engenharia agrícola
Journal of the Brazilian Association of Agricultural Engineering
ISSN: 1809-4430 (on-line)

CHEMICAL PROPERTIES OF SOIL FERTIRRIGATED WITH DAIRY AND SLAUGHTERHOUSE WASTEWATER

Doi:http://dx.doi.org/10.1590/1809-4430-Eng.Agric.v37n6p1244-1253/2017

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ABSTRACT: The aim of this study was to evaluate the soil chemical properties submitted to fertigation with slaughterhouse (SW) and dairies (DW) wastewater. The experiment was conducted in the Environmental Engineering Center and Sanitary of UFLA/MG in PVC columns filled with Dark Red Latosol (Oxisol) and randomly distributed. The treatments applied with nitrogen based load (300 kg ha years^{-1} of N) consisted of four doses of SW and DW (100, 200, 300 and 400% of the recommendation) and A_QT_0 control at random. The soil was collected at a depth of 0.30 m and, subsequently, characterized in terms of physical, chemical and physicochemical. The application of treatment of the largest irrigation of DW provided, after 120 days of monitoring, N concentration of 1.85 g kg^{-1}. However, the treatment with A_QT_0 obtained N concentration of 0.81 g kg^{-1}, in the soil. We observed that the largest irrigation of SW provided increases of 2.62 and 5.49 g kg^{-1}, respectively, in the P and K concentrations of the soil. There was quadratic increase in the N concentration in the 0.30 m soil depth of the columns with the increase in the applied irrigations of SW and DW, being obtained maximum values of 1.85 and 1.02 g kg^{-1} that were obtained in the relative irrigation of the application dose of 600 kg ha^{-1} of N.

KEYWORDS: soil quality, fertigation, plant nutrition, agroindustrial wastewater.

INTRODUCTION

In view of the water scarcity scenario in Brazil, the use of agroindustrial wastewater, via fertirrigation in agriculture, has emerged with an important and efficient destination, since in addition to water supply; nutrients are available to the soil and plant.

The high concentrations of nutrients and organic matter in the wastewater, such as those from dairy and slaughterhouse, are presented as viable alternatives for the reuse of water, organic matter and nutrients, contributing to the reduction of costs with fertilizers and impacts caused by the launch in the hydric bodies (Singh et al., 2012). However, the arrangement in the soil-plant system, when done without agronomic and environmental criteria, can cause problems of soil, surface and groundwater contamination and bring toxicity to plants (Erthal et al., 2010).

Rodrigues et al. (2011), for example, found that fertigation with dairy and slaughterhouse wastewater contributed significantly to the increase in total nitrogen, ammoniacal nitrogen and nitrate content in the soil solution, and also it increased the average yield of *Tainá* lettuce.

In addition to soil support capacity, the soil assimilation of nutrients and pathogens is due to its purifying power, since the combination of physical, chemical and biological mechanisms promote the retention of suspended solids, nutrient removal by adsorption to the soil matrix or absorption by plants, in addition to oxidation of the organic material, promoted mainly by microorganisms that settle in the rhizosphere (Ribas et al., 2008).

Several studies demonstrate the effects of wastewater on soil chemical attributes, but not all of them demonstrate the consequences on cultivated soil. Thus, the aim of this study was to evaluate the chemical attributes of the soil cultivated with Tifton 85 grass (*Cynodon* spp.) fertigated with increasing irrigation levels from wastewater from pig slaughterhouse and dairy and to compare them to conventional chemical fertilization.

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Received in: 1-31-2017
Accepted in: 8-14-2017

MATERIAL AND METHODS

The experiment was carried out at the Federal University of Lavras, Lavras, Minas Gerais, latitude 21°13'45"S, longitude 44°58'31"W, average altitude of 918 m and Cwa climate, (mesothermal or tropical altitude), with dry winter and rainy summer, according to the Köppen classification (Sá Junior et al., 2012).

The soil used in the experiment was classified as Dark Red Latosol (Oxisol) (EMBRAPA, 2013). The chemical, physical and physicochemical characteristics of the soil are shown in Table 1, before the application of the treatments. The Oxisol was collected at a depth of 0.50 m from the soil, dried in an oven, drained and sieved in a 2 mm mesh, to fill the 1.20 m columns.

TABLE 1. Physical, chemical and physicochemical characterization of the soil used for filling the columns.

pH_{water}	N	P_{avail}	K	Na	Ca+Mg	Al	H+Al	SB	CEC	O.M
	$g\ kg^{-1}$	$mg\ kg^{-1}$	--- $g\ kg^{-1}$ ---		---------------- $cmol_c\ dm^{-3}$ -------------					$g\ kg^{-1}$
5.60	0.20	3.21	0.02	-	0.92	0	2.32	0.98	3.30	16.40
Soil classification			Clay	Silt	Sand		Sand (Thick)		Sand (Thin)	
			-------------------------------- $dag\ kg^{-1}$ -------------------------------							
Dark Red Latosol			60	24	-		8		8	

pH – potential hydrogenation in water; N - total kjeldahl nitrogen; P_{avail} – available phosphorus; Na – available sodium; Ca + Mg - calcium plus exchangeable magnesium; Al - aluminum; H + Al - hydrogen plus exchangeable aluminum (potential soil acidity); SB - sum of exchangeable bases; CEC - cation exchange capacity; O.M - soil organic matter.

The experimental system consisted of 27 soil columns constructed of PVC with a diameter of 0.30 m (area of 0.07 m^2) and 1.20 m of height. The columns were filled, from the base, with 0.05 m of # zero gravel, 0.05 m of thick washed sand and 1.05 m of Dark Red Latosol (Oxisol). The soil columns were cultivated with Tifton 85 (*Cynodon* spp.), as shown in Figure 1. The liming of the soil was carried out by the method of bases saturation, in order to theoretically reach V = 60% in the superficial 0.30 m of all 27 soil columns, as recommended for cultivation, adding 2,1 t ha^{-1} of calcium carbonate PA ($CaCO_3$) with a rest period of 30 days, in order to correct the pH of the soil to 7.0 (CFSEMG, 1999). After the liming, no chemical fertilizers were added before planting the grass on the soil surface contained within the columns.

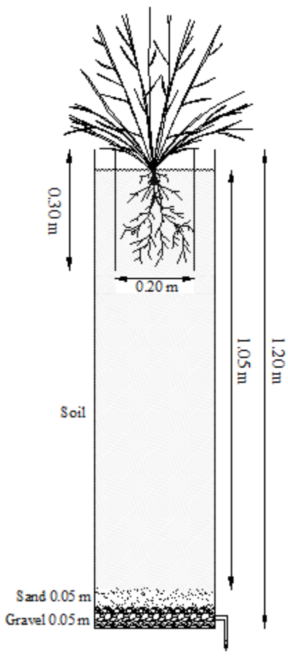

FIGURE 1. Schematic configuration of the soil column profile used in the experiment.

The applied treatments included the application of slaughterhouse wastewater (SW) and dairy wastewater (DW), collected after preliminary treatment with railing and static sieving, respectively, from two agroindustries located in the municipality of Lavras-MG, besides a control, characterized by the application of conventional chemical fertilization (A_QT_0).

Even though the presence of more restrictive chemical elements in the wastewater used in relation to the dose to be applied in the evaluated crop, nitrogen (N) was used as a chemical element of reference for the determination of the irrigation to be applied in the soil, evaluating the effects on soil nutrient accumulation and plant productivity. The application of wastewater to the soil was monthly, from August to December 2015 (beginning - 08/15/2015, end - 12/30/2015), totaling 5 applications, following the recommendation of the 300 kg ha^{-1} year^{-1} rate of N proposed by the Soil Fertility Commission of the State of Minas Gerais - CFSEMG (1999) for pastures.

Thus, by adopting the A_QT_0 standard as a recommended dosage of N, the rates of N application via wastewater (SW and DW) of 100, 200, 300 and 400% of this recommendation were evaluated. Thus, total irrigations of 97.9, 195.8, 293.7 and 391.6 mm, respectively, were applied in the A_AT_1, A_AT_2, A_AT_3 and A_AT_4 treatments, while 180.1, 360.2, 540, 3 and 720.4 mm were applied, respectively in the A_LT_1, A_LT_2, A_LT_3 and A_LT_4 treatments. The Environmental Protection Agency (EPA, 1981) proposed the methodology that was used to calculate the wastewater irrigation to be applied to the soil.

The SW and DW characterizations were performed monthly in the Laboratory of Analysis of Wastewater of the Nucleus of Environmental and Sanitary Engineering of the Engineering Department of UFLA, following the methodology proposed by APHA; WEF; AWWA (2012), as shown in Table 2.

TABLE 2. Characterization of slaughterhouse (SW) and dairy (DW) wastewater applied during the trial period.

Variables	DW				SW			
	Avg + SD	Min	Max	CV (%)	Avg + SD	Min	Max	CV (%)
pH	7.8 ± 0.3	5.2	10.5	31.3	7.7 ± 0.3	7,7	0,3	3,4
EC (dS m-¹)	3.2 ± 0.5	3.1	4.1	14.7	1.2 ± 0.1	0,4	1,6	8,7
COD (mg L^{-1})	7.176 ± 4631	3.367	13.966	64.5	5.813 ± 3007	2.700	10.731	51.7
BOD (mg L^{-1})	2.429 ± 1304	1.245	3.766	53.7	2.360 ± 1139	1.245	3.766	48.3
P (mg L^{-1})	16.1 ± 7.6	7.3	23	47.7	11.9± 9.6	1.2	22.08	80.7
N (mg L^{-1})	84.8 ± 12.8	70	105	15.1	157.5 ± 27.0	115	188	17.2
O&G (mg L^{-1})	2.695 ± 2180	614	5.696	80.9	2.403 ± 1896	386	4.765	78.9
Ca (mg L^{-1})	83.1 ± 29.4	39.2	117.9	35.5	65.0 ± 38.1	24.1	103.4	58.7
Mg (mg L^{-1})	30.7 ± 10.9	14.5	43.6	35.5	89.0 ± 52.2	16.7	33.0	141.0
Na (mg L^{-1})	134 ± 21.7	116.7	164.5	16.2	21.5 ± 3.6	16.7	25.7	16.7
K (mg L^{-1})	16.3 ± 7.6	9.3	28.8	46.6	12.6 ± 5.0	8.1	19.8	39.7
SAR (mmol L)$^{-0,5}$	5.9 ± 1.0	5.2	7.5	16.1	1.3 ± 0.4	1.0	1.8	28.5

pH - hydrogenation potential; EC - electrical conductivity; COD - chemical oxygen demand; BOD - biochemical oxygen demand; P - total phosphorus; N - total kjeldahl nitrogen; O&G - oils and greases; Ca - calcium; Mg - magnesium; Na - sodium; K- potassium; SAR - sodium adsorption ratio; Avg - Arithmetic average median; SD - standard deviation; Min - minimum value; Max - maximum value; CV - coefficient of variation.

During the growth cycles of Tifton 85 grass, SW and DW applications supplied some of the required water, and another part came from irrigation management with water from the UFLA supply system. The climatic data, necessary for the estimation of the reference evapotranspiration (ETo) by the Penman-Monteith equation (Allen et al., 2006; Carvalho et al., 2011), were obtained at the Conventional Weather Station installed on the UFLA campus under monitoring of the National Institute of Meteorology. Drumond et al. (2006) proposed for pasture a kc of 0.8 that was adopted in this study. The variations in temperature, relative humidity and precipitation during the experiment are shown in Figure 2.

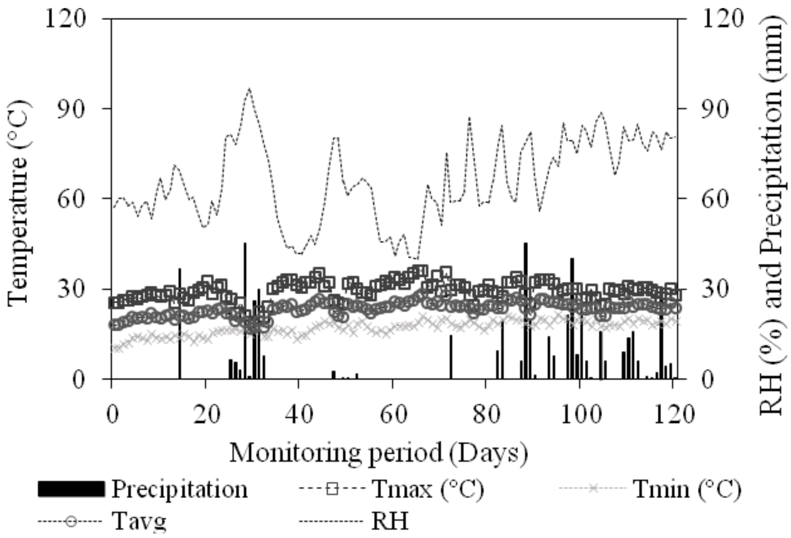

FIGURE 2. Air temperature variations, relative humidity (RH) and precipitation occurred during the experiment.

For the evaluation of changes in soil chemical characteristics, samples were collected after 120 days of the treatments application, at a depth of 0.30 m, which is the soil region with the highest root densification of Tifton 85 grass. After the collection, the samples were air-dried, ground and sieved in a 2.0 mm mesh for the pH determination, in addition to the available nitrogen, phosphorus, potassium and sodium contents and exchangeable calcium and magnesium of the soil, according to EMBRAPA (2013).

The experiment was set up in a completely randomized design (CRD) with three replicates (Figure 3). Soil data were submitted to analysis of variance, using the F test, and the averages were compared to each other using the Tukey test at 5%. In the statistical analyses, the computer program Sisvar 5.1 was used (Ferreira, 2011).

FIGURE 3. Experimental treatment arrangement.

RESULTS AND DISCUSSION

The tests of statistical averages of Tukey test at 5%, done with the fertility data obtained in the depth of 0.30 cm of the soil and evaluated after 120 days of application of the slaughterhouse wastewater (SW), dairy wastewater (DW) and conventional chemical fertilization (A_QT_0), are shown in Tables 3 and 4.

TABLE 3. Averages of variables associated to the fertility of the soil layer filled in columns cultivated with Tifton 85 grass and fertirrigated with SW and A_QT_0.

Treatments	pH_{water}	EC	ESP	TKN	P_{avail}	K_{avail}	Na_{avail}	$(Ca + Mg)_{exch}$
		μS m^{-1}	(%)	g kg^{-1}	mg kg^{-1}	--- g kg^{-1} ---		$cmol_c$ dm^{-3}
A_QT_0	5.91a	114.53a	11.90a	0.81a	1.23b	3.92ab	0.69b	2.80ab
A_AT_1	5.98a	94.07a	17.68a	0.79a	0.45b	2.42b	0.92b	1.89b
A_AT_2	5.99a	118.67a	18.70a	0.87a	0.68b	2.62b	1.07b	2.04ab
A_AT_3	6.05a	97.93a	28.12ab	1.06a	1.15b	3.70ab	2.60b	2.24ab
A_AT_4	5.98a	166.83b	40.24b	1.02a	2.62a	5.49a	5.67a	2.97a
Average	5.98	118.41	22.18	0.91	1.22	3.62	2.19	2.39
CV (%)	0.98	14.08	30.99	23.41	26.15	20.11	47.87	16.72

pH_{water}: hydrogen potential in water; EC: electric conductivity; ESP: exchangeable sodium percentage; TNK: total kjeldahl nitrogen; P_{avail}: available phosphorus; K_{avail}: potassium; Na_{avail}: sodium; $(Ca + Mg)_{exch}$: calcium plus exchangeable magnesium; Averages followed by the same letter in the columns do not differ statistically, by the Tukey test, at 5% significance.

TABLE 4. Averages of variables associated to the fertility of the soil layer filled in columns cultivated with Tifton 85 grass and fertirrigated with DW and A_QT_0.

Treatments	pH_{water}	EC	ESP	TKN	P_{avail}	K_{avail}	Na_{avail}	$Ca + M_{excha}$
		μS m^{-1}	(%)	g kg^{-1}	mg kg^{-1}	--- g kg^{-1} ---		$cmol_c$ dm^{-3}
A_QT_0	5.91a	114.53a	11.90a	0.81b	1.23ab	3.92a	0.69a	2.80a
A_LT_1	6.01a	93.83a	53.35b	1.49a	0.57b	3.87a	6.74b	2.05ab
A_LT_2	6.10a	96.70a	48.35b	1.44a	0.51b	4.88a	6.09b	1.73b
A_LT_3	5.69a	105.47a	49.86b	1.72a	1.60ab	5.44a	7.59b	2.17ab
A_LT_4	5.93a	124.03a	58.26b	1.85a	2.86a	6.19a	9.65bc	1.89ab
Average	5.94	106.91	44.45	1.46	1.36	4.86	6.15	2.13
CV (%)	2.64	30.07	22.55	14.19	53.7	47.49	26.92	16.96

pH_{water}: hydrogen potential in water; EC: electric conductivity; ESP: exchangeable sodium percentage; TKN: total kjeldahl nitrogen; P_{avail}: available phosphorus; K_{avail}: potassium; Na_{avail}: sodium; $(Ca + Mg)_{exch}$: calcium plus exchangeable magnesium; Averages followed by the same letter in the columns do not differ statistically, by the Tukey test, at 5% significance.

In Tables 3 and 4, there was no statistical difference between the average values of soil pH among all treatments receiving SW, DW and A_QT_0, however, the results obtained are between 5.5 and 7.0, and according to CFSEMG (1999), they present good and high agronomic classification, respectively. The low nitrification and the reduction in the mineralization of the soil organic matter due to the increase of the water content in the soil, which reached 302 mm (Figure 2), equivalent to 21.4 L in each column, may have contributed to the few changes in soil pH values, as Iyyemperumal & Shi (2007) and Doelsch et al. (2010) reported. Some studies corroborate with these results, such as Cabral et al. (2011), who evaluated the impact of swine wastewater (SW) on soil and found that the dosages of 0, 150, 300, 450 and 600 m^3 ha^{-1} of SW did not affect soil pH in the layer up to 0.20 m. Smanhotto et al. (2010) found, however, a significant increase in pH from 6.2 to 6.7 after application of 0 (control) and 300 m^3 ha^{-1} of SW, respectively, in a dystroferric Red Latosol.

In Tables 3 and 4, the electrical conductivity (EC) of the soil saturation paste extract did not present statistical differences among all the treatments, even if there were increases of the applied irrigations of SW and DW. However, the presence of salts in the treatments applied with wastewater (Table 2) increased the exchangeable sodium percentage (ESP) of the soil, obtaining statistical differences and maximum results of 40.24 and 58.26% when fertirrigated with A_AT_4 and A_LT_4, compared to 11.90%, obtained in the control treatment.

Souza & Moreira (2010) observed that swine wastewater did not provide changes in the electrical conductivity of the soil saturation paste extract in relation to the recommended fertilization for the tomato after 117 days of cultivation. Lo Monaco et al. (2009) verified an increase in the electrical conductivity of the soil saturation paste extract as the applied doses of coffee fruit processing wastewater (CW) in the soil increased. The authors state that such behavior is associated with the increase of the potassium ion in the soil solution, when high doses of the CW were applied.

The results of EC and ESP indicate salinity and sodicity of the soil solution, due to the application of wastewater, as Richards (1954) highlighted. Thus, all the values of EC and ESP of the soil solution in the fertigated columns with SW and DW (Tables 3 and 4) are above 4 dS m^{-1} and 15%, respectively, and the soil in this condition is classified as saline-sodium (Richards, 1954).In this sense, Bouwer & Chaney (1974) highlight that the salts dissolved in wastewater interact with the soil through ion exchange, dispersion and clays flocculation, and therefore, when it is present in the soil, it can reduce the availability of water to the crops, affecting productive income (Ayers & Westcot, 1985).This demonstrates the inadequacy of the application of large irrigations of these wastewater in the soil.

Nitrogen contents in the soil did not significantly change according to the applied SW irrigation; however, all treatments with DW provided higher soil nitrogen results in relation to the control treatment (Tables 3 and 4).Thus, soil columns that received the highest irrigation of DW (A_LT_4) presented average concentrations of 1.85 g kg^{1} of TKN, while soil columns that received the control treatment (A_QT_0) with application of urea, simple superphosphate and potassium chloride presented concentration of 0.81 g kg^{-1} (Table 3 and Table 4), showing an increase of 100% of the highest applied DW irrigation in relation to the control treatment.

Corroborating the results obtained in this experiment, Oliveira et al. (2014) evaluated the wastewater disposal of dairy in Red Argisol and found that the highest values of N were 217 g kg^{-1} in the 0.10 m depth layer, while Matos et al. (2014) found 1.10 g kg^{-1} of N, after application of 15 kg ha^{-1} of tannery wastewater.

The highest concentrations of available P in the soil, up to 0.30 m from the soil in the columns, were respectively 2.62 and 2.86 mg kg^{-1} in A_AT_4 and A_LT_4 treatments, while the effect of conventional chemical fertilization (A_QT_0) provided concentrations of 1.23 mg kg^{-1}, with statistical significance observed only when comparing SW and A_QT_0 treatments (Tables 3 and 4). However, these results were lower than the concentrations of 3.21 mg kg^{-1} of available phosphorus in the soil before the application of the treatments.

According to CFSEMG (1999), the average available P values found in the 0-0.30 m layer, because they are considered low, indicate the need to use SW and DW as partial source of P, requiring its complementation in the mineral form to meet the needs of the evaluated crop.

Souza et al. (2009) evaluated nitrogen and phosphorus in fertirrigated soil with swine effluent and found, at a depth of 0.10 m, in comparison with the initial conditions of the experiment, there were reductions in available P concentrations in relation to those obtained in the control treatment (recommended fertilization for the tomato). The low concentrations of available P observed in the experiment occurred because the irrigations applied in the treatments with wastewater were established in function of the recommended nitrogen load, which limited the application of P.

The application treatments of DW, SW and chemical fertilization (A_QT_0) provided an increase in available K and Na concentrations in the 0.30 m depth soil layers. There were significant increases in the concentrations of available Na of the soil receiving the highest applied irrigations (A_LT_4 and A_AT_4), while the available K did not show significant increases in relation to the effects of conventional chemical fertilization, as observed in Tables 3 and 4.The highest concentrations were 5.49 and 6.19 g kg^{-1} of available K with the applied irrigations in the A_AT_4 and A_LT_4 treatments, while the available Na concentrations were 5.57 g kg^{-1} (A_AT_4) and 9.65 g kg^{-1} (A_LT_4). Duarte et al. (2013) found concentrations of 0.42 g kg^{-1} of available Na at 0.20 m of soil depth when 45 m^3 ha^{-1} of cassava wastewater was applied. According to Cavalcante et al. (2010), the excess of sodium salts, besides causing damages to the physical and chemical properties of the soil, causes the generalized reduction of the cultivated plants growth causing serious damages to the agricultural activity.

The Ca + Mg supply in the SW treatments was not significant, although the highest SW irrigation provided a concentration of 2.97 $cmol_c$ dm^{-3}, whereas the conventional chemical fertilization (control treatment) presented concentration of 2.80 $cmol_c$ dm^{-3}. However, the supply of Ca + Mg in the control treatment was higher in relation to all the treatments that received the doses of DW (Table 4). The increase of Ca + Mg in the control treatment occurred due to the application of simple superphosphate, which releases calcium sulphate to the soil solution.

Cabral et al. (2011) evaluated the impact of swine wastewater on soil and elephant-grass production, finding 1.18 $cmol_c$ dm^{-3} of Ca + Mg when the soil was submitted to a dose of 643 kg ha^{-1} of N. According to Erthal et al. (2010), the presence of calcium in the control treatment is related to the fertilizers used in the fertilization of Tifton 85 grass, while in the treatments with wastewater are due to the mineralization of the organic matter in its chemical composition.

The concentrations of available N, P and K in function of the applied DW and SW irrigations are shown in Figure 4. The total nitrogen at 0.30 m depth presented a quadratic behavior with maximum concentrations of 1.85 g kg^{-1} in the A_LT_4 treatment submitted to 600 kg ha^{-1} of N (Figure 4A) and quadratic (Figure 4B), with a maximum concentration of 1.06 g kg^{-1} in the A_AT_3 treatment submitted to the dose of 450 kg ha^{-1} of N. Grohskopf et al. (2015) found total nitrogen concentrations at 0.10 m depth of 2.70 g kg^{-1} when received the 200 m^3 ha^{-1} of swine wastewater (SW).

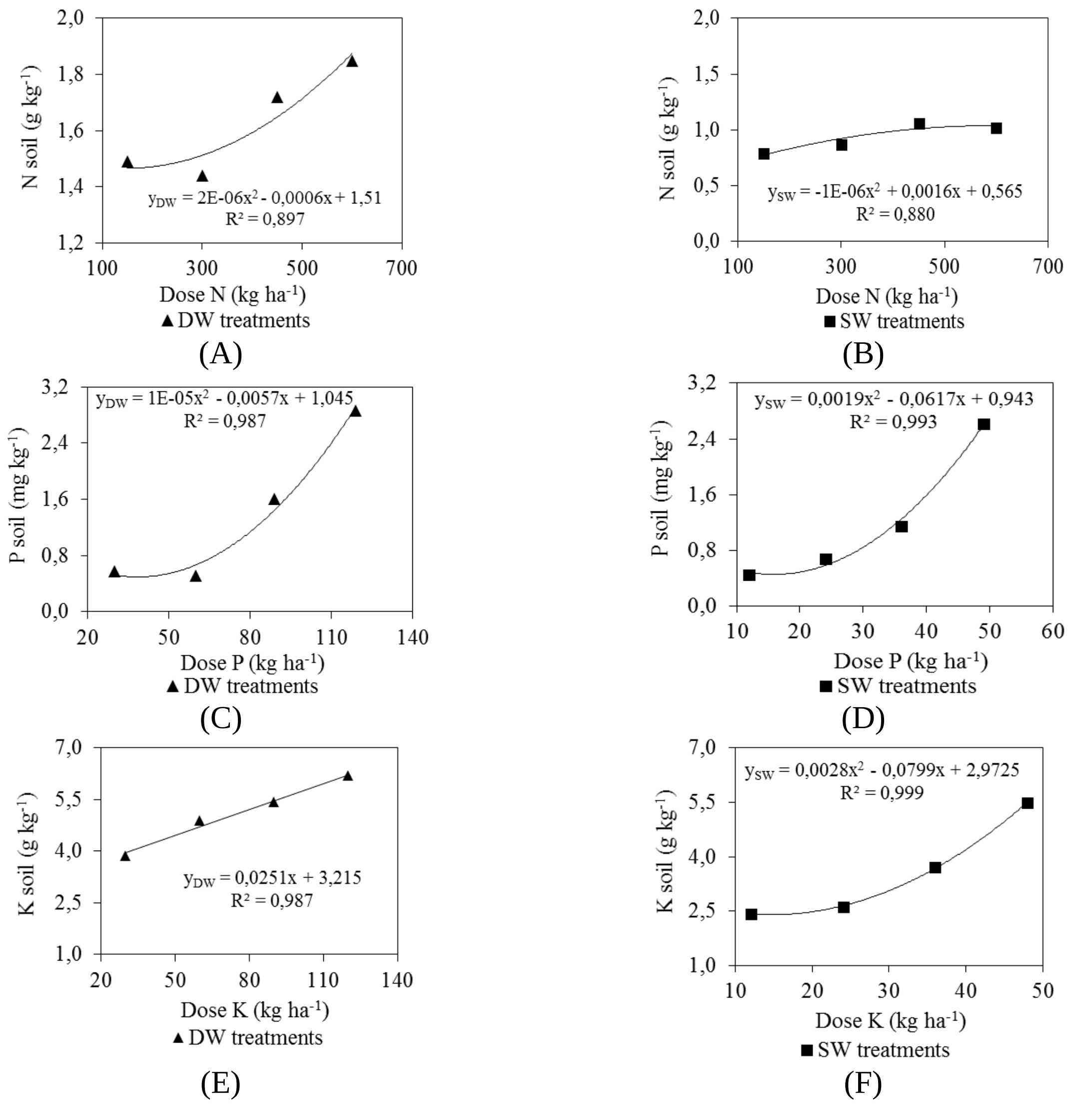

FIGURE 4. Concentration of N, P and K in the layer of 0.30 m depth in function of applied doses of DW and SW.

The predominance of the organic form of nitrogen, added to the treatments through the application of SW and DW, was probably responsible for the increase in the concentration of this nutrient in the soil superficial layers, while the quadratic effect is related to the increment from the wastewater applications during the 120 days of monitoring.

The concentrations of available P in the DW and SW treatments presented a quadratic positive adjustment (Figure 3C) (Figure 3D). There was an increase in the concentrations of available P in function of the SW and DW irrigation applied. However, due to the fact that the doses were established in function of the nitrogen recommendation for pasture, the P rates were different among the wastewater. Thus, the highest available P concentration was 2.86 mg kg^{-1} in the A_LT_4 treatment submitted to the dose of 119 kg ha^{-1} of P, whereas in the SW treatment the highest concentration was 2.62 mg kg^{-1} (A_AT_4) submitted to the dose of 49 kg ha^{-1} of P. Duarte et al. (2013) found similar results, who found maximum concentrations of 3.50 mg kg^{-1} when a dose of 65 kg ha^{-1} of cassava wastewater was applied. The possibility of the P concentration reduction in the soil can also be associated with the slow availability of the phosphorus present in the organic matter contained in the wastewater, via degradation.

Regarding the available K, there was a positive linear adjustment, with a higher concentration of 6.19 g kg^{-1} in the A_LT_4 treatment and a dose of 120 kg ha^{-1}. Differently, the quadratic model was the one that best fit the SW application data, observing the highest concentration of 5.49 g kg^{-1} and 49 kg ha^{-1} dose in the A_AT_4 treatment. According to Malavolta (1997), soil exchangeable potassium contents above 78 mg kg^{-1} are considered high or adequate, evidencing that SW and DW treatments increased the availability of this nutrient in the soil, making it more fertile.

Considering the conditions applied in this study, the application of higher doses than the 100% recommendation of the nitrogen requirement of the Tifton 85 grass should not be considered, because despite the increase in soil fertility, there was an increase in its salinity and sodicity, which may cause crop losses in terms of crop yield, with the decrease in soil osmotic potential. Another aspect that may result from the application of higher SW and DW doses is soil disruption due to elevated sodium concentration, especially when SW is applied, causing damage to the plant soil system.

CONCLUSIONS

The application of the higher SW and DW dosage provided an increase in soil chemical attributes evaluated in samples collected at a depth of 0.30 m, with higher concentrations of available N, P and Na.

There was a considerable increase in the percentage of exchangeable sodium in the soil with the increase in the applied dose of slaughterhouse (SW) and dairy (DW) wastewater.

The maximum doses of the treatments did not provide significant differences in relation to the pH and available potassium in the soil.

Dosages of SW and DW greater than 100% of the recommended nitrogen dosage for Tifton 85 grass should not be applied.

ACKNOWLEDGEMENT

We would like to thank to CAPES for the support and FAMEPIG for the scholarships and resources for the development of the project and the study.

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