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Management of The Area of Deposition of Industrial Liquid Effluents According to the Fractal Dimension of the Soil

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ABSTRACT

The industries that deposit liquid effluents in the soil have the concern that this liquid does not reach the water table and, also, do not form great basins located in open pits. In the absence of any other method of immediate control, the most suitable solution for the liquid deposition is allowing only superficial infiltration of the liquid residue in the area, in a way that it does not reach the water table. In some cases, it could be adopted double or triple's soil layers. For example, a first layer would absorb liquids at a higher rate and a second one would retain and incorporate the pollutants, until those pollutants could be mechanically removed. That simulation could be made through a certain combination of soils with their appropriate fractals dimensions. The soil structure has relationship with the infiltration rate of liquids into his interior, and the fractal dimension could be used as an important tool for the knowledge of that structure. The objective of this work is to study the of infiltration rate of water in two types of soils to supply subsidies to the management of industrial effluents. For the soil with fractal dimension 2.70$\pm$0.002, in a time of 50 minutes, the front watering height was of 15 cm and, for *the soil with fractal dimension 2.49±0.001, in the same time, the front watering height was of 37 cm.*

KEYWORDS: effluent, fractal, soil.

INTRODUCTION

One of the biggest problems that the industries face is the destination of the liquid effluents. Many of these industries opt for sending those effluents to the soil, expecting them not to reach the water table, not to accumulate out doors and be able to be removed when necessary. However, there is no technology up to now to provide an efficient management, but the technology derived from the fractals (MC-D) can collaborate with that activity.

This work related the fractal dimension to the infiltration rate of water in an Alfisol and an Oxisol. The fractal dimension (D) was determined by the MC-D method (SPADOTTO et. al., 1996) and the front watering rate was determined in columns of acrylic through attenuation of the gamma radiation. The results show that the front watering rate is larger in Oxisol, and this agrees with the concept of fractal dimension that states to exist bigger empty spaces in porous materials with larger fractal dimensions.

The fractal dimension has been used in agrarian areas with interesting results, particularly, as far the soil study is concerned, and in this sense, several applications of fractal dimensions were discovered.

In the course of the research, PERFECT & KAY (1992) made use of the fractal theory to study the distribution of the sizes of soils particles. The values for fractal dimension found in that work ranged from 0.67 to 3.92 for D related to the number of particles, and from 0.79 to 4.06 for D related to the mass. These results were contested by some authors, understanding that, for volumes, the values should vary between 2 and 3, agreeing, with the Euclidean Dimension. Objections to values of fractal dimension higher than 3 for volumes were increasing and in the work done RIEU & SPOSITO (1991) relating density and mass of soil aggregates, it was found values of D =2.88 for sand , D=2.91 for sand + clay and D=2.95 for clay. These results point to a relation of the size of the soil particles to the fractal dimension, in the sense that larger particles result in smaller values for D. The authors, also, suggest that the spaces of the pores in plastic soils can exhibit characteristics of structure of fragmented fractal, even so, never surpassing the value 3 with fractal dimension. Agreeing with that work, SCOTT & STEPHEN (1992) related the mass percentage and the ray of the particles, finding values of D between 2.40 and 2.96, and these values increased as the ray decreased and the mass increased.

RIEU & SPOSITO (1991) that supply a distinction between the fractal dimension for aggregate size and a measure of the relation of density and size of the aggregate, reinforcing the method used in that work (MC-D) which relates a compacted volume to the cubic root of the mass of that volume.

This work has the objective of relating the fractal dimension of soil determined by MC-D to the speed of water infiltration in this means, to supply subsidies to the Sustainable Development and Environmental Geotechnology.

ANALYSIS

Samples of Oxisol (LVA) and Alfisol (TRE) collect at Fazenda Lageado (UNESP-Botucatu) were used and were dryed in the air for four days in covered and ventilated environment. A column of acrylic was filled with each soil and presents the following dimensions:

Table 1. Characteristics of the experimental columns.

INTERNAL DIAMETER (cm)	HEIGHT (cm)	THICKNESS OF THE WALL (cm)
5.3	50.0	0.3

Each soil was compacted under different natural densities. The determination of the density of Oxisol and Alfisol in the column was made using a gamma radiation transmitter (Robotron 20046), having as active source ^{241}Am, using the following methodology:

01. Measurement of the environment radiation (BG), using the average of three measures (at the beginning of the measurement, in the middle and at the end);
02. Measurement of the radiation without absorber, for verification of the repeatability of measurement of the equipment.
03. Measurement of the attenuation of the columns (Io) done in the heights of 2 to 44 cm, varying each 2 cm.

The densities were calculated following the equation below:

$$\rho = \ln\left[(Io - BG)/(I - BG)\right]/\mu \qquad (1)$$

where,
ρ= density of the soil (g/cm^3);
Io = attenuation of the gamma radiation due to column of acrylic without the soil;
BG = radiation due to the environment (Background);
I = attenuation of the gamma radiation due to column of acrylic filled with the soil.

For the Fractal Dimension measure, we used the Cubets Method (MC-D) SPADOTTO et. al. 1996.

After the measurements described above, it was done the measurement of watering, in the following way:

01. Concentration 1molar of $CaSO_4$ was used to neutralize ionic activity of the soil and a tube of glass with internal diameter of 4 cm was filled, until a height of 40 cm, sealing its superior part to avoid the atmospheric load. In the inferior part, there are two exits, one is connected to the superior part of the acrylic column for the entrance

of water and the other opened to the atmosphere, ensuring same pressure in the entrance of water in the column.

02. The drop between the glass tube and each column guarantees the entrance of water beginning in the upper level of the column.
03. It was settled a relationship between the front watering height of and the time to reach it.

RESULTS

Three measures were made of each type of soil to determine the Fractal Dimension (D) according to the tables below:

Table 2: Measures of the fractal dimensions (D) of the Alfisol

Alfisol		
$V_2(cm^3)$	M(g)	D
7.19	8.72	2.73
7.50	9.42	2.70
7.19	9.08	2.68
	AVERAGE	*2.70*
	STANDARD DEVIATION	*0.0025*

Table 3. Measures of the fractal dimensions (D) of Oxisol

Oxisol		
$V_2(cm^3)$	M(g)	D
7.19	10.83	2.48
7.50	11.34	2.49
7.50	11.11	2.51
	AVERAGE	*2.49*
	STANDARD DEVIATION	*0.0015*

In times less than 50 minutes, that is where the front of watering rate has non-linear characteristics, therefore, more realistically fractal, the following table was set up:

Table 4: Depth of water front in 50 minutes or moisture profile in depth.

Oxisol	Alfisol
37cm	15cm

CONCLUSIONS

The Fractal Dimension of the Alfisol is larger than the one from Oxisol. It can be assumed that there are more empty spaces among the particles of Oxisol than from Alfisol. Therefore, it is easier for water to drain from an Oxisol soil. This fact agrees with the Theory of Fractal, and it allows that more scientific studies can be realized in this area in the future, to show for any type of soils, the relationship between the Fractal Dimension and the front of watering rate.

Then, new technologies can be developed promoting the fast infiltration of the effluents in the soil. This would avoid the superficial accumulation and retaining them for a longer time in the second layer of soil, in order not to let them reach the water table.

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