Landfill Leachate Treatment by Electrocoagulation Method Using Aluminium and Copper Electrodes

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Abstract-*In this paper, treatment of landfill leachate by Electro-Coagulation (EC) method using aluminum and copper electrodes has been investigated in a batch process. The landfill leachate sample was collected from Avargolla landfill site, closed to Davangere city. The effect of variables like voltage, time and distance were investigated on TDS, TSS, Chloride and COD. The Electro-Coagulation process was carried out in a batch reactor of 5 liter capacity was taken out for batch at 5, 10 and 15 voltages and corresponding times of 15, 30 and 45 min by keeping different distance between the electrodes viz., 3, 4 and 5cm. The optimum removal efficiency of TSS, TDS and COD of 98.41%, 90.04% and 91.32% respectively were obtained at a distance of 3cm, 15V and 45 min. The higher removal efficiency of Chloride of 86.08% was obtained at a distance of 3cm, 10V and 45 min.*

Keywords-Electro-Coagulation (EC), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Chemical Oxygen Demand (COD), Chloride, Municipal Solid Waste (MSW), Aluminum and Copper electrodes.

I. INTRODUCTION

With rapid industrialization and population growth, the status of our surroundings is degrading day by day. As the limits of urbanization are extending to far flying areas in India, the issue of solid waste administration is creating an incredible worry to our surroundings [1]. Because of quick modern development and movement of individuals from towns to urban areas, the urban population is expanding quickly. Waste generation has been seen to increment every year in extent to the ascent in population and urbanization [2]. The per capita era of MSW has additionally expanded massively with enhanced way of life and economic wellbeing of the populations in urban areas [3].

Land filling is a standout amongst the most famous techniques for municipal solid waste transfer because of its relative simplicity as far as transfer systems [4].

The major drawback of landfill is generation of leachate. It is generated from precipitation, surface runoff and infiltration of ground water percolation through the landfill [5].

Landfill leachate is a sort of high focus wastewater that contains numerous poisons. It contains numerous natural matters, minerals, over whelming metals and has high centralization of smelling salts nitrogen, all these lead to the low biodegradability [6]. The leachate qualities changes as indicated by the landfill atmosphere conditions and hydrology, it likewise changes as per the characteristics of the rubbish that is buried in the landfill [7].

Leachate is a major environmental problem affecting the surroundings of landfill sites of municipal solid waste. The leachate, if not properly disposed from the land fill site it might enter the ground water table and contaminate the water. It is necessary to treat the leachate by avoiding its entry in to the ground water and nearby soil stratum. Various treatment methods viz, Coagulation-Flocculation [8], Membrane process, Advanced Oxidation technique, Biological treatment methods in treating landfill leachate have been tried by various researches [9]. Leachate consist of recalcitrant compounds whose BOD/COD ratio is more than 0.5. Hence Electro-coagulation method is one of the efficient methods to treat the leachate from the landfill site.

II. ELECTRO-COAGULATION

Electrocoagulation is one of the Electro-chemical methods applied in the treatment of different types of waste water like textile dye waste water, tannery waste water, dairy waste water, domestic waste water [5]. This technique is characterized by simple equipment, easy operation and decrease amount of sludge [9].

Electrocoagulation is a treatment process of applying electric current in to an aqueous medium in an electrochemical cell using an electrode. The different types of electrodes used in this process are Aluminum, Zinc, Copper, Iron [10].

III. MECHANISM OF ELECTROCOAGULATION PROCESS

In instrument of Electro-Coagulation, an anode material experiences oxidation and henceforth, framed different monomeric and polymeric metal hydrolyzed species. This metal hydroxide expel organics from wastewater by breadth coagulation and by collecting with colloidal particles present in the wastewater to shape greater size rushes and evacuated by settling. Organics contained in wastewater are oxidized specifically at the surface of the anode or oxidizing specialist is electrochemically produced to do oxidation in electro-oxidation procedure of wastewater treatment [11].

Metal hydroxide are delivered amid the electrolytic procedure and go about as coagulants and Flocculants which is changed over into flocs obliged thickness to residue under gravity in the unit. Electromotive power is created from the electrical energy to deliver metal hydroxide.

The responses that occur on the anode surfaces amid electrocoagulation are:

Anode:

$Al(s) \longrightarrow Al3{+}{+}3e{-}$ (1)

$2H2O \longrightarrow O2{+}\ 4H{+}{+}4e{-}$ (2)

Cathode:

$Al3{+}\ +\ 3H2O \longrightarrow Al\ (OH)3{+}3H{+}$ (3)

$Al\ (OH)2{+}{+}H2O \longrightarrow Al(OH)3{+}H{+}$ (4)

$2H2O \longrightarrow 4H{+}{+}4e{-}{+}O2$ (5)

Separation of water by Electrocoagulation creates hydroxide particles, which of the most responsive species which oxidize the natural mixes, Polyhydroxides or Hydroxide have solid bond fascination; Suspended solids will happens in upward heading because of gas advanced at the anodes [12].

IV. MATERIALS AND METHODOLOGY

A. SampleCollection

The landfill leachate sample was collected from Avargolla dumping site, close to Davangere city. Pit based method is followed for disposal of MSW in Avaragolla dumping site. Leachate sample were collected from the landfill site according to the standards and initial characteristics were carried for research facility.

B. Experimental Setup

The Bi-Polar Electrodes set up is showed in fig.1, which for the most part comprises of a measuring glass 5 liter Capacity of reactor to hold a specimen Aluminum/Copper plates of 3 mm thickness and 150 mm x 50 mm measurements was utilized as terminals. In Bi-Polar electrodes dipped in the reactor, DC power source was connected by anode and cathode with 3cm gap of electrode with magnetic stirrer at the bottom to mix the solution. Electrode spacing is maintained 3cm, 4cm and 5cm with direct current power supply (0-30V, 0-2A). All experiments were performed at a room temperature.

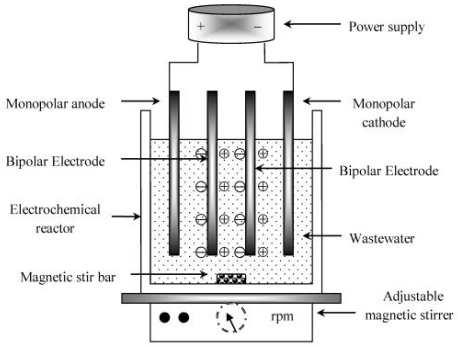

Fig.1 Laboratory Experimental Setup

C. ExperimentalProcedure

The experimentation was carried out by using two electrodes i.e. Aluminum representing cathode and Copper representing anode. Both electrodes were dipped in a container containing leachate with defined spacing between electrodes (3, 4 and 5cm). The time maintained for the experiment was 15, 30 and 45 minutes. At the end of every run, the sludge formed at the top of container was removed and then the treated leachate sample was transferred to the beaker and kept undisturbed for certain periods for floc to settle. The treated leachate effluent is analyzed for several parameters like Chlorides, TDS, COD and TSS as per APHA. The methodology followed in the experimentation is as shown in fig 2.

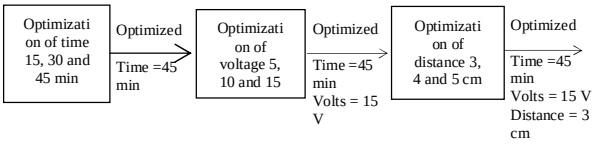

Fig.2 Optimization Study

V. RESULTS AND DISCUSSION

The raw leachate which was collected from Avaragolla dumping site were analysed for various physico-chemical properties to know its initial characteristics and shown in table 1.

Table.1 Landfill Leachate Initial Characteristics

Sl. No.	***Parameters***	***Unit***	***Values***
1	pH	-	5.89
2	Color	Pt Co	23125
3	TDS	ppm	5774
4	TSS	mg/L	4725
5	EC	µS	10420
6	Chloride	mg/L	3450
7	Hardness	mg/L	12500
8	Alkalinity	mg/L	2200
9	BOD	mg/L	13314
10	Turbidity	NTU	5922
11	COD	mg/L	44380

The Electrocoagulation process was influenced by variables such as applied cell voltage, distance between the electrodes and electrolysis time for the removal of various parameters.

A. Reduction of TDS during EC treatment

The effect of electrolysis time (15, 30, 45 min) and applied voltage (5, 10, 15 V) on the removal of TDS by keeping distance of 3cm between the electrodes is shown in fig 3.

With the increase of electrolysis time it was observed that the removal efficiency of TDS also increased. According to Faraday's law increasing the electrolysis time, the concentration of hydrogen ion to form floc is increased, which leads to increase of electrocoagulation flocculation efficiency [11]. The same trend was observed in the applied cell voltage. The maximum TDS removal efficiency of 90.04% was obtained at 15V and 45 min. at this condition the TDS reduced from 5774 to 575 mg/L. The figure showed that at 15V, there was no much variation in the removal efficiency of TDS with the increase in the electrolysis time.

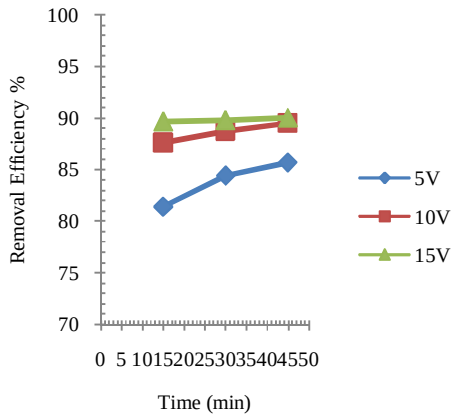

Fig.3 Removal efficiency of TDS with different voltage and time

B. Reduction of TSS during EC treatment

The effect of cell voltage and electrolysis time on removal of TSS by keeping the 3cm distance was tried. The removal efficiency of TSS for 10V was very close to 15V for varying electrolysis time. Higher removal efficiency of 98.01% was observed at 15V, 45min. At this condition the TSS reduced from 4725 to 115 mg/L. As increasing in the voltage and time passes, the TSS removal efficiency goes on constant. The removal efficiency of TSS is as shown in fig 4.

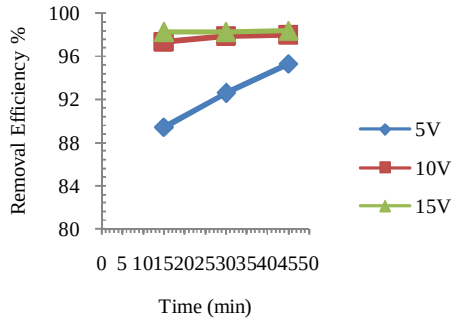

Fig.4 Removal efficiency of TSS with different voltage and time

C. Reducttion of Chloride during EC treatment

The increasing chloride concentration will generate more amount of hypochlorite ion [3]. The effect of applied cell voltage on removal of chloride in the treatment process increases gradually with the initial voltage and the corresponding electrolysis time. As the voltage increased from 10V to 15V, the removal efficiency of chloride concentration decreased. Higher removal efficiency of 86.08% was observed at 10V, 45min. The removal efficiency of Chloride is as shown in fig 5.

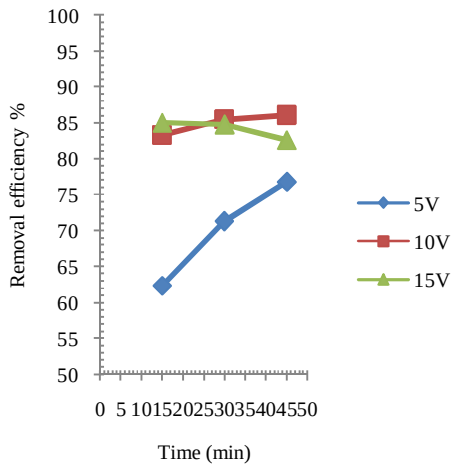

Fig.5 Removal efficiency of Chloride with different voltage and time

D. Reduction of COD during EC treatment

The effect of electrolysis time was investigated up to 45 min and the cell applied voltage of 0 to 15V by keeping a distance between electrodes of 3cm.

During the treatment the electrolysis time increases concentration of electrode ions and their hydroxide floc increases, also the rate of bubble generation increases. The removal efficiency of COD increases with the certain applied voltages, time and optimum distance between electrodes. Higher removal efficiency was observed at 15V, 45min of 91.32%. The removal efficiency of COD is as shown in fig 6.

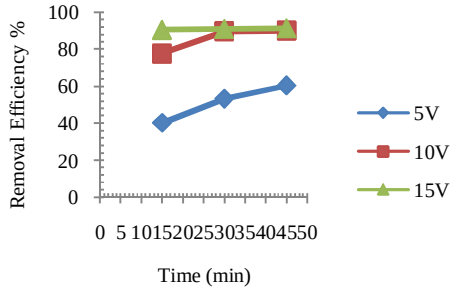

Fig.6 Removal efficiency of COD with different voltage and time

E. Optimization studies during EC treatment

Based on the results, the highest removal efficiency was observed at 15V and 45 min electrolysis time. By taking this optimum applied cell voltage and electrolysis time, the distance between the electrodes were varied (3, 4 and 5cm).

During the electrolysis treatment at a distance of 3, 4 and 5cm at optimum 15V and 45 min duration the removal values of various parameters viz., TDS of 650, 710 and 750 ppm respectively, TSS of 100, 130 and 150 mg/L respectively, COD of 4500, 5595 and 6250 mg/L respectively, Chloride of 500, 555 and 615 mg/L respectively. As the distance between electrodes increases, the removal efficiency of all parameters of leachate decreases with corresponding time. The removal efficiency of Parameters is as shown in fig 7.

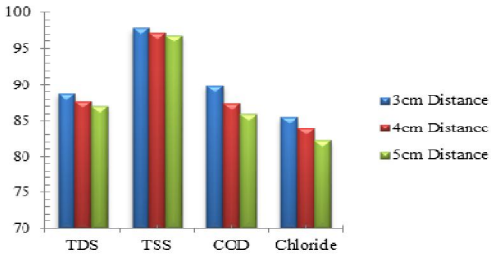

Fig.7 Removal eficiency of parameters at 3,4 and 5cmdistance at 10V and 30cm.

VI. COCLUSIONS

Based on the results achieved from the experimentation, it is concluded that variables like voltage, contact time distance between the terminals, Bi-Polar Connections have great bearing on removal efficiency. It is concluded that the removal of Turbidity, TSS, Chloride and COD show better removal efficiency at Bipolar configuration. The highest removal efficiency of 98.4%, 90.04% and 91.32% of TSS, TDS and COD respectively is obtained at Distance 3cm, Volts 15V, 45 min duration and electrode configuration has Bi-polar electrodes. The highest removal efficiency of 86.08% of Chloride respectively is obtained at Distance 3cm, Volts 10V, 45min duration and electrode configuration has Bi-polar electrodes. It's concluded that during electrolysis process, the electrode distance which were placed a distance of 3cm are more efficient in treating as compared to 4 and 5cm. This study concludes that Electro-Coagulation is one of the effective methods in landfill leachate treatment.

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