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Treatment of landfill leachate effluent by chemical coagulation and electrocoagulation: without correction of pH

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ABSTRACT/RESUME

Abstract: *The objective of the present study is to see the difrence between traditional physicochemical process such as chemical coagulation and electrocoagulation process treating a Landfill Leachate effluent.*
As it's known Leachate is difficult to treat to meet to the discharge standards for its variable composition and proportion of refractory materials.
We used Jar test experiments for chemical coagulation, Aluminium sulphate ($Al_2(SO_4)_3$,10 H_2O) as a coagulant, we also perform to compare the removal efficiencies of different pollutants as phenol, nitrate and total organic carbon for each method.
Experimental results of electrocoagulation using an aluminum electrode with a current density of 166.6 A/m^2 and a residence time of 150 min have shown its important removal capacity as total organic carbon and turbidity were 78.24% and 98 % consecutively, who were better than chemical coagulation results.
Furthermore, it can be concluded that the electrocoagulation technique is rapid since the active agents of coagulation are produced as the experiment proceeds.

I. Introduction

Before Leachate or landfill percolation water is charged bacteriological and especially chemically as mineral and organic substances. It is difficult to predict the composition of leachate as it depends on the type of waste, the amount of rainfall and the stage of degradation reached [1].

As it's known leachate is the major polluting source landfill on the surrounding waters according to their toxicity and dilution .also it's difficult to be treated to satisfy the discharge standards for its variable composition and high proportion of refractory materials [2].
many treatment methods have been examined in the literature to treat leachate, such as biological treatment methods [3], membrane processes[4], advanced oxidation techniques [5], coagulation–flocculation methods [6].
The electrocoagulation (EC) is one of a technique for treating polluted water that has shown its effectiveness in the treatment of certain soluble or colloidal pollutants, such as encountered in Liquid waste containing heavy metals, emulsions, suspensions... [7].
many research interest to treat various types of wastewater by electrocoagulation, their efficiency have been proven as : Wastewater Treatment [8], tannery wastewater pre-treatment [9], treatment of landfill leachate effluent [10,11] and many others.
A simple electrocoagulation reactor consists of an anode and a cathode. When a potential is applied from an external power source, the anode material undergoes an oxidation, while the cathode is subjected to reduction of deposition of elemental metals, The electrochemical reactions with M metal

as anode can be summarized as follows [12]. The particle velocity drop is proportional to the square of their diameter (Stokes law), it is understandable that it's advantageous to combine two small one to make a big one. when we have colloids and small particles, the operation is called coagulation. in the case of larger particles, we speak about flocculation. These processes are to be regarded as an elementary treatment for many solid-liquid separations such as decanting and flotation, etc [13]. Chemical coagulation is the most commonly treatment process that has been adapted successfully for years such as wastewaters treatment, treat leachate [14], and many others effluenets.

II. Materials and methods

The experimental it's a comparison between Chemical coagulation (CC) and Electrocoagulation (EC) by measuring COD, TOC removal under the following operating Conditions for both of EC and CC such as temperature 25°c, without correction of pH before treatment.
In the study ,All the parameters analysis was made according to Standard Methods [15].
The Jenway 3505 brand as pH-meter. The 2100P Turbidimeter HACH brand was used for measuring turbidity, where the removal of colour was quoted as a percentage related to the values measured for the untreated effluent, The total organic carbon (TOC) were measured using a model Sievers innovox laboratory TOC analyzer. The Chemical oxygen demand (COD) was colorimetrically determined following dichromate digestion heated in a COD reactor (Model WTW termoreactor CR 3000) for 120 min after which the absorbance was measured using a spectrophotometer (Model Jasco V-730).

% Removal were calculated as :

$$R\,\% = {}^{(C0 - C)}/_{C0} \times 100$$

Where: C0 is the initial concentration and C the final concentration.

II.1. Chemical coagulation

coagulation-flocculation test was conducted on a jar-test,consisting of a series of blade stirrers, the number of six light mounted on a bench. The paddle speed is adjustable and identical with a stirrer to another (wise stir jar Tester brand).The tests were carried out in beakers of 600 ml. The volume of the treated leachate was 500 ml.we used aluminium sulphate ($Al_2(SO_4)_3$,10 H_2O) as a coagulant, when adding the coagulant, the stirring speed is set at 100 t /min for 2 minutes. This speed is then reduced to 25 t /min for 30 minutes.

After stirring, the mixed samples were settled for 2 hours. The supernatants were analysed for COD, TOC, phenol, nitrate, nitrite and turbidity.

II.2. Electrocoagulation

A batch system in laboratory scale was performed to test the leachate treatment efficiency by electrocoagulation (***Figure 1)***, two aluminum plates (size 150×45×2 mm) were used as electrodes, they were immersed in a beaker containing 500ml leachate.The immersed surface of each electrode was 30 cm^2 and the distance between them is 2 cm, a stirring using a magnetic bar.A digital DC (Electrophoresis power supply,EV 202, 0–220V, 0.0–2.0 A) was used to give an adjusted electricity current to the electrochemical cell.

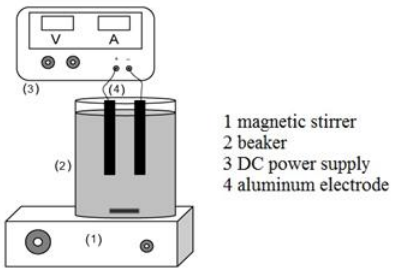

Figure 1.*Experimental set-up.*

III. Results and discussion

The evolution of the efficiency of the electrocoagulation process at a current density of 166.6 A/m^2 according to the time for different pollutants such as (total organic carbon, inorganic carbon, total carbon and the chemical oxygen demand) is represented in Figure 2.a. it shows that an increase in time causes an increase in process efficiency, where COD have a maximum removal efficiency 61 % after 150 min and TOC (56% after 90 min), TC(46% after 120 min),and IC(39% after 120 min) removal efficiencies respectively.
As can be seen in fig. 2. b the efficiency of removal in CC is not important as it is in EC even with higher mass, we have 3.5% of COT removal 7% of COD removal for 48 mg and 40 mg of aluminum added respectively.
After all, the addition of coagulant did not proportionally affect the removal efficiency.

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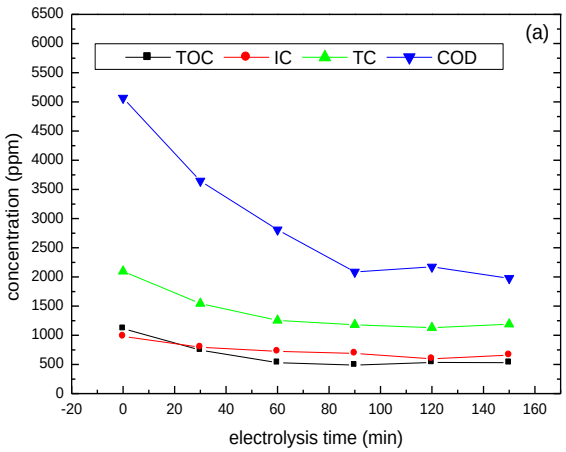


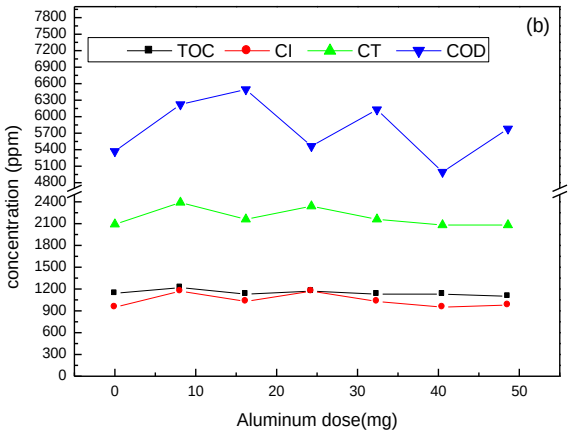
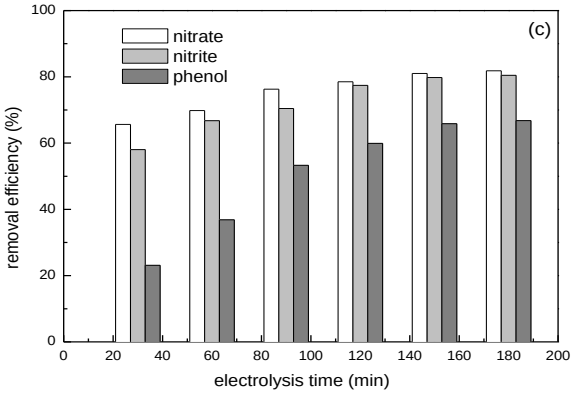


Figure 2. *evolution of COD , TOC , TC AND IC*
(a) Effect of time on EC
(b) Effect of aluminum dose on CC

features of the initial sample were: turbidity 548 NUT, phenol 2110 mg/L, nitrate 320 mg/L and nitrite 40 mg/L

The EC has shown a removal efficiency of Phenol, nitrate and nitrite, are respectively 66%, 80% and 63% (fig 3.c), however in CC removal efficiencies are 5% for nitrate and 17% for nitrite and 7 % for phenol (fig.3.d).



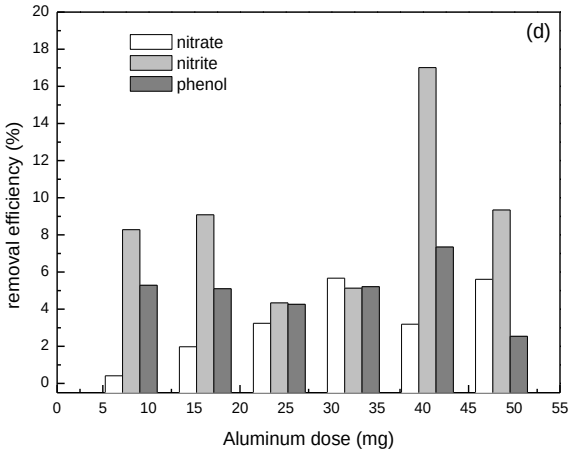
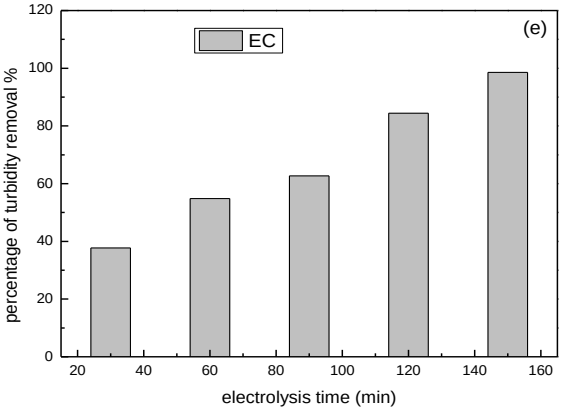


Figure 3. *nitrate, nitrite, and phenol removal effiviency*
(c) *Effect of time on EC*
(d) *Effect of aluminum dose on CC*

Figure 4. e and f showing the percentage of turbidity removal obtained by EC and CC. In CC case the optimum in this series of the coagulant dose is 24.3 mg of Aluminum gives yield of 59%. Thus, for an EC electrolysis time an 150 min gives a yield of 98%, it shows that the removal rate in turbidity increases when electrolysis time increases.



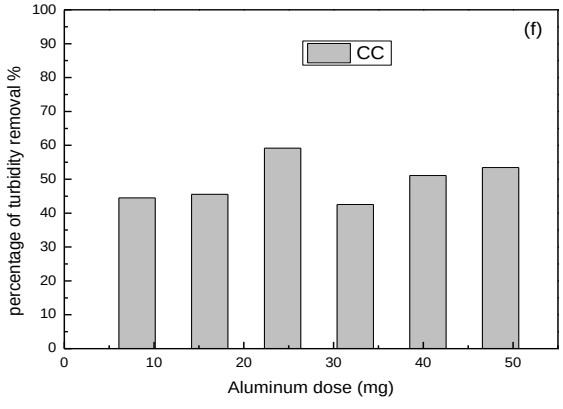


***Figure 3**. percentage of turbidity removal*
***(e)** Effect of time on EC*
***(f)** Effect of coagulant dose on CC*

The amount of metal aluminum ion released into solution by electrolytic oxidation of the anode material can be calculated using the following form of Faraday's law: $w = \frac{itM}{zF}$

w is the metal dissolved (g), $\boldsymbol{i}$ is the current (A), $\boldsymbol{t}$ is the contact time(s), $\boldsymbol{M}$ is the molecular weight of Fe or Al, $\boldsymbol{z}$ is the number of electrons involved in the redox reaction ($\boldsymbol{z}_{Al}$=3), and $\boldsymbol{F}$ is the Faraday's constant (96,500 C/mol) [16].
according to Faraday's law, the amount of aluminum released into the solution linearly increase with reaction time.
in the electrocoagulation under the experimental condition of this study, and for 150 min the amount of coagulation released into the system was calculated to be 839.37 mg of aluminum.

IV. Conclusion

Comparative tests of the performance of the electrocoagulation and chemical coagulation,
Regarding the evolution of pollutants, has been performed, the process efficiency is evaluated by measuring turbidity, nitrate, nitrite, phenol, COT and COD.

as a first objective, the work shows the interest of the electrocoagulation process for the treatment of leachate collected from CET Constantine, characterized by high levels of pollution.
The results demonstrate that the performance of electrocoagulation is very satisfactory even at a low time. As the time of electrocoagulation was increased, the Pollutants concentration in treated water decreased.

furthermore in EC and CC the procedure for elimination of the pollution is also different, so that the chemical coagulation usually leads to settling of pollution, electrocoagulation results in settling and also a flotation of pollution by microbubble gas produced at the cathode and the anode.

As a result the comparison of electrocoagulation and chemical coagulation processes used for landfill leachate effluent treatment without correction of pH (even with its important effect in both of the EC and CC treatment) for each method demonstrated the practical advantage of electrochemical treatment in term effectiveness.

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