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DIAGNOSIS OF ENVIRONMENTAL RECOVERY IN BAUXITE MINING IN THE MUNICIPALITY OF POÇOS DE CALDAS – MINAS GERAIS

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Abstract:-
This research was conducted in order to evaluate the technical and managerial procedures practiced by a company that carried out the bauxite mining, according to the reference coordinates 23S 343200/7587100, in the municipality of Poços de Caldas – Minas Gerais, with regard to its proposals contained in its Degraded Areas Recovery Plan. The methodology adopted was carried out in four distinct phases: bibliographic research, field data survey through technical visit, analysis of its Degraded Area Recovery Plan and use of geoprocessing techniques for the preparation of two maps: Digital Terrain Model and Slope Map, both prepared by ArcGIS, version 10.3. In addition, aerial images were used in order to compare over the years 2005, 2007, 2015 and 2017. The results obtained recommend topographic leveling actions. The smoothing of the area was not effective, which caused erosive processes present in certain cultivated areas, directly affecting the development of local vegetation. In relation to the techniques of exploitation and reforestation, it was noted that the company adhered to extremely common procedures in the region, such as the use of the method of open pit mining and reforestation with eucalyptus plantations.

Keywords:- *Reclamation of Degraded Areas, Surface Mining, Environmental Planning.*

1. INTRODUCTION

The process of unbridled population growth coupled with increased life expectancy has increasingly led to the exacerbated exploitation of natural resources, leading to their exhaustion even before their true potential is discovered. Thus, the discussion that involves the search for natural resources in a sustainable way has gained more and more strength, in order to become indispensable today the use of environmental recovery techniques (FERREIRA et al., 2007) [1].

According to Alba (2010) [2], degradation can be understood as a result of environmental processes that cause the loss of productivity or the decline of environmental quality. Its main causes have been agriculture, deforestation, urbanization and industrial activity, such as mining (FERREIRA et al., 2007) [1]. However, mining projects do not only have negative impacts on society, they also have positive impacts on the community, such as increased tax collection by the municipality, generation of jobs and consequently improvement in the quality of life of people (FLORES, 2006) [3].

In order to solve the environmental degradation carried out by mining, the process of Recovery of Degraded Areas emerged (NERI & SANCHEZ, 2012) [4]. Recovery is the repair of an area and an ecosystem to a condition as close as possible to it is original condition (PNSB, 2013) [5]. In this sense, the ecology of restoration emerges as a process of intentional change of a place to restore something close to the diversity, structure and functioning of the ecosystem that originally occupied that place (CORRÊA, 2009) [6].

Currently, this recovery occupies a significant position in the planning of mining activities, being planned even before its opening. In the past, environmental recovery was a measure taken after mine closure (NERI & SANCHEZ, 2012) [4].

One of the best practices for environmental recovery is the Plan for the Recovery of Degraded Areas, which is a report that should be present in the Economic Use Plan (FLORES, 2006) [3]. The Plan for the Recovery of Degraded Areas should follow the guidelines of NBR 13030 and should include aspects such as suitability and intention for future use of the area, environmental diagnosis, environmental impacts, follow-up and monitoring program, general description of the undertaking and topographic and landscape configuration (ABNT, 1999) [7].

It's important to emphasize the importance of adequate monitoring of these recovery practices, which should be applied throughout the life of the project. Done correctly, they reduce the risk of erosion in the soil and, consequently, improve the area for the growth of vegetation, reduce instability of benches and piles of sterile and increase protection in maintaining the quality and quantity of water resources (NERI & SANCHEZ, 2012) [4]. Geoprocessing techniques are excellent indicators of identification of certain phenomena and important tools for environmental management, such as planning and monitoring the recovery of degraded areas.

In this sense, this study aims to evaluate the technical and managerial procedures practiced by a company in the recovery of a degraded area in the municipality of Poços de Caldas, a tourist city in southern Minas Gerais.

2. MATERIAL AND METHOD

Initially, a bibliographic research was carried out in the books available in the library collection of Federal University of Alfenas, Poços de Caldas – Minas Gerais campus. In addition, materials available online were also used. This step was essentially directed to the available literature on the various aspects involved in the Recovery of Areas Degraded by mining activities, including analysis of concepts, measures usually employed in recovery works, recovery strategies, methods and techniques developed, alternatives to land use in old mining areas and public policies. This procedure was interesting because it provided a consolidated theoretical basis that helped in the later stages.

Furthermore, data and information were searched in the collections of the mining company analyzed here, in addition to comparative references with cases from other Brazilian locations. It is worth mentioning that we also searched for aerial images of the area studied before and after mining, referring to the years 2005, 2007, 2015 and 2017, in order to make a comparison. This procedure was possible with the use of Google Earth Pro software, version 7.3.2.

The field surveys were carried out in order to acquire data and information on the procedures and recovery measures carried out in mining. For this, a technical visit was made to the region on January 21st, 2009, in which with the help of a field booklet, information was collected in order to compare actual data (obtained in the field) with theoretical data (obtained through the Recovery Plan of Degraded Areas of the company).

General data regarding the Recovery Plan for mining in Poços de Caldas – Minas Gerais, among which were examined the alternatives for land use provided for in the rehabilitation process of degraded areas and, also, with regard to the recovery measures proposed by the company, regardless of the link with the planned post-mining use, schedule, deadlines, costs and community participation.

For the study of signs of erosion, two distinct maps were prepared: Slope Map and Digital Terrain Model.

For the elaboration of the mentioned maps, the polygonal of the process under study was lowered in the Sistema de Informações Geográficas da Mineração - SIGMINE (ANM, 2018) [8]. Once this was done, in order to find out in which topographic map such a polygonal was inserted, an overlap was made with the TOPODATA images in the database of the Instituto Nacional de Pesquisas Espaciais (INPE, 2019) [9], on a scale of 1:250,000. This procedure was performed by ArcGIS software, version 10.3.

Subsequently, it was used the digital elevation model provided by INPE of the area analyzed here to obtain the contour lines of the terrain. These models are SRTM satellite images that provide a digital model of elevation in relation to the mean sea level (INPE, 2019) [9]. Then, the topographic map was opened in ArcGIS, version 10.3 to define the georeference system of the image, where the Universal Cross Projection of Mercator (UTM), zone 23 S and DATUM Sirgas 2000 were adopted. Subsequently, the image of TOPODATA was cut out for the area of interest, in this case, given by the polygonal of the process. It is worth mentioning that it was obtained the set of contour lines of the terrain interval every 10 meters.

After obtaining the terrain contour lines, the Slope Map and the Digital Terrain Model were created by ArcGIS software, version 10.3.

3. RESULTS AND DISCUSSIONS

The area studied, of approximately 121.17 hectares, is located in the municipality of Poços de Caldas, located in the south of the state of Minas Gerais, and is known as Sítio Potreirinho do Pinheirinho (**Figure 1**). Access to the region was made from the south exit of the city.

Figure 1: Location of Sítio Potreirinho do Pinheirinho. Source: Google Earth Pro, version 7.3.2.

Through SIGMINE and ArcGIS software, version 10.3, it was possible to obtain the polygonal required by the company (**Figure 2**). The coordinates of the mooring point in UTM, and DATUM Sirgas 2000 are 23S 344000/7587569.

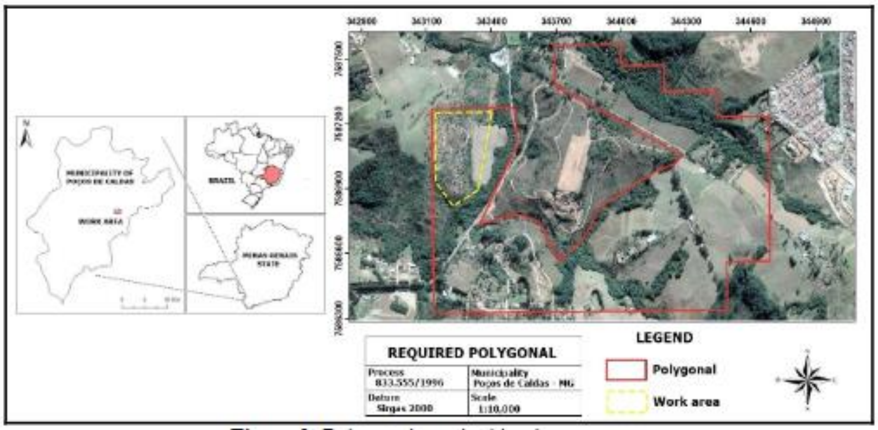


Figure 2:Polygonal required by the company.Source:From the author.

With the technical visit made to the study area on January 21st, 2019 with representatives of the company, images of the site were captured (**Figure 3**) and recorded in the field booklet information that enabled us to compare with the Recovery Plan of Degraded Areas of the institution. The region visited was the northwest sector of the polygonal, the area where bauxite exploitation occurred (**Figure 2**).

Figure 3: Area visited; (A) Photo 1; (B) Photo 2. Source: From the author.

In order to compare the area over time, aerial images of the studied region were collected (**Figure 4**) through the software Google Earth Pro, version 7.3.2, referring to the years 2005, 2007, 2015 and 2017.

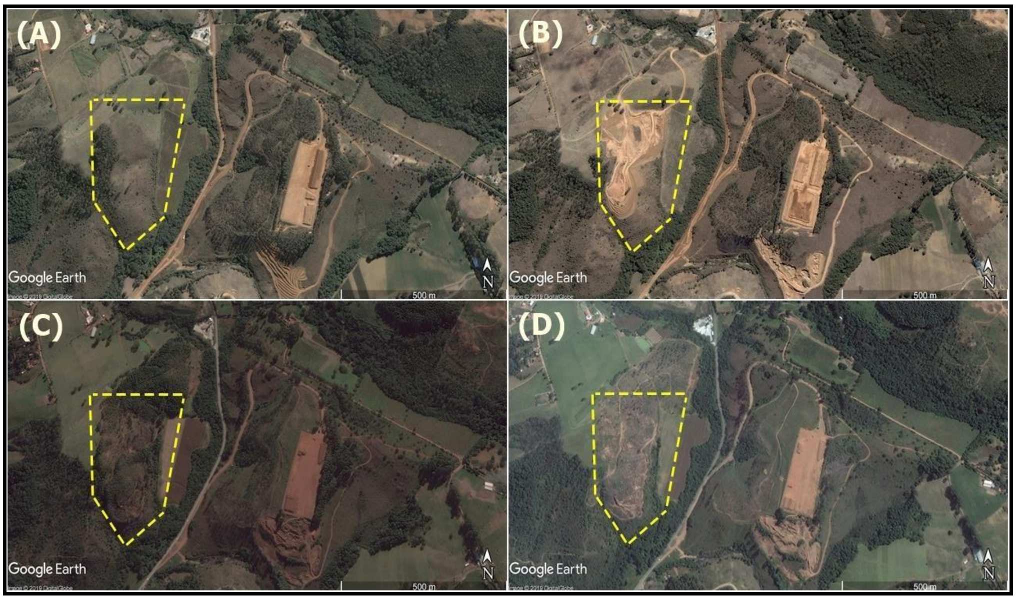


Figure 4: (A) Aerial photo of June 15, 2005; (B) Aerial photo of August 14, 2007; (C) Aerial photo of June 4, 2015; (D) Aerial photo of April 19, 2017. Source: Google Earth Pro, version 7.3.2.

In (**Figure 4A**) one can observe the region before suffering the impacts of mining. At this stage it is important to emphasize that the area was composed mainly of grasses, also containing the presence of eucalyptus plantations.

The exploitation activity is presented in (**Figure 4B**). It is worth remembering that the methodology adopted by the company was open pit mining with the bench method, which is the predominant method in the region. This information was obtained by analyzing its Plan for the Recovery of Degraded Areas.

The end of monitoring in the area was around 2011 and 2012, according to representatives of the company. In the Mining Recovery Plan it was defined that the company would carry out the topographic and landscape reconfiguration of the area, because the changes caused by it in the environment would affect both the physical environment (changes in relief, soil characteristics) and the biotic environment (fauna and flora).

In relation to landscape recovery, the eucalyptus plantation was agreed with the superficial owner, supported by the fact that the place already shelters a reforestation with this species. In (**Figure 4C**) we can observe that in fact the planting of this species has occurred, however, it is observed that in certain areas there was no growth of vegetation. This phenomenon can be explained by the erosion that occurred in the soil, which could be proved through the field visit.

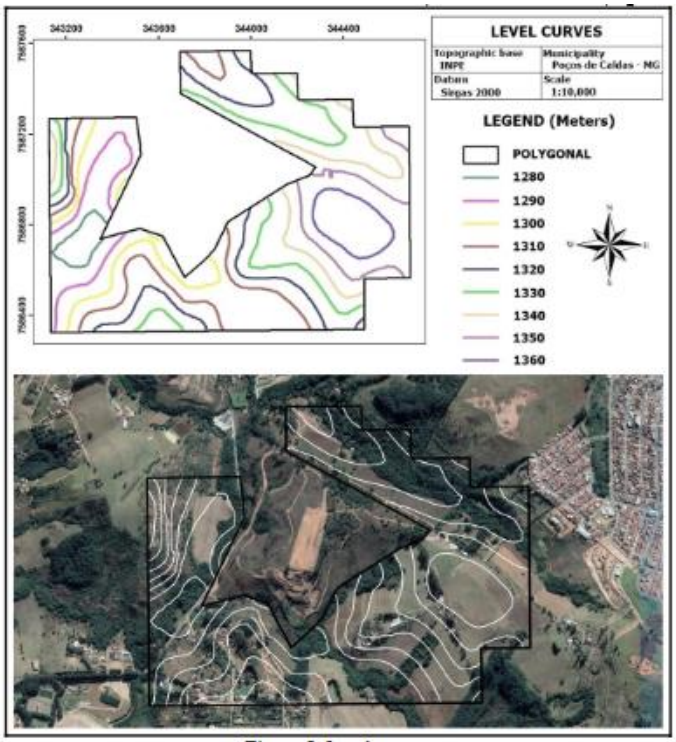
Due to changes in soil natural drainage conditions, the company would perform, for the recovery of the physical environment, a smoothing of the altered portion of the relief, construction of protective windrows to prevent the formation of erosive processes and the carrying of material, construction of sediment containment basins and channels for water redirection. The channels would be installed following the method popularly known as fish spine. Such procedures help to avoid erosion and, consequently, the carrying of material.

Through the technical visit proved the construction of the protection windrows, channels and containment basins. However, it is extremely important to note that the smoothing of the terrain was not adequate, because the terrain had high rates of slope, where the steeper the terrain, the greater the surface runoff. Over time, this fact resulted in soil erosion (observed in **Figure 4C**), which significantly impaired the development of local vegetation. The presence of vegetation in the soil reduces the risk of erosion.

Around 2016 and 2017, the soil owner cut this plantation in order to sell it, and in 2018, he planted a new eucalyptus plantation, which can be seen in (**Figure 2**). It is worth remembering that on the day of the technical visit the eucalyptus plantation on site did not correspond to the plantation carried out by the company, such plantation had already been cut (**Figure 4D**). Thus, the analyses were made through the interpretation of aerial images and information released by the company's legal representatives.

In addition, the company was entrusted with the construction of a siege of the recovering area. This process was attended and can be observed by the field visit carried out. In order to detect erosive processes in the area, geoprocessing techniques were used to create the Digital Terrain Model and Slope Map. The use of these techniques helps us to make decisions, since they provide more information about the territory, in which computational and mathematical techniques are used for the treatment of geographic information (CAMERA; DAVIS, 2001) [10].

It was first obtained the contour lines of the terrain, interval in 10 meters



(**Figure 5**). **Level Corves Source: From the author.**

It is noted that the area is located at an altitude that varies from 1280 m in the sectors of dimensions lower than 1360 m in the sectors of elevated dimensions. Thus, the site's Digital Terrain Model was generated (**Figure 6**), which provides us with a representation of the spatial distribution of the relief characteristics (MITISHITA, 1997) [11]. According to Duke et. al. (2003) [12], this model is an important tool for obtaining data regarding the surface flow of the land.

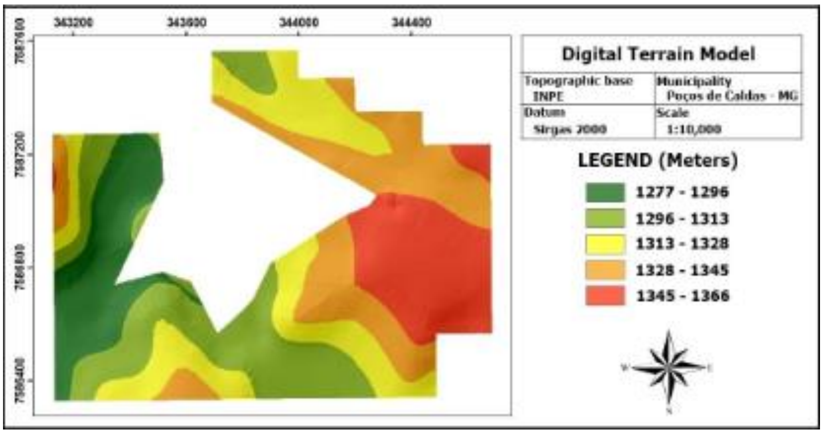


Figure 6: Digital Terrain Model Source: From the author.

Through the analysis of the (**Figures 5** and **6**) it was observed that the direction of surface water flow starts from the highest portions of the ground to the lowest portions. Thus, due to the large variation in altimetry, the terrain was expected to show erosion trends, which can be seen in the on-site visit and satellite images. It is worth emphasizing that elevation is one of the most important factors of interference in surface flow.

In addition, a terrain Slope Map (**Figure 7**) was prepared, which corresponds to the angle of surface slope in relation to the horizontal plane. This slope acts on the balance between surface runoff and water infiltration in the soil (FLORENZANO, 2008) [13].

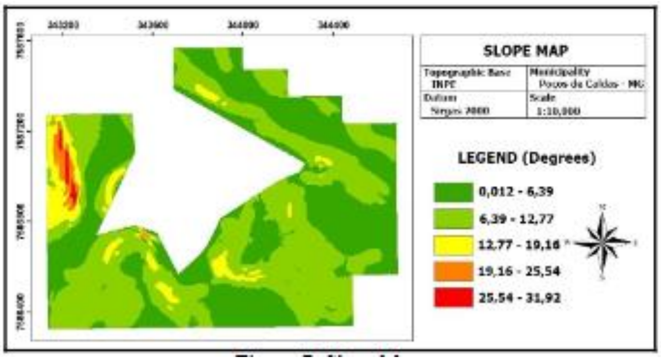


Figure 7: Slope Map Source: From the author.

Analyzing the (**Figure 7**) one can see that the area that was recovered presents high rates of slope in the terrain, which contributes to soil erosion, since the steeper the terrain, the higher the velocity of surface runoff, therefore the sediment carriage will be higher, resulting in erosion.

4. CONCLUSIONS

At the end of this research it can be concluded that, in relation to the bibliographic surveys, the company adopted extremely common procedures among the mining companies present in the town of Poços de Caldas – Minas Gerais, which consists of the exploitation of bauxite through the method of benches and, at the end, the topographic reconfiguration of the area followed by the planting of eucalyptus, according to agreement with the superficial owner of the soil.

In general, the company met most of the requirements of its Recovery Plan for Degraded Areas, such as the construction of windrows, containment basins, channels and fencing. However, it left something to be desired in some, such as the topographic leveling. In this regard, it was observed that the region deserves attention, as it showed great signs of erosion, which made it difficult and will continue to hinder the development of the vegetation that is planted there. The erosion can be proven through geoprocessing techniques such as Digital Terain Model and Slope Map.

The methodology adopted in the eucalyptus plantation in the mined area was also inadequate, and it is important to note that in order to avoid erosion, it is necessary that the plantation occurs following the contour lines. In this way, the velocity of surface water runoff will be reduced, facilitating its infiltration into the soil and, consequently, cushioning the carrying of sediments.

In addition, it was concluded that the company's Recovery Plan for Degraded Areas did not meet all the specifications recommended for the preparation of such a document, hiding information such as the costs involved in the recovery process.

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