ELECTROFLOCCULATION AS A TREATMENT METHOD FOR LANDFILL LEACHATE

Aline P. Dresch[1,*], Caroline P. Cenci[2], Luísa P. Morandini[2], João P. Bender[2] & Guilherme M. Mibielli[2]

[1] *Postgraduate Program in Environmental Engineering and Technology, Federal University of Paraná, Palotina, Brazil.*
[2] *Environmental and Sanitary Engineering, Federal University of Fronteira Sul, Chapecó, Brazil.*
* *Corresponding author's email address:* alinepdresch@gmail.com, guilherme.mibielli@uffs.edu.br

ABSTRACT

Due to the increase in waste production, landfills were created to minimize environmental problems. However, these landfills generate gases and effluents, such as leachate. Landfill leachate has a variable and complex composition. As a result, improper disposal can lead to water contamination and environmental hazards, which is why leachate treatment is required. Electroflocculation is characterized as a physical-chemical treatment and is based on the formation of coagulants in solution by applying an electric current between a cathode and an anode. Therefore, this work aims to study the changes promoted by the electroflocculation process in the treatment of landfill leachate in terms of Chemical Oxygen Demand (COD). The investigation of the combination of the process variables, pH and current intensity, was carried out employing a central composite experimental design, with two variables and three levels, obtaining a reduction in COD as a response. The treatment time was set at 40 minutes and two iron electrodes were used in a solution of 220 mL of leachate with constant stirring. After the experiments, the best condition was set at pH 3.00 and 100 mA and 80% COD reduction.

Keywords: Electrode. Leachate. Chemical Oxygen Demand.

1 INTRODUCTION

Since the approval of Law 12305[1], landfills have been created to minimize environmental problems due to the lack of treatment and proper disposal of municipal solid waste. As this waste decomposes, landfills generate gases and effluents such as methane gas (CH_4) and leachate[2,3]. Leachate from landfills has a variable and complex composition, with large quantities of dissolved organic acids, Chemical and Biochemical Oxygen Demand (COD and BOD), and chlorides, among others. Its formation is influenced by precipitation in the region, the type of waste deposited, the age of the landfill and the decomposition processes that take place inside the landfill cells[4,5,6].

In this way, its diffusion can contaminate water bodies and offer environmental risks. Therefore, leachate requires treatment capable of removing its contaminants. Treatments can be biological, physical-chemical, or through combined processes[6,7,8,9]. Electroflocculation is characterized as a physical-chemical treatment and involves the formation of coagulants such as Al^{3+} and Fe^{2+} through the application of an electric current between a cathode and an anode, mostly aluminum or iron electrodes. These coagulants interact with the slurry and disrupt its stability, leading to the formation of flocs that are capable of sedimentation[10].

Nowadays, electroflocculation is proving to be a very effective technique for treating wastewater, on both small and large scales, based on electrochemical methods. In this process, coagulation is formed by the passage of electric current, without adding other chemical elements[11]. Based on this, the aim is to study the changes in COD promoted by electroflocculation in landfill leachate treatment. In this context, the combination of the process variables pH and current intensity was investigated.

2 MATERIAL & METHODS

The leachate samples were provided by a company specializing in wastewater treatment and collected after a biological treatment. Samples were refrigerated on receipt at the laboratory and all assays were performed in triplicate. The variables' current intensity (mA) and pH were analyzed, setting the time at 40 minutes, with constant stirring. The electroflocculation process (power supply and reactor) is similar to Figure 1.

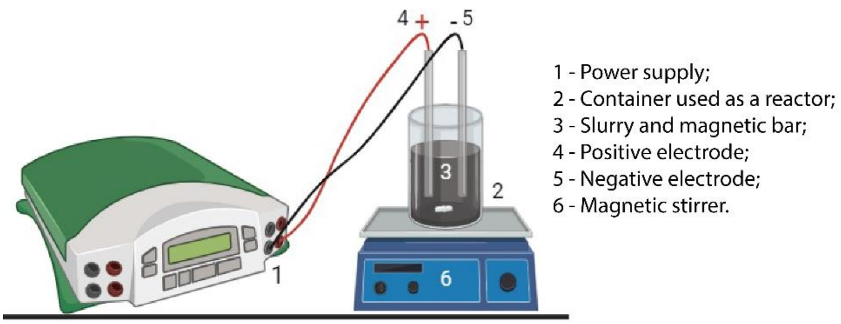

Figure 1 Electroflocculation reactor schematic.

Two iron electrodes were used (anode and cathode), with 1.5 cm distance between electrodes. The contact area was 18.85 cm^2 and the volume used was 220 mL of sample. The current density varied between 2.65 mA/cm^2, 3,98 mA/cm^2 and 5.30 mA/cm^2.

The study of the variables was carried out using an experimental design with two variables (pH and current intensity) and three levels, totaling 7 tests, with a triplicate at the central point. The pH was set at 3.00, 4.50, and 6.00, and the current at 50, 75, and 100 mA. Based on the literature, COD was defined as the response variable. Therefore, a triplicate was taken from each test to determine COD removal after electroflocculation.

The pH was achieved using drops of sulfuric acid P.A. Once the electroflocculation process was complete, the samples were left to rest for 24 hours and after this time, were filtered using a vacuum pump and filter paper. The COD samples were analyzed of the untreated leachate and the treated leachate (after electroflocculation).

The colorimetric method used for this study was based on the Standard Methods for Examinations of Water and Wastewater[12]. The analysis has been adapted, it started to add 1.5 ml of oxidant solution ($K_2Cr_2O_7$ + $HgSO_4$ + H_2SO_4 and deionized water), 3.5 ml of catalyst solution ($H_2SO_4/AgSO_4$), and 2.5 ml of sample. The tubes go to the digester block at 160 °C for 2 hours. After the digestion, the sample rests for about 30 minutes and is read in a spectrophotometer 1600/1800-UV Series Nova Instruments®. The interference of chloride ions was not considered.

3 RESULTS & DISCUSSION

The analysis results are in Table 1.

Table 1 The conditions used in the experimental design and the COD results of the seven tests realized.

Tests	Initial pH	Current intensity (mA)	COD (mg of O_2/L)
T1	3.00	50	1972 ± 198
T2	6.00	50	5564 ± 948
T3	3.00	100	1372 ± 537
T4	3.00	100	5811 ± 749
T5	4.50	75	5531 ± 590
T6	4.50	75	5344 ± 679
T7	4.50	75	5764 ± 410

In this case, the best result was the third test (T3) (initial pH 3.0 and current intensity 100 mA), which presented 80% COD removal after electroflocculation, see Table 2. Also, according the Figure 2, COD reduction contributes to a reduction in the color of the effluent.

Table 2 Comparison between untreated leachate and the best condition of seven tests.

Parameter	Untreated leachate	Treated leachate (T3)
COD (mg of O_2/L)	6.764 ± 820	1.372 ± 537

Figure 2 Visual reduction of color considering the untreated leachate and the best condition (T3).

A percentage of 65% COD reduction was observed for leachate pretreated with a biofilter, at pH 8.94 and a current density of 8.00 mA/cm² [13]. Thus, the numbers show that the percentage COD reduction depends exclusively on the composition of each leachate. Therefore, a direct comparison of the values obtained with the literature is not viable, since the composition is variable and depends on factors such as the type of waste deposited, the pluviometric conditions, and the age of the landfill.

4 CONCLUSION

The best condition for this research was reached with a treatment time of 40 minutes, pH 3.00, and a current intensity of 100 mA. Under these conditions, an 80% COD reduction was obtained. Also, the electroflocculation treatment can be used either as a pre-treatment or as part of an integrated treatment system.

REFERENCES

1 BRAZIL. Law No. 12305, of August 2, 2010. Establishes the National Solid Waste Policy; Amends Law No. 9.605, of February 12, 1998; and Makes Other Provisions. Brasília, DF.

2 MACRUZ, P. D. Evaluation of the treatment of landfill leachate using a coagulation/flocculation process with the coagulant tannin and aluminum polychloride (PAC). TCC - Environmental Engineering Course, Federal Technological University of Paraná, Campo Mourão, 2015.

3 GODOI, M. C. S. Treatment of landfill leachate using electrocoagulation and filtration. 2019. TCC - Environmental Engineering Course, Federal Technological University of Paraná, Londrina.

4 FERREIRA, D. DA S. Comparative study of coagulation/flocculation and electrocoagulation in the treatment of landfill leachate. 2013. Thesis - Chemical and Biological Process Technology Course, Federal University of Rio de Janeiro, Rio de Janeiro.

5 PORTO, T. M. et al. Experimental planning of the electrocoagulation process in the treatment of sewage leach. 2014. Blucher Chemical Engineering Proceedings. Vassouras, Rio de Janeiro.

6 PEREIRA, R. S. *et al*. Evaluation of leach treatment by electrocoagulation process associated with hydrogen peroxide as a catalyzer through the Fenton process. 2018. 11th International Symposium on Environmental Quality. Porto Alegre.

7 CABEZA, A. et al. Ammonium removal from landfill leachate by anodic oxidation. 2007. Journal of Hazardous Materials. 144 (3). 715-719.

8 MOHAJERI, S. et al. Statistical optimization of process parameters for landfill leachate treatment using electro-Fenton technique. 2010. Journal of Hazardous Materials. 176 (1-3). 749-758.

9 GOMES, N. A. et al. Influence of physical-chemical parameters on the composition of toxic constituents in landfill leachate. 2018. 23 (3). Magazine Materia.

10 DIA, O. et al. Hybrid process, electrocoagulation-biofiltration for landfill leachate treatment. 2018. Waste Management. 75. 391-399.

11 GRECCO, N. A.; SOUZA, B. C. A.; ZANONI, M. V. B. Electrocoagulation/electrofloculation for wastewater treatment: non-conventional electrodes and coupling of techniques. 2022. 45 (4). 410-423.

12 APHA. Standard Methods for the Examination of Water and Wastewater. 2000. Sections 4000 – 4500. 4-90.

13 DIA, O. et al. Electrocoagulation of bio-filtrated landfill leachate: Fractionation of organic matter and influence of anode materials. 2017. Chemosphere. 168. 1136-1141.

ACKNOWLEDGEMENTS

The authors thank the Federal University of Fronteira Sul – UFFS for providing the laboratories and materials used in the research.