TOC and COD removal from municipal solid waste leachate using Electrocoagulation method

D.Sivakumar[1]*, J.Rajaganapathy[1], R.Anand[2], S.Mariavensa[1], S.Preethi[1]

[1]Department of Civil Engineering, Vel Tech High Tech Dr.Rangarajan Dr.Sakunthala Engineering College, Avadi, Chennai, Tamil Nadu, India

[2]Department of Civil Engineering, Easwari Engineering College, Ramapuram, Chennai, Tamil Nadu, India.

***Corresponding author: E.Mail: shri.sivakumar1974@gmail.com**

ABSTRACT

This study was focused on removal of TOC and COD in a municipal solid waste dumping yard using the method called electrocoagulation method. The experimental investigations have been carried out by using electrocoagulation method for different temperature, different agitation speed, different concentration and different current densities using aluminium electrodes. The results showed that the maximum percentage removal of TOC and COD in a leachate was obtained was 94.7 % and 98.2 % respectively and this could be achieved at the optimum temperature of 50 ºC, optimum agitation speed of 50 rpm, optimum concentration of 25 % and optimum current density of 40 mA/cm^2 by electrocoagulation method. Thus, this study concluded that electrocoagulation method was effectively used for removing TOC and COD in a leachate of municipal solid waste dumping yard.

KEY WORDS: leachate, solid waste, TOC, COD.

1. INTRODUCTION

Among the various sources of surface water and groundwater contamination, the leachate from municipal solid waste dumping yard stands out as one of the most important, because it generates a considerable high concentrated liquid contains high concentrations of organic matter and inorganic matter along with other properties like total dissolved solids, suspended solids, phenols, chlorides, ammonia, and heavy metals. In the recent years, increasing awareness was created to minimizing surface water and groundwater contamination. Leachate production and control remain a problematic issue, since, surface water and groundwater is contaminated due to percolation of leachate when it is not treated and discharged properly (Sivakumar Durairaj, 2013c; Sivakumar, 2011).

There are several processes that can be adopted for the treatment of municipal solid waste leachate. The suggested treatment methods for the reduce the contaminants in a leachate are physico-chemical method (Kurniawan, 2006), coagulation (Hoda Roushdy Guendy, 2010), adsorption (Sivakumar and Nouri, 2015; Sivakumar, 2014c; Sivakumar, 2014f; Sivakumar, 2014g; Sivakumar, 2014k; Shankar, 2014a; Sivakumar, 2013b; Sivakumar and Shankar, 2012; Karaca, 2008), ion exchange, chemical precipitation, bioremediation (Shankar, 2014b; Sivakumar, 2014d; Sivakumar, 2014e), constructed wetland (Sivakumar, 2013a; Sivakumar, 2014h; Sivakumar, 2015), electrochemical method (Lin, 1994), electro deionization process (Lu, 2010) and electro-dialysis (Sivakumar, 2014i; Sivakumar, 2014j) etc.

But due to certain limitations either in terms of cost or technology or time consumption, an alternative method was pursued to treat the leachate coming from the municipal solid waste dumping yard. Once such process is known as electrocoagulation process (Tchamango, 2010; Hansen, 2007; Vasudevan, 2009) and it has gained a lot of attention in recent past. Compared to traditional methods, electrocoagulation process offers (APHA, AWWA and WEF, 2005) versatility, since it may be used to treat liquid and solid waste by direct and indirect organic compound oxidation, metal reduction and electro deposition, it also offers (Hansen, 2007) environmental compatibility, and since electrocoagulation process is mediated by electron exchange with the electrode surface, dismissing the need for the addition of other chemical agents.

Thus, this study mainly focused on removal of organic matter in terms of total organic content (TOC) and inorganic content in terms of chemical oxygen demand (COD) from the Municipal solid waste leachate using electrocoagulation method. This study is concentrated only for the removal of TOC and COD in a leachate from the municipal solid waste dumping yard, no other properties were not consider by electrocoagulation method.

2. MATERIALS AND METHODS

2.1. Collection of Wastewater Sample: For the present study, the leachate sample was collected from Municipal solid waste dumping yard, Ambattur Industrial Estate, Chennai with the help of air tight sterilized bottles covered with ice cubes. Samples were taken to the Environmental Engineering Laboratory, kept at 4 °C for analyzing the various parameters from the leachate in later stage. The analyses were carried out for TOC and COD along with other properties as given in Table 1.

Table.1.Physico-Chemical Characteristics of Municipal Solid Waste Leachate

Properties	Values	Properties	Values
pH	6.3	Chloride	865 mg/l
EC	38 µs/cm	Phenols	355 mg/l
TDS	5423 mg/l	Cu	40 mg/l
TS	8960 mg/l	Ni	32 mg/l
TOC	4680 mg/l	Cr	63 mg/l
BOD	5860 mg/l	Zn	98 mg/l
COD	11350 mg/l	Cd	17 mg/l
Sulphate	689 mg/l	Pb	12 mg/l

2.2. Experimental Arrangement: The setup consists of a glass beaker, magnetic stirrer apparatus with hot plate, a D.C. power supply, volt meter, ammeter, resistor and Al electrodes. The electrodes were separated by a space of 2.5 cm and dipped in leachate. The electrodes were placed into 200 ml wastewater in a 250 ml beaker. The anode and cathode were connected in a monopolar mode in the beaker. The D.C source was used to power supply the system with 0-15V and 0-3A.

2.3. Treatment by Electrocoagulation: The municipal solid waste leachate sample was treated with the help of magnetic stirrer apparatus and iron electrodes. This method consists of batch experiments involving variations in temperatures such as 30, 40, 50 and 60 °C, agitation speeds of 25, 50, 75 and 100 rpm, concentrations 25, 50, 75 and 100 % and current densities 20, 30, 40 and 50 mA/cm^2. Leachate was taken in a glass beaker of 250 ml capacity and was kept on the magnetic stirrer apparatus for contaminants reduction against various process parameters. The treated sample was allowed to settle for the duration of 2 hours and then filtered with Whatman filter paper. The filtered sample was tested for various parameters as per the standard procedure stipulated by APHA, AWWA and WEF, 2005.

The removal percentage of various parameters in a leachate by electrocoagulation was calculated by using the following formula:

$$\text{Percentage Removal} = \frac{(C_1 - C_2)}{C_1} \text{ x } 100 \qquad (1)$$

in which C_1 and C_2 are the concentration of various parameters in a leachate, expressed in mg/l except pH and EC before and after treatment with electrocoagulation method.

3. RESULTS AND DISCUSSIONS

In the present study, removal of TOC and COD in a leachate by electrocoagulation is presented in detail and the reduction of other properties of leachate (Table 1) was not presented. The experimental investigations have been carried out by using electrocoagulation method for different temperature, different agitation speed, different concentration and different current densities with aluminium electrode (both anode and cathode). The results are presented below.

3.1. Effect of Temperature: The Fig.1 shows the effect of temperature on removal of TOC and COD in a leachate by electrocoagulation. The chosen temperatures for this study are 30, 40, 50 and 60 °C. The result was presented for the parameters TOC and COD against the temperature of 50 °C only not for other temperatures, since, for the temperature of 50 °C maximum removal was obtained. Further, the effect of temperature was done against the agitation speed of 25 rpm, the concentration of 100 % and the current density of 20 mA/cm^2.

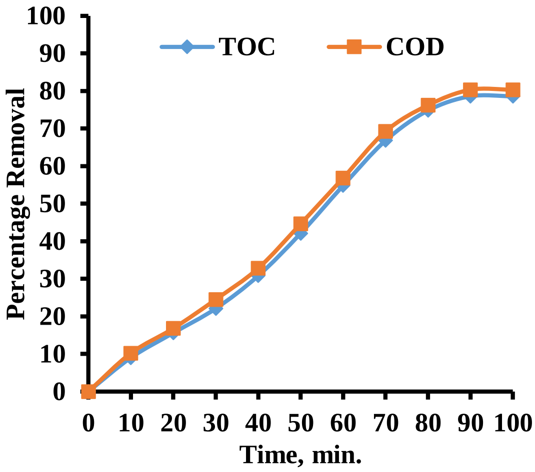

Fig.1 Maximum removal of TOC and COD in a leachate against the optimum temperature of 50 °C, agitation speed of 25 rpm, the concentration of 100 % and the current density of 20 mA/cm^2

From Fig.1, it may be observed that the maximum percentage removal of TOC in a leachate by electrocoagulation is 80.9 % for the temperature 50 ºC. Similarly, the maximum removal of COD in a leachate by electrocoagulation is 83.4 % for the temperature 50 ºC. Thus, an optimum temperature for which maximum removal of TOC and COD is found to be 50 ºC.

It was found that as the temperature increased from 30 to 50 ºC, the percentage removal of TOC and COD was increased and beyond which, there was no much difference of percentage removal for the parameter TOC and COD in a leachate. In other words, the same removal percentage of TOC and COD was obtained for the temperature 50 ºC and 60 ºC by electrocoagulation method. The order of higher removal percentage was found to be COD followed by TOC in a leachate.

3.2. Effect of Agitation Speed: The Fig.2 shows the effect of agitation speed on removal of TOC and COD in a leachate by electrocoagulation. The chosen agitation speed for this study are 25, 50, 75 and 100 rpm. The result was presented for the parameters TOC and COD against the agitation speed of 50 rpm only not for other agitation speeds, since, for the agitation speed of 50 rpm, maximum removal was obtained. Further, the effect of agitation speed was done against the optimum temperature of 50 ºC, the concentration of 100 % and the current density of 20 mA/cm^2.

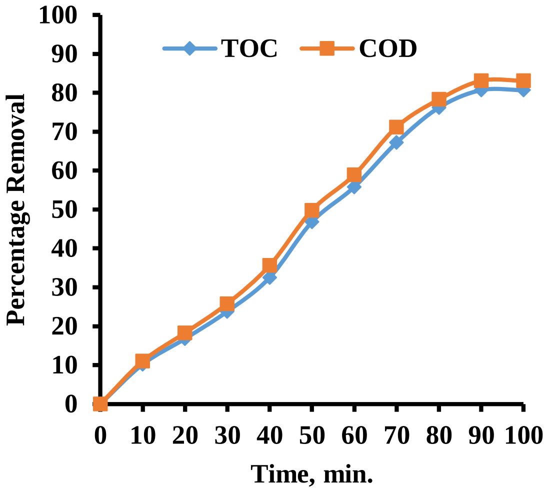

Fig.2 Maximum removal of TOC and COD in a leachate against the optimum agitation speed of 50 rpm, the optimum temperature 50 ºC, the concentration of 100 % and the current density of 20 mA/cm^2

From Fig.2, it may be observed that the maximum percentage removal of TOC in a leachate by electrocoagulation is 84.2% for the agitation speed of 50 rpm. Similarly, the maximum removal of COD in a leachate by electrocoagulation is 86.1 % for the agitation speed of 50 rpm. Thus, an optimum agitation speed for which maximum removal of TOC and COD is found to be 50 rpm.

It was found that as the agitation speed increased from 25 to 50 rpm, the percentage removal of TOC and COD was increased and beyond which, there was no much difference of percentage removal for the parameter TOC and COD in a leachate for the agitation speed of 50, 75 and 100 rpm. In other words, the same removal percentage of TOC and COD was obtained for the agitation speed of 50, 75 and 100 rpm by electrocoagulation method. As similar to effect of temperature, the order of higher removal percentage was found to be COD followed by TOC in a leachate by agitation speed.

3.3. Effect of Concentration: The Fig.3 shows the effect of concentration on removal of TOC and COD in a leachate by electrocoagulation. The chosen concentration for this study are 25, 50, 75 and 100 %. The result was presented for the parameters TOC and COD against the concentration of 25 % only, not for other concentrations, since, for the concentration of 25 %, maximum removal was obtained. Further, the effect of concentration was done against the optimum temperature of 50 ºC and an optimum agitation speed of 50 rpm and the current density of 20 mA/cm^2.

From Fig.3, it may be observed that the maximum percentage removal of TOC in a leachate by electrocoagulation is 86.8 % for the 25 % concentration of leachate. Similarly, the maximum removal of COD in a leachate by electrocoagulation is 89.6 % for the 25 % concentration. Thus, an optimum concentration for which maximum removal of TOC and COD is found to be 25 %.

It was found that as the concentration decreased from 100 to 25 %, the percentage removal of TOC and COD was increased. As similar to effect of temperature and agitation speed, the order of higher removal percentage was found to be COD followed by TOC in a leachate by the effect of concentration.

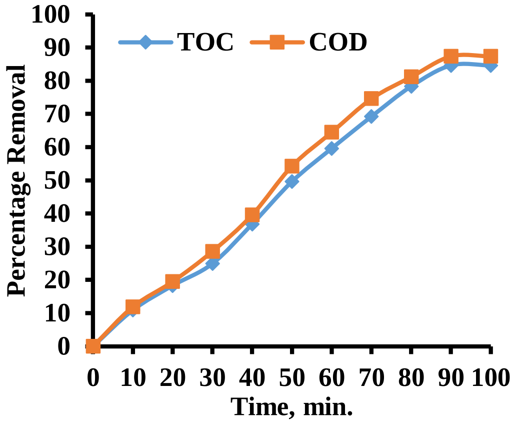

Fig.3.Maximum removal of TOC and COD in a leachate against the optimum concentration of 25 %, the optimum temperature 50 °C, optimum agitation speed of 50 rpm and the current density of 20 mA/cm^2

3.4. Effect of Current density: The Fig.4 shows the effect of current density on removal of TOC and COD in a leachate by electrocoagulation. The chosen current densities for this study are 20, 30, 40 and 50 mA/cm^2. The result was presented for the parameters TOC and COD against the current density of 40 mA/cm^2 only, not for other current densities, since, for the current density of 40 mA/cm^2, maximum removal was obtained. Further, the effect of current density was done against the optimum temperature of 50 °C, an optimum agitation speed of 50 rpm and optimum concentration of 25 %.

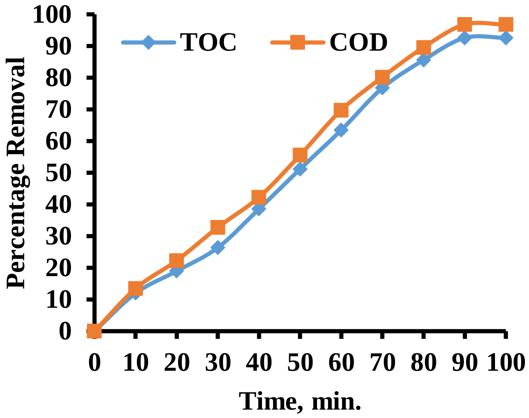

Fig.4 Maximum removal of TOC and COD in a leachate against the optimum current density of 40 mA/cm^2, optimum temperature 50 °C, optimum agitation speed of 50 rpm and the optimum concentration of 25 %

From Fig.4, it may be observed that the maximum percentage removal of TOC in a leachate by electrocoagulation is 94.7 % for the current density of 40 mA/cm^2. Similarly, the maximum removal of COD in a leachate by electrocoagulation is 98.2 % for the current density of 40 mA/cm^2. Thus, an optimum current density for which maximum removal of TOC and COD is found to be 40 mA/cm^2.

It was found that as current density increased from 20 to 40 mA/cm^2, the percentage removal of TOC and COD was increased and beyond which, there was no much difference of percentage removal for the parameter TOC and COD in a leachate for the current density of 50 mA/cm^2. In other words, the same removal percentage of TOC and COD was obtained for the current density of 40 mA/cm^2 and 50 mA/cm^2 by electrocoagulation method. As similar to effect of temperature, agitation speed and concentration, the order of higher removal percentage was found to be COD followed by TOC in a leachate by the effect of current density.

From Figs.1 to 4, this study was found that the maximum removal of TOC and COD in a leachate of municipal solid waste was completed in 90 min. against the various selected process parameters.

4. CONCLUSION

In the present study, experiments have been conducted for removal of TOC and COD in a leachate of municipal solid waste dumping yard using electrocoagulation. The ability of electrocoagulation for removing TOC and COD in a leachate, the experiments was conducted for different temperatures, agitation speeds, concentrations and current densities. The results showed that the maximum percentage removal of TOC and COD was 94.7 % and 98.2 % respectively at the optimum temperature of 50 °C, optimum agitation speed of 50 rpm, optimum concentration of 25 % and optimum current density of 50 mA/cm^2. Further, the order of maximum removal was found to be COD followed by TOC for those selected process parameters. The maximum removal was completed in the duration of 90 min. Thus, this study concluded that the electrocoagulation method was used effectively for removing TOC and COD in a municipal solid waste leachate.

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