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Cultivation of sunflower irrigated with domestic sewage treated in Quartzarenic Neosol

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ABSTRACT: The use of domestic sewage treated in irrigation as an alternative in arid regions. However, due to the high concentration of nutrients, the use these waters can soil degradation. The objective of this study was to evaluate the effect of the use of these waters on soil attributes. The experimental design was a randomized complete block design (4 x 2 x 3) in subdivided plots with four replications. The treatments consisted of three factors, four water sources in the irrigation (A_1 - sewage treated by UASB reactor, A_2 - treated sewage treated with anaerobic filtration, A_3 - treated sewage by anaerobic filtration and A_4 - water supply); two irrigation depths (L_1 - equal to crop evapotranspiration and L_2 - 20% higher than crop evapotranspiration) and three soil layers (0-0.2, 0.2-0.4 and 0.4-0.6 m), the three soil layers were considered as subplots. The use of water sources A_1 and A_2 provided lower concentrations of sodium in the saturation extract. The use of domestic sewage treated in the irrigation provided an increase in the levels of Ca^{2+} and Mg^{2+} solubles in the soil and the EC without reach it saline. Greater nutrient accumulation was verified in the shallow layer of 0-0.20 m being influenced by the effective depth of the root system as well as by the climatic conditions of the region.

Key words: seawage treatament; sodicity; soil salinity; water reuse

Cultivo de girassol irrigado com esgoto doméstico tratado em Neossolo Quartzarênico

RESUMO: A utilização de esgotos domésticos tratados na irrigação desponta como uma alternativa em regiões áridas. Entretanto, devido à elevada concentração de nutrientes, o uso dessas águas pode ocasionar degradação do solo. Desse modo, objetivou-se avaliar o efeito da utilização destas águas nos atributos do solo. O delineamento experimental utilizado foi o casualizado em blocos em esquema fatorial (4 x 2 x 3) em parcelas subdivididas com quatro repetições. Os tratamentos consistiram de três fatores, quatro fontes de águas (A_1 - esgoto tratado por reator UASB, A_2 - esgoto tratado por decanto digestor associado à filtragem anaeróbia, A_3 - esgoto tratado por filtragem anaeróbia e A_4 - água de abastecimento); duas lâminas de irrigação (L_1 - igual à evapotranspiração da cultura e L_2 - 20% superior à evapotranspiração da cultura) e três camadas de solo (0-0,2; 0,2-0,4 e 0,4-0,6 m), considerou-se as três camadas de solo como sub-parcelas. O uso das fontes de águas A_1 e A_2 proporcionaram menores concentrações de sódio no extrato de saturação. O uso de esgotos domésticos tratados na irrigação, elevou os teores de solúveis de Ca^{2+} e Mg^{2+} do solo e a CEes sem torná-lo salino. Maior acúmulo de nutrientes foram verificados na camada superficial de 0-0,20 m sendo influenciado pela profundidade efetiva do sistema radicular como também pelas condições climáticas da região.

Palavras-chave: tratamento de esgoto doméstico; sodicidade; salinização do solo; reúso de água

Introduction

Population growth together with urbanization and industrialization results in wastewater management challenges. In the semi-arid regions, this situation is aggravated by water scarcity, jeopardizing the economic and social development.

The use of domestic wastewater treated in agriculture for the production of oilseeds is increasingly encouraged to meet both the management of water resources (Levy et al., 2014) and to supply the energy demand through oilseed biomass, because with the use of this material as a source of raw material for biofuel, there is practically no risk of contamination due to the development of parasitosis, since the product is not consumed as in the production of fruits and vegetables.

The use of these waters in the irrigation provides benefits such as the elevation of calcium, magnesium and soil organic matter; supply of nitrogen, phosphorus, potassium, calcium and magnesium to crops, besides the increase of water availability and reduction of costs with fertilizer acquisition and application (Azevedo et al., 2013; Blum et al., 2013; Pinto et al., 2013; Marinho et al., 2013). In the environmental issue, there is a reduction in the pollution of water bodies (Bourazanis et al., 2016), and can be used as an alternative to recover and combat soil degradation, by replenishing nutrients (Silva et al., 2015; Gonçalves et al. al., 2015).

Even with the observed advantages of using these waters, the presence of elements such as excess sodium is a limiting factor for the agricultural use (Silva et al., 2012). Studies highlight this element due to the increments in the exchangeable and soluble contents as well as in the values of the sodium adsorption ratio directly reflecting the electrical conductivity of the saturation extract (Azevedo et al., 2013; Aragüés et al., 2014; Urbano et al., 2017). However, these effects may vary mainly due to the characteristics of the wastewater used, the soil type (Bichai et al., 2012; Bourazanis et al., 2016) and the nutrient extraction capacity of the crop.

Therefore, aiming at the sustainability of the production system, the domestic sewage must be treated and applied in quantity and enough form. The objective of this work was to evaluate the effects of four irrigation water sources, two irrigation depth, on three layers of soil cultivated with sunflower.

Material and Methods

The experiment was developed in a Pilot Unit of Hydrous Reuse in the municipality of Ibimirim-PE, whose local coordinates are 8º32’05”S and 37º41’58”W, with an average altitude of 408 m.

The local climatic classification according to Köppen is BSw’h’ type, a very hot dry climate, with a rainy season in the summer lagging in the fall, with an average annual rainfall of 454 mm and a mean annual temperature of 24.7 °C. During the conduction of the experiment, the average temperature recorded was 26.9 ºC and cumulative rainfall of 175.2 mm.

The soil was characterized as typical Quartizarenic Neosol A moderate and a predominantly flat relief (Embrapa, 2013). The soil composition of the soil profile (Table 1) and mean soil densities and total porosity of the layers of 0 - 0.20 and 0.2 - 0.4 m (1.45 e 1.59 Mg m^{-3}) and (45 and 39%) were determined, as well as the chemical and solubility attributes of the soil saturation extract of the experimental area before application of the treatments (Table 2), according to the methodology proposed by Donagema et al. (2011).

A randomized block design in a factorial scheme was used, with subdivided plots and four replications. The first factor consisted of the use of four water sources (A_1 - domestic wastewater treated by anaerobic sludge blanket reactor - UASB, A_2 - domestic wastewater treated by decant digester associated with anaerobic filter, A_3 - domestic wastewater treated by anaerobic filtration and A_4 - water supply). The second factor consisted of the use of two irrigation depth (L_1 - depth equal to crop evapotranspiration (ETc) and L_2 - 20% depth superior to ETc). And the third factor was comprised of

Table 1. Textural characterization of the soil.

Soil layers (m)	Horizons	Sand (g kg^{-1})	Silte (g kg^{-1})	Clay (g kg^{-1})	Textural class
0 - 0.16	A	760	80	160	Sandy loam
0.16 - 0.66	C1	760	80	160	Sandy loam
0.66 - 0.99	C2	680	60	260	Sandy-clay
0.99 - 1.34	C3	680	60	260	Sandy-clay
1.34 - 1.55	C4	720	40	240	Sandy-clay
1.55+	R	740	40	220	Sandy-clay

Table 2. Chemical characterization of the soil of the experimental area.

Layer (m)	pH_{H2O}	Ca^{2+}	Mg^{2+}	K^+	Na^+	SB	H + Al	CEC	ESP	V	P	TOC	Saturation extract					
		(cmol$_c$ dm^{-3})							(%)		(mg kg^{-1})	(g kg^{-1})	pHse	EC (dS m^{-1})	Na^+ (mmol$_c$ L^{-1})	K^+	Ca^{2+}	Mg^{2+}
0-0.20	7.1	2.39	2.30	0.26	0.36	5.31	2.90	8.21	4.38	64.8	71.41	2.97	7.59	0.35	0.05	0.03	0.61	0.68
0.20-0.40	7.0	1.88	2.20	0.25	0.38	4.71	3.26	7.97	4.77	61.4	42.34	1.65	6.85	0.17	0.03	0.02	0.38	0.67

SB - Sum of bases (Ca^{2+} + Mg^{2+} + K^+ + Na^+); CTC - cation exchange capacity; ESP - exchangeable sodium percentage; V - Base Saturation = (SB/CTC) × 100; TOC - total organic carbon; pHse - pH of the saturation extract; EC - electrical conductivity of the saturation extract.

the use of three soil layers (0-0.20, 0.20-0.40 and 0.40-0.60 m), composing the subplots.

The experimental unit was composed of three six-meter-long planting lines, whose plants were sown at a spacing of 0.25 between plants per 1.0 m between lines, using sunflower (*Helianthus annuus* L.) cv. H250. A drip irrigation system consisting of a polyethylene tube of nominal 16 mm diameter was used, with emitters spaced at 0.33 m with a nominal flow of 4.0 L h^{-1}.

A daily irrigation management was performed according to crop evapotranspiration (ETc), estimating reference evapotranspiration (ETo) by the Penman-Monteith method (Allen et al., 2006), with data obtained from a meteorological station of the National Institute of Meteorology, located in Ibimirim-PE. From the 27^{th} day after sowing (DAS) the irrigation depth were differentiated and treatments irrigated with L_2 received 20% more water than treatments irrigated with L_1, totaling at the end of the cycle (95 DAS) the depth of 315.5 mm for L_1 and 370.2 mm for L2 (Figure 1).

The physical-chemical characteristics of the waters used in irrigation during the experiment are shown in Table 3.

Soil samples were collected at 77 DAS in each experimental unit in the layers (0-0.20, 0.20-0.40, 0.40-0.60 m) to evaluate the effects of water sources and irrigation depth. The soil was dried and dewormed and passed through a 2 mm mesh sieve, obtaining fine dry earth in the air. The soil saturation paste was prepared according to the methodology of Richards (1954), for the measurement of the electrical conductivity (EC), and determination of the Ca^{2+}, Mg^{2+}, Na^+, K^+ concentrations and the sodium adsorption ratio (SAR) was calculated in the extracted solution. The exchangeable levels of Ca, Mg, Na and K, the total organic carbon (TOC) and available phosphorus (P) level of the soil were determined using the methodologies compiled by Donagema et al. (2011).

The Mauchly sphericity test was applied to define the type of analysis to be used, univariate analyses with the layers in subdivided plots (characterized by the independence of measurements along the space - layers), or multivariate analysis (which considers the dependence between intra-individual measures when the sphericity hypothesis is violated), interpreted by the significance ($p < 0.05$). Then, the multivariate analysis was performed, applying the tests of Hotelling-Lawley, Pillai, Wilks and Roy or univariate (Test F) ($p < 0.05$), according to the sphericity results of each variable. When significant effects were verified for the factors studied in the analysis of variance, the Scott-Knott test ($p < 0.05$) was used.

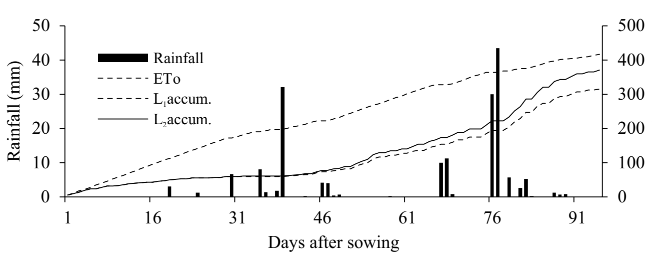

Figure 1. Rainfall data, reference evapotranspiration (ETo) and accumulated irrigation depth (L_1accum. and L_2accum.) during the experiment.

Results and Discussion

There was a significant effect ($p<0.05$) for the Mauchly sphericity test for the variables EC, $K_{(exch)}$ and P available, indicating the need for multivariate analysis of variance for these variables (Table 4).

The effect of the water sources on the variables Na^+, SAR, $Mg_{(excg)}$, $Na_{(exch)}$ and the effects of the soil layers on the variables Ca^{2+}, Mg^{2+}, K^+, $Ca_{(exch)}$, and TOC ($p<0,01$) (Table 5) were verified. The multivariate analysis applied to the variables EC, $K_{(exch)}$ and $P_{available}$, showed a significant effect ($p<0.05$) for the mean vectors of the treatments according to Wilks, Pillai, Hotelling-Lawley, and Roy for the isolated effect of the layers.

The values of EC, Na^+, SAR, $Mg_{(exch)}$, $Na_{(exch)}$ and P available in the soil of the plots irrigated with domestic treated effluents were observed (Table 6), probably because these water sources were rich in salts, and these levels may have

Table 4. Mauchly sphericity test for the variables EC, Ca^{2+}, Mg^{2+}, Na +, K^+, SAR, TOC, and $P_{available}$ in the 0-0.20, 0.20-0.40 and 0.40-0.60 m of soil deep layers.

Variables	Mauchly's criterion	Chi-square (χ^2)	P value
EC	0.737	6.104	0.047
Ca^{2+}	0.806	4.325	0.115
Mg^{2+}	0.951	0.998	0.607
Na^+	0.772	5.164	0.076
K^+	0.800	4.453	0.108
SAR	0.983	0.341	0.843
$Ca_{(ecxh)}$	0.816	4.069	0.131
$Mg_{(ecxh)}$	0.902	2.058	0.357
$Na_{(ecxh)}$	0.812	4.172	0.124
$K_{(exch)}$	0.729	0.133	0.042
TOC	0.745	5.891	0.053
Available P	0.456	15.703	0.004

Table 3. Mean values of physical-chemical parameters of waters used in irrigation.

Sources	pH	EC (dS m^{-1})	N	P	K^+	Ca^{2+}	Mg^{2+}	Na^+	Cl^-	SO_4^{2-}	$CaCO_3$	TSS	COD	BOD	SAR (mmol $L^{-1})^{0.5}$
			(mg L^{-1})												
A_1	6.8	2.1	106.9	10.3	43.6	155.6	44.7	99.1	171.1	19.8	221.6	61.6	395.5	36.1	1.8
A_2	6.8	1.9	74.3	8.7	42.4	109.5	62.9	116.6	159.0	89.6	196.2	44.3	384.6	47.3	2.2
A_3	6.9	1.8	84.3	9.4	53.6	150.7	33.8	111.7	186.2	67.7	222.8	114.6	694.9	65.0	2.1
A_4	6.5	0.2	-	0.3	13.3	32.1	20.6	22.5	38.3	5.2	81.3	22.4	10.8	0.9	0.7

TSS - Total suspended solids; COD - Chemical oxygen demand; BOD - Biochemical oxygen demand; SAR - sodium ratio adsorption (for Na^+, Ca^{2+} and Mg^{2+} in mg L^{-1} were converted to $mmol_c$ L^{-1}).

Table 5. Summary of variance analysis for Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, SAR, Mg_{exch} and TOC from the soil irrigated with domestic effluent cultivated with sunflower.

Source of variation	G.L.	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	SAR	Ca_{exch}	Mg_{exch}	Na_{exch}	COT
		Test F								
Block	3	1.55^{ns}	0.48^{ns}	5.69**	13.15**	7.38**	1.35^{ns}	1.75^{ns}	3.41^{ns}	0.301^{ns}
Water (W)	3	3.66^{ns}	1.73^{ns}	21.08**	3.38^{ns}	30.04**	0.38^{ns}	7.23**	32.35**	0.28^{ns}
Depths (D)	1	0.004^{ns}	0.91^{ns}	1.53^{ns}	0.97^{ns}	3.89^{ns}	1.09^{ns}	0.14^{ns}	0.17^{ns}	0.73^{ns}
W x D	3	1.88^{ns}	1.33^{ns}	2.07^{ns}	0.07^{ns}	3.34^{ns}	0.36^{ns}	0.27^{ns}	1.89^{ns}	0.86^{ns}
Layer (L)	2	17.96**	14.89**	2.04^{ns}	17.27**	0.02^{ns}	11.39**	2.03^{ns}	1.18^{ns}	25.90**
W x L	6	0.35^{ns}	1.37^{ns}	0.36^{ns}	0.33^{ns}	0.36^{ns}	1.28^{ns}	0.46^{ns}	1.06^{ns}	0.54^{ns}
D x L	2	1.18^{ns}	0.39^{ns}	0.06^{ns}	0.14^{ns}	0.06^{ns}	1.36^{ns}	0.77^{ns}	0.03^{ns}	0.57^{ns}
W x D x L	6	0.67^{ns}	1.32^{ns}	0.76^{ns}	0.94^{ns}	0.74^{ns}	0.63^{ns}	1.05^{ns}	0.42^{ns}	1.05^{ns}
CV a (%)		56.26	61.15	54.18	36.32	47.55	25.52	30.57	41.21	54.18
CV b (%)		55.42	55.12	42.07	54.64	65.05	27.47	31.47	49.47	44.16

^{ns}, ** and * - respectively, not significant, significant 1% and 5% probability.

been accentuated by high local evaporation, as verified by Aragüés et al. (2014). These results corroborate the results obtained by Azevedo et al. (2013) when they irrigated *Capsicum frutescens* with domestic effluents and evaluated soil effects.

It was not verified a significant effect of the water sources on the TOC level of the soil, probably due to the increase of the mineralization rate, due to the increase of the microbial activity, a fact favored by the high temperature of the region, corroborating with the results obtained by Marinho et al. (2013), Andrade Filho et al. (2013) and Alves et al. (2015).

The use of treated domestic wastewater promoted an average elevation of 170% in the EC than in the supply water (Table 6). This occurred due to the nutrient input from these water sources (Table 2). Similar effects were observed in other studies, such as in the studies of Azevedo et al. (2013), Bourazanis et al. (2016), Urbano et al. (2017). However, even with this elevation of EC, the soils did not reach saline character, since EC was <4 dSm^{-1}, (Richards, 1954). This may have occurred as a result of only one crop cycle as well as the occurrence of rainfall above 30 mm (Figure 1), associated with high soil permeability, classified as sandy loam up to the depth of 0.6 m (Table 1), favored the leaching of the salts in the soil, since this was always in conditions of high moisture.

As for the soluble Na^{+} level, the values of A_1 and A_2 (Table 6) were lower in domestic effluent sources, explained by the higher concentration of Mg^{2+} in these waters (Table 3), since Ca^{2+} and Mg^{2+} act as stabilizers in contrast to the Na^{+} ion. However, these sources of water (A_1 and A_2) provided the soil with Na^{+} levels on average, five times higher than the irrigated area with water supply (A_4). Elevations of this magnitude were also verified in Silva et al. (2012), Azevedo et al. (2013) and Bourazanis et al. (2016). The increase in the Na^{+}, SAR and Na_{exch} level (Table 6) implies a high soil sodification potential, even with the use of the 120% ETc irrigation depth. This result can be attributed to the extraction of Ca^{2+} and Mg^{2+} by the sunflower crop, as well as the precipitation of some of these ions in the soil since these two nutrients are responsible for balancing the soluble Na^{+} level.

The plots irrigated with water A_1, A_2 and A_3 had an average increase of 429% in SAR than in the A_4 source (Table 6), which is a predominance of Na^{+} in relation to Ca^{2+} and Mg^{2+} cations. These parameters should be monitored periodically to prevent further damage to the soil. Studies developed by Arienzo et al. (2012) and Levy et al. (2014) found that the use of water with SAR less than 5 $(mmol\ L^{-1})^{0,5}$ is enough to cause adverse effects in smectic soil and the use in water irrigation with high SAR values leads to a reduction in concentration of soil electrolytes.

High values of SAR in the soil solution can also be a consequence of carbonates (CO_3^{-2}), bicarbonates (HCO_3^{-}), which under high evaporation rates and because they are less soluble precipitate the Ca^{2+} and Mg^{2+}, ions, leaving the Na^{+} in solution, which even though presenting less exchange power, it can displace the other cations by mass action (Ribeiro et al., 2009). When working with wastewater, one of the ways to minimize the effects of Na is to enrich them with Ca^{+2} sources and maintain the soil moisture in the field capacity, so the Ca^{2+} and Mg^{2+} ions remain in solution.

Mean soil $Mg_{(exch)}$ levels of the treatments irrigated with water A_1, A_2 and A_3 were on average 39.2% higher than those obtained with water A_4 (Table 6). This increase in $Mg_{(exch)}$

Table 6. Comparison tests for water sources in the electrical conductivity of the saturation extract (EC), soluble sodium level (Na^{+}), sodium adsorption ratio (SAR), Mg and Na and P available.

Water sources	EC ($dS\ m^{-1}$)	Na^{+} ($mmol_c\ L^{-1}$)	SAR ($(mmol\ L^{-1})^{-0.5}$)	$Mg_{(exch)}$	$Na_{(exch)}$	P ($mg\ dm^{-3}$)
				($cmol_c\ dm^{-3}$)		
A_1 - UASB	1.01 a	5.16 b	4.05 a	0.60 a	0.34 a	55.62 a
A_2 - DD + FA	1.21 a	6.37 b	4.86 a	0.56 a	0.41 a	68.5 a
A_3 - FA	1.43 a	8.24 a	5.53 a	0.51 a	0.47 a	61.36 a
A_4 - water supply	0.45 b	0.96 c	0.91 b	0.40 b	0.11 b	38.02 b

Averages followed by the same letter (between lines) do not differ significantly from each other by the Skott Knott test at 5%.

Table 7. Mean comparison test for the factors soil layers for the variables: electrical conductivity of the saturation extract (EC), potassium (K^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), exchangeable calcium (Ca_{exch}) total organic carbon (TOC) and available phosphorus (P).

Layer (m)	EC	K^+	Ca^{2+}	Mg^{2+}	$Ca^{2+}_{(exch)}$	TOC	P
	(dS m^{-1})	(mmol$_c$ L^{-1})			(cmol$_c$ dm^{-3})	(g kg^{-1})	(mg dm^{-3})
0 - 0.20	1.40 a	0.89 a	3.68 a	2.33 a	1.25 a	3.10 a	83.36 a
0.20 - 0.40	0.81 b	0.44 b	1.20 b	1.29 b	1.04 b	1.67 b	47.83 b
0.40 - 0.60	0.86 b	0.49 b	1.82 b	1.25 b	0.90 b	1.60 b	36.43 c

Averages followed by the same letter (between lines) do not differ significantly from each other by the Skott Knott test at 5%.

levels is one of the benefits of using domestic wastewater in irrigation since these nutrients recompose soil fertility and will be available later to the plants. Similar results regarding the accumulation of magnesium in the soil due to the use of wastewater were also observed by Bourazanis et al. (2016), when they tested the application of domestic effluents in the hydraulic conductivity of the soil and by Abegunrin et al. (2016), when they evaluated the use of different types of effluents in the chemical and physical properties of the soil in relation to the water supply, both concluded that the domestic effluent can be an alternative of Mg to the soil. On the other hand, opposing these results and working with Cucurbita maxima Duch, irrigated with wastewater, Oliveira et al. (2016) verified a reduction of Mg levels in the soil. Thus, it can be concluded that the nutrient intake of the wastewater varies for each condition and it is necessary to pay attention to the requirement of the crop.

In the Na^+ exchangeable, treatments irrigated with sources A_1, A_2 and A_3 presented an average increase of 270% than in the A_4 source (Table 6), corroborating with the results of Varallo et al. (2012) and Azevedo et al. (2013). Sodding, passing from Na^+ from the soluble ion form to the exchange complex, begins to matter when this cation represents half or more of the soluble cations in the soil solution (Richards, 1954). With the increase of the Na^+ level in the soil, there is a tendency to increase the ESP and deterioration of the physical properties, specifically the clay dispersion in which it can de-structure the soil from the breakage of the aggregates causing the pores blocking, and consequently the reduction of the permeability from the soil. This process, which occurs continuously, can negatively affect the hydraulic conductivity of the soil, damaging the growth of the plants, reducing leaching, leading to salinization (Varallo et al., 2012; Urbano et al., 2017).

There was an average increase of 62.6% in the P available level in the soil in the treatments irrigated with domestic effluents (A_1, $A_{2,}$ and A_3) (Table 6) than in the irrigation with source A_4. However, there was no significant difference ($p> 0.05$) in the P available level in plots irrigated with domestic effluent sources. These results are in agreement with those obtained by Marinho et al. (2013) when they tested the use of domestic effluents for irrigation of rose bushes.

When compared to the P level in the soil before the implantation of the experiment, it was verified on average that there was no alteration, justifying the absorption by the cultures of the P contributed to the water sources, as well as it may have occurred complexing of this nutrient by matter added together with the wastewater to form salts of low solubility such as calcium phosphate. Similar results were also verified by Blum et al. (2013) when they tested the use of domestic effluents and verified that the amount of leached P was the equivalent of 100 g ha^{-1}, considered very low, and without risk of environmental contamination.

Regarding the soil layers, the accumulations of K^+, Ca^{2+} and Mg^{2+} in the superficial layer (0-0.20 m) was verified, reflecting directly in the EC (Table 7). This can be attributed to two factors: the effective layer of the system (0.20 m), which causes intense suction of the solution, concentrating a large part of the nutrients in this region and the semiarid condition characteristic of the region of the experiment, conditioning high evaporation of the water of the nutrient solution, accumulating in the superficial layer, a characteristic also observed by Adrover et al. (2017).

Higher values of $Ca_{(exch)}$, TOC and P available were also observed in the 0 - 0.20 m layer. Costa et al. (2009) reported that TOC and P available tend to remain in the more superficial layers because they present rapid precipitation and soil adsorption reaction, reacting with organic matter and with iron and aluminum ions and oxides.

Conclusions

The use of A_1 waters from the anaerobic sludge blanket reactor - UASB and A_2 from the digester decant plus anaerobic filter provided lower concentrations of soluble Na^+, indicating a lower environmental impact in the types of wastewater tested.

The irrigation with treated domestic sewage increased the soluble Ca^{2+} and Mg^{2+} levels of the soil and the electrical conductivity of the saturation extract, without reaching the saline character.

Higher nutrient accumulation was verified in the superficial layer of 0-0.2 m being a consequence of the effective depth of the root system, as well as the climatic conditions of the region.

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