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TREATING LANDFILL LEACHATE BY ELECTROCOAGULATION

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Abstarct -Hazardous waste generation and its disposal in hazardous waste landfill is an unavoidable result of industrialization. The leachate produced from such landfills is very complex and toxic in nature and it possess huge potential to contaminate nearby surface and ground water resources. Therefore the collection and treatment of this leachate is essential for sustainable management of hazardous waste. Various conventional, chemical and advance processes have been applied to treat this most complex form of waste water but all technologies are associated with certain limitation and disadvantages. Major limiting factors are cost involved in treatment, operability of the process and huge sludge generation. Looking at the necessity to establish a competent treatment process which can overcome above mentioned limitations, Electrocoagulation was applied to check its efficiency for treating leachate.

Electrocoagulation produces combined effect of chemical coagulation, floatation, precipitation and oxidation when applied efficiently. In this study, leachate from hazardous waste landfill was treated with electrocoagulation using different electrodes. Efficiency of the process was checked at different sets of operating condition so that the results can be optimized. COD removal was taken as parameter of concern and the average COD removal through electrocoagulation was observed as 91.6%.

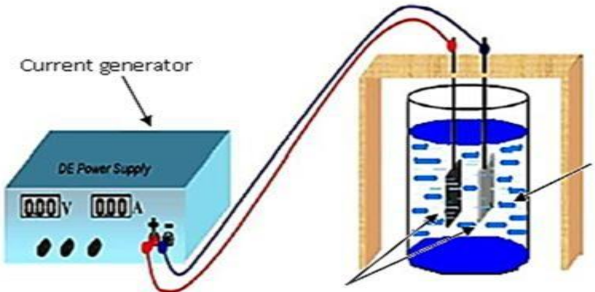
Keywords: Electroagulation, COD removal, landfill leachate, DC supply

1. INTRODUTION

Rapid industrialization and urbanization has resulted in generation of huge quantities of solid waste in and its management has become one of the major environmental issues these days [3.0, 3.2]. Landfilling is one of the most prevalent method used by many countries to manage this ever increasing solid waste quantities round the globe [3.0]. This landfill over the period of time behaves like a bioreactor where degradation of the organic fraction of solid waste takes place. Even landfills dealing with industrial waste undergo various physical and chemical changes, as a result of this process, a highly concentrated liquid is produced containing very complex characteristics and termed as leachate [1.5, 4.0].It has been reported that leachate contains large amounts of organic matter, ammonical nitrogen, heavy metals, and chlorinated organic and inorganic salts[1.5,3.3,3.4,4.2]which makes it very difficult to treat through conventional treatment technologies. Research is going on to develop more technologies which can efficiently treat this complex effluent. Different technologies developed for leachate treatment includes advanced oxidation processes, ion exchange, membrane filtration processes, coagulation, flocculation, electrocoagulation, ionization, ion resins adsorption, chemicals precipitation, lagoons and wetland [3.0,3.1,3.2,3.3,3.4,2.2,4.2,1.1]

It operates by way of precipitation of ions such as heavy metals and colloids, organic and inorganic compounds, coagulated by electricity. Electro coagulation (EC) is an advanced water treatment technology and used to remove a wide range of pollutants such as metal ions, suspended solids, colloidal solids, coloured compounds, dissolved solids, fat, oil, diesel, complex organic compounds, bacteria and viruses.

EC usually consists of two iron or aluminium electrodes connected to the DC power supply. When power is applied, metal will be oxidized and water will be reducing into OH^- . Together they form complexes due to their polarity they attract pollutants. Most of these complexes dissolve poorly in water and will therefore precipitate and withdraw pollutants from the waste water. The EC reactor is the reactor that electrochemically treats the Waste water. The treatment will remove the COD and BOD particles, partly nitrogen components, Phosphates and colour. All these components will be captured in the coagulation flocs and will be removed from the water by sedimentation or floatation. Benefits from using this process include: relatively low cost, less sludge formation, easy operation, less equipment requirement, shorter treatment period, versatility, safety, amenability to automation and environmental compatibility. [1.8]



[Figure : Schematic Diagram of experimental set-up for Electrocoagulation Process]

2. THEORY OF ELECTROCOAGUALTION

Electrocoagulation (EC) is a method of treating polluted water where sacrificial anodes corrode to release active coagulant precursors into solution.

2.1 Mechanism of Electrocoagulation:

Water is also electrolyzed in a parallel reaction, producing small bubbles of oxygen at anode and hydrogen at the cathode. Electro coagulation, precipitation of ions (heavy metals) and colloids (organic and inorganic) using electricity has been known as an ideal technology to upgrade water quality for a long time and successfully applied to a wide range of pollutants. Electro coagulation is the technique to create conglomerates of the suspended, dissolved or emulsified particles in aqueous medium using electrical current causing production of metal ions at the expense of sacrificing electrodes and hydroxyl ions as a result of water splitting. Metal hydroxides are produced as a result of EC and act as coagulant/flocculent for the suspended solids to convert them into flocs of enough density to be sediment under gravity. Destabilization of the contaminants, particulate suspension, breaking of emulsions, and aggregation of the destabilized Phases to form flocs. The EC mechanism for iron and aluminium anode could be represented as follow:

In the iron electrode,

Anode:

$$Fe_{(s)} \rightarrow Fe^{+2}_{(aq)} + 2e^{-} \quad \ldots\ldots\ldots (1)$$

$$Fe^{+2}_{(aq)} + 2OH^{-}_{(aq)} \rightarrow Fe\,(OH)_{2\,(s)} \quad \ldots. (2)$$

Cathode:

$$2H_2O_{(l)} + 2e^{-} \rightarrow H_{2\,(g)} + 2OH^{-}_{(aq)} \ldots (3)$$

Overall:

$$Fe_{(s)} + 2H_2O_{(l)} \rightarrow Fe(OH)_{2(s)} + H_{2(g)} \quad ...(4)$$

Due to oxidation in an electrolyte system, iron produces form of monomeric ions, Fe $(OH)_3$ and polymeric hydrox complex such as: $Fe(H_2O)_6^{3+}$, $Fe(H_20)_5^{2+}$, $Fe(H_2O)_4(OH)_2^{+}$, $Fe(H_2O)_8(OH)_2^{4+}$ and $Fe_2(H_2O)_6(OH)_4^{4+}$ depending upon the pH of the aqueous medium.[2.2]

In the case of aluminium electrodes the reactions are as follows:

Anode: $Al_{(s)} \rightarrow Al^{3+}_{(aq)} + 3e$….. (5)

Cathode: $3H_2O_{(l)} + 3e^- \rightarrow 3/2\, H_2 + 3H^+$… (6)

For the aluminium electrodes, $Al^{3+}_{(aq)}$ ions will immediately undergo further spontaneous reaction to generate corresponding hydroxides and polyhydroxides. Due to hydrolysis of Al^{3+}, $Al(H_2O)_6^{3+}$, $Al(H_2O)_5OH_2^{+}$, $Al(H_2O)(OH)^{2+}$ generated .This hydrolysis products produced many monomeric and polymeric substance such as, $Al(OH)^{2+}$, $Al(OH)^{2+}$.[2.2]

3. MATERIALS AND METHOD

3.1 Sample and material:

The experimental work was done in our college named Shroff S.R Rotary institute of Chemical Technology, Vataria, Valia, Bharuch, Gujrat,India. Stainless steel electrode material were purchased from local market. Measure dimension of the electrode was cut with a metal cutter and clean before used. Laboratory grade chemical was used according to advice from our guide and lab assistant. The leachate is carried out from the landfill near to our college named Bharuch Enviro Infrastructure Ltd. (BEIL) plot- 9701-9716 GIDC Estate, Ankleshwar-393002, Dist.- Bharuch, Gujarat, India. Other materials and equipments used are COD digester, Ferroin Indicator, Potassium dichromate ($K_2Cr_2O_7$), Ferrous Aluminium Sulphate(FAS), H_2So_4 conc., Ag_2So_4, $HgSo_4$, Distilled water, Glass wares, Stainless steel electrodes, Glass beaker, Magnetic stirrer, DC power supply, pH meter. These all chemicals, equipment and glass wares were available in our college.

3.2 Experimental procedure:

First, for the electrocoagulation, the reactor made up of acrylic material with the dimensions of 30cm x 15cm x 12cm was used. The working volume of the reactor was 1L. The EC unit consisted of two Stainless steel material electrodes connected with the DC power supply. The dimensions of the electrodes were 10cm x 5cm x 1mm.The representation of the experimental setup is shown in Fig above. After the initial characterization of leachate, experimental studies were conducted to optimize the various parameters such as pH, electrolysis time (ET), COD and voltage. Experiments were performed with two electrodes connected to the DC power supply to determine optimum conditions. In the bipolar connection of electrodes, there is no electrical connection between inner electrodes; only the outer electrodes are connected to the power supply. The space between the two electrodes was maintained 2cm in all the experiments. In each run, the voltage was 2V. To maintain homogenous mixing of the reactor content, magnetic stirrer is used. The wastewater concentration was reduced to half the strength throughout the study to reduce the time and current consumption and to obtain better efficiency. The EC experiments were performed for 4 hours and in each run samples were collected at every half an hour.

3.3 Experiment for analysing COD:

3.3.1 Objective

To determine the COD of given landfill leachate sample.

3.3.2 Apparatus

Conical flask, Magnetic stirrer, Burette, Beaker, Pipette, Glass tube, COD digester

3.3.3 Chemicals

0.1N Potassium dichromate solution

0.1N Ferrous ammonium sulphate solution (FAS)

$AgSO_4$ with concentrate H_2SO_4

$HgSO_4$ powder

Ferroin indicator.

3.3.4 Procedure

Take all glass wear and wash them with distilled water. Now take given waste water sample and dilute it with distilled water in ratio of 1:249. Make up it up to 250 ml. Take conical flask or beaker and add 20ml diluted sample in it. Now add 10 ml of potassium dichromate (K2Cr2O7) in it. Add 30ml of concentrated H2SO4 mixed with 0.4mg of HgSO4. Mix it with magnetic stirrer. Now take blank solution as per the same procedure. Pour this solution of sample & blank in glass tube & put these glass tubes in COD digester with reflux condenser on it. Now allow for digestion up to 2 to 2.5 hrs at 150° C. After that take out and cooled it down for some time Add this solution in beaker then add 6 to 8 drops of ferroin indicator and titrate this solution again ferrous ammonium sulphate solution till red wine colour appear from blue green. Note down this result for sample as well as blank solution

3.3.5 Calculation formula

COD (mg/L) = (A-B) x N x 8 x 1000 / ml of sample taken

Where,

A = ml of Ferrous ammonium sulphate used for blank

B = ml of Ferrous ammonium sulphate used for sample

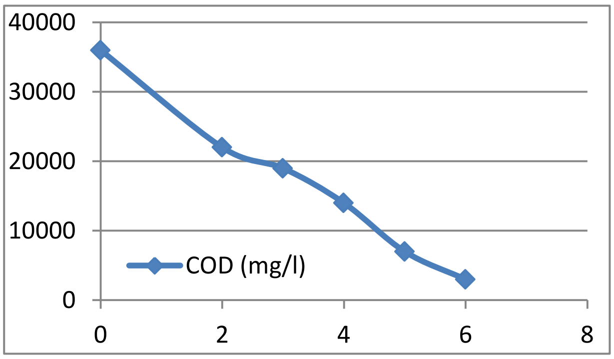
N = normality of Ferrous ammonium sulphate 8 = mill equivalent weight of oxygen

4. RESULT AND DISCUSSION

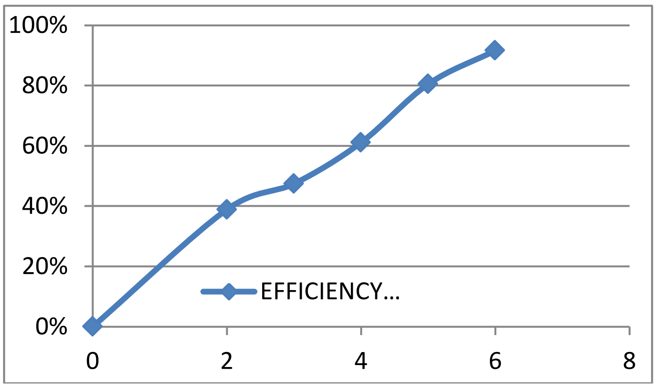
SR NO.	pH	TIME (min)	ELECTRODE DISTANCE (cm)	VOLTAGE (V)	COD (mg/l)	EFFICIENCY (%)
1.	7	180	2	0	36000	0%
2.	7	180	2	2	22000	38.88%
3.	7	180	2	3	19000	47.42%
4.	7	180	2	4	14000	61.11%
5.	7	180	2	5	7000	80.5%
6.	7	180	2	6	3000	91.6%

[Result table]

The table shows to treat 1L of effluent at different voltages like 2, 3, 4, 5 and 6. It is clear from the table that as the voltage increases the reduction in COD will also increase. At 6 voltage, the reduction efficiency is 91.6% achieved. Therefore, the voltage is optimized at 6 voltage with removal of COD 36000 to 3000 mg/l. Also the maximum removal COD efficiency by electrocoagulation process is 91.6%.



[Graph: Voltage v/s COD]



[Graph: Voltage v/s COD efficiency]

5. ADVANTAGES

EC is a simple equipment and easy to work with adequate operational scope that can overcome most of the problems that may be encountered during the operation. EC is the Combination of oxidation, coagulation, and precipitation which results in lower capital cost. EC reduced the need for chemical reagents which results in less sludge production so risk of secondary pollution is also reduced. EC require equipment without moving parts means that low energy require for this process or solar power can be used for energy resulting operating is reduce.

6. DISADVANTAGES

The major disadvantage of EC is it need for maintenance. The 'sacrificial electrodes' are dissolved into leachate/ wastewater streams as a result of oxidation, and need to be regularly replaced. The use of electricity may be expensive in many places. An Electrode passivation or impermeable oxide film may be formed on the cathode leading to loss of efficiency of this unit. Due to high conductivity of the wastewater/leachate suspension is required.EC process has lack of systematic reactor design.

7. CONCLUSION

As per our project experimental work, we can say that electrocoagulation is more efficient and cost reliable as compare to other process for the removal of COD from landfill leachate and for its treatment. Stainless steel electrodes are found to be more efficient as compare to other electrodes. Thus the experiment performed by using Stainless steel electrodes and by applying DC power supply.

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