sociedade & natureza

DOI: http://dx.doi.org/10.14393/SN-v31n1-2019-45624

Papers

Analysis of the physical-chemical spatial variation of surfacial materials of the Gloria Watershed - Uberlândia-MG

Análise da variação espacial físico-química de materiais superficiais da bacia hidrográfica do córrego do Glória-Uberlândia-MG

Fabiana Cristina dos Santos[1]
Silvio Carlos Rodrigues[2]

Abstract
The distribution of surface materials in the Cerrado environment has intrinsic characteristics which are related to topographic positioning, slope shape and water runoff. All these aspects are associated with climatic seasonality typical of this environment. In this way this work aims to investigate the physical and chemical attributes of the surface materials concerned with the geomorphological characteristics influenced by their spatial variability which plays a predominant role in the quality of these ecosystems. The study area is a hydrographic basin located in the county of Uberlândia in the southeast region of the Triângulo Mineiro. The methodology was based on the analysis of the physical, chemical and mapping of some parameters. We analyzed: texture, apparently density, total porosity, organic matter, CEC, V, H + Al, pH, K +, hypsometry and use and coverage. In addition to three maps containing the percentages of clay, silt and sand for the elaboration of the exploratory map and its peripherals of the hydrographic basin. About 80% of the basin is occupied by agriculture and anthropogenic action. The prognostic analysis correlated the physical-chemical attributes subjectively because it is a study based on probabilities considering the available knowledge about each attribute in the national literature. The analysis of the superficial materials added to the mapped attributes offers to the researchers important information endowed with great geographic value, be it in the scope of the geomorphology, or in what refers to the studies of the physical environment integrated to the sectors of planning and environmental management..
Keywords: Physical and chemical attributes, Surface Geochemistry, Hillslope Geomorphology.

[1] Universidade Federal de Uberlândia, Programa de Pós-Graduação em Geografia. Uberlândia, MG, Brasil. fabianaqgufu@gmail.com
[2] Universidade Federal de Uberlandia, Uberlândia, MG, Brasil. silgel@ufu.br
Article received in: 22/10/2018. Accepted for publication in: 04/02/2019.

Resumo
A distribuição dos materiais superficiais nas vertentes em ambiente de Cerrado dispõe de particularidades intrínsecas, que estão relacionadas com o posicionamento topográfico, formato das vertentes e com escoamento superficial da água. Todos estes aspectos estão associados com a sazonalidade climática, típica deste ambiente. Dessa forma, este trabalho objetiva investigar, os atributos físico-químicos e sua relação com os materiais superficiais-paisagens, concernentes com as características geomorfológicas, influenciadas por sua variabilidade espacial, a qual exerce papel preponderante na qualidade destes ecossistemas. A área de estudo trata-se de uma bacia hidrográfica localizada no município de Uberlândia, na região sudeste do Triângulo Mineiro. A metodologia baseou-se na análise das propriedades físicas, químicas e mapeamento da distribuição espacial dos mesmos através de técnicas de Krigagem. Foram analisados: textura; densidade aparente; porosidade total; matéria orgânica; CTC, V, H+Al, pH, K+, hipsometria e uso e cobertura da terra, além de três mapas contendo as porcentagens de argila, silte e areia para a elaboração do mapa exploratório do terreno para toda bacia hidrográfica. Cerca de 80% da bacia está ocupada por agropecuária e ação antrópica. A análise prognóstica correlacionou os atributos físico-químico de forma subjetiva, por se tratar de um estudo embasado em probabilidades, considerando o conhecimento disponível sobre cada atributo na literatura especializada. A análise dos materiais superficiais, somada aos atributos mapeados oferece informações importantes, dotada de grande valor geográfico, seja no âmbito da geomorfologia, seja no que se refere aos estudos do meio físico integrados aos setores de planejamento e gestão ambiental.
Palavras-chave: Atributos físico-químicos, geoquímica superficial, geomorfologia de vertente materiais superficiais-paisagem

Introduction

The Cerrado possesses particularities that result in the distribution of flows of matter and energy within the systems of hydrographic basins. The conformation of the slopes in these basins affects the arrangement of the surface materials, as well as the use of the existent soil. In this paper, a predominantly erosive environment, where the disposition of surface materials follows the combination of the conditions and elements of the soils and deposits, is the study area.

The textural nature of the surface materials contributes to the classification of its constituent elements, for it is a stable characteristic, once the sizes of the particles of mineral materials are not subject to fast changes. Besides that, there is the fact that the proportion of each fraction group is not passive of alteration. Thus, it is clear the importance of its participation in quantitative analyses.

According to Santos, Barcelos, and Rodrigues (2015), the surface materials are constantly in chemical activity, wherein a number of reactions happen at the same time, each of which in their respective state (solid, liquid, and gas), as well as among themselves, and between them and the environment. The greatest part of the phenomena occurs in the smaller particles, called colloidal fraction, due to its high reactivity.

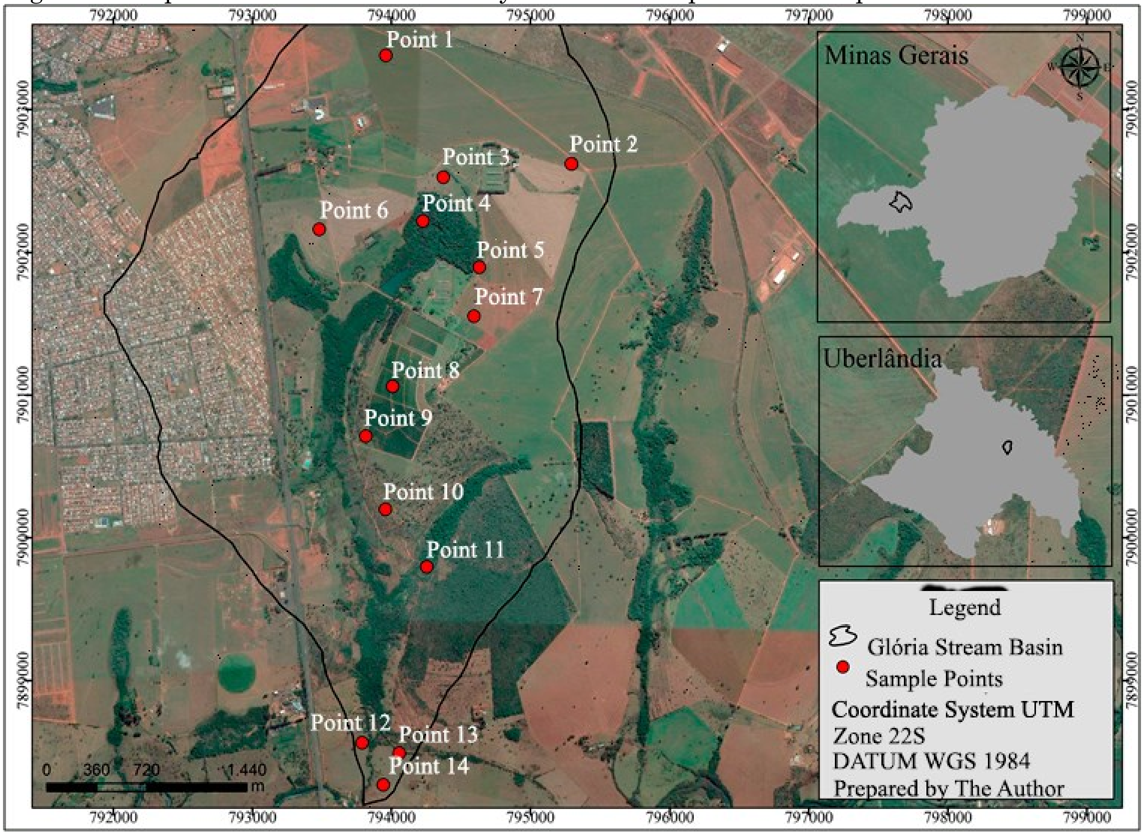
In this context, the research's general goal was to characterize the physical and chemical features of the surface materials of the Glória hydrographic basin, in order to assess properties that might be used for reflection on the surface material-landscape relationship, for this is an area that has been completely modified by human action and pedogenesis and morphogenesis.

Study Area

The research was developed in the Glória Hydrographic Basin, in the city of Uberlândia – MG, as seen in Figure 1, in the geographic coordinates 18º56'56" latitude South and 48º12'21" longitude West of Greenwich. The basin's elevation varies between 920 and 865 meters from sea level.

According to Alves (2007), the wet and dry seasons last six months each in this area, due to the shift of the air masses that affect the region, which are: the Continental Equatorial Air Mass, the Atlantic Tropical Air Mass, and the Polar Air Mass.

Figure 1:-Map of the location of the study area and sample collection points



Org.: Authors, 2018.

According to Ab'Saber (1977), the Cerrado Morphoclimatic Domain is characterized by tablelands that are covered by cerrado vegetation and gallery forests that penetrate along the water streams. The natural vegetation of the study area is divided into three types – the cerrado stricto sensu, the mesophytic woodland, and the wet camp.

Cenozoic sediments (Detrital-Lateritic Deposits) in the area of flattened hilltops and Mesozoic ones (Marilia Formation) in the slopes that cover the basin barely in its totality characterize the lithology of the Glória hydrographic basin. Gravel pits, heterogeneous and poorly-selected sandstones, and basalts blooming in the valley bottoms (Serra Geral Formation) compose the slopes of the basin. Due to weathering, few original structural characteristics of the stones remain (ALVES, 2007). The landform pattern of the study area, according to Costa, Barcelos, and Rodrigues (2018), presents hills whose tops are flattened.

Operational Procedures

The operational procedures had three stages. First, bibliographical and cartographical reviews were undertaken to identify the study area. Afterward, the researchers chose the approach typology for the materials to be collected and which maps to be produced, and field research for the collection of the materials was performed. Finally, analyses were run and the interpretational elements (maps and tables) developed.

The field work was performed through visits to the Glória hydrographic basin, with the goal of collecting samples of surface material for the evaluation of the following physical analysis: apparent density (AD), total porosity (TP), and texture (T); and chemical analysis: pH, K(potassium), Ca (calcium), H+Al (exchangeable aluminum), CEC, V% (base saturation), and OM. The sampling collected simple samples in 14 points in the hydrographic basin (Figure 1), taking into consideration the topography, slope shape, and a randomized distribution within the variations found in these elements.

The Laboratory of Geomorphology and Soil Erosion (LAGES) ran the physical analyses, while the chemical analyses were outsourced in the laboratory of GEAP – Agrosciences. Table 1 presents the main information about the physical-chemical analyses.

Table 1: Physical-chemical parameters evaluated for the study area

	Parameters	Unit	Method	Depht
Chemical	pH		pH in H_2O-Embrapa(1997)	Dutch Brought 0-10cm
	K	$cmol.dm^{-3}$	Colometry -Vettori(1969)	Dutch Brought 0-10cm
	Ca	$cmol.dm^{-3}$	Titulometry-Embrapa(1997)	Dutch Brought 0-10cm
	CEC	$cmol.dm^{-3}$	Embrapa (1997)	Dutch Brought 0-10cm
	H+Al	$cmol.dm^{-3}$	Embrapa (1997)	Dutch Brought 0-10cm
	V	%	Embrapa (1997)	Dutch Brought 0-10cm
Physical	Organic Matter	$dag.k^{-1}$	Adapted method Daniels (1971)	Dutch Brought 0-10cm
	Density	$g.cm^3$	Volumetric ring-Embrapa (1997)	Undisturbed sample 0-10cm
	Porosity	%	Embrapa (1997)	Undisturbed sample 0-10cm
	Texture	%	Embrapa (1997)	Dutch Brought 0-10cm

Org.: authors, 2018.

Georeferenced sample points were used (Table 2) and a Kriging interpolation (ordinary method, with spherical semivariogram, extending the processing's coverage area through a manually-created bounding rectangle) was rendered from data generated in the laboratory tests.

Table 2: Characterization of sampling points.

Points	Coordinats Latitude/Longitude		Use classes	Altitude	Shape of the strand
1	18° 58' 17,2"	48° 12' 21,5"	Cultivation	945	Plan
2	18° 58' 16,7"	48° 12' 21,3"	Cultivation	945	Plan
3	18° 58' 16,4"	48° 12' 21"	Cultivation	925	Concave
4	18° 58' 15,9"	48° 12' 21"	Vegetation	903	Concave
5	18° 58' 15,8"	48° 12' 20,5"	Vegetation	912	Rectilinear
6	18° 58' 16,3"	48° 12' 18,7"	Cultivation	897	Concave
7	18° 58' 17,1"	48° 12' 19,4"	Cultivation	908	Rectilinear
8	18° 58' 17,6"	48° 12' 19,8"	Cultivation	882	Convex
9	18° 58' 17,5"	48° 12' 20,5"	Pasture	870	Convex
10	18° 58' 17,8"	48° 12' 21,6"	Pasture	865	Convex
11	18° 58' 18,3"	48° 12' 18,9"	Vegetation	847	Concave
12	18° 58" 17,1"	48° 12' 18,5"	Pasture	814	Convex
13	18° 58' 16,6"	48° 12' 17,8"	Pasture	820	Rectilinear
14	18° 58' 16,4"	48° 12' 18,1"	Pasture	810	Rectilinear

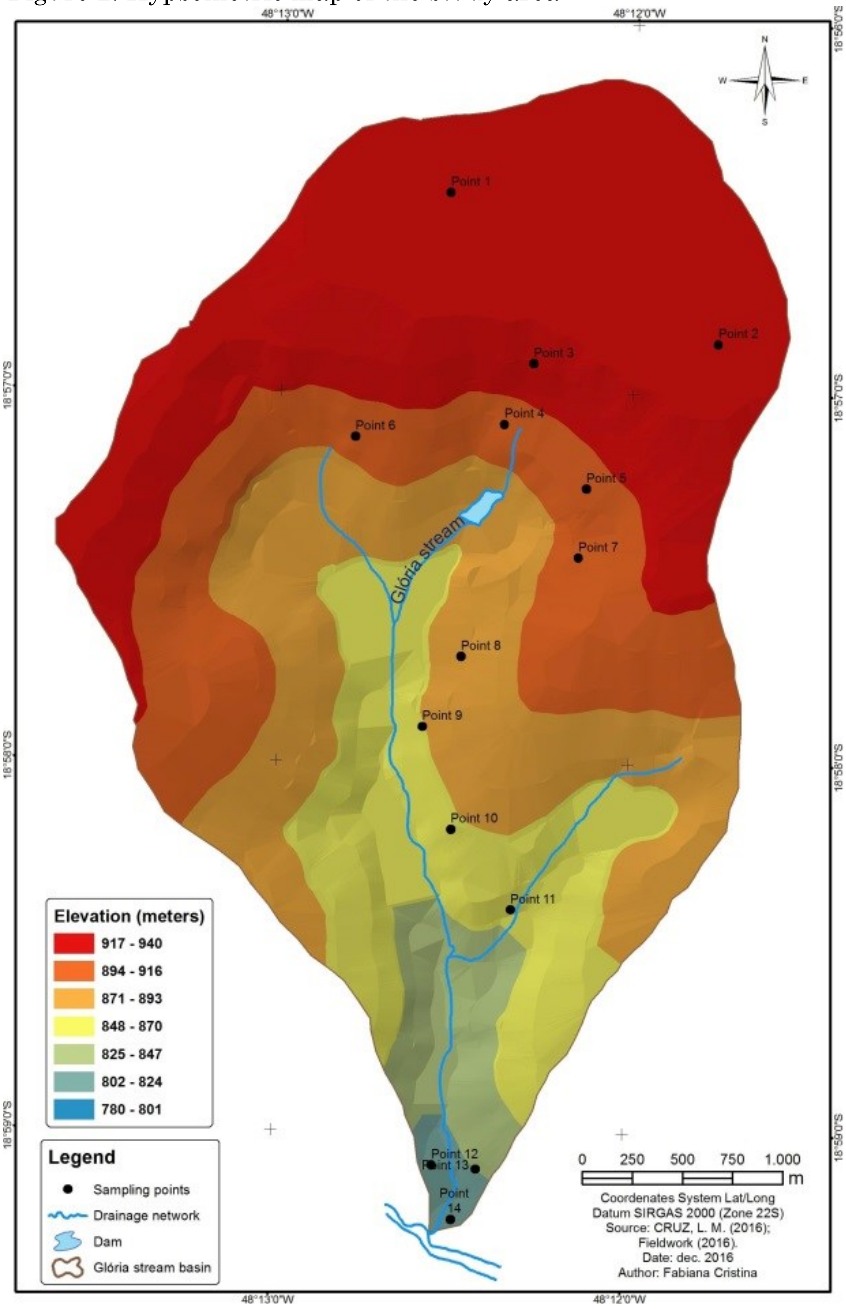
Org.: authors, 2018.

The polygons that limit the areas with predominant specific textures (sandy, silty or clayey) were elaborated according to the generated kriging and also using the topographical chart's contour lines. As a final procedure, the layout was made, displaying the resulting data of the kriging of each physical-chemical element analyzed in the research. The technique of manual vectorization by photo interpretation was used for the construction of the map of use and occupancy. The image's composition is of a natural color type.

Results and Discussion

The order of this study's structuring stages guides the presentation of the results. The hypsometric groups (Figure 2), represented in the thematic maps are important because they favor the demarcation of topographic units, which are responsible for the definition of the limits between the areas. As such, the topographic unevenness of the study area was evaluated; the results showing a declining slope in the relief and the predominant topographic patterns in addition to the interfluvial dimensions.

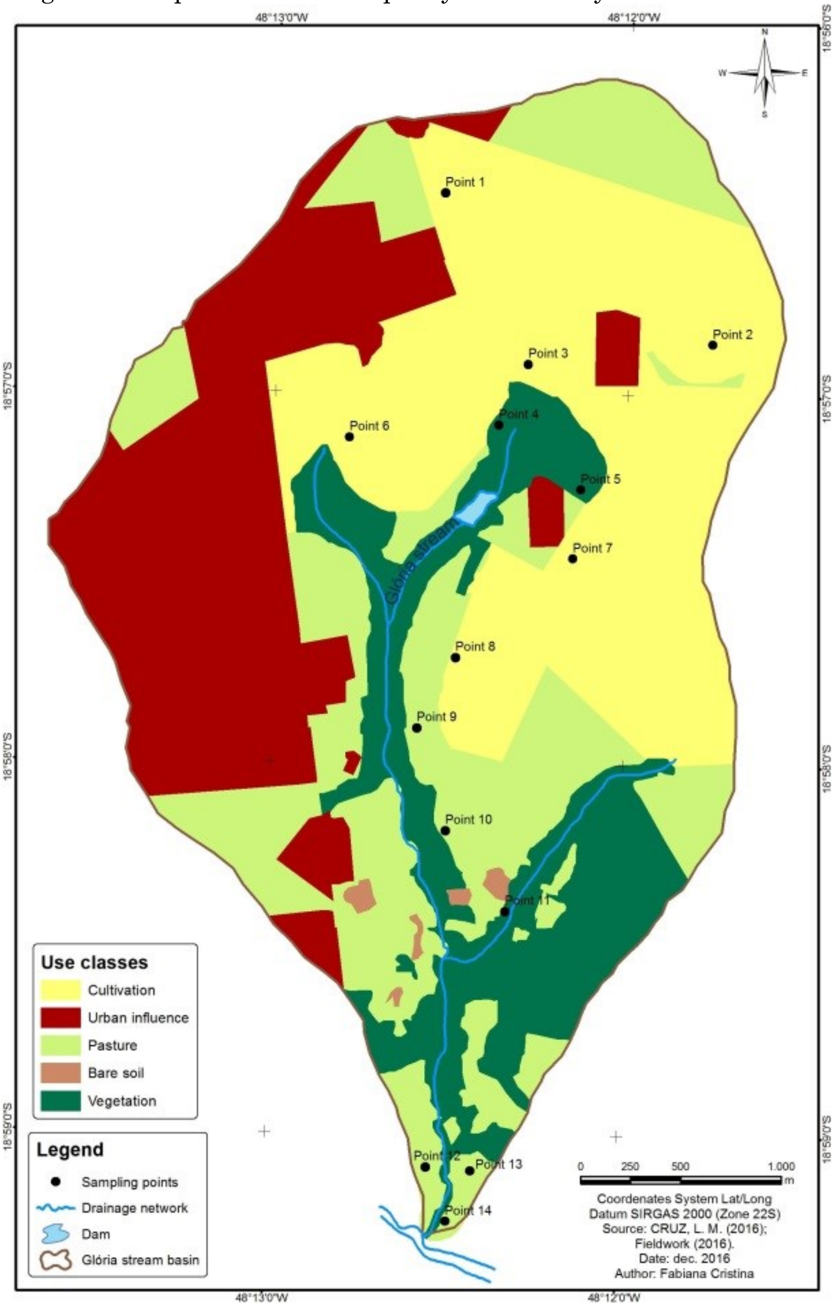
Figure 2: Hypsometric map of the study area



Org.: authors, 2018.

Figure 3 presents the variety in use and occupancy of the hydrographic basin's soil, which has a total area of 12.8 km². Table 3 lists the different types of use and occupancy, highlighting the predominance of cultivation (33,08%).

Figure 3: Map of use and occupancy of the study area.



Org.: authors, 2018.

Table 3 – Distribution of use classes in hydrographic basin.

Use classes	ha	%
Cultivation	423,4	33,08
Urban influence	308,9	24,14
Pasture	330,3	25,81
Bare soil	5,7	0,43
Vegetation	211,3	16,51
TOTAL	1.279,7	100

Org.: authors, 2018.

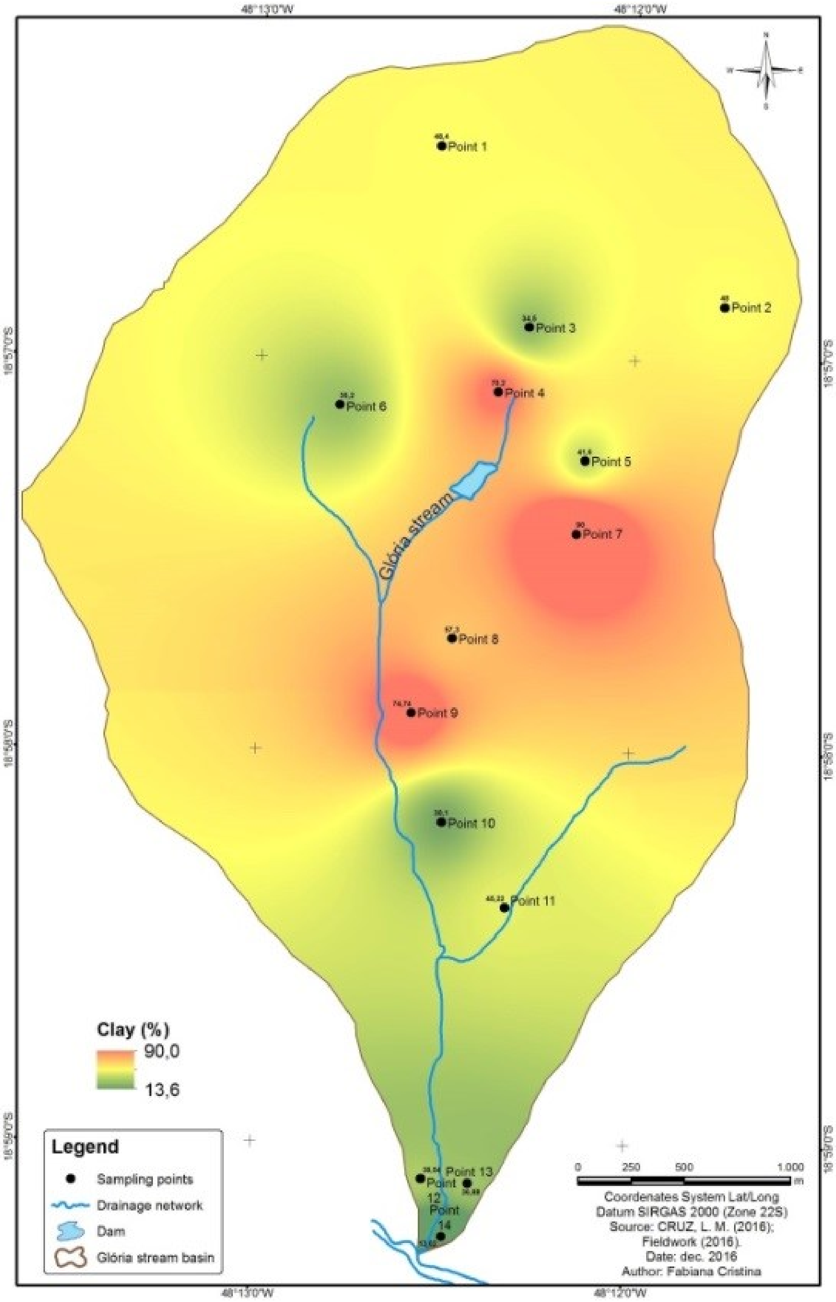
On the one hand, the sum of the areas destined to agriculture (33,08%), pasture (25,81%), and urban influence (24,14%) tally to 83,03% of the areas under investigation in the hydrographic basin. On the other hand, the area occupied by vegetation adds up to only 16,51% of the basin. Considering this, the susceptibility of the surface materials, due to the absence of vegetal cover, represents an aggravating circumstance in the processes of degradation of water resources in this hydrographic basin.

Although representing only 16,51% of the basin, the vegetation exerts a fundamental role in the preservation and maintenance of the quality of surface materials and of water. Through the visual analysis of Figure 3, the reduction and discontinuity of the gallery woodlands that follow all of the Glória Stream's bank are clear, which is a result of anthropic interference moved by the opening of new agricultural areas. Therefore, it stands out that the hydrographic basin's area is almost exclusively destined for agricultural activities.

Figures 4, 5, and 6 present the results obtained from the granulometric analysis of the samples that were collected in the hydrographic basin. The figures display the spatialization behavior of the samples – which owes to the composition of the interlinked individual particles in the surface materials – thus exhibiting that a great lot of the reactions of surface materials are attributed to surface phenomena, such as the adsorption of ions.

In the solid state of surface materials, mineral and organic, chemical reactions happen due to the presence of positive and negative surface electrical charges, which attract anions and cations, respectively. Therefore, a higher value is observed for clay, with a 90% composition, as it is the smaller fraction of the surface material, also known as colloid. (Figure 4).

Figure 4: Spatial distribution of clay in the hydrographic basin.

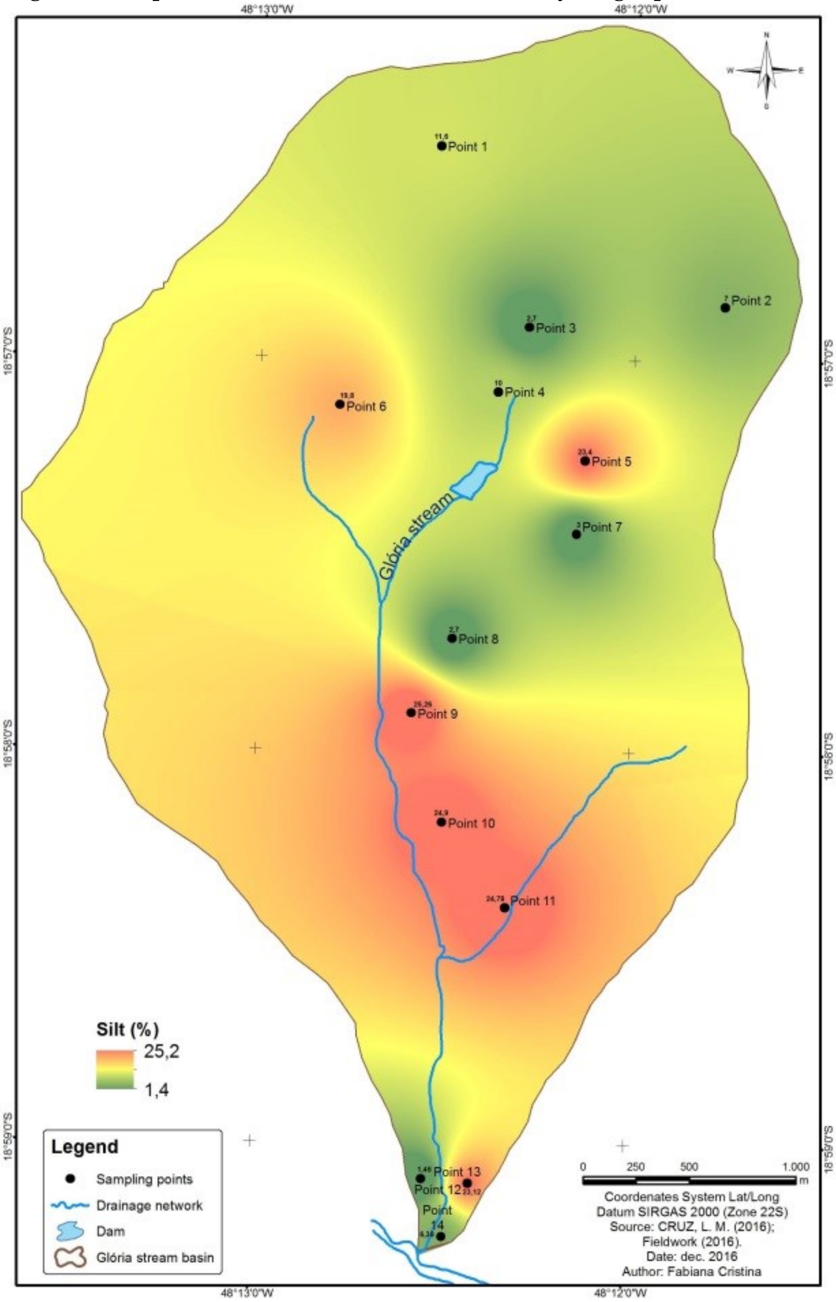


Org.: authors, 2018.

This exhibits that this attribute, among those that compose the texture of surface materials, is the one that shows the least variability and the largest spatial continuity, thus rendering better precision in the estimations of non-sampled locations.

The silt/clay relationship displayed regular variation. In general, those that presented lower values indicated larger degrees of weathering. (Figure 5)

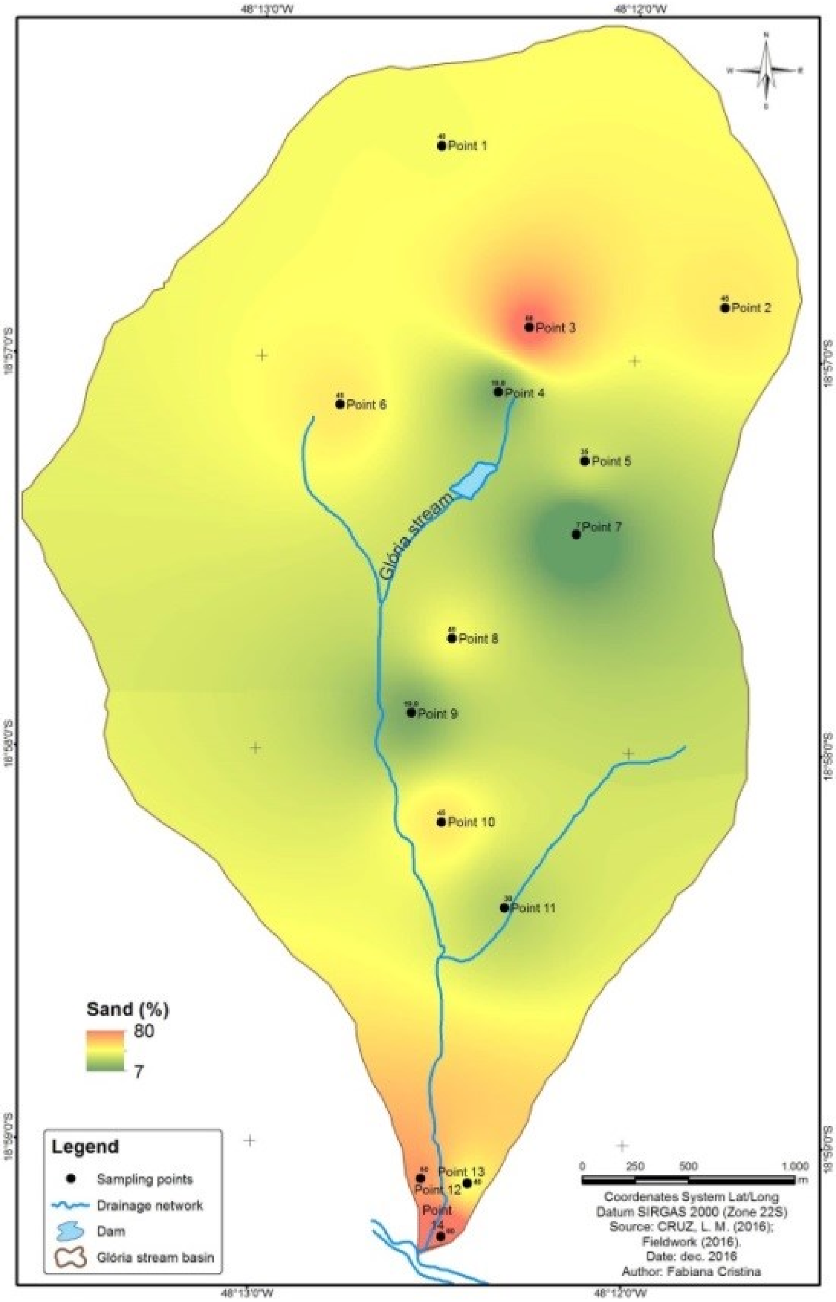
Figure 5 – Spatial distribution of silt in the hydrographic basin



Org.: authors, 2018.

The levels of sand (Figure 6), on their turn, were larger in the areas of vegetation and pasture (Figure 3), when compared to other materials. This behavior is owing to the influence of the geological substratum.

Figure 6:- Spatial distribution of sand in the hydrographic basin.



Org.: authors, 2016.

The pattern of distribution of apparent density was shown as heterogeneous, pointing variability in the values: with 6 points equal to 1,2 g/cm-3 and 7 points of 1,4 g/cm-3 in the sample points under inquiry, as displayed by Table 4.

Table 4: Physical attributes of the study area

	Depth		
	0-10 cm	**0-10 cm**	**0-10 cm**
Points	**Density(g/cm³)**	**Organic matter(dag.kg^{-1})**	**Porosity%**
1	1,30	1,0	40,0
2	1,30	1,0	45,8
3	1,28	1,0	46,0
4	1,13	1,0	40,5
5	1,39	1,0	25,2
6	1,40	1,0	40,0
7	1,12	1,0	45,0
8	1,55	1,0	20,0
9	1,50	1,0	43,7
10	1,37	1,2	44,0
11	1,75	1,2	35,0
12	1,35	1,2	76,0
13	1,32	1,2	48,0
14	1,23	1,2	47,0

Org.: authors,2018.

The greater exposure of the 0-10 depths to the movement of surface materials, mainly in the areas of cultivation and pasture, as well as to traffic of machinery, leads to the greater variability of apparent density in such levels. According to Greenwood and Mckenzie (2001), density and porosity are the most applied physical properties for the quantification of physical attributes of surface materials.

Porosity showed a top value in point 12, intermediate values in points 1, 2, 3, 4, 6, 7, 9, 10, and 14, and low values in points 5,8, and 11 (Table 4). The sandy group showed the top value for porosity (point 12; 76%), reflecting its less dense and cohesive features, which is in the area with vegetation cover, as seen in the map in Figure 4. This analysis is similar to Dambros' work (2012), who run a study in a forest area constituted of sandstone.

The comparison of the spatial distribution pattern of total porosity and geomorphological features such as elevation and declivity (Table 4) helps to observe a larger influence of the relief in the spatial distribution of the fractions of sand and clay. This displays the divergent behavior of the coarse sand and fine sand fractions as a function of the dynamic between water and relief, thus indicating the importance of the subdivision of the sand fraction in pedo-geomorphological studies.

The larger size of the sand fraction does not favor its transport through long distances; as opposed to clay, whose transport is easier via surface runoff. That being said, an effect of increase of the water volume through the accumulated flow serving as the main conditioning agent of zones with more sandy surface materials with larger total porosity, can be suggested. Moreover, the loss of finer particles of surface materials with the size of the silt and clay fractions, as well as of the organic matter in the course of surface runoff, may cause a bigger loss of nutrients.

The analysis of the organic matter, on the base of its averages, shows that the almost all the points show levels of organic matter at 1,0 dag.kg-1 (Table 4), this being a level of high susceptibility to erosion (GREENLAND et al., 1975 in GUERRA, 2007). This characteristic also has a direct relationship with the sandy texture of the surface materials found in the study. Surface materials with fine texture possess more OM and have better water and nutrient retention, thus providing ideal conditions for the development of plants. Sandy materials, on their turn, are airier and with a faster OM decomposition, due to the presence of oxygen.

It is worth noting that use and occupancy, climate, and the characteristics of surface materials, notably texture, influence the dynamic of organic matter. In this context, soil inversion and machinery traffic reduce vegetal cover, thereby maximizing erosion risks and directly affecting the organic matter index.

In a study taken in palm swamps located in two distinct environments, Ramos (2008) verified that organic matter arises as a great contributor to the solid state of the soils in the lower third of the slopes of the palm swamps in both environments, but mainly in the lower third of the slopes of the chapada palm swamps.

The same authors presented results wherein the levels of OM are also higher in the surface layer of the middle and superior thirds of the slopes of such palm swamps. In a palm swamp examined in the state of Minas Gerais, in the edge of an area (most elevated region) with the cerrado, the occurrence of better drainage and, in return, a smaller level of organic matter (GUIMARÃES et al., 2002), was observed.

This fact arises, probably, from the more intense decomposition and mineralization of organic matter that is observed in conditions of better aeration.

Table 5 describes the results of the chemical attributes. The values for cation-exchange capacity (CEC) varied between 8,9 and 2,2 cmol.dm-3. The CEC value has an intrinsic relationship with organic matter and clay levels. Point 7 presented the largest value for this feature, 7,92 cmol.dm-3, which is justified by the 80% clay level and the location in a cultivation area (Figure 3 and 4).

The surface materials, in this case, will probably be acids, as confirmed by the pH values in Table 5. This situation might be common in tropical areas, such as the subject of this study, and which had already been detected in the same area in the study of Costa, Barcelos, and Rodrigues (2018) and Pinese Junior, Cruz, and Rodrigues (2008). The cationic-exchange capacity (CEC) displayed higher values in point 14; this result is due to the use of soil for cultivation in this region of the basin (Figure 3).

Table 5 – Analyses of chemical properties of surface materials in the hydrographic basin.

Profundidade 0-10 cm					
Pontos	K (cmol.dm^{-3})	H+Al (cmol.dm^{-3})	pH (H_2O)	CEC(cmol.dm^{-3})	V(%)
1	0,13	1,7	6,2	5,8	70,8
2	0,21	1,0	7,2	7,6	86,9
3	0,22	1,8	5,6	4,2	57,3
4	0,28	2,7	5,3	6,5	58,3
5	0,07	2,4	6,6	3,0	19,2
6	0,04	3,7	5,5	4,5	18,5
7	0,12	3,8	5,2	6,1	37,9
8	0,08	2,6	5,0	4,9	46,7
9	0,08	1,7	5,4	3,0	43,0
10	0,1	2,1	6,0	2,8	25,0
11	0,05	1,7	5,9	2,2	24,4
12	2,3	2,0	6,1	5,9	66,2
13	0,6	2,4	5,7	3,8	36,2
14	0,17	6,0	5,2	8,9	32,4

Org.: authors, 2018

Higher CEC values usually occur in locations where the levels of OM and clay are high (Figure 4). These attributes contribute to the increase of negative charges, therefore favoring the retention of nutrients. Another factor that must be considered in the study area is topography, which probably contributed to the accumulation of clay and consequently with the increase of

CEC in the surface. Therefore, heterogeneity is noted in the spatial distribution of this attribute.

The lower CEC values, observed in locations of pasture and vegetation (Figure 3), can be explained by the absence of liming, as well as by the advanced stage of degradation of the system under pasture.

The base saturation (V) fluctuated between 86,9% and 18,5% (Table 5). It is important to highlight that surface materials in the cerrado region usually show V < 50%, that is, they are dystrophic. Points 1, 2, 3, 4, 12, and 14 presented values higher than 50%, which is justified by the fact that they are in areas of cultivation and pasture that have already been exposed to chemical interventions through liming. The sandy texture has a relation of proportion with values higher than 50%, for it enables the leaching of bases in solution.

High base saturation values (V) contribute to high pH values in water. Lower observed values might be caused by a position that favors the addition of ions from higher parts and the reduction of losses through leaching because of the draining condition.

The surface materials of tropical regions are usually acid and present high levels of exchangeable Al (Ronquim, 2010). Point 7 of Table 5 showed the highest value (3,8 cmol.cdm-3) and 5,5 pH. The explanation for such fact is related to the mineralogic fraction and textural of the study area, where Al and Fe oxides predominate, both in the crystalline (gibbsite, goethite, and hematite) and the amorph forms. (Ronquim, 2010).

Exchangeable aluminum (H + Al) was predominantly formed by H^+ ions, once the levels of Al^{+3} were not significative. The highest value of exchangeable aluminum (Point 14) is found in the surface layer (Table 5), indicating that the oxidation of organic matter may be an important component in the generation of acidity. Exchangeable aluminum also shows a behavior inverse to that of the base saturation values, for it is higher in sandy textures (Figure 6), thereby confirming the values obtained by Nunes et al (2001), who examined the soil-landscape-source material relationship in soils of Minas Gerais.

As for the pH of surface materials, all points presented a pH lower than 7,5 (Table 5), which confers acidity to the surface materials, a normal behavior in the study area (OLIVEIRA, 2011).

8 of the 14 analyzed points showed acidity above the average, with values fluctuating between 5,2 and 5,9. In face of these results, the importance of vegetal cover helping surface materials to maintain cohesion among its particles is stressed, once that they might be susceptible to erosion, taking into consideration the pH results. According to Yoshioka (2005), erosion may also be one of the causes of acidity, for there is the removal of the surface layer, which has larger levels of bases, thus favoring acidification as more acid soil layers become exposed. The lowest pH value was found in P8, a cultivation area, with 20% porosity and 1,55 g/cm3 of apparent density.

The temporal variation of the solution's pH and its behavior is verified by a slight reduction in the areas of pastures and an increase in the area of vegetation (Figure 3). This reduction was stronger in the pasture zone without vegetal cover, where the leaching of bases showed to be more intense because of the cultivation areas where liming is performed. Furthermore, the reduction of the solution's pH may be attributed to the elevation in the concentration of H+ in the environment, as a consequence of organic matter decay caused by microbial activity that comes with the beginning of a wet period after a dry season.

The results for the chemical element potassium (K+) show a close relationship with the sandy textural group (Figure 6). This behavior is caused by the mobility of potassium in solution, as weathering increases, especially in tropical conditions. The higher pH of surface materials favors the exchange of cations and the growth in the levels of K+. Furthermore, although the study area received no fertilization or acidity correction (vegetation area), the values of exchangeable cations were high.

As cultivation takes over the areas, these differences may interfere in the management of fertilization. The highest levels of K+ were found in point 4 (Table 5). However, no spatial dependence was detected, which might be explained by the weathering of source materials, once this element presents high mobility that facilitates its transport through the water flow, thus resulting in divergent chemical characteristics in the area.

Final Considerations

In face of the analyses, some reflections on the physical-chemical dynamic of the hydrographic basin as a study object could be attained, including the possibilities of evolution of the surface materials-landscape that the region suggests:

- Variations in the topography influence the properties of the surface materials.
- As time goes by and weathering acts, surface materials are conditioned by their position in the landscape, due to erosional and depositional processes that are associated with the water flow.
- The physical-chemical attributes present spatial dependence to texture and topography.

As already mentioned, the area has been suffering intense anthropic action as a consequence of the fast expansion of the city of Uberlândia. The physical-chemical study gains importance insofar as it tries to characterize the spatialization, the dynamic, and the explanation of the relations of the surface materials with the landscape, once it brings to light the possibilities for the evolution of the relief – a subject of geomorphological interest to both the academy and the planning sectors.

The analysis of the physical-chemical parameters in the hydrographic basin shows that the topography and the position of the landscape are relevant because they generate varied influences over the properties of the surface materials, even when these are strongly weathered and possess a high degree of homogeneity.

The analysis of the texture of the surface materials in the basin displayed that granulometric fractions in surface materials are attributes that do not fluctuate sharply as a result of weathering. Their variation is conditioned by their position in the landscape, due to erosional or depositional processes associated with the water flow.

The use and occupancy cartography points out that the Gloria Stream's hydrographic basin presented over 80% of anthropic and agricultural occupancy. However, the predominant forest cover still acts as a protector of surface materials against the establishment of erosive processes.

The kriging analysis techniques facilitated the evaluation of the spatial variability of the physical-chemical features of the surface materials for both the hydrographic basin and the slope. The physical-chemical attributes displayed spatial dependence and correlated respectively with texture and topography.

Finally, there was attention regarding the acquisition of primary and secondary data, with the mappings, the analyses of surface materials, and fieldwork. There is particular importance to field activities performed in the area and the use of geotechnologies for the achievement of the goals. From the indicators here under use, it is clear the participation of humankind as a catalyzing agent in the process of landscape modification.

The importance of the analyses of surface materials is here highlighted, for they were one of the indicators for the final prognosis. Knowing the physical and chemical properties from the results of the laboratory tests contributes in a more precise way for the studies, indicating their dynamic in the landscape – both the removal and the transport.

Acknowledgement

The authors thank the Conselho Nacional de Desenvolvimento Cientifico e Tecnológico for providing access to resources and financial support to accomplish the research (Project 302654/2015-1 and CAPES for the 1 st. author.

References

AB'SABER, A. N. **Os domínios morfoclimáticos na América do Sul: primeira aproximação**. Geomorfologia, São Paulo, v. 52, p. 1-22, 1977.

ALVES, R. A. **Monitoramento dos Processos Erosivos e da Dinâmica Hidrológica e de Sedimento de uma Voçoroca: estudo de caso na Fazenda do Glória na zona rural de Uberlândia- MG**. Mestrado em Geografia - Instituto de Geografia, Universidade Federal de Uberlândia, 2007.

COSTA, Y. T.; BARCELOS, A. C. ; RODRIGUES, S. C. . Fire effects on soil and vegetation in a degraded Brazilian Savanna. **MERCATOR** Fortaleza, v. 17, p. 1-13, 2018. Disponível em: <http://www.mercator.ufc.br/mercator/article/view/RMv17Txt16p1a16_2018en>. Acessado em: 18 out. 2018. doi:https://doi.org/10.4215/rm2018.e17016.

DAMBRÓS, C. Comparação da porosidade total, granulometria e condutividade hidraúlica de amostra de solo em área florestada e de campo. **Revista Geonorte**, Edição Especial, V.1, N.4, p.566 – 577, 2012.Disponível em: http://www.periodicos.ufam.edu.br/revista-geonorte/issue/view/115. Acesso em: 20 de dez 2017.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA (Embrapa). Centro Nacional de Pesquisa de Solos. **Manual de métodos de análise de solo**. 2. Ed. Rio de Janeiro: Embrapa CNPS, 1997.

GREENWOOD K. L, MCKENZIE B. M. Grazing effects on soil physical properties and the consequences for pastures: a review. **Australian Journal of Experimental Agriculture** 41, 2001,p.1231,1250. Disponível em: https://dl.sciencesocieties.org/publications/sssaj/abstracts/54/6/SS0540061682> Acesso em 19 de mai 2016. https://doi.org/10.1071/EA00102

GUERRA, A. J. T. Processos Erosivos nas Encostas. In: **Geomorfologia – Uma Atualização de Bases e Conceitos.** GUERRA, A. J. T. & CUNHA, S. B. (orgs). Rio de Janeiro: Bertrand Brasil, 7ª edição, 2007, p. 149-209.

GUIMARÃES, A. J. M.; ARAÚJO, G. M.; CORRÊA, G. F. C. Estrutura fitossosiológica em área natural e antropizada de uma vereda em Uberlândia, MG. **Acta Botanica Brasilica**, v.16, p.317-329, 2002. https://doi.org/10.1590/S0102-33062002000300007

NUNES, U.R.; ANDRADE JÚNIOR, V.C.A.; SILVA, E.B.; SANTOS, N.F.; COSTA, H.A.O.; FEREIRA, C.A. Produção de palhada de plantas de cobertura e rendimento do feijão em plantio direto. **Pesquisa Agropecuária Brasileira**, v.41, p.943-948, 2001. https://doi.org/10.1590/S0100-204X2006000600007

OLIVEIRA, D. de. Técnicas de Pedologia. In: VENTURI, L. A. B. (org.). **Geografia: práticas de campo, laboratório e sala de aula.** Editora Sarandi: São Paulo, 2011, p. 83-106.

PINESE JÚNIOR, J. F.; CRUZ, L. M.; RODRIGUES, S. C. Monitoramento de erosão laminar em diferentes usos da terra, Uberlândia - MG. **Sociedade & Natureza**, v. 20, p. 157-175, 2008. https://doi.org/10.1590/S1982-45132008000200010

RAMOS, A. L. L. S. **Características Micromorfológicas de Latossolos Vermelho Amarelos da Porção Norte da Bacia do Córrego do Rio Grande, em Gouveia (MG)**. (Dissertação em Geografia) - Belo Horizonte - UFMG - 2008. Disponívelem:www.bibliotecadigital.ufmg.br/dspace/handle/1843/MPBB-8BYNUR>Acesso em 18 de mai 2016.

RODRIGUES, S. C. Análise da fragilidade do relevo. Abordagem empírico-experimental. **Revista Sociedade & Natureza**. v12 n. 23, p.167-189, 2000.

RONQUIM, C. C. **Conceitos de fertilidade do solo e manejo adequado para as regiões tropicais.** Embrapa Monitoramento por Satélite, Campinas – São Paulo, 2010.

SANTOS, F. C. ; BARCELOS, A. C. ; RODRIGUES, S. C. . Distribuição de atributos físicos do solo sob vertente em ambiente de Cerrado nativo do Triângulo Mineiro / **Cad. Geografia**, v. 25, p. 66-77, 2015. DOI 10.5752/P.2318-2962.2015v25n43p66.

SANTOS, F. C.; RODRIGUES, S. C. Variabilidade espacial físico-química de materiais superficiais sob uma vertente de Cerrado em estágio de recuperação.**Cad. Geografia**, , v. 27, n. 48, p. 200-209, 2017. https://doi.org/10.5752/P.2318-2962.2017v27n48p200

YOSHIOKA, M. H.; LIMA, M. R. de. **Experimentoteca de solos pH do solo. Projeto Solo na Escola,** 2005. Disponível em http://www.escola.agrarias.ufpr.br/arquivospdf/experimentotecasolos7.pdf. Acesso em: 03 jan 2017