Highlighting the harmful effects of industrial noises and vibrations resulting from mining operations on local ecosystems

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Abstract:

The environmental situation of our planet is concerning due to contemporary global issues such as greenhouse gas emissions, air pollution, and climate change. In this research paper, we will address an ecological and health concern that is often overlooked despite the significant risks it poses to both environmental and human health. Noise pollution and vibrations present substantial threats to soil and ecosystems. The mining sector is a major contributor to this type of pollution, as heavy machinery and explosives disrupt the soil and alter drainage patterns, potentially increasing the risk of contamination. Industrial noise adversely affects human health, leading to stress, decreased concentration, hearing loss, and sleep disorders. In this regard, the World Health Organization (WHO) reported that 16% of adults worldwide experience hearing loss due to exposure to workplace noise. Prolonged exposure to noise can also result in habitat migration and a heightened sense of threat among organisms.

Keywords: *degradation of ecosystems; industrial noise pollution; mining; vibrations; occupational diseases.*

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Introduction:

Undoubtedly, economic and industrial sectors have significantly contributed to the development and advancement of economies worldwide (Tausova, Culkova, Domaracká, et al, 2017), particularly the extractive industry, such as mining (McMahon & Moreira, 2014).

Due to its crucial role in energy production and the provision of construction materials and gas for transportation, it is indispensable. Furthermore, it contributes to electronics technology and the development of semi-pharmaceutical materials (7 Reasons Why the Mining Industry Is Still Critical - Stark Resources, 2023).

However, this does not mean we should overlook the dark side of this sector, which manifests in the creation of numerous sensitive environmental issues that adversely affect human health. The term "overburden" refers to uneconomic rock, or, in other words, layers that lack economic value. For this reason, mining engineers typically blast this material using various types of explosives (Gleason, 2021). The mass of these explosives varies according to specific needs and naturally depends on the size of the excavation.

One of the significant adverse effects of this industrial sector is associated with blasting operations, a preparatory phase in mineral extraction. These operations generate metallic dust particles of various sizes (e.g., PM2.5, PM5), which can be inhaled into the human respiratory system. Such dust poses health risks, potentially leading to respiratory diseases such as asthma and silicosis, and may contribute to the deterioration of nearby vegetation and water bodies. (Djedid, Bounouala, Bouslama et al., 2024).

Therefore, firstly Mining depends mainly on a field study of the site. The materials to be exploited are first excavated and their economic value determined, and then a decision is made regarding the possibility of starting the project given the economic feasibility it offers, the opening mode… etc (Étapes du projet minier - Ministère des ressources naturelles et des forêts, 2021).

In this study, we will discuss noise pollution and vibrations resulting from various activities in the mining sector, starting with drilling operations, then mechanical treatment, and concluding with transporting the final product. These are all contributing steps to this type of pollution. Therefore, this research paper aims to identify the problem of industrial noise pollution in its various forms and work to reduce it. What are the most important wastes of this sector? How is this type of pollution formed? What are the ways it affects nearby systems? In order to reduce and limit its severe effects, which are the most effective solutions?

1. Mining phases:

The exploitation of mines relies on several geotechnical and mechanical steps. It is well established that a preliminary study encompassing all economic and profitability aspects is essential before initiating any investment project. This is achieved through a field study that includes the exploration of ore grade, or mineral content by analyzing soil samples in the laboratory. Subsequently, the development process is initiated, including the determination of the access method and the construction of exploitation stations like crushing and grinding equipment before commencing the actual exploitation, as illustrated in Figure 1.

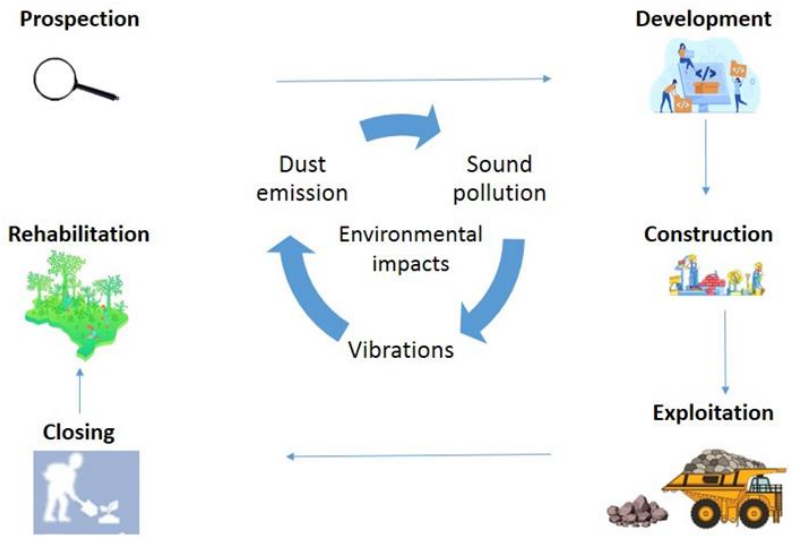


Figure 1: Mining life cycle stages (Prepared by F.Djedid).

After the mineral composition has undergone various preparatory steps to achieve the desired volume, the product is transported in its final form for marketing purposes (Jessica, 2024). It is important to note that each of these steps is accompanied by negative impacts on the environment, workers, and nearby communities, resulting in pollution that affects air, water, and soil quality.

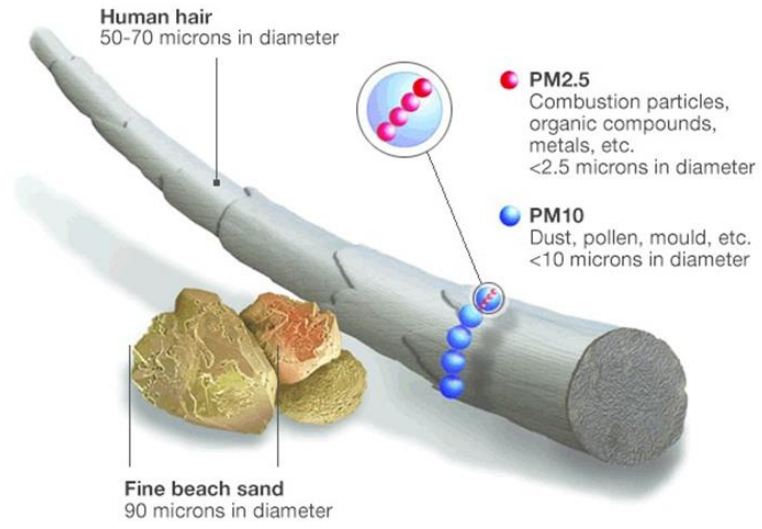
2. Problem statement:

The negative environmental impacts of mining vary depending on the material being extracted. For instance, the extraction of coal produces effects that differ from those associated with the extraction of aggregates. Similarly, the consequences of gold extraction differ from those of copper or phosphate mining. Additionally, the chosen method of extraction whether surface or underground also plays a critical role in determining the nature and extent of these environmental impacts.

In general, these impacts are considered to represent a temporary to permanent loss, notwithstanding the benefits gained from the extraction processes (Vinayagam, Sathishkumar, Ayyamperumal et al., 2023).

a. Negative effects of mining on air Quality:

The surface mining method, also known as open-pit mining, is regarded as more polluting compared to underground mining techniques. Recent research indicates that the air pollution associated with this method is significant and poses serious threats to the human respiratory system, particularly for workers in quarries and mines who experience continuous exposure to fine particulate matter such as PM2.5 and PM5 (Patra, Gautam and, Kumar, 2016; Djedid, Bounouala, Bouslama et al., 2024).



Source: US EPA

Figure 2: particulate matter in comparison with a human hair and a beach sand, (Micronics, 2023).

According to figure 2, we can notice that the size of these particles is relatively tiny compared to a human hair. The small red balls represent particles of 2.5 micrometers, while the blue ones represent particles smaller than 10 micrometers. The size of beach sand grains is approximately 90 micrometers, as illustrated in the drawing. This comparison highlights the extremely small size of metal dust particles that can enter the respiratory system and lead to serious diseases, such as lung conditions, and asthma (Micronics, 2023).

b. Negative effects of mining on soil and water bodies

Regarding soil pollution, several studies have confirmed that mining plays a significant role in the contamination of soil like acid mine drainage AMD (Akcil & Koldas, 2005). It is a chemical reaction resulting from uncontrolled mining discharges, typically occurring due to the interaction between iron sulfide particles, water, and oxygen. This type of pollutant leads to significant problems for both soil and water bodies (Acid Mine Drainage (AMD): Definition, Causes, and Treatment, 2024).



Figure 3: Acid Mine Drainage Acid Mine Drainage (AMD): Definition, Causes, and Treatment, 2024)

In addition to the aforementioned issues, mining activities can also contribute to soil erosion and instability, which in turn hinders the soil's ability to support plant growth. Moreover, these activities can alter the soil's composition as a result of airborne dust and other factors (Mhaske, Pathak, Dash et al., 2021).

c. Investigating the Sources of Noise and Vibration in Mining Operations

Among the most significant direct impacts of mining operations, which occur at every stage of the mine or quarry life cycle, are the vibrations and noise generated during the exploration, construction, and production (blasting) phases, as well as during the transportation of the final product (IRMA, 2018). As is well known, the mining sector is characterized by high noise levels due to the nature of the activities involved, which are essential. Therefore, it is crucial to explore further to understand how these impacts affect the environment, infrastructure, and, primarily, human health.



Figure 4: The installation of the crushing station at Heliopolis Guelma gravel quarry, Algeria, (Photography by F.Djedid)

As noticed in the previous figure 4, the installation of crushing stations produce a huge quantity of noises and vibration waves. There are several diseases associated with noise exposure, such as hypertension and stress. Additionally, individuals exposed to high levels of noise may experience a decrease in hearing ability, and in some cases, complete hearing loss. Furthermore, many individuals subjected to noise, chaos, and loud sounds report experiencing sleep disturbances (Effects of vibration, 2020).

d. Environmental and Health Impacts of noises and vibrations:

Several studies have documented the adverse effects of noise pollution on biodiversity, confirming that it threatens the survival of numerous plant species and animals (birds, mammals, and fishes) regardless of whether the noise originates from industrial activities, heavy vehicles, or other sources. These factors collectively have a detrimental impact on biodiversity (Sordello, R., Ratel, O., De Lachapelle, F. F.,et al., 2020).

Figure 5 presents an illustration of the effects of industrial vibrations and noise produced by mining machinery on the surrounding environment. On the right side, an excavator is depicted in operation, generating ground vibrations, which are indicated by a warning symbol alongside the text “Ground-borne vibration.” These vibrations may affect the water and nearby structures, such as the house. Additionally, sound waves are illustrated in relation to the aquatic life and the individual fishing, demonstrating the noise generated by the machinery.

Furthermore, fish are shown swimming away in the water, highlighting the potential effects of these disturbances on aquatic fauna (Aimon, Simpson, Hazelwood et al., 2021). Overall, the image emphasizes the interactions between human activities and the natural environment.



Figure 5: This is a simplified schematic illustrating the effects of vibrations and noise generated by mining machinery on the surrounding environment: water movement, fish stress and escape behavior, building cracking, and threats to safety. https://fr.vecteezy.com (Modified by Author F.Djedid).

3. Legislative Measures

The European Union has established a maximum exposure limit for vibrations at 0.5 m/s² in order to mitigate their adverse effects (the United Kingdom Control of Vibration at Work Regulations, 2005). As for noise, a value of 85 dB (A) was determined following the Occupational Health and Safety Regulations of 2007 in Victoria, without exceeding a maximum of 8 hours (Exposure Hazards, 2015).

Regarding Algerian legislation, it has affirmed its commitment to implementing noise threshold values from various institutions and sectors to ensure the safety of citizens and protect public health. This is reflected in the latest official publication in Official Gazette No. 71, issued on November 11, 2023. The value was set at 70 decibels, as specified in Executive Decree No. 184 of 93, dated July 27, 1993(Gramez, 2010).

4. **Recommendations:**

- Establishing threshold values for noise and vibrations specifically at quarries and open-pit mines.

- Imposing financial penalties and issuing written warnings for instances where noise and vibration levels exceed recommended limits, targeting those responsible for projects that cause such pollution.

- Implement periodic health assessments for workers by specialists in general medicine, hearing issues, and blood pressure management.

- Reducing the duration of exposure to mechanical noise and vibrations by periodically rotating workers to minimize their hours of exposure and, consequently, mitigate the harmful effects.

- Conducting audits to verify compliance with the established noise and vibration thresholds.

- Utilizing modern machinery that is environmentally friendly and quieter, featuring advanced technology.

- Efforts should be made to organize training and awareness programs for workers in the mining sector, with the aim of implementing safety protocols and promoting best practices in noise and vibration control.

- It is also essential to engage local communities through consultative processes and fostering a culture of communication to address concerns and potential impacts of industrial noise and vibrations, thereby enhancing transparency and cooperation.

Conclusion

In summary, the preceding discussion indicates that the mining sector has significant environmental impacts that adversely affect our daily lives, including respiratory health, water quality, soil degradation, and noise pollution. Therefore, all stakeholders need to collaborate in mitigating these effects and advancing a green economy that prioritizes the well-being of humanity and the community. To make this objective achievable, it is necessary to implement more legislative measures aimed at minimizing these issues.

Efforts should be directed toward reducing fatal accidents caused by significant vibrations, such as those generated by blasting operations in mineralized areas for extraction purposes. Unfortunately, multiple local regions have experienced such incidents, leading to the loss of personnel, including both male and female workers. A particularly tragic example is an accident that occurred last year at a quarry in Guelma Province, where a young engineer lost her life on-site due to a rock collapse resulting from the vibrations generated by an explosion.

Therefore, all the key points discussed in this research contribution should be taken into careful consideration, with the primary goal of preserving human security and safeguarding ecosystems, as they are an essential and inseparable part of us.

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