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Characterization of the bauxite mining of the Poços de Caldas alkaline massif and its socio-environmental impacts

Caracterização da mineração de bauxita no maciço alcalino de Poços de Caldas e seus impactos socioambientais

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Resumo

O uso intensivo dos recursos minerais traz consigo alterações significativas no meio ambiente. O setor minerário é fundamental para a economia mundial, desde que operado em bases tecnicamente coerentes, socialmente justas e ambientalmente corretas. O presente trabalho teve como objetivo caracterizar a mineração de bauxita no planalto de Poços de Caldas - MG, analisando seus respectivos impactos socioambientais. Por meio do panorama apresentado, concluiu-se que a mineração de bauxita realizada no planalto de Poços de Caldas, na maioria das situações, mitiga seus respectivos impactos socioambientais negativos de forma satisfatória, além de gerar impactos sociais positivos; os métodos de restauração dos ecossistemas perturbados pela mineração vêm sendo aperfeiçoados continuamente e há necessidade que sejam reproduzidos nos empreendimentos de pequeno e médio porte.

Palavras-chave: Mineração, impactos socioambientais, meio ambiente.

Abstract

The intensive use of mineral resources brings along significant changes to the environment. The mining sector is essential for world economics, as long as it is operated on a basis that is technically coherent, socially fair and environmentally correct. This study aimed to characterize the bauxite mining of the Poços de Caldas plateau, MG, investigating its respective socio-environmental impacts. Through the overview presented, one can conclude that in most situations, the bauxite mining at the Poços de Caldas plateau mitigates its negative social and environmental impacts in a satisfactory manner in addition to generating positive social impacts; and the restoration methods of the mining-disturbed ecosystems have been continually improved and should be replicated by small-and-medium-sized companies.

Keywords: Mining, social and environmental impacts, environment.

1. Introduction

One of the main causes of modifications in environment has been the advent of the industrialization process, this being, responsible for the acceleration of the demand on the natural resources on a short term (Borges et al., 2009). The growth of the cities and towns in the last decades have increased the pressure upon the natural resources all over the planet, it being the case that, practically there is no ecosystem which has not undergone direct influence and/or indirect of the man-made actions, resulting into the decrease of the diversity of habitats and consequent loss of biodiversity.

Mining is an operation impacting on the environment which generally does not represent extended large areas especially when compared with the other impacting agents such as farming and livestock rais-

ing. Nevertheless, its environmental effects are severe, due to its deep movement of the soil layers, plant cover removal and alteration of the water run-off regime, becoming a potential source of problems of physical, chemical and biological nature. Knowing previously the problems associated with both the installation and operation of the business by means of the instruments of evaluation of impacts and environmental planning, one can adopt measures which either prevent or mitigate them, reducing environmental damages and, consequently the costs involved in its mitigation (Bacci et al., 2006).

Currently it is the consensus that the planning of the mining closure should be designed even before the start of the mining operations, undergoing reviews along the useful life of the ore deposit, since

the social, economic and environmental parameters tend towards change from a generation to another. In this sense, Sánchez (2011) stresses the uncertainties in the planning, which involves mine closure. This planning should involve all the parties concerned, encompassing all from the employees and suppliers up to the neighboring players in order to leave a positive and lasting legacy in the community (ICMM, 2008), making an extremely complex challenge.

For the planning of the mining operation, the knowledge of the respective associated impacts is fundamental. Thus, the present work aims at characterizing bauxite mining in the Poços de Caldas plateau, MG, as well as investigating the significant social and environmental impacts generated by the mining operations.

2. General characterization of the region

The Poços de Caldas Plateau situated in a range region of which geological substrate is constituted by an alkaline massif in a approximately circular shape, covering an area of 6,558 km² (Cavalcante et al., 1979). The altitudes ranged between 1,000 and 1,300 m with culminating points above 1,640 m. This area is encom-

passed by drainage network belonging to the Paraná River drainage basin, Rio Grande sub-basin (Gatto et al., 1983).

The climate is of the type Cwb, altitude subtropical, according to the Köppen climate classification (mesothermal with mild summers and dry winters drought). The rain season

extends from October to March; the average annual rainfall rate is 1,482 mm. The annual average temperature is of 19.9°C, whereby, the absolute minimum and maximum temperatures are respectively -6.0°C and 31.7°C. Average annual relative humidity is 79% (Poços de Caldas, 1992).

3. Characterization of bauxite deposits

The first record of the occurrence of bauxite in the Poços de Caldas Plateau dates back to 1919 when geologist John Branner recorded the presence of bauxite in the region in his book on the geology of Brazil (Williams, 2001). Since then, there are a number of works conducted about the geology of the region, addressing subjects such as mineral resources, thermal waters among others (Moraes, 2007).

Ellert (1959) developed one of the most important works about the geology of the plateau, both for the pioneering and for the amount of information and for the quality of the information and recognized

the volcanic nature of the region. The author presented a synthesis of the works which had been conducted about the region in his paper entitled "Contribution to the Geology of the Poços de Caldas Alkaline Massif".

According to Parisi (1988), the deposits are classified into two types: a) the steep mountain slope deposits (*jazidas de serra*), formed by the decomposition of the alkaline rocks of the ring dike which delimits the plateau (northern part), their being homogeneous and highly thick (sometimes thicker than 10 m), but with smaller distribution in area than the deposits situated in the

interior of the plateau. The ore is compact in the surface and porous in the lower part, commonly forming directly over the bedrock without the presence of a clayey layer. Generally, it is found in native forest-covered areas; b) grassland deposits are the ones formed in the interior of the plateau on the tops of rolling hills, presenting discontinuous ore bodies, interrupted laterally whether by the presence of topographic depressions whether by the presence of zones of low content or pure clay ranges. The ore presents aspect similar to that of the steep mountain slopes, but, occurring almost always in a clayey matrix.

4. Mining method

The mining methods consist in the specific set of work planning, sizing and carrying out the tasks according to the uniqueness of each type of mining. Another important aspect in the definition of the mining methods is concerned with

the need for defining the future landuse of the mined area (Reis & Sousa, 2003).

After the demarcation of the mineralized body, the process of mining preparation is started, which takes places through open pit mining operation. This

consists in the removing of the organic layer of the area to be mined (*topsoil*) through the use of bulldozers. This layer is made up of A horizon soil, rich in organic matter, seeds and decomposing microorganisms, their being fundamental to the

revegetation of mined areas (Koch, 2007). Next, a temporary rain water drainage system is set up sized according to the time in which the area will remain open, terrain slope and surface of stripped area, its being made up of ditches and containment basins dug out in the soil.

The mining methodology employed by the mining companies in the Poços de Caldas Plateau region was technically developed and adapted along time

according to the geological and topographical characteristics of the region as well as the market demands. Mining is performed in the open pit generally with down slope advance, which presents the best development conditions according to the characteristics of the orebodies and of the ease which it provides at the moment of environmental rehabilitation (Williams, 2001).

With the depletion of the mining

bench, the topographical reshaping is started with the spreading of the *topsoil*, followed by subsoiling (Gardner & Bell, 2007); establishment of the definitive draining system and revegetation.

During the bauxite mining process in the Poços de Caldas plateau region, there is no consumption of electric energy and water, since the ore in its natural unconsolidated form demanding only small size equipment for its excavation.

5. Analysis of the socioenvironmental impacts

Introduced initially in the United States after the enacting of the Federal Law which established the National Environmental Impact Assessment (NEPA), in 1969, and soon after adopted in the developed countries, the Environmental Impact Assess-

ment (AIA) was legally introduced into Brazil by the Federal Lei number 6.938/1981, which deals of the National environment Policy (Brasil, 1981). But, it was not until 1986, by means of the CONAMA 001 Resolution which established technical

criteria and the general guidelines for preparing the Environmental Impact Study (EIA) and of its respective environmental Impact Report (RIMA) (CONAMA, 1986). From this moment on, AIA began effectively to be conducted in all the states.

Anthropic Environment

For the communities in the surroundings of the mining operation, the visual impact of the landscape due to the removal of the vegetation and exposition of the lower layers of soil is the main negative effect of mining. In this sense, Mechi & Sanches (2010) state that some types of rehabilitation work on mined areas have an incipient feature, aiming, primordially, at attenuating the visual impact generated due to pressures coming from the local population.

In spite of the efforts of the companies as to the environmental recovery methodologies of the mined areas, it falls on them an increased involvement with the local community, especially in regard to awareness of the temporary character of the visual impact as well as the publicizing of the actions of environmental character developed by the companies. Research of environmental perception carried out with the community of the surroundings of mining operations, reveal that the companies need to improve their opera-

tions in order to better the perception of the community as for the developed operations as well as in relation to the environmental issues related to mining (Drummond, 2009).

The impacts related to the maintaining of people who had occupied lands prior to mining and given conditions to remain on the lands after mining can be thought of as the most important among those positive ones generated by the mining, for they prevent their exodus to the big cities, but they generate a small number of service stations as the studies by Ferreira et al. (2010) show for the bentonite mining in the state of Paraíba.

The mining operations are of great importance to the towns within reach of the projects, since the interests paid can be reverted into benefits, improving so, the town infrastructure. Another not less important issue is the mineral transformation that, in some cases, also occurs in the mining region, increasing the town's tax collection and job offer (Williams, 2001).

Carvalho (2011) stands out that the

Brazilian Tax System (Sistema Tributário Brasileiro), regulated by the National Tax Code (CTN), Lei number 5.172/1986 (Brasil, 1986), is complex and comprehends taxes at the three levels of Government (Federal, State and Municipal). In that way, the relevant tax burdens for the companies operating in the mining and mineral product sector are several different types.

The taxes reverted to the town due to the mining operation is through the CFEM Financial Compensation for the Exploitation of Mineral Resources (Compensação Financeira pela Exploração de Recursos Minerais), the rate of which is 3% upon the net sales generated by the sale of bauxite, represent a very low amount as compared with those generated in the manufacturing step. Out of the total collected, 65% are intended to the town, this resource being applied into projects which revert in behalf of the local community, as improvement the infrastructure of the environmental quality, health and education (DNPM, 2010).

Physical Environment

Corrêa & Bento (2010) state that the work whose objective is the restoration of mining ecosystems should be developed aiming at strengthening the edaphological systems with techniques which improve the physical quality of the substrates and do not exceed the natural fertility levels. The main impacts generated potentially

upon the edaphological system focus on the alteration of the topography and interruption of the nutrient cycling. Bauxite mining implies the removal of the A horizon as well as the ones of the subsoil layers, in particular horizons B and C. In addition to endangering the topographical profile by lowering the elevation, the permeability

of the remaining terrain is also affected.

The soils in mining areas are compacted and according to Guadagnin et al. (2007), they present poor total porosity, predominance of micropores and still poor infiltration rates. The compaction of the mining surfaces decreases the porosity which affects directly the permeability

in the remaining profile. That last factor enhances the terrain erodibility, in particular, during the period in which this becomes bare and exposed to bad weathers.

According to Meurer (2010), the soils are structured natural bodies and constitute environments where organism develop according to the supplies of water and mineral nutrients, in the absence of toxic elements is called soil fertility (Nicolodi et al., 2008). In this sense, Costa & Zocche (2009) stated that low contents of organic matter and phosphorus and high acidity can present restrictions to the development of plants. In this way, the suppression of the vegetation interrupts that interaction, causing the edaphic biota to be partial or wholly endangered.

In mining operations, the impacts on the subsoil caused by seepage, such as those of oils and greases coming from equipment as excavators, crawler tractor and trucks, endanger the soils and put into pollution risk the surface and ground waters. According to Lopes et al. (2008), the polluting load of present society in industrialized countries is equivalent to 40,000 inhabitants per ton of oil poured

in bodies of water, that is, at every ton of oil poured in the waterbodies, 40,000 inhabitants are affected, directly or indirectly by the environmental and social upsets generated.

According to the internal procedures of the Environmental Management Systems (Sistemas de Gestão Ambiental (SGA)) of a mining company in the region, oil seepages with volumes above 25 liters characterize environmental incident (ALCOA, 2011), this sort of event being recorded, investigated and simultaneously reported to the environmental agencies.

The possible impacts brought about by the generation of domestic sewages take place via the use of outdoor toilets or cesspools in the working areas. Use of these procedures can, depending on the generated amount, contaminating surface or ground waters. According to Ayach et al. (2009), a great part of the problem causing environmental degradation in the natural resources stems from the inadequate removal several sorts of residues, domestic sewage standing out. In this way, largest size companies establish support structure, consisting of metallic

mobile house, with independent cafeteria and chemical toilet, the waste being periodically collected by hydro vacuum trucks, which carry these effluents to waste treatment plants. The supply of water to these mobile toilets is done weekly by water truck.

As characterized by Ferreira et al. (2010), dust emission is inevitable in the case of the mining operations on the occasion of the natural effects, its being able to generate harmful consequences to the health of the workers and of the population living in the surroundings of the operations. So, use of water also becomes necessary, especially for the wetting and suppression of dust on mine roads.

Equipment movement also results in the emission of gases coming from fissile fuel burning. Gas emission contributing towards the deterioration of air quality, but, they do not represent an impact of greatest importance within the investigated context. Nevertheless, several companies use the Ringelmann scale for both gauging and monitoring of the fumes emitted by the diesel engines of the equipment (Carvalho et al., 2007).

Biotic environment

The Poços de Caldas plateau lies in the region of the Atlantic Forest domain (Veloso et al., 1991), the forest formations being classified as Tropical Montane Semideciduous Seasonal Forest (Floresta Estacional Semidecidual Alto-Montana) (Oliveira-Filho et al., 2006), in addition to presenting phytophysiognomy of gallery forest and high altitude grasslands (Guimarães et al., 2008).

In the situations of ore bodies situated under native grasslands, the environmental licensing procedure is quite simple, since these are not yet recognized as important areas in terms of conservation of the local biodiversity. But, with the publication of the CONAMA Resolution 423/2010, which determines about basic parameters for identification and analysis of the vegetation of the high altitude grasslands within the Atlantic Forest biome (CONAMA, 2010), the trend is that this process becomes more restrictive as to the revegetation technique after mining. This resolution stresses the importance of these areas in terms of biodiversity, as the work carried out on the Poços de Caldas plateau in the 1980s identified the occurrence of 65 native grass species (Pereira, 1986).

According to Coutinho (2006), the

climate is one of most important factors in the formation of the different types of vegetation, for which the several species prove adapted, these adaptations being more conspicuous when in severe climates, showing physiological and structural responses to those environments. Although, almost all the tropical vegetation formations are endangered, the altitude formations de altitude lie particularly affected by climate changes, which impact the temperature, rains and the formation of the clouds in the mountain areas (Bubb et al., 2004; Aldrich et al., 1997). Due to that importance, the work developed by Alcoa stand out, which since 2007, have sought to restore these places with species in the high altitude grasslands of the plateau through the use of seeds of the native grass of the genus *Aristida* sp, known popularly as annual sedge (capim barba-de-bode) and which presents a high frequency in the native grasslands in the region (Pereira, 1986).

One can consider that the situations of ore bodies localized under native forest are those which present most critical situations in terms of environmental licensing. This is aggravated by the fact that the ma-

jority of the mining operations conducted formerly in those locations presented few satisfactory results for the return of forests with typical structural metrics of native forest (Nappo et al., 2005).

In a number of cases, the vegetation coming from rehabilitation after a decade resembles to a scrubby grazing land rather than early regeneration stage of native forest. But since 2005, Alcoa has been developing a methodology for the effective restoration of these sites. This work is based upon the practical application of a number of concepts of tropical forest ecology, especially in the search for the replication of processes vital to the sustainability and maintenance, such as structural dynamics, ecological succession and “plant x animal” interactions (Guimarães, 2008). The Poços de Caldas plateau also presents conditions favorable to the maintenance of populations of medium-sized mammals, although, some of these find themselves extinction-endangered and have as feature high environmental sensitivity: the brown howler (bugio) (*Alouatta guariba clamitans*), the maned wolf (lobo-guará) (*Chrysocyon brachyurus*) and the ocelot (jaguaritica) (*Leopardus pardalis*) (Drum-

mond, 2009), in addition to the rodent *Rhagomys rufescens* (Monteiro-Leonel, 2004). Among the species of medium and large sized mammals recorded in the region, it is worth while to stand

out that some present forest habit and others which have their occurrence associated with the high altitude grasslands (Drummond, 2009). Research works demonstrated an outstanding wealth for

avifauna, Pereira & Fontes (2010) identified 275 species in the São Domingos Range Town Park (Parque Municipal da Serra de São Domingos) situated close to the urban area of the town.

6. Final remarks

The mining sector is of outstanding importance to the economic development of the country. However, the respective socioenvironmental impacts inherent to the mining operations should be evaluated, investigated and studied aiming at the decrease of the general extent of the damages.

The small and medium-sized companies, although, with less monetary power, should adopt effective practices to mitigate their environmental impacts, seeking technical support in the methodologies employed by the large-sized companies.

The social impacts generated by the bauxite mining on the Poços de Caldas plateau, most of the times are positive,

collaborating with the regional development, by means of the tax collection, creating jobs whether direct and indirect, development of environmental actions to the community and the fixing of man in his location of origin.

The impact of the bauxite mining operations upon the physical environment can be significantly negative if not mitigated correctly; generating risks of making the environmental rehabilitation processes unviable owing to the impossibility of return to the original properties of soil and water resources.

The high altitude grasslands, a great deal of times, are neglected, even as being an important phytophysiognomy of the Atlantic Forest biome, which undergoes

a high anthropic pressure, which can put in risk the regional biodiversity, generating greatly encompassing future impacts.

The scientific acknowledgement of the methods utilized for the environmental rehabilitation of mined areas both in high altitude grasslands and semideciduous seasonal forests in the region of the Poços de Caldas Plateau is undeniable. One has to work in the improving of these methods, mainly those used for the high altitude grasslands, for they are still little known. In addition, the companies should improve the publicizing of these results, sensitizing the community and making the environmental agencies more effective in the inspection of the restoration methods of these environments.

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