Experimental study of clogging in drainage systems

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ABSTRACT:

In the systems that compose the contamination control on sanitary landfills there is a risk of occurring biological clogging of geotextile voids. This phenomenon consists on blocking the interface soil/filter by existents microorganisms on the liquid waste of deposited material in the landfill (leachate), harming the drainage systems development, during its lifetime. The biological clogging evaluation is very important on sanitary landfills, because, although there was no risk of biological degradation of the polymer, the leachate can show deposition of iron salts and microorganisms that may causes of clogging. The purpose of this study is to assess the biological and physical clogging of geotextiles using permeability tests with recycling leachate. Each trial test lasted thirty, sixty and ninety days. Two different types of geotextiles with the same mass per unit area (250 g/m^2), woven and continuous filament nonwoven were used. In order to simulate a real condition of field application in laboratory, an interface of materials with rock placed on the top of the geotextiles was used. The geotextile was characterized by porosimetry test to obtain the average diameter of the voids of the tested specimen. After each series of permeability tests, the microorganisms present in leachate and the development of the biofilm were observed by scanning microscopy. The results indicate significant clogging and allow a comparison between the types of geotextiles studied, indicating estimates of drainage systems lifetime on sanitary landfills.

1 INTRODUTION

Due to the huge expansion of the urban centers and the increase of population occurred since industrial revolution, when the population started to migrate to the cities, it has been noticed a gradual raise in the production of solids wastes, as a consequence of this phenomenon. The inappropriate treatment of these wastes is causing a big impact to the environment, mainly the contamination of soil, water table, and air. The engineering tries to contribute with the decrease of these impacts, using and developing techniques and solutions that make possible such purposes, for example, building sanitary landfills, and using manufacture materials in substitution of natural filters systems.

The filters and drainage systems made by natural materials, such as sand and gravel, are being replaced by synthetic materials, mainly due to difficult of obtaining good quality natural materials, beside restrictions imposed by environmental agencies, and the difficult of transporting materials from great distances. Another important factor for the use of synthetic materials is that they replace the natural materials with many advantages. Noteworthy the agility of execution of work, transportation and stocking facility, costs reduction with hand labor and thickness reduction of filter layer causing an increase in storage capacity of the landfill waste.

Two criteria must be met in designing of filtration system: the retention and the permeability. The permeability criteria shows that the filter must allow the flow without reduction of hydraulic energy. Designing retention criteria is used to assure the obstruction of soil particles transported by flowing fluids inside of geotextile. Giroud (1992) related that the lost of soil for passage in nonwoven geotextile must not be higher than 30%, while for woven geotextile this lost cannot be higher than 4%.

Palmeira and Gardoni (2000) show that physics clogging occurs with particles higher than geotextile voids size. Palmeira (2003) related three possible causes of occurring physics clogging: the blinding, blocking, and internal clogging. Others researches show the influence of the biological clogging in the filter systems (Cancelli and Cazzuffi, 1987; Koerner and Koerner, 1990; Yaman, Martin and Korkut, 2005; Palmeira et al., 2006).

In this context, this paper presents the experimental study of clogging and filters and drainage systems, focusing on the possible kinds of clogging that could occur on the exposed geotextile. A basaltic rock prefilter was used, and the test was realized without prefiltering of leachate, enabling biological and physical clogging. The chemical clogging analyses is necessary, but it was not the focus of this research.

2 MATERIALS

Two types of geotextiles were used in this research, a continuous filament polyester nonwoven and a polypropylene and polyethylene woven, both with same mass per unit area (250 g/m²). The materials were characterized by permissibility tests, in accordance with ASTM D 6767-08 and porosimetry tests. Leachate collected from São Carlos sanitary landfill and basaltic rocks were used.

3 METHODS

The porosimetry test consisted in the intrusion of mercury under pressure in the geotextile for the determination of some aspects of the porous medium, such as opening sizes and the distribution of diameters in the sampled area. The equipment used was a PoreSizer Micromeritics 9320, which has a range for testing of distribution of pores from 300µm to 0.006µm, using a pressure varying from 0.5 psi to 30,000 psi. This test was conducted with the purpose of characterizing the material, focusing on area and volume of pores. Table 1 shows the results of porosimetry analysis in each geotextile.

Table 1 results of tests on porosimetry

Parameter	Nonwoven Geotextile	Woven Geotextile
Total pore area	27.240 (sq-m/g)	4,952(sq-m/g)
Median pore diameter (volume)	105.9756 æm	88.2951 æm
Median pore diameter (area)	0.0086 æm	0.0075 æm
Average pore diameter (4V/A)	0.4011 æm	0.0718 æm
Bulk density	0.1126 g/mL	0.6087 g/mL
Apparent density	0.1626 g/mL	0.6436 g/mL
Porosity	30.75 %	5.41 %

For the development of the research were manufactured three permeameters, where specimens were placed at half the height of the permeameter, submitted to an upflow of leachate. Figure 1 shows the layout of the equipment used in research. A pre-filter composed of basaltic rock was installed to simulate a real field situation. This rock was chosen because it do not influence the physical clogging of geotextiles, and do not consider reduce hydraulic energy in the pre-filter significantly.

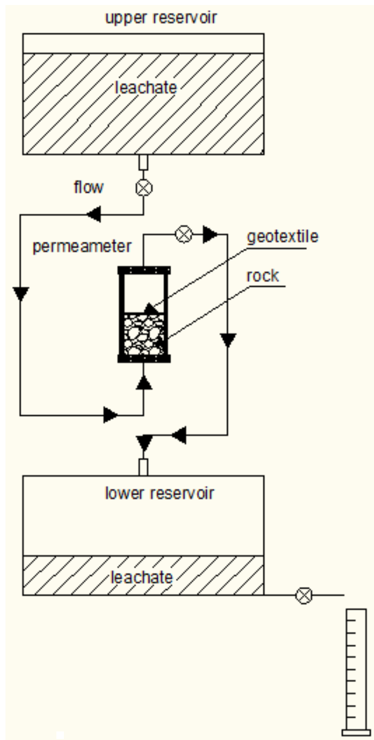

Figure.1 Layout of equipment used to measure permeability

The test consisted of a total of five readings of flow rates for each day analyzed to minimize possible errors in reading. It was used two different types of geotextiles with the same mass per unit area (250 g/m^2), a woven and a nonwoven with continuous filament. The materials were subjected to tests porosimetry tests in order to analyze the opening size of the materials, and permittivity, for performed with water flow, for characterization of materials and meet the criteria design proposed by Giroud (1992). The woven geotextile was chosen because there is few researches with them in the literature. On the other hand, the non-woven geotextile was chosen in order to compare its results with others from current literature.

The microscopy analyses were performed to evaluate the biofilm evolution over time. To perform these tests was necessary to remove the 1 cm^2 of the material, and a covering with a layer of gold to make the visualization the microorganisms possible.

4 RESULTS AND DISCUSSION

Through readings of flow rate was possible to calculate the permeability of geotextiles tested. The calculations show noticeable reduction permeability after first days in the nonwoven, indicating a possible clogging of the material. However the woven geotextile had not demonstrated the same behavior, since there was not significant reduction of permeability, same may be physical clogging, because the leachate was not filtered before the test can present suspended solids. Figure 2 shows the behavior of materials, with respect to permeability of the period studied.

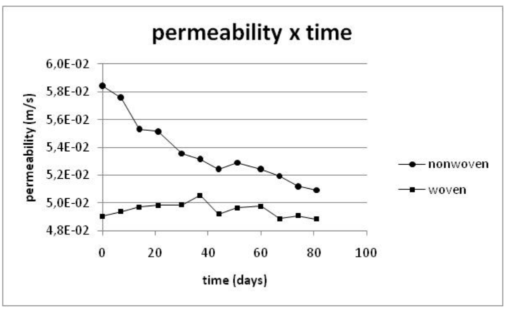

Figure.2 Variation of permeability x time

According to Figure 2 shows a tendency to clogging of nonwoven with time, because the coefficients of permeability tend to lower with time, until there is a complete blockage of the voids of the geotextile. The permeability coefficient of the woven geotextile shows that the capacity flow tends to remain constant, without clogging.

The calculations for reduction permeability did not take into account the loss on crushed rock, and the connections used in equipment, as seen previously.

Tests using scanning electronic microscopy showed that the nonwoven clogged in the first months of testing, as shown in Figure 3, which shows the evolution of the biofilm over time.

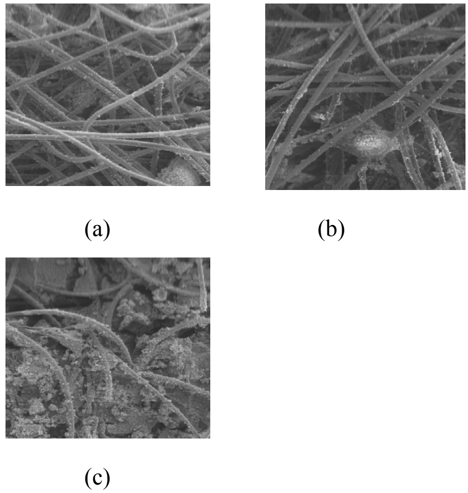

Figure 3-Nonwoven geotextile clogging: (a) 30 days; (b) 60 days; (c) 90 days

In woven geotextile is possible to see the formation of colonies of bacteria, specifically as seen in Figure 4 where it noted a greater physical clogging, due to the accumulation of solids present in manure.

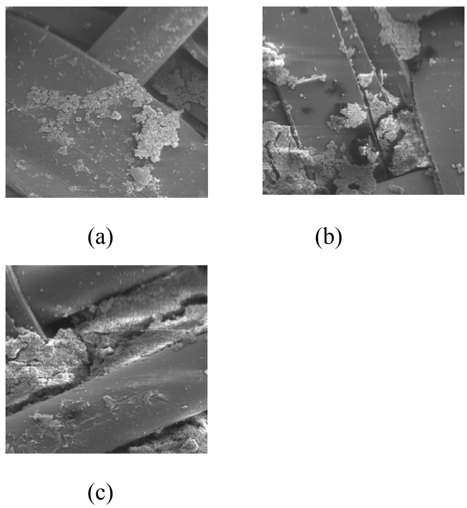

Figure 4-Woven geotextile clogging: (a) 30 days; (b) 60 days; (c) 90 days

Based on the permeability tests and scanning electronic microscopy it was possible perceived the clogging of nonwoven geotextile more than perceived in woven geotextile, which remained with permeability almost constant during the tests. Microscopy also shows that there was formation of bacteria colonies and microorganisms in the nonwoven geotextile. However in woven geotextile there was a deposition of solids, but was not possible to verify the formation of bacteria colonies in the same. It was possible to verify that the permeability of the woven geotextile was not much affected by the deposition of solids, from the point of view of filter performance.

Porosimetry tests were important for estimating the pore diameter and the percentage of those scattered by the sample, it is possible to estimate the number of voids by area.

5 CONCLUSION

This paper examined the performance of woven geotextile and nonwoven geotextile subjected to flow of leachate. Through this it was possible to reach some conclusions, described below:

- The equipment allowed a simplification of the test and showed consistent results;
- The test porosimetry allowed an estimate with respect to opening size and the quantity existing in the sample;
- The geotextiles showed different behavior with respect to reduction of hydraulic energy;
- The nonwoven geotextile showed biological clogging, while the woven geotextile showed physical clogging;
- The test demonstrated the evolution of the biofilm over time by scanning electron microscopy.

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