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Multicriterial Analysis Applied to the Urban Environment of The Industrial Area of the City of Uberlândia - MG

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ABSTRACT: *The urban framework studies are nowadays constituting important tools to support the decision-making process of municipal public administrations around the world. Through these studies, municipalities and competent bodies can guide the planning, execution and monitoring of the urban infrastructure of their cities, thus guaranteeing their populations efficient, high-quality sanitation, energy, transportation and housing equipment. In this sense, the present work carries out a study of the urban environment of the Córrego do Liso Hydrographic Basin, one of the most important urban subbasin of the municipality of Uberlândia – MG (Brazil) which suffers from conflicts arising from the use and occupation of its soil for domestic and industrial activities. For this study, geoprocessing and remote sensing techniques, as well as laboratory tests on soil and water samples, were used to collect georeferenced information about the main urban, environmental, geotechnical and hydrological parameters of the study area. With this data in hand, the technique of Multicriteria Analysis (or map algebra) was applied to correlate the data obtained and to formulate a sequence of documents, tables, infographics and mappings that synthesize the present urban reality of the studied basin.*

Keywords: *Civil engineering, GIS, remote sensing, urban engineering, urban planning.*

I. INTRODUCTION

Since the birth of the first civilizations, the human being has become an individual capable of transforming the environment in which he lives. These transformations were effected in order to satisfy the physical and natural needs of the human species. In this way, man has always promoted changes in the environment, whether by clearing forests, building houses and shelters, planting crops and pastures, channeling water, taming animals, etc. Currently, the process of urbanization and construction of cities can be highlighted as the most significant environmental modification promoted by man. In this way, urbanization can be understood as a phenomenon on a global scale and that promotes intense changes in natural ecosystems, generating a series of impacts that may jeopardize the integrity of these environments and the quality of life of their populations.

Within this context, the concern for environmental preservation and the provision of quality and efficient urban infrastructure is a direct consequence of the processes of urban and industrial expansion experienced throughout the world and has become, today, an intense object of study by the Civil Engineering. Historically, urban agglomerations develop without taking into account the limits imposed by the misuse of natural resources available in the environment in which they are inserted. In this way, in general, the human occupation and urban-industrial evolution occurs in the first instance, disregarding the implications that they cause in the natural ecosystems.

However, it is possible to guarantee the conformity between urbanization and environmental preservation by promoting efficient mechanisms to assist in the process of urban evolution and sustainability of the space constructed and occupied by man. It is, therefore, in the formulation and implementation of these tools that the use of Geotechnologies has been consolidating as a fundamental instrument to promote the search for sustainable urban development (CASILHA and CASILHA, 2009).

Geotechnologies can be defined as being the set of technologies for collecting, processing, analyzing and offering information with a well-defined geographical reference. These technological resources are comprised of hardware and software solutions that, together, serve as powerful tools for civil engineers and urban engineering researchers to assure aid in the decision-making process in different aspects of anthropogenic activity (ROSA, 2005).

At present, we can highlight Geographic Information Systems (GIS), digital cartography, Remote Sensing, global positioning systems by Global Navigation Satellite System (GNSS) and Geoprocessing as the main Geotechnologies used to obtain data to support decision making. Thus, these resources have been widely used with respect to the professional practice of Civil and Urban Construction Engineering to promote studies and diagnoses that make it possible to understand the urban dynamics of the environment built and occupied by man (BONHAM-CARTER, 1996).

With the elaboration of these studies, it is possible to directly assist in the elaboration of policies and actions that aim to guarantee the sustainable urban development of human communities in Brazil and around the planet. Thus, based on the technologies disseminated by the Geosciences (Cartography, Topography, Geodesy, Remote Sensing, among others), it is possible to produce analyzes, diagnoses, projects, plans and policies of the built space in order to provide a convergence between urbanization and environmental preservation (VITTE and KEINERT, 2009).

In this scenario, the present work uses techniques of Remote Sensing and Geoprocessing to carry out a study of urban and constructive framing of the Córrego do Liso Hydrographic Basin, located in the urban area of the city of Uberlândia – MG. This basin is one of the main micro urban watersheds in the Triângulo Mineiro and Alto Paranaíba region, and currently experiences a series of problems arising from the use of the soil of its drainage area for conflicting domestic and industrial activities.

Therefore, this work aims to provide sufficient technical scope to the municipal public administration of Uberlândia in the form of qualitative and quantitative information about the main urban, constructive and environmental parameters of the drainage area of Córrego do Liso. Based on these data, the competent bodies can improve their policies to territorial management actions in the area of study in order to seek the provision of infrastructure and efficient urban resources for the local population and promote the conjunction between urban development, environmental preservation and quality of Life of the inhabitants.

II. OBJECTIVES

This work aims to carry out a study of the diagnosis and framing of the updated urban and environmental reality of the drainage area of the Córrego do Liso Hydrographic Basin (actually, the Industrial Area of Uberlândia – MG, Brazil) through the use of eotechnologies and geoprocessing techniques. In addition, are specific objectives of this work:

- Characterize the Córrego do Liso Hydrographic Basin based on environmental, geotechnical and construction parameters;
- Analyze the relationship between the parameters collected and the current urban and environmental situation of the basin;
- Apply eotechnologies (such as GPS, total stations, remote sensing) and geoprocessing techniques to study the configuration of the built and occupied space in the drainage area of the Stream of Smooth;
- Develop, through softwares (ArcGis and SPRINGS), the land use and occupation map of the Córrego do Liso Basin;
- Compare the current land use and land use map with previous versions of the land in order to study the dynamics and constructive trends in the basin area;
- Collect and analyze deformed soil samples from the basin to perform granulometric studies and classify the local soil according to ABNT NBR7181 / 84;
- Analyze the main problems and environmental impacts related to soil grading and the use of the same for domestic and industrial purposes;
- Collect and analyze surface water samples from the Smooth Stream to determine its physicochemical parameters;
- Trace possible relationships between pollution and the surface quality of the stream;
- Analyze constructive aspects of buildings, paving structures and other urban infrastructure systems in the basin area;
- Apply concepts of Spatial Geodesy within the area of professional performance of Civil Engineering, especially in the area of Urban Engineering, Transportation and Urban Planning;
- Propose solutions to minimize the urban and environmental impacts caused by the process of land use and occupation in the Basin region;
- Collaborate with policies aimed at adapting regional urban development and its concomitance with sustainable actions.

III. THEORETICAL FOUNDATION

The use of eotechnologies became a constant in man's daily life since the advent of new information systems at the end of the twentieth century, with the implementation of the Third Industrial Revolution. Through the emergence of computer networks, artificial softwares and satellites, geospatial information and their resulting analyzes and studies have become an instrument of great importance for the search for improvements in the quality of human life all over the planet.

Nowadays, the use of these eotechnologies can be noted in the use of drones and satellite imagery for air traffic control, monitoring and preservation of environmental resources, management of civil engineering works, as well as in urban planning and engineering. Within the scope of this latter application, the use of geospatial information regarding the implementation of studies and policies aimed at framing urban and environmental resources in a given area can be highlighted in order to ensure sustainable urban development (BORSOI & JUNIOR , 2009).

The concern with environmental preservation is a direct consequence of the processes of urban and industrial expansion experienced throughout the world and now, a question of study by de civil and urban engineering's around world. Historically, urban agglomerations develop without taking into account the limits imposed by the misuse of natural resources available in the environment in which they are inserted. In this way, in general, human occupation and urban-industrial evolution occurs in the first instance, disregarding the implications that they cause in natural ecosystems (BRAGA, 2003).

In the case of underdeveloped and developing countries, such as Brazil, the discrepancy between urbanization and environmental preservation is even more noticeable. Rooted in economic, social and political problems, the process of urbanization in these countries demands increasingly capable professionals to promote the concomitance between constructive development and environmental management (GUERRA, 2001).

In this way, the existence of a strong dichotomy between the practice of urban planning and environmental preservation can be noticed. However, it is possible to guarantee the conformity between these two actions and to promote efficient mechanisms to assist the process of urban evolution and sustainability of the space constructed and occupied by the man. It is, therefore, in the formulation and implementation of these tools that the use of eotechnologies becomes fundamental.

The preparation of urban and environmental studies obtained through the use of geoprocessing techniques assists directly in policies and actions that aim to guarantee the sustainable urban development of human communities around the planet. Thus, based on the technologies disseminated by the Geosciences (Cartography, Topography, Geodesy, Remote Sensing, among others), it is possible to produce analyzes, diagnoses, projects, plans and policies of the built space in order to provide a convergence between urbanization, Recovery (BOHAN-CARTER, 1996).

Thus, using these eotechnologies, this work conducts a study of the urban activities and the environmental resources of the Córrego do Liso Watershed. This basin, located in the urban area of the municipality of Uberlândia – MG, is one of the main micro urban watersheds in the region and experiences a series of problems arising from the use of the soil of its drainage area for domestic and industrial activities.

In the drainage area of Córrego do liso, the Municipal Industrial District of Uberlândia is allocated, generating an intense logistics fleet of vehicles, goods and human resources. Currently on the responsibility of the state government, the district has a high number of buildings in the vicinity of the stream bed, many of them not respecting the determinations of CONAMA Resolution No. 303/2002, Law 4,771 / 1965 and the Municipal Organic Law, which says: "*(...) It is considered areas of permanent preservation in the urban area the springs, the margins in a range of thirty meters and the water courses of the streams, being forbidden the launching of domestic and industrial tributaries in all its course; The remnants of riparian forests, bush beds and burials; A band of fifty meters wide in both tracks of the Uberabinha River, in all its extension in the urban zone; And parks, reserves, squares and other public places of ecological, scenic and cultural value* "(UBERLÂNDIA, Lei Orgânica Municipal, Artigo 210. 2011).

Previous works which carried out in the same study area have observed that part of the industrial buildings inserted in the drainage area of the Córrego do Liso Basin does not comply with the legislation. In addition, due to the rapid urban expansion of the study region, a large number of domestic buildings also do not comply with the legal provisions and promote the undue occupation of the banks of the stream, as well as the clandestine eviction of polluting effluents in water resources of the basin.

The quickly process of human occupation experienced by the drainage area of the Basin occurred in a way that did not accompany public and private investments in urban infrastructure systems in the region. In this way, the districts installed there developed without providing their residents with basic sewage services, water distribution, solid waste collection, electric lighting networks, traffic systems and asphalt paving, besides not having the proper constructive assistance in buildings.

In this sense, it can be said that the insufficiency of resources in urban infrastructure that affects the Córrego do Liso Hydrographic Basin is a problem of conjectural order within the scope of civil engineering linked to the planning of the city. Thus, it is necessary to develop mechanisms that allow a better efficiency in the management of the drainage area of the basin in order to adapt the land use to the demand of its residents, as well as to reconcile the local constructive practice with the offer of quality of life for the man and preservation of the environment.

Therefore, it was important to carry out the study of the urban and environmental framework of the Córrego do Liso River Basin due to the reality experienced by this region within the municipality of Uberlândia. With this study, it is possible to understand the functioning of local urban dynamics and to minimize the environmental, economic and social impacts caused by the use and occupation of the soil of the region.

Therefore, this framework can provide, in the future, public administration and private initiative, scopes for the conscious use of the drainage area of the Córrego do Liso, in order to collaborate for the sustainable urban and socioeconomic development of the basin, as well as of the entire municipality. Thus, this study is an example of the use and application of eotechnologies in the field of modern urban engineering, seeking to guarantee the full evolution of the knowledge of geosciences in concomitance with the quality of life of contemporary man and the environmental preservation of the environment in which he is inserts.

IV. METHODOLOGY

This work was developed in two distinct stages that were later correlated. These stages were configured as Field Studies and Geoprocessing Studies, as explained below. Field studies were the initial part of this work. In this stage, technical visits and field trips were undertaken in the drainage area of the Córrego do Liso and its tributaries (Córrego do Lobo and Córrego Buritizinho), in order to verify the conditions of use and occupation of the local soil. With this, a database with updated photographic documentation of the constructive, urban and environmental reality of the Basin was obtained.

The visits were undertaken at different times and, whenever possible, concomitant to the tracing of the routes and georeferencing of the same ones through the use of GPS (Global Positioning System) platforms. Thus, it was possible to follow the geospatial progress of the work and ensure that it covered almost the entire area of the basin studied.

The Geoprocessing Studies, in turn, were configured as the second part of the activities of this research. At this stage, we sought to acquire and analyze maps, charts, charts, graphs and aerial photographs of the Stream Basin by means of Geoprocessing techniques. This stage was carried out in specialized laboratories within the facilities of the Institute of Geography (IGUFU) and the Faculty of Civil Engineering (FECIV) of the Federal University of Uberlândia (UFU). In this stage, we tried to promote the elaboration of several laboratory tests to formulate a GIS (Geographic Information System) with the main urban and environmental parameters of the study area, as Table I.

Table I. Parameters to scope the SIG.

Crieria	Parameter	Characteristics	Representation form
1	Geographic	Geographical location and geospatial distribution	Satellite image by GoogleEarth
2	Geotechnical	Sieve classification of local soil based on ABNT NBR 7181/84	Soil Particle Graph
3	Topographic	Declivity, relief, altimetry and geomorphology	Topographic charts
4	Hydrological	Surface water quality based on Resolution 274 of CONAMA	Physical and chemical parameters of water
5	Urban	Mapping of land use and occupation of the basin	Map of land use and occupation
6	Environmental	Vegetation, climate, rainfall, fauna and ecology	Theoretical reference and photographs
7	Structural	Domestic, industrial buildings, water and sewage networks, traffic and paving systems etc.	Photos

As can be seen in Table 1, in addition to theoretical studies to support Socioeconomic, Environmental, Topographic and Geographic parameters, laboratorial tests were carried out to acquire Geotenic and Hydrological data. These tests were carried out in the Geotechnical Laboratory and in the Sanitation Laboratory

of the Faculty of Civil Engineering of the Federal University of Uberlândia. In the geotechnical field, the tests provided in ABNT NBR 7181/84 – Granulometry (thick sieving, fine sieving, sedimentation by Stokes method and grain size curve) were carried out on deformed soil samples from the study region. In the hydrological area, the standard tests of surface water quality criteria established by the Ministry of Health and CONAMA (turbidity, total suspended solids, biochemical oxygen demand, presence of heavy metals) were made.

With the elaboration and organization of the data in the form of a GIS, the so-called Map Algebra (or Multicriteria Analysis) was applied to elaborate the final diagnosis of the urban setting of the study area. According to Tomlin (1990), the process of Map Algebra can be understood as the technique in which data referring to a given agent or geographical field, represented in the form of different variables and parameters, can be correlated by means of mathematical instruments and algebraic. This correlation generates as a final product a sequence of thematic maps, tables, graphs and other instruments of visual interpretation that synthesize the correlation between the criteria that form the GIS analyzed.

Each of the seven criteria obtained was studied and analyzed according to the form in which they are represented. Thus, a sequence of seven distinct results was possible in relation to the study performed above the characteristics of the selected parameters. In this way, the Multicriteria Analysis technique was applied in order to search for possible correlations between the results obtained, generating cause-consequence and collateral inferences among the main variables of the study area.

With the correlation of the parameters and criteria that structure the GIS of the Córrego do Liso Hydrographic Basin, it was possible to elaborate the Urban and Environmental Diagnosis of the study area, represented by the criteria analysis. This diagnosis was configured as the final result of this work and is exposed at the end of the next section.

V. RESULTS AND DISCUSSION

5.1 Geographic characterization of the Córrego do Liso Water Basin

The Córrego do Liso Hydrographic Basin is located in the urban area of the municipality of Uberlândia - MG, between the Universal Transverse Coordinates of Mercator (UTM) 7.910.000 to 7.914.000 meters North and 781.000 to 786.789 meters West, in spindle 22. This location corresponds to the geographic space between Latitudes 18º51'27 "and 18º53'48" South and Longitude 48º15'31 "and 48º19'00" West, as can be seen in Fig 1.

Fig 1. Geographic location of the Water Basin in the urban area of Uberlândia.

The drainage area of the Liso stream is one of the main urban hydrographic basins of the municipality of Uberlândia due to its location and dimensions. The region of the basin has an area of approximately 15.78 km², corresponding to 7.73% of the municipal urban area, and is inserted in the confluence between highly populated districts and the Industrial District of the city (CHUERUBIM, ML et al., 2015).

The Basin is basically composed by the association of three distinct watercourses: the Córrego do Liso, the Córrego do Lobo (or Córrego do Carvão) and the Córrego Buritizinho. The Córrego Buritizinho is located to the Southeast of the main course of the basin. It has a length approximately equal to 2,250 meters and covers an exclusively domestic area of the study region. On the other hand, the Córrego do Lobo is located to the northeast of Córrego do Liso and is approximately 1,500 meters long. Finally, the Córrego do Liso (the name of which is given to the Basin), is the largest in extent and volume of water, having approximately 5,000 meters in length.

5.2 Geotechnical and geomorphological parameters

According to Nishiyama (1989), the Córrego do Liso Hydrographic Basin (as well as the whole municipality of Uberlândia) is located in a predominantly lateritic soil region with an old podological origin. In this way, the drainage area of the Liso Stream follows the theoretical tendencies experienced by the soil of the *Chapadões* Domain (or Brazilian Cerrados), in order to present deep, unstable, thick soils with a low degree of compaction / compactness. When analyzing, specifically, the drainage region of the Córrego do Liso, mineralogical and crystallographic examinations diagnosed that the local soil originates from arenitic and basaltic rocks, dating from the Mesozoic, Cenozoic and Cretaceous Ages.

In addition, the Córrego do Liso Hydrographic Basin presents itself as a predominantly flattened spatial region. The basin area is at sea level altitude approximately equal to 825m and has few geographical faults and significant relief accidents. In general, the Córrego do Liso Hydrographic Basin presents mean slopes between 1% and 5%, so that the study region can be considered relatively flat (NISHIYAMA, 2008).

According to the tests performed at the Geotechnical Laboratory of the Faculty of Civil Engineering (FECIV) of the Federal University of Uberlândia (UFU), provided for in ABNT NBR 7181/84, the soil of the Córrego do Liso Basin was classified as a bad graded fine sand with a high content of clay in its thin portion (Fig 2, 3 and 4).

Fig 2. Points of soil collect in the Water Basin.

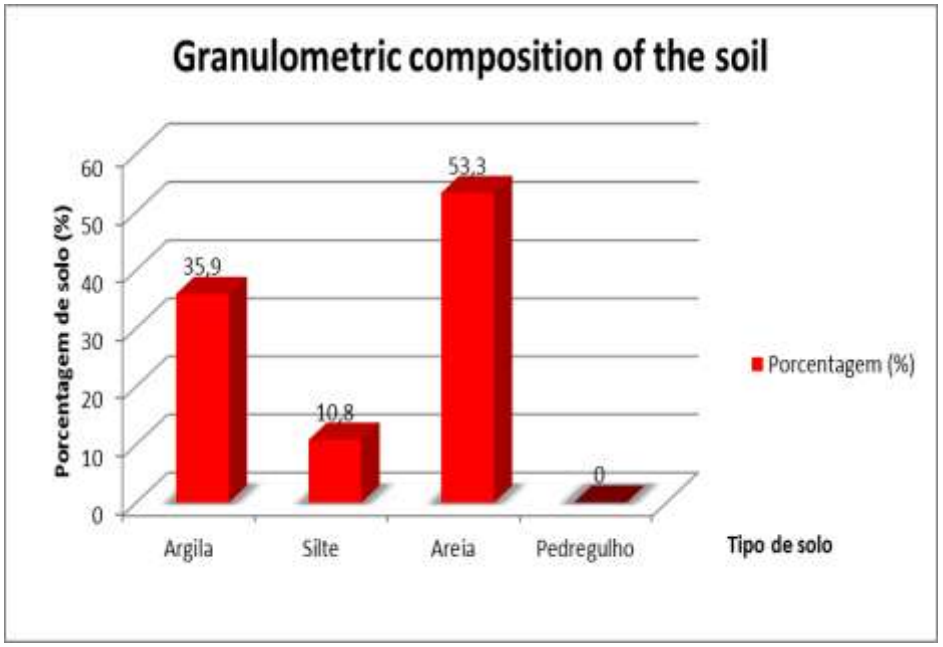

Fig 3. Granulometric composition of the soil of the Córrego do Liso Water Basin.

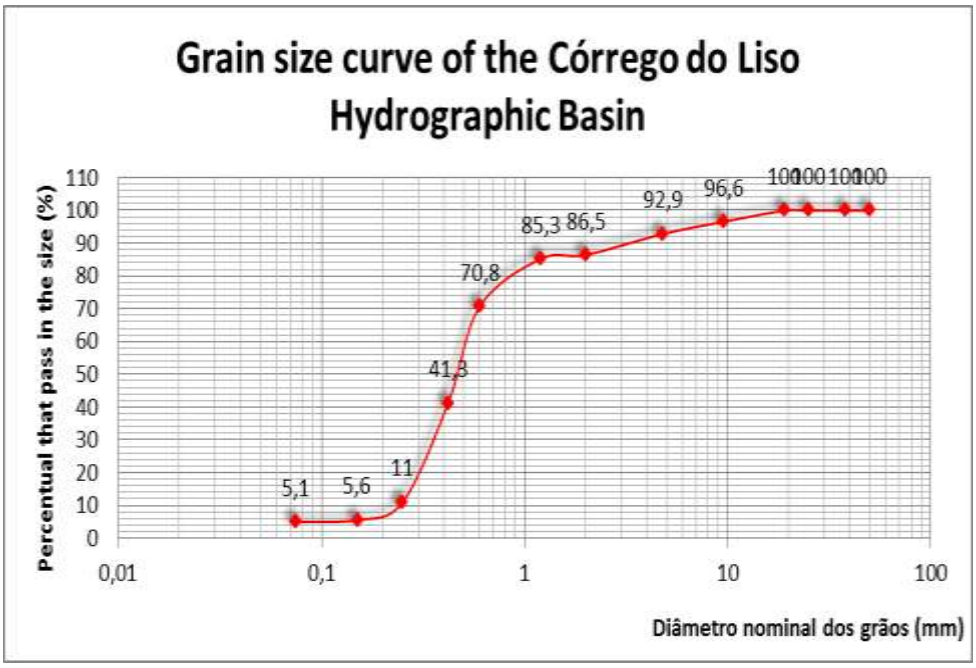

Fig 4. Granulometric curve of the Córrego do Liso Hydrographic Basin.

5.3 Hydrological characterization

As they are located in an urban area (Fig 5), the surface watercourses of the basin are degraded and have a high content of organic matter (dissolved and suspended). This factor is responsible for the increase of the Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), turbidity, sulfides, nitrides and nitrites of the local water. The water samples collected for the tests at the FECIV Sanitation and Hydraulics Laboratory proved the aforementioned changes in the physical-chemical parameters of the water in the streams of the Córrego do Liso River Basin.

Fig 5. Location of the watercourses (blue) and the Permanent Protection Area (green) in the basin.

It was observed that the values estimated for BOD were very high for the samples collected, ranging from 6 to 13 mg / L. Regarding the COD, the values obtained were of the order of 11 to 21 mg / L, which suggests that evictions of industrial origin occur in the study area. High DBQ values indicate the presence of polluting effluents and / or harmful substances in the aeration process in the water resources analyzed. Surface water turbidity ranged from 13 to 15 NTUs.

In addition, the pH measured in the Straight Stream sampling ranged from 5.24 to 5.5. These values are lower than those recommended by Class 2 standards, which establishes a minimum pH of six and a maximum of 9 for potential water courses for human consumption and / or recreational activities. For the Nitrogen series, analysis of ammonium nitrogen concentration indicated a variation between 0.34 and 0.51. For the Nitrite, the estimated values were of the order of 0.02 to 0.03. As for total solids, which indicate the amount of organic matter present in a water sample, the values obtained were 58 to 74 mg / L.

Finally, in relation to the sulphides, the values found were of the order of 0.08 to 0.13 mg / L. The analyzes of the concentration of Total and Fixed Volatile Solids ranging in the order of, respectively, 87.2% to 89.7% and 10.3% to 12.8%. The metals, in turn, presented a concentration of 0.13 to 3.30 mg / kg. In relation to total coliforms, the values found were of the order of 2400 (MPN / 100 ml) for all samples.

5.4 Urban infrastructure characterization and environmental situation

In order to analyze the spatial configuration of existing urban infrastructure in the water basin, a Soil Use and Occupancy Map was developed (Fig 6). The map was made through the algebraic manipulation of Quickbird and Landsat satellite images available through the GoogleEarth professional version software and the SPRING, a free Brazilian software, provided by INPE (National Institute for Space Research) and TerraView, another free Brazilian software of map manipulation. In numerical terms, Fig 7 represents the percentages in area occupied by the segments listed in the land use and occupation map of the basin.

In order to generate the map, it was necessary to cross several different satellite images. With this crossbreeding, a photointerpretation key was created that diagnosed different categories of use and occupation of the local soil based on the comparison between distinct patterns of images. The different patterns were then categorized and placed under the same scale and orientation, being georeferenced. After that, these data were work on the digital platforms of the previously cited programs and the final map was elaborated.

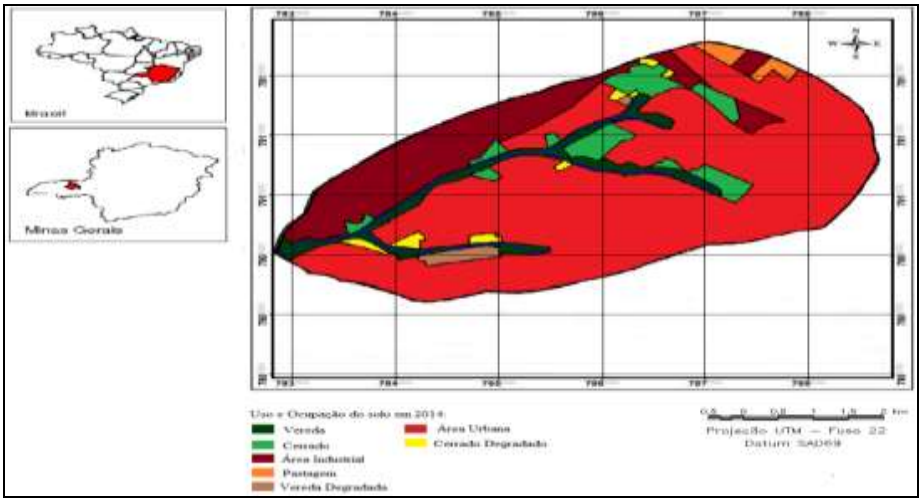

Fig 6. Use and Ocupation of Soil Land Map of the Córrego do Liso Water Basin.

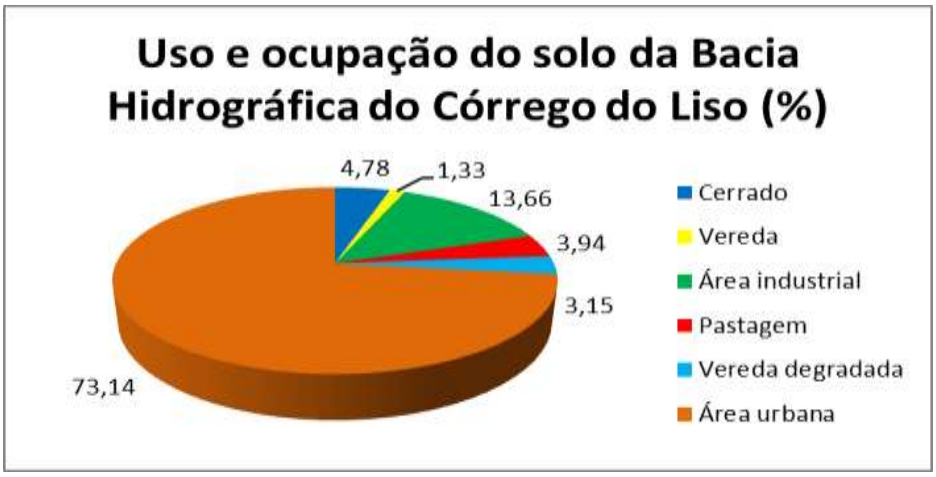

Fig 7. Numeric use and occupation.

Based on the map and the graph that were elaborated, it is observed that in the drainage area of the Córrego do Liso there is a predominance of domestic occupation (urban area - 73.14%), followed by industrial occupation (13.66%). In addition to these activities, we can highlight the Cerrado (a Brazilian type of flora - 4.78%), degraded forest (3.15%), pasture (3.94%) and preserved forest (1.33%).

The predominance of urban and industrial areas contributes to the existence of a discrepancy between the supply of basic housing, sanitation, transportation and energy infrastructures and the real demand on the part of the local residents. On the part of the Public Administration, there is a certain prevalence of investments in the structuring of an efficient transport and logistics network for the productive flow of the Industrial District. On the other hand, basic housing constructions, urban drainage systems and waste collection, domestic exhaustion, water distribution and electricity supply are neglected.

Still in the way of the analysis of urban dynamics, the Córrego do Liso Hydrographic Basin currently has three Permanent Protection Areas (APPs) maintained by the Municipal Public Administration of Uberlândia. These areas are Victory Siqueirolli Municipal Park (237,152.75 sq.m. in extension), the Spring Stream Park (120.603,04 sq.m.) and the Industrial Environmental Park (250,000 sq.m.). The three APPs are located in a largely urbanized region, as can be seen from the local land use and occupation map.

The solid waste produced by the population increase and its domestic activities, as well as the increase in the production of polluting effluents by the industries culminated in the inadequate deposit of these materials in the Permanent Preservation Areas (Fig 8). Thus, these products affected the quality of the surface water resources of the APPs and the local soil, which could be proved by the laboratory tests in the water samples collected. Among the main environmental impacts resulting from the inadequate deposit of solid wastes in the basin, we can highlight the occurrence of erosive processes, the loss of flow of streams, contamination of soil and streams and the silting of Córrego do Liso (Fig 9).

The monitoring of the constructions in the APPs proved to be inefficient over the years. Currently, a large number of buildings are installed in the vicinity of watercourses and discharge solid waste and domestic and industrial pollutants directly into the streams, as can be seen in Fig 10. In this way, the demarcation of Permanent Protection Areas does not imply In the effective preservation of the existing springs in the Córrego do Liso Stream Hydrographic Basin, in order to demand better techniques of control and inspection of the anthropic activities in the place.

In view of this inadequate disposal and the improper occupation of APPs, through the laboratory analysis of water samples collected in the field, it was possible to conclude that the water quality standard of the Córrego do Liso Basin does not comply with the standards required by Ordinance 518 Of the Ministry of Health, and may pose risks to consumer health, and consumption is considered unsafe. In order to adapt it to the required potability, the water in the basin must undergo conventional treatment and ensure that its quality is preserved up to the building connections.

Finally, it is worth mentioning that the pollution found in the samples collected were detected as industrial effluents and as wastewater from sanitary waste. Therefore, it is important to adopt policies and actions that aim to adapt the water resources of the drainage area of the basin to the needs of the local population, so as to ensure the full development of local domestic and industrial activities, without jeopardizing the integrity of surface water and biota in the region.

Fig 8. Clandestine dumping of solid waste below bridge.

Fig 9. Watercourse sedimentation.

Fig 10. Pollution of water resources in APP.

5.5 Final urban environment of the Córrego do Liso Hydrographic Basin

The fundamental proposal of this work was to carry out a study / diagnosis of urban environment of the industrial area of the city of Uberlândia - MG, Brazil. This region corresponds to the geographical unit of the Córrego do Liso Water Basin, which this study was limited to analyze.

Within this context, the diagnosis of the urban framework proposed by this work is structured in the form of a set of relevant data within the scope of civil and urban construction engineering. This information was obtained through the use of geotechnologies (such as remote sensing and GPS) and laboratory tests in the Geotechnical Engineering and Hydraulic and Sanitary Engineering scenario. In addition, the information was georeferenced in order to guarantee the conformity of the data obtained with the real situation of the studied area.

However, in general, there is no consensus among researchers and professionals in the area of Geosciences and Urban Engineering regarding a precise formula to elaborate these framework diagnoses. Thus, the absence of standardization makes the promotion of these studies often extremely complex and costly, requiring the knowledge of diverse human resources to elaborate a precise, comprehensive and technically relevant framework.

In this way, this work chose to standardize the diagnosis of urban framing based on the process of Map Algebra (or Multicriteria Analysis). Thus, all the criteria that were analyzed during the elaboration of this work were organized in the form of written documents, photographs, graphs and tables, and saved in folders discriminated in a private database in commercial Windows platform. Each folder contains georeferenced data about the parameters that form the analysis criteria (hydrography, geology, geographic location, geomorphology, urban characteristics, etc).

With this data in hand, it was decided to elaborate a sequence of three informative tables that correlated the georeferenced information, parameters and criteria, in order to guarantee semantic relations between them. The first table that composes the urban framework diagnosis proposed by this work is of numeric character and attributes a weight value to the contribution that determined action and / or criterion analyzed provokes in the current reality of the study area (Table 2).

Table 2. Numeric contribution of parameters in Córrego do Liso Hydrographic Basin

Weights contribution to the local reality	
Weights	**Contribution**
1	Very low contribution
2	Low contribution
3	Medium contribution
4	High contribution
5	Very high contribution

After the determination of the weights system, a second table was elaborated with the general criteria of analysis of the Multicriteria Analysis process proposed by the methodology of this work (Table 3). Thus, each of the seven criteria / parameters analyzed and stored in the database was assigned a numerical value of weight varying according to the degree of contribution of this parameter to the urban / environmental reality experienced by the industrial area of Uberlândia (Córrego do Liso Hydrographic Basin) nowadays.

Table 3. Numeric Contribution of parameters in general environment framework.

Diagnosis of the Urban Landscape of the Córrego do Liso Water Basin			
Parameter	Problems found	Suggested solutions	Weight
Geographic	-	-	1
Geotechnical	Coarse sandy soil with clay	Compaction and densification actions, soil geotechnical improvement by insertion of composites, stabilization works of natural slopes	4
Topographics	Low slope	Adequacy of natural terrain slope when necessary	1
Hydrological	Low water quality of rivers and streams	Treatment of polluting effluents and domestic and industrial solid waste	4
Enviromental	Erosion of slopes, pollution and degradation of PPAs, deforestation, silting of watercourses	Intensive monitoring actions in the study área	3
Urbanistic	High density of domestic and industrial buildings in the vicinity of the banks of the streams	Revision and adjustment of the urban restrictions and urban guidelines of the region	4
Structural	Buildings with pathologies related to geotechnics and local hydrology	Improvement in project design, execution and monitoring techniques	4
TOTAL WEIGHT OF CONTRIBUITION FOR WATER BASIN GENERAL SITUATION			3

Table 2 also shows the main problems encountered in the area of the Basin and the parameters with which they were related. In addition, suggestions and possible solutions to the problems listed were also introduced in the table, in order to guide in general the territorial management policies and actions of the study area. Table 2 also shows the main problems encountered in the area of the Basin and the parameters with which they were related. In addition, suggestions and possible solutions to the problems listed were also introduced in the table, in order to guide in general the territorial management policies and actions of the study area. Finally, the tabular data were converted into a graph (Fig. 11) in order to improve the geometric and visual interpretation of the influence of each one of the parameters in the urban and environmental reality of the Stream of Liso and neighborhoods.

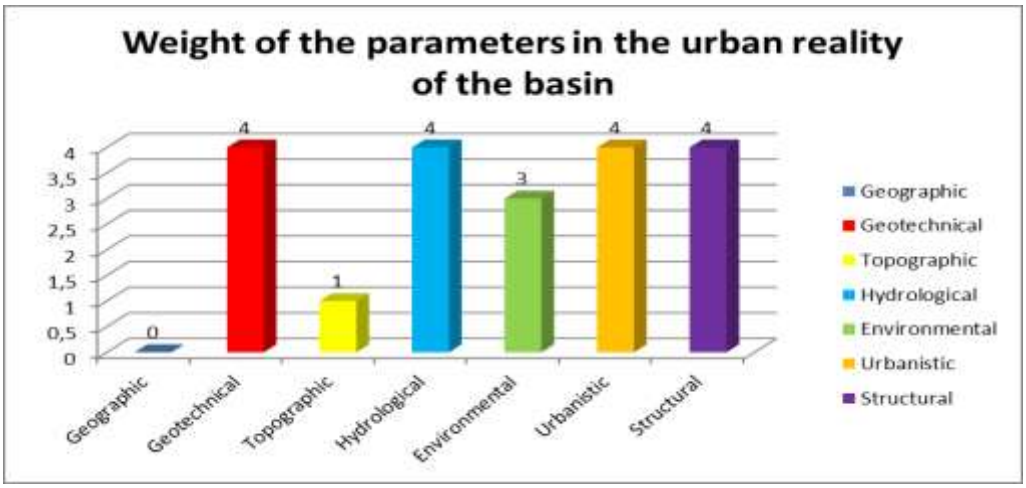

Fig 11. Weight of the parameters in the urban reality of the basin.

However, as shown in the land use and land use map, the Córrego do Liso Hydrographic Basin is an almost totally urbanized region within the municipality of Uberlândia. In this region, residential, mixed and industrial zones form the industrial area of Uberlândia, the main industrial, logistic and financial center in the interior of the state of Minas Gerais, Brazil.

In this sense, Table 3 assigns new weight values to parameters that are unique and relevant to the urban configuration of the industrial area of the city of Uberlândia. In it, problems encountered in the area (however, problems of an infrastructural and relevant nature in civil engineering) were also presented and solutions proposed for them.

Table 3. Infrastructure parameters and its weights.

Framework of urban infrastructure in the industrial area of Uberlândia - MG			
Urban structural parameters	Problems found	Proposed solutions	Weight
Urban roads, streets and highways	Deflectometric basins, cracks and fissures in pavements, surface wear of pavement	Improvement of traffic resistance and fatigue and collapse of pavement	3
Rain and river galleries	Flood points, insufficient slope, low quantity of culverts and gutters	Complete adaptation of local drainage and water distribution network	4
Residential and mixed buildings	Common constructive pathologies, surface wear, time action	Improvement of planning, execution and monitoring of works	2
Industries and commercial buildings	Common constructive pathologies, surface wear, time action	Improvement of planning, execution and monitoring of works	2
Areas of permanent preservation	Advanced environmental degradation, deforestation, contamination and pollution of streams	Increased monitoring and monitoring, reforestation and environmental preservation policies	5
Livestock and grazing areas	Heavy deforestation for livestock, local soil erosion, slope instability	Limitation of areas for livestock and agriculture, effective implementation of the CAR	4
Savanah, sidewalks and ciliary forest	Clandestine deposit of solid waste, pollution of soil and water resources	Increased control of native vegetation areas and reforestation and depollution policies	5
Total Weight Of Contribuition For Urban Situation			3,571

The tabulated data were also converted into a graph (Fig 12) in order to improve the visual and geometric understanding of the contribution of each of the parameters and criteria to the urban and environmental situation of the study area.

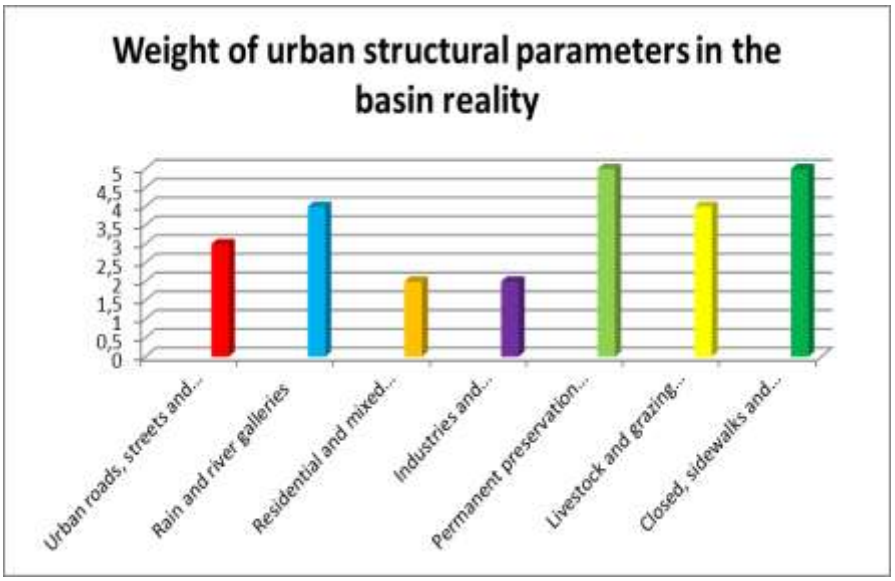

Fig 12. Weight of urban structural parameters ins the basin reality.

With these data, it was possible to calculate the average weight of contribution of the analyzed parameters to the general reality of the Córrego do Liso Hydrographic Basin and to the urban reality of the Uberlândia industrial area. This calculation was based on the simple arithmetic mean of the values of the weights assigned for each sector.

Thus, for the general situation (urban, geotechnical, environmental and hydrological) of the Córrego do Liso Hydrographic Basin, a weight value of 3 was obtained. For the urban situation of the basin (taking into account only the industrial area),a weight value of 3.571 was obtained. These values characterize that the parameters and criteria analyzed by this work contribute significantly (average and high contribution) with the situation experienced by the study area.

In this way, it can be said that the main factors that contribute to the reality of environmental degradation, pollution of surface water resources, occurrence of erosive processes, silting of water beds, deforestation and desertification, burning, soil pollution, native vegetation, aggression to fauna and flora and constructive pathologies in the local urban infrastructure are related to the criteria and parameters contemplated by this work.

VI. CONCLUSIONS

With the accomplishment of this work it was possible to establish a diagnosis of the urban and environmental reality experienced by the Córrego do Liso Hydrographic Basin in Uberlândia - MG and relate it to several geographic, geotechnical, construction and hydrological parameters of the site. This diagnosis was only possible through the use of Geotechnologies and the application of geoprocessing techniques applied to the professional and academic practice of Civil and Urban Construction Engineering.

It was observed that the application of geotechnologies is fundamental for the promotion of studies aimed at understanding the behavior and dynamics of contemporary cities and their relationship with anthropic activities and impacts on the environment. Thus, the use of geotechnologies assists in the elaboration of urban policies, in order to guarantee the support in the process of decision making by competent authorities to seek the development of cities and their concomitance with the provision of infrastructure services Urbanization, basic sanitation and preservation of the natural resources of ecosystems.

Based on the parameters chosen by this study, it was possible to establish a direct relationship between the geotechnical configuration of urban hydrographic basins and the impacts caused by the use and occupation of the soil. In general, it was observed that basins installed on thick soils have high potential of percolation and contamination by polluting effluents. In addition, buildings and buildings installed on these soils tend to present unstable behavior, as well as to present constructive pathologies due to the occurrence of mechanical and biological phenomena in the soil. In the case of the Córrego do Liso Basin, it was necessary to carry out efficient geotechnical and soil characterization studies before the construction of buildings in the region with the objective of collaborating in the establishment of master plans and soil occupation guidelines that provide less impact on buildings, the population and the environment.

It was also concluded that the hydrological characteristics of the surface waters of urban watersheds are highly influenced by the land use and occupation processes of these regions. In the case of the Córrego do Liso area, it was observed that the anthropic action in the manantial areas produced a large amount of solid waste and domestic and industrial polluting effluents that reached the water resources of the basin and altered the physical-chemical patterns of the local water, Making it unfit for human consumption.

Finally, it was also possible to note that the demarcation of permanent preservation areas in the region of urban hydrographic basins is not an effective instrument for environmental preservation. It is necessary, therefore, the elaboration of policies of supervision and surveillance of the areas of stock in order to control the process of anthropic occupation on them.

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