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RESEARCH ARTICLE OPEN ACCESS

Evaluation of the Habitated Risk Area and Indication of Solutions for the Shangrillá and Vila Formosa Districts in Anápolis

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ABSTRACT
Areas of risk are places considered unfit for housing, and these are subject to natural disasters. Because of the process of urbanization and city growth, more and more people are living in these areas. In this context, this work has the objective of analyzing and mapping the problems that are leading the area of risk to the level of public calamity by soil degraded by creeping in Vila Formosa and Residencial Shangrillá in Anápolis in the State of Goiás, through Engineering, Chemistry and Geotechnics, in order to verify the possibility of occurrence of movement of potential masses to natural disasters. Through multicriteria capacitated decision making supported on land, planialtimetric "in loco" with the RTK - Geodetic device, soil and study analysis, calculations of rainfall intensity and sociological study. The methodological procedures involved bibliographical review, fieldwork to update risk zoning and questionnaires in risky housing. As results were selected the relevant criteria, soil and vegetation cover and exposure of the residents to the risk, were subdivided predominant factors attributed by technical consensus, for decision making, a thematic map was also obtained with the spatial distribution of the classes of Potential susceptibility to erosive processes and mass movements in the desired area.

Keywords: Erosion, mass movements, rain intensity, environmental analysis, vulnerability.

I. INTRODUCTION

There are several factors that affect the locations chosen by people to establish themselves through often inadequate buildings such as slopes with high risk of landslides. Thus, not all sites are suitable for human occupation, due to mass movements and undue human action (VARGAS, et al, 2012) [1].

The mass movement is defined by Bigarella (2003) as "displacement of large volume of material (soil and rock) slope below under the influence of gravity, being triggered by direct interference of other means or independent agents such as water, ice or air" [2].

According to Fernandes and Amaral (1996) the mass movement is "the movement of soil, rock and / or vegetation along the slope under the direct action of gravity. The contribution of other medium such as water or ice is due to the reduction of the resistance of the strand materials and / or the induction of the plastic and fluid behavior of the soils. According to the authors, undue human actions are presented in the Brazilian metropolis by means of sharp incidences of landslides induced by cuts for the implementation of housing and access roads, deforestation, mining activities, wastewater discharge and garbage, causing significant damages [3].

One of the ways to reduce the effects of natural phenomena on society is by undertaking disaster risk management work. In order for this management to be effective, it is necessary to increase the chances of predicting a disaster. Thus, it is necessary to assess the risk of a given region (MACHADO E ZACARIAS, 2016) [4].

Therefore, the objective of this work is to analyze and map the problems that are leading the area of risk to the level of public calamity by soil degraded by creeping in Vila Formosa and Residencial Shangrillá in Anápolis in the State of Goiás, through techniques of Engenhariasa, In order to verify the possibility of occurrence of movement of potential masses to natural disasters. To reduce the effects of these events on society, a work of risk management and disaster prevention was carried out to carry out the recovery of the urban area.

This research is justified by the need to solve the environmental problem caused by heavy rains, decline and human occupation over the territory of the studied districts. It adopted as a methodology of scientific work the bibliographic revision, aiming to base the developed activities and field research in order to obtain data useful to the study.

This article is structured in five sections. In this section we present, besides the introduction, the definition of the research problem, the objective, the justification and importance of the study and the structure of the present research. Section 2 brings the theoretical framework, with the formation of a conceptual and theoretical basis, that provide subsidies for the development of this study. Section 3 presents the method employed and the methodological techniques and procedures used. Section 4 describes the results obtained in the research. Finally, section 5 provides the purpose of the article, how it was achieved and suggestions for improvements.

II. LITERATURE REVIEW

Mass movements are dynamic processes that occur in slopes, being the main environmental situation for occurrence of natural disasters (BISPO et al., 2011). Prevention and emergency actions can prevent or minimize situations of natural disasters, it is up to the competent bodies to make decisions based on the physical and socio-environmental reality of the area of occurrence (RODRIGUES; CALHEIROS and MELO, 2013) [5; 6].

According to the management methods employed and the type of soil studied, different techniques can be used to evaluate soil quality. The quality of the soil will depend on the extent of the soil, the natural composition of the soil and will be related to the interventionist practices of man (Aráújo et al., 2012; Marzall & Almeida, 2000) [7; 8].

The rapid movements of the soil, called landslides and landslides, are of great importance because of the interaction with anthropic activities and the variability of causes and mechanisms. This material displacement occurs at different scales and speeds, varying between fast and slow movements. An action that avoids this displacement of the particles through the rains and the wind, and consequently the erosive processes, is the revegetation, which consists in reestablishing a new vegetation cover to the ground (IPT 1989, Chlorley et al., 1984) 9; 10].

Soil movements can become a problem when they are intensified by human occupation, removing the vegetation cover, exposing the soil, making it more prone to displacement in the event of heavy rains. It can be considered events of risk, phenomena of natural or anthropic origin that cause damages to the biophysical and social means (ZUQUETTE et al., 1995) [11].

Problems related to erosion and processes of mass movements are related to the socioeconomic situation, because of the lack of structure to avoid or control such phenomenon, making these problems more accentuated and difficult to be controlled (WAR, 2011). The combination of natural and social sciences such as soil science, social anthropology, rural geography, agronomy and agroecology, is called ethnopedology. (BARRERA-BASSOLS & ZINCK, 2003). Participatory research can integrate the knowledge of researchers in soil science and the local knowledge of rural populations and can facilitate this process (AUDEH et al., 2011) [12; 13; 14].

The slope of the relief slopes in relation to the horizontal plane is directly related to the speed of material displacement and the transport capacity of solid and liquid masses in the terrain. A slope above 30º presents the risk of more frequent landslides (MUÑOZ, 2005). This variable has great importance in geomorphological processes, conditioning water courses and displacement (CHRISTOFOLETTI, 1980). It is related to the processes of migration and accumulation of water, minerals and organic materials in the soil through the surface, provided by gravity. (SCHMIDT et al., 2003) [15; 16; 17].

III. METHODOLOGICAL RESEARCH PROCEDURES

The study area includes the Vila Formosa 3rd stage and the Shangrillá residential area located southeast of Anápolis, located in the macro zone of the river Antas with geographical coordinates 16o 21'76' and 48o 56'34", in the municipality of Anápolis in the State of Goiás, as shown in Figure 1.

Figure 1: Location of the areas studied.

The choice of this area to carry out the study was due to the process of disordered urban occupation and soil crawling in this region (NASCIMENTO and SOUZA, 2013). The disasters caused by these phenomena cause damage to the functioning of the community or society involving human, material, economic and environmental losses (TOMINAGA et al., 2009) [18; 19].

The emergence of the mass crawling has a strong relation with the half-slope launch of rainwater captured upstream of the tributary of the stream Góis. These water flows did not receive dissipation of the energy and with this they infiltrated with ease in the little thick soil existing in the place, as shown in Figure 2.

Figure 2: Area affected by advanced crawling causing calamity in 2016.

In order to evaluate the soils, it used classificatory methodologies based on the limits of land use for urban construction, which considers factors and difficulties related to the soil, relief, climate and forage typology of the surface of the affected area. In all, we combine the evaluation of the limitation of the areas destined to urban use for edification with others, classes capable of performing maintenance for land use, observing the methodologies indicated in Lepsch (1983) and Uberti et al. (1991). The application of this last methodology to the area susceptible to erosion was inferred by the own class of aptitude of use and, mainly, by the crossing between aptitude class and current land use (MARTINI et al, 2006) [20; 21; 22].

This study uses bibliographical revisions, for reasons for the activities developed and field work for data collection. It is characterized as a descriptive research, observing the nature of the objective, with the purpose of describing the area and the soil involvement that was carried to the calamity in the studied urban sectors due to the mass movement.

For the recognition of the subsoil conditions, laboratory and / or field tests and the use of field instrumentation were performed to allow the observation of soil behavior. We used investigations to define the stratigraphy of the subsoil and the estimation of the geomechanical properties of the materials involved and tests to obtain the parameters of representation of the characteristics of strain x deformation x resistance, indicating the factors that influence the behavior of the material.

IV. DISCUSSION AND DISCUSSION OF RESULTS

The Anápolis geology is composed by the stratigraphic units indicated in the map below, and the Anápolis-Itauçú Granulitic Complex predominates in the urban area, consisting essentially of basic and ultrabasic volcanic rocks from the Neoproterozoic period (850 to 651 million years). These rocks underwent the action of tectonic processes that caused the crustal slicing and overlapping generating a series of transcurrent faults with dominant orientation WNW / ESSE (JESUS, 2013). Observing the drainage map, however, we can see a greater number of NE / SW oriented drainage, such as the headwaters of the Antas river of the Catingueiro stream (FERNANDES; PEIXOTO, 2015) [23; 24].

The main hydrographic basins that make up the city of Anápolis are located in the west and east portion of the city, being the Antas river basin to the east and the Catingueiro stream to the west. The Antas River, affluent along the right bank of the Corumbá River, has as main sub-basins the Reboleiras stream basin and the Piancó stream (Anápolis water supply source) on its left bank and the extreme river bank on its right bank. The Catingueiro stream basin is a tributary of the João Leite river basin, where water abstractions are made to supply Goiânia (FERNANDES, PEIXOTO, 2015). Figure 3 presents the Simplified Geological Map of Annapolis [24].

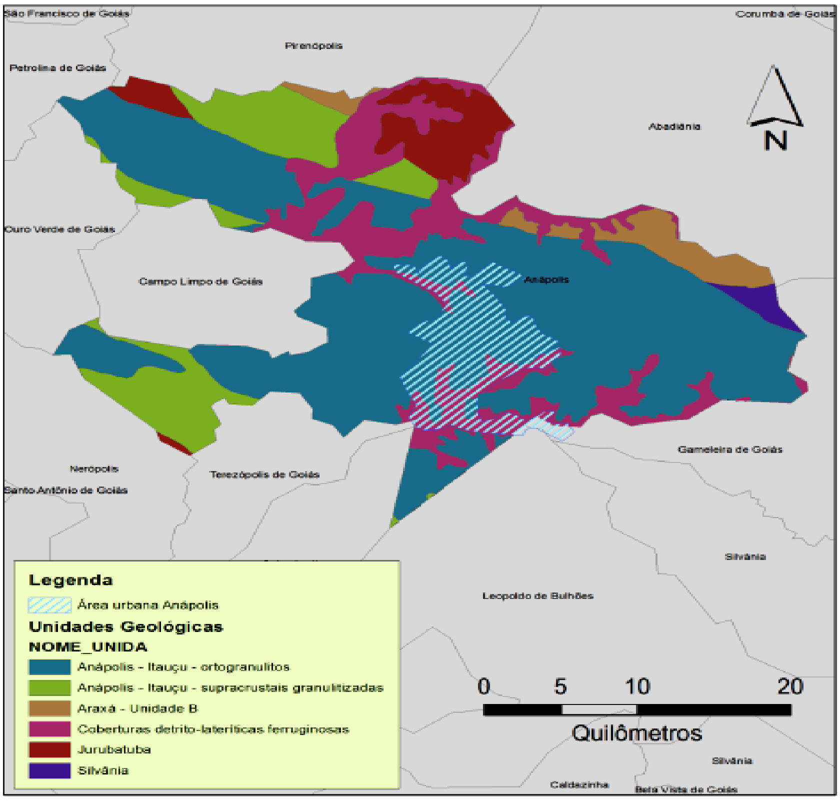


Figure 3: Simplified Geological Map of Anápolis. Source CPRM (2016)

In the studied area, the waterproofing at the perimeter increased the surface runoff, and this made the rainwater receiving point the only receiving end of the majority of the microbasin surface runoff. This denotes a concentrated flow of water conducted under the gallery, in volume exceeded that projected, contributing to the formation of mass displacement downstream of the rainwater network, supported mainly by the water jib.

The gallery in this microbasin is damaging the water runoff. This impoundment of the water in the soil upstream of the gallery envelopes the soil and configures the problem as a slow mass movement called creeping. This type of movement exerts pressure on the larger closed conduit rainwater that these can withstand. As can be seen in Figure 4.

Figure 4: Gallery damaged by soil pressure with crawling

According to Nimer (1989), the dominant climate in the Cerrado region is of the warm subhumid tropical type characterized by two well defined seasons, a drought that corresponds to the fall-winter period, and another drought with very heavy rains corresponding to the period Of spring-summer, where 70% of the rainfall accumulated during years and concentrates between November and March, being generally rainier the quarter from January to March, when it rains on average 45 to 55% of the annual total 25.

The surveyed area, with respect to the topography, presents a marked difference, not being semi-flat, the adjacent drainage is of the Rio das Antas basin. The city as to its geology is in the domain of the Goiano complex, with rocks of the granulitic complex (Arqueano), Grupo Araxá (mesoproterozoic) and Detrito-Lateritic Coverage (tertiary and quaternary). It also presents to the south-west the predominance of lateral canga relief flattened and granulites in the dissected areas (SILVA; MARTINS, 2015) [26].

The area reached by the crawl was isolated and built urban drainage systems. It carried out a planialtimetric survey to identify the water dividers and delimit the basin of rainwater contribution, following the necessary procedures to obey the techniques of Engineering. The levels curves described in Figure 5 were identified to find the slopes indicative of the degrees of decidas that the soil crawl has been presenting even after the insertion of the work that contains the galleries for collecting rainwater and ladder to cushion these drained waters.

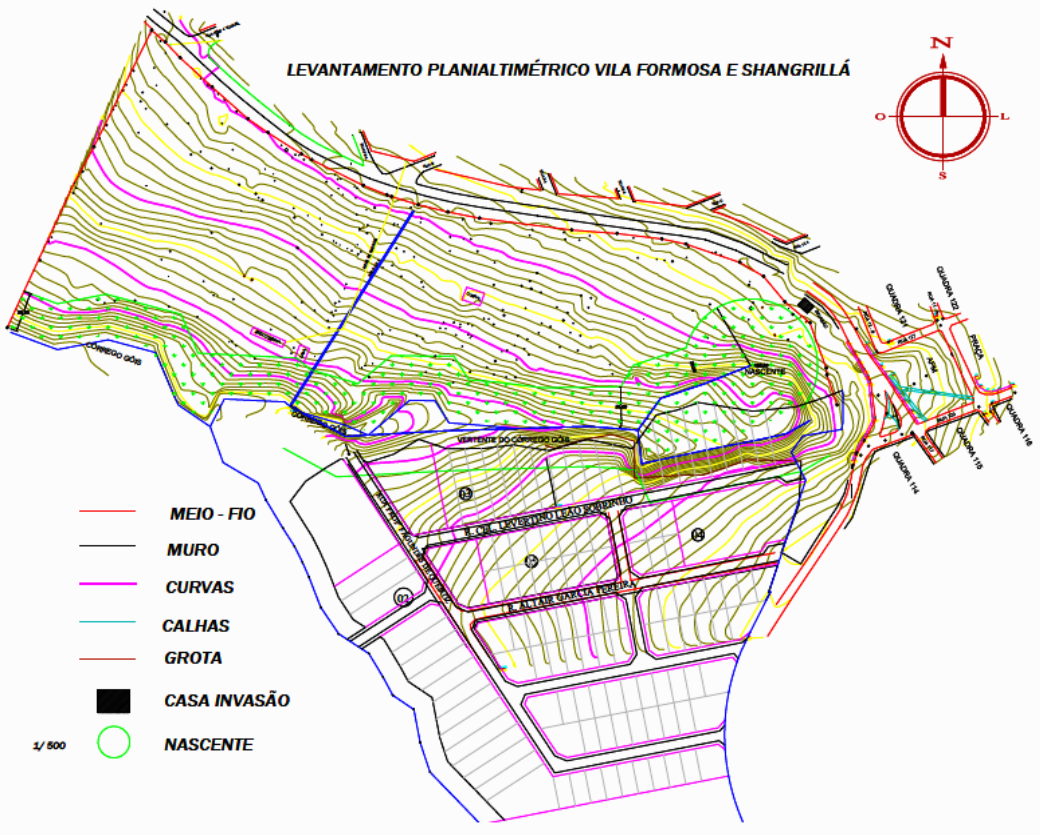


Figure 5: Planialtimetric - contour lines identified in the contribution basin

In the two study areas of this study, soil samples were collected within the areas with level curves for Fertility (Chemical) + Zinc, Physics (clay-texture, silt, sand), Sulfuric Extract (SiO2, Al2O3, TiO3, Fe2O3, Ki, Kr), Real and apparent Density, Water-dispersed clay, NaOH clay (calgon) Coarse sand, fine sand and silt, Heavy metals (Cd, Cr, Ni, and Pb) and the results obtained in Laboratory are shown in Figure 6. We observed the indices of rainfall with piezometers and installed inclinometers and plates of repression for complementary studies indicated in Figure 5.

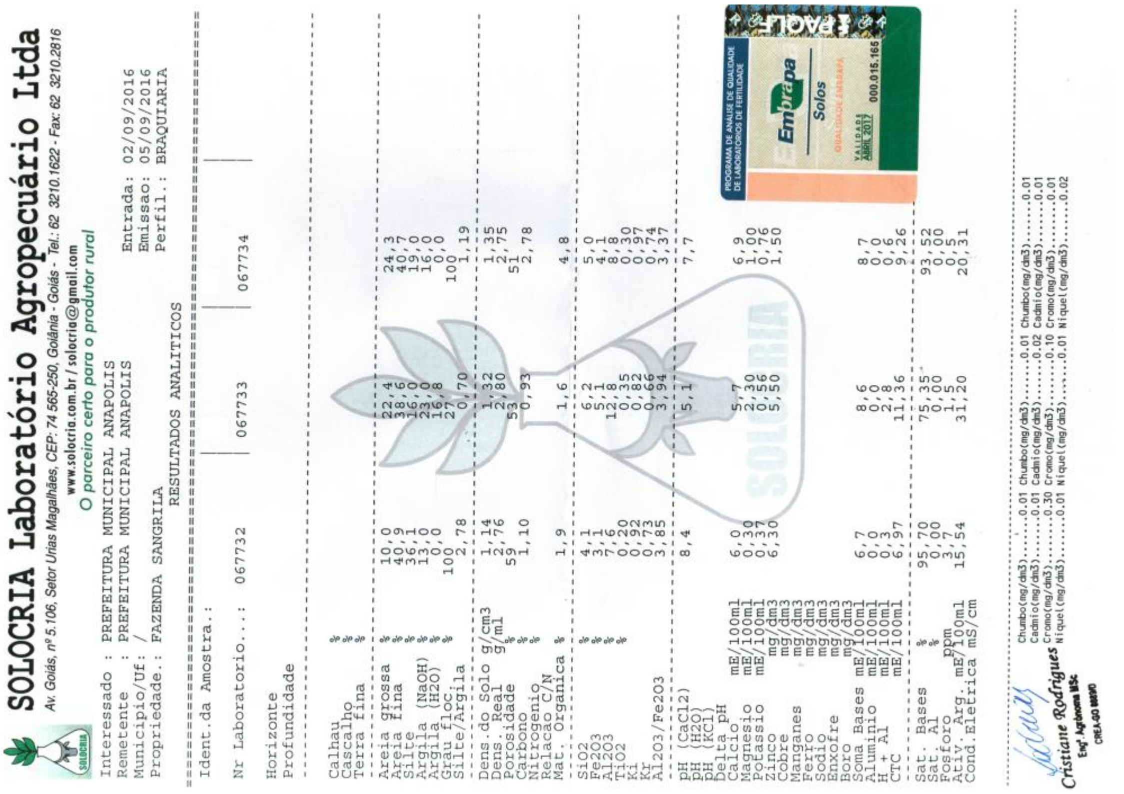
Because it presents a fairly large number of variables, it is necessary to use quality

For the analysis, the environmental variables (information plans) participating in the evaluation were used: geomorphology, altitude, lithology, slope and macro modeling, selected in the database.

The studied soil is formed mostly by clays of the kaolinite type whose particles are covered by iron oxides which are responsible for the typical reddish colors. The transition between horizons is gradual or diffuse, except for a darkened horizon

indicators. These can be chosen according to some criteria, such as: relationship with natural processes of the ecosystem; Ease of use in the field, so that experts and producers can use them to assess soil quality; Susceptible to climatic and management variations; Be a component of a database. The choice of certain indicators depends on the purpose and intrinsic characteristics of each environment. These Soil Quality Indicators are measurable (quantitative or qualitative) properties that allow characterizing, evaluating and monitoring the changes that have occurred. (ARAÚJO et al., 2012) [7].

with uniform texture. In this context, the structure is composed of round-shaped aggregates of very small sizes (0.5 to 3.0 mm) and is accommodated so as to leave a large amount of macropores between them, providing a high permeability to water, Even with high clay content and because of the intense weathering to which they are subjected, most of the Oxisols are poor in plant nutrients. (BRITTO et al, 2014) [27].



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Municipio/Uf: /
Propriedade.: FAZENDA SANGRILA

Entrada: 02/09/2016
Emissao: 05/09/2016
Perfil.: BRAQUIARIA

RESULTADOS ANALITICOS

Ident.da Amostra.:				
Nr Laboratorio...:		067732	067733	067734
Horizonte				
Profundidade				
Calhau	%			
Cascalho	%			
Terra fina	%			
Areia grossa	%	10,0	22,4	24,3
Areia fina	%	40,9	38,6	40,7
Silte	%	36,1	16,0	19,0
Argila (NaOH)	%	13,0	23,0	16,0
Argila (H2O)	%	0,0	16,8	0,0
Grau floc.	%	100	27	100
Silte/Argila		2,78	0,70	1,19
Dens.do Solo	g/cm3	1,14	1,32	1,35
Dens. Real	g/ml	2,76	2,80	2,75
Porosidade	%	59	53	51
Carbono	%	1,10	0,93	2,78
Nitrogenio	%			
Relacao C/N				
Mat. Organica	%	1,9	1,6	4,8
SiO2	%	4,1	6,2	5,0
Fe2O3	%	3,1	5,1	4,1
Al2O3	%	7,6	12,8	8,8
TiO2	%	0,20	0,35	0,30
Ki		0,92	0,82	0,97
Kr		0,73	0,66	0,74
Al2O3/Fe2O3		3,85	3,94	3,37
pH (CaCl2)		8,4	5,1	7,7
pH (H2O)				
pH (KCl)				
Delta pH				
Calcio	mE/100ml	6,0	5,7	6,9
Magnesio	mE/100ml	0,30	2,30	1,00
Potassio	mE/100ml	0,37	0,56	0,76
Zinco	mg/dm3	6,30	5,50	1,50
Cobre	mg/dm3			
Manganes	mg/dm3			
Ferro	mg/dm3			
Sodio	mg/dm3			
Enxofre	mg/dm3			
Boro	mg/dm3			
Soma Bases	mE/100ml	6,7	8,6	8,7
Aluminio	mE/100ml	0,0	0,0	0,0
H + Al	mE/100ml	0,3	2,8	0,6
CTC	mE/100ml	6,97	11,36	9,26
Sat. Bases	%	95,70	75,35	93,52
Sat. Al	%	0,00	0,00	0,00
Fosforo	ppm	3,7	1,5	0,5
Ativ. Arg.	mE/100ml	15,54	31,20	20,31
Cond.Eletrica	mS/cm			

PROGRAMA DE ANÁLISE DE QUALIDADE DE LABORATÓRIOS DE FERTILIDADE
Embrapa Solos
QUALIDADE EMBRAPA
VALIDADE ABRIL 2017
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Chumbo(mg/dm3).......0.01 Chumbo(mg/dm3).......0.01 Chumbo(mg/dm3).......0.01
Cadmio(mg/dm3).......0.01 Cadmio(mg/dm3).......0.02 Cadmio(mg/dm3).......0.01
Cromo(mg/dm3)........0.30 Cromo(mg/dm3)........0.10 Cromo(mg/dm3)........0.01
Niquel(mg/dm3).......0.01 Niquel(mg/dm3).......0.01 Niquel(mg/dm3).......0.02

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Figure 6: Soil analysis of the level curves obtained in the laboratory

Table 1: Interpretation of classes of soil P contents indicated for grasses

Textural class from soil	Phosphor extractor	Classes of soil phosphorus content		
		Low	**Medium**	**High**
		ppm		
Argilose (36-60%)	Mehlich-1	< 6	6 a 10	> 10
Average (15 to 35%)	Mehlich-1	< 11	11 a 20	> 20
Sandy (<15%)	Mehlich-1	< 21	21 a 30	> 30
	Resin	< 16	16 a 40	> 40

Source: COELHO & FRANCE (1995).

Table 2: Classes of interpretation of availability for phosphorus, according to the soil clay content or the remaining phosphorus value (P-rem) and for potassium.

Feature	Classification				
	Very low	**Low**	**Medium**	**Good**	**Very good**
	$(mg/dm^3)_1$				
Clay (%)	**Match available (P) 2**				
60 - 100	<2,7	2,8 - 5,4	5,5 - 8,03	8,1 - 12,0	> 12,0
35 - 60	<4,1	4,1 - 8,0	8,1 - 12,0	12,1 - 18,0	> 18,0
15 - 35	<6,7	6,7 - 12,0	12,1 - 20,0	20,1 - 30,0	> 30,0
0 - 15	<10,1	10,1 - 20,0	20,1 - 30,0	30,1 - 45,0	> 45,0
P-rem (mg/L)					
0 - 4	<3,1	3,1 - 4,3	4,4 - 6,03	6,1 - 9,0	> 9,0
4 - 10	<4,1	4,1 - 6,0	6,1 - 8,3	8,4 - 12,5	> 12,5
10 - 19	<6,1	6,1 - 8,3	8,4 - 11,4	11,5 - 17,5	> 17,5
19 - 30	<8,1	8,1 - 11,4	11,5 - 15,8	15,9 - 24,0	> 24,0
30 - 44	<11,1	11,1 - 15,8	15,9 - 21,8	21,9 - 33,0	> 33,0
44 - 60	<15,1	15,1 - 21,8	21,9 - 30,0	30,1 - 45,0	> 45,0

Potassium available (K) 2					
	<16	16 - 40	41 - 70	71 - 120	> 120

Source: ALVAREZ V. et al. (1999).

Tables 1 and 2 present the critical levels of the classes according to the clay content or the remaining phosphorus value. The upper limit of this class indicates the critical level of Phosphorus remaining in the soil. No ranges of availability of the phosphorus obtained by the resin were considered, since there was no analysis by this method.

It is observed in the results of the soil analysis in the area of the objects of study that the concentration of organic matter, especially humic acids, is not present in order to have a greater capacity of retention of metallic cations, even in a lower depth, mainly in the Which leads to a reduction in the transport of metallic pollutants in the soil, since the humic substances act as strong complexing agents due to the presence of binder sites formed by carboxylic and phenolic groups. Therefore, a higher concentration, for example, of bivalent cations in the samples of the studied horizon of the soil is expected, and the effect of the presence of silicate compounds in the metal retention, in which a higher cation exchange capacity (CTC) of the soil denotes a higher availability of binding sites for the metal after the exit of cations or protons associated with these silicates, due to the negative surface charge of the latter (VAZ JUNIOR, 2013; CLAPP et al, 2001) [28; 29].

Table 3 summarizes the results of the tests resulting from the reduction of the densification tests.

Table 3: results of soil densification tests.

Hole	**Prof. (m)**	**Wi (%)**	e_0	η (%)	γh
SP-1	4	61,46	1,618	62	1,718
	5	100,41	2,662	73	1,454
SP-2	11	66,74	1,164	62	1,573
	13	66,8	1,643	62	1,671
SP-3	2	69,21	1,491	60	1,898
SP-4	2	49,83	1,57	61	1,629
	5	136,6	3,18	76	1,355
	3	97,89	2,598	72	1,439
SP-5	5	150,39	2,985	75	1,283
	12	146,33	3,264	76	1,396

Source: Soil study

The standard penetration test (SPT) tests performed in the area of this study show a soft soil geotechnical profile with a silt clay layer and a certain presence of medium to fine sand, organic clay layer. It obtained water presences at 2.0 m. The number of Percussion Drills (NSPT) for the organic clay layer varied by <2 to 4 strokes, denoting that the soil is of very soft consistency as well as the high voids index as shown in Figure 7.

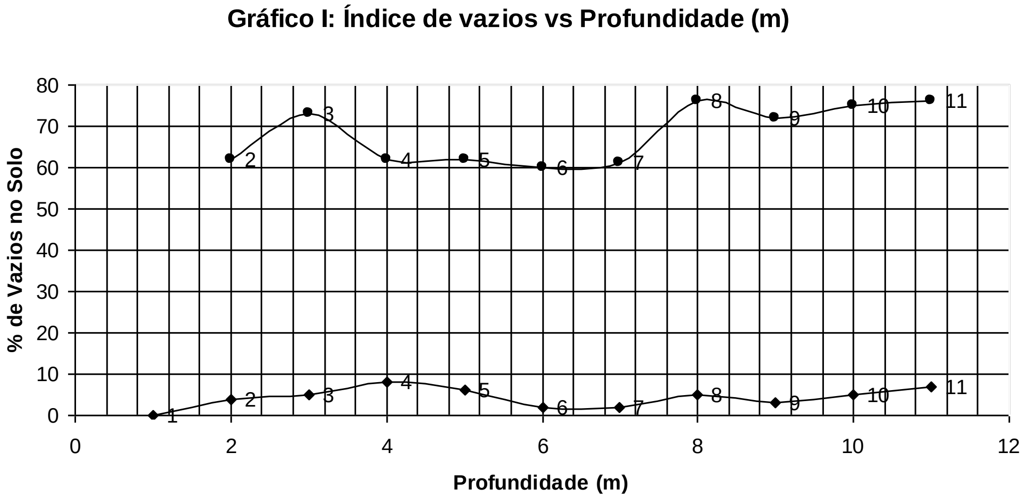

Figure 7: Soil study (Voids vs. Depth).

The geotechnical data presented previously are from the study carried out in the contours of the area of influence to the soil crawl without geodrenes. It used a safety factor of less than 1.50, to indicate the need to accelerate the settlements in the curve intervals, so that the soft soil has its resistance increased. DALASTA et al. (2005) states that "geotechnical problems are mainly associated with the possibility of slipping and falling of blocks of rocks" [30].

The study observed a depth of 2.00 m. The parameters found offer data in which the soil of interest has a soft organic clay void index of thickness 2 m. This feature has low resistance and high compressibility, thus offering no safety for building, as it has no resistance to the forces acting on it, thus causing a displacement in different planes as indicated in Figure 8, 9 and 10.

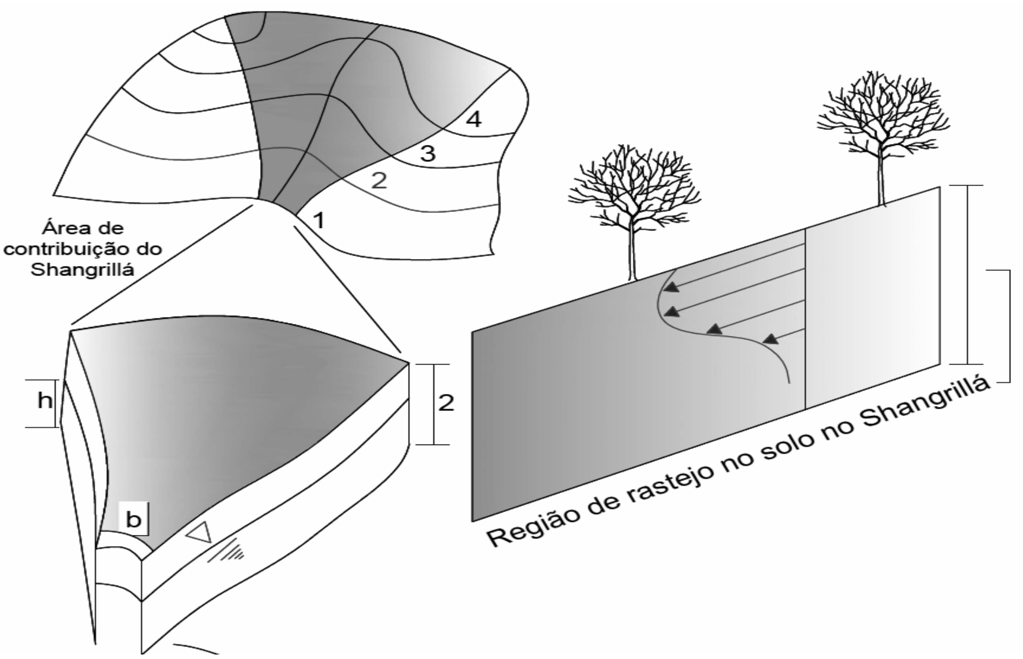

Figure 8: Displacement of the crawl in the interior of the massif. Adapted from Fiori 2016

Figure 9: Actual displacement of the crawl inside the massif "in loco".

Figure 10: Soil impoverishment caused by crawling in the "in loco" massif.

The strong slope of the slopes observed in Figure 5 associated to the volume and intensity of rainfall and the withdrawal of vegetation cover by agricultural activity and unplanned urban occupation, give this unit a high susceptibility to erosive processes (NASCIMENTO and SOUZA 2013) 18].

All rainfall contributions were monitored, within the contour basin contours, using control instruments to monitor the performance of the layer of interest in the massif. It controlled the pore-pressure dissipation, evolution of the settlements and the horizontal displacements.

Data from the Vila Formosa and Shangrillá massifs were extracted in the following groups of instruments: displacement measurement and pore-pressure measurement. It also used inclinometers for the measurement of horizontal displacements and pressure plates for the measurement of vertical displacements. The location of each instrument is shown in Figure 11.

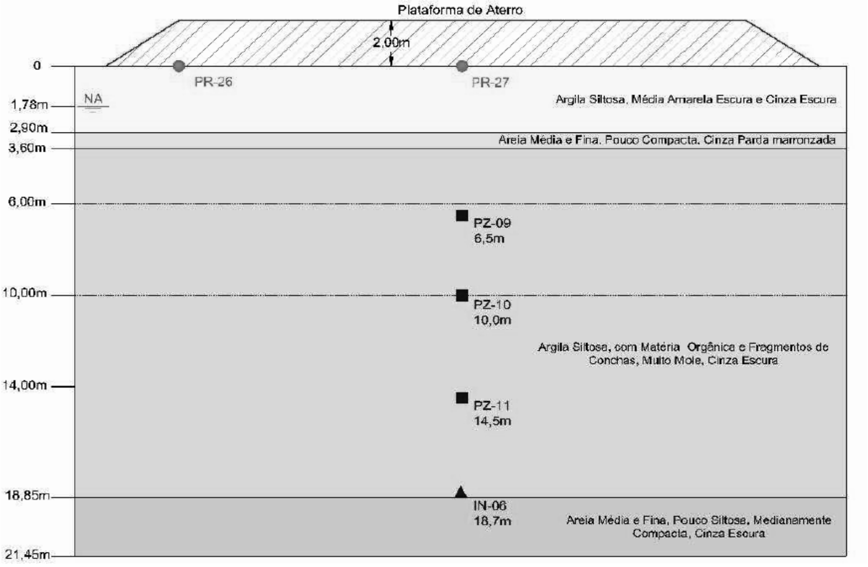

Figure 11: Locating the instruments.

He observed the indexes of rainfall with piezometers and installed inclinometers and plates of repression for complementary studies indicated in Figures 12 and 13.

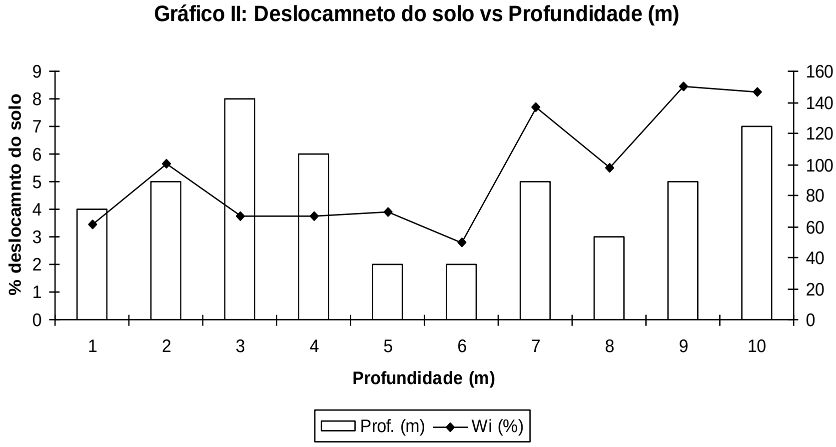

Figure 12: Soil study (Displacement)

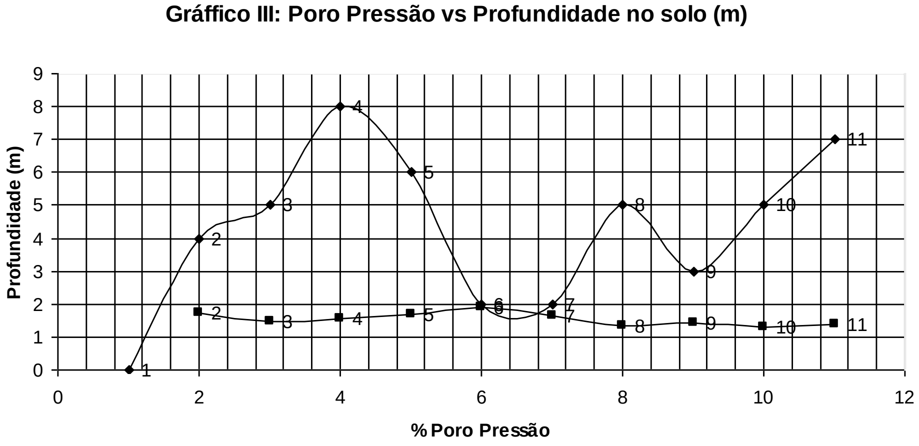

Figure 13: Soil study (Pressure vs. Depth)

Applied calculations - Soil depth: 3 m, adapted from Fiori 2016
The study collected the following data "in loco" Consider the rain equation of the old meadow (Fendrich, 2000):

1. = 26 kN (m3) -1;
2. = 7 kN (m2) -1;
3. Cs = 13 Kn (m2) -1;
4. Sr = 7 KN (m2) -1;
5. a = 13,333 m2;
6. b = 133 m;
7. Tm = 87m2.dia-1;
8. = 40 and = 45 and T = 4KN.m-1.
9. Consider the wind pressure as 1.0 KN (m2) -1.

$$q_c = \frac{T_M\, bseni}{a}\left[\frac{Cs + Sr + T\left(sen\ \theta tg\ \phi + \cos\ \phi\right) - \sigma_{ve}}{\gamma_a h \cos\ itg\ \theta} + \left(1 - \frac{tgi}{tg\ \phi}\right)\left(\frac{\gamma_{nat}}{\gamma_a} + \frac{\sigma_a}{h\gamma_a}\right)\right] \quad \text{(eq. I)}$$

And in it replacing the collected data, we have:

$$q_c = \frac{87\ x133\ xsen\ 30}{13.333}\left[\frac{13 + 7 + 5x\left(sen\ 60\ tg\ 53\ \cos\ 60\right) - 1_{ve}}{13\ x\,4\,x\ \cos\ 30\ xtg\ 53} + \left(1 - \frac{tg\ 30}{tg\ 40}\right)\left(\frac{26}{13} + \frac{5}{30}\right)\right]$$

It follows that qc = 0.120 m / day or 5.0mm.h-1.
The time of recurrence of the slip event, as a function of the rain intensity, is determined:

$$i = \frac{\left(3.221,07\right)T_r^{\ 0,258}}{\left(t + 26\right)^{1,010}} \quad \text{(eq. II)}$$

Substituting the values given in the previous equation we have:

$$5,0 = \frac{\left(3.221,07\right)T_r^{\ 0,258}}{\left(300 + 26\right)^{1,010}}$$

It follows that Tr = 13.0 years and if the slope does not have vegetation, we obtain:

$$q_c = \frac{T_M\, bseni}{a}\left[\frac{C}{\gamma_a h \cos\ itg\ \theta} + \frac{\gamma_{nat}}{\gamma_a}\left(1 - \frac{tgi}{tg\ \phi}\right)\right] \text{(eq.III)}$$

$$q_c = \frac{87\ x133\ xsen\ 30}{10\ .333}\left[\frac{13}{\cos\ 30\ xtg\ 53} + \frac{20}{10}x\left(1 - \frac{tg\ 30}{tg\ 53}\right)\right] = 0,44\ \text{m.dia}^{-1}$$

The calculated value of qc = 0.44m.day -1 corresponds to 18.50 mm.h -1. In this case, Tr = 3.20 years.

Applied calculations - Soil depth: 3 m, adapted from Fiori 2016

The study collected the following data "in loco" Consider the rain equation of the old meadow (Fendrich, 2000):

1. = 26 kN (m3) -1;
2. = 7 kN (m2) -1;
3. Cs = 13 Kn (m2) -1;
4. Sr = 7 KN (m2) -1;
5. a = 13,333 m2;
6. b = 133 m;
7. Tm = 87m2.dia-1;
8. = 40 and = 45 and T = 4KN.m-1.
9. Consider the wind pressure as 1.0 KN (m2) -1.

(Eq. I)

And in it replacing the collected data, we have:

It follows that qc = 0.120 m / day or 5.0mm.h-1.

The time of recurrence of the slip event, as a function of the rain intensity, is determined:

(Eq. II)

Substituting the values given in the previous equation we have:

It follows that Tr = 13.0 years and if the slope does not have vegetation, we obtain:

(Eq.III)

M.dia-1

The calculated value of qc = 0.44m.day -1 corresponds to 18.50 mm.h -1. In this case, Tr = 3.20 years.

Flow – Calculus

Considering the drainage basin in the study area data from Table 1, it was possible to determine the saturation levels of the slope considering its slope equal to 10º, 27º and 40º. Considering Tm = 65 m2 / day and qt = 0.07 m / day

Table 4: Data for calculations of soil saturation by slope.

Area a (m2)	Length b (m)	Reason (a b) x 1000
a_4=10.270	b_4=400	25
a_3=20.800	b_3=300	69
a_2=26,533	b_2=150	176
a_1=30.266	b_1=100	302

Source: Authors' own

Solution

For the current slope of the terrain i = 10º, we have that:

$$\frac{T}{q_1} seni = 161\ ,20\ m \quad \text{(eq. IV)}$$

Applying the following calculation, the slope will be saturated between curves 3 and 4, a few more of curve 3 than of 4. In the case of slope having a slope of 27º, then:

$$\frac{T}{q_t} seni = 421\ ,56\ m$$

This slope will be saturated between level 2 and 3 curves, with the saturation line closest to curve 2. In case the slope has a slope of 40º, then:

$$\frac{T}{q_t} seni = 596\ ,8\, m$$

In this case, the terrain saturation should reach approximately the level 2 curve.

It is worrying the occupation verified at Residencial Shagrillá, because its slope accentuates to 20% with poorly consolidated soil, because it develops on a lithological formation with low resistance to erosion processes. As urbanization was not orderly and unplanned, this contributes to raising the environmental fragility of the area.

In fieldwork, he observed that no landfill was cut for housing construction and this contributes to slow movements in the relief, of the creeping type. Trees with exposed roots, signs of soil loss, as well as sloping trees, signs of mass movements were also identified at the site, as shown in Figure 2.

Finally, an opinion survey was carried out in the residences of the neighborhood to verify the approval of this study about the soil crawl in Vila Formosa and Shangrillá Residential in Anápolis in the State of Goiás. The research was carried out in a total of 164 residences being 35 at Rua Orlando Orlando de Queiroz, 30 at Coronel Levertino Leão Sobrinho Street, 28 at Jabra Draguer Street, 35 at Adail Alves de Oliveira Street, 10 at Rua 115, 14 at

Rua 114 and 12 at Rua 117. With a total of 367 Interviewees, where 100% approval was obtained in relation to the objective question (approve or not approve).

V. CONCLUSION

This study aimed to analyze and map the problems that are leading the area of risk to the level of public calamity by soil degraded by creeping in Vila Formosa and Residencial Shangrillá in Anápolis in the State of Goiás, through Environmental and Sanitary Engineering , Chemistry and Geotechnics in order to verify the possibility of occurrence of movement of potential masses to natural disasters.

The area of influence occurs slow and continuous movements, without a well defined rupture surface, encompassing large areas, without there being a clear differentiation of the mass in movement and stable region. The causes of movement are attributed to the action of gravity associated with effects caused by temperature variation, soil moisture impoverishment. The displacement occurs in a state of tensions, inferior to the resistance and the shear, occurring a certain variation of the state of tensions within the mass reaching the point of reaching the resistance of the movement in the mass becoming a process of slipping, with well-defined rupture surface .

The studied soil does not indicate resistance, because it lacks natural cement that promotes a certain process of agglutination of the grains due to connections exerted by attractive potential of molecular or colloidal nature. The results obtained from the soil analysis in the parameters Fertility (Chemical) + Zinc, Physical (clay-clay, silt, sand), Sulfuric Extract ($SiO2$, $Al2O3$, $TiO3$, $Fe2O3$, Ki, Kr) (Cd, Cr, Ni, and Pb), observed that this soil also does not present capillary pressure effect in the interstitial water of its mass.

The soil in the Shangrillá residential can be considered the same as the one in Vila Formosa, because in these sectors the horizons of these are not compact and resistant, not having a certain visible structural organization, which is why the large clumps are dissolved in small fragments. These have a certain macro porosity generally linked to the biological activity, the detection of the fine pores inside being complicated. In some points it is possible to observe a fragmented structural organization, with presence of structure of the type subangular blocks generally associated to the small concentration of organic material originated from the decomposition of biological roots or activity.

In the study area, with a slope of 30º in the terrain, associated with the amount of rainfall it receives, it begins to rupture in a vegetation slope in the period of recurrence taking into account that the slope has no vegetation. The results show that, in order to cause slipping in this area, it should be considered vegetated slope in the same geotechnical conditions that a slope not vegetated with rain intensity should be approximately 4.08 times greater. The time of recurrence of slip events for the vegetated slope is 13,095 years, while for non-vegetated slope it is approximately 3.20 years, that is, about 3.20 times smaller.

With respect to Creep or Creep, its use in this study makes it possible to deal with the uncertainties inherent in natural phenomena. Moreover, as pointed out earlier, this method makes possible the generation of scenarios more favorable to the studied phenomenon. The addition of the vertical curvature and horizontal curvature variables to the model proved to be effective in the refinement of this model. The delimitation of the scenario (radius of influence) with addition of the vertical and horizontal curvatures made by the planialtimetric survey was comparable to the risk map obtained by social sector, showing that these variables are affecting the population of that region when it is desired to reveal limits of use and occupation Well-defined soil conditions and, in particular, when it is desired to delimit potential areas to the occurrence of landslides.

Finally, the responses of the residents interviewed in the area studied showed that they were satisfied with the initiative. He did not identify any cases of dissatisfaction on the part of the residents interviewed. The inference of the great spatial dependence between the elements of the physical environment (pedology, geology, geomorphology, vegetation cover, etc.) makes the use of all part of the area of influence unfit, since the use of slope Susceptibility to mass movements would be very similar to the thematic map of slope.

In general, this study made it possible to verify the potential and flexibility of soil crawling in the two districts of this environmental study, and, in particular, made possible the risk analysis for the resident population in this place, since the soil is not reliable for Build housing in your area.

As an improvement, it suggests interventions, such as: removal of housing at risk; Engineering works to contain the banks, to prevent erosion; Improvements in urban infrastructure, such as street paving and the implementation of an efficient drainage system for rainwater and a correct destination to natural drainage; Implementation of urban control policies to avoid constructions and inadequate interventions in areas of permanent protection; Reforestation and reconstitution of the areas, being able to create a public use, with the implantation of parks and natural drainage; Implantation of the warning system for anomalous rains and implantation of rain gauges to monitor the water content and inorganic and organic characteristics of the soil in solution, which occupy the soil micropores.

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