BIOFACTORY FOR PRESERVATION OF THE FLORA BIODIVERSITY IN IRON MINING AREAS

ABSTRACT

The plants formation, the formation of plants, are associated with the most important iron mining areas of Brazil, in many situations, are presented as unique communities because of geoecology peculiarities, resulting in high endemism, rarity and specificity. The licensing of mining enterprises depends on the technical efficiency proven to mitigate impacts of this flora. In 2015 the Vale implemented the first biofactory of the world, focused exclusively in the preservation of flora biodiversity in iron mining. Using biotechnology to obtain native species of flora on a large scale under a significantly reduced cost, especially those that are endangered and who have difficulty propagation by traditional means. In the first year it was possible to obtain plants of 550,000, comprising 88 different species of 21 botanical families. One of the highlighted species is the *Hoffmannseggella milleri*, a native orchid in superficial iron crusts, once considered extinct in the wild by the scientific community as a result of iron mining. And from individuals rediscovered in 2014 in preserved areas of the company were obtained 15,000 seedlings with high genetic diversity through seed germination in vitro, collected from mother plants in the field. In contrast to the conventional method was used, which is the division of clumps, as well as obtaining only a few dozen new plants, also the collection of these plants would be necessary in their habitats, the total cost would be changed of 2.5 times by plant. The production of native flora plants in biofactories opens up new perspectives, such as the ability of reproduction of species never before propagated by conventional means, the significant increase in the production capacity of the production units of plants, reducing costs, and, especially, increase chance of future generations have access to plants genetics resources.

KEYWORDS

Biofactory of native plants, licensing of mining enterprises, mitigate impacts of this flora, reducing costs, mining sustainability

INTRODUCTION

The Iron Quadrangle, in Brazil, is one of the main extractors regions of iron ore of the world (Rosière & Che male, 2000), and is also known for its importance in gold, topaz and emerald (Roeser & Roeser, 2013).

It occupies an area of about 7,000 km² (Dorr, 1969), and is in transition between two brazilian biomes, and hotspots, the Cerrado (Brazilian Savanna) and Atlantic Forest.

It integrates diverse backgrounds vegetables, such as fields rocks, savannas and forests, consisting also one of the main regions of high floristic diversity of South America (Giulietti et al, 1997), notable for its high degree of endemism (~ 30 %), threatened, rare, and of potential ornamental and medicinal uses (Jacobi & Carmo, 2008).

In this scenario, the pressure to impact as little as possible and mitigate the impacts of the best way, has been the technical impositions licensing of mining projects in the region. Another point is the need to reduce costs scenario that the industry has been seeking.

Thus arose the Biofactory of Native Seedling Production Center Vale S/A, founded in 2015 is the first in the world focused solely on conservation of flora biodiversity impacted by mining.
SUSTAINABLE MODEL OF RESTORATION AND REHABILITATION IN KAOLIN MINED AREAS AT CABO DE SANTO AGOSTINHO – PERNAMBUCO

ABSTRACT

Mining is fundamental to a country’s economy and contributes to creating a high quality of life for present and future generations. Developing a balanced (equal) society is crucial, but in order to achieve this, it has to be operated in a socially and environmentally responsible way, following the precepts of Sustainable Development. Many authors believe that incorporating the mining industry into these precepts (Sustainable Development) is an antagonistic challenge. As a viable solution, this article offers a case study of a consortium between mining and farming activities, contemplating the “Caulim Itapoama Mineração LTDA”, located in the city of Ipojuca - Pernambuco by the KM 12,80 of the PE-60 road. Here they carry out the extraction of aluminosilicate clay, used in the ceramic industry, along with sugar cane plantation, which is considered the Secular Economic Activity of the region. It is in this context that Operational Sustainability can be defined. The two most important industries of the primary sector of economy coexist in harmony, offering present and future generations the comfort of industrialized products and the continuity of farming in the region. The implementation of well-planned mining techniques will ensure rehabilitation of the land right after the mining itself, rendering in this case the used area to retain healthy and ready-to use soil.

KEYWORDS

Operational sustainability, Mining restoration, Kaolinite, Terrace mining, Mining and agriculture

INTRODUCTION

The mineral industry is one of the pillars of modern economy serving as basis for virtually all other industrial activities. According to Dubinski (2013), the mining industry is one of the oldest documented kinds of human activity. Brazilian economy, for example, always lied on a mining basis. First there was the gold rush in the 17th century that populated states like Minas Gerais and Mato Grosso making the contingents moves from the shore to the countryside. After that first rush we also had diamonds, silver, aluminum, copper and etcetera.

The whole construction industry is fomented by mining since it delivers the iron for siderurgy, limestone for cement production and crushed stone and sand for concrete production. It also provides all metals for production of electronics, photovoltaic cells and etcetera.

Even though the context has changed and we have a solid transformation industry, banks and also technology development enterprises, Brazilians favorable trade balance is still strongly dependent on the results of the iron industry for example.

That dependence on the mining industry goes worldwide. The cement consumption per capita, for example, is an international reference for social development. As the famous physicist Max Planck said once, Mining is not everything but without mining everything is nothing.

Mining is also a long-term enterprise that may live, between conception and extinction, many decades of even centuries. (Hartman, 2002) Divided a mining enterprise in five phases: prospection, exploration, development, exploitation and recuperation. Each of these phases are different hence their social and environmental impacts differs. It is important to know each of these phases in order to understand the impacts that can be caused due to mining activity. The first and second are previous to mining activity itself and they focus on finding a mineral deposit and define its characteristics like volume, structural and geomorphological condition and etcetera.

Prospection: uses direct and indirect methods of evaluation to define whether there is a possible deposit and if it is worth studying it furthermore. Some of these methods are air-photographs, geophysics/chemistry. Exploration: that’s when the tonnage, richness and other information of the
deposit are calculated. Through that phase invasive methods like drilling are used. The information acquired with those 2 phases are used to define whether is there economical/technical viability to proceed with the project into the 3rd phase and 4th. In Brazil economical/technical viability is summarized by the 23rd article of the Mining Code.

Development: in this phase the infrastructure needed by the project is implemented. The access roads are created, the soil, vegetation and overburden are striped and buildings are lifted so the area is ready to receive the mine operation. Also the bureaucracy needed is done. In Brazil that includes acquisition of mining rights, negotiate the terrain with the owner and get all other licenses for legal operation.

Exploitation: that when the company starts the production of minerals and all operations are done at the same time. In a general case drilling and blasting is done while pairs of truck/loader loads and transports the mined material to its destiny. The mining method is defined in order to achieve the best economical-environmental efficiency.

It’s in development and exploitation phases that the damages to environment are done. The vegetal coverage is removed with the soil, great amounts of earth are moved changing topography and contributing to air pollution. After the exhaustion of the mine (or as in some other cases along with the mining operation) the activities for recuperation of the area are implemented. Recuperation can be considered the conclusion of mining operations in a sustainable way guaranteeing the posterior use of the used area.

MINING AND ITS ENVIRONMENTAL IMPACTS

The mining industry is treated as an environmental villain for many media vehicles and lately that bad image has only been aggravated by events like the SAMARCO dam burst in Minas Gerais, Brazil, that contaminated a whole river with thousands of tons of mud killing people, fauna and flora.

The impacts that can be caused by the extraction of minerals are topographical deformation, various changes of water relations, impoverishment of soil, contamination of soil and water, gas and dust emissions, vibrations, noise, deforestation and others.

Some of them are inherent to the activity like the deforestation and topographical deformation and some of them may never happen if there is a proper planning and execution of the activities like the contamination of soil and water.

It’s also important to acknowledge that mining differs from other industries in a very important concept: Time. As minerals are a finite resource, all mining projects are conceived with the idea that it will finish its activities once those resources are no longer an asset thus the closing of an operation can be due to stagnation of the reserve or the impossibility of extracting it in an economic viable way. That fact is relevant to understand that mining damages are not like other industries. At some point the activity will necessarily stop and measures for the recuperation of the area shall take place.

One of the greatest problems on open-pit mines in Brazil, especially amongst small business, is the lack of planning or, in many cases, the bad planning. That reflects on a poor choice of mining equipment and is directly related to low productivity, high costs and wastes of resources.

Being the mining sector so important to the country, the Brazilian Environment Ministry, amongst other departments such as National Department of Mining Production and the Pernambuco’s Agency of Environment, adopted a series of management tools as mandatory for starting and operating in this sector of the economy. The effort aims to guarantee that all national operations are in conformity to legislation on production and environmental areas.

Those management tools are known by their initials as: PRAD, SLA, PCA and a few others that changes from state to state. Each one of them is related to different phase of the process.

The PRAD (planning for recovery of used areas) assures that by the beginning of the operation there already is a plan for recovering the used areas. That leaves no room for excuses like there “is no money for it”. Enterprises have no way of starting a business on mining without planning its future.

The SLA (Environmental Licensing System) is the tool the state uses for controlling the environmental impacts the project can generate prior to its occurrence. It is divided in three layers (Prior, installation and operation licenses) and are only given to projects considered environmentally viable. Though there is no straight definition of viability, it is common sense that if the negative impact of the project is small, no risk to fauna/flora in danger of extinction, the damage caused can be reversed and the community will benefit from it, the project is environmentally viable.
Brazilians laws for environmental control of mining activities are really effective but there is still a need of professionals and structure to assure that law enforcement agencies are able to properly supervise establishments and enforce the laws.

CARACTERIZATION OF THE STUDIED AREA: KAOLIN MINING OF CABO DE SANTO AGOSTINHO – PE.

The area studied is located in the Cabo de Santo Agostinho city. It is 41 Km away from the capital of Pernambuco, Recife and it is known for being the host, along with Ipojuca, of the Suape Port and Industrial Complex. Its economy relies on industry and service sectors being those alone responsible for approximately 90% of its GDP according to IBGE (Brazilian Institute of Geography and Statistics).

![Figure 1 - Mine location](image)

The region is composed by a volcanic-sedimentary sequence, Cabo Formation, where the kaolinite deposit was discovered. The proper geological knowledge of the deposit was a key point for the election of the mining method.

The kaolinite deposit in study is situated in a near-horizontal (cross-bedding) sedimentary structure composed of 3 layers. The first one is an yellow clay 50 cm thick. The second has another 50 cm of a gray clay and the third goes for 3 more meters of gray clay with siliceous sand, as can be seen in Figure 2.

![Figure 2 - Stratigraphic profile of the region](image)
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The Itapoama Mineração extracts economically both the aluminosilicate clay (the gray one) at a rate of 36,000 tons/year and 12,000 tons/year of siliceous sand. The clay is mainly selling for the ceramic industry due to its white burning property while the sand produced is destined to the Caulim do Nordeste S.A. that uses it on the construction industry, glass production and etcetera.

THE MINING OPERATION

The choice of the mining method in small enterprises in the northeast of Brazil is usually the Crater Mining. That comes from a historical use of that method in the region by quarry, granite, gypsum and others mines. Only with a proper basis on mining engineering and a careful analysis of geological data that choosing the best mining method is possible.

The Itapoama case is a singularity. The fact that the deposit of kaolinite has a cross-bedding structure and it is located in a sugar-cane plantation region obligated the company to carefully choose its mining method so the viability wouldn’t be compromised by high rent fares due to the cease of the agricultural activity while the productivity of that method achieves the company needs.

They wouldn’t be able to use the Crater Mining method since its use passes necessarily for a long term occupation of the area so and instead they chose the Striping-Mining method.

Strip mining method is a technique where mining and landscape recuperation are done ensemble. First the area is divided in benches following the structure of the ore. The soil is removed and stored for future restoration of the area. Then the overburden is removed and placed in an adjacent area that was already mined. After that the ore (in this case the kaolin) is extracted, and one cycle is finished. The operation moves to the next bench and the process is repeated.

That method is largely applied for coal mines and the machinery used are generally able to mine and transport the material at the same time like Draglines and Bucket Well Excavators (BWE). Both are designed for incessant operation so they can be used to its maximum capacity. This method achieves very high productivity with low unitary cost. The Figure 3 displays a scheme of the method.
There are a few particularities to this case in study that makes the traditional arrangement of strip mining not viable:

- The amount of ore extracted is relatively small (no more than 50,000 tons a year in total) making it impossible to pay for heavy machinery like BWE;
- The operations cease at least once a year due to rainy season;
- Ore thickness is too small and so is overburden;

With that accounted, the Itapoama arranged their operation as follows:

- The top soil is removed with a bulldozer and stored for later recomposition;
- The overburden is removed with a pair loader/truck and directly deposited on the last mined site;
- The ore is removed the same way the overburden was but transported to a storage site to be processed and sell.

The operation format can be seen on the photo that follows.
Another particularity of this case is the orebody that is almost 3 times thicker than sterile so in order to recompose the topography it is necessary to bring material from outside of the mine. The company brings a ferriferous clay from a close farm so that the recomposition is possible.

MINING INDUSTRY ON THE PRECEITS OF SUSTAINABLE DEVELOPMENT

The term “sustainability” has been widely used by all sectors of economy with many different meanings depending on perspective. In order to be accurate, this paper is guided by the definitions proposed by A. Han Onn and Alan Woodley from the Queensland University in Australia. Their research divided the mining sustainability agenda within 3 tiers.

- Tier 1: Perpetual Sustainability, which focuses on benefits to shareholders and the continuation of mining;
- Tier 2: Transferable Sustainability, which extends benefits to the broader community and environment;
- Tier 3: Transitional Sustainability, which focuses on providing intergenerational benefits to the broader community and environment, including after the completion of mining.

Their study showed that the first is an old concept where enterprises consider as results only the amount of capital that is produced ignoring completely the environment and the community (perpetual sustainability). That old and greedy administration method is evolving towards a more social/environmental friendly one where enterprises are profitable and interact in a positive way with the community.

Mining can insert itself on the 3rd tier if they work on the reduction of its negative impacts on society and environment, keeping an open channel of communication with the community and also making sure that once the deposit is exhausted their heritage won’t be minesite left as a liability. There are many different possible ways to achieve that but any of those has to start with a proper planning of the activities.

The Itapoama Mineração show that in the location it is inserted it is possible to be sustainable in a particular way. Its striping operations are done so the vegetal and the top soil are removed separately for later recomposition of the mined area. They have proper installations for maintenance of
equipment so no oil or other contaminants are spilled on the soil. The mined areas are recomposed right after extraction of the kaolinite so the posterior usage of those areas isn’t delayed.

**FINAL CONSIDERATIONS AND CONCLUSIONS**

What makes that operation a unique case is the fact that it occurs concomitant with the agroindustry. They share the area in a mutualistic relationship where the mining industry operates when the sugarcane plantation is stopped due to soil rest. The mining method chosen does the recuperation of the mined area along with the extraction of the kaolinite and allows agriculture to take place right after the operations. It is also important to take into consideration that the exchange of an aluminosilicatic clay for a ferriferous achieves an increase in saccharose concentration. According (Vasconcelos & Garcia, 2005) that happens because the Al³⁺, that is abundant on the kaolinite, reduces the development of sugar-cane roots. On the other hand the recomposition clay used is rich in Fe³⁺ that aids on formation of chlorophyll.

The main concept of operational sustainability is the constant reduce of resources use along with increase of productivity. In this case it was achieved by the correct election of the mining method. The use of the terrace mining method allows the process to be more efficient reducing the carbon footprint (by reducing transport distance and fuel use), the area needed for operations (since there is no need for a wastedump) and restoring the used land right after the mining activity giving it an immediate after use and reducing the landscape impact.

As a consequence of operational sustainability, in this case, that operation is also inserted on the 3rd tier (Transitional Sustainability) granting jobs for local community while the agroindustry is stopped and ensuring the continued use of mined areas providing a better condition for sugar-cane plantation with higher productivity making local agroindustry stronger with higher possibility to survive in the Brazilian competitive market. The Itapoama Mineração ensures an efficient production and delivers a series of benefits for the next generations of people that will depend on the mined area and local economy.

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