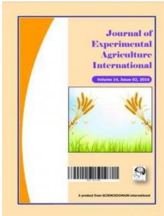

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Chemical and Physical Quality of the Entisol in a Natural Regeneration Area in the Semiarid Region of Paraiba

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The change in the use of the soil causes an imbalance in the ecosystems, altering the chemical and physical properties, which can make their natural recovery unviable. This study aimed to characterize chemically and physically an Entisol under the Caatinga area in a 30 years ecological succession stage in the Semiarid region of Paraiba. The experiment was carried out at the Experimental Station Professor Ignácio Salcêdo, belonging to the National Institute of Semiarid (INSA), located in the municipality of Campina Grande, in the state of Paraíba, soil samples were collected in the 0-10 cm layer, for the determination of pH levels (H_2O), exchangeable acidity (Al^{3+}) and potential acidity (H + Al), Ca^{2+}, Mg^{2+}, K^+, P, Na^+, CTC and SB, Total organic carbon (TOC) and

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organic matter (OM). In the physical analyses, texture, soil density, particle density, total porosity and aggregate stability were determined. The chemical characterization observed the presence of high levels of K^+, Ca^{2+}, Mg^{2+}, CTC and SB, and low levels of Al^{3+} and Na^+ with reduced OM and TOC contents in the 0-10 cm layer. As for physics, the textural classification was sandy loam soil, the soil density, soil porosity and aggregate stability showed values below the critical root growth index in sandy soils. The soil presented recovery characteristics of its chemical and physical quality. The description of the Entisol in the field in soil surveys contributes to a new database in order to predict a better way of use, and these results are references in studies of soil quality recovery in degraded areas in the Caatinga area.

Keywords: Caatinga; soil quality; soil use; conservation.

1. INTRODUCTION

The Semiarid region of Paraiba, Brazil, has a great diversity of soil classes and vegetation cover. According to mapping based on vegetation cover and soil classes, most of the Semiarid region of Paraiba has a sensitivity to desertification, where the main causes are deforestation and the intensive use of the soil (agriculture and livestock) that increase the erosion and deteriorate soil properties [1]. Due to the poor conservation of soils in the state of Paraíba, it recommend the use of Soil conservation practices [2].

The Caatinga is a unique semiarid ecoregion in the world, its current situation is of deforestation of around 45% of the biome, the remainder is being found in several successional stages, the soils, in general, are presented with signs of degradation. As a result, several nuclei of desertification have been identified in the region [3].

The Entisolss, a class that predominates in the Semiarid region, are potentially limited soils because they are shallow and commonly stony and rocky. They present diverse fertility, and the loss of soil by erosion is naturally very high, being aggravated when removed the original vegetation and causing deterioration of the soil structure [4].

Soil degradation can occur due to the loss of chemical quality characterized by the decrease of the original organic matter and important mineral elements, for values below those considered critical for agricultural productivity [5]. The loss of physical quality may result from processes of disaggregation, superficial and subsurface compaction of the soil [6].

Soil electrical conductivity (EC), macro and micronutrient contents, and soil organic matter (SOM) stocks are among the soil chemical properties that are influenced by land use type and used as soil quality indicators [7].

Thus, in order to provide subsidies for adequate soil management, in addition, providing data from this process for a better knowledge of the soils of the country, contributing to a new database for global monitoring, the present study aimed to analyze the chemical and physical characteristics of a Entisols in an area of Caatinga in a natural regeneration stage in the state of Paraiba.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The research was developed in a native forest area of the Caatinga biome, belonging to the Experimental Station Professor Ignácio Salcêdo, of the National Institute of Semiarid, (INSA). It is located in the municipality of Campina Grande, located in the geographic mesoregion of the Agreste of Borborema, in the state of Paraiba, between the coordinates 7º15,341’ and 7º17,168 of latitude South and 35º59,473’ and 35º57,627’ of longitude west with an average altitude of approximately 480 meters above sea level.

The type of climate is Aw’i, according to Koppen's climatic classification and is considered sub-humid dry. The rainy season is located between January and June as shown in Fig. 1. The maximum annual average temperature is 28.7°C and the minimum 19.8°C varies slightly throughout the year. The soil of the area is a fragmented eutrophic Entisol, horizon A moderate, very gravel-textured medium texture.

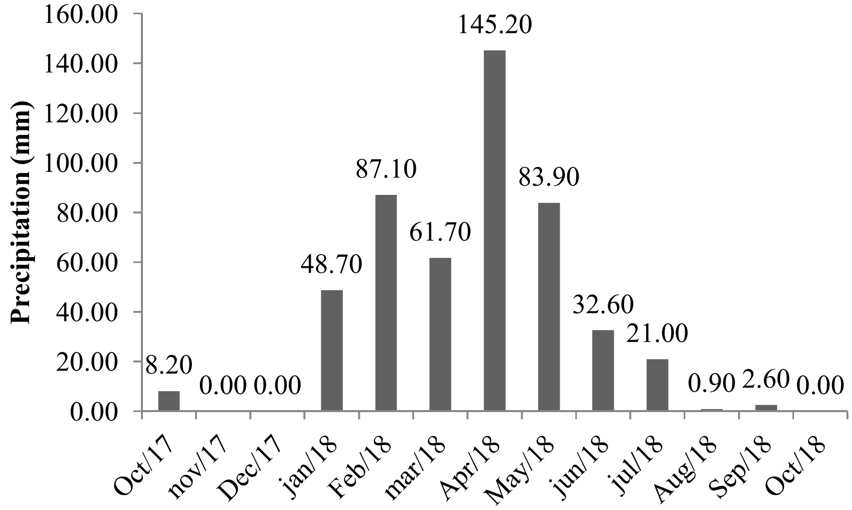

Fig. 1. Monthly precipitation for 1 year in Caatinga area in natural regeneration stage

The experimental station has an area of 675 ha, of which approximately 300 ha is preserved Caatinga in various stages of regeneration, the historic use of the area was grazing and use of woody biomass by neighboring communities. In the area is installed a tower for studies of heat and mass exchange between the biosphere and the atmosphere (eddy covariance technique, in an area under preserved caatinga vegetation, which subsidizes desertification research.

The soil samples were collected in the depth of 0-10 cm, randomly, along with a transect exposed in Fig. 2; this depth was the maximum possible range due to the difficulty of handling the soil that has gravel texture.

Fig. 2. Location of the area and C1, C2, C3, C4, C5 e C6 the soil collection points
Source: LAVORATO, F.F.D.

2.2 Soil Preparation for Analysis

Three simple samples were collected from each sampling point to obtain a composite sample, the samples were collected in the depth of 0-10 cm with the aid of an auger. Undeformed samples were also collected in the same depth, with the aid of a volumetric ring for soil density analysis. The soil samples were air-dried, disaggregated, homogenized and sifted in a 2.0 mm mesh sieve to obtain the thin air dry soil (TADS).

2.3 Physical and Chemical Analyses of Soils

From the air-dried soil samples, according to the methods described by [8], the following physical and chemical analyses were determined: pH in water in the proportion 1:2.5 (soil/water) and phosphorus, potassium, sodium, calcium, magnesium, exchangeable acidity, potential acidity, total organic carbon and soil organic matter, as well as the sum of bases and cation exchange capacity were calculated. For the physical attributes, the granulometric analysis by the pipette method, using a 0.1 N NaOH solution and mechanical agitation in low-rotation apparatus, for 16 hours, the clay fraction was separated by sedimentation; Coarse and thin sand were by tamisation and silt calculated by difference, soil density by the volumetric ring method, particle density was determined by volumetric flask method, and aggregate stability index, according to the formula developed by [2].

3. RESULTS AND DISCUSSION

3.1 Soil Chemical Characterization

The values of the chemical attributes of Entisol can be found in Table 1. The soil showed a moderately acidic reaction, with a pH value in water of 5.15. Similar results were observed by [9,10], in areas of caatinga in regeneration in a Entisol in the RN.

The phosphorus content (P) found in the soil under preserved Caatinga was 5.08 mg dm^{-3}, classified as low. [11] also observed low P levels in sandy soils under native Caatinga in the Brazilian semiarid, reaching up to 7.4 mg dm^{-3} in the layer of 0-10 cm deep. Tropical soils are characterized by high degree of weathering and low levels of phosphorus in the form available to plants [12]. In these soils phosphorus is the most limiting nutrient for agricultural production [13]. Because it presents low soil mobility [14] In addition, P is often the factor that restricts plant growth [15].

For the potassium content (K^+) as shown in Table 1, it was relatively high in the superficial horizon (layer 0-10 cm). The value of potassium was high in relation to the value obtained by [16], where the value obtained by him was 61 mg dm^{-3}, while the values obtained here reached up to 117.38 mg dm^{-3}. It is possible that such high values of this element are associated to the continuous supply of vegetal residues, which promoted an increase in CTC, favoring the retention of this nutrient, in addition to the absence of rotation, which favors the accumulation of nutrients at depth [17]. The sodium content (Na^+) observed in the soil under preserved Caatinga was 0.06 $cmol_c$ dm^{-3} (Table 1). Therefore, this low concentration of Na^+ does not offer limitation to plants, which is a very important and beneficial condition for management, because Na, as well as other excess salts, can compromise plant growth, besides affecting some physical properties of soil, such as hydraulic conductivity, infiltration and aeration [18].

The content of Al^{3+} of 0.37 $cmol_c$ dm^{-3} is considered low, presented tolerable values without level of toxicity to the plants. The high aluminum content causes toxicity, inhibiting the absorption of essential cations and the development of the root system. The value of the potential acidity (H + Al) was 6.11 $cmol_c$ dm^{-3}, [19] observed that the values of potential acidity were higher in the soil under native forest when compared with the various agricultural crops. This was due to the higher organic matter content, [20]. The exchangeable calcium and magnesium values were 2.21 and 2.55 $cmol_c$ dm^{-3} respectively. Approximate values of calcium and magnesium were found by [21] when studying toposequences and their respective profiles in soils of northeastern semiarid.

The soil presented a sum of bases (SB) of 5.12 $cmol_c$ dm^{-3} considered as high, for the 0-10 cm layer. According to [11], the substitution of native vegetation by agricultural cultivation results in higher values of sum of bases. Similar results were observed by [19], under native. CTC was 11.24 $cmol_c$ dm^{-3} and was classified as relatively high. [22] observed the opposite result in relation to native Caatinga (3.33 $cmol_c$ dm^{-3}), being classified as low (1.61-4.3 $cmol_c$ dm^{-3}). A low value of CTC indicates that the soil has a small capacity to retain cations in exchangeable form.

Table 1. Chemical characterization of the Entisols in the 0-10 cm layer in a Caatinga area in a regeneration process in the Semiarid region of Paraiba

Depth.	pH	P	K^+	Na^+	H^+Al	Al^{3+}	Ca^{+2}	Mg^{+2}	SB	CTC	M.O	C.O.T
--(cm)--	--H_2O-- (1:2,5)	--mg m^{-3}--		----------------------cmol$_c$ dm^{-3}--------------------							------g kg^{-1}------	
0-10	5.15	5.08	117.38	0.06	6.11	0.37	2.21	2.55	5.12	11.24	20.36	10.19

Table 2. Physical characterization of the Entisols in the 0-10-cm layer in a Caatinga area in a regeneration process in the Semiarid region of Paraiba

Depth. (cm)	Sand	Silty	Clay	Soil density	Particle density	Total porosity	Texture Class
	----------------gkg^{-1}------------------			---------g cm^{-3}--------		--m^3 m^{-3}--	
0-10	718	117	165	0,37	1,36	0,49	Sandy loam

The organic matter content, an important indicator of soil quality, was 20.36 g kg in the 0-10 cm layer. For practical purposes, the MO varies from 5 to 50 g kg^{-1} [23]. In these soils, the highest MO concentration in the upper soil layer is common. In relation to total organic carbon (TOC) the value found was 10.19 g kg^{-1}, a similar result was found by [1] attributing this result to the deposition of organic material in the most superficial layer.

3.2 Soil Physical Characterization

The values of the physical attributes of the Litóic Entisols are shown in Table 2. The contents of sand, 718 g kg^{-1}, clay 165 g Kg^{-1}, and Silt, 117 g kg^{-1}, allow to classifying this soil as a sandy loam soil textural class. In general, the Entisols of Paraiba are sandy soils with low fertility, as most soils of the semiarid region [24]. The soil density in the 0-10 cm layer was 0.37 g cm^{-3}, correlate the result found, [25] observed in their studies similar soil density values for soils under native Caatinga. These values are lower than the critical index of the root growth of sandy soils, 1.65 g cm^{-3}.

The value of particle density was 1.36 cmol$_c$ dm^{-3} is close to the value found by [5] which was 2.65 cmol$_c$ dm^{-3} in soils under native caatinga vegetation. For the total porosity the value found was 0.49 m^3 m^{-3}, in their work [26] observed that the intense use of the soil was sufficient to cause reductions in total porosity, which probably explains this value, because it is a disturbed environment and more exposed to weather (temperature, rain and wind).

The aggregate stability presented in Table 3 was 0.460 mm, similar to the value found by [27] in a Entisol under native forest, where most of its aggregates were smaller than 0.590, this characteristic is attributed to the revolvement and degradation of the superficial horizon, the nature of such soils associated with the lack of adequate management techniques explain the disruption of aggregates, which increases soil susceptibility to water and wind erosion.

Table 3. Aggregate stability Index (DMPAu/DMPAs) of a Entisol in a Caatinga area evaluated in dry and rainy seasons

Depth (cm)	Aggregate stability Index DMPAu/DMPAs ---------mm---------
0-10	0.460

4. CONCLUSIONS

The chemical characterization showed the presence of high levels of K, Ca, Mg, CTC and SB, and low levels of Al and (H + Al) and Na, presence of organic matter, which facilitates the conditions for soil management and does not offer impediment to root growth.

For soil physics, the textural classification was sandy loam, which favors infiltration and decreases water retention in the soil. Soil density, porosity and aggregate stability showed values that are lower than the critical root growth index in sandy soils.

The description of the Entisols in the field in soil surveys contributes to the understanding of them, aiming to provide subsidies for adequate soil management, and conservation practices, besides providing data from this process for a greater knowledge of the soils of the Country.

The reduction of soil fertility under the caatinga may be intrinsically related to its level of deforestation and the removal of vegetation as well as the use of fire. Low-cover soils are more susceptible to erosion and leaching, so it is essential to eliminate these bad practices in these areas, allowing the vegetation to regenerate, allowing them to contribute to the enrichment of these soils through the cycling of nutrients, also offering protection as mulch.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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