Transport Parameters of Electrical Conductivity of Wastewater in Brazilian Soils

Joelma Sales dos Santos[1], Leda Veronica B. Dantas Silva[1], Vera Lúcia Antunes de Lima[1], João Carlos Ferreira Borges Júnior[2], Fillipe Araújo do Nascimento[1]
[1] Universidade Federal de Campina Grande, [2] Universidade Federal Rural de Pernambuco
Corresponding author's E-mail address: joelma_salles@yahoo.com.br

ABSTRACT

To evaluate the behavior of electrical conductivity (CEa) from treated domestic wastewater and swine trials took place in columns of glass with Argisol Red-Yellow Eutrophic and Entisol soils. The columns were filled up to 20 cm high with particles of diameter less than 2 mm, after that were left at rest for 36 hours in distilled water for saturation. After saturation, each column was connected to a Mariotte bottle containing distilled water until it percolated 2 volumes of pores then, another Mariotte bottle containing wastewater was connected to the column until it leached 3.75 volumes of pores divided into 25 aliquots. The electrical conductivity was monitored during the tests, with such information elution curves were generated and the parameters of transport through the DISP. Was observed that in Entisoil columns the values of CEa, was recovery of the initial electrical conductivity of the fluid displaced even before the pre-set volume (3.5 volumes of pores). The same did not occur with as happened with Argisol Red-Yellow Eutrophic columns. Whatever type of wastewater (domestic or swine), the highest values of dispersive diffusive coefficient (D) and retardation factors (R) were observed for the Red-Yellow Eutrophic soil.

Keywords: Wastewater; retardation factor; dispersive-diffusive coefficient, Brazil.

1. INTRODUCTION

The various human activities have generated waste with different conditions of reuse in agriculture and other areas. But when used improperly that waste can contaminate the ground-water-plant. It's not known that the fate and effects of transport of such substances in soil, water resources act as integrators of biogeochemical processes in any region, and when chemicals are released, the water, are superficial, are underground, appear as the main destination (GOMES et. al., 2004).

The water-soluble ions incorporated into the soil profile, through processes of fertilization practices, irrigation and waste disposal, are liable to accumulate in the root system or to be leached, depending on the convective processes of diffusion and interactions of solutes with the ground (Goedert, 2007). According to Piffer (1989), the importance of studying the transport of solutes in the soil lies in the fact that from the knowledge of the properties and interactions of

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The displacement of miscible fluids is a process that occurs when a fluid mixture with another fluid and moving it. The leaching of salts in the soil profile is an example of miscible displacement (Ferreira, 2001). Silva (2005), says that the solutes transport in soils is based on the analysis of the variation of the concentration of the percolating solution e through a volume of soil.

Several theoretical models have been developed with the objective of describing the solutes transport in soil. But for the success of these models depend largely on the ability to quantify the parameters of transport, which are input variables. The most important parameters are the flow of fluid, the coefficient of dispersion (D) and retardation factor (R), the latter represents the effect of adsorption between soil and solute (van Genuchten and Wierenga, 1986).

Considering what was said, it was evaluated the potential for leaching of electrical conductivity present in treated domestic wastewater and swine water, in columns of soil classified as Eutrophic Red Yellow and Typic Regolithic Eutrophic.

2. MATERIALS AND METHODS

The tests were performed at the Laboratory of Irrigation and Drainage of University Federal of Campina Grande in the city of Campina Grande, PB, with the following geographic coordinates: latitude 7^{o}15'18", "35^{o}52'28 west longitude, with average altitude of 550 m.

In the tests used, two soil samples were classified as Eutrophic Red Yellow and Neosoil Regolithic Eutrophic collected in Campina Grande and Lagoa Seca, municipalities located in the state of Paraíba, collected at depth of 0 to 20 cm, which were air dried after collection, breaked in small pieces and sieved in a mesh of 2mm of opening. Then subsamples were analyzed in the laboratory of Soils, of University Federal of Paraíba, in accordance with methodology of Embrapa (1997), Table 1.

For filling the columns with the same soil was air dried and sieved in the mesh of 2 mm. We used glass columns of 26 cm as height and 6 cm internal diameter, which was placed 20 cm of soil. The soil was accommodated in the column with the aid of a wooden disc of a diameter less than the internal diameter of the column, and the disc loaded with nails, intended for the accommodation of soil and soil. Each column was filled to obtain the same density found near or in the laboratory. After making each column was placed in a plastic container, filled to 2/3 of the height of the soil column with distilled water, leaving them to stand for 36 hours.

Table 1: Chemical analysis of soil samples of Red Yellow Eutrophic and Neosoil Regolithic eutrophic, used in the tests

Characteristics	**Eutrophic Red Yellow**	**Neosoil Regolithic Eutrophic**
Sand (g kg^{-1})	637	926
Silt(g kg^{-1})	88	54
Clay (g kg^{-1})	275	20
Dispersed Clay(g kg^{-1})	51	0.0
Degeree of flocculation (kg dm^{-3})	815	1000
Soil density(g cm^{-3})	1.14	1.52
Particle density (g cm^{-3})	2.65	2.66
Total porosity	0.57	0.43
pH	5.16	4.97
Phosphorus (mg dm^{-3})	3.60	4.97
Potassium (mg dm^{-3})	156.0	43.10
Sodium (cmol dm^{-3})	0.06	0.06
Calcium (cmol dm^{-3})	1.50	0.55
Magnesium (cmol dm^{-3})	0,80	0.30
H^{+}+Al^{2+} (cmol dm^{-3})	6.93	1.65
Sulfur (mg dm^{-3})	8.87	7.84
Copper (mg dm^{-3})	0.265	0.33
Iron(mg dm^{-3})	49.56	15.33
Zinc (mg dm^{-3})	0.80	0.85
Manganese (mg dm^{-3})	5.10	4.32
Borre (mg dm^{-3})	0.45	0.14
MO[1] (g kg^{-1})	16.53	4.06
CTC[2] (cmol dm^{-3})	9.79	2.67
SB[3] (cmol dm^{-3})	2.76	1.02

[1]M.O.: Matéria Orgânica; [2]CTC: Capacidade de Troca Catiônica e [3]SB: Soma de Bases Trocáveis

The water used in the tests was from the PROSAB (Programa de Pesquisa em Saneamento Básico) where the sewage of the city of Campina Grande, PB, and activities from pig was sold for a breeding pig farm located in Puxinanã, PB. Is in Table 2 the characterization of wastewater made in the Laboratory of Irrigation and Salinity, LIS, University Federal of Campina Grande, using methodology proposed by Embrapa (1997).

Then the column filled with soil and properly saturated, was connected to a Mariotte bottle containing distilled water for a sufficient period to move approximately two volumes of pores, keeping a constant layer of 4 cm above the ground. After the two percolated pore volumes of distilled water and its complete infiltration in the soil, the column was connected to another Mariotte bottle containing the residues which was also kept a layer of 4 cm on the surface.

Table 2. Characterization of treated domestic wastewater and swine

Characterization	Values	
pH	7.28	8.16
Electrical conductivity (dS m^{-1})	1.320	5.65
Calcium ($mmol_c$ L^{-1})	0.87	2.02
Magnesium ($mmol_c$ L^{-1})	3.41	9.90
Sodium ($mmol_c$ L^{-1})	6.14	27.58
Potassium ($mmol_c$ L^{-1})	0.53	7.39
Sulphate ($mmol_c$ L^{-1})	0.0	0.0
Carbonates ($mmol_c$ L^{-1})	0.00	1.40
Bicarbonates ($mmol_c$ L^{-1})	8.26	13.18
Chlorides ($mmol_c$ L^{-1})	5.62	28.17
RAS*	4.20	11.30
Water class	C3S1	C4S1

*Relação de Adsorção de Sódio

The pore volume of each column was determined by Equation (1):

$$V_p = \pi r^2 h \left(1 - \frac{D_s}{D_p}\right) \qquad (1)$$

Where: Vp - pore volume (cm^3)
r - radius of the column (cm)
h - column length (cm)
Ds - density (g cm^{-3})
Dp - particle density (g cm^{-3})

The water percolated monitoring through the column began with the leaching of the first drop of water in its lower end, after the total infiltration of distilled water in the soil 3.75 were applied number of pore volumes of wastewater in each column.
The flow (q) of each column was calculated using the relationship:

$$q = \frac{Q}{A} = \frac{Ve}{At} \qquad (2)$$

Where: q - flow rate (cm min^{-1})
Q - flow rate (cm3 h^{-1})
A - cross section of the column (cm^2)
Ve - total volume of effluent (cm^3)
t - time interval to collect the volume Ve (h)

The speed of advance of the percolating solution for each soil was determined using the Equation 3:

$$V_f = \frac{q}{\alpha} \qquad (3)$$

Where: Vf - feed rate (cm h^{-1})
q - flow rate (cm $min-^{1}$)

α - Total porosity ($cm^3\ cm^{-3}$)

The retardation factors and the diffusion-dispersion coefficient were determined using the computational model DISP (software to calculate the parameters of solute transport in soil miscible displacement of fluids) developed by the Department of Agricultural Engineering of Federal University of Viçosa, by Borges Jr. and Ferreira (2006), with it set the effluent curves for the electrical conductivity.

3. RESULTS AND DISCUSSION

Table 3 are the characteristic values of the pore volume, flow and speed of advancement of the solution, obtained during tests with the columns filled with soil and Red Yellow Eutrophic and Neosoil Regolithic and leachate with treated swine and domestic wastewater.

Table 3. Mean values of characteristics of pore volume, flow and speed of advancement of the solution in columns of soil, during the tests

Characteristics Physico-hydrics	Domestic		Swine	
	Argisoil	Neosoil	Argisoil	Neosoil
Pores volume (cm^3)	305.93	235.81	312.71	235.81
Flux ($cm\ h^{-1}$)	17.25	39.17	15.98	29.60
Avance velocity ($cm\ h^{-1}$)	31.89	93.93	28.90	70.98

There is, Table 3, the highest values found for both the flow and the speed progress of treated swine and domestic wastewater observed when the columns were filled with Neosoil Regolithic Eutrophic. These results are consistent with the observed values of porosity for the soil and the volume of pores observed in the same Table.

It is perceived that there was a reduction in the values calculated for the flow and speed of progress in columns filled with soil and Red Yellow Eutrophic and Neosoil Regolithic Eutrophic when compared with the columns filled with the same soil and leachate with domestic wastewater, this reduction may have occurred because the water used in swine production has not been subjected to treatment or with dilution, therefore, waste of animal feed as well as particles of soil.

Table 4 are the data on the dispersive diffusive coefficient (D) and retardation factors (R) for the electrical conductivity, obtained by the adjustment of experimental data for the physical model implemented in the flow concentration in the DISP.

Table 4. Means the values of dispersive diffusive coefficients (D) and retardation factors (R), calculated for the curve of the electrical conductivity of the effluent

Soils	Domestic		Swine	
	D ($cm^2\ h^{-1}$)	R	D ($cm^2\ h^{-1}$)	R
Argisoil	1677.840	9.582	89.244	1.440
Neosoil	7932.474	8.402	173.414	1.158

In this analysis, focused on levels of salinity, seeks to study the interaction between the soil matrix and the number of ions present in wastewater and domestic swine. The values found for the factor of delay above 1 in both soils, indicating the interaction between the ions present in wastewater and solid fraction. The greatest value of the retardation factor (R) Red Yellow soil Eutrophic, is related to the higher cation exchange capacity and increased amounts of organic matter in soil, Table 1.

The speed of progress, Table 3, may have been another factor that contributed to this change in the value of the factor of delay for the land in question, where the higher speed in Typic Regolithic Eutrophic resulted in less interaction and consequent lower delay.

The results of factor of delay found for the electrical conductivity on alert to the care being taken to agricultural use of water, avoiding contamination of the water table. Ayers and Westcot (1999) reported that the main limitation of the use of wastewater in agriculture is their chemical composition (total dissolved salts, presence of toxic ions and sodium concentration) and crop tolerance to this type of effluent.

Are notorious for the high values of dispersion-diffusion coefficients (D) is seen to be observed, even after the passage of 3.75 pore volume of the columns, the relative electrical conductivity (EC) of the curve of effluent did not exceed the value of 0.6, leading to uncertainties in the values of diffusion coefficients of dispersion obtained by adjusting observed values of electrical conductivity on the theoretical model. The same observation is relevant to the values found for the retardation factor, mentioned in Table 4.

The fact that the value of diffusion coefficient of dispersion, Table 4, calculated for Eutrophic Red-Yellow (89.244) is approximately half the value found for the Neosoil Regolithic Eutrophic (173.414) may have occurred because the physical characteristics of the Typic Regolithic Eutrophic, greater quantity of macroporosity and tortuosity, submitted by the soil.

Looking up, still the chart above, notice that the values found in the retardation factor (R) show a high interaction of ions present in domestic wastewater treated with the two soils, which results in gaps of average speed of advance of solutes in relation to the average speed of advance of the solution, whose effect can be seen in Figure 1. In the same figure are the graphics on the electrical conductivity of the effluent according to the number of pore volumes of leachate from treated swine and domestic wastewater, obtained from tests with columns filled with Red and Yellow Eutrophic and Neosoil Regolithic Eutrophic.

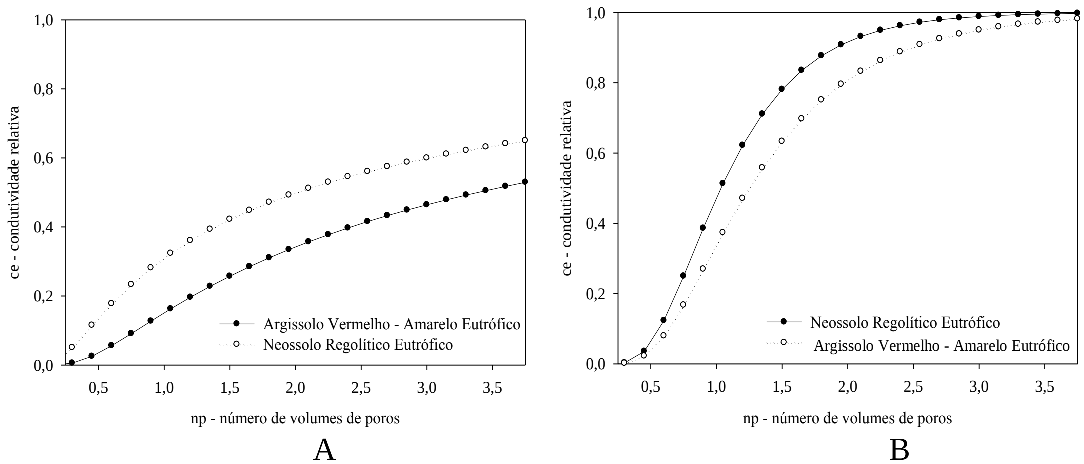

Figure 1. Curves of average electrical conductivity of the effluent, observed during the tests and adjusted by the computer program DISP for the Red Yellow soil and the Neosoil Eutrophic Eutrophic Regolithic and treates pigs (B) and domestic wastewater (A)

It is observed in Figure 1A, the number of volume of pores corresponding to the relative electrical conductivity of 0.5 is close to 2, indicating the significant effect of interaction between ions and the soil matrix on the electrical conductivity of the leachate.
Note that in Eutrophic Red Yellow, even moving in columns around the pore volume of 3.75, there was no recovery of the concentration of EC entry, CEO, as part of the soil retained salts in the solution, which is due to, probably, the high capacity of adsorption of ions that this land has, due to high cation exchange capacity and quantity of organic matter. Probably, this ability has been increased due to the passage of two pore volumes of distilled water, which promoted the moviment of ions adsorbed to the soil matrix before the application of wastewater from swine.
Depending on the flow in columns filled with Neossolo Regolithic Eutrophic be greater due to the macroporosity and also because the very structure of this soil, we find the recovery solution for entry faster. This occurs, probably due to the low cation exchange capacity (CEC) of the Franco-sandy soil (Neosoil Regolithic Eutrophic) which, combined with their high permeability, low retention of salts causes these soils.
Based on the comparison of the curves of distribution of waste land that received the two waters, treated water from swine and domestic, we find an inverse relationship between the value of the electrical conductivity of the solution applied and the time of recovery of electrical conductivity in the effluent.

4. CONCLUSIONS

The higher values of retardation factors observed for the Red Yellow Eutrophic indicate greater retention of ions dissolved in soil.
The speed of the solution in the columns filled with Neossolo Regolithic Eutrophic provided to obtain higher dispersion-diffusion coefficient higher.

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