

# Undigested Distillery Spentwash Treatment by Electrocoagulation process Using Al-Al and Fe-Fe Electrodes

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**Abstract**— Electrocoagulation (EC) of undigested distillery spentwash with high color removal efficiency and COD was investigated using a set of aluminium and iron electrodes. The distillery spentwash was characterized for various parameters as per standard method of analysis. The effect of operating variables such as voltage (V), electrode distance (cm), and electrolysis time (minute) on removal efficiency of color and chemical oxygen demand (COD) were studied. At a voltage of 20V, electrode distance of 3 cm and constant pH 7, the highest color removal of 87% and COD removal efficiency of 88 % were obtained with Fe-Fe and Al-Al electrodes respectively for 150 minutes of electrolysis time. The process proved the ability to effectively remove the COD and Color content which when high in industrial wastewater can lead to serious impacts on the environment.

**Index Terms**— Aluminium, Chemical Oxygen Demand, Decolorization, Distillery Spent wash, Electrocoagulation.

## I. INTRODUCTION

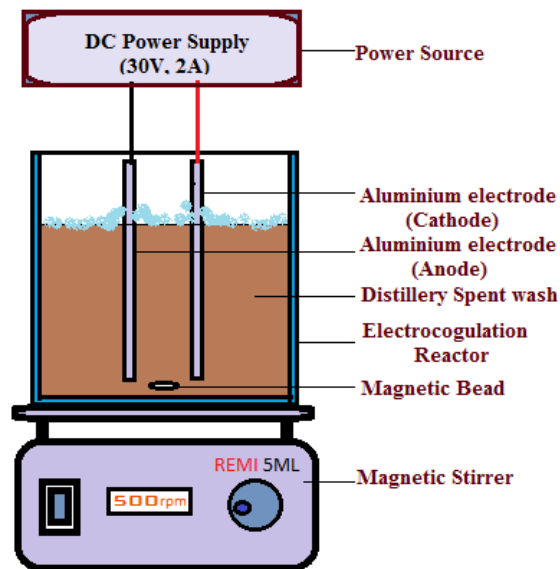
Distillery industry is one of oldest industries which is highly complex, high BOD, COD, Total solids, odor and color. Untreated Distillery wastewater when discharged directly into the water bodies or onto the open land causes irreversible damage to environment. Spent wash is one of the most pollutant fluid produced by distilleries both in terms of magnitude and strength [1]. For every liter of alcohol produced, molasses-based distilleries generates 8-15 L of wastewater characterized by high Chemical Oxygen Demand (COD), high Biological Oxygen Demand (BOD), and high recalcitrant organics with dark brown color. Most of these organics are known to persist in nature [2]. The presence of melanoidin that are having complex structure and toxic polymers result in recalcitrant nature, which are formed by amine-carbonyl reaction [3]. De-contamination is based on the following effect. There exist a numerous technical papers on wastewater treatment depending upon the type and strength of wastewater. Electrocoagulation is one of the most significant electrochemical treatment utilized in modern wastewater treatment to diminish suspended and colloidal materials, Color, COD in wastewater.

## II. DISTILLERY SPENT WASH

In this study, distillery spent wash was collected from the Indian Cane Power LTD, Duggavathi, Davangere. It was subjected to treatability studies using electrocoagulation reactor. Wastewater was analyzed for various parameters viz, pH, suspended solids, COD, BOD, and chlorides. The characteristics are shown in Table 1. It can be seen that the solids concentration is very high, and the COD and BOD values varied in the range 110000-138000 mg /L and 55000-68500 mg/ L respectively. Which indicates that the wastewater contains high amount of organics. Which suggests that there is a presence of recalcitrant nature of organics in the wastewater [4].

## III. ELECTROCOAGULATION REACTOR SETUP

Electrocoagulation experiments were conducted in a Borosil-glass laboratory scale batch reactor having dimension of 15 × 9 × 18 cm with a working volume of 1.5 L and maximum volume of 2 L was used. The aluminum plate of size 5.5 cm x 11 cm was used as both anode and cathode electrode in a monopolar connection. The electrodes were placed at a varying distance of 3 cm apart by the head plate of the reactor. The experimental setup is shown in Figure.1. A direct current power supply unit (APLAB LD3202, 0–2 A, and 0–32 V) was used for power supply. The reactor was operated under completely mixed condition facilitated by a magnetic stirrer at a constant speed of 500 rpm to avoid concentration gradients. The samples were collected at regular time intervals of 30minutes which as then allowed to settle for a duration 30minutes and the samples then collected were analyzed for various parameters. All the analytical procedures adopted were according to the standard methods for examination of water and wastewater [5]. The experiments were conducted to study the effect of the three operating conditions viz., voltage (V), electrode distance (cm) and electrolysis time (minute).



**Figure 1** Schematic view of experimental setup

**Table 1** Characteristics of distillery wastewater

Sl No.	Parameter	Unit	Values
1	pH	-	3.0-4.5
2	TDS	mg/L	90,000-150,000
3	Turbidity	NTU	2,470
4	Conductivity	$\mu\text{s/cm}$	39,000
5	TSS	mg/L	13,000-15,000
6	SS	mg/L	3500-5200
7	Chlorides	mg/L	8000-8500
8	Total Alkalinity	mg/L	1200-1800
9	Total Hardness	mg/L	1000-1400
10	BOD <sub>5</sub>	mg/L	55000-68500
11	COD	mg/L	110,000-138,000

#### IV. ELECTROCOAGULATION EXPERIMENTS

The electrocoagulation studies were conducted by neutralizing wastewater sample to pH 7 of the undigested distillery wastewater to find the optimum electrolysis duration at which maximum COD removal takes place. At the optimum electrolysis duration, further experimental runs were conducted at electrode distance of 3, 4, and 5cm. The optimum electrode distance, which resulted in maximum COD removal, was fixed up for further experiments with varying voltage. Thus, all the experimental conditions such as electrolysis time, electrode distance, and voltage were optimized on the basis of maximum percent COD and Color removal efficiency.

#### RESULTS AND DISCUSSION

Experiments were performed to study the electrocoagulation process for the treatment of distillery spent wash. The effect of the various parameters on the electrocoagulation process were investigated and the results obtained are discussed below.

##### Effect of voltage

Experiments were performed at different voltage of 10, 15 and 20volts to study the effect of voltage on Color and COD removal. The experiments were conducted for 150 minutes keeping constant agitation speed (500 rpm) and the effluent pH 7 at a varying electrode distance (3 to 5cm) and the results are shown in **Figure. 1(a)**. It can be noticed that the maximum COD removal efficiency Al-Al 87.94% and Fe-Fe 82.39 % was obtained at an applied voltage of 20volts for Al-Al and Fe-Fe combination of electrodes respectively. The COD removal efficiency was found to increase with an increase in the voltage. This is due to the fact that with an increase in the voltage, the anode dissolution increases due to the Faradays law. Further, with an increase in the voltage, there is an increase in the potential needed for the production of chlorine/hypochlorite leading to increased generation of chlorine/hypochlorite at higher current densities [6]

##### Effect of electrode distance

The experiments were performed to study the effect of inter-electrode distance on the COD removal efficiency of the spent wash by varying the distance (3, 4 and 5cm) between the electrodes and the results are shown in **Figure. 2**. The COD removal efficiency was found to decrease with an increase in the electrode spacing from 3 cm to 4 cm for both combinations of electrodes.

The increase in COD removal efficiency was more in the case of Al-Al electrodes in comparison with Fe-Fe electrodes. But on further increase in distance between the electrodes from 4 cm to 5 cm, a significant reduction in COD removal efficiency was noticed for Fe-Fe electrodes. There was significant change in the COD removal efficiency for Al-Al and Fe-Fe with an increase in electrode distance from 4 cm to 5 cm. This may be due to the electrostatic attraction between the ions generated from the electrodes. When the distance between the electrodes is low (3 cm), the attraction between the generated ions is more, resulting in the high movement of the ions. The generated ions continuously keep on colliding due to availability of less space and preventing the formation of flocs required to coagulate the organic content. On further increasing the distance between the electrodes (5 cm), the resistance between the electrodes increases and the generation of ions decreases for a constant voltage. The movement of ions becomes slower and the ions get sufficient time and space to form flocs required for settling of the organic matter. The coagulation of the organic matter will keep on increasing with an increase in the electrode distance till an optimum distance between the electrodes is reached. On further increasing the distance between the electrodes beyond the optimum value, the amount of anode dissolution decreases and the ions have to travel a longer distance for interaction to form the flocs [5]. This will reduce the formation of flocs leading to a reduction in the COD removal efficiency of the spent wash. The optimum distance between the electrodes was found to be 3 cm. and further experiments were performed keeping the inter-electrode distance of 3 cm.

#### Effect of electrolysis time

Electrolysis time is an important parameter as it influences the treatment efficiency of the electrochemical process. Experiments were performed to study the effect of electrolysis duration on the removal efficiency. It can be noticed that with an increase in the electrolysis time, there is an increase in COD removal efficiency of the spent wash for all the electrodes. The COD removal efficiency depends directly on the concentration of hydroxyl and metal ions generated on the electrodes and the electrolysis time determines the generation rate of  $Al^{3+}$  and  $Fe^{2+}$  ions from electrodes. An increase in the electrolysis duration leads to more generation of the ions resulting in the higher COD removal efficiency of the spent wash.

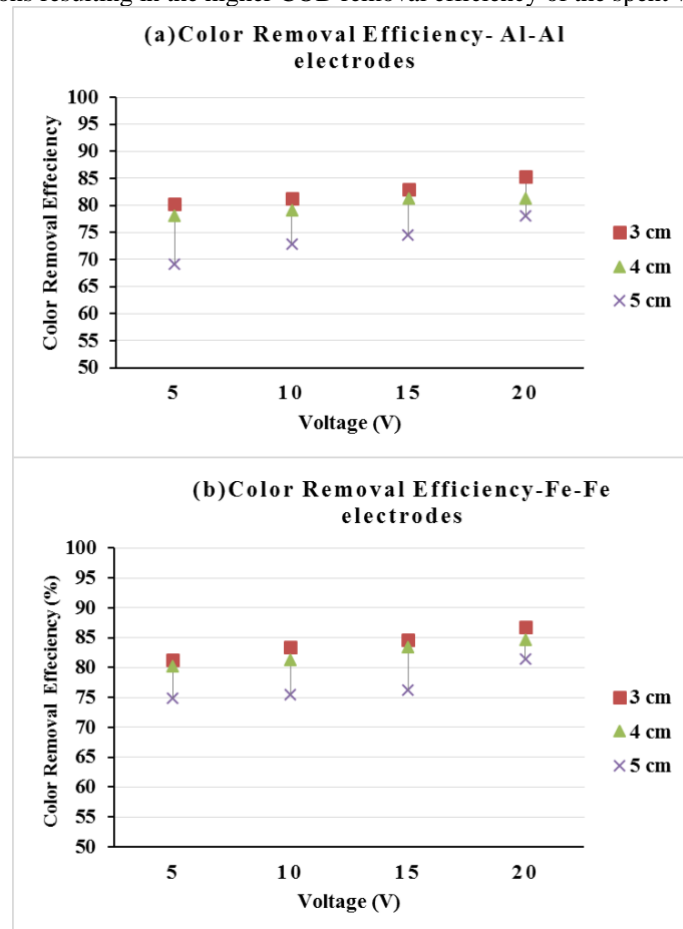
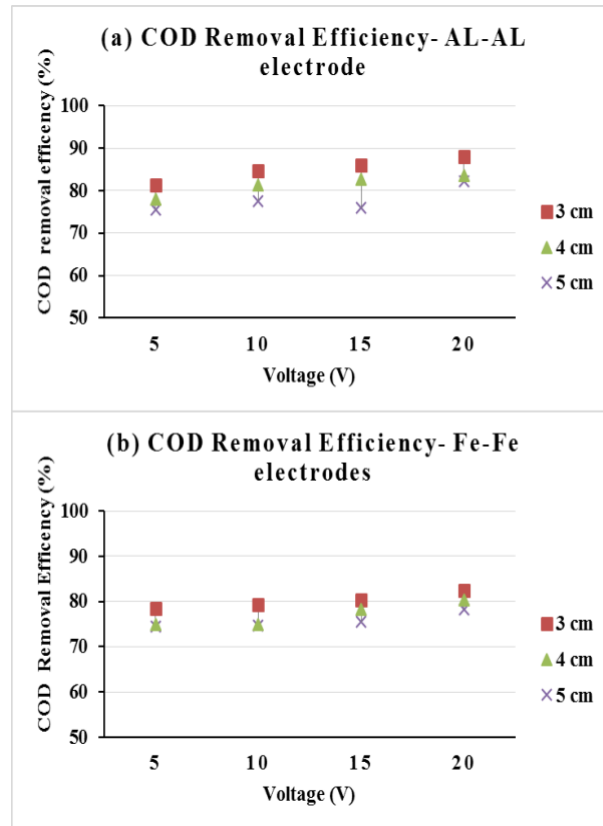


Figure 1 (a) & (b) : Effect of voltage on the Color removal efficiency (pH 7, electrode spacing 3 cm, 4cm & 5cm agitation speed 500rpm, and electrolysis time 150 minutes)

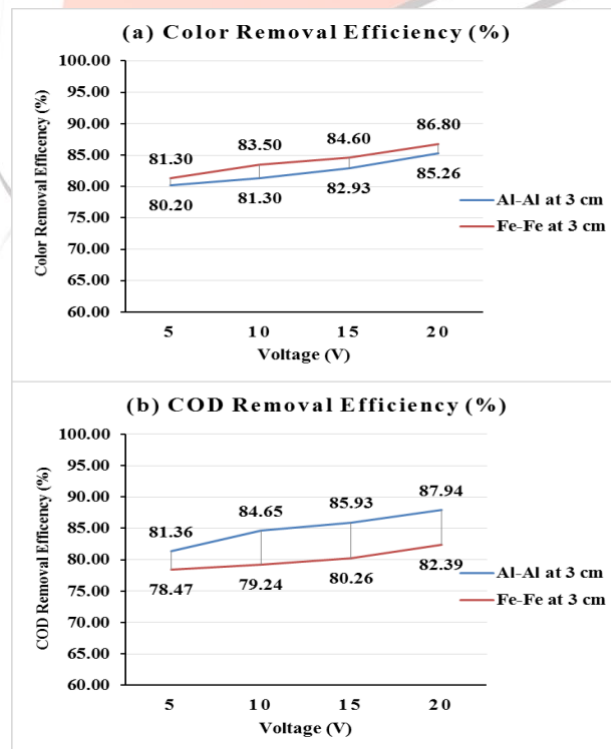


**Figure 2 (a) & (b) : Effect of voltage on the COD removal efficiency** (pH 7, electrode spacing 3 cm, 4cm & 5cm agitation speed 500rpm, and electrolysis time 150 minutes)

**Comparison of the electrodes**

It can be noticed that the COD removal efficiency of Al-Al electrodes is higher as compared to the Fe-Fe electrodes. The Fe (II) ions generated during the EC process from iron electrodes has high solubility at acidic conditions and are easily oxidized into Fe (III) [8-12]. Since Fe (III) is difficult to settle, it leads to the decrease in COD removal efficiency for iron electrodes.

Whereas the Color removal efficiency of Fe-Fe electrodes is higher as compared to the Al-Al electrodes from the experimental analysis.



**Figure 3 (a) (b): Comparison of Al-Al and Fe-Fe electrodes on Color & COD Removal efficiency (%)**

## V. CONCLUSION

Electrocoagulation is one amongst the most significant electrochemical treatments employed for the treatment of distillery spentwash for color, and COD removal present in the distillery spent wash. The operating parameters such as voltage, electrode distance and electrolysis time, were varied to determine optimum treatment conditions. Samples were retrieved at regular intervals and were analysed for color and COD. The sludge formation and weight of electrode dissolution were recorded after each set of experimentation. The optimum conditions for the maximum COD and Color removal from the spent wash employing aluminium and iron electrodes were found to be, voltage 20V and an electrolysis time of 150min with a distance of 3 cm along with an agitation speed of 500rpm. Electrocoagulation process adopted for the present study was found to be very effective since the chemicals utilized for the experimentation part were cost effective and are easily available too. The process can be completed within a short duration of time. The overall analysis employing Electrocoagulation was found to be effective as well as economical.

## VI. ACKNOWLEDGMENT

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