Evaluation of the fouling potential of landfill leachate treated by coagulation/flocculation in nanofiltration and reverse osmosis processes

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The production of municipal solid waste (MSW) represents one of the greatest challenges of nowadays (Alfaia *et al*, 2017). Globally, population growth combined with technological advancement contributes to the significant increase in solid waste generation, representing a significant risk to the environment and public health (Dolar *et al*, 2016).

Landfill is the most widely used technology worldwide, and is considered a safe solution for the treatment of waste, even generating leachate and biogas, effluents with potential to cause environmental impacts (Dong *et al*., 2014). The need to treat leachate mainly to remove organic material and ammonia nitrogen, as well as other toxic components, is a fundamental prerequisite to comply with the criteria for the discharge of effluents into recieving bodies.

However, in the case of mature landfill, biological treatment is not enough to reach the required level of removal, especially in the case of leachate with recalcitrant characteristics (Renou *et al*., 2008). Therefore, the association of other treatment techniques for the quality of the final effluent to acquire the necessary standards for disposal (Renou *et al*., 2008). In this context, several works in the literature indicate that the combination of physical-chemical treatment (coagulation/flocculation) with membrane separation process (MSP) can be a promising alternative for the treatment of leachate (Zhang *et al*., 2013).

To assess the treatability of the leachate with NF or RO membranes the SDI (silt density index) or MFI (modified fouling index) can be used (Metcalf & Eddy, 2003). The sample must be passed through a 0.45 µm filter at 210 kPa gage to determine any of the indexes. The SDI is defined as follows:

$$SDI = \{100[1-(t_i/t_f)]\}/t \quad (1)$$

Where t_i= time to collect initial sample of 500 mL;
tf= time to collect final sample of 500 mL
t= total time for running the test.

MFI is determined using the same equipment and procedure used for SDI, but the volume is recorded every 30 s over a 15-min filtration period. Derived from a consideration of cake filtration, MFI is defined as follows:

$$1/Q = a + MFI \times V \quad (2)$$

Where Q= average flow, L/s
a= constant
MFI = modified fouling indesx, s/L^2
V= volume, L

The objective of the present work was to evaluate the potential of fouling in membranes after pretreatment of coagulation-flocculation process of raw leachate.

In this work, samples of stabilized leachate from Gericinó controlled landfill (Rio de Janeiro City, Brazil) were used. The physicochemical parameters were determinated according to APHA (2005). In order to determine Humic Substances (HS) was used colorimetric method described in Sheng *et al.* (2007) and Šir *et al*. (2012).

The coagulation/flocculation process was performed as pre-treatment of the leachate, for which both $FeCl_3$ and $Al_2(SO_4)_3$ were applied as coagulating agents. The dosage of the agent and the initial pH were also evaluated. In order to compare the efficiency of removal of the pollutants by these two coagulant agents, the initial dosages applied were standardized to equal cation values (86; 172; 345; 517; 689 and 1378 $mgFe^{3+}/L$ or $mgAl^{3+}/L$).

The MFI (modified fouling index) and SDI (silt density index) parameters were used to estimate the formation of deposits in the nanofiltration (NF) or reverse osmosis (RO) membranes. For this purpose, the

pressurized flat membrane system was used in which the effluent passes through a 47 mm diameter microfiltration membrane at a fixed pressure appropriate to the respective test according to ASTM D8002-15 and D4189 -07 (ASTM, 2002). The tests were performed in duplicate.

Table 1 presents, in summarized way, the results of best conditions of coagulation/flocculation process and fouling index measurements.

Table 1 Results of coagulation/flocculation (at best conditions) and fouling index

Condition	COD (mg/L)	TOC (mg/L)	Absorbance at 254nm	Color (mg/LPt-Co)	N_{NH3} (mg/L)	Chloride (mg/L)	HS (mg/L)	MFI (s/L^2)	SDI
pH 6 + 3000 mg$FeCl_3$/L	650	248	3.6	2883	620	3143	250	600	16.57
pH 6 + 4000 mg$Al_2(SO_4)_3$/L	650	338	4.8	377	816	2600	217	$3.58x10^4$	18.37
Raw leachate	1460	460	24.70	3295	1683	2703	560	$1,64x10^6$	19.58

Since SDI measures suspended solids, mainly colloidal material, derived from silicates of aluminum or iron and organic material (Kucera, 2010), it is probable that a portion of the pollutant material remained in solution, so that the value of SDI was not significantly reduced despite the long removal of suspended material by pretreatment. The MFI of leachate pretreated with $FeCl_3$was 100 times lower than leachate pretreated with $Al_2(SO_4)_3$ and about 10000 times lower than raw leachate. This can be attributed to the influence that the organic matter exerts on the MFI. Therefore, the results showed coagulation/flocculation would be a good pretreatment for nanofiltration or reverse osmosis treatment of landfill leachate.

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