SOIL ALTERATIONS IN A OVERLAND FLOW DOMESTIC SEWAGE UNIT TREATMENT [11]

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SUMMARY:

The objective of the present study was to detect physical and chemical alterations in a soil submitted to an overland flow sewage treatment system. The system consisted of a preliminary treatment and 12 irrigation strips cultivated with coastcross grass (*Cynodon dactylon* (L) **Pers**.). The application rates of 0,24 and 0,36 $m^3.h^{-1}.m^{-1}$ were tested. Two strips irrigated with water were used as control parcel. Soil samples were collected before land leveling and after 10 months of sewage application. The organic carbon and the soil pH concentrations were not influenced by the wastewater application, while the concentrations of phosphorous, calcium potassium and magnesium increased with the sewage application. The soil water holding capacity decreased after the wastewater application.

KEY WORDS: wastewater, coastcross-grass, overland flow

INTRODUCTION

The wastewater use, from treated or not treated effluents, in the agriculture, is an alternative to control the water bodies pollution, water and fertilizing availability for the crops. It involves techniques from two specific engineering areas: sanitary, which seeks the liquid residue purification; and the agricultural, which seeks the use of water for irrigation.

Considering that one of the means of environmental preservation is the treatment and final disposal of domestic sewage in water bodies, and for that, significant resources are necessary, alternatives which are at the same time of low implanting and operation costs should be found, provided that the treatment area neighboring population salubrity and the environmental preservation are assured. The domestic sewage treatment through the soil disposal has shown to be economically viable and simple to

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implant, and can be especially suitable to the named *Rural Sanitation*, although it can also be extended to bigger sized communities.

US ENVIRONMENTAL PROTECTION AGENCY – EPA (1981), METCALF AND EDDY (1985), BERNARDES (1986) and PAGANINI (1997) mentioned that the sewage disposal in the soil obeys, in a certain way, the basic line commended for the agricultural irrigation concerning the uniform distribution of the effluents in the soil surface, in order to avoid variation in its structure due to physical and chemical actions.

The overland flow method consists of sewage application in the beginning of cultivated strips with slopes from 2 to 8%, being the treated effluent generated, collected and launched in the collective water bodies (EPA, 1981). The soils used in this practice should have low permeability, in order to have low probability of ground water contamination. The sewage purification depends on the vegetation, responsible for the absorption of the minerals made available by the organic matter decomposition and the microorganisms, which develop, in the biological film, formed in the plant-soil interface.

Border irrigation consists in the application of water on land leveled strips, with longitudinal slopes from 0 to 6%, separated by elevations named dams or mud-wall. Whenever possible the traverse declivity should be zero to obtain a better uniformity of the water distribution. The water loss by runoff at the end of the area is a characteristic of this irrigation method. The flowing section geometry is simple, and the water infiltration in the soil occurs basically in the vertical direction (SOARES, 1998). According to BERNARDO (1995), this irrigation method can be adapted to most crops grown with small plant spacing, and that cover the entire soil surface, such as pastures, rice, wheat, hay, grasses and others.

Any irrigation project planing and operation, in which the highest yield and the good product quality are sought, using the water in an efficient way requires soil-water-plant-atmosphere interrelation knowledge. When beginning an irrigation project, the increase in the production, the saving of work and water, and the minimizing of the soil structure deterioration and nutrients loss should be considered (BERNARDO, 1995).

The following points should be considered in the selection of the area for the implantation of an overland sewage unit treatment unit: soil characteristics (texture, CTC, pH and infiltration/permeability), topography (declivity and contention), climate (precipitation levels, evapotranspiration, temperature, culture planting season, wind velocity and direction), crop (adaptability to the new planting conditions, productivity, and nutrient removal capacity), and ground water depth (CAMPOS, 1999).

According to the CFSMG (1989) the soil physical and chemical characteristics knowledge is an aspect of fundamental importance to guide not only the pasture fertilizing practice, but also the species to be chosen, or the crops more adapted to the considered conditions.

To implant a sewage system treatment unit through the overland flow, EPA (1981) recommended the evaluation of the soil physical and chemical characteristics up to 1m deep, the ground water depth, the infiltration rate and the hydraulic conductivity of the soil.

EPA (1981) recommended that the soil hydraulic conductivity in the domestic sewage treatment area, through overland flow, should be less than 0,5 $cm.h^{-1}$, that is, classified as slow. So as not to have any ground water contamination risks, it should be at a minimum depth of 0,90 m.

The objective of the present study was to detect physical and chemical alterations in the soil submitted to a continuous sewage application using the overland flow method.

MATERIALS AND METHODS

The fieldwork was conducted in the experimental area of the Mechanization Laboratory of the Agricultural Department of the Federal University of Viçosa (UFV), in Viçosa, MG, Brazil.

The domestic sewage comes from a residential suburb called Condominium Bosque Acamari, composed by 136 one-family residential units, situated in the city of Viçosa, Mata Zone in Minas Gerais State, near the UFV, south latitude - $20^0 45^{'}$, and west longitude - $42^0$51', 689 m altitude.

The Experimental Sewage Treatment Station (ETEe), with a total area of $700m^2$, consists of preliminary treatment, composed of screen, sedimentation tank, short channel with a weir to measure the discharge and equalization tank of 1 m^3 , where was installed a 2,0 cv motor with 3.500 rpm, to avoid sedimentation; and secondary treatment in an area divided in six land leveling plans, each one with two borders of 2,0 m of width, 20 m of length and 2% of slope, cultivated with coastcross grass (*Cynodon dactylon* (L) **Pers**.).

Two out of the 12 borders were used as control plot and irrigated with water from a dam close to the experimental area, two were discarded due to operation problems and 8 were irrigated with sewage. The sewage was applied in the beginning of the borders and distributed through PVC tubes with a 100mm nominal diameter and the discharge was controlled using drawer valves. Transversal concrete canals were built in the beginning of the borders, to uniform the effluent application and in the end to gather the runoff and throw it in the UFV sewage net.

In Table 1, average daily values from the sewage treatment operation through the overland flow method are presented, for a sewage application frequency of five days, and an eight-hour daily application, evaluated from March/99 to September/99.

The soil physical and chemical characteristics were evaluated at depths 0-10 , 20-30 and 30-60 cm, before and after the land leveling, and after 10 months of sewage application. Samples were taken in the beginning, middle and end of the borders, making a composed sample, irrigated with water and sewage with discharges of 0,24 and 0,36 m^3, h^{-1}, m^{-1}.

The soil physical and chemical analyses were carried out according to the recommendations established by EMBRAPA (1997) and their classification were obtained according to OLIVEIRA et al. (1992) (Table 2). The following analyses were made: textural, organic carbon; pH in water; phosphorous; potassium; calcium; magnesium and total CTC – capacity of cationic change to pH 7,0.

The soil water retention curve was determined before and after land leveling and after 10 months of sewage application, using the tensions of 0,01; 0,03; 0,1; 0,5; 1,0 and 1,5 MPa. The Cc and Pm were estimated according to the soil moisture contents at tensions of 0,03 and 1,5 MPa, respectively.

Table 1 - Operational conditions of the station of sewer treatment for the method of the overland flow

Studied Variables	Borders	
	2, 3, 4, 5	6, 7, 8, 9
Average discharge ($m^3.h^{-1}.m^{-1}$)	0,36	0,24
Border inflow discharge (L.s^{-1})	$0,20 \pm 0,00^A$	$0,13 \pm 0,01^B$
Average runoff discharge (L.s^{-1})	$0,08 \pm 0,00^A$	$0,04 \pm 0,02^A$
Average application rate (cm.dia^{-1})	$14,1 \pm 0,16^A$	$9,12 \pm 1,03^B$
Detention time (min)	$24 \pm 2,32^A$	$43 \pm 8,88^B$
Advance time (min)	$62 \pm 7,55^A$	$118 \pm 27,51^B$
Basic intake rate - VIB (cm.h^{-1})	$1,10 \pm 0,42^A$	$0,85 \pm 0,40^A$
Average flow depth (mm)	$84 \pm 16,99^A$	$57 \pm 16,17^A$
Deep percolation (%)	$59 \pm 0,12^A$	$72 \pm 0,15^A$
Runoff (%)	$41 \pm 0,12^A$	$28 \pm 0,15^A$

Source: FONSECA et al. (2000)

Table 2- Soil texture before and after land leveling.

Depths (cm)	Characteristics	Before land leveling	After land leveling			
			0,36 $m^3.h^{-1}.m^{-1}$		0,24 $m^3.h^{-1}.m^{-1}$	
			Water	Sewer	Water	Sewer
0 – 10	Coarse sand (%)	35	31	29	30	27
	Fine sand (%)	17	20	15	17	14
	Silte(%)	11	11	13	11	12
	Sands (%)	37	38	43	42	47
	Classification	Sands sandy	Sands :sandy	Sands	Sands	Sands
20 – 30	Sands thick (%)	23	31	29	29	26
	Sands fine (%)	17	20	15	19	16
	Silte(%)	9	11	11	11	16
	Sands (%)	51	38	45	41	43
	Classification	Sands	Sands	Sands	Sands	Sands
50 – 60	Sands thick (%)	19	21	19	18	22
	Sands fine (%)	13	20	14	19	16
	Silte(%)	10	10	11	12	7
	Sands (%)	58	50	57	51	56
	Classification	Sands	Sands	Sands	Sands	Sands

RESULTS

The soil chemical alteration was expected due to the earth movement during the land leveling, the application of superphosphate and nitro-calcium fertilizers in the establishment of the crop, and the chemical composition of the sewage (Table3).

There were no organic carbon alterations in the first 10 cm of the soil, however these contents increased along the soil profile, being slightly higher in the 20-30 and 50-60 cm depths in the strips with application rate of 0,36 m^3. h^{-1}.m^{-1}, probably due to the higher volume of sewage and consequently amount organic matter applied to the strips.

The pH values (Table 4) indicate medium acidity, from the 0 to 60 cm depth, before and after the operation, in general; however, in the first 10 cm of the soil, at the rate of 0,24 m^3. h^{-1} m^{-1} after the sewage application in the soil, there was a pH increment, classified as weak acidity.

The Phosphorus contents increased in the 0-10, 20-30 and 50-60 depths, after the sewage application in both sewage applications rates. The increment was higher in the layers of 0-10 and 20-30 in which the rate was 0,36 m^3. h^{-1}. m^{-1}. Considering that the Brazilian soils are poor and show great capacity of Phosphorus adsorption, the sewage treatment through soil disposition becomes an excellent option to add this nutrient to the soil.

The available potassium concentration in the soil increased with the sewage application in both application rates and this tendency was more significant for higher depths (Table 3), probably due to its high mobility in the soil. Besides that, since K is strongly absorbed by the plants, there could have been greater removal of the cation in the soil superficial soil layers were the roots were more active.

There was a slight increase in the concentrations of changeable calcium and magnesium with the sewage application, particularly in the superficial layers of the soil. Since these cations are of medium mobility in the soil it was not expected because accumulation the lower depths.

Table 3 – Physical and chemical characteristics of the sewage used in the experiment and limit values allowed in the effluent to be throw in natural water bodies and to be used in irrigation

Parameter	Unit	Sewage	Parameter	Unit	Sewage
pH	-	6,8	Lead	$mg.L^{-1}$	<0,05
Total dissoved saltes	$mg.L^{-1}$	354	Copper	$mg.L^{-1}$	<0,024
Chlorates	$mg.L^{-1}$ Cl	55	Chromium	$mg.L^{-1}$	<0,05
Conductivity	$dS.m^{-1}$	0,48	Iron	$mg.L^{-1}$	1,3
Sulfites	$mg.L^{-1}$	64	Manganese	$mg.L^{-1}$	0,03
DBO_5	$mg.L^{-1}$	400	Mercury	$mg.L^{-1}$	< 0,001
DQO	$mg.L^{-1}$	800	Prata	$mg.L^{-1}$	< 0,027
Phosphorus	$mg.L^{-1}$	2,8	Selenium	$mg.L^{-1}$	0,005
Nitrogen	$mg.L^{-1}$	35,0	Zinc	$mg.L^{-1}$	0,28
Arsenic	$mg.L^{-1}$	<0,005	Barium	$mg.L^{-1}$	<0,20
Cadmium	$mg.L^{-1}$	<0,005			

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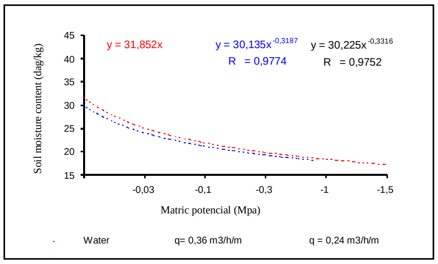
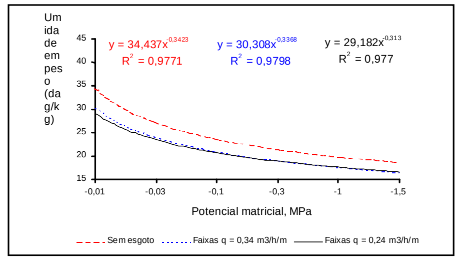
Table 4 –Chemical characteristics of the soil before land leveling, in the begining and in the end of 10 months of operation, with application rates of 0.36 and 0.24 $m^3.h^{-1}.m^{-1}$ of water or sewer.

Caracteristics	Depths (cm)	Before land leveling	q = 0,36 $m^3.h^{-1}.m^{-1}$				q = 0,24 $m^3.h^{-1}.m^{-1}$			
			Strips With Water		Strips with sewer		Strips With Water		Strips with sewer	
			Beginning	End	Beginning	End	Beginning	End	Beginning	End
Organic carbon ($dag.kg^{-1}$)	0-10	2.38			2.42	2.35			2.35	2.42
	20-30	0.86			2.15	2.28			2.08	2.42
	50-60	0.82			1.01	1.41			1.01	1.14
pH in water (1:2,5)	0-10	5.2	5.6	5.7	5.5	5.7	5.7	5.6	5.6	6.6
	20-30	5.3	5.6	5.7	5.4	5.6	5.8	5.8	5.4	5.5
	50-60	5.5	5.5	5.5	5.3	5.3	5.5	5.6	5.3	5.3
P total ($mg.dm^{-3}$)	0-10	2.4	5.4	4.6	8.8	22.6	3.4	3.2	9.6	14.4
	20-30	0.7	4.7	4.6	8.7	18.5	9.5	4.4	7.6	12.9
	50-60	0.8	1.9	1.8	1.8	9.3	1.7	1.3	8.7	6.6
K exchangeble ($mg.dm^{-3}$)	0-10	91	123	126	42	49	113	97	31	36
	20-30	20	121	126	54	71	105	196	34	58
	50-60	9	31	64	47	66	41	88	47	64
Ca^{2+} exchangeable ($cmol_c.dm^{-3}$)	0-10	1.60	2.48	2.28	2.35	3.02	2.55	2.28	2.55	2.66
	20-30	0.30	2.28	2.28	2.08	2.57	2.82	2.68	2.03	2.35
	50-60	0.30	1.30	1.27	1.27	1.55	1.56	1.60	1.36	1.41
Mg^{2+} exchangeable ($cmol_c.dm^{-3}$)	0-10	0.70	0.83	0.75	0.41	0.74	0.85	0.82	0.55	0.71
	20-30	0.70	0.75	0.75	0.46	0.69	0.62	1.03	0.50	0.64
	50-60	0.50	0.70	0.57	0.54	0.47	0.66	0.60	0.46	0.47
H+ Al ($cmol_c.dm^{-3}$)	0-10	3.0	4.5	3.6	3.6	2.6	3.8	3.6	2.6	3.0
	20-30	1.5	4.2	3.6	3.6	3.3	3.4	3.5	3.0	2.6
	50-60	1.2	2.2	2.3	1.7	2.6	2.0	2.4	1.3	1.7
CTC total ($cmol_c.dm^{-3}$)	0-10	5.56	8.02	6.90	6.47	6.49	7.54	6.91	5.78	6.46
	20-30	2.56	7.48	6.90	6.28	6.74	7.15	7.65	5.62	5.74
	50-60	2.10	4.30	20.76	3.63	4.79	4.30	4.80	3.24	3.74



(a)



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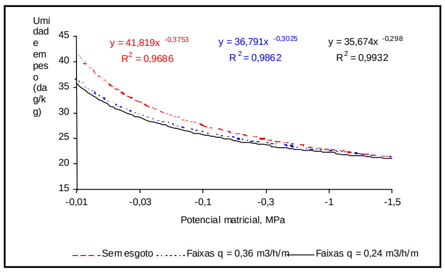

(c)

Figure 1 – Soil charateristics curves at depths of 0-10 (a), 20-30 (b) and 30-60 cm(c), after 10 months of sewage application.

There was no tendency of variation in cation exchange capacity (CEC) of the soil with the sewage application. However, the tendency of decreasing with the soil depth remained. That was expected, since most of the cation concentration and organic matter decreased with depth.

The water holding capacity decreased with the sewage application, mainly in the 20-30 and 50-60 cm layers (Figure 1). Such behavior can be associated to the fat present in the sewage, which involved the soil particles avoiding the water absorption

CONCLUSIONS

The soil pH did not oscillate with the sewage application, while the phosphorus and changeable concentration of calcium, potassium and magnesium increased with sewage application and the soil water retention decreased.

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