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Effect of pH and time on the leachate treatment by coagulation

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Abstract
Landfilling of solid waste is the disposal route used in most Moroccan cities. However,from an ecological point it is far from being sustainable, the waste is very wet which generates large amounts of highly polluted leachate.It causes significant impacts to the natural and human environment.This article presents the study results of leachate treatment on the landfill OumAzza (Rabat - Morocco) by coagulation - flocculation using ferric chloride and, of the effect of pH and retention time on the removal of turbidity, Chemical Oxygen Demand (COD) and Organic Matter (OM) in order to improve the performance of membrane treatment by reverse osmosis that will be retained as final treatment.The results show that the pH and the retention time have an effect on the removal efficiency of these parameters. Thus, with a pH = 5.7 and a time of 15 min, the removal efficiency reaches 82% of turbidity, 72% of the COD and 94% of OM.

Keywords:Landfill, leachate, coagulation-flocculation, organic matter, COD, ferric chloride

1. Introduction
Landfill is one of the most widely employed methods for disposing of municipal solid waste [1-3, 12]. Consequences this method generates the leachate and gaz. The leachate has an impact on the environment particularly through contamination of groundwater and surface water, as well as soil pollution [1,4,8,10,27]. The composition of leachate depends on several factors such as the waste composition, site hydrology, climatic conditions, design and operation of the landfill and its existence [8-11,21,26]. The leachates may contain large amounts of organic matter consisting of humictype substances, like humic and fulvic acids that are heterogeneous organic constituents, heavy metals, chlorinated organic and inorganic salts [5,9,18-21] this requires an effective treatment for these leachates to meet the discharge standards.
The performance of certain leachate treatment units remains weak and requires improvement combining biological and physical-chemical processes [21,22,24,25]. Among the many techniques giving the best results in the treatment of leachate we would mention membranes, especially those with reverse osmosis [12,13,24].
In the case of treatment of leachate discharge Oum Azza (Rabat-Morocco), the selected chain consists in a biological pretreatment with aeration, followed by decanting before passing through the membrane by reverse osmosis. However, using the treatment by reverse osmosis is limited by fouling of the membranes [16] and by the production of large volumes of the concentrate; which requires in turn: specific treatment. The obvious solution on this leachate treatment is to reduce the load prior to passage through these membranes. The technique used in our study is the coagulation-flocculation.
Among many proposed physical-chemical methods [16, 21-23, 27], the coagulation-flocculation-sedimentation remains a relatively simple technique [6-8,13], mainly applied for the removal of heavy metals and organic compounds [3,15,17], and widely used for the treatment of water which contains a high organic matter [8]. Many factors can influence the effectiveness of such treatment: coagulant type, pH, temperature, mixing speed, the

retention time [14].
Before the passage to pilot testing, a study was conducted in the laboratory, to determinate treatment performance based on different parameters: the characteristics of the pretreated leachate, coagulant type, pH, retention time. And also the elimination of certain parameters: COD, turbidity, pH, conductivity and OM content were performed.
Several tests were realized using various coagulants as ferric sulfate $Fe_2(SO_4)^3$, ferric chloride ($FeCl_3$), aluminium sulphate ($Al_2(SO_4)^3$).The choice of ferric chloride coagulant was dictated by its efficiency to reduce turbidity and organic matter in the leachate, in addition to its validation by previous studies, the iron salts seem to be more effective than the aluminum [16, 21].
This article reproduces the results of coagulation-flocculation treatment followed by a decantation over a period ranging from 2013 and 2014. The tests of the performance of this treatment according to the ferric chloride content showed that optimization was at a concentration of 0,65g $FeCl_3$ /l. In parallel, in order to avoid the adverse effects of pH on the membranes of the reverse osmosis, pH adjustment should remain limited between 4 and 9.

2. Experimental

The physical-chemical analyzed the leachate samples at the outlet of the decanter and before entry to the processing units using reverse osmosis as well as the samples of the supernatant after treatment with coagulation-flocculation. The monitoring of the pH is done by using a pH meter 206 Lutron, the conductivity using the conductimeter WTW LF90, the turbidity using the turbidimeter portable 2100P, and COD analysis using the process AFNOR NF T 90-101. The organic matter content is determined by the evaporation of samples in porcelain capsules weighed at first, then in an oven at 105°C and then reweighed, then after conditioning these capsules in oven at 550°C, which is cooled and reweighed.
The flocculation-coagulation tests were performed according the Jar-Test protocol (JLT6 Leaching VELP Scientifica) which comprises 6 agitators, is equipped with 6 beakers that allow to stir simultaneously and at the same speed the leachate solutions and the coagulant. The coagulant used is ferric chloride ($FeCl_3$ 6H2O) as a classical coagulant at a concentration of 0,65g $FeCl_3$ /l. In the six beakers we add the same volume of leachate (700ml), same volume of $FeCl_3$ (70 ml) and different pH values (4,6 ; 5,7 ; 6 ; 6,4 ; 7), the pH is adjusted by addition of H_2SO_4. These beakers are subjected for 3 min at rapid stirring of 120 rev / min. The speed is thereafter reduced to 40 rev / min for a period of 20 min. After, the mixture is subjected to a decantation 15 min, 30 min, 45 min, 60 min. The performance of the treatment is expressed using the following equation:

$$RemovalEfficiency(\%) = \frac{(C_0 - C_f)}{C_0} \times 100,$$

C_0 and C_f the initial and final concentrations of each of the parameters (COD, turbidity, pH and organic matter).

3.Results and discussion

3.1.Characteristics of leachate

The characteristics of the selected sample of the leachate to the outlet of the decanter are summarized in the following table 1.

3.2.Effect of pH on turbidity

Figure1 shows the change in turbidity as a function of the retention time, for the different samples of pH compared with that of the control (pH 8.7). It is important to point out a very important reduction in turbidity of 82% for the sample to pH 5.7 and 67% for the sample to pH 6 just after 15 min.
The most important result of this experiment lies according to figure 2 in obtaining at pH 5.7, a reduction of turbidity - suspended matter- of the order of 82-84% after 15 minutes of decantation; the same remark is to be retained for pH 6 with a reduction of about 67%. In parallel, a slight variation in the pH ranging from 5, 7 to 6, causes a significant decrease in this abatement.

Table 1: Characteristics of the leachate

pH	8.7
Conductivity (µS/cm)	48700
Turbidity (NTU)	840
CDO (mg O_2/l)	14400
BOD_5 (mg O_2/l)	6200
Total Solids(g/l)	41.88
Organic Matter (g/l)	19.19
Temperature (°C)	16.6

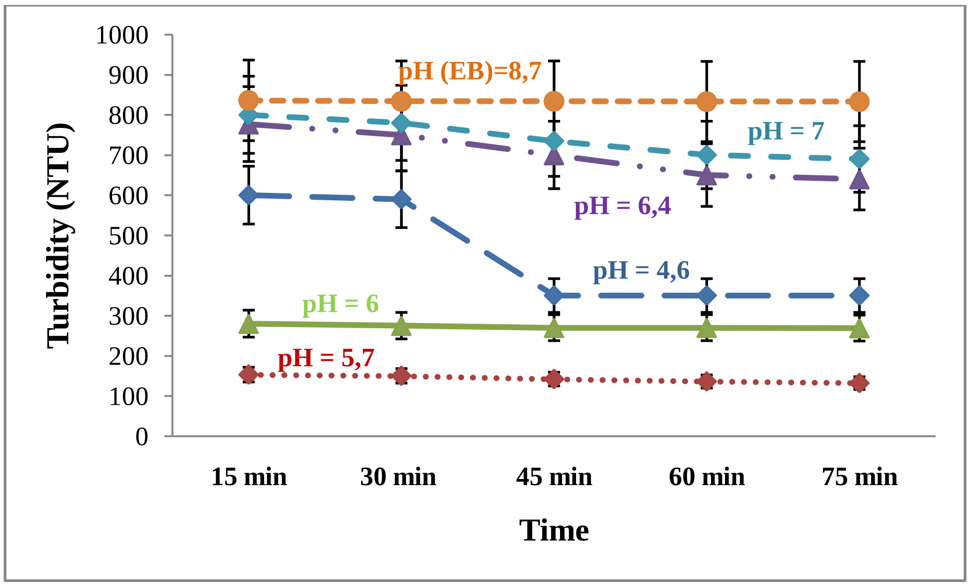

Figure 1: Variation of turbidity as a function with retention time

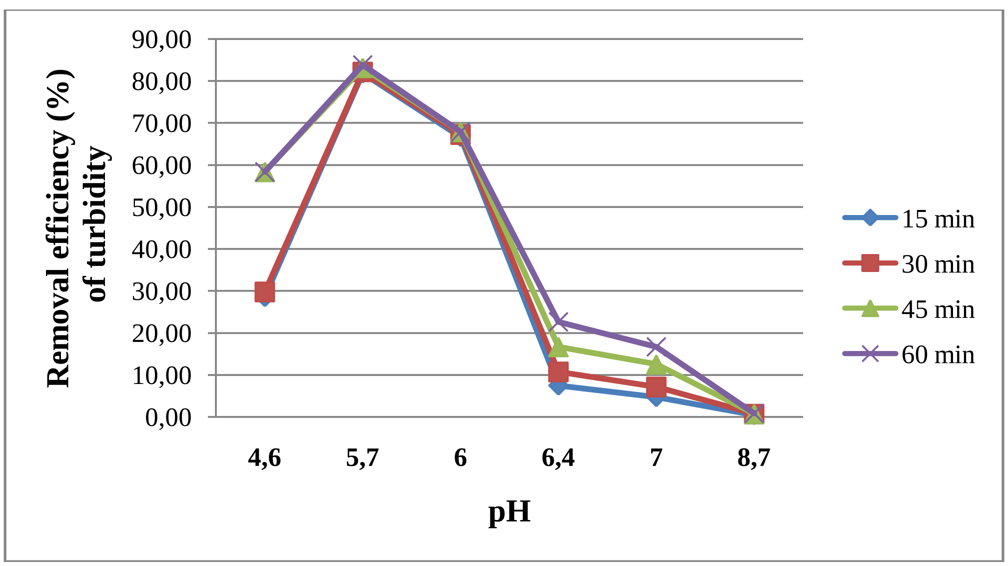

Figure 2: Effect of pH on the removal efficiency of turbidity with retention time

3.3.Effect of pH on conductivity

At the addition of $FeCl_3$, conductivity passes from 48,7 to 55,6 ms/cm, according to the results obtained in figure3, and notwithstanding the pH adjustment to values between 4,6 and 7, the conductivity does not undergo significant variation from 49 to 54 ; thus, the variation in pH has a slight influence on the conductivity, whatever the retention time.

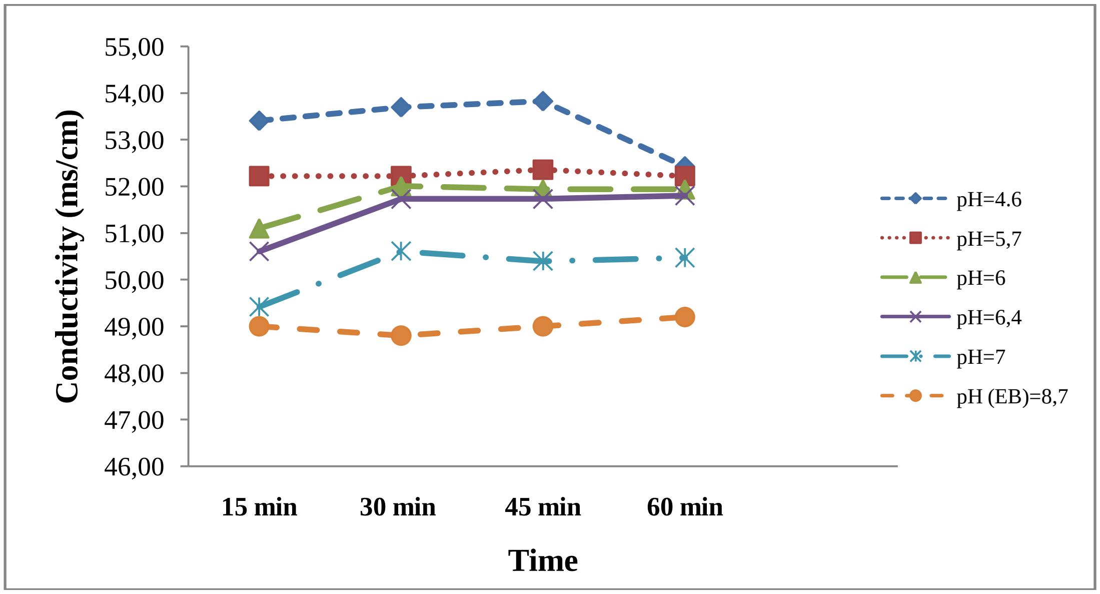

Figure 3: The effect of pH on the conductivity with retention time

3.4.Effect of pH on removal of COD

According to figure 4, the COD of the various treated samples, with the exception of pH 4.6, knows a decrease into function of time, which is important for the acidic pH values.

Best COD reduction yields are observed, by the figure 5, at pH 5,7 with an important reduction, in the first 15 min, from 72% to attain 86% after 60 minutes of decantation.

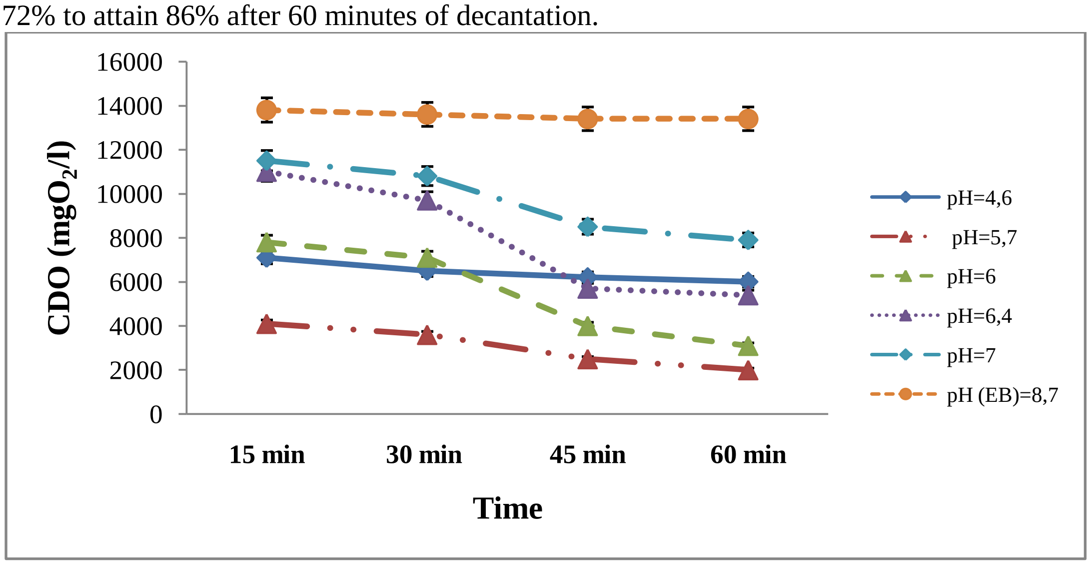

Figure 4: The variation the COD with retention time at different pH

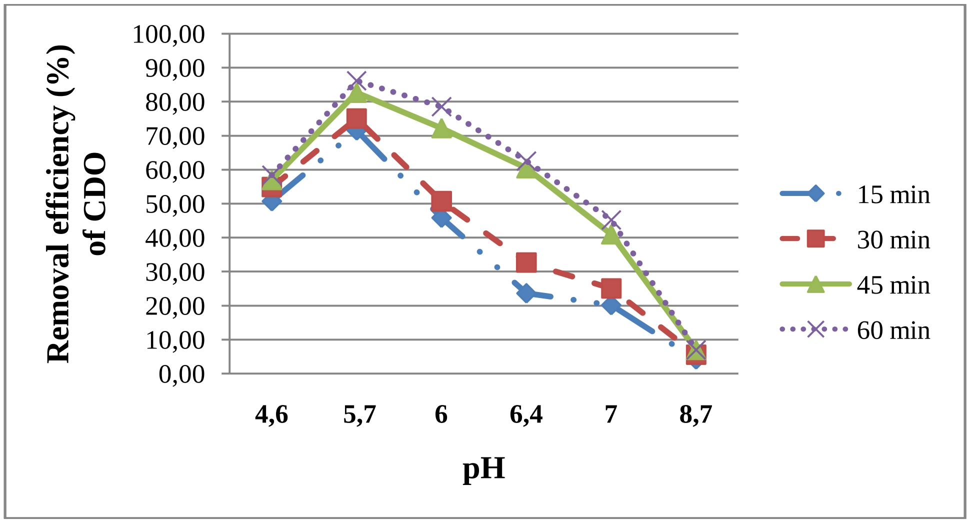

Figure 5: Effect of pH on the removal of CDO with retention time

3.5.Effect of pH on removal of OM

In parallel with the small variation in the OM content of the witness sample, Figure 6, the yield reduction of OM remains above 64% throughout the period of decantation and for different pH. Figure 7 shows that the adjustment of the pH between 5,7 and 7 leads to a significant reduction in organic matter and to more than 90% after the first 15 min.

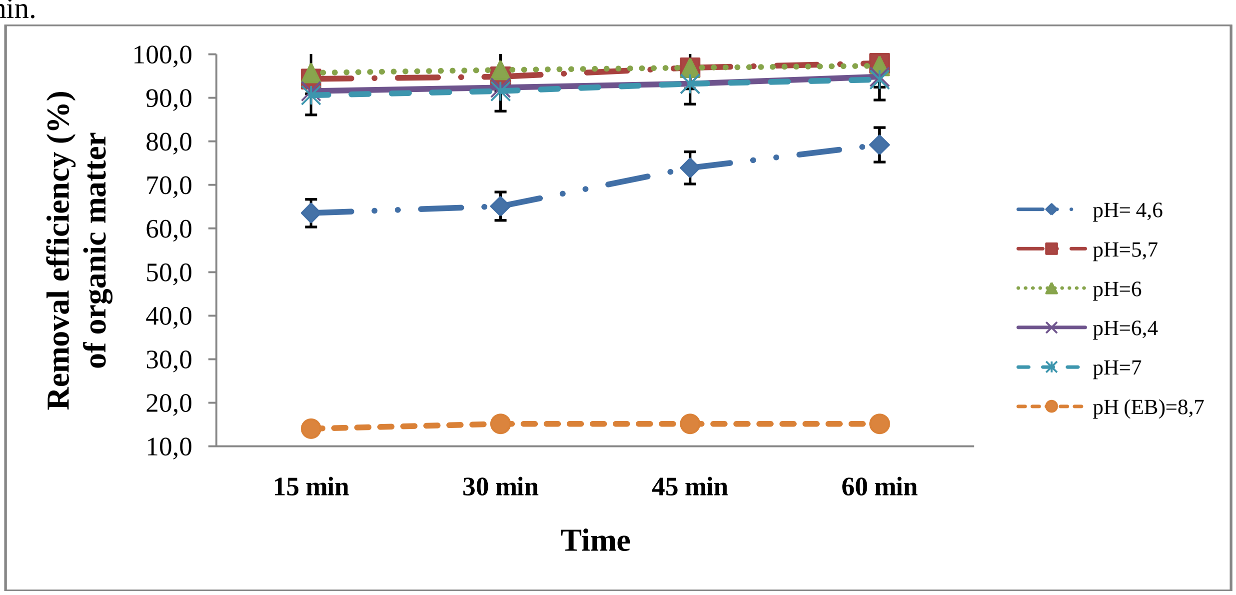

Figure 6: Removal of OM with retention time at different pH

3.6.Confirmation the removal efficiency optimization

Considering the importance of retention time on the dimensions of the treatment works, the optimization of the processes chosen consisted in confirming the results obtained and defining the optimal conditions. Thus, as shown in photo 1, the utilization of $FeCl_3$ after 15 min, allows to obtain after adjustment of pH ranging from 8,7 to 5,7, allows to obtain important removal efficiency in turbidity, COD and organic matter (figure 8).

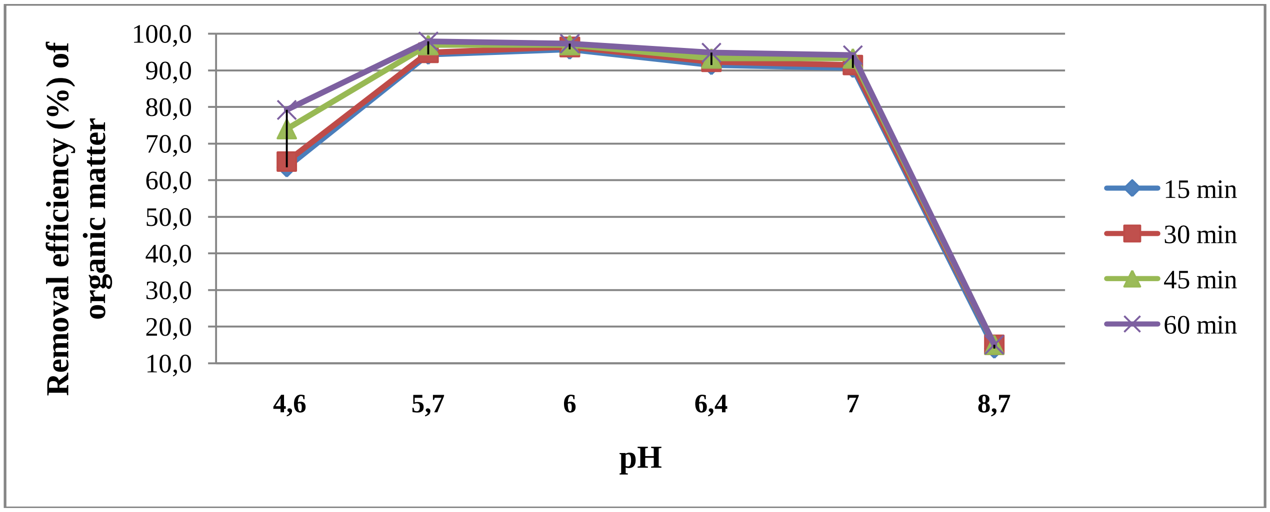

Figure 7: The effect of pH on the removal of organic matter with retention time

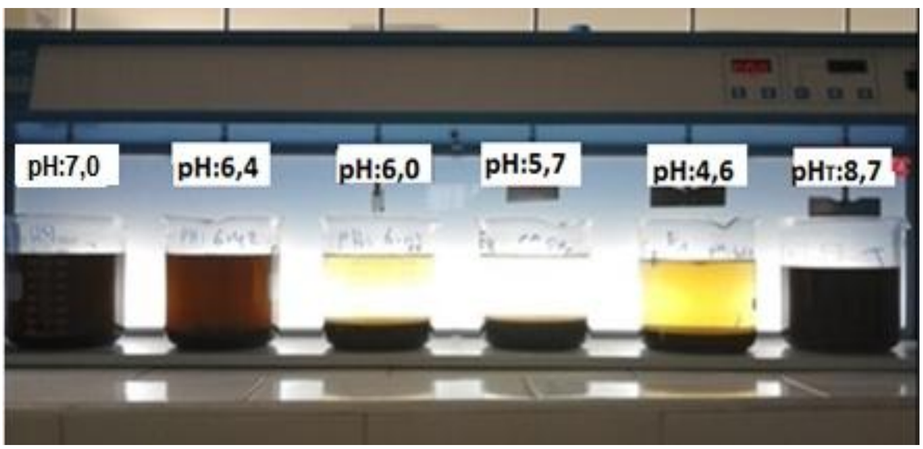

Photo1: Visualization of the results obtained after 15 min of decantation

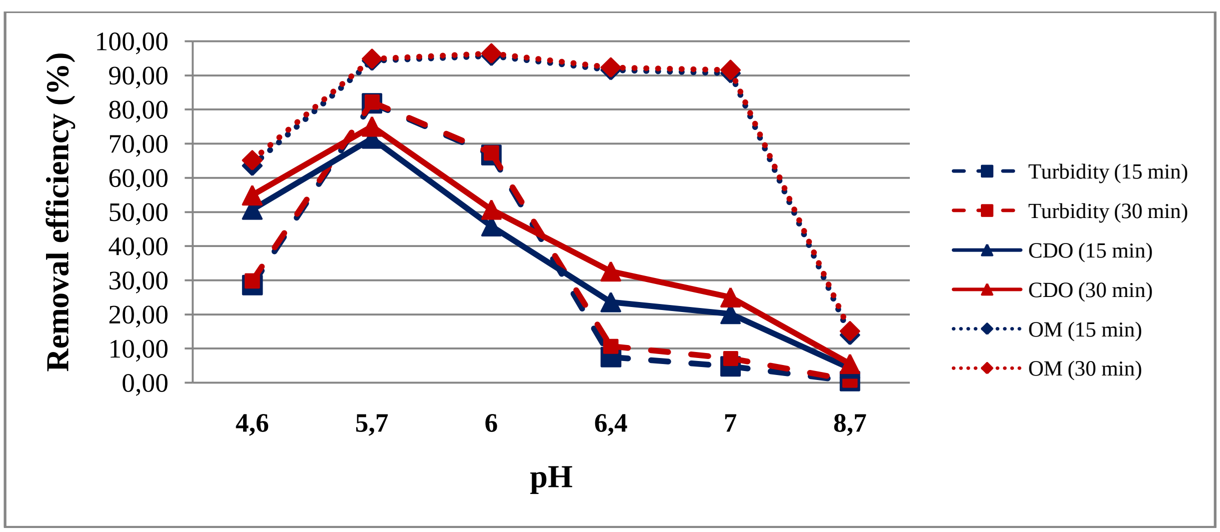

Figure 8: Removal efficiency of Turbidity, COD, OM depending on pH at time 15 and 30 min

Conclusion

These results confirm the choice of ferric chloride for coagulation flocculation of pretreated leachate. This method allows -after adjusting the pH to a value of 5,7- to obtain the first 15 minutes of decantation, important removal efficiency above 82% of turbidity, 72% of COD and 94% of the organic matter content. Such treatment, in addition to this removal efficiency and clarification of leachate, allows also reducing the dimensions of the decanters, given the small time needed to obtain these results.

Like all biological or physical-chemical treatment, the sludge are generated and require their laps the specific treatment. The advantage of being in a landfill is the use of thickened sludge in covering layers of buried waste.

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