Treatability Study of Leachate by Electrocoagulation - Iron Electrode

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Abstract— Disposal of solid waste through landfill generates landfill leachate. It leads to sever environmental harmful and health effects. Treatment of Sanitary landfill leachate is considered as one of the most significant environmental issues. This paper has been investigated Electrocoagulation treatment process using Iron electrode for sanitary landfill leachate in terms of efficiency and economical beneficial. The effects of process variables like pH, applied cell voltage, operating time are on COD and NH3-N removal efficiencies. This process was carried out in a batch reactor of 1 litter capacity and samples of 0.5 l were taken out for analysis at 15, 30, 45 minutes of operation and at 3, 6, 9V . Results obtained from the experiments showed that COD and NH3-N removal efficiency 45.79% and 43.21% for 9V, 30 minutes of operation.

Key words: Leachate, Electrocoagulation, Electrodes

I. Introduction

India currently is facing a municipal solid waste dilemma, for which all elements of the society are responsible. In spite of a stringent legislation in place, open dumping is the most wide spread form of waste disposal. The possible reasons for poor implementation could be a combination of social, technical, institutional and financial issues. With the rapid industrialization and population growth, the status of our environment is degrading day by day. According to Ministry of Urban Affairs, Govt. of India estimate, India is generating approximately 100,000 metric tons of solid waste everyday of which 90 % is dumped in the open place[14].

Leachate is one of the major pollution problems caused by the MSW landfill, which is generated as a consequence of precipitation, surface run-off and infiltration or intrusion of groundwater percolating through a landfill. Landfill leachate is generated by excess rainwater percolating through the waste layers in a landfill. Generally, leachate may contain large amounts of organic matter (biodegradable, but also refractory to biodegradation), as well as ammonia-nitrogen, heavy metals, chlorinated organic and inorganic salts, which are a great threat to the surrounding soil, groundwater and even surface water [2,17]. In order to reach environment-friendly criteria for landfill leachate, one must bring these values to an acceptable discharge limit [13].

The composition of landfill leachate, the amount generated and the extraction of potential pollutants from the waste depend upon several factors, including solid waste composition, degree of compaction, absorptive capacity of the waste and waste age, seasonal weather variations, levels of precipitation, Landfill temperature, size, hydrogeological conditions in the vicinity of the landfill site, engineering and operational factors of the landfill, pH, landfill chemical and biological activities. [3, 6, 11, 16]Three main groups of landfills are classified as young (less than five years), intermediate (5-10 years), and old or stabilized (more than 10 years).

Landfill leachate treated by various methods like [5, 13, 15, 19]

– Biological (aerobic and anaerobic),
– Membrane process,
– Advanced oxidation process,
– Coagulation-flocculation,
– Adsorption methods
– Lagoons and wetlands application
– Electrocoagulation

II. Electrocoagulation

A. *Why Electrocoagulation?*

Electrocoagulation process shows several benefits in terms of costs and safety. It is well known for its simplicity, efficiency, environmental compatibility, flexibility and cost effectiveness.

B. *What is Electrocoagulation?*

Electrocoagulation is the process where an electrical current is introduced into an aqueous medium in an electrochemical cell, usually with an electrode. Different types of electrode used in this process like Aluminium, Iron, Graphite, Stainless still whichever Aluminium and Iron electrodes gives best reduction in leachate treatment and easily available in market.

C. Mechanism of Electrocoagulation Process:

In mechanism of Electrocoagulation, an anode material undergoes oxidation and hence, formed various monomeric and polymeric metal hydrolysed species. This metal hydroxide remove organics from wastewater by sweep coagulation and by aggregating with colloidal particles present in the wastewater to form bigger size flocks and removed by settling. Organics contained in wastewater are oxidized directly at the surface of the electrode or oxidizing agent is electrochemically generated to carry out oxidation in electro-oxidation process of wastewater treatment [7, 8, 10, 12].

In Electrocoagulation process, the destabilization mechanism of the contaminants, particulate suspension and breaking of emulsion may be summarized as follows;

1) Compression of the diffuse double layer around the charged species by the interactions of ions generated by oxidation of the sacrificial anode.
2) Charged neutralization of the ionic species present in leachate by counter ions produced by the electrochemical dissolution of the sacrificial anode. These counter ions reduced the electrostatic inter particle repulsion to the extent that the Van der Waals attraction predominates, thus causing coagulation. A zero net charge results in the process.
3) Flock formation: The flock formed as a result of electrocoagulation creates a sludge blanket that entraps and bridges colloidal particles that are still remaining in the aqueous medium.

The main aim of the work has been investigate the treatment of a landfill leachate by electrocoagulation techniques. The experimental work covers COD and NH_3-N removal performances under different electricity currents and durations for different applied voltage, formation of sludge, and variations in pH.

Parameters	Characteristics
Colour	Black
Odour	Unfavourable
pH	8.66
Temperature	37°C
TDS	7560 mg/L
COD	14986.66 mg/L
DO	Not available
Electric Conductivity	39.42 µS/cm
Turbidity	163.3 NTU
NH_3-N	485.5 mg/L

Table 1: The properties of untreated leachate

III. Materials and Methods

A. *Experimental Set Up:*

The experimental setup of electrocoagulation unit is shown in Fig.1. A 1000 ml glass beakerwas used as the reaction media for the leachate treatment. 0.5 litter leachate sample was used as the untreated influent into the reactor. The reactor was placed on a magnetic stirrer during each run to keep the mixture homogeneous. The reactor was operated in batch mode in each run. Two iron electrodes were used as both cathode and anode in order to treat leachate. Each electrode was 140 mm in height, 25 mm in width and 3 mm in thickness. The space between electrodes was maintained 4cm in all experiments. In each run voltage was varied to a desired value of 3, 6, 9V. Both electrodes were then connected to a direct current DC power supply (0-30 V, 0-5 A).

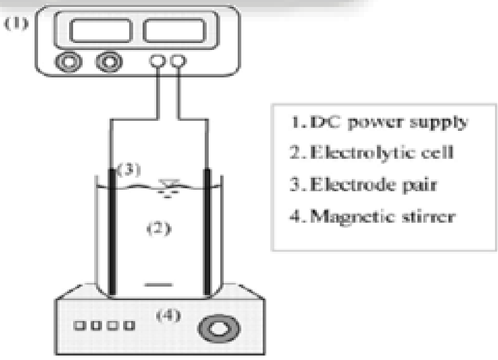

Fig. 1: Laboratory experimental set up

B. *Analytical Analysis and Methods:*

To investigate the raw leachate properties, real leachate sample were analyzed to evaluate its initial TS, TSS, VSS, BOD, COD, DO, turbidity, and pH. To evaluate the electrocoagulation treatment efficiency, COD, colour and turbidity of the treated effluent were immediately measured after the filtration of the reactor mixture through Whatman filter paper after each batch run. All the experimental analysis was made according to Standard Methods [4]. COD tests were performed as recommended in the open reflux method, and ammonia nitrogen tests using the titration method. All the runs were performed at room temperature.

IV. Results and Discussion

A. *Effect of Time on COD and NH_3-N Removal Efficiency:*

The effect of electrolysis time was investigated in the range 0 to 45 minutes by the following conditions: 8.08initial pH. Shown in Fig. an increase in the time from 0 to 45 minutes yield an increase in the efficiency of COD removal from 18.85 to 45.79% and the NH_3-N removal from 20.98 to 43.21% at 30 minute. After that time increases removal efficiencies are decreases. When the electrolysis time increases the concentration of iron ions and their hydroxide flocks increase, also the rate of bubble-generation increases. The pollutants in leachate were removed by the effect of coagulation and flotation.

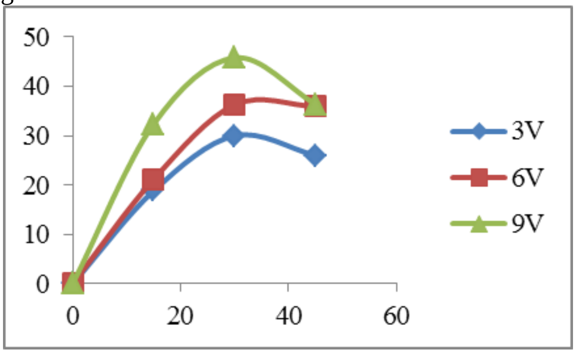

Fig. 2: Effect of Time on COD removal efficiency

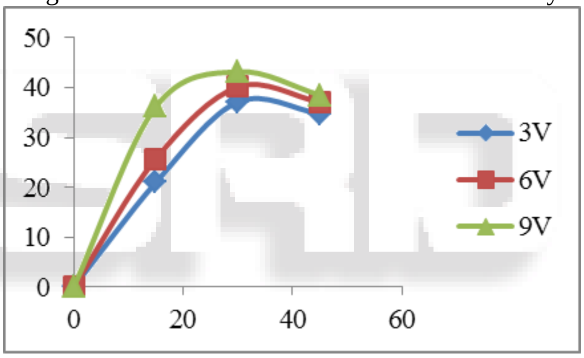

Fig. 3: Effect of Time on NH3-N removal efficiency

B. *Effect of Cell Voltage on COD and NH_3-N Removal Efficiency:*

In experimental studied that the removal efficiency of COD and NH_3-N varies at different cell voltage. When voltage increases removal efficiency also increases from 3V to 9V in these experiments, but after that increases voltage decreases removal efficiency. However the below figure showed that, maximum COD, NH_3-N removal of 45.79% and 43.21% are obtain at time of 30 minutes at cell voltage 9V.

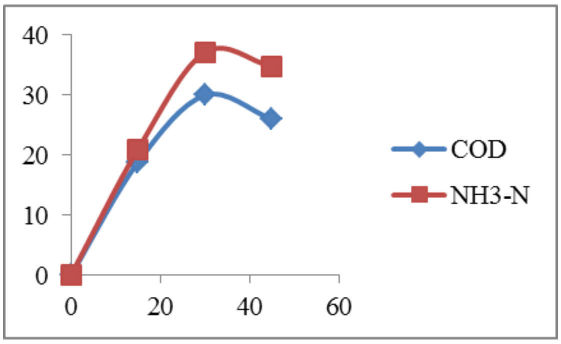

Fig. 4: Effect of applied voltage on COD and NH3-N removal efficiency (3V)

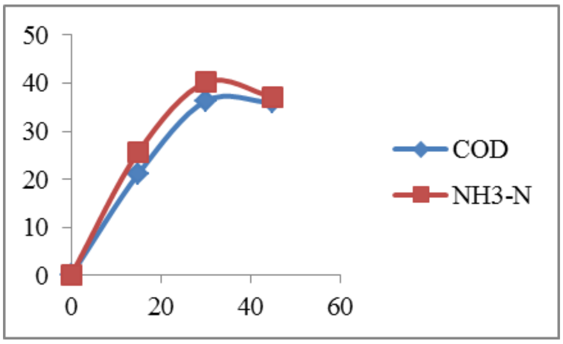

Fig. 5: Effect of applied voltage on COD and NH_3-N removal efficiency (6V)

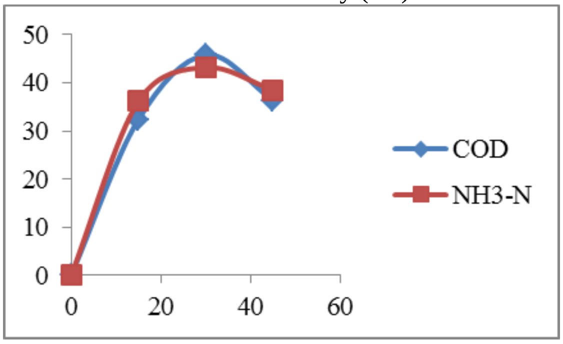

Fig. 6: Effect of applied voltage on COD and NH3-N removal efficiency (9V)

V. Conclusion

From the laboratory experiments of leachate treatment by electrocoagulation, this paper studies that the factors like applied cell voltage, operating time are affecting on COD and NH_3-N removal efficiencies. The results show that electrocoagulation can be used to the leachate pre-processing. Using both iron electrodes as cathode and anode optimum removal efficiency of COD and NH_3-N are obtained45.79%, 43.21% with 30 minutes of electrolysis time at 9V respectively.

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