Low cost Fenton process applied as additional stage in leachate treatment

POSTER
Ph.D. Student: N
Journal: YES

H.D. Traid[1,2]*, F.A. Schmidt*[1,2]*, M.L. Vera*[1,2]*, G. Escalada*[2]*, A.N. Dwojak*[1,2]*, C.G. Silva*[2]*, M.I. Litter*[3]*. (1) Instituto de Materiales de Misiones (CONICET-UNaM), Félix de Azara 1552, Posadas, Argentina, traidhernan@gmail.com (2) Facultad de Ciencias Exactas, Químicas y Naturales, Universidad Nacional de Misiones, Félix de Azara 1552, Posadas, Argentina (3) Instituto de Investigación e Ingeniería Ambiental, Escuela de Hábitat y Sostenibilidad, Universidad Nacional de General San Martín-CONICET, Campus Miguelete, Av. 25 de Mayo y Francia, Buenos Aires, Argentina.*

The variability and heterogeneity of the leachates produced in landfills have led to the application of AOPs as complementary stages to achieve an adequate treatment. In this presentation, a Fenton process was evaluated for application in the treatment of a real leachate. The influence of common variables such as pH, temperature, or reagent ratios is relatively well known. However, the main limitation for an extensive application of this technology is the treatment cost. In the Fenton process, about an 80% of the treatment costs can be attributed to reagents (Fe^{2+} and H_2O_2), whereby a compromise between the reagent concentration and the pollutant degradation must be taken into account. In the present work, a very low concentration of reagents and low cost operational conditions were used, achieving a significant decrease in COD and a high efficiency, with promissory results.

Introduction

By a combination of physical, chemical, and microbial processes, a municipal solid waste (MSW) generates a leachate where the pollutants contained in the solid are transferred to the liquid phase. The composition of the leachate depends on the MSW composition, landfilling technology, weather and leachate age [1]. The heterogeneity and variability in composition and generation rate of the leachate render a conventional treatment sequence insufficient to achieve the decontamination degree required by the regulations; thus, additional stages are necessary to complete the purification process [2,3].

Advanced Oxidation Processes (AOPs) generate the very reactive hydroxyl radical ($HO^•$), which is the principal oxidant to effectively destroy refractory compounds. One of the most used AOPs is the Fenton process, where H_2O_2 is activated by Fe^{2+} to generate strong reactive species, mainly $HO^•$ [4,5]. This technology can be included in the process of the leachate decontamination to improve its efficiency.

Although the influence of the Fenton variables on the efficiency of the leachate treatment is relatively well known [5 and refs. therein, 6], the application of this technology is not widely spread due to the treatment costs. About 80% of the treatment costs could be attributed to the Fenton reagents. In the present work, a very low concentration of the reagents and low cost operational conditions were used.

Material and Methods

Leachate samples were taken from the Fachinal sanitary landfill (Misiones, Argentina, 27º38´25´´ S, 55º48´0´´ W) after the first five treatment steps: facultative ponds, biological nitrification, coagulation-flocculation, filtration and chlorination [7]. The Table 1 presents the range of the values of COD, BOD, ammonia (NH_4^+), alkylbenzene sulfonate (ABS) and color in samples of the leachate determined by standard methods [8].

Table 1. Leachate characteristics.

Parameter	Range of the value [mg/L]
COD	2500-1250
BOD	90-80
NH_4^+	60-30
ABS	30-10
Color	8350-3500

For the Fenton experiments, $FeSO_4.7H_2O$ (Servinlab, industrial quality), H_2O_2 (Anedra, 30%), H_2SO_4 (Cicarelli, 25%) and Na_2CO_3 (Biopack, reagent grade) were used. 0.5 L of leachate was treated per assay.

COD was used as a global decontamination parameter and Na_2CO_3 was employed as an inhibitor of the remaining H_2O_2 of the process on the COD determination [9]. The COD reduction/initial $[H_2O_2]$ ratio was used to evaluate the efficiency of the reagents.

The initial conditions for the assays were established in previous works [7 and refs. therein]: atmospheric pressure, room temperature (25 ºC), initial pH 3, $[H_2O_2]/[Fe]$ molar ratio = 50, $[H_2O_2]$ = 0.2 M and magnetic agitation. In order to reduce the treatment costs, two strategies were adopted: the initial H_2O_2 concentration was decreased up to 0.05 M and the agitation was restricted to the reagent addition stage. Also, the influence of temperature, working at 40 ºC,

was evaluated for H_2O_2 0.1 M. The other variables remained unchanged.
Samples were taken periodically from the bulk of the solution for agitated assays and from the supernatant when the agitation was conducted during the addition of the reagent. The samples were labeled as: initial H_2O_2 concentration [M]-temperature [ºC]-agitation mode.

Results and Discussion

Figure 1 shows the temporal evolution of COD.

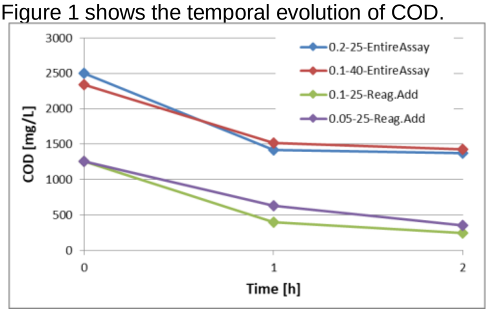

Figure 1. COD temporal evolution.

As noted, a lower initial reagent concentration slightly reduced the kinetics of the treatment. In all the assays, after 1 h of treatment, a relatively significant decrease in COD values was found. However, a COD reduction of about 1000 mg/L was achieved after 2 h for all assays, without influence of the initial reagent concentration or initial COD. The increase of the temperature, from 25 to 40 ºC, allowed to achieve almost the same COD reduction using half reagent concentration.

Table 2 shows the COD reduction/initial H_2O_2 concentration ratio for each assay after 2 h of treatment.

Table 2. COD reduction/initial H_2O_2 concentration ratio after 2 h of treatment.

Sample	COD reduction/initial H_2O_2 ratio [mg/L*M]
0.2-25-EntireAssay	5625
0.1-40-EntireAssay	9110
0.1-25-Reag.Add	10050
0.05-25-Reag.Add	18080

The efficiency was higher at a lower reagent concentration and in the samples taken from supernatant. This indicates that a settling stage after the Fenton process is highly recommended, allowing to treat the sludge separately and, eventually, incorporating an iron recovery stage, to reduce the operative cost of the agitation.
On the other hand, BOD, NH_4^{+}, ABS and color showed reductions of about 20, 50, 40, and 50%, respectively (not shown).

Conclusions

A Fenton process was successfully used as an additional stage to treat a real leachate and shown to be highly efficient under very low cost conditions: low concentration of reagents and agitation carried out only during reagent addition. These results are auspicious for an extensive application of a Fenton process as a step in the treatment of a real leachate.

Acknowledgments

The authors would like to CONICET (PUE-CONICET-2019-574-APN project) and to AESA Misiones S.A. to support this work.

References

[1] P. Kjeldsen, M.A. Barlaz, A.P. Rooker, A. Baun, A. Ledin, T.H. Christensen, *Critical Reviews in Environmental Science and Technology*, 32 (2002) 297.
[2] S. Renou, J.G. Givaudan, S. Poulain, F. Dirassouyan, P. Moulin, *Journal of Hazardous Materials*, 150 (2008) 468.
[3] M.I. Litter, M.E. Morgada, J. Bundschuh, *Environmental Pollution*, 158 (2010) 1105.
[4] Y. Deng, *International Journal of Environment and Waste Management*, 4 (2009) 366.
[5] J.J Pignatello, E. Oliveros, A. MacKay, *Critical Reviews in Environmental Science and Technology*, 36 (2006) 1.
[6] S.K. Singh, W.Z. Tang, *Waste Management*, 33 (2013) 81.
[7] H.D. Traid, M.L. Vera, G. Escalada, I.E. López, A.N. Dwojak, M.I. Litter, *Case Studies in Chemical and Environmental Engineering* 5 (2022) 100208.
[8] *Standard methods for the examination of water and wastewater*, L.S. Clesceri, A.E. Greenberg, A.D. Eaton (Eds.), New York, American Public Health Association, American Water Works Association, Water Environment Federation,1999.
[9] T. Wu, J.D. Englehardt, *Environmental Science & Technology*, 46 (2012) 2291.