GEOTemas, Pau dos Ferros, RN, Brasil
ISSN: 2236-255X, v. 11, 2021.

KAOLIN MINERAL EXTRACTION: LEGISLATION, PRODUCTION PROCESS AND ENVIRONMENTAL IMPACTS

Extração mineral de caulim: legislação, processo produtivo e impactos ambientais

Extracción de Kaolín: legislación, proceso de producción e impactos ambientales

Edmar do Nascimento SILVA – Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Norte (IFRN).
ORCID ID: https://orcid.org/0000-0002-7026-1674.
URL: http://lattes.cnpq.br/3855651448901980
EMAIL: edmarpmpb@gmail.com

Ilton Araújo SOARES – Laboratório de Estudos Costeiros e Áreas Protegidas (LECAP) UERN.*ORCID ID*: https://orcid.org/0000-0002-9130-9622.
URL: http://lattes.cnpq.br/5597018927711691
EMAIL: iltonet@yahoo.com.br

Article History
Reveived: 14 september 2021
Accepted: 09 november 2021
Published: 19 november 2021

SUMMARY

This article aimed to analyze the legal aspects and identify the main adverse environmental impacts of kaolin mining activity. The search was held in the municipality of Junco do Seridó, located in the state of Paraíba. Initially, through a bibliographic review, we sought to know important concepts related to environmental impacts. Then, a consultation was carried out with the Laws and Decrees in force in Brazil that govern the mineral economic activity and compared with the existing reality in the study area, through procedural searches of the companies operating in the municipality, carried out on the website of the National Mining Agency. The research showed the discrepancy between the rigor of current legislation and the existing reality in kaolin mineral exploration in the municipality of Junco do Seridó, since most companies do not have an environmental license. The following adverse environmental impacts were identified: landscape degradation, air pollution, soil erosion and contamination, and reduction of local biodiversity. Regarding the production process, some beneficial practices were observed that are being adopted by companies, such as the replacement of wood ovens by open air dryers and the reuse of all the water used in kaolin processing. The only waste produced and which is a worrying environmental liability is the mineral waste that is available in heaps close to the processing units and their exploration territories. Finally, in order to mitigate the identified impacts, it is necessary to obtain environmental licensing for mining companies and to draw up and execute monitoring and recovery plans for degraded areas.

Key words: Kaolin production; Mining; Ambiental degradation; Junco do Seridó.

RESUMO

Este artigo teve como objetivo analisar os aspectos legais e identificar os principais impactos ambientais adversos da atividade mineradora de caulim. A pesquisa foi realizada no município de Junco do Seridó, localizado no estado da Paraíba. Inicialmente, por meio de uma revisão bibliográfica, buscou-se conhecer conceitos importantes relacionados a impactos ambientais. Em seguida foi realizada uma consulta às Leis e Decretos em vigor no Brasil que regem a atividade econômica mineral e comparada com a realidade existente na área de estudo, através de buscas processuais das empresas atuantes no município, realizadas no site da Agência Nacional de Mineração. A pesquisa evidenciou a discrepância entre a rigorosidade da legislação vigente e a realidade existente na exploração mineral de caulim no município de Junco do Seridó, visto que a maioria das empresas não tem licença ambiental. Foram identificados os seguintes impactos ambientais adversos: degradação da paisagem, poluição do ar, erosão e contaminação do solo e redução da biodiversidade local. Em relação ao processo de produção, observaram-se algumas práticas benéficas que estão sendo adotadas pelas empresas, como a substituição dos fornos de lenha pelos secadores a céu aberto e o reaproveitamento de toda água utilizada no beneficiamento do caulim. O único rejeito produzido e que é um passivo ambiental preocupante é o rejeito mineral que fica a disposição em montes próximos às unidades de beneficiamento e seus territórios de exploração. Por fim, para mitigação dos impactos identificados torna-se necessário o licenciamento ambiental das empresas de mineração e a elaboração e execução de planos de monitoramento e recuperação de áreas degradadas.

Palavras-chave: Produção de caulim; Mineração; Degradação ambiental; Junco do Seridó.

RESUMEN

Este artículo tuvo como objetivo analizar los aspectos legales e identificar los principales impactos ambientales adversos de la actividad minera del caolín. La investigación se realizó en el municipio de Junco do Seridó, ubicado en el estado de Paraíba. Inicialmente, mediante una revisión de la literatura, buscamos conocer conceptos importantes relacionados con los impactos ambientales. Luego, se consultaron las Leyes y Decretos vigentes en Brasil que rigen la actividad económica minera y se compararon con la realidad existente en el área de estudio, mediante búsquedas procesales de las empresas que operan en el municipio, realizadas en el sitio web de la Agencia Nacional de Minería. La investigación evidenció la discrepancia entre el rigor de la legislación vigente y la realidad existente en la exploración minera de caolín en el municipio de Junco do Seridó, ya que la mayoría de las empresas no cuentan con licencia ambiental. Se identificaron los siguientes impactos ambientales adversos: degradación del paisaje, contaminación del aire, erosión y contaminación del suelo y reducción de la biodiversidad local. En relación al proceso productivo, hubo algunas prácticas beneficiosas que están adoptando las empresas, como la sustitución de los hornos de leña por secadores al aire libre y la reutilización de toda el agua utilizada para el procesamiento del caolín. Los únicos relaves que se producen y que son un pasivo ambiental preocupante son los relaves minerales que están disponibles en pilas cerca de las unidades de procesamiento y sus territorios de exploración. Finalmente, para mitigar los impactos identificados, es necesario obtener licencias ambientales para las empresas mineras y elaborar e implementar planes de monitoreo y recuperación de áreas degradadas.

Palabras-clave: Producción de caolín; Minería; Degradación ambiental; Junco do Seridó.

1 INTRODUCTION

The main problems that occur in natural ecosystems are related to anthropic actions that exploit certain areas, modifying the landscapes for the extraction of mineral and biological resources. These explorations usually occur on a large scale, causing serious damage to the existing natural biotic and abiotic relationships, causing adverse environmental impacts, causing the suppression or insertion of certain elements in the environment, or even overload - stress factors beyond the support capacity of the environment - that generates imbalances (SÁNCHEZ, 2008).

One of the economic activities that cause the most negative environmental impacts is mining. The National Water Agency - ANA, mentions that technological knowledge is available, that there are solutions to minimize or compensate for environmental losses, however, what makes these actions difficult are the numerous projects without control or with precarious environmental control (ANA, 2006). According to Dias (1999, p. 154) “[...] the potential negative environmental impacts of the Non-Metallic Minerals Industry are related to atmospheric and water emissions and the generation of waste and noise in manufacturing plants, which can cause pollution of air, water and soil [...]”.

It is important to point out that, even causing numerous environmental impacts, the extraction of minerals is governed by a strict set of Laws and Decrees that regulate economic activity, as well as there are bodies responsible for issuing environmental licenses, selection and availability of areas that can be used in mineral extraction plants, as well as regulation and inspection of these areas and companies so that they can follow sustainable exploration models, helping in the development of mitigating actions to reduce these negative impacts and punishing those who violate these sets of rules in accordance with current legislation.

Chaves and Silva (2016, p. 46) make an important reflection on the 2030 National Mining Plan and highlight the need to move away from an extractive model towards a model that seeks:

> [...] to reduce regional inequalities and increase domestic consumption of mineral resources, through investments in the manufacturing industry and knowledge and research focused on boosting the economy, associated with better income distribution. Another point is how to resolve conflicts arising from the impacts of large projects, which we will resolve in the export problem, but leaving aside the chronic problems of the lack of technology policy applied to the region and its society.

Silva (2017) explains that mineral extraction activities must be based on the precepts of sustainable development, since economic growth must be aligned with the preservation, conservation, restoration and maintenance of biological diversity. The term Sustainable Development can be defined as that capable of meeting the needs of the current generation, without compromising the ability to meet the needs of future generations (BRUNDTLAND, 1987).

Kaolin[1] represents great importance in the economic scenario. In 2013 there was a small drop in Brazilian production compared to 2012, however, Brazil remained in 5th position in the world ranking and growth prospects were 3.3% per year until 2017 in kaolin production. The domestic market of our country absorbs kaolin both for the production of cement and for the production of white ceramics and paper (DNPM, 2014). For the municipality of Junco do Seridó, kaolin mining is the most important activity, as it employs local labor. Due to its chemical and physical properties, kaolin is applied in various types of products, highlighting the use in the manufacture of common and coated papers, as well as in ceramics and refractories (SILVEIRA, 2016).

In the studies carried out by Vila Nova et. al (2019), between the municipalities of Ecuador - RN and Junco do Seridó - PB, it was possible to identify numerous impacts caused by anthropic activities related to mining, highlighting abandoned areas providing an increase in erosion processes, large depositions of tailings by active extraction units , identification of clandestine mines and large-scale loss of native biodiversity in the region.

These clandestine units highlighted by Vila Nova et. al (2019) may be one of the causes cited by Santana (2017), when describing that the existing kaolin deposits in the Borborema-Seridó province are often exploited without any specialized monitoring, without studies of the site for the development of mines, not seeking not even knowing the geology of formation of deposits in the region, which makes it difficult, according to the author, the correct use of mining and processing technologies, causing numerous problems, including significant losses of kaolinite.

This work is justified by the importance of knowing the economic activity in the region and what has been practiced by mining companies in relation to extractivism versus the environment, since in the Borborema region, in the State of Paraíba, the municipality of Junco do Seridó is one of the main producers of kaolin.

Identifying the legality of companies and the negative impacts caused by economic activity are of paramount importance so that effective mitigating actions can introduce sustainable environmental practices and proper management of waste produced.

[1] “This terminology is used both to designate the rock that contains kaolinite and other associated minerals (muscovite, feldspar and quartz), and the product generated in the industrial processing stages of the ore” (AZEVEDO, 2019).

In this sense, the objective of this research was to analyze the legal aspects and identify the main adverse environmental impacts of the kaolin mining activity.

2 KAOLIN PRODUCTION PROCESS AND ENVIRONMENTAL IMPACTS

It is often difficult to distinguish differences between environmental impacts, environmental degradation and environmental aspects. Degradation is something that is contained in environmental impact and refers to something concentrated in a purely negative sphere, unlike environmental impact, which has a broader, more comprehensive meaning, involving aspects that can be positive or negative, according to Sánchez (2008) . The environmental aspect, according to the same author, does not directly refer to impact, however, the impact is a consequence of an environmental aspect.

Sánchez (2008), defines environmental impact as a change caused by human action, which can have beneficial or adverse changes. As for the environmental aspect, for the same author, it can be understood as a mechanism through which anthropic actions cause an environmental impact, and environmental degradation as being an adverse alteration of the environmental quality – just a negative effect – corresponding to a negative environmental impact. According to ANA (2006), no matter how efficient a mining project is and executed with a strict environmental control system, it becomes aggressive and highlights that the most common term for the impacts generated by surface mining is “destruction”.

When it comes to discussing the environmental impacts of kaolin mineral extraction, it is important to understand the difference between environmental aspects and environmental impacts. Deforestation, opening of galleries, extraction of sedimentary material, consumption of water for processing, emission of gases and particulate matter (PM) into the atmosphere, emission of noise, emission of waste, are environmental aspects related to economic activity, anthropic action. Reduction of native vegetation, extinction of local fauna and flora species, deterioration of air quality, soil contamination by waste, contamination of springs, rivers and groundwater, inconvenience to residents caused by the constant circulation of trucks and heavy machinery, are factors considered negative environmental impacts.

Another worrying fact highlighted in studies carried out by the authors Ndagijimana, Pareyn and Riegelhaupt (2015) in the states of Paraíba and Ceará refers to deforestation. According to these authors, 56% of the firewood extracted in the State of Paraíba alone is the result of illegal deforestation and only 13.9% comes from forest management. Only 1.2% of the woody material extracted comes from authorizations for the suppression of vegetation (ASV) and 28.9% attributed to the extraction of mesquite trees, pruning of fruit trees and residues. In kaolin processing, the use of firewood is the main energy source used by miners in ovens to dry the product.

These data refer to the reduction of local biodiversity, which has the installation of kaolin extraction units as an aggravating factor. Human activities are the ones that most interfere with the most diverse components of the earth, bringing a series of harmful effects to the balance of ecosystems, mainly the reduction of habitats, interruption of gene flow corridors and deaths of several species of terrestrial and aquatic fauna and flora, often leading them to extinction (MECHI and SANCHES, 2010). For Freeland (2005), human lives have been claimed due to the enormous damage caused by the bad use of the soil.

Referring to soils, we have the aggravating factor of erosion, caused by the opening of galleries. In the definition of Florenzano (2008), erosion is the best known form of degradation, being the removal and transport of weathered materials. Silva (2017) adds that the chemical and physical deterioration of the soil directly promotes the formation of degraded areas. Moreira (2004) defines degraded areas as being natural extensions that have suffered disturbances and thus lost their productive capacity, and may not recover their ecosystem functions.

Mining effluents are another concern. According to Feng and Aldrich (2004), mine effluents have a cloudy appearance and small particles, which makes treatment difficult, not indicating disposal in rivers or lakes. Aguiar, Novaes and Guarino (2002) point out that these effluents generate negative impacts, both in the trophic chain and for humans, since they contain heavy metals that reduce the self-purifying capacity of the waters exerted by the microorganisms existing in these habitats, due to their toxic action. Lima (2010) stresses that these contaminants may contain high concentrations of metals such as Iron (Fe), Aluminum (Al), Zinc (Zn) and Cadmium (Cd). Therefore, the quality of the effluent released into the environment is of fundamental importance. In the processing of Kaolin, water recycling needs studies to determine whether there is an impact on whiteness[2] (ANA, 2006).

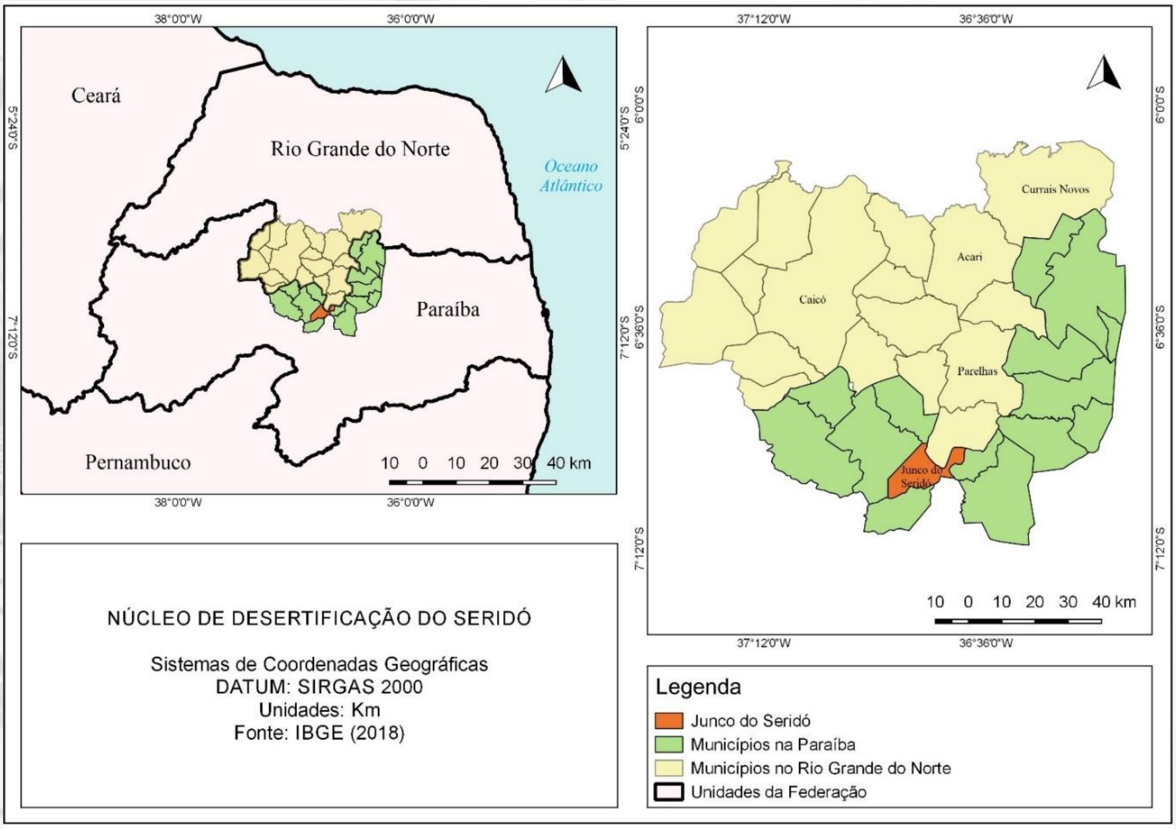
[2] "Property of measuring the reflectance of kaolin, through devices such as the ZE (Zeis Elrepho), the Photovolt and the GE/Reflectometer" (COELHO, 2019).

3 MATERIALS AND METHODS

3.1 Characterization of the study area

The Seridó Desertification Nucleus, a name that emerged through the studies of Vasconcelos Sobrinho (1971), is located between the states of Rio Grande do Norte and Paraíba, covering 32 municipalities (LIMA, 2017), among which is the municipality of Junco do Seridó, the location chosen for carrying out the studies and which is located in the state of Paraíba, as we can see in figure 01.

Figure 01 – Seridó Desertification Center - RN/PB



Source: Prepared by the authors (2021).

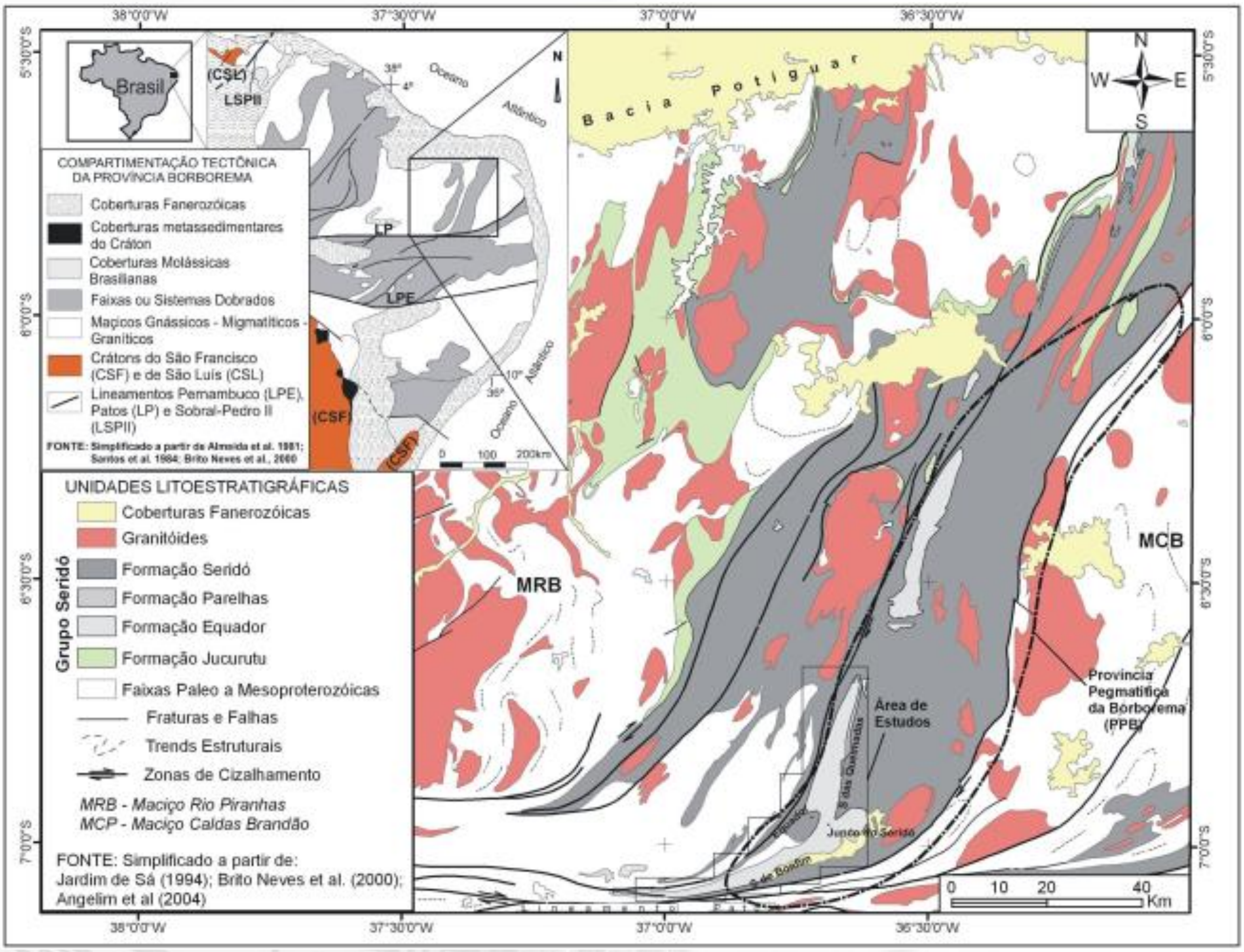
Oliveira (2019), points out that there is a tendency of medium to severe risk with regard to desertification in this nucleus and that this process is the product of a construction social, anthropic and historical with the mining process, since there is a intensification of the exploitation of natural resources from the mid-twentieth century onwards. Perez-Marin et. al (2012) emphasize that one of the main reasons that aggravate the processes of desertification in this core are anthropic actions. Lima (2017) points out that Junco do Seridó has more than 30% of rural properties smaller than the fiscal module and that, the owners do not use sustainable land management practices, in addition, these areas do not offer minimum conditions of sustenance of families, causing depletion of natural resources, especially soil and vegetation.

Junco do Seridó is a municipality of 7,195 inhabitants – estimated population for 2020 – (IBGE, 2020), located in the Western Seridó of Paraíba, with a territory of 180,425 km2, located at an altitude of 590 meters in relation to sea level, with the aim of geographic coordinates latitude 6° 59' 41” South and longitude 36° 42' 41” West. According to the Köppen classification, the municipality has a Warm Semi-Arid climate - BSh with average annual temperatures of 22.3 °C and average monthly rainfall of 43.5 mm, that is, below 800 mm per year. The months with the highest rainfall are from February to May, with rainfall between 90 and 150 mm, a period that coincides with the summer rains provided by the BSh climate (ALVARES, et. al, 2013).

This Region is highlighted by Ferreira (2003) as an area of occurrence of pegmatites, with homogeneous, heterogeneous and mixed pegmatites being found. Santana (2017) emphasizes that the kaolin deposits that occur between the municipalities of Junco do Seridó - PB and Ecuador - RN, are associated with alterations of feldspars in pegmatites. Most of the Northeast Pegmatite Province is located in Seridó, between the states of Paraíba and Rio Grande do Norte (OLIVEIRA, 2019). These pegmatites, according to Santana (2017), extend over an area of approximately 11,250 km2, in the southeast of the Seridó folding belt. This range can be better understood through studies by Silva and Crósta (2011), as shown in figure 02.

The predominant vegetation is from the Caatinga biome, being one of the 195 municipalities, out of a total of 223 existing in the State of Paraíba, which are part of the new delimitation of the Brazilian semi-arid region (SUDENE, 2017). The vegetation is divided into primary (natural), composed of shrub forests, many of which have thorns, microphyly and xerophytic characteristics, and secondary (anthropized), found in extensive areas that suffer from human action (LIMA, 2017), either by practice agriculture, livestock or mineral extraction.

Figure 02 – Location of the Borborema Pegmatitic Province



Source: Silva and Crósta (2011).

The economy of the municipality is directly linked to mining, mainly kaolin, representing for the economy of the municipality between 50% and 75%, followed by the secondary sector, 20 to 40% and finally, the tertiary sector, representing from five to 25% (IBGE, 2010).

3.2 Methodological procedures

The methodological course of this research took place from the following stages:

a) Documentary and literature review - Searches were carried out in the administrative processes of each company, through the processes tab of the National Mining Agency - ANM website, whose protocol unit for obtaining data was 48415 - Paraíba, specifically the municipality of Junco do Seridó, also highlighting as superintendence, the

PB regional management. For an even more specific study, the substance Kaolin was selected, the type of industrial use, seeking all procedural phases in an active situation. Documents and databases from bodies such as the National Water Agency - ANA, the National Mining Agency - ANM, the Brazilian Institute of Geography and Statistics - IBGE and the Cooperative of Miners of the Municipalities of the Regions Seridó, Cariri and Curimataú da Paraíba Ltda. - COOPERJUNCO.

b) Field research – The initial purpose of the research was to visit all the kaolin mining companies located in the municipality of Junco do Seridó. However, during field research, only one allowed entry for an on-site visit, data collection and photographic record.

c) Interview – A semi-structured questionnaire was prepared and an on-site visit was made to all companies in the municipality, but all refused to answer the proposed questionnaire. However, one company agreed to show the production process and the production of some images without being identified. Faced with this refusal, we sought to understand the reasons and started to analyze the database of the National Mining Agency - ANM and current legislation.

4 ANALYSIS AND DISCUSSION OF THE RESULTS

4.1 Mineral exploration and legislation

First we need to understand some concepts. A company in the research authorization phase is not suitable for economic exploitation, it has only received the right to carry out studies in the area. According to the Federal Government's website (https://www.gov.br/pt-br/servicos/obter-autorizacao-de-pesquisa-mineral), the Request for Research Authorization “claims authorization for mineral research, in which works to define the deposit, its evaluation and the determination of the feasibility of its economic use” (BRASIL, 2020). The Research Request precedes the Research Authorization, being the phase in which authorization is requested to carry out studies in the area. This research authorization cannot be less than one year or more than three years, according to Decree No. 9,406, of June 12, 2018, highlighted in its Art. 21 (BRAZIL,

It was observed that, of the 36 companies that operate in the municipality, according to ANM data, four are in the mining application phase and one in the Right to Request Mining. The others, five are in the research application phase and 26 with research authorization. These companies, even though they are not fully legalized, have been mining in the municipality for years, which may explain the fact that none of those responsible for the companies wanted to answer the questionnaire, since one of the questions was to seek information about the stage of the process. at ANM for licensing the company, and for economic exploitation to take place, Decree-Law no. 227, of February 28, 1967 in its Art. 37, Item I, highlights that “the deposit must be surveyed, with the report approved by the DNPM” (BRASIL, 1967).

Decree No. 9406 of June 12, 2018, also highlights in its Art. 28 that “once the final research report is approved, the holder will have one year to apply for the mining concession and, in this case, he will be able to negotiate the mining right” (BRASIL, 2018). This report is developed and filed with the ANM after the area's research period (one to three years). The five companies existing in the municipality that have already filed an application for a mining concession have already passed this study phase and had their research report approved by the ANM. However, Law No. 7805 of July 18, 1989, in its Art. 1st, Sole Paragraph highlights:

> For the purposes of this Law, the mining permission regime is the immediate use of a mineral deposit that, due to its nature, size, location and economic use, **can be mined, regardless of previous research work** (emphasis added), according to criteria set by the National Department of Mineral Production – DNPM (BRASIL, 1989, emphasis added).

Observing carefully, a contradiction is perceived, since, in that same Law, it is described in its Articles 3, 13 and 16 that, “the granting of mining permission depends on prior environmental licensing granted by the competent environmental agency”. This environmental licensing is regulated by the National Council for the Environment – CONAMA, in accordance with Resolution 237/1997. That same resolution, in its Annex 1, defines mining activities as extraction, treatment, research with a user guide, open pit and underground mining, with or without processing and prospecting mining as subject to Environmental Licensing (CONAMA, 1997).

Of the five kaolin mining companies in the municipality of Junco do Seridó that filed a Mining Request, two have already filed the Environmental Licensing, that is, they obtained the Environmental Licensing and filed with the ANM to receive the right to request mining. Of the two companies, one is able to apply for mining rights, since the Environmental Licensing is a requirement of the administrative process at ANM. The other three companies that filed a mining application will still go through the environmental licensing requirement.

This shows that none of the companies operating in the municipality would be able to exploit kaolin.

The position highlighted in the article cited below, refers to a device in Law No. 7,805, which may be directly influencing the reality of the municipality of Junco do Seridó with regard to kaolin mining and reinforces what has already been highlighted in its Art. 1, Sole paragraph, described in its Art. 14:

> Art. 14. **Priority is assured to mining cooperatives for obtaining authorization or concession for research and mining in the areas where they are operating** (emphasis added) provided that the occupation has occurred in the following cases:
> I - in areas considered free, under the terms of Decree-Law No. 227, of February 28, 1967;
> II - in areas required with priority, until the entry into force of this Law,
> III - in areas where they hold mining permits.
> § 1 The cooperative will prove, when necessary, the previous exercise of mining in the area.
> § 2 The National Department of Mineral Production - DNPM will promote the delimitation of the area and propose its regulation in the form of this Law (BRASIL, 1989, emphasis added).

With that, we cannot say that these companies act irregularly, as we do not have access to documents that can demonstrate that these areas that are being explored are free areas, required with priority, that they already have mining rights or that the Cooperative has proved to ANM that all its associates, including the Cooperative itself, are working in areas that were previously explored, since neither the Cooperative nor the acting companies responded to the research form of this study.

The 36 companies that operate in the municipality economically explore an area of 12,329.66 hectares, according to data collected from each company through consultation of processes in the ANM database. It is worth noting that, for the ANM, this entire area is still in the research phase. Only four companies have their own exploration area, the others operate on third-party properties. According to data from COOPERJUNCO, these companies employ an average of eight employees and the daily production of processed kaolin reaches 1,440 tons, an average of 40 tons/day per company.

Another detail provided for in Decree No. 9,406, of June 12, 2018, is found in its Art. 29:

> After the period referred to in Art. 26 without the holder or his successor having applied for a mining concession, his right will expire and it will be up to the ANM to declare, through a public notice, the availability of the

> researched deposit, for the purposes of requesting a mining concession (BRASIL, 2018).

We have legislation that repeatedly emphasizes the legal conditions for mineral exploration in a given area, however, the inspections in the research phase do not occur satisfactorily, since the applicant, upon having the research authorization, immediately begins the illegal exploration of the area, waiting for the mining concession phase and, as this research needs one to three years, when it reaches the concession phase, the process is allowed to lapse, the ANM releases the area for availability through a public notice and the installed company abandons the area leaving for another location, configuring the clandestine and abandoned units highlighted by Vila Nova:

> it can be seen that mining in this region causes a great loss of biodiversity due to the destruction of vegetation, where these mines are often abandoned and are left in the open, increasing the erosion process. With this, it is necessary to map the extraction zones so that you can have control over the growth of the mine or the company in the place and also for the monitoring of clandestine mines (VILA NOVA et.al, 2019, p.255).

With regard to the mineral waste produced, Art. 6o-A of Law No. 14,066, of September 30, 2020, mentions that it is the responsibility of the concession holder until the closure of the mine. The same Law, still in its Art. 6-A, Sole Paragraph, mentions that:

> The exercise of mining activity includes:
> I - the responsibility of the miner for the prevention, mitigation and compensation of the environmental impacts arising from this activity, including those related to the well-being of the communities involved and the sustainable development in the vicinity of the mine;
> II - the preservation of workers' health and safety;
> III - the prevention of environmental disasters, including the preparation and implementation of the contingency plan or related document; and
> IV - the environmental recovery of the impacted areas (BRASIL, 2020).

We observe that the current legislation always highlights the necessary legal paths for mineral exploration, as well as emphasizes the responsibility of the miner with regard to the impacts resulting from the extractive activity, however the reality observed in the field differs in many aspects and it is clear the lack of inspection by Organs competent bodies to contain and require these companies to take mitigating actions that minimize the negative impacts caused in the region of the municipality of Junco do Seridó.

4.2 Kaolin production process

Even though it was not possible to obtain more precise data through the application of a research form, one company allowed to show the production process of a kaolin processing unit. With all this amount of processed kaolin produced by these companies, as previously mentioned, one can predict the negative impacts that these companies have been causing to the environment in general.

We can see in figure 3, the change in the environment caused by anthropic actions through companies and prospectors that work in the municipality. Garimpeiros often act independently, extracting raw kaolin from their private properties and selling it to processors (companies). Clearly visible negative impacts in relation to the local native vegetation and the soil, where we can see accentuated erosion processes, disposal of tailings, openings of pits for the extraction of raw kaolin, vegetation suppression and the proximity of rural residences.

These caves mentioned above are called galleries by local miners when the extraction takes place in the surface layers of soil in a given area, as we can see in figure 03, or stools, when the mineral extraction takes place underground, in which the raw kaolin extracted is transported to the surface by small handmade elevators built by the miners themselves, called shells by them.

These stools resemble anthills, with a small opening on the surface of the ground and huge underground halls where excavations take place. The shells are installed on the surface, next to the opening of the stool.

Figure 03 - Site of mineral extraction of kaolin on the surface

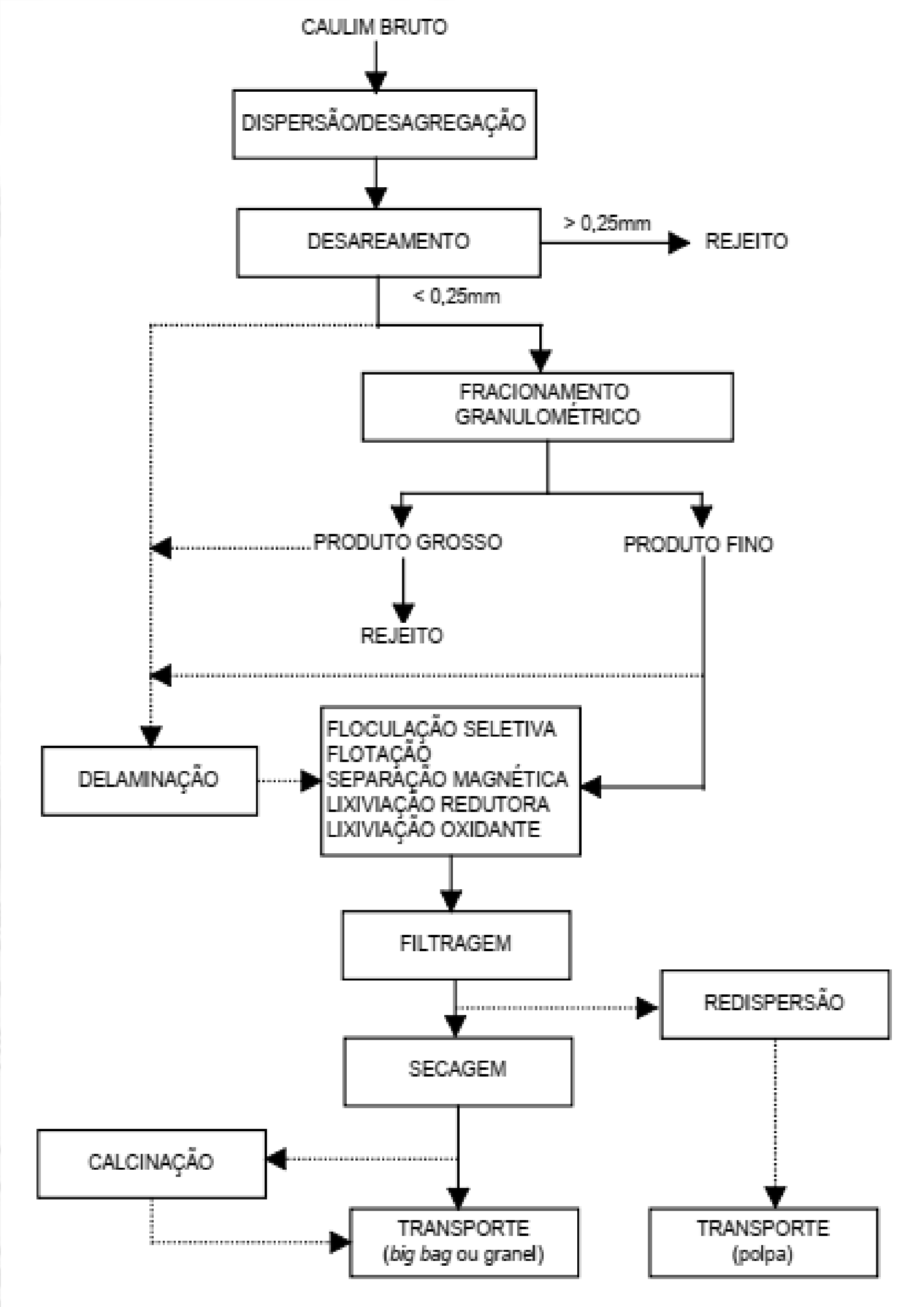
Source: Images obtained by the author (2021).

All companies located in the municipality work with the wet method, a method that involves water throughout the processing process, from dispersion/disaggregation to the presses, producing a pulp that passes through meshes and flocculation and decantation tanks to reach the granulometry and desired purity (LUZ et. al, 2005), as we can better understand in the processing flowchart (Figure 04). Dry process, according to COOPERJUNCO, only occurs in companies that use kaolin waste to produce grout[3] The dry process is more expensive in terms of installing the kaolin processing and beneficiation plant, however less impact on the environment, as there is greater use of kaolin during the separation of the mineral aggregates that make up the raw kaolin.

It is important to highlight that not all companies operating in the municipality follow the flowchart shown above. The magnetic separation, reductive leaching and oxidizing leaching phases are only carried out by companies that sell processed kaolin to companies that produce paints, kaolin produced without any impurities and very white, these being the companies that have greater investments in machinery and equipment.

[3] "Product based on pozzolamic material, aluminous silica, calcium hydroxide, fine aggregates, inorganic binders in a thickness of 1.0 cm" (RIBEIRO, et. al, 2019).

Figure 04 - Kaolin processing flowchart by wet process



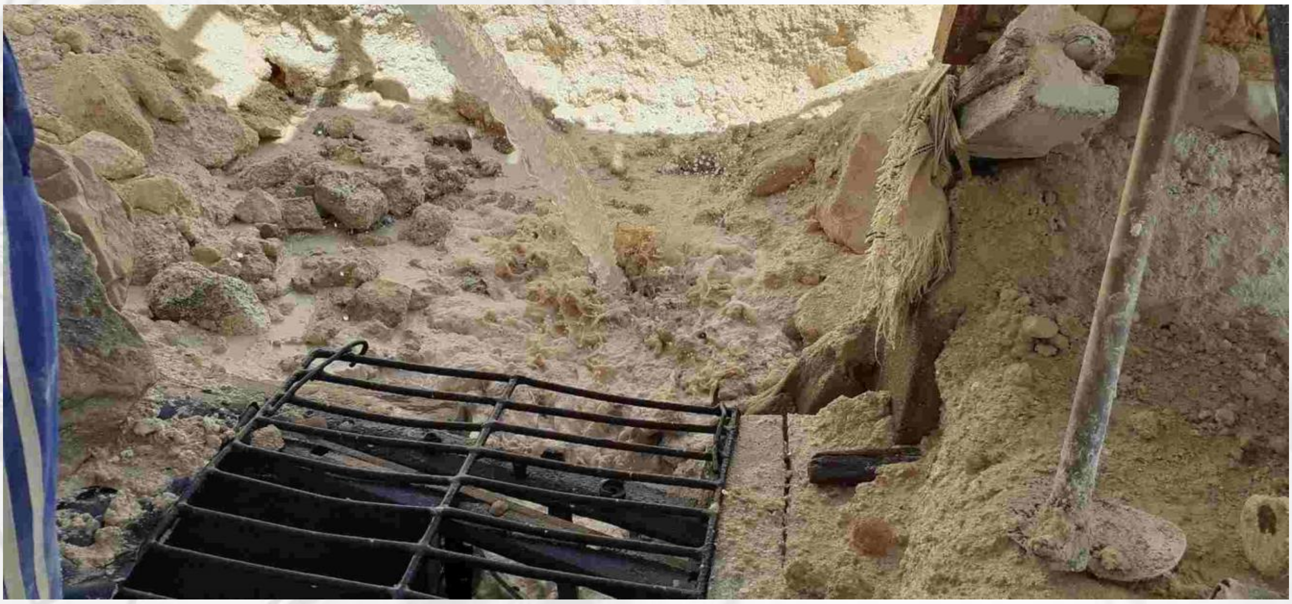
Source: Luz et. al (2005).

Dry processing is simpler, where the raw kaolin is fragmented in crushers and taken for drying in rotary dryers. This drying is necessary, because even without using water in the processing process, the raw kaolin arrives wet at these units. After drying, the kaolin undergoes a spraying process on rollers for subsequent granulometric classification, which process is called air flotation. This type of processing is only possible when the whiteness and granulometric distribution of the raw kaolin are suitable for the process (LUZ et. al, 2005), which does not occur in the study area of this research.

This waste highlighted in the previous paragraph comes from the first cut, when the raw kaolin passes through the first mesh. According to the flowchart, it is the waste produced in the coarse product phase. This waste corresponds to five to 10% of the total waste and only this is used in the production of sealing blocks (REZENDE, 2007), alkaline activation (BURKHARD, 2018), white ceramics (NOBRE E ACCHAR, 2010), production of ecological paint (SOUZA, et. al, 2019), composition in the manufacture of red ceramics (ARAÚJO, COSTA and DANTAS, 2019).

In the dispersion/disaggregation phase (Figure 05) and desanding (Figure 06) the first waste is produced, which has no use and is accumulated around the processing units (Figures 07, 08 and 09).

Figure 05 - Dispersion/Disaggregation



Source: Images obtained by the author (2021).

The waste produced by the other stages of processing is accumulated near the companies, creating an environmental liability. We can see in figure 08, at the bottom of the image, the shrubby vegetation trying to stand out in the oldest deposits of tailings. The 90-95% of the tailings, which are not commercialized, do not have a defined destination, being piled up near the processing units or in areas belonging to the companies, directly affecting the soil, vegetation and increasing air pollution by the dispersion of particulate matter.

Figure 06 - Desiring

Source: Images obtained by the author (2021).

Figure 07 - Waste produced

Source: Images obtained by the author (2021).

It can be seen in figure 8 that even in a small unit it is possible to produce large volumes of tailings and that all the organization of the heaps is done by backhoe machines, as we can also see in the same image on the right (highlighted). They are true mountains that form over the years, directly impacting the local environment.

Figure 08 - Disposal of tailings in a small processing unit

Source: Images obtained by the author (2021).

Figure 09 - Disposal of tailings on private properties

Source: Images obtained by the author (2021).

After desanding (Figure 06), the raw kaolin and water mixture goes through the granulometry phase (Figure 10), so that the flocculation and decantation tanks can receive a refined material, close to kaolin, with the characteristics that one wants to achieve and commercialize, that is, with the highest degree of purity and desired granulometry. In this phase, the aforementioned mixture passes through meshes so that other compounds such as quartz, mica and iron oxides with granulometry above 0.25 mm can be removed (LUZ et. al, 2005).

Figure 10 - Granulometry

Source: Images obtained by the author (2021).

In the flocculation and sedimentation phase (Figure 11), part of the water and the suspended compounds return to the dispersion/disaggregation phase and the decanted part again passes through finer meshes, thus achieving the desired characteristics, whose gum already goes to the press tanks.

Figure 11 - Flocculation and sedimentation

Source: Images obtained by the author (2021).

The gum tanks for the press receive the ready-made pulp to be sent to the presses. This pulp already has the desired granulometry and purity. Just below we can see how these tanks are, very similar to the flocculation and sedimentation tanks (Figure 12).

Figure 12 - Gum tanks for presses

Source: Images obtained by the author (2021).

Figure 13 - Presses

Source: Images obtained by the author (2021).

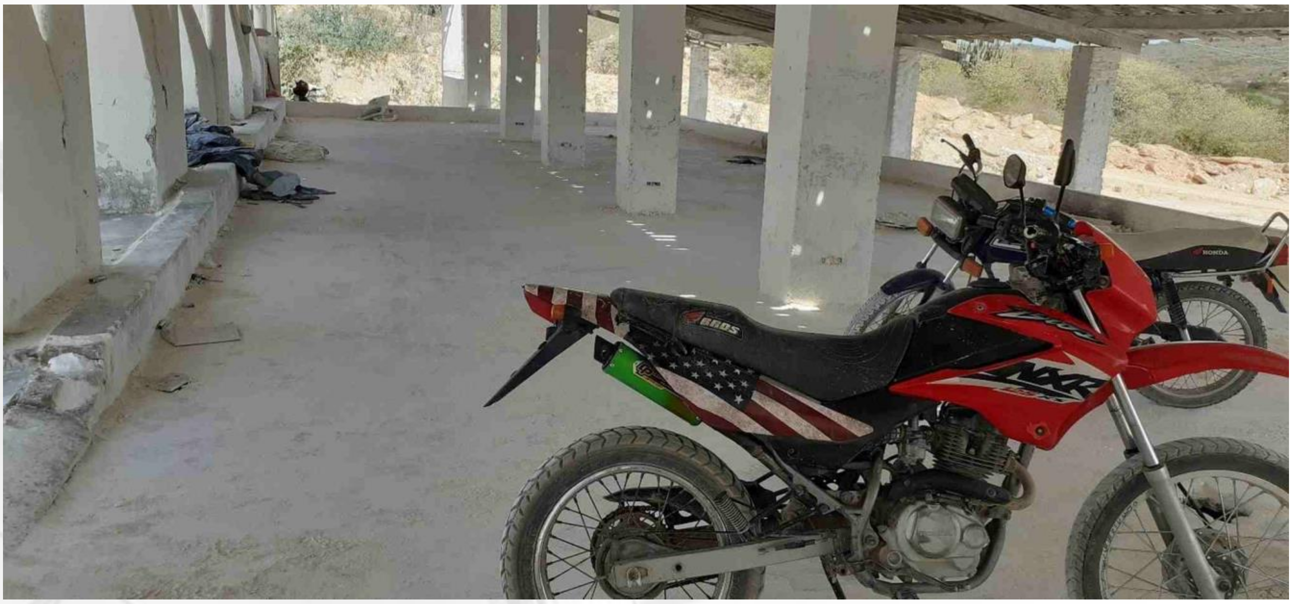
After the pulp arrives at the final tank, the starch tank for the press (Figure 13), the presses receive this pulp to remove as much moisture as possible, so that the cakes that will go on to the drying process are formed (Figure 14). The cakes are shaped like pressed kaolin disks, with a low moisture content at this stage. These disks are transported in carts to the dryers and placed on shelves so that all moisture is eliminated by wind action and solar radiation, making the product ready for sale, in disks or ground.

Figure 14 - Outdoor dryers

Source: Images obtained by the author (2021).

After pressing and forming the cakes, the drying process begins. The companies in the municipality do not sell pulp, only dried kaolin, a product obtained by drying in outdoor dryers (Figure 14). Not to be confused with dry processing, which is another process as previously defined, not used by any company operating in the municipality of Junco do Seridó. This drying process dispenses with wood-fired ovens (Figure 15), a way to minimize inspections due to the reduction of vegetation suppression for firewood consumption. Vegetation suppression for opening areas for kaolin extraction is something evident and that generates many negative impacts, as previously observed.

Figure 15 - Deactivated oven



Source: Images obtained by the author (2021).

Regarding the water used in wet processing, this is obtained from artesian wells or pumped from extraction galleries, however, nothing is wasted during the cycle. When arriving at the presses, the last wet phase before drying, the remaining water also returns to the dispersion/disaggregation phase through pumping, since most companies use slopes to build processing units so that the production process of the phase from dispersion/disaggregation until the press stage takes place by gravity. The only loss of water in the process occurs through natural evaporation, when the kaolin gum is found in the tanks in the decanting process.

We can also highlight the transport of raw and processed kaolin by trucks, which frequently circulate on rural roads and city streets, providing constant noise, dispersion of pollutants by truck exhausts and particulate material in the atmospheric air from cargo, compromising the quality of the product. air, since the trucks do not use tarpaulins to transport these products, as shown in figure 16.

Figure 16 - Transport of kaolin

Source: Images obtained by the author (2021).

In all areas where vegetation is suppressed for kaolin extraction, roads are opened so that the still raw mineral can be transported to processing units, contributing to the increase in this suppression. These mineral extraction areas are far from the rural roads that already exist in the municipality, leaving only the processing units on the margins of these main roads to facilitate the flow of the post-processing product.

5 CONCLUSION

The rigor of the existing legislation in relation to the economic activity of mineral extraction was observed, however, a contradiction when observed the reality. Companies acting for years while waiting for deadlines in administrative processes for their regularization and the lack of inspection by Organs competent bodies, has favored economic exploitation before the legalization and licensing of companies, which contributes to the occurrence of negative impacts on the local environment, since, none Mitigating action is developed by these companies to mitigate environmental liabilities, since they still do not meet the environmental licensing requirements.

As the main environmental impacts observed, we can highlight the vegetation suppression to open mineral exploration areas, accumulation of tailings and erosion processes due to the removal and transport of sediments, accumulation of tailings in the vicinity of processing units, causing visual pollution, degradation of local ecosystems and soil infertility, in addition to the irregular transport – the non-use of protective tarpaulins in the buckets – of sediments, which causes dispersion of particulate matter in the atmospheric air and constant noise caused by heavy machinery and trucks.

Only between five and 10% of the waste produced is sold. Those 90 – 95% that create environmental liabilities need specific studies so that they can be used, that is, there is an urgent need for mitigating actions so that these produced liabilities cease to be a problem in kaolin processing. The recovery of degraded areas, reforestation programs in disused areas, supervision of sediment transport, are mitigating actions that can be encouraged by the municipal government through the Mining Secretariat created in August 2021, together with the local Cooperative and environmental inspection to minimize the impacts observed in relation to the extraction of kaolin in the municipality of Junco do Seridó.

REFERENCES

ALVARES, C.A., STAPE, J.L., SENTELHAS, P.C., GONÇALVES, J.L.M.; SPAROVEK, G., 2013. **Köppen's climate classification map for Brazil**. Meteorologische Zeitschrift, DOI: http://dx.doi.org/10.1127/0941-2948/2013/0507

ANA. Agência Nacional de Águas. **A gestão dos recursos hídricos e a mineração**. Org. Antônio Felix Domingues; Patrícia Helena Gambogi Boson; Suzana Alípaz. Brasília: 2006. 334 p.: il.

AZEVEDO, G. H. de. **A produção mais limpa nas indústrias de extração e beneficiamento do caulim no Estado do Rio Grande do Norte**. 2019. 121f.: il. Dissertação (Mestrado)-Universidade Federal do Rio Grande do Norte, Centro de Tecnologia, Programa de Pós-Graduação em Engenharia de Produção, Natal, 2019.

BRASIL. Decreto-Lei nº 227, de 28 de fevereiro de 1967. Dá nova redação ao Decreto-lei nº 1.985, de 29 de janeiro de 1940. (Código de Minas). **Diário Oficial da União**. Brasília, DF, p. 2417, 28 fev. 1967.

BRASIL. Lei nº 7.805, de 18 de julho de 1989. Altera o Decreto-Lei nº 227, de 28 de fevereiro de 1967, cria o regime de permissão de lavra garimpeira, extingue o regime de matrícula, e dá outras providências. **Diário Oficial da União**, Brasília, DF, p. 12027, 20 jul. 1989, Seção 1.

BRASIL. Decreto n° 9.406, de 12 de junho de 2018. Regulamenta o Decreto-Lei nº 227, de 28 de fevereiro de 1967, a Lei nº 6.567, de 24 de setembro de 1978, a Lei nº 7.805, de 18 de julho de 1989, e a Lei nº 13.575, de 26 de dezembro de 2017. **Diário Oficial da União**, Brasília, DF, ed. 112, 13 jun. 2018. Seção 1, p. 1.

BRASIL. Lei nº 14.066, e 30 de setembro de 2020. Altera a Lei nº 12.334, de 20 de setembro de 2010, que estabelece a Política Nacional de Segurança de Barragens (PNSB), a Lei nº 7.797, de 10 de julho de 1989, que cria o Fundo Nacional do Meio

Ambiente (FNMA), a Lei nº 9.433, de 8 de janeiro de 1997, que institui a Política Nacional de Recursos Hídricos, e o Decreto-Lei nº 227, de 28 de fevereiro de 1967 (Código de Mineração). **Diário Oficial da União**. Brasília, DF, 30 set. 2020.

BRASIL. Ministério do Meio Ambiente. **Resolução CONAMA Nº 237**, de 19 de dezembro de 1997. Dispõe sobre a revisão e complementação dos procedimentos e critérios utilizados para o licenciamento ambiental.

BRUNDTLAND, G. H. Nosso futuro comum. Rio de Janeiro: FGV, 1987.

CHAVES, D. A.; SILVA, J. M. P. da. O Plano Nacional da Mineração (2010 – 2030) e seu rebatimento no Território Amazônico. **Revista Política e Planejamento Regional**, Rio de Janeiro, v. 3, n.1, p.39-52, jan./jun./2016.

COELHO, L. F. de O. **Potencial do caulim em filtros tipo Cynamom para o tratamento de efluentes de laticínios**. 2019. 65 f. Dissertação (Mestrado Profissional em Sistemas Agroindustriais) - Programa de Pós-Graduação em Sistemas Agroindustriais, Centro de Ciências e Tecnologia Agroalimentar, Universidade Federal de Campina Grande, Pombal, Paraíba, Brasil, 2019.

DIAS, M. C. O. (Coord.) **Manual de Impactos Ambientais**: orientações básicas sobre aspectos ambientais de atividades produtivas. Fortaleza: Banco do Nordeste, 1999. 297 p.

DNPM. Departamento Nacional de Produção Mineral. **Sumário mineral 2014**. Brasília: 2014. Volume 34, 141 p.: il.; 29 cm.

FENG, D.; ALDRICH, C. Recovery of chromite fines from wastewater streams by column flotation. **Hydrometallurgy**. 72, p. 319-325, 2004.

FERREIRA, V. M. **Caulinita e caulins de Pegmatitos da Borborema Seridó nos estados da Paraíba e Rio Grande do Norte – Composições e origem**. Dissertação (mestrado). Coordenação do curso de pós-graduação em Engenharia de Minas da Universidade Federal de Campina Grande. Campina Grande: 2003.

FLORENZANO, T. G. **Geomorfologia**: conceitos e tecnologias atuais. São Paulo: Oficina de textos, 2008.

FREELAND, S. **Direitos humanos, meio ambiente e conflitos**: enfrentando os crimes ambientais. (original em inglês – tradução de Francis Albert). Revista Internacional de Direitos Humanos. São Paulo: v.2, n.2, 2005.

IBGE. Instituto Brasileiro de Geografia e Estatística. **Censo 2010**. IBGE Cidades.

SILVEIRA, G. C. L. da. **Caracterização de caulim de resíduo de granito para formulação de gres porcelanato.** Congresso Brasileiro de Engenharia e Ciência dos Materiais, Natal – RN, 2016.

LIMA, R. da C. C. **Sistema de avaliação e comparação espacial do processo de desertificação no Seridó Potiguar e Paraibano, Semiárido Brasileiro**. UFCG, Campina Grande, Tese Doutorado. 2017, 150 f.

LIMA, R. C. O. **Diagnóstico dos impactos ambientais decorrentes do beneficiamento de caulim no município de Equador – RN**. Campina Grande: Revista de Biologia e Ciências da Terra, Universidade Estadual da Paraíba, v.10, n.2, 2010, p. 91-96.

LUZ, A. B. da.; CAMPOS, A. R. de.; CARVALHO, E. A. de; BERTOLINO, L. C. **Caulim**. Rochas e Minerais Industriais. CETEM. 2005, p. 231-262.

MECHI, A.; SANCHES, D. L. **Impactos ambientais da mineração no Estado de São Paulo**. Estudos Avançados [online]. 2010, v. 24, n. 68 p. 209-220.

MOREIRA, P. R. **Manejo do solo e recomposição da vegetação com vistas à recuperação de áreas degradadas pela extração de Bauxita**. Poços de Caldas: 2004. 139 f. Tese (Doutorado) Ciências Biológicas. Instituto de Biociências, Universidade Estadual Paulista, Rio Claro, 2004.

NDAGIJIMANA, C.; PAREYN, F. G. C.; RIEGELHAUPT, E. Uso do solo e desmatamento da caatinga: um estudo de caso na Paraíba e no Ceará – Brasil. *In*: BRASIL. Ministério do Meio Ambiente. **Estatística Florestal da Caatinga**. Recife, p. 18-29, 2015.

OLIVEIRA, E. M. **Mineração do caulim como tendência à desertificação no Seridó paraibano**. Recife: 2019. 183 f. Tese (Doutorado) Desenvolvimento e Meio Ambiente. Programa de Pós Graduação da Associação em rede Plena. Universidade Federal de Pernambuco. Recife. 2019.

PEREZ-MARIN, A. M.; CAVALCANTE, A. de M. B.; MEDEIROS, S. S.; TINÔCO, L. B. de M.; SALCEDO, I. H. **Núcleos de desertificação no semiárido brasileiro**: ocorrência natural ou antrópica? V. 17, n. 34, p. 87 – 106. Brasília – DF. 2012.

RIBEIRO, I. J. da C. et al. Implantação de métodos de tratamento para combater as eflorescências. **Revista Principia - Divulgação Científica e Tecnológica do IFPB**, [S.l.], n. 38, p. 43-53, fev. 2018. ISSN 2447-9187. Disponível em: <https://periodicos.ifpb.edu.br/index.php/principia/article/view/1206>. Acesso em: 26 Out. 2021. DOI: http://dx.doi.org/10.18265/1517-03062015v1n38p43-53.

SÁNCHEZ, L. E. **Avaliação de impacto ambiental**: conceitos e métodos. São Paulo: Oficina de Textos, 2008.

SANTANA, V. L. **Beneficiamento de caulim na Região do Junco do Seridó/PB e Equador/RN através da classificação de partículas em hidrociclone**. 2017. 94 f. Dissertação (Mestrado) – Pós Graduação em Exploração Petrolífera e Mineral, UFCG, Campina Grande, 2017.

SILVA, F. L. da. **A extração de caulim no município de Equador – RN**: implicações ambientais e sociais. 2017. 93 f. Dissertação (Mestrado) – Pós Graduação em Desenvolvimento e Meio Ambiente, PRODEMA/UFRN, Natal, 2017.

SILVA, S. M. P. da.; CRÓSTA, A. P. Mapeamento de pegmatitos da Faixa Seridó (FSe) com base na análise por componentes principais de imagens TM/Landsat-5 e Terra/ASTER e o apoio da espectroscopia de reflectância. In: **Anais XV Simpósio**

Brasileiro de Sensoriamento Remoto – SBSR. Curitiba, PR, Brasil, 30 de abril a 05 de maio de 2011, INPE p.3597

SUDENE. SUPERINTENDÊNCIA DE DESENVOLVIMENTO DO NORDESTE. Resolução 115 de 2017.

VASCONCELOS SOBRINHO, J. **As regiões naturais do Nordeste, o meio e a civilização**. Conselho de Desenvolvimento de Pernambuco, Recife: 1971.

VILA NOVA, J. S. S.; PANTA, D. L. S.; ALMEIDA, I. C. S.; GOMES, D. D. M. **Panorama ambiental das zonas de mineração de caulim na formação Equador, nordeste do Brasil.** Revista CC&T/UECE, do Centro de Ciência e Tecnologia da Universidade Estadual do Ceará. Fortaleza: v. 1, n.3, p. 249-256, jul./dez. 2019.

***