CAPÍTULO 07

CHARACTERIZATION OF *NEOSSOLOS REGOLÍTICOS (*PSAMMENTS*)* THROUGH A PLUVIOMETRIC GRADIENT IN BRAZILIAN SEMIARID

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ABSTRACT: There is still little information about *Neossolos Regoliticos* (Neosols) , therefore, generating information about fertility, genesis and mineralogy is important to define the proper use and management. The work aimed to characterize morphologically, physically, chemically and mineralogically three *Neossolos Regoliticos* (Psamments) along a pluviometric gradient (<400 mm;> 400 and <600;> 600 mm). For this purpose, trenches were opened, where the description and collection of soil samples proceeded. It was not possible to notice rainfall interference in the differentiation of horizons and depth of soils. However, increased clay contents from very dry soil to the sub-humid zone, showing the influence to rainfall that is also reflected in the natural fertilityof *Neossolos Regoliticos* (Psamments).

KEYWORDS: Mineralogy; Soil classification; Pedogenesis.

RESUMO: No Brasil, o conhecimento sobre esses solos é escasso, o que demanda geração de informações sobrea sua fertilidade, gênese e mineralogia, entre outros aspectos, para o uso e manejo adequados. O objetivo desse trabalho foi realizar a caracterização morfológica, física, química e mineralógica deNeossolos Regolíticos ao longo de um gradiente pluviométrico no semiárido Paraibano. Para tanto,dividiu-se a região em três zonas de acordo com a precipitação média anual: muito seca (< 10 400 mm), seca (≥> 400 e ≤< 600 mm) e subúmida (> 600 mm) onde foram abertas três trincheiras para coleta e descrição dos solos em cada horizonte. Não foi possível notar interferência da pluviometriana diferenciação dos horizontes e na profundidade dos solos. Os teores de argila aumentaram do solo da zona muito seca para a subúmida, evidenciando a influência das precipitações pluviométricas que também se refletiram na fertilidade natural dos Neossolos Regolíticos. A mineralogia da fração argila mostrou-se relativamente semelhante entre os solos estudados com caulinita, quartzo, feldspato e mica.

PALAVRAS-CHAVE: Mineralogia; Classificação de solo; Pedogênese.

1. INTRODUCTION

Neossolos Regoliticos (Psamments) occupy about 5 % of the total area of Paraíba State and aregrown mainly with consortia of corn, beans, potatoes, among other typical crops of family farming.Even with a predominantly sandy texture, low water retention capacity and nutrient adsorption, in addition to a low content of organic matter and nitrogen, they are intensively used in agriculture, especially for their favorable physical characteristics.

They are soils which are very susceptible to erosion, especially when turned over, and often require nitrogen and phosphate fertilizers. Allied to this, sandy texture provides an intense leaching of nutrients (GALVÃO, SALCEDO and OLIVEIRA, 2008; CAVALCANTE *et al.*, 2005). However, the most important agricultural limitation refers to the environmental conditions of the semi-arid region, notably low and irregular rainfall, but also high-intensity rains when they happen, and also high evapotranspiration. The agricultural use of these soils must be carried out carefully in order to minimize the effects caused by erosion and to avoid intensive leaching of nutrients. In addition, it is desirable to use techniques that aim to improve fertility, aggregation and the ability to retain moisture. Therefore, these soils need to be well characterized in order to adopt management techniques compatible to their weaknesses.

As for their morphogenetic characteristics, *Neossolos Regoliticos* (Psamments) are soils with lithic contact at a depth larger than 50 cm and the horizon A overlying the horizon C or Cr, being able to admit a horizon Bi less than 10 cm thick (SANTOS *et al*., 2018).

The climate has a decisive influence on soil formation, especially in tropical regions, such as Brazil, since high rainfall and temperatures are important for triggering the chemical and physical reactions (chemical and physical weathering) that transform soil origin material (TOLEDO, OLIVEIRA and MELFI, 2001). On the other hand, in semi-arid regions, the climate, characterized by low levels of precipitation and high temperatures, hinders the evolution of soils, so that they retain many characteristics of the source material.

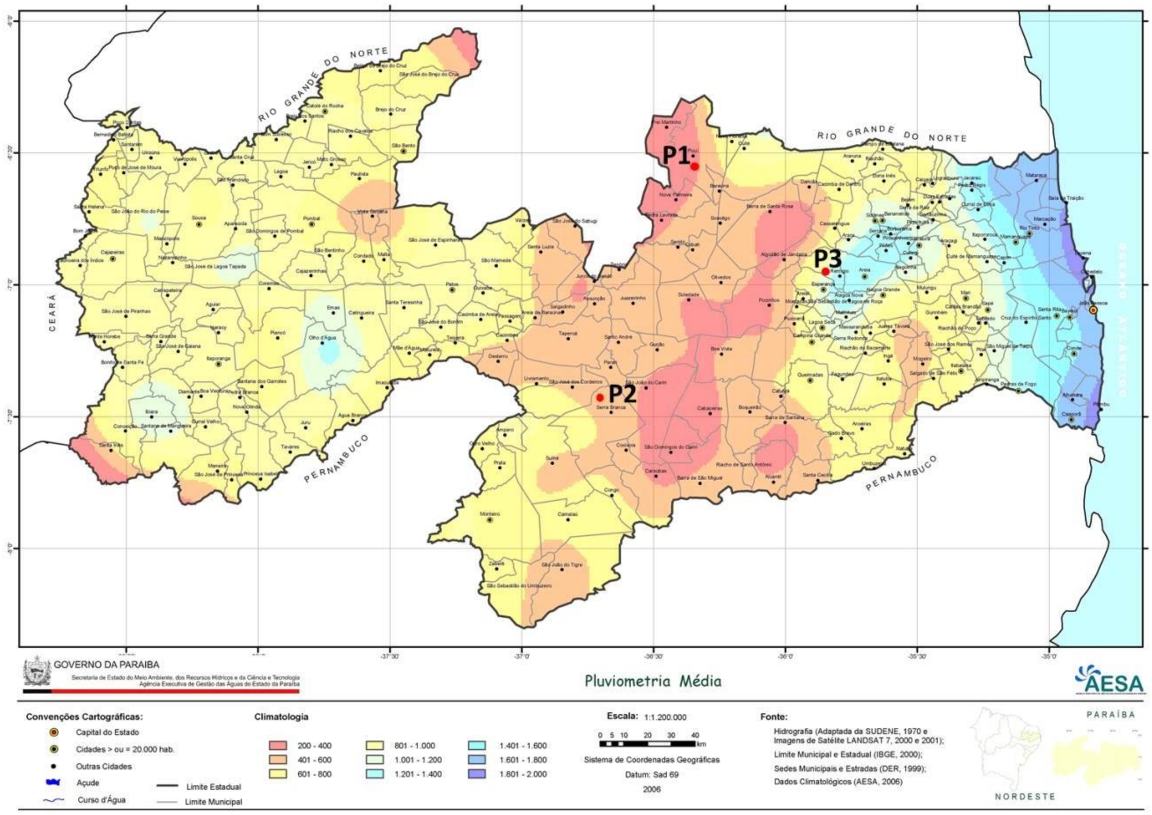
Physical, chemical, morphological and mineralogical soils characterization is a way of providing subsidies for the development of practices for the use, management and conservation of soils (JACOMINE, 1996). In semi-arid regions, where soils are generally very poor in organic matter, the study of the mineralogical composition and the morphological, chemical and physical transformations that occur in the soil is fundamentally important to understand its pedogenesis.

The technical-scientific scenario on soils in the semiarid region has evolved considerably inrecent years. However, knowledge in some areas of soil science such as pedogenetics and mineralogics is still limited. Therefore, they need more in-depth and specific studies to support other areas of research, such as soil fertility and chemistry, as well as in the planning of programs and activities aimed at the sustained development of this region. Considering the above, the present work was developed with the aim of describing the morphology and characterizing the mineralogy and physical and chemical attributes of three *Neossolos Regoliticos* (Psamments) in a pluviometric gradient in the Brazilian Semiarid.

2. MATERIALS AND METHODS

The studies were performed in the semi-arid region of Paraíba, considering a pluviometric gradient and the occurrence of *Neossolos Regoliticos* (Psamments). Paraíba's exploratory-soil recognition map (JACOMINE *et al.,* 1972) and Paraíba's rainfall map (AESA, 2007) were used as a reference. Three zones were considered, according to rainfall, designated as follows: very dry - precipitation <400 mm; drought - precipitation ≥ 400 mm and ≤ 600 mm; and sub-humid - precipitation> 600 mm (Figure 1).

Figure 1 – Average rainfall of Paraiba, with profile collected points from Neosoils in a pluviometrica gradient (AESA adapted, 2007)



The P1 profile corresponds to the *Neossolos Regoliticos* (Psamments) located in the very dry zone, collected in a flat top situation under degraded caatinga vegetation, whose source material is associated with indiscriminate granitoids.

The P2 profile corresponds to the *Neossolos Regoliticos* (Psamments) dry zone, located at the top of a slightly flat area, whose regional relief is flat to smooth undulating and the vegetation is thehyperxerophilous caatinga composed of quince, catingueira, rosemary, xique-xique among others, originated of granitic rocks.

The P3 profile corresponds to the *Neossolos Regoliticos* (Psamments) sub-humid zone, collected in an area of smooth wavy to wavy relief and under pasture vegetation, annual and fruit crops, whose original material is a syenogranite with muscovite.

In each selected area, a trench was opened for the morphological description of soil profilesand the collection of deformed and undeformed samples, as Santos *et al.* (2015). Soils were classified according to the Brazilian Soil Classification System - SiBCS (SANTOS *et al.*, 2018) and correlated with the North American Soil Taxonomy classification (Soil Survey Staff, 1999).

The physical analyzes of the soils were carried out according to the methodology presented by Teixeira *et al.* (2017) and included the following determinations: granulometry, clay dispersed in water (CDW), density of soil and particles and calculated the degree of flocculation and total porosity.

The analysis of the chemical attributes of the soil included determination of the contents of exchange able bases (Ca2 +, Mg2 +, Na + and K +), Al 3+ and potential acidity (H + + Al +3), adopting the method of KCl 1 mol L-1 ; phosphorus (assimilable P), pH in water and pH in KCl and electrical conductivity (EC). All analyzes were performed according to the methodologies described by Teixeira et al. (2017). Based on these determinations were calculated: sum of bases (S), cation exchange capacity (CTC), base saturation (V), percentage of saturation by sodium (PST) and percentage of saturation by aluminum (m). The organic determination was based on Yeomans and Bremner methodology (1988).

For the assessment of soil fractions mineralogy, samples from the upper, middle and lower horizons were selected in the studied profiles. The air-dried fine soil samples (TFSA) were subjectedto the wet fractionation process (sand) and decantation (silt and clay). The clay fraction was subjected to treatment to eliminate free iron oxides and then subjected to treatments for saturation with K + and Mg + 2 for assembly of oriented aggregates on glass slides for further analysis by X-ray diffraction (XRD) (JACKSON, 1975).

The clay fraction was analyzed by XRD in the form of non-oriented powder (clay without pre-treatments), as well as in the form of aggregates oriented on glass slides, considering the following treatments: saturated with K + at room temperature - K 25, heated to 350 ° C (K 350), heated to 550 ° C (K 550); and saturated Mg2 + (Mg) and Mg2 + solvated with glycerol (Mg-Gl). All samples were irradiated at room temperature in a Shimadzu XRD-6100 diffractometer, operatingat a voltage of 40 kv, with a current of 20 mA, copper Kα radiation, with scanning range 3 to 30º, with a step 2θ / min.

The interpretation of the reflections in the diffractograms and the identification of the minerals of the clay fraction, compared to the treatments carried out on the samples, were carried out according to criteria in force in Jackson (1975); Dixon and Weed (1989); Whittig and Allardice(1976) and Moore and Reynolds (1989).

2. RESULTS AND DISCUSSION

2.1 Morphological properties

The profiles of studied *Neossolos Regoliticos* (Psamments), in general, show similarities regarding to their morphological attributes and there is no clear interference from the rainfall gradient of the semiarid in the depth of these soils. The three profiles showed similar depths, rangingfrom 1,50 to 1,95 m, with a sequence of horizons of type A-C (Table 1).

Table 1 – Morphological features of three studied Neosoils in a pluviometrical gradiente in the Paraiba dry region

Hor.	Depth	Colour		Tex.	Structure		Consistency	
	(cm)	Humid	Dry			Dry	Humid	Wet
P1 – Neosoil – very dry area (Picuí)								
A	0-15	10 YR 6/3	10 YR 8/2	Sd	1 Sm-Md	Sm	TC	NPl SS
CA	15-35	10 YR 6/4	10 YR 8/2	Sd	1 Sm-Md	Sm	TC	NPl NSt
C	35-110	10 YR 6/3	10 YR 8/2	Sd	1 Sm-Md	Sm	TC	NPl NSt
Cn	110-155	10 YR 6/4	10 YR 7/3	Sd	1 Sm-Md	Sm	TC	NPl NSt
C’	155-195	10 YR 6/3	10 YR 8/2	LoS	1 Sm-Md, Sb	Un	Un	NPl NSt
P2 – Neosoil – dry area (Serra Branca)								
A	0-12	10 YR 5/3	10 YR 7/3	LoS	1 Sm-Md	Sm-SH	TC	SPl NSt
CA	12-35	10 YR 7/3	10 YR 8/2	LoS	1 Sm-Md	Sm-SH	TC	NPl NSt
C1	35-100	10 YR 7/3	10 YR 8/2	LoS	2 Sm-Md, Sb	Sm-SH	TC	NPl NSt
C2	100-160	10 YR 7/3	10 YR 8/2	LoS	1 Sm-Md, Sb	Sm	TC	NPl NSt
R/Cr	160-190+							
P3 – Neosoil – humid area (Remígio)								
Ap	0-14	10 YR 3/2	10 YR 5/2	SL	2 Sm, Gt	Sm	TC	NPl NSt
AC	14-37	10 YR 2/2	10 YR 5/2	LoS	1 Sm, Sb	Sm-SH	TC	NPl NSt
C	37-70	10 YR 4/3	10 YR 6/2	LoS	1 Sm	Sm	TC	NPl NSt
Cn1	70-130	10 YR 4/3	10 YR 6/2	LoS	1 Sm-Md	Sm	TC	NPl NSt
Cn2	130-150+	10 YR 5/3	10 YR 6,5/3	LoS	1	Sm	TC	NPl NSt

Hor.: horizon. Dep.: depth. Tex: texture; Sd – sand; LoS – low sand; Francoarenosa – sandy loam (SL). Structure: 1 – simple grit; 2 – Clump; Sm – small; Md – medium; Sb – subangle blocks; Gt – grint. Consistency: Un – Unsleash; Sm – smooth; SH – slightly hard; TC – too cold; NPl – non plastic; SPl – slightly plastic; NSt – Non sticky; St – sticky; SS – slightly sticky.

The *Neossolos Regoliticos* (Neosols) from the very dry zone (Picuí - P1) and the dry zone (Serra Branca - P2) have an A horizon with 12 to 15 cm thick, color with a value ≥ 4 in wet soil andvalue ≥ 6 in dry soil, and CO, less than 6 g kg^{-1}, featuring a weak A horizon. The *Neossolos Regoliticos* (Psamments) from the sub-humid zone (Remígio - P3) showed a relatively thick surface horizon, 37 cm thick, with a dark color, base saturation below 65 %, featuring a prominent A horizon according to criteria established by SiBCS (SANTOS *et al.,* 2018).

As for color, all profiles of *Neossolos Regoliticos* (Psamments) studied fit the 10YR hue with gray, and white colors (Table 1) reflecting the characteristics of the searched material. The textural class ranged from sand to fullsandy, with a predominance of the sand fraction over the others. As for the soil in the sub-humid zone, it is possible to infer that it is slightly more developed than the others because it has a slightly finer texture throughout the profile. For comparison, the studied profiles in the Exploratory Survey-Recognition of Soils of Paraíba State (JACOMINE *et al.*, 1972) present more than 80 % of quartz in its composition, mineral which gives whitish color to the soils.

The structure of the soils is predominantly of the simple grains type and a weak part small to medium subangular blocks. According to Santos et al. (2012), the climatic conditions and the similar nature of the source materials throughout the semiarid region are responsible for the small variation in the morphological characteristics of the soil profiles of the class of *Neossolos Regoliticos* (Psamments) in Pernambuco's semiarid region.

2.2 Physical properties

In the studied profiles, coarse fractions (pebble + gravel) have little representation in the soilmass, with maximum values of 9 % (data not shown). The total sand contents varied from 692 to 932 g kg^{-1} soil in the superficial horizons and from 781 to 870 g kg^{-1} soil in the subsurface horizons (Table 2). When comparing similar horizons with each other, it is possible to notice that the lowestlevels of sand occur in the sub-humid condition, which may be related to slightly more accentuated weathering in this condition. Fernandes *et al.* (2010) also observed high levels of sand in *NeossolosRegoliticos* (Psamments) of semi-arid region in Sergipe State, often above 700 g kg^{-1} soil.

Table 2 – Physical characteristics of the three profiles of Regolitic Neossols studied in a pluviometric gradient in thesemi-arid region of Paraiba

Hor	AFLD	Granulometrical composition of fine land					CDW	FD	Silte/ Clay Rel.	Densities		Poros.
		Sand			Silte	Clay				Soil	Part.	
		Gross	Slim	Total								
----------------------------- g kg⁻¹ -----------------------------								%		-- Mg m⁻³ --		dm³.dm³
P1 – Neosoil – very dry area (Picuí)												
Ap	976	712	221	932	11	56	0	100	0,20	1,59	2,50	0,36
CA	978	638	233	870	83	47	0	100	1,75	1,59	2,66	0,40
C	963	672	198	870	65	65	0	100	1,00	1,52	2,49	0,39
Cn	913	817	83	899	40	60	25	58	0,67	1,65	2,55	0,35
C'	909	675	180	855	58	87	25	71	0,67	1,70	2,85	0,40
P2 – Neosoil – dry area (Serra Branca)												
A	999	509	333	842	90	68	0	100	1,33	1,60	2,66	0,40
CA	998	518	298	815	119	66	25	62	1,80	1,60	2,56	0,38
C1	997	605	245	850	100	50	25	50	2,00	1,59	2,66	0,40
C2	998	521	312	833	111	56	25	55	2,00	1,66	2,56	0,35
P3 – Neosoil – humid area (Remígio)												
Ap	969	524	168	692	201	107	13	88	1,88	1,30	2,56	0,49
AC	981	538	240	778	118	104	15	86	1,13	1,33	2,62	0,49
C	972	550	231	781	95	124	18	85	0,77	1,44	2,61	0,45
Cn1	983	526	282	808	80	112	12	89	0,71	1,47	2,60	0,43
Cn2	983	540	275	815	75	110	14	87	0,68	1,43	2,60	0,45

Hor.: horizon; AFLD: Aired fine land; CDW: Clay dispersed by water; FD: flocculation degree; Part.: Particuly; Poros.: porosity

There was a coarse sand fraction predominance in all horizons of the *Neossolos Regoliticos* (Psamments) profiles, revealing that the studied soils are pedogenetically underdeveloped. The sand contents are inversely correlated with the rainfall indexes of each region, showing that the lower thehumidity in the system, the lower the weathering rates, resulting in coarser textured soils.

In the superficial horizons (A) the silt contents varied from 11 to 201 g kg^{-1}, with an increasein the contents of this fraction due to the increase in the humidity in the environment. Since these are poorly developed soils, the higher levels of silt in the sub-humid condition may reflect the favoring of weathering processes due to humidity, which promotes the reduction of the size of the largest particles in silt and clay (OLIVEIRA *et al*., 2008) .

In general, clay contents were very low, varying from 56 to 107 g kg-1 soil in the superficial horizons and from 50 to 124 g kg^{-1} soil in the subsurface horizons (Table 2), always with the highestsoil contents of the sub-humid condition. The influence of the rainfall gradient in the rocks and minerals weathering in semi-arid conditions is evident when comparing similar horizons with eachother. The low clay content represents a characteristic of this soil class, which has an essentially sandy texture. In spite of this, the values found in the studied soil profiles are slightly higher than those of the profiles of this soil class previously described and presented in the Exploratory Surveyof Soil Recognition of Paraíba State (JACOMINE *et al*., 1972), which varied between 30 and 70 g kg^{-1} soil.

The highest soil density was observed in the dry condition (Table 2), probably because it had the lowest organic C content. This is evident when observing the profile data of the sub-humid condition with the highest levels of organic carbon (Table 3), as observed by Santos *et al.* (2012). The physical characteristics of the studied soils, with the predominance of the sand fraction in its granulometry and low clay contents, give these soils an excessive drainage and low water retentionand storage capacity. These properties are important for the choice of the crop to be implanted, for the definition of management practices, as well as for planning of soils fertilization and irrigation programs.

2.3 Chemical properties

Neossolos Regoliticos (Psamments) showed H_2O pH in ranges of values that classify them as strong to slightly acidic (Table 3). Results similar to those observed by Silva *et al.* (2014) in *Neossolos Regoliticos* (Psamments) in the semi-arid region of Rio Grande do Norte State. The acidityof these soils may be related to the substitution of bases exchangeable with H^+ ions in the exchange complex and also to the low levels of clay.

The levels of organic carbon present in the horizons A of the studied *Neossolos Regoliticos* (Psamments) varied between 8,77 and 2,66 g kg^{-1} soil (Table 3), revealing a clear influence of rainfallIn the organic carbon accumulation in the soil as expected. The observed levels of this element arelower than those observed by Santos et al. (2012) who studied *Neossolos Regoliticos* (Psamments) in the semiarid region of Pernambuco, with values of 6 to 14 g kg^{-1} soil, in the superficial horizons.

The Ca^{2+} ranged from 0,20 to 3,64 cmolc kg^{-1} soil, in the superficial horizons (Table 3), with soil increase of the sub-humid condition, being in agreement with the levels of organic carbon. The contents of Mg^{2+} varied from 0,07 to 0,43 cmolc kg^{-1} soil in the superficial horizons, being similar in the dry and sub-humid conditions. The influence of moisture content is evident when assessing Mg^{2+} levels in the subsurface horizons, where the highest values are in P3 (sub-humid zone). In spite of this, these values are lower than those of *Neossolos Regoliticos* (Psamments) of Agreste paraibano studied by Menezes and Salcedo (2007), up to 60 cm deep.

Table 3 – Chemical characteristics of three profiles of Regolitic Neossols in a pluviometric gradient in the semi-aridregion of Paraíba.

Hor.	pH		OC	P	Ca+Mg	Na	K	SB	H	CEC	V	SS	AlSm	EC
	H2O	KCl	g kg^{-1}	mg kg^{-1}	---------------- (cmolc kg^{-1}) ---------------						----------- (%) --------			dS m^{-1}
P1 – Neosoil – very dry area (Picuí)														
Ap	5,35	4,26	2,66	2,88	0,27	0,04	0,05	0,36	3,63	3,99	8,90	1,00	0,00	0,56
CA	5,99	4,58	3,37	2,60	0,14	0,04	0,08	0,26	2,31	2,57	10,89	1,56	0,00	0,54
C	5,91	4,56	2,66	1,56	0,27	0,03	0,08	0,38	2,03	2,41	15,38	1,25	0,00	0,87
Cn	5,20	3,96	1,60	2,44	0,11	0,35	0,10	0,55	3,75	4,30	12,80	8,14	0,00	0,57
C’	5,66	4,34	0,71	2,72	0,21	0,05	0,06	0,32	1,20	1,52	20,76	3,30	0,00	0,53
P2 – Neosoil – dry area (Serra Branca)														
A	5,61	4,49	6,53	3,90	0,74	0,02	0,09	0,84	3,22	4,06	20,73	0,49	0,00	1,20
CA	5,48	3,54	3,26	5,18	0,31	0,02	0,06	0,38	3,02	3,40	11,17	0,59	0,00	0,54
C1	5,10	3,53	3,44	5,28	0,11	0,02	0,05	0,17	2,64	2,81	6,04	0,71	0,00	0,56
C2	5,58	3,43	1,85	1,87	0,14	0,06	0,05	0,25	1,93	2,18	11,34	2,76	0,00	0,51
P3 – Neosoil – humid area (Remígio)														
Ap	6,22	5,28	7,41	7,22	4,07	0,08	0,20	4,35	3,42	7,77	55,99	1,06	3,35	1,26
AC	5,52	4,51	8,77	4,48	1,87	0,05	0,06	1,97	4,25	6,23	31,68	0,78	1,49	0,97
C	4,89	4,08	4,94	5,19	0,77	0,24	0,05	1,07	4,61	5,68	18,88	4,26	12,67	0,98
Cn1	6,32	4,26	1,43	5,18	0,79	0,42	0,04	1,25	5,00	6,25	20,02	6,76	7,76	0,83
Cn2	5,89	4,14	3,30	4,93	0,53	0,36	0,03	0,92	4,72	5,64	16,26	6,31	5,07	0,65

Hor.: Horizon; OC: Organic Carbon; SB: Sum of Bases; CEC: Cation exchange capacity; Value V: Saturation bybase; SS: Sodium saturation; AlSm: Saturation by aluminum; EC: Electrical Conductivity.

Despite most of the horizons of the studied *Neossolos Regoliticos* (Neosols) have low Ca +Mg contents, these two cations contribute at least 53 % of these soils base sum (S value), except in the Cn horizon in very dry condition - P1 , where the largest contribution is from the Na + cation (Table 3). The higher levels of sodium in the horizons Cn1 and Cn2 of P3 and Cn of P1, reaching a percentage of sodium saturation above 6 % and <15 %, give these horizons the solodic character (SANTOS *et al.,* 2018).

As they are excessively heavily drained soils, the values of electrical conductivity (EC) are low and ranged from 0,51 dS m^{-1} on the C2 horizon of P2 to 1,26 dS m^{-1} on the Ap horizon of P3, representing no risk of salinization to the soil, nor impediment to the development of the cultures. In these soils there is a tendency to increase CTC with an increase in the humidity of theenvironment, corroborating with the results already presented for the contents of organic carbon andCa, both in the superficial horizons and in the subsurface (Table 3).

In the case of *Neossolos Regoliticos* (Neosols) from the sub-humid condition, it is importantto note that the CTC also received a contribution from Al levels, which ranged from 0,09 to 0,72 cmolc kg^{-1} soil (data not shown). The results for the CTC values are lower than those obtained by Silva *et al.* (2014) in *Neossolos Regoliticos* (Psamments) in Rio Grande Norte semi-arid region. Theselow levels of CTC can be attributed to the nature of the soil texture, which is essentially sandy, as explained by Santos *et al.* (2012) when they studied several *Neossolos Regoliticos* (Psamments) in Pernambuco state.

In areas with very dry (P1) and dry (P2) humidity conditions, *Neossolos Regoliticos* (Psamments) were found in highly degraded hyperxerophilous caatinga vegetation and, at times, subject to water erosion, due to the intensity of rainfall in a short period of time. , and also to wind in the dry period. In the sub-humid condition (P3), soil was under cultivation of annual and fruit crops, in addition to a dense layer of native pasture with an abundant root system.

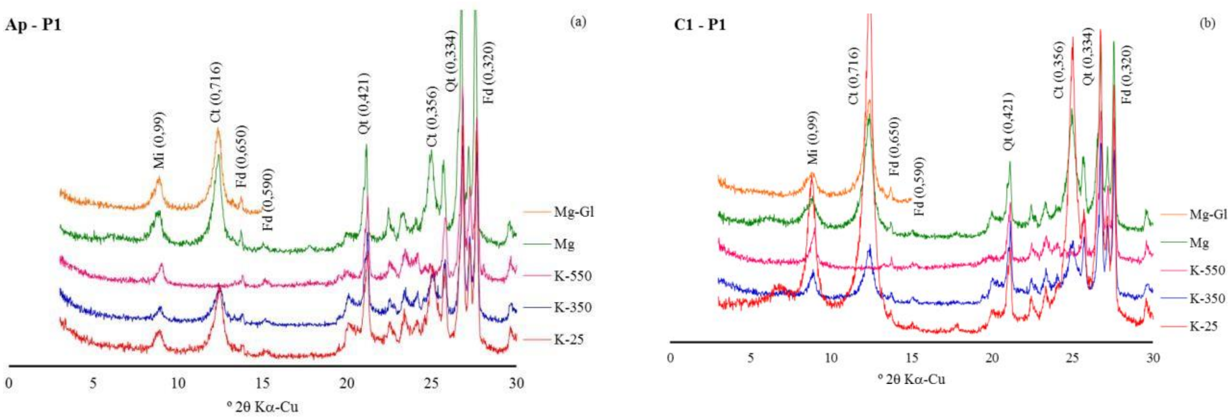
The three profiles studied showed base saturation (V value) below 50 %, except for the Ap horizon of *Neossolos Regoliticos* (Psamments) in the sub-humid condition, which reached the value around 56 % (Table 3) due to the higher content of bases and organic matter on the horizon. In the semi-arid region, these soils are intensely used in family farming that uses rudimentary cultivation techniques. However, they do not always guarantee an adequate supply of plants nutrients, which can cause deterioration of their low fertility natural ness.

Soil management alternatives for three moisture situations studied in this research should beguided by environmental sustainability, and it can be suggested, according to the availability of moisture in the different environments, that in the drier areas these soils should be used with naturalpasture and for protection of local fauna and flora (P1 - Picuí); in areas with intermediate humidity conditions, management systems for native vegetation integrated with the cultivation of pastures and fruit trees and the creation of small animals can be adopted (P2 - Serra Branca), a practice known as enriching the caatinga; and in the condition of greater water availability, the adoption of Agroforestry Systems - SAFs is indicated, which integrate the use of soil with native vegetation, planting of fruit trees, pastures and annual crops (P3 - Remígio).

2.4 Mineralogy

Regarding mineralogy, X-ray diffractograms (XRD) of the soils clay fraction are represented in figures 2 to 4. It basically comprises kaolinite and mica. However, in the very dry zone it was also possible to verify the presence of quartz and feldspars. The presence of easily alterable primary minerals, such as feldspar, is an important characteristic of *Neossolos Regoliticos* (Psamments), as it isused in the distinction between the Quartzarênicos and Regolítico suborders (SANTOS *et al.,* 2018), being responsible for the greater agricultural potential of the latter (SANTOS *et al.*, 2012).

Figure 2 – X-ray diffractograms of the clay fraction saturated with potassium at room temperature (K-25), heated to 350 ºC (K-350) and 550 ºC (K-550) and saturated with magnesium (Mg) and solvated with Glycerol (Mg-Gl) from the horizons Ap (a), C1 (b) and C' (c) of P1 (Neosol Regolytic from very dry zone - Picuí). Mi - Micca, Ka - kaolinite,Fd - feldspar, Qt - quartz.



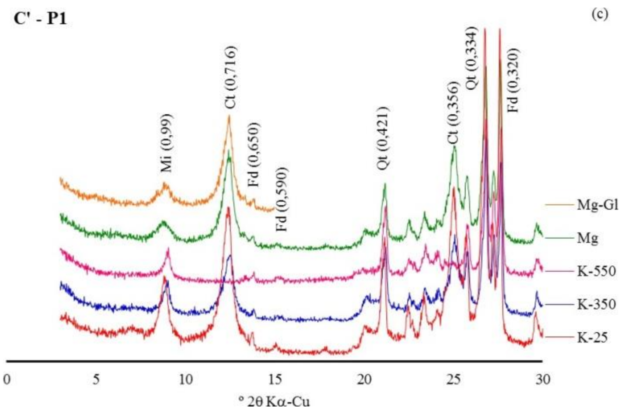
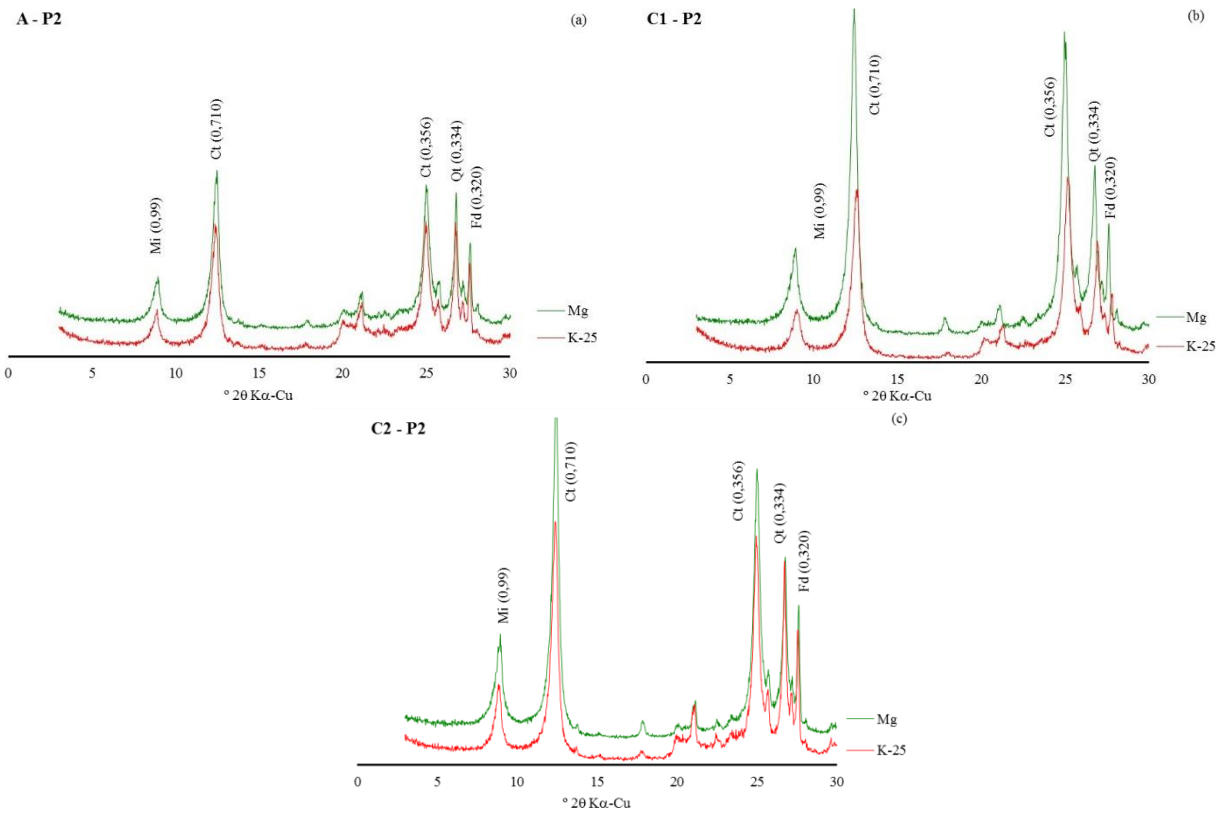
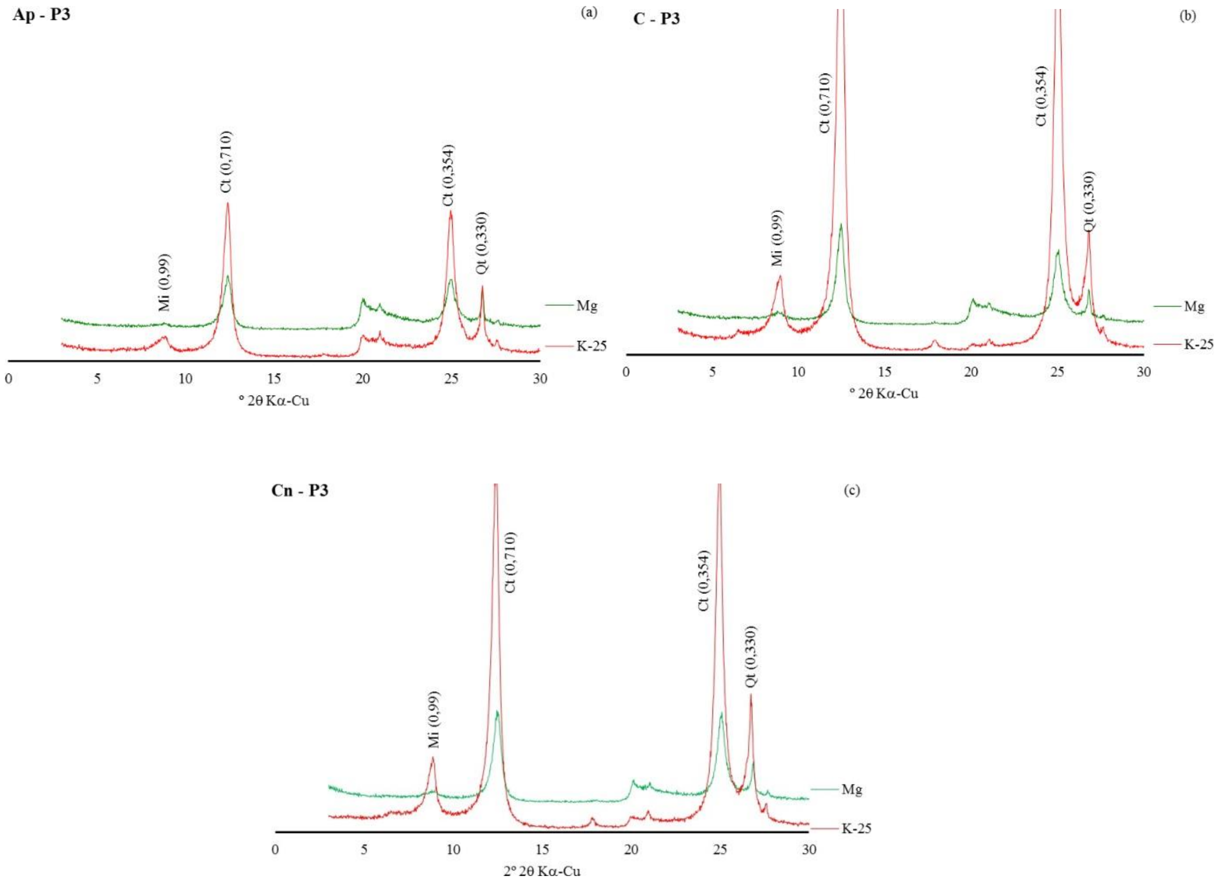


Figure 3 – X-ray diffractograms of the clay fraction saturated with potassium at room temperature (K-25) and saturated with magnesium (Mg) from horizons A (a), C1 (b) and C2 (c) of P2 (Regolitic Neossol) from dry zone - Serra Branca).Mi - mica, Ka - kaolinite, Qt - quartz, Fd - feldspar.



In the mineralogical assembly of the studied horizons in the P3 - *Neossolos Regoliticos* (Psamments) of the sub-humid zone, the presence of mica (0,99 nm), kaolinite (0,710 nm) and quartz (0.334 nm) is more prominent (Figure 4), possibly due to the effect of environmental humidity.

Figure 4 – X-ray diffractograms of the clay fraction saturated with potassium at room temperature (K-25) and saturatedwith magnesium (Mg) from the horizons Ap (a), C (b) and Cn (c) of P3 (Regolitic Neossol) from sub-humid zone - Remígio). Mica, Ct - kaolinite, Qt - quartz.



The presence of kaolinite in the studied soils is confirmed by the peak collapse (0,716 nm) in the saturated treatment with potassium and heated to 550 C. This kaolinite was formed, probably,from the alteration of feldspars that underwent chemical weathering caused by the action of the infiltration water in the bedrock.

In general, profiles are very similar to each other and have a practical identical mineralogical composition. Quartz and feldspar appear in all horizons of the studied profiles, as also observed by Almeida et al. (2015) in *Neossolos Regoliticos* (Psamments) in Pernambuco state. The presence of quartz in the clay fraction is possibly linked to the coarse clay fraction, given the reduction of its stability in the smaller fractions. This is indicative of low degree of soils pedogenetic developmentin semi-arid regions, according to Oliveira *et al.* (2004).

Feldspars are present in all fractions of the studied *Neossolos Regoliticos* (Psamments), however they decrease in the clay fraction of the sub-humid zone. According to Santos *et al.* (2012) this mineral is decisive in the new formation of kaolinite in semiarid soils and when present in the finer fractions, it represents an important reserve of nutrients, especially when it comes from soils with a sandy texture and low CTC.

Mica is a mineral that occurs in the clay fraction of all the horizons of the studied *Neossolos Regoliticos* (Psamments) profiles. In most cases, it is inherited from the source material it self, and is a precursor to 2:1 clay minerals. Micas have the potential to be an important source of K for plants, releasing it during their weathering (RESENDE *et al.,* 2011).

Despite the low degree of development of the studied soils, the presence of minerals such as feldspar and mica can represent an important reserve of nutrients for the soil and for plants. Such nutrients will be released as the weathering reactions are processed. Techniques adoption promote the maintenance of soil moisture, such as mulch and shading offered by larger plant species, may promote the acceleration of chemical reactions and release of these nutrients.

2.5 Soil taxonomy considerations

The studied soils represent a core concept of the *Neossolos Regoliticos* (Psamments) and, in thesecond categorical level, they are framed in the suborder of the SiBCS *Neossolos Regoliticos* (Neosols) (SANTOS *et al.,* 2018), as they do not present a diagnostic B horizon, nor fragmentary lithicor lithic contact within 50 cm from the surface, nor do they meet the requirements of the other *Neossolos Regoliticos* (Neosols) suborders in SiBCS. Because they are soils with a predominance of sandy texture within 150 cm surface, they are all included in the same large group of *Neossolos Regoliticos* (Psamments) in the third SiBCS categorical level.

From the fourth categorical level (subgroups), soils start to differentiate among themselves according to the percentage of sodium exchange (PST), types of surface horizon (weak, moderate and prominent), differences in texture classes (from sandy in the dry zone to fullsandy in the sub-humid zone) and also due to small differences in the mineralogy of the clay fraction (increase in the proportion of kaolinite from the dry to sub-humid zone). In the fourth SiBCS categorical level, the last level to be considered in this study, the P1 and P3 profiles were classified as solids psolitic *Neossolos Regoliticos* (Psamments) for presenting sodium saturation larger than or equal to 6 % and less than 15 % within 150 cm in thd surface of the ground; and P2 was classified as a typical psamitic *Neossolos Regoliticos* (Psamments). Such differences in sodium saturation are mainly due to variations in the mineralogical composition of the soil source material and according to local drainage conditions.

4. CONCLUSIONS

The physical and mineralogical attributes of *Neossolos Regoliticos* (Psamments) were influenced by the pluviometric gradient, since the clay contents increased gradually as well as therewas a visible change in the soil proportion of kaolinite/mica from the very dry to the sub-humid zone.

The natural fertility of *Neossolos Regoliticos* (Psamments) was also influenced by the precipitation indices, which was mainly reflected in the higher levels of CO, Ca^{2+}, Mg^{2+}, K^{+} and CTC in *Neossolos Regoliticos* (Psamments) of sub-humid condition in relation to the other *Neossolos Regoliticos* (Psamments).

Three soil profiles studied could be classified adequately in SiBCS up to the fourth categorical level in the following classes: P1 and P3 - Soluble *Neossolos Regoliticos* (Psamments); and P2 - Typical *Neossolos Regoliticos* (Psamments) Kaolinite, quartz, feldspars and mica are the most common minerals present in the clay fraction of all horizons of *Neossolos Regoliticos* (Psamments) evaluated in this work. The last two minerals are highly important in sandy texture soils, as they represent a potential source of nutrients.

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