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TREATMENT OF SUGAR INDUSTRY WASTE WATER BY ELECTROCOAGULATION (EC) TECHNIQUE.

REMOVAL OF COLOR AND TDS

Chethan Marol [1], Siddaling Talawar [2], Dattatreya Narale[3].
[1]Departement of civil engineering Secab Engineering collage vijayapur,karanataka.
[2]Departement of civil engineering Secab Engineering collage vijayapur,karanataka.
[3]Departement of civil engineering Secab Engineering collage vijayapur,karanataka.
.Assistant Proffesor and Departement Of Civil Engineering, Secab Engineering Collage, Vijayapur, Karanataka, India,

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 Aluminum electrodes as sacrificial anode in bipolar connection system. The effects of operating parameters such as pH, voltage and electrolysis duration on the removal of Color and TDS 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 25V, 7.0 and 1 hours respectively. The experiments revealed that color and TDS in aqueous phase was effectively removed. The analysis of the treated water showed that the maximum color and TDS removal efficiencies were 95% and 94% 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:- *Sugar effluents, Electro-coagulation treatment, Aluminum electrodes, Color, TDS.*

I. INTRODUCTION

Effluent discharges from agro based industries like sugar are characterized by high COD due to their high level of organic contents and this effluent contains milk and milk products with wash water[1]. Rapid urbanization and industrialization in the developing countries like India pose severe problems in collection, treatment and disposal of effluents. This situation leads to serious public health problems. Unmanaged organic waste fractions from industries, municipalities and agricultural sector decompose in the environment resulting in large scale contamination of land, water and air. These wastes not only represent a threat to the environmental quality but also possess a potential energy cane crushed. Because of high value which is not fully utilized despite the fact that they are cheap and abundant on most parts of the world [2]. Large quantity of wastewater originates due to their different operations. The organic substances in the wastes comes either in the form in which they were present in milk, or in a degraded from due to their processing. As such, the dairy wastewater, though biodegradable, are very strong in nature sugar waste effluents are concentrated in nature, and the main contributors of organic charge to these effluents are carbohydrates, proteins and fats originating from milk. The liquid waste from sugar industries originates from different sections like receiving station, bottling plant, cheese plant, casein plant, condensed milk plant, dried milk plant and ice cream plant. The sugar industry wastes are very often discharged intermittently. The nature and composition of waste depends on the type of products produced and size of the plant [3]. Increased research has been dedicate towards the treatment of wastewater using electrocoagulation (EC) and advance oxidation process (AOP's) such as Fenton reaction or ozone process because of the increase in environmental restrictions on discharge of untreated wastewater.

Electrocoagulation (EC) is an electrochemical method for the treatment polluted water which has been successfully implemented in of soluble or colloidal wastewater pollutants found in slaughterhouses, vegetable oil refineries and dairy manufacturing facilities.

Electrocoagulation is an electrochemical technique that consists of the generation of coagulants in situ by dissolving electrically through either aluminum or iron ions from electrodes. The metal ion generation occurs at the anode, when the hydrogen gas is released from the cathode. The hydrogen gas assists in floating the flocculated particles to the surface. During this process the electrodes can be arranged in a mono-polar or bipolar mode [4].

II. THEORY OF ELECTROCOAGULATION

The EC is a process in which the anode material undergoes oxidation whereas the cathode subjected to reduction and hence, various monomeric polymeric metal hydrolyzed species are formed at the electrode surface. These metal hydroxides remove organics from wastewater by sweep coagulation and by aggregating with colloidal particles present in the wastewater to from bigger size flocs and ultimately get removed by settling. The metal ions generation takes place at the anode and hydrogen gas is released from cathode. This hydrogen gas would also help to float the flocculated particles out of the water by process called electro-flotation.

When aluminum is used as electrode materials, the electro-coagulation reactions are as follows [5].

At Anode:

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

At Cathode:

$3H_2O + 3e^- \longrightarrow 3/2 H_2 (g) + 3OH^-$ ----- (2)

In the solution:

Al^{3+}

$(aq) + 3H_2O \rightarrow Al(OH)_3 + 3H^+ (aq)$ --------- (3)

As seen in the above reactions EC is a combination of oxidation, flocculation and flotation. The EC occurs in three steps. In first step, coagulant is formed because of oxidation of anode. In second step, pollutants get destabilized and in last step the destabilized matters get united and then remove.

III. MATERIALS AND METHODS

3.1 Analytical measurements

The sugar effluent used in this study was collected from nearby sugar factory in karjol. The analysis of wastewater was carried out as per Standard Methods. The various characteristics of sugar effluent are shown in Table I.

Table.I
Characteristics of sugar effluents

S. NO	***Parameters***	***Values***
1	***Ph***	***6.3***
2	***COD***	***3095.21mg/l***
3	***Turbidity***	***234.2NTU***
4	***TDS***	***1280mg/l***
5	***Conductivity***	***15.23ms/cm***
6	***Chloride***	***1425.12mg/l***
7	***Color***	***Greenish Yellow***

3.2 Batch experimental setup and methodology

A batch EC reactor was designed and fabricated for the treatment of sugar effluents. The reactor was made up of acrylic material with a total working volume of 1.5L and with the dimensions of 15cmx10cmx10cm. The DC source of 30V and 0-2A was used as a power supply to the system. The EC units having a pair of six electrodes were connected in mono polar parallel system. Aluminum electrodes having dimensions of 10cmx5cmx0.1cm were immersed to a depth of 5cm in the reactor. The space between the electrodes was maintained at 1cm. A magnetic stirrer was used for mixing to form homogeneous solution at 250rpm. The schematic representation of the experimental EC set up is shown in the Fig.1

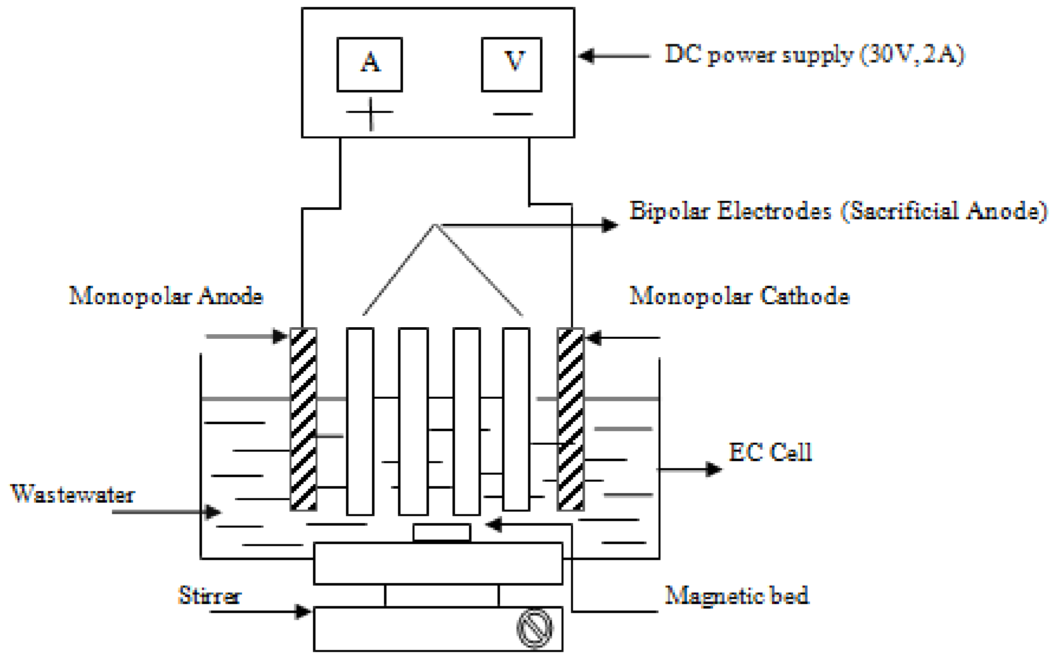

Fig: 3.1 Bench-scale EC reactor with Bipolar Electrodes in parallel connection

After the initial characterization of sugar effluents, the batch EC experiments were conducted to optimize the various parameters such as pH, applied voltage and ET. During each run the voltage was varied to desired value of 10V, 15V, 20V and 25V; whereas pH of the solution was adjusted 5-7 by adding either dilute HCL or NaOH as per the requirement. Before EC experiments, the electrodes were abraded with sand paper to remove scale and were washed with 15-20% HCl followed by a detergent wash for the removal of impurities from the electrode surface. About 2g/L of boric acid was added as electrolyte during the process to increase the conductivity; and also it acted as buffer, so that there was no much change in pH. The EC experiments were performed with 1.5 L of effluent for 45 minutes; and in each run samples were collected at every 15 minutes interval for necessary analysis. All the samples were allowed to settle for one hour before the determination of Conductivity, Total Dissolve Solids and phosphate concentration of treated sugar effluent.

IV. RESULTS AND DISCUSSION

4.1Effect of ph and voltage on color removal

Initially the electrode coagulation process was adopted for the treatment of sugar industry waste water with six aluminum electrodes, three as anode and other three as cathode, connected to the DC power supply. The experiments were conducted at lower voltages but desired efficiencies were not obtained. Hence, the treatment process was carried out for 75mins without adjusting the pH of raw waste water at higher voltages varying between 10, 15, 20 and 25V. The color analysis of the samples was carried out by retrieving sample at every 15mins interval. The Color removal efficiencies obtained were 7%, 15%, 16.25% and 25.35% for 10V,15V, 20V and 25V respectively. The results are represented in the fig 2.1. The removal of cod at different voltage 10V, 15V, 20V and 25V and the efficiency respectively are the 75%, 81%,89 % and 90%.

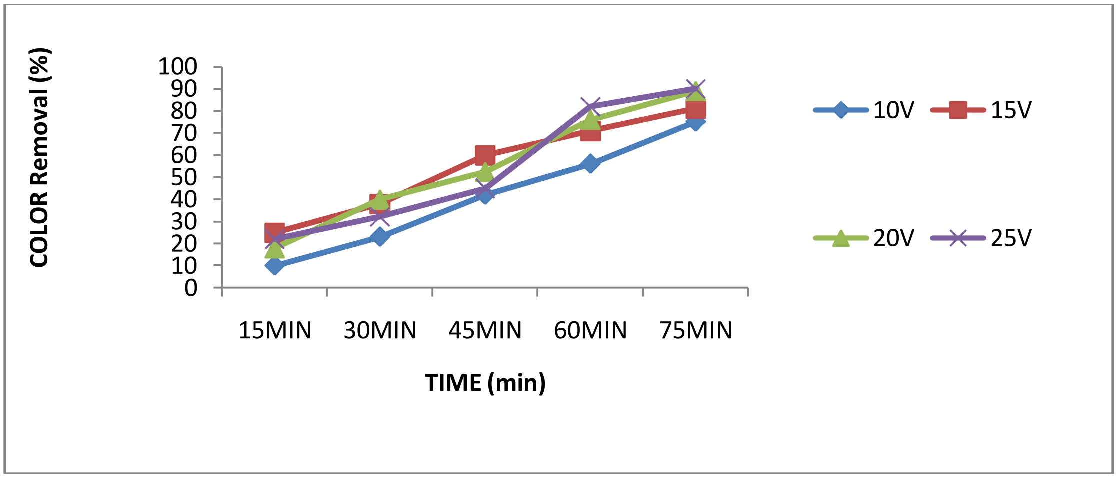

Fig:- 4.1(A) Color removal with Time at different voltages for pH 6.0

The Color removal efficiencies obtained during above mentioned operating conditions are too low to adopt for any practical operations. This may be due to lesser surface area of the electrodes available for the process to take place or because of higher Color value (4.91) of the waste water. Hence further study was carried out using four electrodes in bipolar connection and also by reducing wastewater concentration to half its strength. Bipolar connection was adopted because of its ease of maintenance during the operation of process. Fig2.2

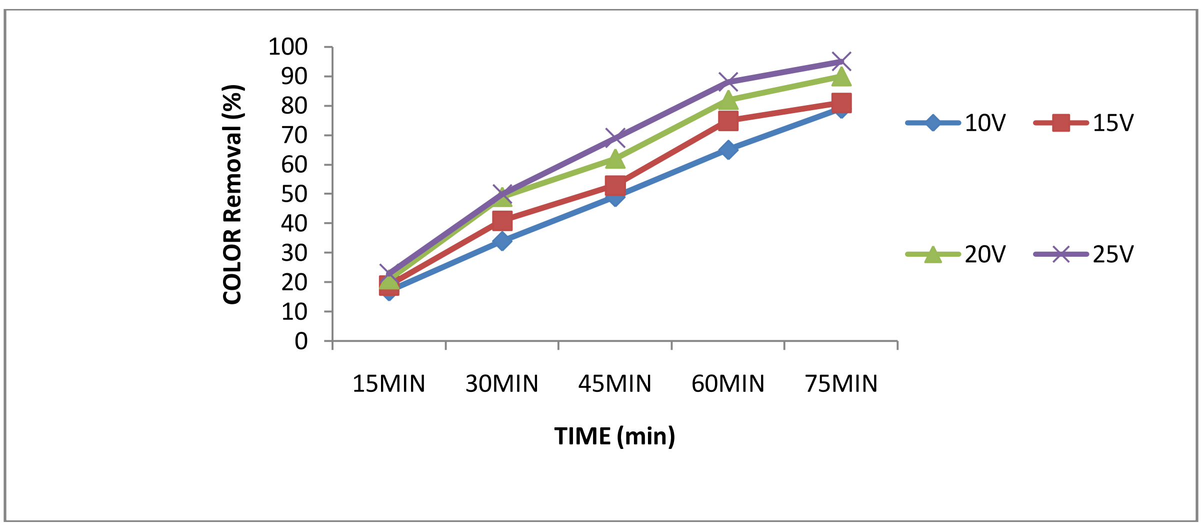

Fig 4.1 (B) COLOR removal with electrolysis time for different voltages at pH 7.0

When experiment was carried out by further increasing the pH to 7.0 with different voltages 10V,15V,20Vand 25V, the COLOR removal efficiencies were found to be 79%,81%, 90 and 95% COLOR from wastewater respectively for 60mins of electrolysis duration and remained constant for 75mins. Fig2.3.

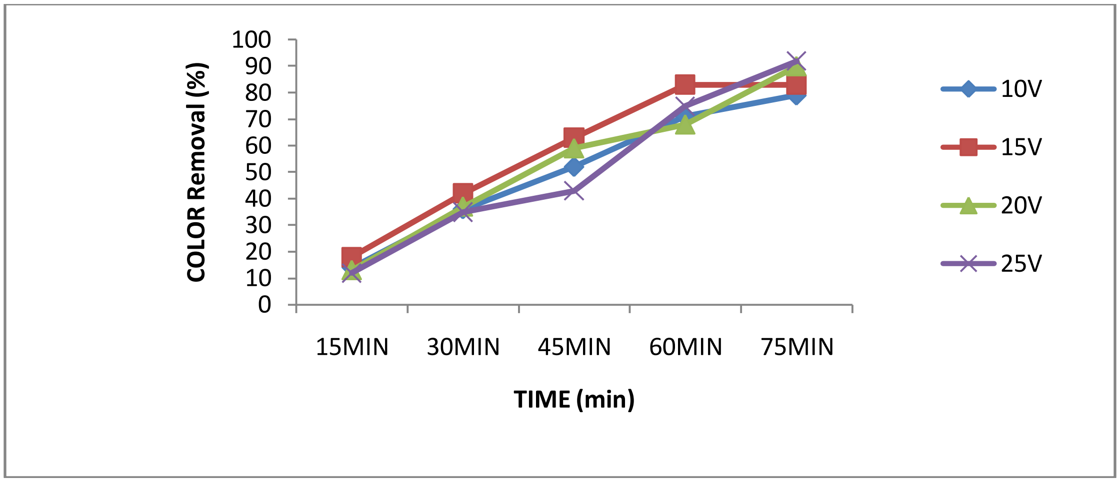

Fig 4.1 (C)COLOR removal with electrolysis time for different voltages at pH 8.0

The results in the above graphs showed that removal efficiency 79%, 83%, 90% and 92% are with respect to voltages 10V, 15V, 20V and 25V increased with increase in applied voltage up to electrolysis time of 60mins. Also during the process it was observed that the density of bubbles increases and their size decreases with an increase in applied voltage resulting in greater and faster removal of pollutants it may be also due to the fact that greater amount of hydroxide flocs were produced by increasing the applied voltage leading to an efficient Color removal. The graphs also indicated an increase in the color removal with the increase in the electrolysis duration. Increase in the electrolysis duration in the electrocoagulation process gives rise to a higher concentration of free ions inside the system, consequently increasing the removal efficiency. Increase in the pH value did not increase the removal efficiency but maximum efficiency 95% was obtained at pH 7.0. Thus for the COD removal of sugar industry wastewater the optimum operating parameters were found to be 7.0 pH, 25V and 50mins of electrolysis time

4.2 EFFECT OF pH AND VOLTAGE ON TOTAL DISOLVED SOLID (TDS) REMOVAL

The turbidity removal efficiencies of the electrocoagulation process on the sugar industry wastewater were studied by varying pH(6,7 and 8), voltage (10V, 15V, 20Vand 25V) and electrolysis duration (75mins). Turbidity results were checked at every 15mins of electrolysis time.

Initially, the experiment was carried out at pH 6.0 with different voltages 10V, 15V, 20V and 25V. The turbidity reduced 80%, 92%, 91% and 94% efficient in removing turbidity from wastewater respectively for 60mins. The TDS removal efficiencies remained constant for electrolysis duration of 75mins.Fig.

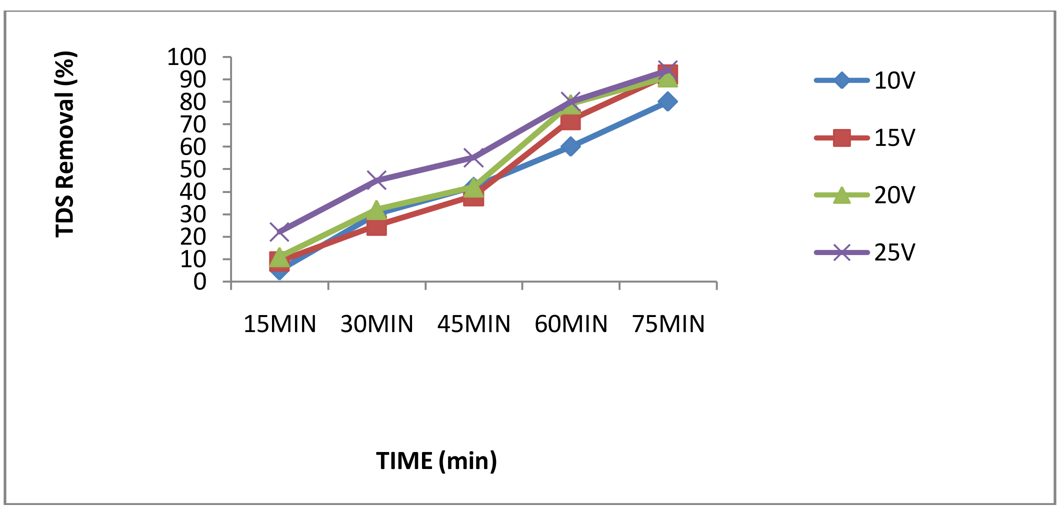

Fig 4.2 (A) TDS removal with electrolysis time for different voltages at pH 6.0

Later, EC experiment was carried about by adjusting pH to 7.0 with different voltages of 10, 15, 20V and 25V. The turbidity reduced 80%, 86%, 90%and 94% efficient in removing turbidity from wastewater respectively for 60mins of duration (Fig 1.8). The results remained constant at 75mins.Fig .

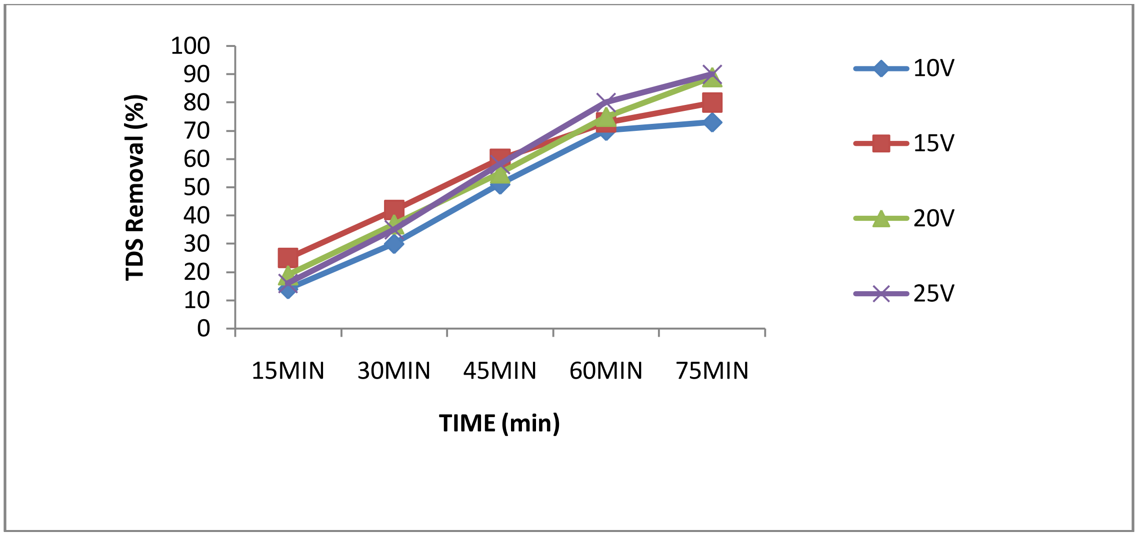

Fig 4.2(B) TDS removal with electrolysis time for different voltages at pH 7.0

When experiment was carried out at pH 7.0 with different voltages 10V, 15V, 20V and 25V, the Tds removal efficiencies were found to be 73%, 80%,89% and 90% for 60mins of electrolysis duration. The results are represented in Fig

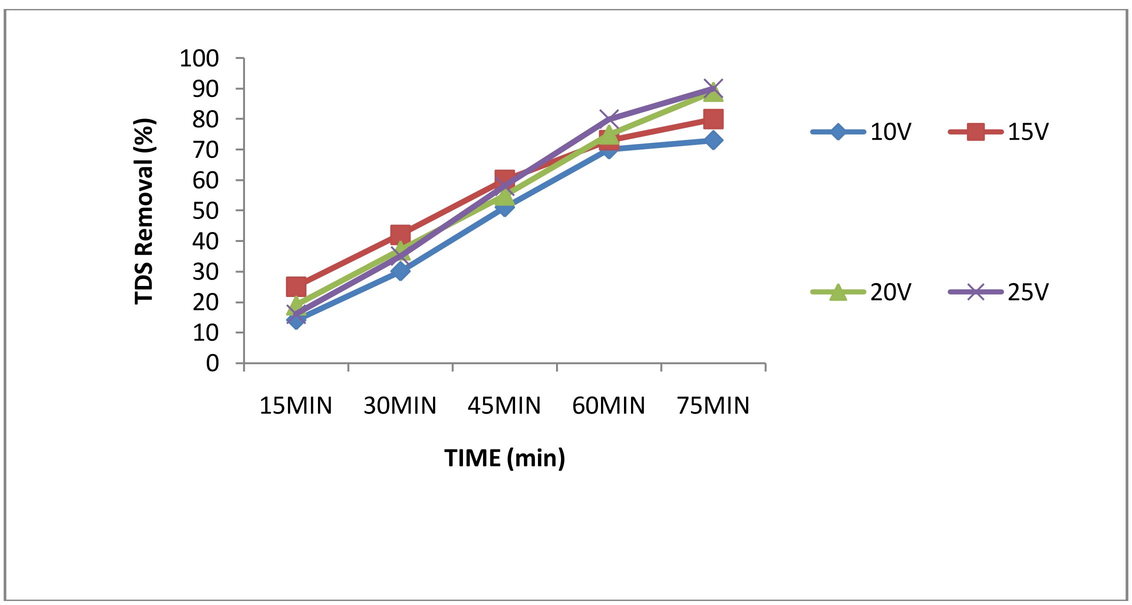

Fig 4.2 (C) TDS removal with electrolysis time for different voltages at pH 8.0

The studies indicate that, the turbidity removal was dependent on the applied voltage. As the voltage values increased there was increase in the removal of turbidity. At different pH, there was not much difference in the turbidity removal. The maximum turbidity removal of 94% was observed at 25V and 50mins for pH 7.0 because with increase in time and voltage the hydroxyl ion generation also increased. The suspended solids, colloidal matter present in the solution were observed by the ions and were settled at the bottom, hence removing the turbidity of the solution.

V. CONCLUSIONS

Based on the experimental findings, the electrolysis duration of 1 hours, pH 7.0 and 25V were found to be the critical operating parameters for the treatment of wastewater using iron as electrode material. Maximum Color removal of 95% and total dissolved solid (TDS) removal of 94% were obtained at these optimum operating conditions. Hence, it can be concluded that the electrocoagulation technology using aluminum 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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