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CATION CHARACTERIZATION AND WATER SELF-POWER CAPACITY WATERSHED IN SANTA CATARINA

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Abstract: The suinicultural activity in southern Brazil generates jobs, has a positive economic impact, but generates a large amount of waste, which is usually applied in agricultural areas as a form of disposal and fertilization. The waste has in the composition pollutants and/or contaminants of the environment, which can cause degradation of water bodies. The study aimed to evaluate the contents of dissolved oxygen (OD), electrical conductivity (EC), total dissolved solids (TDS) and cationic characterization, in waters in a hydrographic basin of southern Santa Catarina, with intense swine activity. The present study was developed from July/2015 to June/2016, in the municipality of Braço do Norte, Santa Catarina. Water samples were collected from four agricultural farms and three points of the Coruja River. Soil samples were also collected at the properties. The contents of dissolved oxygen (OD), electrical conductivity (EC), total dissolved solids (SDT) and cationic characterization (Ca, Mg and K) were evaluated in the water samples. The available levels of ca, mg and exchangeable K were evaluated in soil samples. The OD values in waters, in general, were lower than the minimum limit value established by the legislation, indicating high organic load that may be being conducted from adjacent agricultural areas to surface waters. For dissolved EC, SDT, Ca, Mg and K, there is no delimitation of maximum levels in CONAMA Resolution No. 357/2005. Therefore, not indicating contamination and / or pollution by these elements in water or soil.
Keywords: Dissolved oxygen, electrical conductivity, total dissolved solids, swine manure.

INTRODUCTION

The swine activity is strongly established in the Southern States of Brazil, with Paraná, Santa Catarina and Rio Grande do Sul responsible for 54% of the national production (ABPA, 2016), being present in small properties, with predominance of family agriculture. This activity generates a considerable amount of waste, which must be carried in the production units which, usually, use the application of these wastes in agricultural areas as a source of nutrients for annual crops and/or pastures. But also, in some situations applications are carried out as a way of disposing of these residues, presenting potential risks of contamination to water bodies (VEIGA et al., 2012).

This practice has positive aspects in relation to soil chemical attributes, increasing the availability of nutrients such as N, P, Ca, Mg, Cu and Zn (LOURENZI et al., 2016), thus improving soil fertility. However, it presents potential risks of soil contamination and, through surface runoff and percolation processes, surface and subsurface water bodies (GIROTTO et al., 2013; LOURENZI et al., 2015). The main contaminant present in waste is P, which causes eutrophication processes (CAPOANE et al., 2015). However, in addition to P, there are different types of contaminants that can compromise the quality of surface and subsurface waters, which can lead to local or regional problems, since the degradation of water sources has been increasing in recent decades (MIGUEL et al., 2014). This degradation occurs due to the use of water resources to dump domestic, industrial and agricultural effluents (MULLER et al., 2016).

Thus, the dumping of domestic and/or agricultural effluents in water sources, as well as the indiscriminate application of pig manure in agricultural areas, which via surface runoff reach water sources, causing the degradation of their quality. In this respect, the dissolved oxygen content is one of the parameters that significantly presents alterations with the increase of pollutant compounds and contaminants that, in association with the dissolved ion content and dissolved organic matter, alter the self-purification capacity of water bodies (MARÇAL & SILVA, 2017).

The dissolved contents of Ca and Mg or even other elements do not have a direct indication of pollution and/or contamination of water bodies, but are indicative of direct anthropic action, such as the dumping of effluents in water bodies or waste applications in nearby agricultural areas, which causes an increase in electrical conductivity and total dissolved solids (MOURA et al., 2010). The study aimed to evaluate the contents of dissolved oxygen (OD), electrical conductivity (EC), total dissolved solids (TDS) and cationic characterization of water samples in a hydrographic basin of southern Santa Catarina with intense swine activity.

MATERIAL AND METHODS

LOCATION OF THE STUDY AREA

The present study was carried out in the Rio Coruja/Bonito hydrographic basin, which has approximately 52 km^2. The hydrographic basin is located in the southeast region of the municipality of Braço do Norte, in the locality of Pinheiral (28°12'461" S, 49°05'170" O). The climate of the region is classified as Cfa, according to the Köeppen-Geiger classification. During the study period, precipitation and temperature values were obtained from the online meteorological data of the Meteorological Station of the National Institute of Meteorology (INMET), located in the municipality of Urussanga, and the values of 1,512 mm of total accumulated precipitation and 18.7°C of average temperature were obtained (Figure 1).

The study was carried out from July 2015 to June 2016, and four agricultural properties were selected within the Rio Coruja/Bonito watershed. Three properties had pig rearing and intensive use of manure in crops and one without pig farming, but with the use of bovine and pig manure. In addition, three collection points were selected in the Coruja/Bonito River. The points were identified according to the type (supply wells = PA; springs = N; dams = A; river = R) and the property number and, or, river point (1, 2, 3 and 4), totaling fifteen collection points; three in the Coruja River (R1, R2 and R3), five supply wells (PA1.1, PA1.2, PA2, PA3 and PA4), two springs (N1 and N2) and five reservoirs (A1.1, A1.2, A2, A3 and A4). Water collections were carried out in July, October and December 2015 and March and June 2016.

COLLECTIONS AND ANALYSES

At each point,approximately 300 mL of water were collected and, *in loco*, the dissolved oxygen (OD) and electrical conductivity (CE) values were determined using a conductimeter (YSI Model 85, Brazil). From the Ce values, the values of Total Dissolved Solids (TSS) were calculated, multiplying the EC values by the constant of 0.67 (Equation 1) (COPETTI et al., 2009). SDT (mg $^{L-1}$): CE X 0.67Equation 1

After collection, in the laboratory, the samples were filtered in cellulose membranes of 0.45 μm and the Ca and Mg contents were obtained in atomic absorption spectrophotometer (Perkin Elmer, AAnalyst 200, Italy). K contents were obtained in a flame photometer (Digimed, B262 Micronal, Brazil).

In December 2015, soil collection was performed in places adjacent to points PA1.1, PA1.2, PA2, PA4, A1.1, A1.2, A2, A3, A4 and N2 of water collection, to verify possible sources of contamination of water sources from the soil. The points were chosen because of the dynamics of the water flow of adjacent crop areas that received pig manure. Soil samples were collected in triplicate in the layers of 0-5, 5-10, 10-20 and 20-40 cm.

The samples were air-dried, ground, passed in a sieve with a 2 mm mesh, and later, the exchangeable contents of Ca and Mg were determined and available for K, as described by Tedesco et al. (1995). In the extracts obtained, the ca and mg contents were determined in atomic absorption spectrophotometer (Perkin Elmer, AAnalyst 200, Italy). K contents were determined in a flame photometer (Digimed, B262 Micronal, Brazil).

For the dissolved contents of Ca, Mg and K, as well as OD, CE and SDT in the water, because there was no repetition of the determinations performed, the means were obtained. For the exchangeable levels of Ca and Mg and available of soil K, the data were submitted to variance analysis and, when significant difference was observed, the means were compared using the Tukey test with 5% probability of error, using the Sisvar version 5.3 program (FERREIRA, 2011).

RESULTS AND DISCUSSION

WATER QUALITY

For OD levels, a variation of 1.60 to 10.12 mg $^{L-1 \text{ occurred}}$ (Figure 2). Resolution No. 357/2005 establishes for this parameter the minimum content of 5 mg $^{L-1}$ for class 2 waters. The waters are intended for the supply for human consumption, after conventional treatment, for the protection of aquatic communities, to the recreation of primary contact, such as swimming, water skiing and diving, use for irrigation of vegetables, fruit plants and parks, sports and leisure fields, where the public has direct contact, aquaculture and fishing activity (BRAZIL, 2005). In this sense, the od contents are, in most points, with values below the limit established by the legislation (Figure 2). For the PA1.1, PA1.2, PA2 and PA4 supply wells, higher OD values were expected because they are underground, which would allow greater control regarding the arrival of contaminant compounds, especially organic material. However, leaching of these compounds from areas adjacent to the evaluation points, such as nitrogens that require oxygen to perform reactions (PERREIRA & MERCANTE, 2005), is a probable explanation for the low OD contentobserved in the evaluated supply wells.

For the points of the Coruja River (R1, R2 and R3), only for the collection of Jul/2015, in point R3, values above 5 mg $^{L-1 \text{ were observed}}$. This is because the anthropic action on the banks of the river affects its dynamics and, even presenting rapids, there are no OD values compatible with the maintenance of aquatic forms of life, thus altering the entire biological balance of the river (ALBERTONI et al., 2017).

In the springs (N1 and N2) and dams (A1.1., A1.2, A2, A3 and A4) studied, the application of pig manure in agricultural areas contributes to the presence of nitrogen compounds, which require oxygen for transformations in the environment, due to nitrification and denitrification processes, where to oxidize 1.0 mg of NH_3 4.3 mg of OD (PERREIRA & MERCANTE, 2005). In addition, the presence of P in water, which causes the eutrophication of water bodies, develops a series of reactions that consume oxygen available in water bodies, affecting the availability and maintenance of aquatic life forms (ALBERTONI et al., 2017).

For EC, the values varied from 26 μS $^{cm-1}$ to 336 μS $^{cm-1}$ (Table 1). These values indicate intense anthropic action, since values close to 100 μS $^{cm-1 \text{ indicate}}$ a high concentration of dissolved ions in the water body, especially from areas with waste application and effluent discharge (BEM et al., 2015). For the points of the Coruja River, as well as for the springs and reservoirs evaluated, it is inferable that the application of waste in agricultural areas, dumping of domestic effluents and the presence of pig slaughterhouses in the

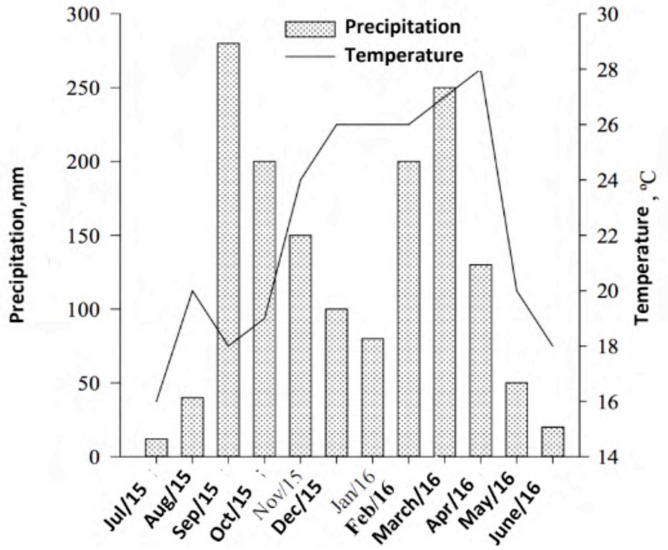

Figure 1. Average monthly values of precipitation (mm) and temperature (°C) for the study period.

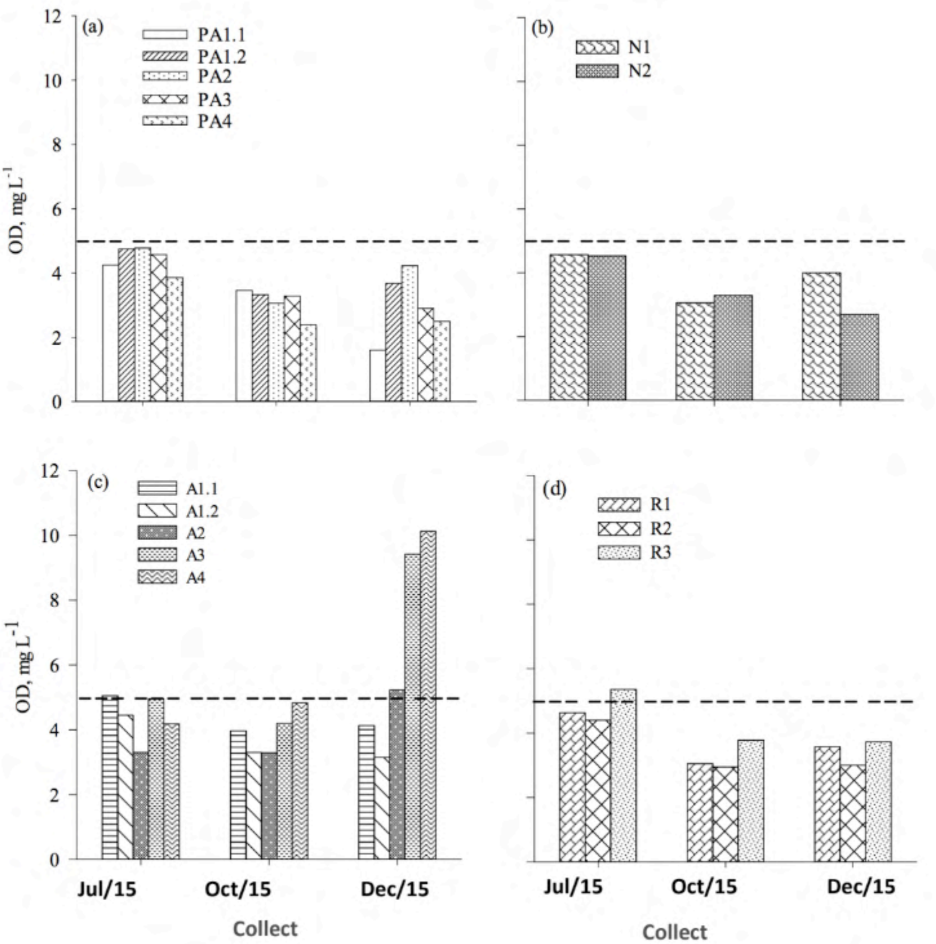

Figure 2. Dissolved Oxygen (OD) values for supply wells (a), springs (b), dams (c) and river (d) of the Rio Coruja/Bonito watershed. Dashed lines represent the minimum values according to Resolution Number 357/2005 (BRASIL, 2005).

watershed are interfering in the EC, while for the supply wells the processes of leaching of ions in the soil affect the electrical conductivity, being directly associated with rainfall events, in which there is greater soil erosion and particle supply to water bodies (BUZELLI & CUNHA-SANTINO, 2013).

For TDS, values ranging from 17.62 mg $^{L-1 to}$ 225.12 mg $^{L-1}$ were observed, according to data presented in Table 1. Among these values, it is observed that, for points PA1.2, PA4, A4 and R3, in the march/2016 collection, and points PA1.1, PA3 and PA4, for the June/2016 collection, SDT values higher than 100 mg $^{L-1}$ were observed. The supply wells presented higher levels of SDT, and it can be attributed to this phenomenon that the water of the other collection environments, present as lyotic bodies, and may increase or decrease their water flow and particle spooling according to the rainfall events that occurred in the basin, as well as by the application of swine manure in nearby agricultural areas (MOURA et al., 2010; BERTOL et al., 2011).

For the dissolved levels of Ca, Mg and K in water there is no establishment of borderline values by CONAMA Resolution No. 357/2005. However, the presence of Ca, Mg and K indicate direct anthropic action, especially effluent discharge in water bodies, presenting an indirect indicative character of pollution. According to Vendramini et al. (2014), the levels of Ca^{+2} and Mg^{+2} in water are generally components of diffuse origin associated with rock dissolution, while K^{+} contents are associated with soil fertilization.

In relation to the ions that alter the self-purification capacity and the characteristics of the water, Ca and Mg do not have characteristics that make them indicative of pollution and contamination of soils, but due to their reactivity to the soil, they can be carried to water bodies in intense rainfall events (BERTOL et al., 2011). Thus, the dissolved contents of Ca and Mg do not have a direct indication of pollution and/or contamination of water bodies, but are indicative of direct anthropic action, especially the discharge of effluents in water bodies, which causes an increase in electrical conductivity and the contents of total dissolved solids.

Regarding the dissolved Ca content observed in the study points, the months of Oct/15 and Jun/16 presented, for points PA1.1, PA1.2, PA2, PA3 and PA4 the highest concentration (Jun/16) and the highest variability between the points (Oct/15), which may be associated with the higher concentration of Ca dissolved in water due to the water flow in the soil above the wells, that may have carried soil particles with Ca^{+2} adsorbed to them. The increase in dissolved Ca concentration for the collection of Out/15 may be associated with the application of pig manure in areas adjacent to the wells, which by leaching processes in the soil caused a higher concentration of this element in the water of the supply wells.

For points N1, N2, A1.1, A1.2, A2, A3, A4, R1, R2 and R3, it is observed that the Ca^{+2} contents present in water are related to water flow, where with the increase in the flow of the water body there is an increase in dissolved Ca concentrations due to the contribution of surface runoff of areas adjacent to water bodies (VENDRAMINI et al., 2014).

For points PA1.1, PA1.2, PA2, PA3 and PA4, dissolved Mg contents were higher when compared to the other study points in the Coruja / Bonito basin, and saturation of adsorption sites of reactive particles in the surface layers can be attributed, thus occurring in depth leaching processes; which increases the concentration of Mg dissolved in groundwater, as well as to the fact that the water from the wells is confined and in as long as with the soil. For points N1, N2, A1.1, A1.2, A2, A3, A4, R1, R2 and R3, the levels of Mg

Collection	Point														
	PA1.1	PA1.2	PA2	PA3	PA4	N1	N2	A1.1	A1.2	A2	A3	A4	R1	R2	R3
							Ce, µS $^{cm-1}$								
Dec/15	134,6	62,8	90,0	49,4	90,0	33,8	92,4	28,0	46,6	41,0	40,0	40,6	54,7	58,6	26,2
Mar/16	126,5	236,0	26,4	36,2	230,0	34,2	119,7	26,3	49,4	92,4	36,2	184,0	58,1	50,9	223,0
Jun/16	215,0	74,7	39,4	53,4	157,3	45,6	336,0	33,3	66,2	120,0	48,8	53,3	128,3	109,5	115,7
							SDT, Mg $^{L-1}$								
Dec/15	90,18	42,08	60,30	61,91	60,30	22,65	33,10	18,76	31,22	27,47	26,80	27,20	36,65	39,26	17,55
Mar/16	84,75	158,12	17,69	80,20	154,10	22,92	24,25	17,62	33,10	61,90	24,25	123,28	38,92	34,10	149,41
Jun/16	144,05	50,05	26,40	225,12	105,39	30,55	35,78	22,31	44,35	30,55	32,70	35,71	85,96	73,37	77,52
							Dissolved Ca, mg $^{L-1}$								
Jul/15	0,18	0,18	0,02	0,15	0,23	0,09	0,12	0,17	0,21	0,18	0,09	0,27	0,22	0,20	0,21
Oct/15	1,62	1,10	0,00	0,26	2,02	0,14	1,56	0,02	0,99	0,62	0,00	1,33	1,12	1,10	0,89
Dec/15	0,21	0,16	0,03	0,08	0,22	0,09	0,23	0,08	0,17	0,10	0,06	0,16	0,18	0,17	0,21
Mar/16	0,32	0,24	0,16	0,15	0,22	0,10	0,20	0,21	0,19	0,15	0,17	0,33	0,29	0,28	0,25
Jun/16	1,50	3,40	2,20	2,70	2,40	2,50	1,70	3,00	3,60	5,40	1,60	2,30	1,50	1,60	1,50
							Dissolved mg, mg $^{L-1}$								
Jul/15	7,95	2,38	0,90	0,82	1,72	1,31	1,03	0,98	1,35	1,48	0,90	1,15	2,17	1,56	1,39
Oct15	6,20	3,16	1,64	1,46	2,05	1,46	2,29	1,32	2,43	1,98	1,15	2,03	2,08	2,12	2,00
Dec/15	5,41	2,13	0,62	0,49	0,94	0,62	1,93	0,62	1,35	0,94	0,45	1,35	1,35	1,31	1,97
Mar/16	0,69	0,62	0,94	1,80	1,76	1,39	2,30	0,33	0,82	0,98	1,56	0,82	1,48	1,44	1,31
Jun/16	0,58	0,58	0,12	0,05	1,17	0,04	0,05	0,62	0,48	0,13	1,25	1,21	0,97	1,54	2,13
							Dissolved K, mg $^{L-1}$								
Jul/15	9,80	5,37	4,17	3,70	26,03	3,50	6,87	5,67	3,53	3,53	4,47	10,03	8,40	7,80	7,10
Oct/15	13,10	4,20	2,75	7,40	17,45	3,35	8,10	3,70	6,55	6,55	4,75	12,08	7,40	6,90	5,85
Dec/15	16,70	7,90	5,10	4,75	17,40	3,60	7,45	3,70	7,75	7,75	6,20	10,60	7,20	7,80	5,35
Mar/16	16,77	9,13	3,23	5,83	6,67	6,60	10,23	5,63	9,93	9,93	7,83	3,80	1,80	7,20	9,50
Jun/16	2,50	2,00	1,50	1,30	9,60	0,70	5,70	4,60	4,60	4,60	1,70	3,60	4,30	3,70	3,10

Table 1. Values of electrical conductivity (EC), total dissolved solids (TS), Ca, Mg and K contents dissolved in the study points in the Coruja/Bonito river basin.

dissolved in water can be attributed due to the application of pig manure in areas adjacent to the water bodies and, consequently, the transport of this element via flow in rainfall events.

For dissolved K contents, not only effluent discharge can alter water concentrations, geological formation is also an important factor in this process, as the dissolution of rocks can occur through weathering processes (BORTOLIN et al., 2014), as well as the application of potassium fertilizers in the soil (VENDRAMINI et al., 2014).

For points N1, N2, R1, R2 and R3, the dissolved K contents were lower when compared to the supply wells, being attributed these values due to the constant flow of water they receive, and may even be released K into the water through the erosive processes that water provides in the margins of water bodies. For the dams, the contents of K dissolved in the water were constantly presented, corroborating with Thebaldi et al. (2017). The authors when evaluating some parameters of water quality in the Fundão and Josino Lagoons, in the municipality of Formiga/MG, observed constant Levels of K in the water. However, the Collection of Jun/16 presented lower levels, which can be attributed to the reduction of rainfall indices, causing lower water supply to adjacent water bodies.

CA, MG AND K IN SOIL

The levels of tradable Ca and Mg and available K in the soil of the study points are presented in table 2. In general, the contents of exchangeable Ca and Mg present higher values in the surface layers of the soil, due to adsorption to the functional groups of reactive particles of the soil, which decreases the mobility in the soil; and the constant application of DlS in agricultural areas (VEIGA et al, 2012). Thus, it is observed that soil collection points receive constant application of pig manure or are influenced by applications in adjacent agricultural areas, which can interfere in the dissolved contents of these elements in water. Especially for the lyotic water bodies under study (N1, N2, A1.1, A1.2, A2, A3, A4, R1, R2 and R3), there may be an increase in the levels of Ca and Mg dissolved due to the losses of these by soil erosion, where soil particles are carried from tillage areas to the water bodies during or after rainfall events, through surface flow processes (BERTOL et al., 2011).

For the contents of exchangeable K in the soil (Table 2), it is observed that the levels are lower when compared to the levels of Ca and Mg available in the soil and higher levels when the dissolved contents in water were evaluated, and it can infer that soil weathering can be a source of K for water. According to Uberti (2005), K contents can be justified by the weathering of the source material of the region under study, which contains feldspars and micas, which, through the weathering of rocks, release K into the water. Thus, not only the application of waste in agricultural areas contributes to the elevation of the elements in water, but their source material can present itself as a source of the element. It can also be inferred that due to K presenting greater mobility than Ca and Mg in the soil, leaching processes may occur in the soil profile, which cause greater release of K in underground water bodies and that the higher the dose of scum applied, the greater the increment of this element in depth (CASSOL et al., 2012).

FINAL CONSIDERATIONS

The swine activity in the region under study, is inferring in the water quality, as observed by the values of Dissolved Oxygen, where the study points were below the minimum limit established by the legislation, indicating high organic load, which may be carried from adjacent agricultural areas that

Prof., cm	Stitches									
	PA1.1	PA1.2	PA2	PA4	N1	A1.1	A1.2	A2	A3	A4
					Ca available, $cmol_c$ dm-3					
0-5	3.65to[1]	2.54 ab	3.56 to	6.77 ab	1.07 to	7.13 to	3.36 to	5.28 to	2.36 to	3.82 to
5-10	1.23B	3.11 to	2.23 to	9.46 to	2.67 to	4.19 to	3.72 to	3.62 ab	3.24 to	7.10 to
10-20	2.36B	2.06 ab	2.03 a	4.17 B	1.59 to	4.94 to	2.29 a	2.06 B	2.23 to	4.86 to
20-40	3.05a	1.62 B	2.28 to	10.59 to	1.83 to	1.02 to	2.17 to	2.43 B	2.09 a	4.49 to
CV, %	39,49	19,81	35,57	20,32	50,83	20,18	29,98	29,89	26,96	26,92
					Mg available, $cmol_c$ dm-3					
0-5	2.25a	0.96 ab	3.63 to	4.75 to	1.38 to	3.27 to	2.02 a	4.26 to	1.83 to	3.00 ab
5-10	1.83ab	1.46 to	2.48 to	4.19 to	0.43 b	2.44 ab	1.79 to	2.82 B	0.10 b	3.21 ab
10-20	1.41B	1.34 to	2.54 to	2.55 B	0.28 B	1.67 B	1.90 to	1.51 c	1.59 to	3.47 to
20-40	1.29B	0.44 B	1.02 b	2.92 B	0.13 b	1.11 b	2.16 to	1.53 c	0.61 b	2.82 B
CV, %	16,43	25,66	21,15	10,45	36,09	23,93	11,62	17,04	21,36	6,27
					K available, mg $^{L-1}$					
0-5	66.0b	155.2 to	159.3 to	150.5 to	118.5 to	35.5 b	77.7 to	130.0 to	73.4 to	89.8 to
5-10	41.5c	38.8 B	138.5 b	102.1 to	51.7 b	56.3 B	73.2 to	29.3 B	45.0 to	47.8 B
10-20	24.1C	50.6 b	101.0 c	140.2 to	31.5 bc	24.0 b	79.0 to	29.5 b	42.1 to	42.5 b
20-40	97.8A	35.3 B	75.8 D	134.8 to	22.0 c	137.0 to	92.3 to	32.8 B	35.6 to	87.0 to
CV, %	13,03	41,16	5,06	17,72	16,19	23,42	10,98	16,99	32,17	10,26

(1) Means followed by different letters in the column show statistical difference by the Tukey test at the level of 5% probability of error.

Table 2. Exchangeable contents of Ca, Mg and K in the soil of the study points in the watershed of the Coruja/Bonito River.

receive application of liquid waste from pigs. For the other chemical parameters, there is no delimitation of maximum levels in CONAMA Resolution No. 357/2005. However, Ca, Mg and K ions alter organoleptic characteristics of water. The soil contents do not indicate contamination and/or pollution, however because soil particles are strongly linked, and can be carried to water bodies in intense rainfall events.

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