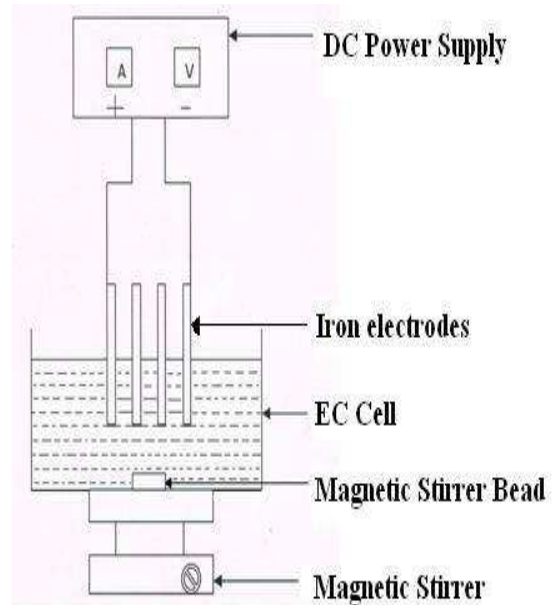


Fig 1: Schematic representation of the Experimental Set-up

3. RESULTS AND DISCUSSION

Wastewater sample was collected from the nearest sugar industry and was characterized for quality parameters. The various parameters of wastewater are shown in Table 1.

Table 1: Characteristics of Sugar industry Wastewater

Sl No.	Parameters	Values
1.	pH	5.1
2.	Color	Greenish Yellow
3.	Turbidity	249.1 NTU
4.	Suspended solids	380 mg/L
5.	BOD ₅	2250mg/L
6.	COD	6400 mg/L
7.	Total Dissolved solids	1008 mg/L
8.	Nitrate	6.2mg/L
9.	Phosphate	0.8mg/L

The study was mainly focused on the electrocoagulation of the sugar industry wastewater with high concentration of COD for determining effects of operating parameters such as pH, voltage and electrolysis time on COD and turbidity removal.

Initially, the experiment was carried out without adjusting pH of raw wastewater at pH 5 with varying voltages. The COD reduced from 6400mg/L to 2080, 1440 and 1120 mg/L thereby giving 67.5%, 77.5% and 82.5% COD removal efficiencies respectively for 8V, 10V and 12V at 4 hours (Fig 2). However, the COD removal efficiencies remained same for 5 hours of electrolysis time. The turbidity reduced from 92 NTU to 27, 21.5 and 15 NTU thereby being 70.67%, 76.82%, 83.49% efficient in removing turbidity from wastewater respectively for 8V, 10V and 12V at 4 hours (Fig 3). The turbidity removal efficiencies also did not change further for 5 hours of electrolysis duration.

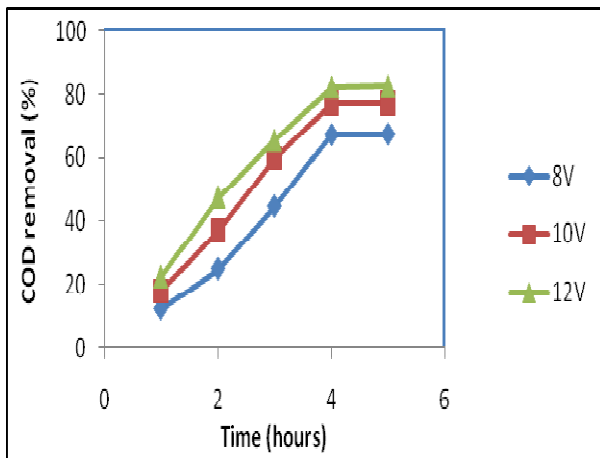


Fig 2: COD removal vs time at different voltages at pH 5

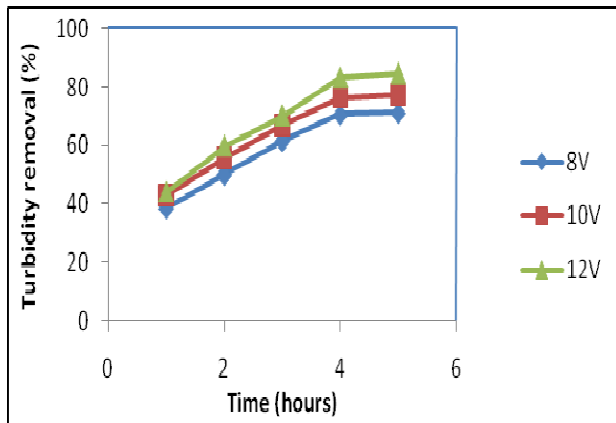


Fig 3: Turbidity removal vs time at different voltages at pH 5

Next the experiment was carried out by increasing pH to 6.0 with different voltages 8V, 10V and 12V and maximum COD removal efficiencies of 72.5%, 85% and 92.8% respectively were obtained for 4 hours (Fig 4) which remained constant for 5 hours of electrolysis time. Similarly, maximum turbidity removal efficiencies of 78.91%, 84.68% and 92.4% for 4 hours (Fig 5) were obtained.

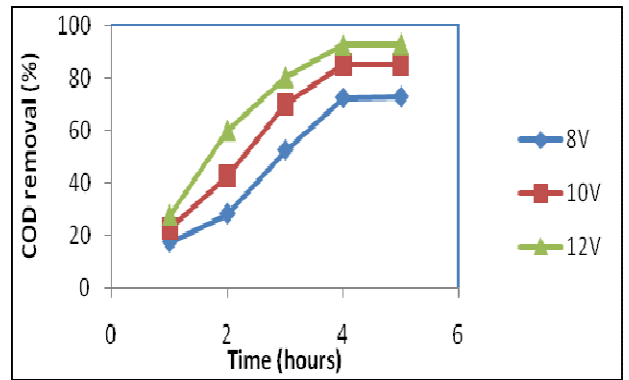


Fig 4: COD removal vs time at different voltages at pH 6

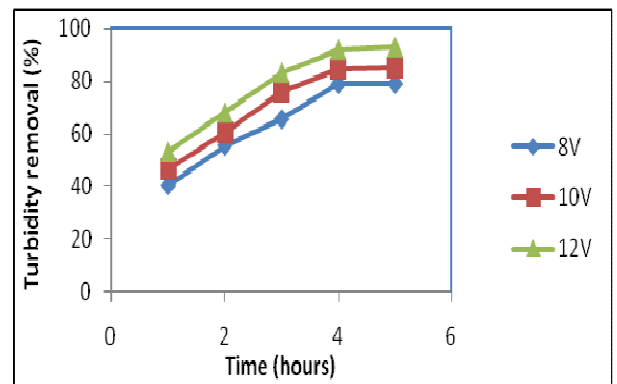


Fig 5: Turbidity removal vs time at different voltages at pH 6

When experiment was carried out by further increasing the pH to 7.0 with varying voltages 8V, 10V and 12V, the maximum COD removal efficiencies were found to be 70%, 82.5% and 87.5% respectively for a duration of 4 hours (Fig 6) and remained unchanged for 5 hours of electrolysis time. Similarly, the maximum turbidity removal efficiencies obtained were 72.4%, 80.09% and 88.76% for 4 hours of ET (Fig 7).

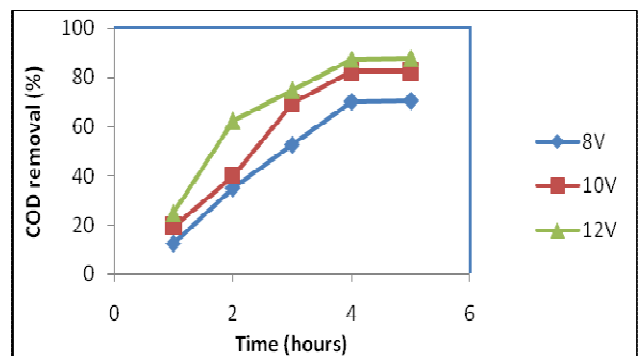


Fig 6: COD removal vs time at different voltages at pH 7

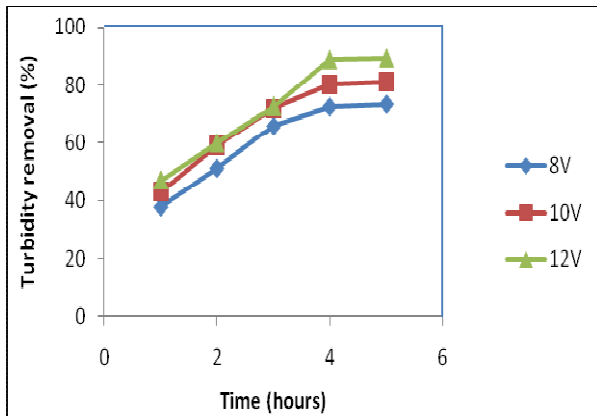


Fig 7: Turbidity removal vs time at different voltages at pH 7

From the above analysis, it was found that maximum COD removal efficiency 92.8% and turbidity removal of 92.4% were obtained at optimum operating parameters of pH 6, 12V and 4 hours of electrolysis duration. At these operating conditions COD reduced from 6400 mg/L to 460 mg/L and turbidity reduced from 92 NTU to 7 NTU.

CONCLUSIONS

Based on the experimental findings, the electrolysis duration of 4 hours, pH 6.0 and 12V were found to be the critical operating parameters for the treatment of wastewater using iron as electrode material. Maximum COD removal of 92.8% and turbidity removal of 92.4% were obtained at these optimum operating conditions. Hence, it can be concluded that the electrocoagulation technology using iron electrodes appears to be a feasible alternative for the treatment of sugar industry wastewater. Thus electrocoagulation is an efficient process for treatment of sugar industry wastewater which is fast, easy, and economical and can be operated using less equipment and limited space.

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