

# Electroflux® Pilot Plant for Primary Wastewater Treatment of Leachate

Nilson Marriaga-Cabrales<sup>1\*</sup>, Fiderman Machuca-Martinez<sup>1\*\*</sup>, Dayana Donneys-Victoria<sup>1</sup>, Christian E. Alvarez-Pugliese<sup>1</sup>

1: Universidad del Valle. Cali, Colombia \* nilson.marriaga@correounivalle.edu.co

\*\* fiderman.machuca@correounivalle.edu.co

## ABSTRACT

The Electroflux® process consists of a stage of iron electro-dissolution and a subsequent flocculation step for the treatment of landfill leachate and other effluents. It has been developed at the Universidad del Valle since 2007 as a primary treatment, and has been patented in Colombia, Mexico and the United States.

In 2016, it was possible to scale up the process with the design, construction and set up of a portable pilot plant with capacity to treat up to 1,200 liters / hour. The pilot plant was installed at a sanitary landfill in Valle del Cauca (Colombia) region, and is coupled with a reverse osmosis system. Preliminary results are promising, after the Electroflux® process the flux in the reverse osmosis system increases up to 133% with a reduction of up to 66.8% in the chemical oxygen demand (COD). The recent application of the pretreatment at a pilot scale brings this technology to the market and bring closer the technological maturity, with several companies interested in testing the technology.

**Keywords:** landfill leachate, electroflux, wastewater treatment, electrochemical, iron.

## 1 INTRODUCTION

Landfill leachates are liquid effluents produced by the percolation of rainwater, extraction of water contained in solid wastes and due to biodegradation processes inside the landfill. This effluent represents a serious environmental challenge for final disposal sites, even after the useful life of the landfill, as they continue to be generated for decades. In the recent years, the leachate management at different landfills has been questioned generating interest at national and international level, which has led to the implementation of more stringent environmental regulations for the control of this liquid effluent.

This effluent is characterized by high concentration of suspended solids, inorganic salts consisting mainly of chlorides and sulfates, heavy metals such as lead, cadmium, nickel and chromium, organic and inorganic matter and ammoniacal nitrogen. This complex composition can cause an environmental imbalance if it is discharged in to water bodies. If it is irrigated in land can reduce crop productivity due to the inhibition of photosynthesis processes,

modification of soil structure. Also, can contaminate groundwater and adversely affect human health.

Many treatment methods [1] have been used to treat landfill leachate, such as biological, membrane, coagulation–flocculation, and flotation processes. However, the difficulty to satisfy the discharge standards requires the coupling of existing or novel technologies. Because of this, it is necessary to explore alternative treatments complementary to those currently implemented that are technically and economically feasible.

Membrane technologies like ultra-filtration, nano-filtration and reverse osmosis (RO) have been implemented in different landfill in Colombia, however they are presenting high maintenance costs due to incrustations, accelerated membrane damage and low permeate to concentrate ratio (in the case of RO), which is causing the increase of organic and inorganic matter concentration in the leachate lagoons or reservoirs.

New technologies like the Electroflux® process that consist of a stage of iron electro-dissolution and a subsequent flocculation stage has been developed as new primary treatment for several industrial wastewater [2]–[5]. In 2016, an Electroflux® portable pilot plant was designed and built to treat 1.2 m<sup>3</sup>/h of leachate. This plant was installed at a local landfill and operates as a primary treatment coupled to an existing RO plant. In the Electroflux® process, unlike electrocoagulation, flocculation is carried out in a separate step, enabling the formation of flocs to be controlled in a practical manner by the addition of auxiliary agents and with appropriate pH control. The energy consumption during electrocoagulation process are in the range of 4-58 kWh/m<sup>3</sup>[6], while in Electroflux® in can be less than 1 kWh/m<sup>3</sup> [2].

The variations in the characteristics of the feed effluent do not significantly affect the efficiency of the Electroflux® process, as usually happens with biological treatments. In addition, RO membrane fouling is avoided due to the pollutants removal at alkaline pH (>10) which favors the precipitation of calcium and magnesium ions, as well as the carbonate ions.

Thus, the Electroflux® process was considered as a potential pre-treatment for the leachate treatment process at a landfill located in the Valle del Cauca (Colombia) region.

Pilot scale test were performed for the removal of suspended solids content, chemical oxygen demand and hardness, that were generating operational problems during the downstream RO process.

## 2 EXPERIMENTAL SETUP

The continuous Electrofloxx® pilot plant for the landfill leachate treatment (Figure 1) has two sections, the first one is the electrolytic reactor where the flocculant-coagulant iron solution is being produced and the second one is the flocculation-sedimentation stage where the pollutants removal take place. In addition, it also includes a storage and dosing section.

The electro-dissolution of the iron electrodes (CS plates) in the electrolytic reactor is carried out on a sulfuric acid solution at a current density of 2 mA/cm<sup>2</sup>. In section 2, the raw leachate is mixed with high density lime slurry (35% in solids) to raise the pH. Then it is mixed with the iron solution which is pumped from the electrolytic reactor to promote coagulation. The leachate continues to a fast flocculation tank where anionic polymer is added to promote floc growth. The process continues towards a lamellar settler where the separation of the two phases occurs, a sludge phase that is removed by the bottom of the settler and the supernatant that is removed by the top and stored to feed the RO system.

The sludge from the settler is drained to a basket filter where it is concentrated to a humidity of 90%, the withdrawn water is returned to the process. The wet sludge is disposed in a drying bed external to the plant.

The supernatant was stored in a 20 m<sup>3</sup> tank and pumped to the RO plant. In total, the RO plant was operated in five batches with the Electrofloxx® supernatant. It is important to note that in lots 4 and 5 the RO unit was operated with new membranes, while lots 1, 2 and 3 were processed with membranes with 2 years of usage.



Figure 1: Electrofloxx® Pilot plant.

## 3 RESULTS

The chemical oxygen demand (COD) of the supernatant (Figure 2) decreased between 32.1% and 40.6% compared with the raw leachate; turbidity decreased between 43.2% and 51.1% and conductivity between 15% and 20.3%. On the other hand, the RO permeate obtained, when feeding the Electrofloxx® supernatant, present a conductivity reduction between 28.3 and 37.1% and COD reduction between 35.18% and 66.18% compared to the permeate generated with raw leachate.



Figure 2: Raw leachate and Electrofloxx® supernatant.

Table 1 presents the RO flow rate and differential pressure data for the five batches. When the supernatant was used to operate the RO system, permeate flow rate was increased over 177% at a lower operation pressure ( $\Delta P$  up to -58 psi), this behavior can be observed in Figure 3. Additionally, permeate flow rate remained above typical values for more than two hours after suspending the supernatant feed.

Table 1: Summary of RO flow rates with Electrofloxx® supernatant.

Batch	RO 1*	RO 2**	RO 3***	Flow rate increase (%)	$\Delta P$ (psi) Electrofloxx® vs raw leachate.
1	9.00	5.95	9.30	56%	-5.39
2	9.00	7.04	13.80	96%	-10.64
3	9.00	5.51	10.96	99%	-9.00
4	9.00	5.34	8.76	64%	-7.50
5	9.00	3.00	8.31	177%	-58.54

\*RO 1: Concentrate flow rate (m<sup>3</sup>/h).

\*\*RO 2: Permeate flow rate (m<sup>3</sup>/h) fed with raw leachate.

\*\*\*RO 3: Permeate flow rate (m<sup>3</sup>/h) fed with Electrofloxx® supernatant.

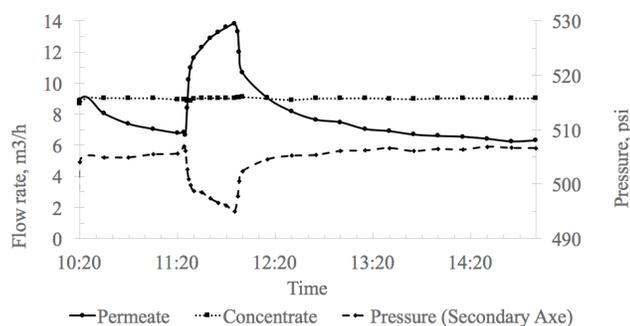


Figure 3: Reverse osmosis flow rate and pressure profiles for batch 2.

In the case of the COD parameter, when the RO unit operates with the old membranes (batches 1, 2, and 3), the Electroflux® supernatant allowed to fulfill with the legal discharge limit (COD <2,000 ppm). However, when the new RO membranes (batches 4 and 5) were used the supernatant's COD is reduced by one order of magnitude (<200 ppm).

Additional characterizations of the raw leachate and supernatant revealed that almost all the calcium and iron were removed by 100% and 99.6% respectively. This result is relevant because during the Electroflux® process there is a continuous dosage of calcium and iron as coagulating agents exceeding the effluent discharge limits, however it is evident that the amounts added in the process were successfully removed in the sludge.

The pH range for water discharge limit in Colombia is between 6 and 9 units, however, the effluent produced in the Electroflux® process and the RO permeate has a pH close to 10 units, due to the nature of the alkaline precipitation process. The pH can be adjusted in the permeate storage tank with low dosages of nitric or sulfuric acid.

The average pH value obtained for the sludge was 10.7 (minimum value 9.5, maximum value 11.19), which reflects that the Electroflux® sludge has an alkaline pH. This pH value is beneficial, since most microorganisms cannot survive to this condition, as is the case of total and fecal coliforms, molds, yeasts, clostridium, sulfite-reducing bacteria, among others.

Regarding the microbiological parameters in the sludge, there was an absence of fecal coliforms. This can be also associated with the pH of the sludge samples, since the pH range for their growth is between 4.0-8.5. In the case of pathogenic bacteria such as E. coli, there was no presence in the sample, so it can be inferred that the mud does not present contamination associated with fecal matter. For helminth eggs the results show no presence, this is a key parameter to guarantee the safety of the biosolids. These

results established the harmless condition of the Electroflux® sludge.

Finally, the Figure 4 shows the color removal effect on the RO permeate samples when operating with Electroflux® supernatant and raw leachate.

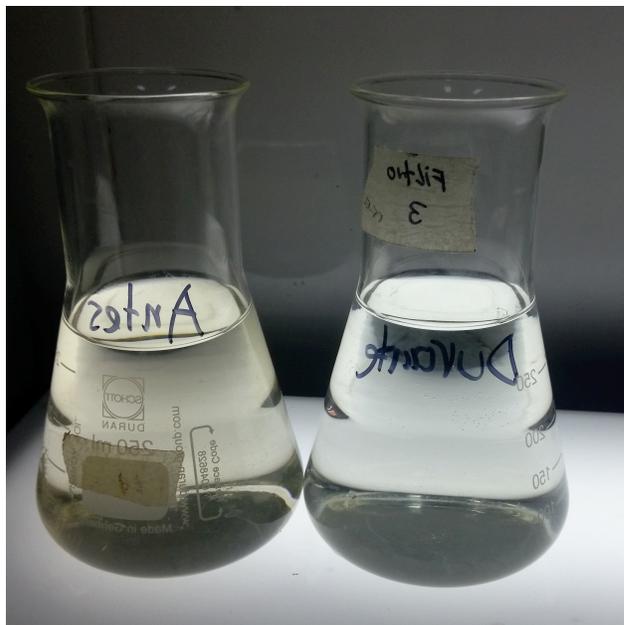


Figure 4: Permeate produced in the batch 5, with new RO membranes. (Left: operation with raw leachate. Right: operation with Electroflux® supernatant).

## 4 CONCLUSIONS

The most outstanding result of the Electroflux® process coupled with a RO system for the treatment of leachate from a regional Colombian landfill, is the increase in the permeate flow rate during the whole operation up to 177%, when the RO was fed with the Electroflux® supernatant, also, the RO operates at a lower pressure; then less fouling occurred in the membranes which translate into longer life of the RO system, ensuring lower operation and maintenance cost (due to the increase in the time interval between chemical cleaning procedures). Additionally, it was evidenced that the amounts of calcium and iron added in the pretreatment were successfully.

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