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Electrocoagulation Treatment for Removal of Color and Chemical Oxygen Demand in Landfill Leachate using Aluminum Electrode

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Abstract*: The present research work mainly deals with the removal percentage of Color and Chemical Oxygen Demand (COD) on landfill leachate by using electrocoagulation (EC) process. An EC process was carried out with an aluminium electrode and it act as both anode and cathode. The study mainly targets the factors affecting on electrode material, electrolysis time, initial pH, applied voltage, inter-electrode distance. The experimental result reveals that there was raise in BOD/COD ratio from 0.11 to 0.66 and the maximum percentage removal achieved were COD and Color 78.4% and 77.0% respectively. The optimum inter-electrode distance 1cm with electrode surface area 35 cm2 and optimum electrolysis time of 90 min at optimum applied voltage 10V, stirring speed 250 rpm and pH is 9.3. These results showed that the EC process is appropriate and well-organized approach for the landfill leachate treatment.

Keywords* : Landfill leachate; Electrocoagulation; Aluminium electrode and Process parameters.

I. INTRODUCTION

Leachate is produced from rain water percolation through waste and decomposition of waste. A serious environmental problem can occur from landfill leachate discharge and it includes heavy metals, biodegradable/non-biodegradable carbon, organic/inorganic salt and recalcitrant. Many factors that influence the leachate quality, i.e., landfill age, seasonal weather, precipitation, type of waste, and composition.

The leachate composition mainly depends on the age of landfill. As the landfill age increases, COD and other organic concentrations are decreased, and ammonia nitrogen concentrations increased. Naturally, the landfill leachates are in the form of liquid and strongly odour, the physical appearance of leachates are orange or yellow cloudy liquid and offensive smell due to the presence of nitrogen, hydrogen, and sulphur rich organic species.

The landfill leachate has some basic parameters such as pH, suspended solids, biochemical oxygen demand (BOD), chemical oxygen demand (COD), ratio of BOD/COD and ammonia nitrogen etc. Stabilized leachate will be formed due to recirculation of leachate, which results degradable of carbon compounds but a higher concentration of ammonia, it improves COD and BOD and it will be eliminated. The

classification and characterization of landfill leachate based on age are depicted in Table 1. Based on the literature survey, some of the treatment methods such as coagulation-flocculation [1], membrane processes [2-3] activated carbon adsorption [4]. combined physicochemical-nanofiltration [5]. biological treatment [6]. have been reported in the literature. Electrocoagulation (EC) process treating various types of wastewater, for example electroplating wastewater [7], Distillery wastewater [8] [9], Dairy wastewater [10]. The main importance of research work is to optimize the parameters like initial pH, electrolysis time, current density, inter-electrode distance on the landfill leachate treatment using EC process with aluminum electrodes.

Table 1 Landfill leachate classification of landfill age

Parameters	Leachate Type		
Landfill age (Years)	<5 Young	5-10 (Medium)	>10 (old)
BOD_5/COD	>0.5	0.1-0.5	<0.1
pH	<6.5	6.5-7.5	>7.5
COD (mg/l)	>10,000	<10,000	<5,000

II. EXPERIMENTATION

A. Study Area

Mysore city is located at 12.30°N 76.65°E by having an average altitude of 770 meters. Dumpsite situated vidyaranyapuram and 8 km away from the Mysore city.

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Fig 1 Landfill leachate collection tank

Especially this site is used for dumping garbage from past 6-7 years, which has gathered waste of about 2,50,000 cubic meters, and dumping area is occupying 41.47 acres to accumulate wastages.

The present study attempts to treat landfill leachate using Electrocoagulation process. The sample Landfill leachate was collected from the tank in which the leachate is coming from the pipes, as shown in Fig 1, and it was analyzed for various physical, chemical parameters. The initial characterization of the sample has been given in Table 2.

Table 2 Initial characterization of the landfill leachate Parameters

Sl. No.	Parameters	Concentration
1	pH	8.67
2	Conductivity	38.5 mS/cm
3	Turbidity	140NTU
4	Total solids	15800(mgL^{-1})
5	Total Dissolved Solids	14240(mgL^{-1})
6	COD	13760(mgL^{-1})
7	Phosphate	198.5(mgL^{-1})
8	Total suspended solids	1560(mgL^{-1})
9	Nitrates	95.5(mgL^{-1})
10	BOD	1503(mgL^{-1})
11	Chloride	6098(mgL^{-1})
12	BOD/COD	0.109 (mgL^{-1})
13	Color	8750 PCU

B. Experimental Setup for Electrocoagulation

Experiments are performed in a plexi-glass laboratory scale, Batch electrochemical reactor (11cm x14cm x13cm) of 2L capacity with the working volume 1.75L at room temperature. The reactor content was kept under complete mixed condition facilitated using a magnetic stirrer speed 250rpm to avoid concentration gradients. The T shaped electrode materials such as aluminum plates of size 5cm x 7cm are used in a monopolar arrangement as anode and cathode having 35 cm^2 effective surface area. For easy stirring, 2cm gap was kept between the bottoms of the electrodes. The analytical details were depicted in Table 3.

Table 3 Analytical Details

Parameters	Analytical technique/Method	Instruments/Equipment's Used, Make
pH	Digital pH meter	-------
BOD	27^o C, 3 days incubation/ Titrimetric/ Modified Winkler's method	
COD	COD digester (Open reflux system)/Titrimetric	Hach 389, USA
Color	Platinum-cobalt method	------
Solids	Gravimetry	Hot air oven
Chlorides	Argentometric method	Standard method
Conductivity	Conductivity meter	-----
Sulphate	Spectrophotometric method	UV spectrophotometer
Nitrate	Phenoloic disulphonic Acid Method	UV spectrophotometer
Phosphate	Ammonium Vandate/Molybdate	UV Spectrophotometer
DC Power Supply Unit	0-10 A, 0-15 V, DC power supply unit	APLAB, Regulated dual DC power supply LD3210.

Before each treatment, the electrodes were cleaned and degreased. Experimental run conditions were maintained using DC power supply; the distance was varied from 1cm - 4cm by maintaining 4V. The total electrolysis duration was 180 min during electrolysis; samples were drawn at regular intervals of 15 min. Experiments were conducted by varying the effect of operating parameters like inter-electrode distance, electrolysis duration, voltage (current density). Electrocoagulation experimental setup is shown in Fig 2.

Fig 2 Experimental set up of electrocoagulation treatment in a lab scale

III. RESULT AND DISCUSSION

A. Effect of inter electrode distance on landfill leachate treatment by EC:

From Fig 3 (a-b) it is observed that the electrolysis time increases with an increase in the removal of COD and Color, respectively. Experiments are conducted with different inter-electrode distance, such as 1cm, 2cm, 3cm, and 4cm. The better performance obtained with 1cm inter-electrode distance. From that condition, the percentage removal of COD and Color 60.50% and 47.50% respectively is achieved.

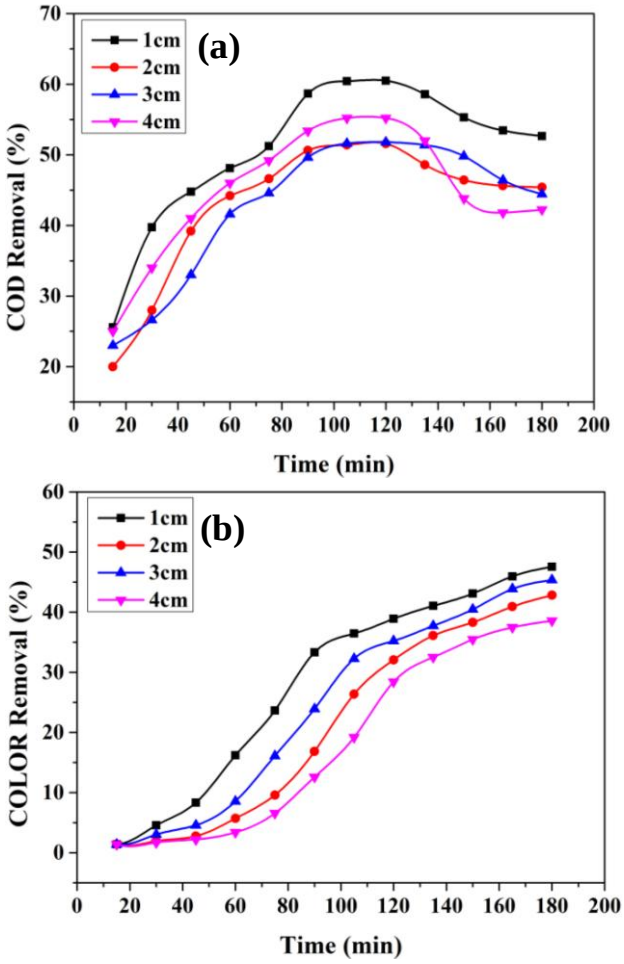

Fig 3 (a-b) Percentage removal of COD and Color with different distance

This is due to the shortest distance facilitates the higher removal efficiency; the similar results obtained by [11]. Some of the researchers reported as increased inter-electrode distance leads to higher power consumption and increased operating cost. The proper placement of electrode distance, which affects the current density. If the electrode distance is too close, the flow of fluid and solids are clogged that cause higher electrical resistance.

B. Effect of applied voltage on leachate treatment by EC Applied:

From Fig 4 (a-b) is noticed that the electrolysis time increases with an increase in the removal of COD and Color. EC experiments have been carried out at 4V, 6V, 8V, 10V, and 12V. From the experimental analysis, 10V exhibits higher removal efficiency and the percentage removal of COD obtained 78.48%. Color removal was achieved 77.09%. For 90min, indicating that increase the destabilization of a colloidal particle with an increase in electrolysis duration. The reaction between generated chlorine/hypochlorite that results in decolorization.

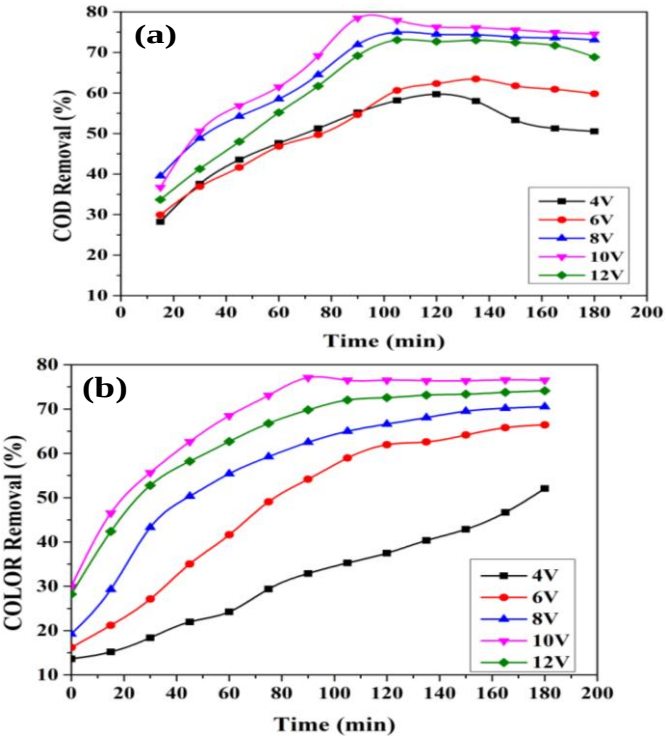

Fig 4 (a-b) Percentage removal of COD and Color with different voltage

Treatment efficiency also increased by increasing the current density and also which influence the higher rate of bubble generation and dosage of coagulant [12]. Operating voltage was not raised beyond 12V due to faster dissolution.

C. Effect of pH changes during an electrocoagulation process:

The pH value is strongly dependent on the electrocoagulation technique and initially, the pH value of leachate 8.67. The electrolysis time increases, pH also increases.

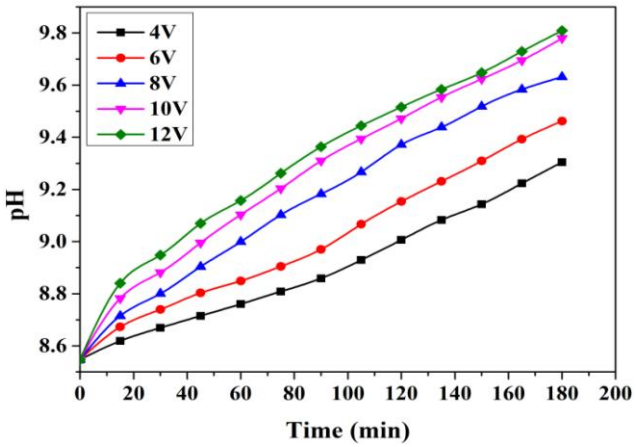

Fig 5 Effect of pH versus electrolysis time

From the experimental work, the better performance is observed at 90min of electrolysis time, and pH value shows 9.3 at 10V, as shown in Fig 5. pH of the leachate solution is evident in the alkaline range a slimy layer of floating contaminants is removed easily at the top, which leads to maximum removal of Color and COD.

The pH progressively increased due to foremost activities of the cathode and pH of leachate solution is expected to be high after electrocoagulation treatment [13]. Some researchers found that COD removal is not much impact on the variation of pH. The alkaline condition is more effective for the treatment of landfill leachate wastewater [14]. Decolorization of leachate is very low at acidic pH condition and very high at neutral and alkaline pH condition.

D. Effect of BOD/COD ratio changes during the EC process:

From Fig 6, it is observed that there was a development in biodegradability of landfill leachate with an increase in the ratio of BOD/COD from 0.11 to 0.66. This is due to increasing voltage. Under different voltage, the other operating condition was altered, and the performance of the reactor also affected. The low BOD/COD ratio (0.11) in the effluent indicates that it contains recalcitrant substances which were not easily biodegradable or non- biodegradable material present in leachate.

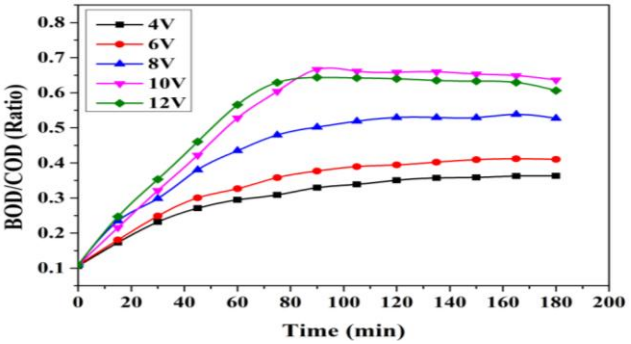

Fig 6 Effect of BOD/COD ratio vs. electrolysis duration

IV. CONCLUSIONS

The present study shows that the performance of electrocoagulation is an efficient process for treating landfill leachate. Aluminum electrodes were used for performing electrocoagulation. To optimize the process parameters such as electrolysis time, inter-electrode distance, applied voltage, and effect of initial pH. From that experimental work, some of the conclusions are drawn.

The maximum removal achieved was COD and Color, 60.50% and 47.50% respectively, at the shortest inter-electrode distance of 1cm.

The higher removal efficiency was obtained COD and Color, 78.48% and 77.09% respectively, at the optimum inter-electrode distance 1cm, optimum electrolysis time of 90 min. At optimum applied voltage 10V, stirring speed 250 rpm and pH 9.30. .

The electrocoagulation process is more effective for removal of Color and COD, BOD/COD ratio raises from 0.11 to 0.66.

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