SOIL COVER AND CHEMICAL AND PHYSICAL ATTRIBUTES IN OXISOL IN THE ATLANTIC FOREST BIOME[1]

Ana Paula Almeida Bertossi[2*], Paulo Roberto da Rocha Júnior[2], Paulo Henrique Ribeiro[2], João Paulo Cunha de Menezes[3], Roberto Avelino Cecílio[4] and Felipe Vaz Andrade[5]

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[2] Universidade Federal do Espírito Santo, Programa de Pós-Graduação em Produção Vegetal, Alegre, ES - Brasil.. E-mail: <anapaulabertossi@yahoo.com.br>, <pauloagro09@hotmail.com> and <phribeiroac@yahoo.com.br>.

[3] Universidade Federal de Lavras, Departamento de Agricultura, Lavras, MG - Brasil. E-mail: <jpaulo_bio@hotmail.com>.

[4] Universidade Federal do Espírito Santo, Centro de Ciências Agrárias, Departamento de Engenharia Florestal, Jeronimo Monteiro, ES - Brasil. E-mail: <racecilio@yahoo.com.br>.

[5] Universidade Federal do Espírito Santo, Centro Agropecuário, Departamento de Produção Vegetal, Alegre, ES - Brasil. E-mail: <felipevazandrade@hotmail.com>.

[*]Corresponding author.

ABSTRACT – The objective of this study was to evaluate the chemical and physical attributes of different soil cover in a Oxisol with a strong wavy relief in the Atlantic Forest Biome, in which were selected three watersheds, employed with grazing (watershed P), forest (watershed M) and coffee (watershed C). Deformed and not deformed samples were collected in three depths for physical and chemical characterization. The chemical characteristics of soil in different watershed studies presented low levels of fertility. It was observed an elevation of pH in the soil and contents of Ca^{2+} and Mg^{2+} in the watersheds P and C in relation to the watershed M. Due to deforestation and the establishment of agriculture and livestock, there was a decrease in the contents of soil organic matter in the watershed P and C, not altering the physical characteristics of the soil in the watershed P. The implementation of coffee plantation is causing a reduction in the soil quality of watershed C in comparison to the watershed P and M, therefore indicating a need to adequate soil management in this area.

Keywords: Land use; Aggregates; Organic carbon.

COBERTURA DO SOLO E ATRIBUTOS QUÍMICOS E FÍSICOS SOB LATOSSOLO VERMELHO AMARELO NO BIOMA MATA ATLÂNTICA

RESUMO – Neste trabalho propôs-se avaliar os atributos químicos e físicos de diferentes coberturas vegetais num Latossolo Vermelho Amarelo no bioma Mata Atlântica, onde foram selecionadas três microbacias de cabeceira, ocupada por pastagem (microbacia P), mata (microbacia M) e cafeeiro (microbacia C). Foram coletadas amostras de solo em três profundidades para caracterização física e química. As características químicas nas diferentes microbacias estudadas apresentaram baixos níveis de fertilidade. Foram observadas a elevação no pH do solo e nos teores de Ca^{2+} *e* Mg^{2+} *nas microbacias P e C em relação a microbacia M. Com a retirada da mata e o estabelecimento da agricultura e pecuária houve uma redução dos teores de matéria orgânica do solo nas microbacias P e C, não alterando as características físicas do solo na microbacia P. A implantação da lavoura de café está ocasionando a redução da qualidade do solo na microbacia C em comparação as microbacias P e M, indicando a necessidade de adequação do manejo do solo nesta área.*

Palavras-chave: Uso do solo; Agregados; Carbono orgânico.

1. INTRODUCTION

In Brazil, it is common the occurrence of landscapes where the natural vegetation has been replaced by crops and pastures in an attempt to expand the agricultural frontier areas and to enable new areas of agriculture, aiming at the best physical, chemical and biological conditions found in these newly deforested areas compared to lands already used for farming (GREGGIO et al., 2009).

The substitution for crop cover has caused negative changes in soil properties and consequently led to the degradation of large areas, causing a decline in their quality (ROCHA JUNIOR et al., 2014). However, the loss of soil quality has been attributed not only to the conversion of vegetation (forest/agriculture), but above all, to the management adopted in the area after the substitution (WENDLING et al., 2005).

Management practices inserted into a non-conservation concept have resulted in the reduction of soil quality by promoting a decline in nutrient stocks and loss of structure due to the raise in erosion, with consequent reduction of plant reproductive capacity (AGUIAR et al., 2010; SHIGAKI et al., 2006).

When evaluating the attributes of a Red Latosol in the *Cerrado* (Brazilian savannah) in different cropping systems on crop rotation compared to the native Cerrado, Fonseca et al. (2007) found in the surface layer (0-2.5 cm), the rise of soil density by 28%, as well as a reduction in macroporosity of 14.81% and in the soil organic carbon content in 41.82% after the transformation of the native area in the area of agricultural cultivation.

Neto et al. (2013), when studying chemical properties of a Quartzipsamment found the increase in mechanical resistence to penetration and a decrease in the levels of organic matter in degraded pasture area in relation to the area under native vegetation.

Azevedo et al. (2007), studying physical and chemical properties of a Oxissol in the *Cerrado* in northeastern Maranhão under different management systems in relation to a native forest, found higher soil density values (7.88%) and lower porosity values (9.89%) in cropped systems. However, the soybean no-tillage crop had higher total organic carbon content (1.85%) compared to native forest.

In the Atlantic Forest biome, such studies are still scarce, thus it is important that several studies should be carried out in different environments and managements in order to establish the main determinant factors of the differences in organic carbon accumulation and changes in chemical and physical characteristics of the soil as native vegetation is replaced.

Thus, the objective of the present study was to evaluate the physical and chemical properties of different plant cover (forest, pasture and crops) in watershed in a Oxissol in uneven relief in the Atlantic Forest.

2. MATERIAL AND METHODS

2.1. Area description

The study was conducted in the Corrego Horizonte Basin River, delimited under the geographical coordinates 41º32' and 41º38' West longitude and 20º43' and 20º51' South latitude, with an approximate area of 1,265.36 ha, located in the municipality of Alegre (state of Espírito Santo) (Figure 1). According to the Köppen classification, the climate in the region is Cwa, characterized by dry winter and rainy summer.

Three headwater watersheds were selected for soil collection, each occupied by different covers that characterize land use in the region (NASCIMENTO et al., 2006): pasture (watershed P), forest (watershed M) and coffee crop (watershed C), as shown in Fig. 1. The relief of watersheds C and M is ranked as strongly wavy to hilly and watershed P as wavy and strongly wavy (EMBRAPA, 1979). The soil of the three watersheds was rated Oxissol, according to EMBRAPA (2006).

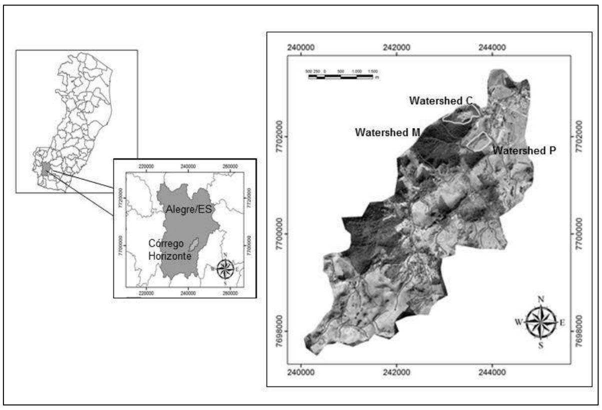

Figure 1 – Location of the watershed in the Córrego Horizonte and the watersheds studied.

***Figura 1** – Localização da Bacia Hidrográfica do Córrego Horizonte e das microbacias estudadas.*

Coffee has been grown in the watershed C for 12 years, which was previously cultivated with grassland. Coffee was cropped in this area in contour lines and fertilization is carried out twice a year, one in November and the other in April, using the formulated 25-5-20 (N-P-K). For the crop setting, it was carried out soil tillage and planting were performed in holes. The only chemical control in the area is performed with herbicides once a year, before harvest, in April.

The forest in watershed M is classified as seasonal semi-deciduous and it has been a natural regeneration area for 48 years, where coffee was previously grown. The pasture in watershed P is used for mixed continuous grazing by cattle, sheep and goats, where no input is used, following the model adopted for most of the pastures in southern Espirito Santo state.

2.2. Soil sample collection and analysis

Soil samples were collected at representative sites of each area. Deformed and not-deformed samples were collected at three depths, 0-0.10 m; 0.10-0.20 m and 0.20-0.40 m.

The determinate physical soil attributes were: soil density, set by volumetric ring method (BLAKE; HARTGE, 1986); total porosity, obtained by the ratio between soil density and particle density (1-Ds/Dp); soil texture by the slow stirring method (RUIZ, 2004); clay dispersed in water (CDW); and the degree of flocculation (FD) according to EMBRAPA (1997); and stability of aggregates set by wet path with subsequent calculation of DMG (RUIZ, 2004).

The chemical properties determined were: total organic carbon (TOC) determined by oxidation in wet path (YEOMANS; BREMNER, 1988); exchangeable acidity (Al^{3+}), extracted with KCl 1 mol L^{-1} and titrated with NaOH 0.025 mol L^{-1}; potential acidity (H + Al), extracted with calcium acetate 1 mol L^{-1}at pH 7.0 and titrated with NaOH 0.060 mol L^{-1}; calcium and magnesium (Ca^{2+} e Mg^{2+}), extracted with KCl 1 mol L^{-1} and determined by atomic absorption spectrometry; potassium (K^{+}), extracted with Mehlich^{-1} and determined by flame photometry; full and effective cation exchange capacity; the sum of bases (SB); percentage of base saturation (V); and percentage of aluminum saturation (m) (EMBRAPA, 1997).

2.3. Statistical analysis

Because it is sampling, firstly, descriptive analysis of data was carried out, setting the mean, amplitude (minimum and maximum values) and the standard deviation for all evaluated characteristics, stratified by depth collection of soil. To express the magnitude and variation within each evaluated characteristic, the comparison between means was performed for the watersheds (coffee crop, pasture and forest).

3. RESULTS

3.1.Chemical characterization

Chemical analysis indicate that the assessed soils have limited nutrient availability due to low values of cation exchange capacity (CEC) and total bases (SB) found (Table 1) (ALVAREZ et al., 1999; PREZOTTI et al., 2007).

It is observed that the Mg^{2+} showed low to very low levels in the soil for all assessed watersheds, ranging from 0.11 to 0.30 $cmol_c$ dm^{-3}. However, for Ca^{2+}, levels ranged from low to good between 0.62 to 2.62 $cmol_c$ dm^{-3} (ALVAREZ et al., 1999; PREZOTTI et al., 2007).

It is understood that the lower contents of Ca^{2+} e Mg^{2+} are seen in the watershed M. it can be seen that the average values of this basin at all depths are near minimum range (Table 1). The higher average values of base saturation (V) and lower average values of aluminum saturation (m) were found in watersheds P and C. Moreover, an opposite result has been detected in the soil of watershed M, where there was a low V (%) and high m (%) (Table 1).

In general, the average values for pH, Ca^{2+}, Mg^{2+} and V (%) of watersheds P and C presented higher levels than the overall mean for all assessed treatments and replicates, near the upper range, especially in the watershed P. On the other hand, the watershed M presented average levels lower than that overall mean (Table 1).

When the average values of Al^{3+}, H+Al and m (%)m (%) where assessed, it seems that the values closer to the upper range was found in the watershed M, thus ponting to higher acidity in the soils of this area (Table 1).

The highest contents of available-P were found in the soils of the watershed C; however they are still

Table 1– Mean, maximum and minimum values and standard deviation of chemical attributes in the Oxisol in three watersheds in the city of Alegre- ES.
Tabela 1– *Valores médios, máximos, mínimos e desvio padrão dos atributos químicos de um Latossolo Vermelho em três microbacias no município de Alegre-ES.*

Watersheds	Depths(m)	pH	P	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H+Al	SB	t	T	V	m
			mg dm^{-3}		cmol$_c$ dm^{-3}							%	
Forest	0,00-0,10	4,80	2,04	61,33	0,62	0,12	0,47	2,81	0,89	1,27	3,71	24,35	34,35
Coffee		5,57	3,21	48,00	2,04	0,15	0,03	2,64	2,31	2,34	4,95	48,46	1,55
Pasture		5,81	1,77	72,00	2,52	0,30	0,00	2,59	3,00	3,00	5,55	53,29	0,00
Mean		5,39	2,34	60,44	1,73	0,19	0,19	2,68	2,04	2,14	4,43	41,64	4,65
Minimum		4,67	1,23	23,00	0,52	0,10	0,00	1,70	0,65	1,22	3,13	21,23	0,00
Maximum		5,94	4,73	108,00	3,90	0,38	0,60	4,10	4,48	4,58	6,96	64,46	44,23
S.D		0,48	1,03	24,74	1,06	0,09	0,22	0,84	1,15	1,01	1,37	16,17	16,93
Forest	0,10-0,20	4,80	1,72	60,33	0,68	0,11	0,50	2,81	0,95	1,45	3,75	26,67	34,45
Coffee		5,57	3,43	47,67	2,24	0,15	0,10	2,64	2,51	2,61	5,15	49,09	4,01
Pasture		5,81	1,68	73,67	2,52	0,27	0,00	2,20	2,98	2,98	5,18	55,71	0,00
Mean		5,39	2,34	60,44	1,73	0,19	0,19	2,68	2,14	2,35	4,69	43,82	13,38
Minimum		4,67	1,23	23,00	0,52	0,10	0,00	1,70	0,75	1,35	3,24	15,97	0,00
Maximum		5,94	4,73	108,00	3,90	0,38	0,60	4,10	4,51	4,51	6,82	66,15	44,35
S.D		0,48	1,03	24,74	1,06	0,09	0,22	0,84	1,17	0,98	1,18	15,26	17,09
Forest	0,20-0,40	4,80	2,04	59,33	0,70	0,11	0,43	2,92	0,97	1,40	3,89	25,58	30,93
Coffee		5,55	4,19	48,33	2,28	0,15	0,03	2,15	2,57	2,34	4,69	54,11	1,48
Pasture		5,82	2,26	75,00	2,60	0,28	0,00	2,59	3,07	3,07	5,66	52,56	0,00
Mean		5,39	2,34	60,44	1,73	0,19	0,19	2,68	2,19	2,36	4,74	44,08	11,20
Minimum		4,67	1,23	23,00	0,52	0,10	0,00	1,70	0,77	1,37	3,22	20,77	0,00
Maximum		5,94	4,73	108,00	3,90	0,38	0,60	4,10	4,70	4,70	7,01	67,09	43,51
S.D		0,48	1,03	24,74	1,06	0,09	0,22	0,84	1,22	1,06	1,04	16,57	15,91

S.D.: Standard Deviation.
SB: Sum of bases; t: Effective cation exchange capacity; T: Total cation exchange capacity; V: Base saturation; m: Aluminium saturation.

rather low levels (ALVAREZ et al., 1999; PREZOTTI et al., 2007). The lowest levels were observed in soils of watersheds P and M, below the overall average and near the lower range (Table 1).

For K^+, higher levels for watershed R are found, opposite to the lower values found in the watershed M and C, especially in the last (Table 1).

With regard to total organic carbon (TOC), in general, higher levels in the watershed M are found, and among watersheds with agricultural use, that used with coffee crops had lower levels (Figure 2).

3.2. Physical characterization

Based on the analysis of particle size of the soil (Table 2), it can be ranked at all depths (0.00-0.10; 0.10-0.20 and 0.20- 0.40 m), as average texture, except that in the watershed P, which was classified as clay soil. It appears that the levels of silt and fine sand, regardless the watershed, were low. On the other hand, clay and thick sand present higher levels (Table 2).

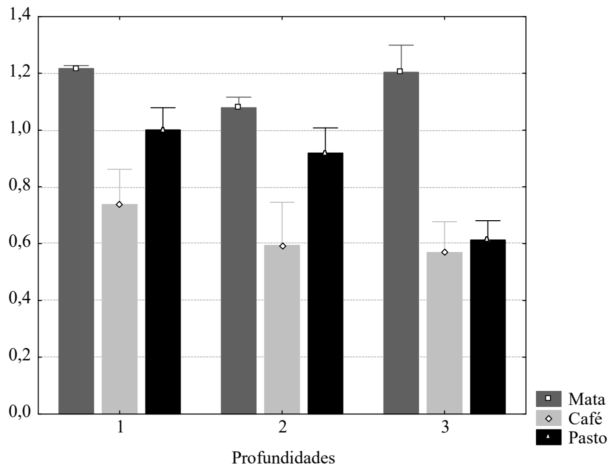

Figure 2 – Average contents of total organic carbon (OC dag kg^{-1}) in three depths (1: 0,00-0,10, 2: 0,10-0,20 e 3: 0,20-0,40 m) in the watershed covered by Forest, Coffee and Pasture.
Figura 2 – *Teores medios de carbono organico total (CO dag kg^{-1}) em três profundidades (1: 0,00-0,10, 2: 0,10-0,20 e 3: 0,20-0,40 m) em microbacias cobertas por Mata, Café e Pasto.*

For Ds, it is observed that the highest mean values are found in the watershed M. In addition, average values are higher than the overall average at all depths (1.38 kg dm^{-3}) and closer to the upper range (Table 2). At the layer 0.00 - 0.10 m, the smallest reduction of Ds is seen in the watershed C, presenting a reduction of 5.9% compared to the watershed M, while the watershed P decreased by 4.1% compared to the watershed M. For the layer 0.10 - 0.20 m, the reduction of Ds was even greater, the watershed C presented a reduction of 13.7% to Ds and watershed P was reduced by 7.9% in relation to watershed M (Table 2).

When Dp of the soil is assessed**,** a small variation is seen by the average values found in the watersheds, values from 2.62 to 2.76 kg dm^{-3}. It was also observed that the average values of the watersheds were near the overall average (2.73 kg dm^{-3}), showing a low average standard deviation (Table 2).

When Pt was evaluated, a small variation was observed. It is noted that the average values are between 0.50 m^{3} m^{-3} to 0.45 m^{3} m^{-3}. However, in layers 0.00 to 0.10 and 0.10-0.20 m, the watershed M showed average values (0.49 m^{3} m^{-3} and 0.50 m^{3} m^{-3}, respectively) higher than the overall average (0.48 m^{3} m^{-3} at the depths 0.00-0.10 m and 0.10-0.20 m), which are closer to the maximum values (Table 2)

In relation to the degree of flocculation (DF), it can be seen that all areas had low DF values and high levels of clay dispersed in water (CDW). Such result was observed at all depths. Among the watersheds, the watershed M was the one with the smallest flocculation, and this aspect was found at all depths (Table 2)

Watershed P provided the greatest stability among soil aggregates with DMG values ranging from 2.39 mm at the layer 0.00 - 0.10 m to 2.16 m at 0.20-0.40 mm layer. In the surface layer, watershed M had the lowest DMG (1.53 mm). However, in the underlying layers (0.10-0.20 and 0.20-0.40), what is observed is the enhanced stability of aggregates in that area compared to watershed C.

Table 2 – Mean, maximum and minimum values and standard deviation of physical attributes in the Oxisol in three watersheds in the city of Alegre- ES.
Tabela 2 *– Valores médios, máximos, mínimos e desvio padrão dos atributos físicos de um Latossolo Vermelho em três microbacias no município de Alegre-ES.*

Microbacias	Depths (m)	Ds	Dp	Pt	ADA	GF	DMG	A.G.	A.F.	Silt	Clay
		kg dm^{-3}		m^{3} m^{-3}	g kg^{-1}	%	mm	%			
Forest	0,00-0,10	1,43	2,73	0,49	31,11	6,38	1,53	38,86	17,15	20,61	33,12
Coffee		1,35	2,72	0,48	32,92	11,69	1,61	42,20	15,58	21,43	31,37
Pasture		1,37	2,74	0,47	31,81	14,22	2,39	25,84	19,30	28,60	36,95
Mean		1,38	2,73	0,48	31,95	10,76	1,84	35,63	17,34	23,55	33,81
Minimum		1,31	2,33	0,44	25,72	1,77	1,16	21,92	11,08	12,18	29,88
Maximum		1,51	3,17	0,56	41,68	26,26	2,67	47,03	20,47	33,22	39,00
S.D		0,08	0,21	0,04	5,23	7,29	0,49	8,10	2,97	7,24	3,15
Forest	0,10-0,20	1,49	2,69	0,50	32,27	7,00	2,08	39,62	16,55	9,57	34,63
Coffee		1,31	2,63	0,49	32,20	11,03	1,69	41,92	15,46	21,19	30,48
Pasture		1,38	2,67	0,45	35,13	14,81	2,28	27,85	19,17	26,81	38,23
Mean		1,38	2,73	0,48	31,95	10,76	1,84	35,63	17,34	23,55	33,81
Minimum		1,31	2,33	0,44	25,72	1,77	1,16	21,92	11,08	12,18	29,88
Maximum		1,51	3,17	0,56	41,68	26,26	2,67	47,03	20,47	33,22	39,00
S.D		0,08	0,21	0,04	5,23	7,29	0,49	8,10	2,97	7,24	3,15
Forest	0,20-0,40	1,49	2,62	0,46	30,80	7,98	2,13	41,23	15,21	13,36	33,04
Coffee		1,47	2,76	0,48	28,75	15,32	1,91	41,67	15,78	17,99	34,44
Pasture		1,42	2,69	0,46	34,52	14,13	2,16	33,90	17,36	20,90	40,20
Mean		1,38	2,73	0,48	31,95	10,76	1,84	35,63	17,34	23,55	33,81
Minimum		1,31	2,33	0,44	25,72	1,77	1,16	21,92	11,08	12,18	29,88
Maximum		1,51	3,17	0,56	41,68	26,26	2,67	47,03	20,47	33,22	39,00
S.D		0,08	0,21	0,04	5,23	7,29	0,49	8,10	2,97	7,24	3,15

S.D.: Standard Deviation.
Ds: Soil density; Dp: Particle density; Pt: Total porosity; ADA: Clay dispersion in water; GF: Flocculation; DMG: Geometric mean diameter; A.G.: Coarse sand; A.F.: Thin sand.

At the surface layer both in watershed M and the watershed C have average values of DMG below the overall average, close to the lower range. However, watersheds P and M presented values higher than the overall average, closer to the upper range at the layers 0.10-0.20 and 0.20-0.40.

4. DISCUSSION

4.1. Chemical characterization

The limited availability of nutrients found in all watersheds is related to the characteristics of the source material associated with the high degree of weathering of these soils. Latosols of the Alegre River Basin region are soils formed by felsic origin material, which suffered a high degree of leaching mediated by weathering, which naturally conditioned the formation of low fertility soils (PACHECO, 2011).

Low fertility may also be the cause of high acidity found in the watershed M, which favored the rise in aluminum saturation with the output of the bases of the exchange complex.

It is observed in the watersheds used as agricultural areas (C and D) that a low acidity or its lack occurs there. This result is related to the interventions carried out when pasture was being set and soil correction was performed annually in the coffee crop. These practices raise the levels of Ca^{2+} in the soils of these watersheds compared to watershed M, which promotes the reduction in aluminum saturation.

It seems that levels of Ca^{2+} found in the soil of the watershed M ranges from low to very low. However, in watersheds P and C, the variation is between average to good. Overall, when Mg^{2+} was evaluated regardless of the watershed, low to very low levels are found (ALVAREZ et al., 1999; PREZOTTI et al., 2007).

For the available-P, low levels of this nutrient in the soil was expected because the soils are very weathered, which determines the gradual changes in some characteristics of the soil, increasing its ability to adsorb anions such as phosphate (NOVAIS; SMYTH, 1999). On the other hand, the slight enhancement in the availability of P-available found in the watershed C may be related to annual phosphorus fertilization in the coffee crop.

For K, in general, the mineralogical composition of the source material in the region of Alegre is effective in providing this nutrient to soil since the rocks in the Paraíba do Sul complex present feldspar-k frame in its structure (CPRM, 2007), a mineral that is source of potassium to the soil. Thus, it is assumed that the average K availability in these soils is related to the presence of larger amounts of these minerals in the soil (BESOAIN, 1985).

It can be seen that there was a slight improvement in the chemical characteristics in the soil cultivated with coffee compared to the soil in the forest. This is due to the correction practices and fertilization performed in the watershed C.

The low average nutrient values found in the soil under the watershed M, is partly explained by the fact that most of the nutrients are allocated in biomass in this site, as it was found in the study by Portugal et al. (2007).

Among the three watersheds studied, the highest levels of nutrient, except for P-available, were found in the soil in the watershed P (Table 1). It is likely that the adopted grazing management is contributing to this result, favoring nutrient cycling. In addition, this watershed does not exhibit signs of soil exposure or erosion provided by animal trampling, which raises the density of the soil, reduces the macroporosity and consequently, increases the superficial runoff that is a great responsible for the loss of soil and nutrients (COURNANE et al., 2011).

On the other hand, in the watershed C, the lack of coverage on between the rows should be considered. This lower global supply of dead plants associated with lower protection of plant cover in the soil, increases soil losses (SILVA et al., 2011) and therefore provides a greater loss of nutrients (SCHAEFER et al., 2002), explaining the higher nutrient content in the soil of the watershed P when compared to watershed C.

It can be found that the anthropic use has led to the reduction of soil organic matter, since a decrease in the TOC was observed when compared to the forest in relation to other agricultural uses (Figure 2). The reduction of TOC in the areas submitted to farming or livestock can be attributed to the increase in erosion besides the increased acceleration of mineralization of soil organic matter from its disturbance or due to the lower amount of organic intake in managed systems compared to native forests (PORTUGAL et al., 2007; ROCHA-JUNIOR et al., 2014).

3.2. Physical characterization

Considering that the particle size composition of the soil depends on the rock of origin and to the degree of weathering it has overcome (RESENDE et al., 2007), the largest content of clay and thick sand found in the particle size analysis of this study is justifiable. This happens because whereas the granite-gneiss is the material that originated the Latosols in the studied area and also because they present fine-medium particle size (BRASIL, 1983), they may originate soils with different textures that are likely to have influenced the results.

The lower contents of clay found in the watersheds M and C (Table 2) at all depths suggest that a greater removal of clay occurred in these areas, when compared to the watershed P. It is found in these two watersheds, a strongly wavy to hilly relief, which leads to a greater loss of clay, explaining the lower content of clay found in the particle size analysis. On the other hand, in the watershed P, it can be seen a wavy to strongly wavy relief, providing a more conservative environment, leading to a lower loss of clay by laminar erosion.

Lower values of silt found in the three assessed watersheds (Table 2) indicate that they are rather weathered soils since the reduced silt/clay ratio is an indicator of the degree of soil weathering (EMBRAPA, 2006).

Most soil Ds in the watershed M (Table 2) suggests that the withdrawal of the forest for setting up the crop and livestock did not negatively affect this physical property of the soil.

The lower average value of Ds found in the watershed C in the surface layers (0.00-0.10 and 0.10-0.20 m) in relation to the other watersheds may be related to soil disturbance at the time of coffee crop setting up (Table 2). The grid used to prepare the soil may have broken its structure and reduced the Ds in this watershed, as a consequence.

Although watersheds C and P presented lower DS values than watershed M, they are still high for this class of soil (Latosol). It is possible that the mineralogy of this soil may be influencing this result. The presence of kaolinite may influence the structural development of Latosols influencing Ds (FERREIRA et al., 1999a). This occurs because the “face-to-face” adjustment of kaolinite promotes the development of dense plasma, granting higher values of Ds, and thereby, the increase in the content of kaolinite leads to Latosols with higher Ds (FERREIRA et al., 1999b).

The values of Dp (2.62 to 2.76 kg dm^{-3}) (Table 2) points to a predominance of kaolinite in the clay fraction and quartz in the sand fraction (MACEDO; CRESTANA, 1999). A small variation for the Dp values was expected because all watersheds are within the same origin material, granite-gneiss from the Paraiba do Sul complex.

When Pt was evaluated, a small variation was observed, suggesting that different management practices are not affecting this physical property of soil (Table 2). This reinforces the hypothesis that the proper management in the areas of pasture does not provide negative impacts on soil structure (COMTE et al., 2012).

For flocculation degree, the low values found and the high levels of ADA (Table 2), at all depths, regardless of watershed, may be related to the occurrence of kaolinite, which have a higher density of negative charges (SPOSITO, 1989) in the pH values of all assessed soils (>4.8), which in turn may be causing repulsion between particles and lower soil flocculation.

When studying the pedogenesis of soils in the Alegre river basin, Pacheco (2011) concluded that the soils of this region are predominantly electronegative, and due to the intense weathering, they present predominance of low crystallinity kaolinite in the clay fraction of soils.

In addition, the lower degree of flocculation and the higher content of water dispersed clay may be related to practices of chemical nature such as soil correction used at the time of the pasture setting and the annual correction of coffee, or of mechanical nature such as the preparation of soil at the time of coffee crop implementation (FERREIRA et al., 2010).

By comparing the watersheds, the lowest floculation in the watershed M (Table 2) besides a likely kaolinitic mineralogy may be related to the highest levels of organic matter (Figure 2), and to the quality of the matter provided to the soil. This same aspect may be influencing the stability of aggregates in the superficial layer of the soil (0.00- 0.10 m).

From the management perspective, the soil organic matter may exhibit dispersing or aggregating effect, being dependent on the amount and quality of the contributed matter (BENITES; MENDONÇA, 1998).

According to Correa et al. (2008), short chain organic acids promote greater dispersion of clay in relation to the most recalcitrant material, a fact that may be occurring in the surface layer of the watershed M since a rich litter layer was visually found. On the other hand, the more humified organic material promotes lower dispersion of the soil clay, favoring the physical conditions of the soil, what is occurring in the sub-surface layers of the watershed M.

Lower values of DMG in the subsurface (Table 2) found in the watershed C is related to lower levels of organic matter (Figure 2) and to the soil plowing at the time of crop establishment. Nunes et al. (2010) found similar results in a coffee area conventionally managed, keeping the rows free of organic waste, where they observed lower DMG in relation to forest area.

At all depths, the watershed P displayed the highest average values for DMG (Table 2). These results are in agreement with the study carried out by Chan and Hulugalle (1999) who found that higher aggregate stability in soils under native pasture when compared to cropped soils. This fact is justified by the higher content of clay in the soils besides the greater degree of flocculation, which leads to a greater soil aggregation. In addition, areas with pasture show an intense renewing of the root system that promotes a constant restructuring in the soils.

5. CONCLUSIONS

The soil chemical characteristics in the different assessed watersheds showed low fertility levels.

A small rise was observed in the pH and in the contents of Ca^{2+} and Mg^{2+} in the watersheds P and C in relation to watershed M.

By removing the wood and setting up crops and livestock, a decline in the levels of soil organic matter was found in watersheds P and C.

The substitution of the forest for the implementation of livestock did not change the physical characteristics of the soil in the watershed P, in general.

Coffee crop setting is leading to the reduction of soil quality in the watershed C, pointing to the need for adjustment of soil management in this area.

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