Systematic review on the reclamation of areas degraded by mining

Revisão sistemática sobre a recuperação de áreas degradadas pela mineração

Recuperación de áreas degradadas por la minería: una revisión sistemática

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Abstract
The concern with the economic context and the need for metallic and non-metallic minerals in the current state of world globalization, has caused the abandonment of areas degraded by mineral exploration without any action for their recovery. The objective of this research was to analyze literature about the exploitation of mineral resources for various uses, as well as to seek an answer to the guiding question about the importance of the recovery of these areas

after extraction. The method applied was a systematic review with quantitative and qualitative coverage. The data analyzed the occurrence of this type of extraction on a global level. In the Asian continent, China (coal for energy) and Indonesia (sand and gravel for construction) accelerate mineral exploration and this causing environmental impacts such as loss of soil fertility by AMD. In the African continent (Au extraction) in the open air and in an artisanal way, which determines the presence of mercury in water bodies. On the European continent, Poland, the chemical degradation due to the exploitation of iron and brown coal, is accentuated; on the South American continent, the exploitation of lithium in the Atacama Desert, of gold (in an artisanal way), bauxite, clay, sand, agate, iron, among others, present abandoned areas and without any type or proposal for their recovery, which is causing loss of endemic flora and fauna. Thus, it is affirmed that the economy and the advance of technology are not associated with the importance of maintaining the balance of natural ecosystems and do not evaluate, or do so in an incipient way, the importance of the recovery of areas degraded by mineral exploration.
Keywords: Alteration of environmental quality; Loss of vegetation cover; Decrease in soil functionality.

Resumo
A preocupação com o contexto econômico e a necessidade de minerais metálicos e não metálicos no estado de globalização mundial atual, tem causado o abandono de áreas degradas pela exploração mineral sem qualquer ações para recuperação delas. O objetivo dessa pesquisa foi analisar literaturas acerca da exploração dos recursos minerais para usos diversos, bem como buscar resposta a questão norteadora quanto a importância da recuperação dessas áreas pós extração. O método aplicado foi o de revisão sistemática com abrangência quantitativa e qualitativa. Os dados analisaram a ocorrência desse tipo de extração a nível global. No continente asiático, China (carvão para energia) e Indonésia (areia e cascalho para construção civil) aceleram a exploração mineral e isso causando impactos ambientais como perda da fertilidade do solo por DAM. No continente africano (extração do Au) a céu aberto e de maneira artesanal, o que determina a presença mercúrio nos corpos hídricos. No continente europeu, a Polônia, a degradação química devido a exploração de Ferro e carvão marrom duro, é acentuada; no continente sul-americano a exploração de lítio no deserto de Atacama, do ouro (de forma artesanal), bauxita, argila, areia, ágata, ferro, dentre outros, apresentam áreas abandonadas e sem qualquer tipo ou proposta para recuperação delas, o que está causando perda de fauna e flora endêmicas. Com isso, afirma-se que a economia e o avanço da tecnologia não estão associados à importância da manutenção do equilíbrio dos ecossistemas naturais e não avaliam, ou ainda o fazem de forma incipiente, a importância quanto a recuperação das áreas degradas pela exploração mineral.
Palavras-chave: Alteração da qualidade ambiental; Perda cobertura vegetal; Diminuição da funcionalidade do solo.

Resumen
La preocupación por el contexto económico y la necesidad de minerales metálicos y no metálicos en el actual estado de globalización mundial ha provocado el abandono de las áreas degradadas por la exploración minera sin que se realicen acciones para su recuperación. El objetivo de esta investigación fue analizar la literatura sobre la explotación de los recursos minerales para diversos usos, así como buscar una respuesta a la pregunta guía sobre la importancia de la recuperación de estas áreas después de la extracción. El método aplicado fue el de revisión sistemática con alcance cuantitativo y cualitativo. Los datos analizan la ocurrencia de este tipo de extracción a nivel global. En el continente asiático, China (carbón para la energía) e Indonesia (arena y grava para la construcción) aceleran la prospección de minerales, lo que provoca impactos medioambientales como la pérdida de fertilidad del suelo por AMD. En el continente africano (extracción de Au), al aire libre y de forma artesanal, lo que determina la presencia de mercurio en las masas hídricas. En el continente europeo, Polonia, se acentúa la degradación química debido a la explotación del hierro y del lignito; en el continente sudamericano, la explotación del litio en el desierto de Atacama, del oro (de forma artesanal), de la bauxita, de la arcilla, de la arena, del ágata, del hierro, entre otros, presentan zonas abandonadas y sin ningún tipo o propuesta para su recuperación, lo que está provocando la pérdida de fauna y flora endémicas. Así, se afirma que la economía y el avance de la tecnología no están asociados a la importancia de mantener el equilibrio de los ecosistemas naturales y no valoran, o lo hacen de forma incipiente, la importancia de la recuperación de las áreas degradadas por la exploración minera.
Palabras clave: Alteración de la calidad ambiental; Pérdida de la cubierta vegetal; Disminución de la funcionalidad del suelo.

1. Introduction

In the process of searching for minerals that involve prospecting, mineral research, mining, and decommissioning of a mine, there is always vegetal suppression, soil disturbance, loss of habitat, interference in the climate, loss, or escape of invertebrate and vertebrate fauna is immense due to the modified biogeographical conditions in search of the economically viable mineral resource that in general, is great vertical depths, which causes modifications in the landscape and in the communities that inhabit the area where mineral exploration occurs, in addition to contamination or water pollution (Oliveira & Fontgalland, 2022; Pratiwi et al., 2021).

In countries whose mineral reserves are extensive, such as Brazil, their socioeconomic development, directly or indirectly, has the exploratory activities of natural resources to meet as its main support. In general, the need for foreign market inputs, where mining, can be highlighted as one of the main ways of using natural assets and enabling socioeconomic gains through the generation of employment and income. One of the Brazilian federal states that presents this history is Minas Gerais, where iron (Fe), is explored in the municipality of São Gonçalo do Rio Abaixo, but it also occurs in the state of Pará, In Serra dos Carajás (Ferreira et al., 2018; Milanez, 2017).

In the national territory, mineral exploration uses the soil temporarily, because of this, this economic activity must find mechanisms that, when exhausting the explored mineral vein, can mitigate the damage caused and restore, at least in part, the ecosystem functions that that area exercised before as, for example, thermal regulation (Rosa, 2019) About the licensing for this potentially polluting activity, in 1940, the decree-law nº. 1.985 (Brasil, 1940), had new wording and, in article 2, five regimes for the use of the mineral resource: from concession to monopolization.

Twenty-seven years later, this code has new wording, now stipulated by the decree-law, no. After 19 years, this decree-law was altered by law 9.314 (Brasil 1996), with the same wording and the responsibility of the National Department of Mineral Production, the licensing regime. Until then, there is no mention of recovery of these areas, which only occurs in 1981 with the promulgation of the National Policy on the Environment (Brasil, 1981), based on Article 225, § 1, the item I, § 2 of the Federal Constitution of Brazil (Brasil, 1988).

In these last two legislations, describe that the objective of this recovery is to reestablish (?): The original triad as to the physical, chemical, and biological of the degraded area so that it obtains again the functional capacity it had before the mineral exploration. This requirement determines by Decree-Law No. 97.632 (Brasil, 1989), which requires mining enterprises, the composition of the Environmental Impact Studies, and the Environmental Impact Report (EIA/RIMA), to submit such documents to the responsible environmental agency (Barbosa et al., 2022).

But what is a degraded area? Conceptually, it is defined by Decree-Law No. 97.632/1989, as the result of damage that was caused to the environment and that determined the reduction or loss of natural properties such as productivity. Therefore, it is stated that human intervention, in this case, mineral exploration, causes a severe environmental imbalance such as contamination and water pollution, which can even, compromise its very survival of it, since water is vital to life. In the case of mining, the cause-effect relationship is evident and, because of this, the actions that will allow the recovery of it must address numerous command and control instruments (Ex: PNMA, PNEA), in addition to the involvement of the community that remains at the site or the vicinity of the degraded site (Haren et al., 2019).

Therefore, the implementation of these activities in mineral resource exploration projects is aimed at protecting ecosystems and mineral resources, ensuring human well-being and health, reducing environmental problems, and developing the country's economic and social development sustainably. But the impacts they cause must be constantly studied and evaluated, which justified this research and increased its relevance, and allowed the elaboration of the objective, which was the search for the guiding question: Why is it important to reclaim areas degraded by mining

2. Methodology

This research employed the Systematic Review (SR) method, as summarized by Sousa et al. (2018). These authors state that the use of this type of review covers a large amount of information in a single study. As for the approach, two of them were used: quantitative and qualitative, according to what was described by Pereira et al. (2018). About the quantitative

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research, they wrote that one can use a metric scale, with or without units. Regarding qualitative, they stated that the researcher should use data more directly, while still being concerned with the product he wants, in this case, the academic literature. Then the five steps for this SR were applied (Char 1).

Chart 1. Steps that comprised the purpose of this SR.

Steps	Title	Action
1	Identifications	Access to direct access databases: Google Scholar, Portal of Periodicals of the Coordination for the Improvement of Higher Education Personnel (CAPES), Scientific Library Electronic Online (SciELO), Web of Science, and Scopus.
2	Screening	2.1 Language: English and Portuguese. 2.2 temporal cut-off was set in the last eight years (2017 - 2022). 2.3 application of four selective descriptors (elective Keywords) from the research theme: recovery, mining, degraded area, and environmental licensing, in the sections: title, abstract/abstract, keywords/Keywords/Palabras-clave) of each of the academic literature involved with the research theme 2.4 first in an isolated way and then associated with operators that connect the input, with the use of search strings: recovery *and* degraded area plus mining; "degraded area *and mining*;" " recovered area *and* post-extraction ", "recovery *and* degraded areas," among others. This use intends to clarify the link between descriptors found, in pairs or trios.
3	Eligibility	Selection of the literature that presented at least one selective descriptor, isolated and/or associated.
4	Exclusion	Literature that did not satisfy item 2 was discarded.
5	Inclusion	The literature satisfied conditions 1 and 2, respectively.

Source: Authors (2022).

To develop the guiding question, the "PICO strategy" used for nursing research was adapted: Patient; Intervention; Control, and Outcome. There were two adaptations: 1. The patient was adapted to "Problem"; 2. The comparison was adapted to Control (Chart 2). This action is justified due to an elaboration with greater accuracy to the focus of this research.

Chart 2. PICO strategy was adopted for this research.

Strategies	Description
Problem	The degradation of post-mining areas.
Intervention	The analysis and application of command-and-control tools.
Control	Supervision by the environmental organs.
Outcome	Mining no longer pollutes as before and applies new techniques for extracting mineral and non-mineral resources.

Source: Authors (2022).

Finally, the statistical analysis of the data obtained was conducted with the application of electronic spreadsheets contained in the Excel 2013 software, for the application of Descriptive Statistics, to calculate the values for absolute (fi) and relative (fr%) frequency, mean ($\bar{x}$) and standard deviation (σ).

3. Results

3.*1 Literature Selection*

3.1.1 Application of selective descriptors in isolation

Regarding the associated descriptors, it was verified the frequent use of these terms in the literature, especially focused on the last decade, indicates the importance and relevance of the theme today, both internationally and nationally (Table 1).

Table 1. Values for absolute and relative frequency, the mean and standard deviation of isolated and associated environmental descriptors identified in academic literature.

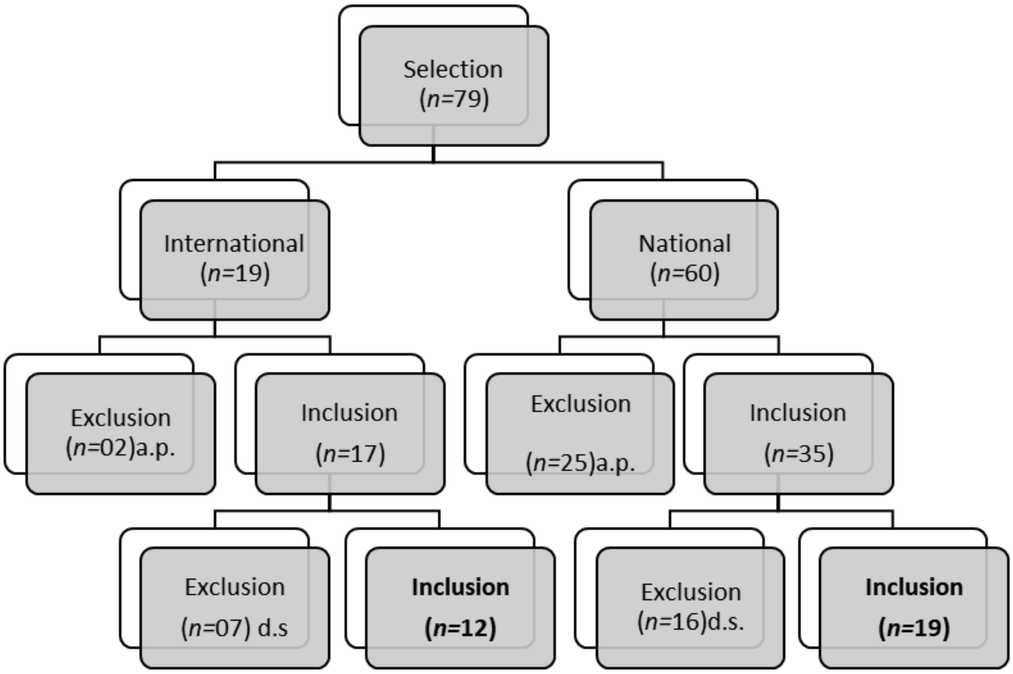
Isolated Descriptors	Títle	Abstract	Keywords	$\bar{x} \pm \sigma$
Mining	6 (19,3%)	3 (9,7%)	6 (19,3%)	5,0±1,7
Degraded areas	--	--	1 (3,2%)	0,3±0,6
Environmental licensing	--	--	1 (3,2%)	0,3±0,6
Associated Descriptors	**Títle**	**Abstract**	**Keywords**	$\bar{x} \pm \sigma$
Recovery and degraded areas more mining	12 (38,7%)	3 (9,7%)	1 (3,2%)	5,3±5,9
Degraded area and mining	3 (9,7%)	--	--	1,0±1,7
Recovery areas and post extractions	1 (3,2%)	--	--	0,3±0,6
Recovery and degrade areas	2 (6,4%)	1 (3,2%)	2 (6,4%)	1,7±0,6

Source: Authors (2022).

3.2 *Exclusion and inclusion process of the selected literature*

The data obtained and analyzed indicated that the international and national selection processes satisfied the guidelines established regarding the application of the selective descriptors (Figure 1).

Figure 1. Scheme applied to the processes of exclusion and inclusion of academic literature.

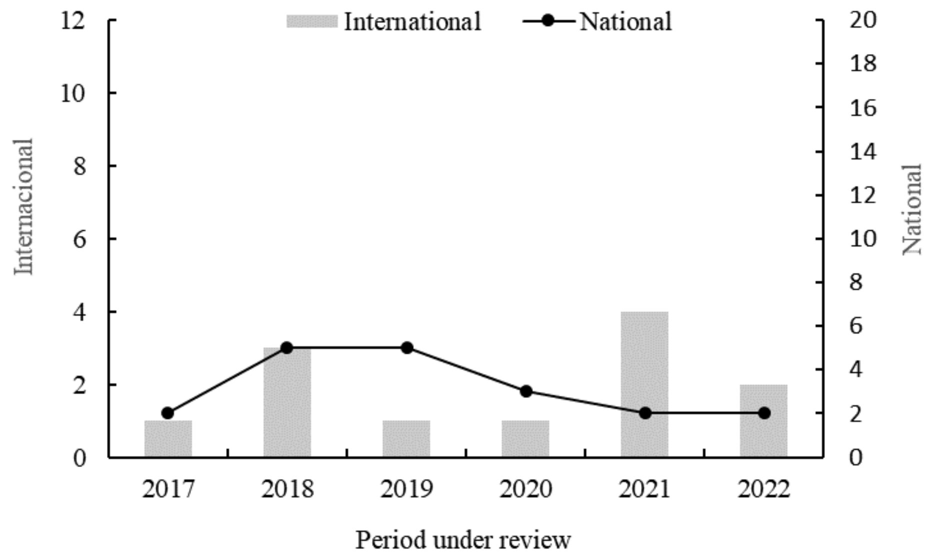


Legends: a.p.: year of publication; d.s.: selective descriptors. Source: Authors (2022).

3.3 Distribution of the selected literature on the temporal and geographical scale

The data obtained regarding the distribution of the 31 selected publications, indicated that the most prolific period for international publications, occurred in 2019 and 2021, already in the triennium 2018-2019-2020, the publications of national research were more effective (Figure 2).

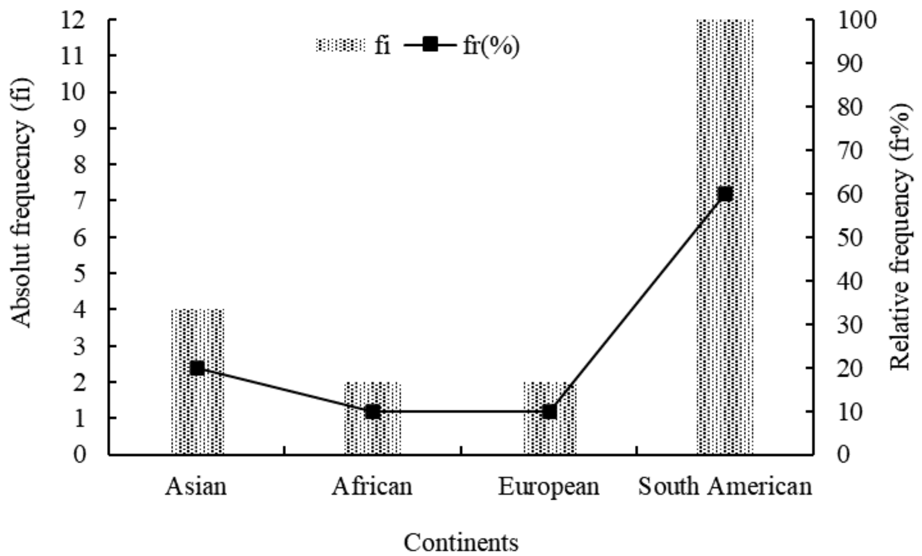
Figure 2. Distribution of the selected literature according to the period: 2017-2022.



Source: Authors (2022).

For the geographic distribution, the data analyzed indicated that the South American continent was the most prolific in the period analyzed (2017 - 2022). This may have occurred due to the natural resource reserves, especially in the Amazon (Figure 3).

Figure 3. Continental geographic distribution of the selected literature in the pre-established period: 2017-2022.



Source: Authors (2022).

4. Discussion

The concern with environmental degradation via mining is worldwide due to the occurrence of 21. 060 exploration sites that total 57,272 km2 (Maus et al., 2020) and, among them, there are, in exploitation, coal (3,119 mines), gold (Au) 1,500 mines, and silver (Ag), 1,002 mines. This range of exploitation of natural resources (commodities) generates environmental degradation such as the disintegration of ecosystems, loss of soil fertility, pollution of surface and groundwater, and climate change. All these facts make the management of natural resources difficult (Rahmonov et al., 2022), as well as raising the cost of the degradation of impacted areas.

Despite this nefarious view, on the Asian continent, degraded areas are amenable to recovery, especially of ecosystem services, from vegetation re-covering. In Indonesia (Pratiwi et al., 2021), reforestation of degraded areas is a passive occurrence if, during coal mining, there is a control or use of the material of high capacity of absorption of acid mine drainage (AMD). This care is associated with the view that biological aspects should be considered, especially by the choice of plant species, which will by contributing to the decomposition of soil fertility and soil biota.

Two other natural resources exploited in this country, are sand and gravel (Putra & Purnaweni, 2018). They are useful for civil construction and have caused environmental problems in water resources since they are taken from the central channel of these water bodies. The legislation about this exploitation, as a tool and command and control, exists, but this does not prevent the clandestine exploitation of these resources and, consequently, there is loss, not only of water quality for public supply via wells, but also for agricultural use, and this shows that the degradation is not punctual but diffuse because there are losses of recreation areas, such as bathing.

Still on this continent, in Beijing, China (Han et al., 2021), the proposal to verify the ability to recover areas degraded by mining, was directed to the use of georeferencing images via Normalized Differential Vegetation Index (NDVI) from the comparison of historical series of images between 2000 and 2019, the loss and restoration of vegetation cover, which determined a qualification of the areas in Recoverable (R), Degraded (D), Degraded-Recovered (D-R) and no chance of recovery (NC). This fact called attention because there was no concern with the state of soil fertility, and the quality of the water after mining, although there are hydro climatological studies. However, there may be plant species that have adapted to the new lithological conditions, and whose nutritional capacity is low. In addition, faunal diversity may not return to the sites where the vegetation cover has regenerated, or the establishment of alien species may occur.

The concern for soil fertility in this country, in post-mining degraded areas, has not ceased to be the subject of study (Wang et al. 2021), since the Hongliulin coalfield in the Um Us Desert on the Loess Plateau is exploited as the primary source of energy used by the Chinese: coal, where ¼ of the area is already degraded. The nutritional loss of the soil is accentuated due to the sinking of the soil, loss in the capacity for infiltration and percolation of water, as well as deep cracks in the surface of the soil, and the loss of fertility in addition to its humidity.

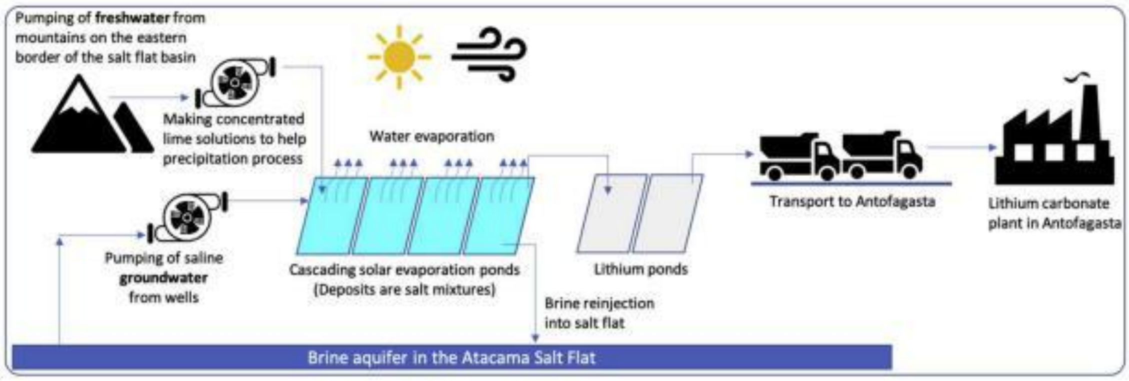
On the African continent, in Kenya (Odumo et al., 2018), environmental degradation occurs in the face of Au mining, in an artisanal manner and with the use of Arsenic (As), in the districts of Migori and Transmara, since 1930, and since 2008, industrial mining has been initiated. There, the use of arsenic (As) is still used to separate the gold from the rock and, therefore, the effluent produced has heavy metals and metalloids in its composition, there is an accumulation of rocky and contaminated waste in the open air, and constant soil erosion. In the Limpopo Province in Zimbabwe (Mhlongo & Akintola, 2021), gold exploitation occurs in underground and surface mines, magnesite (surface mine), but copper only in underground mines. Most of them are abandoned after the exhaustion of the vein without any action for reclamation of the degraded area, and the rivers are highly concentrated in Ni, Zn, As, and Pb, which also occur in the soils around the abandoned areas. However, there are no reports of proposals for the partial or total recovery of the abandoned areas with environmental impacts, other than landscape restoration.

On the European continent, in Poland (Pusz et al., 2017), chemical degradation and erosive processes after iron ore (Fe) mining have been identified. In addition, loss of water quality, especially groundwater, by infiltration of MAD occurred due to the piling of mineral waste that in rainy season formed runoff channels, but in dry season serve as conduits for landslides of the accumulated soil where they found cadmium (Cd), Zn and Pb concentrations, in addition to ammonification and nitrification of the soil. No efforts for the recovery of these areas have been reported, nor whether they are still amenable to recovery, as vegetation is present in some areas of waste rock deposition, which may be iron canga vegetation.

In this country, in the village of Pita Mtyn (Rurek et al., 2022), the exploitation of hard and brown coal, which is an energy source, has modified the natural environment since it occurs at great depths, resulting in soil subsidence and generating an excessive volume of waste, but to reach such depths, the surface area also changes (e.g., removal of vegetation cover, soil disturbance to open tunnels that, when accumulated, can slide, disperse, and silt up water bodies, in addition to the loss of flora and fauna, both in the terrestrial and aquatic ecosystems.

As for the South American continent, the Peruvian Amazon, in the Madre de Deus district in the municipality of Cusco (Espejo et al., 2018), presents the same object of environmental degradation that occurs in Kenya: artisanal gold mining. In addition, there is an even greater environmental responsibility: this activity, in the Amazon, has already caused forest loss, and changes in the landscape, and, with this, the rate of fixation of residual forest carbon decreases, increases the content of soil and water contamination, via Hg, used in artisanal mining practiced in this region. In Chile (Liu et al., 2019), the exploitation of Lithium (Li), necessary for electric car batteries, contained in the salt present in the Atacama Desert, is already the object of mineral exploitation and a major cause of environmental degradative pressure. This country is responsible for 38% of the world's production of this mineral. In addition, the clean water used for extracting the brine Li is evaporated in plates, in the form of islands (Figure 4), which may threaten their use by both fauna and flora.

Figure 4. Schematic of salt extraction in the Atacama Desert in Chile.



Source: Liu et al. (2019).

In Brazil, mineral exploration is also effective. In the northeast region, in Fortaleza-CE (Garcia et al., 2017), manganese (Mn) is the focus of this action. The waste produced post-extraction, is numerous: high environmental toxicity, inhibition of plant growth, and changes in their communities. To mitigate these degradative effects, the application of phytoremediation via mycorrhizae and legumes of the species Mimosa caesalpiniaefolia Benth, Leguminosae family, is being developed.

In the South region, in the state of Rio Grande do Sul-RS (Silva et al., 2018), the exploitation is directed to Agate, applied in the production of jewelry and objects for ornamentation. The final evils of this exploitation are like the others, that is, deforestation, water and noise pollution, land subsidence, silting of rivers, impacts on the landscape, and, especially on flora and fauna. Another fact that shows similarity is open-pit mining, as occurs in Kenya and Peru, with artisanal gold mining. So, environmental degradation is not dependent on the type of ore/mineral exploited, but on the techniques employed and the legislative responsibilities, before, during, and after this action.

Still in this region, in Florianópolis-SC (Corrêa et al., 2019) in the municipality of Icara, clay exploitation occurs. The raw material needed for potteries, and ceramic tile factories. Like artisanal mining, this extraction occurs in the open sky and results in vegetal suppression, loss of fertile soil layer, vulnerability to soil erosion, imbalance of ecosystems, changes in the landscape, and environmental discomfort. In other words, open-pit mining is one of the major factors of environmental degradation on any continent of occurrence.

The Midwest region, concerning the mineral exploration, shows similarity with the Asian continent: in both occur the exploitation of gravel for construction. On the campus of the Federal University of Goias-GO, the use of gravel removed from the environment was directed to the internal paving of this area (Vilela et al., 2018). The revegetation of the degraded area after obtaining the gravel was done with the species *Genipa americana* L., Rubiaceae Family, and *Hymenaea stigonicarpa* Mart. ex Hayne, Fabaceae Family.

However, there is no data regarding the biology of the soil, and the arboreal, fruit-eating, and pedofauna fauna. In another municipality of this state, Crixás and Sun hat (Ribeiro et al., 2019), gold was exploited in an artisanal way (pumping of water jets and with the use of Hg and cyanide) and from the installation of the Serra Grande S/A mining company, in 1990, in Vermelho River, in a clandestine way, and this generated socio-environmental damage to the communities because they lost income, leisure, food, and contracted diseases that did not previously exist in the community: mental retardation, hydrocephalus, Down syndrome, and neurological problems, all proven by the Technological Center of Mining (CETEM).

Already Southeast Region, in Belo Horizonte-MG (Almeida et al., 2019), found that in areas degraded by Fe extraction, both native and exotic species can be used. However, it is necessary that the choice of vegetation is made according to the environmental state of the degraded area, especially regarding soil fertility, infiltration, and percolation capacity, to observe if there was the reception of the acid mine drainage. One should also keep in mind that the recovery of biodiversity is also necessary since it makes up the ecosystem and acts in seed dispersal and biological control of the site.

In the state of São Paulo, in the municipality of Salto do Pirapora-SP (Lima et al., 2020), limestone exploration, both for agriculture and construction, occurs in an ecotone area, whose residue is deposited on the soil forming a pile of so-called "sterile". It has no commercial value, but it has organic matter and, therefore, fertility, and plants grow on it. At this site, we identified species in transition, from the series or ecstasy stage to the climax stage, with the species Leucaena leucocephala (Lam.) de Wit., Fabaceae family, whose vernacular name is "lead tree", is the most adapted and frequent. However, once again, there was no description of the edaphic fauna, avifauna, and vertebrates, among others.

The Central Plateau, in Brasília-DF (Teran et al., 2020), is also the object of mineral exploration and the natural resource is like that exploited in Goias and Kenya: gravel. The difference lies in the fact that this action occurs inside an Environmental Protection Area (APA) called Cafuringa, in the São Bartolomeu River basin. The post-exploitation degradation picture showed erosive processes, no vegetation cover, and soil with high phosphorus content (1.2mg/dm^3; recommended = 10-15 mg kg ^{1}), which characterizes degraded soil.

In the northern region, in Belém-PA, municipality of Capitão Poço (Sauma Filho et al., 2021), pebble extraction occurs and, in this area, post-mining, recovery, and/or regeneration is not occurring for two reasons: 1. The removal of the fertile layer of soil; 2. The erosive processes are caused by mineral exploration. In the southeast of Pará state, in the municipality of Paragominas (Cerqueira et al., 2021), bauxite has been exploited since 2007, in the area called the "deforestation belt". The extraction method is strip mining, which requires the removal of the surface layer, therefore the layer with the highest concentration of organic matter (OC), but before this, it is necessary to promote vegetal suppression, thus altering the local landscape, with the escape of fauna, and therefore loss of biodiversity. To mitigate these problems, the mining company that operates at the site has adopted three techniques in its PRAD: direct planting, nucleation, and natural regeneration.

5. Conclusion

Regardless of the continent, country, state, or municipality, the extraction of metallic and non-metallic mineral resources, whether gold, silver, copper, clay, pebble, sand, or gravel, cause modifications to the landscape, flora, fauna, water resources, either by post-exploitation waste deposition or using chemical substances such as arsenic, mercury, and cyanide. In many places, mines exploited until the vein was exhausted, are not being recovered or regenerated, although there are already technologies, such as NDVI, that can be used to track the development of vegetation cover or revegetation in these areas.

It is significant to recover the areas after mineral extraction to restore the balance of ecosystems, and that there is a return of services provided by them, such as thermal regulation, and provisioning, among others. However, the analysis of these literatures still does not contemplate, with few exceptions, activities, and projects for the recovery of these areas and, when they exist, it is noted that there is no concern with the directives cited in the PNMA and the new Forest Code. Another importance is associated with the 17 sustainable development goals, especially the third, which deals with health and well-being, and the sixth, which deals with water potability. However, this item when related to mining and the non-recovery of the areas degraded by it, it must be considered that the use of fat-soluble metals and accumulators in the environment will act on the potability of the water and, therefore, will cause the appearance of diseases as it already occurs in the municipality of Crixás.

Thus, besides being important, the recovery of degraded areas must be a priority, not only at the legislative level, but also in the actions and inspections of the constituted powers and of the community in general, which feeds and uses the natural resources on a daily basis, without interfering in the international and national economic development, from the use of innovative technologies, whether for the maintenance, regeneration, recompositing, restoration of the area that watered riches to others, but that continue to improve the communities living there.

The literature that was the object of this review showed that the research about the recovery of areas degraded by mining, whether of a metallic or non-metallic mineral resource, is the basis for further research to be developed, generating more data to support this activity and the recovery of the areas when the vein is depleted.

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