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The environmental impact of mining activities in Europe: a comprehensive analysis

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Abstract
Mining activities have emerged as major contributors to environmental damage. This paper offers an analyse of the actual situation of environmental damages caused by mining activities in Europe. Alarmingly, pollution from mining activities in the European Union is increasing. Surface and underground mining have detrimental effects on air and water quality, land degradation, waste disposal, noise pollution, deforestation and loss of biodiversity, endangered species, microbiota, economy, and health. Moreover, the risk of dam destruction because of climate change is increased. Globally this fact ranked Europe in second place in terms of dangerousness. The situation of protected species is critical and their status remains poor. The rehabilitation cost is exorbitant, and enforcement of regulations is lacking. It is evident that, due to economic demand for metals, mining will play a central role in EU's future despite the growing emphasis on green initiatives and transition. Unfortunately, public awareness regarding environmental impact of mining activities is insufficient, and their voices are often disregarded. In order to reduce the negative impact of mining on the environment, economy and public health, it is necessary to take urgent political and technical measures. This paper aims to present a comprehensive overview and offer suggestions for future actions.

Keywords
Mining activities; Environmental impact; Land degradation; Deforesting; Biodiversity; Europe

Introduction

European countries, including those outside the EU, have a significant history and ongoing engagement in the mining sector. Mining activities are associated with many impacts, which are difficult to be descry-bed. Today, the growth of mining activity is closely related to local and international factors. On the other hand, cyclical changes in the economy bring risks that also affect the mining activity (Mononen et al., 2022). Minerals are generally considered as national assets and their exploitation follow numerous regulations, especially those related to environmental pro-tecttion. In the development of mining activities, European countries adhere to regulations outlined in EU Directives for: Landfill of Waste (Council of Europe

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Portal, 1999); Environmental Impact Assessment (European Union, 2014); Environmental Liability (European Union, 2004); Protection of natural habitat, Flora and Fauna (EUR-Lex, 2023); Industrial Emissions (EUR-Lex, 2010); Pollution Prevention and Control (EUR-Lex, 1996); Mining waste (EUR-Lex, 2023); Water Directive (EUR-Lex, 2000), etc. Despite the existence of regulations, the impact of mining activities in environment remains significant and varies in scale among different countries. Historically, mining activities have been the subject of numerous debates. While society benefits from mining jobs and products, there is also a highly sensitive concern for environmental protection. Usually, the life of a mine ranges from 10 to 30 years, but the impacts on the environment can be forever. The impacts of mining are commonly divided into four main categories (Mononen et al., 2022): (1) Environmental; (2) Social; (3) Political; (4) Cultural.

According to the HitHorizons Database, updated on 2024, the number of European companies in the mining sector is 60,067. The top ten mining countries are: Russian Federation, United Kingdom, Spain, Ukraine, Italy, Romania, Poland, Germany, and France. (HIT HORIZONS 2024). Additionally, Eurostat data indicates that in 2020 there were 17,100 people employed in EU mining sector (Eurostat 2024).

Damages caused by mining activity

It is known that every mining activity consist on mineral exploitation passing four stages: (1) Exploration; (2) Opening and Preparation; (3) Exploitation; (4) Closure. The greatest environmental effects occur during phases 2 and 3. Inside the mining area two main problems arise: Mineral exploitation and Environmental transformation (Hoxha, 2004). There are three main categories of damages caused by mining activities, at the macro level as damages on: (1) Environment; (2) Economy; (3) Health. Another classification for the damages caused by mining activities is based on the method used to exploit minerals.

Impact on Air quality

Regardless of the methods used for the development of mining activity, underground or surface, the operations that affect air pollution are: (1) The opening; (2) Preliminary processing; (3) Transportation; (4) Processing in enrichment factories; (5) Refining (Priya Singh, 2022).

From another point of view several sources of air pollution with different characteristics can be identified during the stages of mining: (1) Mobile sources; (2) Immovable sources; (3) Fugitive emissions. The dust produced in open cast mining operations can contain metal or sulphides, and transportation brings the emission of greenhouse gases. Generally polluted air affects leaves and roots of plants. This impact appears by disrupting the metabolic function of leaves as well as reducing the ability of roots to absorb resources from the soil (Weber et al., 2021). In Albania, for example, the negative impact of mining transport on air quality has increased, due to the higher number of vehicles (UNCE, 2018). One extreme case is the Kruja opencast mine in Albania, where extensive explosions and heavy machinery operations generate significant amounts of dust that settles in the surrounding forests and agricultural lands. This not only poses health risks to the local population but also affects the touristic city of Kruja, creating an unfavourable environment for both residents and visitors. The mining sector is responsible for 4% to 7% of global GHG emissions. If we analyze the contribution of mining industry, in carbon release, it arrives in 8%. According to Eurostat statistics for 2021, the CO_2 air emissions from Mining and Quarrying amounted to around 22,996,661 Tonne. The country with the lowest emissions is Island, while Norway has the highest emissions (Eurostat, 2022). In terms of pollution release in the EU, mining activity ranks the second place in 2021. The energy sector contributes 60.8% of CO_2 emissions, while the mineral industry accounts for 11.3%. It is concerning that CO_2 emissions from the minerals industry have increased from 10.3% in 2007 to 11.3% in 2021 (EIEP, 2021).

Impact on Land degradation

The extent and impact of soil pollution is different in different countries of Europe. Although the release of heavy metals and organic pollutants from industry and transport has decreased, evidence shows that these pollutants continue to be deposited in the soil, what brings that levels of copper and zinc exceed the permitted limits (EEA, 2023). Mineral extraction in open-cast mining is one of the biggest factors contributing to land degradation. It causes not only the permanent change of the earth's surface but also destroys the original vegetation. Due to mining activity, landscape damage is very serious and can be described as catastrophic. The most negative im-

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pacts are: Creation of artificial lakes; Damages to pastures and vegetation; Damages to flora and fauna; Sinkholes; Land subsidence; and Erosion.

Creation of artificial lakes.The formation of lakes due to mining activity is a special phenomenon. It occurs more often in abandoned mines, but there are also cases in active mines. Interesting examples are: Chabařovice open cast mine, of the town of Ústí nad Labem, (Prikryl et al., 2011); Milada Lake in a mining pit in the Czech Republic, (Fig.1); León province in Spain, (Vega et al., 2017).

Figure 1. *The Milada Lake created by filling the open cast mine of Chabařovice (DRONESTAG, 2023)*

To provide a clearer understanding of the environmental damages arising from open cast mining activities, the ten largest surface mining by production in Europe in 2021, according to GlobalData's mining database, are presented. These mines are as follows: (1) Aitik Mine, a copper mine located in Sweden (Wikimedia Commons 2003) (Fig.2); (2) Belchatow Mine, a coal mine in Poland (Bellona, 2014); (3) Hambach Mine, a coal mine in Germany (DW, 2017); (4) Garzweiler Mine, a coal mine in Germany (Wikimedia Commons 2023); (5) Maritsa East Mine, a coal mine in Bulgaria (Darik.News English, 2002); (6) Ptolemais South Field Mine, a coal mining in Greece (Kavouridis and Agioutantis, 2006); (7). Inden Mine, a coal mine in Germany; (8) Welzow-Sud Mine**,** a coal mine in Germany; (9) Nochten Mine**,** a coal mine in Germany; (10) Veliki Krivelj (VK) Mine, a copper mine in Serbia (Global Data, 2021). The extraction activities of these mines have significant environmental impacts on the surrounding ecosystems and communities. Evaluating and addressing these damages is crucial to mitigate their adverse effects and encourage more sustainable mining practices.

Figure 2. *Aitik Mine, a copper mine located in Sweden (Wikimedia Commons, 2003)*

Damage to pastures. Mining activity causes great damage to pastures as well. The main reasons are massive eruptions and erosion. The dust created in surface mining contains metals or sulphides that change the conditions of plant growth.

Damage to flora and fauna. Mining activity also causes damage to flora and fauna. As a result of mining operations, many plants are destroyed due to excavations, or are covered by deposited soils. Also, as a result of loud noises, air and water pollution, many animals leave the areas with mining activity. All these activities result in the impoverishment of flora and fauna.

Sinkholes. Sinkholes are caused as a result of the sudden collapse of mining works. This phenomenon results in the creation of pits that reach the superficies (Singh, Kalendra B. 1997). The unexpected collapse of the ground creates a big hole in the surface. Because this collapse occurs without any warning, it poses a serious risk to life and property. (Fernandez et al., 2007). Figure 3a shows cases of collapse sinkhole in Spain (Wikimedia Commons 2023), but similar examples can be found in Ukraine and Albania as well. Scientific studies conducted in Ukraine have focused on surface deformations in the Solovyov salt mining and show that, although the conclusion of mining operations in 2010, ongoing sinkholes formations have been observed, expanding at a maximum line-of-sight deformation rate of 5 cm/yr (Eszter. et al., 2021).

Land subsidence. The expansion of underground mining operations to grater depths has resulted in significant empty area underground, which can lead to land subsidence on the surface. In Albania for

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example, the operations in Bulqiza Cr Mine is extended to deeper levels that part of the old town site of Bulqiza town has been severely affected by land subsidence, especially in elementary school building in the old town (Shibata et al., 2010). Another example is city of Tuzla, located in Bosnia and Herzegovina. As a consequence of artificial uncontrolled leaching of salt layers land subsidence has occurred leading to the formation of "Pannonica" lakes in Tuzla, Bosnia and Herzegovina (Fig. 3b) (Pannonica, 2018).

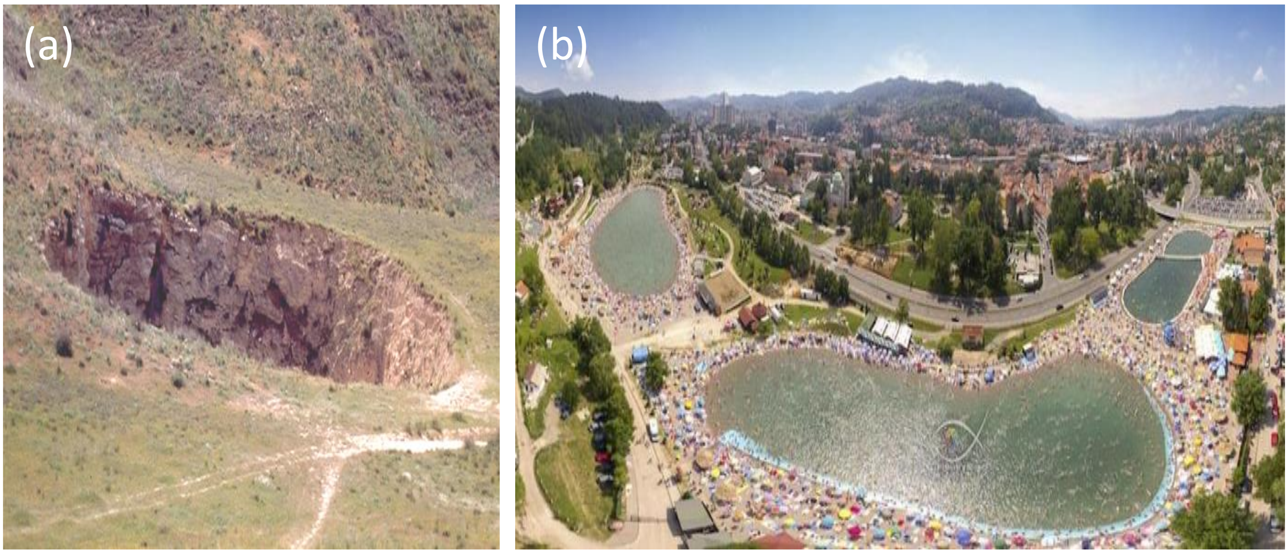

Figure 3. *Collapse of sinkholes.* (a) *Sinkhole in Chinchón, Spain (Wikimedia Commons 2015);* (b) *Artificial lakes in Tuzla, Bosnia and Herzegovina (Pannonica 2018)*

Erosion. Mining activity affects the increase of erosion. This is especially noticeable on the slopes of hills, waste stocks, and dumps and banks of streams and rivers (Calvin et al., 2014). Soil erosion brings the decrease of the amount of water needed for plant growth, and as a result also leads to a decrease in their species (Moreno-de las Heras, 2009). Experience has shown that the main causes of erosion are heavy rainfall, poor land management and mining activity (Wantzen and Mol, 2013). In general, in non-forested areas, mining can result in the destruction of ecosystems and habitats, while in agricultural areas they can destroy pastures and agricultural lands (Zhang et al., 2015). One report, published by the EC in 2017, evaluated that mining activities, surface, underground and abandoned mining sites, in EU have caused damage to over 500,000 ha of land (Soleille et al. 2017). On a global scale, the total surface of land used for mining purposes is 101,583 km^2. Out of this total, six countries (Russian Federation, China, Australia, USA, Indonesia, and Brazil) accounts for 52% of the mining land use. Europe accounts for 185,552 km^2, which represents 18.3% of the global mining land (Maus et al., 2022).

Impact on Water pollution

Both surface and underground mining activities contribute to hazardous water pollution. Potential impacts on water include: acid mine drainage; contamination of ground water and surface water; changes in hydrology; eater scarcity in arid regions; dam accidents; contamination risks; wastewater discharges and changes in water quality. Opencast mines often deposit stockyards near water sources, leading to pollution of springs and negatively affecting water quality for livestock and agriculture. Rivers affected by tailings spills serve as water sources for agricultural and drinking proposes, affecting local populations (Koço and Hoxha, 2019). The main problem associated with closed mines is related to acidic waters. These waters affect both surface and underground waters. For this reason, measures must be taken to prevent the spread of high chemical concentrations in surface and underground waters. It is very important that these waters do not mix with surface waters or flow into forests. An illustration of this is the Rio Tinto River region (Fig.4) (Fernández-Remolar. et al., 2005).

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Figure 4. *Acid mine drainage in Rio Tinto River in Spain (Paco Naranjo Jimenez)*

Another issue related to the mining activity is dissolution and transport of heavy metals through runoff and groundwater. An example is the abandoned Skouriotissa copper mine, in Cyprus (Fig. 5). It should also be taken into account that environmental changes, global warming and increased mining activity may increase the concentration of heavy metals in waters coming out from the mine (Huang, X. et al. 2010).

Figure 5. *Skouriotissa copper mine in Cyprus (MeanStreets)*

Impact of Waste disposal

Mining operations generate significant volumes of waste, which can have potential environmental impacts. Waste disposal in mining activities are categorized into two types: (1) Direct waste deposition in the mining area, including stockpiles, spoil tips and tailing dams; and (2) Industrial waste connected with mining operations.

Stockpiles and Spoil tips. A Spoil tip is created by the accumulation of coal or other mineral waste, or during the opening of tunnels. While spoil tips are referred to as slag heaps in certain regions, must be noted that they are not created by slag. The main part of the waste has a carbonaceous composition that burns easily, and for this reason, it can be the cause of accidental ignition of fires (Richards et al., 1993) (Fig. 6a).

Tailing dam. Tailing Dam consists of waste produced by the process of separation of ore and tailings in ore enrichment factories. These types of waste are stored in pits, existing natural valleys, or artificial dams. These dams are used for long periods of time, 30-40 years (Fig. 6b). The waste deposited in Dam is very dangerous because it can pollute the waters and fauna through the release of toxic metals (Franks et al., 2011).

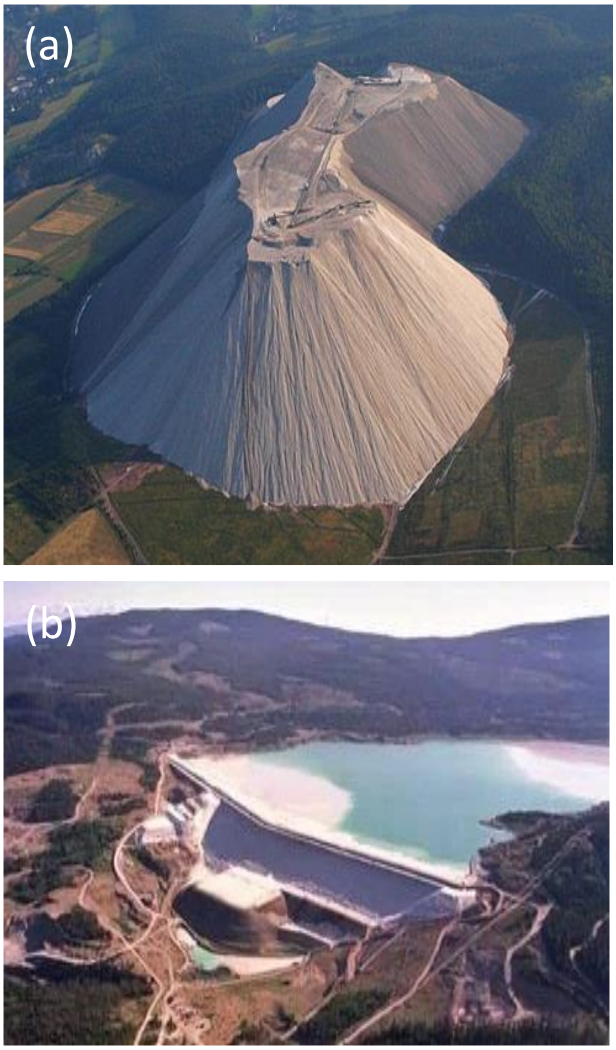

Figure 6. *Spoil tip and tailing dam.* (a) *Spoil tip "Monte Kali" in Heringen, Hesse, Germany (Wikimedia Commons, 2023);* (b) *Tailing dam in Highland Valley copper mine (Tailings. Info 2023)*

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Today, a hard challenge related with tailings dams is the impact of climate change on their stability and lifespan. Because the existing dams were designed and built based on different climatic conditions, they are at risk from ongoing climate change and today's extreme weather. Because of that, it is very important to design strategies to protect dams from the consequences of weather changes. One research shows that Europe is in the second place for reported accidents and environmental impacts related to tailings dam failures, with 18% of incidents. Further, more than 90% of accidents happened in active mines, while the remaining 10% were linked to ponds that are abandoned (Mayte Rico et al.. 2008). In 2019 there were estimated a number of around 18,000 working tailings dams or tailings storage worldwide. There have been reported many concerns about the security of these structures. A report published by The World Mine Tailings Failures Organization highlighted 40 significant dam failures during the period from 2007 to 2017 (World mine Tailings 2023). Climate change also has its effect on the durability and lifespan of dams. These effects are: (1) Increase in acid discharges from the mine; (2) Increasing the amount of heavy metals and other pollutants, which are transported by precipitation; (3) Increased risk of pollution incidents due to extreme weather; (4) Weakening of the dam structure due to the contraction and expansion cycle.

Industrial waste connected with mining activity. Industrial waste associated with mining activities includes various types of waste disposal in sites close to mineral processing plants, concentrator plants, smelter plants, and waste dump areas (slag). Figure 7 shows one of the worst examples of pollution caused by mineral processing plants in Europe, the case of Kiruna, in Sweden. This mining related pollution had so negative effects that the city centre was moved to a different location.

Figure 7. *Mining in Kiruna city in Sweden (Nunatsiaq News 2013)*

Impact on Acoustic pollution

Acoustic pollution stands as another significant impact arising from mining activities. The reasons are attributed to different factors, including noise and land vibrations resulting from controlled detonations and aerial exploration. An illustrative case can be observed at the Kruja opencast mine in Albania, where a quiet and relaxed area was transformed into a noisy region due to massive explosions. The noise levels have exceeded acceptable standards, disrupting the tranquillity and natural equilibrium of the region. It is important to note that mining activities often take place in protected areas and without respecting the criteria for obtaining the relevant permit (Koço and Hoxha, 2019).

Impact on Deforestation

The opening of a mine is often accompanied by the cutting of large forest areas and their destruction. This action brings great economic and ecological damage. Deforestation also increases the likelihood of flooding, endangering people, increasing the spread of disease and reducing the ability of forests to prevent erosion (Hoxha, 2023). Different types of mining have different levels of impact on deforestation. These negative impacts can persist even after mining operations have concluded, prolonging the process of land restoration due to land quality degradation (Prasad Siva Dontala, et al. 2015). In Albania for example, a debatable case has been the Kuksi area, where local government authorized the clearance of 33.60 ha of forest for mining company exploitation. Similarly, in Kruja, a comparison between images from 2007 and 2019 revealed extensive damage to a 145 ha forest area (Koço and Hoxha, 2019). A recent report by the World Wide Fund for Nature (WWF) shows that mining activity is currently the fourth factor affecting deforestation and affects up to 1/3 of forest ecosystems in the world (Kramer et al.. 2023)

Impact on Biodiversity

The opening phase of a mine is responsible for the major alterations to the landscape, vegetation, and hydrology. Usually, mining areas are enclosed or fenced off, disrupting natural animal movement and

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annual migration routes. These processes result in habitat loss and land parceling on small plots. Parceling affects many species that depend on uninterrupted habitat (Hobbs and Gunn, 1988). Most of the mines dispose their waste in tailings or dams, both of which can contaminate nearby rivers. Studies show that concentrations of heavy metals and the effect on biodiversity are reduced by moving away from the mine (Jung and Thornton, 1996). Damage or excessive modification of the area where the mining activity takes place results in a significant impact on its biodiversity (Sonter et al., 2020). On the other hand, habitat damage is a key factor that contributes to the loss of biodiversity. In this case, the mining activity affects negatively through water pollution. This pollution causes food and water poisoning which is used by animals, plants and microorganisms. The place where animals live and feed can be damaged not only by chemical pollution but also by non-chemical elements, such as rock fragments that are deposited in the surrounding landscape, despite of their impact on the natural habitat (Diehl et al.. 2004). The examination of the Rehova copper mine in Albania reveals that the interaction between underground and surface water with cooper minerals results in a mixture of waters containing chemical elements such as silica, pyrite and others that are used in during the mineral processing (Hoxha, 2023). Mines cause an important and disruptive impact on the environment, particularly on soil and water quality. Although most plant species tolerate the high concentrations of metals in the soil. The degree of sensitivity varies depending on the species. For example, while different grasses are less affected by high pollutant concentrations, shrubs and bushes are more vulnerable (Mummey et al., 2002). However, some plant species show high resistance and survive even in environments with high concentrations of metals (Steinhauser et al., 2009).

It is known that in the areas where mining activity takes place, some of the trees try to divert their roots to leave the polluted areas, making them vulnerable to the force of the wind, which causes them to collapse (Larrocea et al., 2010). Even though the area can be rehabilitated, due to previous mining activity and the presence of pollution, the diversity of plant species decreases (Mummey et al., 2002). Depending on the way of mining exploitation, it may happen that all the vegetation is damaged before the start of the mining activity (Huang et al., 2014). Mining activity damages the mine area and the surrounding area. Thus, for example, the yields of agricultural plants decrease (Orji et al., 2021). Construction and exploitation mining activity often result in the extensive destruction of natural habitats, which forces animals to leave their native sites (Cristescu et al., 2016). Additionally, mine products and residues can directly poison animals. Bioaccumulation in plants or smaller organisms that are part of the animals' diet, can also lead to poisoning. In certain areas, animals like horses, goats and sheep may be exposed to toxic concentrations of copper and lead in the grass they consume (Pyatt et al.. 2000). Even when mining operations have ceased for more than two decades in some cases, many of these species have not returned to their original habitats. For instance, areas with high copper levels in the soil near copper mines tend to have fewer ant species (Diehl et al., 2004). An illustrative example is the Rehova copper mining area in Albania. Prior to mining, this area was full of wild animals. However, approximately 20 years after mining activities ceased, many of these species have not returned to the area (Hoxha, 2004). This emphasizes the long-lasting impact of mining on local ecosystems and biodiversity. Different types of contamination from mining activities have different impacts on biodiversity. Species vary in their resistance to these contaminants and some stay in the polluted area while others leave. Achieving full rehabilitation requires time and implementation of additional measures. Furthermore, studies indicate that rehabilitation is a lengthy process and, in most cases, cannot fully restore the original biodiversity that existed before the mining activity started. Some other examples reinforce these challenges. In Rosia Montana, Romania, mining impacted and destroyed 350 ha of forest; in the Kryvyi Rih region of Ukraine, open-pit mining led to the destruction of significant areas of forest and grassland ecosystems. In Sweden, mining has had significant impacts on forests, wetlands, and aquatic ecosystems, resulting in habitat loss of several threatened and endangered species. The endemic species are very sensitive and because of that they need very specific environmental conditions. The reasons of animals leaving the mining area are different, such as noise, land vibration, etc. It is very important that species and habitats are preserved. In general, all European countries have established rules to protect animal and plant species. However,

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most of the protected species in Europe, due to various pressures, have a poor or bad conservation status. The European Union (EU) Directives on Habitats and Birds and the Berne Convention (Council of Europe Portal, 2024) include a number of requirements for the protection of species. The Natura 2000 Network (European Commission 200) and the Emerald Network protect some of the most endangered species (EEA, 2023). For some special species, the EU has set very strict rules, covering about 1,000 species. This strict regime prohibits killing, capturing, disturbing the species or destroying their breeding and resting places. However, even with this strict regime, studies show that only 27% of protected species have a good protected status, while 63% have a poor or bad status (Nauman et al., 2020).Mining activity can also affect the soil and water microbiome. This implies structural and functional changes of the microbial community. Microorganisms have an important role in soil biogeochemical cycles and ecosystem services. Most important are nutrient cycling, carbon sequestration, and pollutant degradation (Symochko et al., 2023). Microorganisms are very sensitive to modifications of environment (Symochko et al., 2021). Modification of pH, temperature, chemical concentrations, etc can decrease or not the total soil bacteria (Steinhauser et al., 2009). Changing soil pH can also provoke a reactivation of pollutants (Rasher and Van Schalkwyk, 2000). A study (Mummey et al., 2002) has shown that, in a rehabilitated area, after twenty years of mining activity, the microbial biomass is much reduced compared to the habitat before mining activity. However, there are some mushrooms that have the ability to absorb pollutants thus cleaning the soil. On the other hand, there are some microbes that can negatively affect the environment by increasing SO_4 in water (María del Pilar Ortega-Larrocea et al. 2010). If we see algae, they are less diverse in acidic water containing high zinc concentration (Niyogi et al., 2002) and the stress of mine drainage decreases their primary production. The activity of mines, impact the aquatic biodiversity through direct poisoning, or water pH modification (Steinhauser et al.. 2009). This fact makes it difficult to distinguish the direct impact from that caused by pH changes (Ek and Renberg, 2001). Influencing factors in microorganisms living in mines with acid flow are related to time changes and seasons. Long-term changes in temperature, precipitation, Ph, salinity and metals have a significant impact on them. Alterations in pH or temperature not only influence metal solubility but also directly impact the bioavailable quantity affecting organisms. Furthermore, pollution persists over time. This is proven by the persistence of low water pH and the dominance of acidophilic bacteria populations, even ninety years after the closure of a pyrite mine (Kimura et al., 2011). Mining activity causes the entire aquatic environment, along with aquatic insects, around the mining area to change. This leads to the reduction of trophic wealth and its dominance by predators (Gerhardt et al., 2004). This problem can be solved, maintaining high biodiversity of invertebrates also, by replacing sensitive species with tolerant ones (Malmqvist and Hoffsten, 1999). Fish can also be affected by pH, temperature changes and chemical concen-trations (Wong et al., 1999). Considering above results that mining activities and biodiversity are linked in a complex relationship. To summarize the various factors and their impacts discussed above, Figure 7 provides a comprehensive ilustration of the mining activity impact on the environment, using the Bulqiza chromium mine in Albania as a case study. This visual representation offers a global perspective of the interconnected effects associated to mining, including aspects such as air quality, biodiversity, deforestation, water pollution, habitat loss, and more. It serves as a comprehensive overview of the environmental challenges posed by mining, emphasizing the imperative for sustainable and responsible practices in this sector.

Mining activity in the framework of the Green Deal

In order to improve the quality of the environment, the European Commission has decided, compared to 1990, to reduce the net emissions of greenhouse gases by 2030, by at least 55%. This reduction corresponds with the long-term objectives of the European Green Deal. One of the main aspects of the EU transformation is the achievement of net zero greenhouse gas emissions by 2050. Within the context of the European Green Deal, the mining sector plays an essential role facilitating green transition. The sector’s objectives can be roughly divided into three main areas: (1) Enhancing environmental impact; (2) Ensuring a stable supply of raw materials to EU industries; (3) Promoting circular economy of metals and minerals. Overall, the mining sector's alignment with the goals of the

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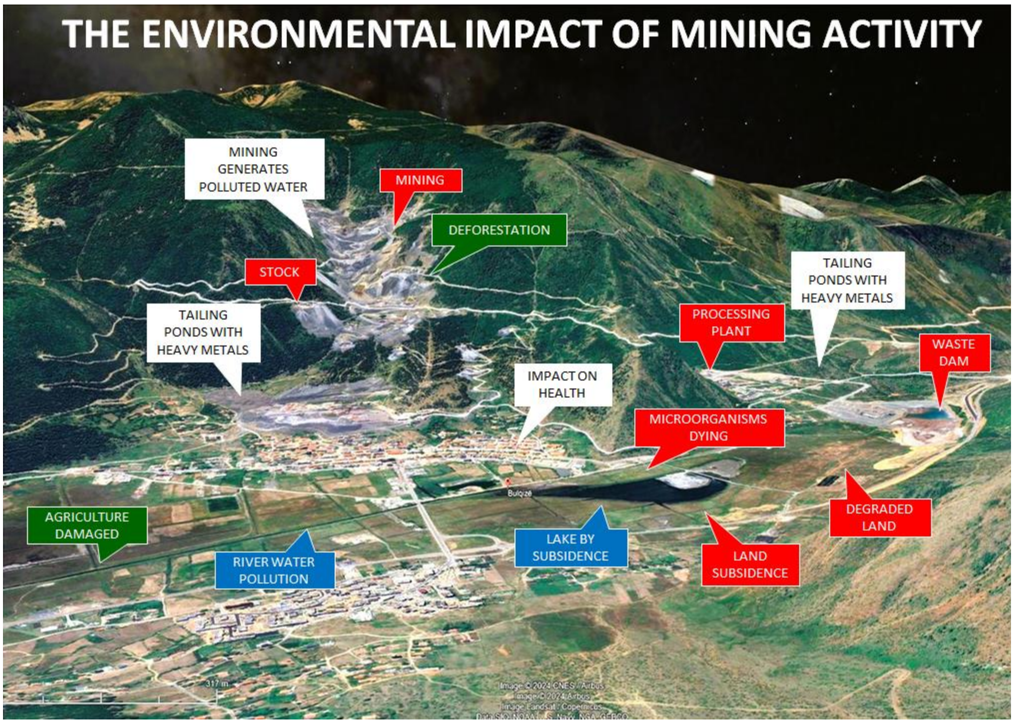

Figure 8
Illustration of the impact of mining activity in environment.
Source: Illustration by Edmond Hoxha, Bulqiza Cr mine, Albania; Image Google Earth ©

European Green Deal emphasises its commitment to contributing to a more sustainable, environmentally friendly, and economically viable future for the European Union.

Conclusions and Recommendations

Conclusions

Based on the reviewed information and their personal experience, the authors arrived on the following conclusions: (1) The pollution from mining activities in EU in 2021 increased by 11.3% compared to 2007 (10.3%); (2) The most negative impacts of mining on the environment are water pollution and land degradation; (3) The greatest risk associated with tailings ponds is the potential dam failure. Europe is in the second place for reported accidents; (4) Mining activities are responsible for up to 10% of global deforestation; (5) Mining activities contribute significantly to the habitats damaging, resulting in biodiversity loos. Only 27% of protected species have a good protected status, while 63% have a poor or bad status; (6) Mining can impact directly and indirectly the microbial biodiversity; (7) Currently is missing a full database that provides information on the environmental impact of mining activities in the European Union; (8) The existing legislation has enough tools to protect the environment, but the implementation and enforcement it is not effectively in practice.

Recommendations

In the light of the conclusions reached, the following recommendations are proposed: (1) It is necessary to review strictly the criteria for open cast mine licensing; (2) Strict measures should be implemented to effectively treat and manage water pollution originating from mining areas; (3) It is recommended to conduct a comprehensive investigation of all major dams in Europe. This should be accompanied by the development and approval of new rules, regulation and standards on dams design and construction; (4) It is recommended to prioritize careful management and monitoring of mining activities in forested areas and also to force mining companies to conduct comprehensive environmental assessments and adhere to stringent regulations to minimize their impact on forests and other ecosystems; (5) Considering the projected increase in future metal demand, it is crucial to prioritize the initiation of a dialogue among mining companies, policy-makers and conservation organizations. Furthermore, abandoned mines need to be studied to assess their potential as food resources for wildlife; (6) It is urgent to implement specific measures for improving the situation of protected species; (7) In order to address the high cost of rehabilitation and ensure effective environmental restoration, it is crucial to closely monitor the implementation of rehabilitation plans. The rehabili-

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tation of the exploited mining field must be obligatory for the companies before starting a new mining field. High environment rehabilitation costs can be reduced by strictly law implementation; (8) It is crucial to enhance public knowledge and awareness regarding mining activities and their environmental impact; (9) It is imperative for the EU to: establish long-term strategies aimed at reducing the environmental impact of mining activities; to increase Funding for the rehabilitation of environmentally damaged areas by mining activities; to strongly implement the legislation; (10) The new digital technology in environmental monitoring should be implemented in a larger scale, especially in dam wastes, stockpiles and land subsidence areas; (11) There is an urgent need for a comprehensive, updated, and transparent open-source database that encompasses all mining activeties, with a particular focus on environmental hotspots; (12) The curricula of mining and environment protection education should be enhanced to incorporate the principles of climate change and Green Deal. Universities and scientific research institutions should receive better support and resources to develop comprehensive programs to address environmental challenges effectively; (13) In the framework of the Green Deal, mining operations should strive to maximize their use of renewable energy sources.

References

BELLONA (2014) Belchatow Poland. Published on April 22, 2014 by Bellona Europa, https://network.bellona.org/content/uploads/sites/3/Belchatow-Poland.jpg

COUNCIL OF EUROPE PORTAL (1999) Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste. Official Journal L 182, 16/07/1999 P. 0001-0019 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri= CELEX:31999L0031&from=EN

COUNCIL OF EUROPE PORTAL (1979) Bern Convention. Convention on the Conservation of European Wildlife and Natural Habitats https://www.coe.int/en/web/bern-convention/emerald-network,

CRISTESCU B.,. STENHOUSE G.B.., BOYCE M.S.. (2016) Large Omnivore Movements in Response to Surface Mining and Mine Reclamation. Scientific Reports. 6: 19177. https://doi.org/10.1038/srep19177

DARIK (2022) News English. Mine "Maritsa East" for the first time starts exporting coal. https://darik.news/en/mine-maritsa-east-for-the-first-time-starts-exporting-coal.html,

DIEHL E; SANHUDO C.E.D; DIEHL F. (2004) Groud-dwelling ant fauna of sites with high levels of copper. Brazilian Journal of Biology. 61 (1): 33–39. https://doi.or/10.1590/S1519-69842004000100005

DRONESTAG (2023) Lake Milada, Ústí nad Labem, Czech Republic. https://www.dronestagr.am/lake-milada-usti-nad-labem-czech-republic,

DW (2017) https://www.dw.com/en/the-battle-for-villages-and-forests-in-germanys-coal-country/a-39964913; Image Elian Hadj-Hamdi.

EC-European Commission (2000) Natura https://ec. europa.eu/environment/nature/natura2000/index_en.htm

EEA - European Environment Agency (2022) Emerald Network-General Viewer. https://emerald.eea.Europa.eu

EEA - European Environment Agency (2023) Soil pollution and ecosystems, https://www.eea.europa.eu/publications/zero-pollution/ecosystems/soil-pollution

EK, A. S.; RENBERG, I.(2001) Heavy metal pollution and lake acidity changes caused by one thousand years of copper mining at Falun, central Sweden. Journal of Paleolimnology. 26 (1): 89–107. https://doi.or/10.1023/A :1011112020621

EIEP - European Industrial Emission Portal (2021) Pollutant releases in EU 27. Minerals, https://tableau-public.discomap.eea.europa.eu/views/Analyse-Releases Air/AnalysisSectorAir?:embed=y&sheetname=AnalysisSectorAir&:display_count=n&:showVizHome=n&:origin=viz_share_link&:device=desktop

EU – European Union (2004) https://eur-lex.Europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:143:0056:0075:en:PDF, last acces 30 June 2023. Environmental Liability Directive. Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage. Official Journal L 143, 30/04/2004, pp. 0056–0075.,

EU – European Union (2014) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0052&rid=1. Environmental Impact Assessment Directive. Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment. OJ L 124, 25.4.2014, pp. 1–18.

EUR-LEX. (1992). Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A01992L0043-20130701

EUR-LEX (1996): Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control. OJ L 257, 10.10.1996, pp. 26–40. https://eur-lex.europa.eu/legal-content/EN/TXT/ ?uri= CELEX%3A31996L0061 ,

DOI: 10.6092/issn.2281-4485/20521

EUR-LEX (2000) Water Framework Directive. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Official Journal L 327, 22/12/2000, pp. 0001 – 0073. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri =celex%3A32000L0060

EUR-LEX (2006) Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC - Statement by the European Parliament, the Council and the Commission. OJ L 102, 11.4.2006, pp. 15–34. https://eur-lex.Europa.eu/leg al- content/EN/TXT/?uri= celex%3A32006L0021,

EUR-LEX (2010) Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions. OJ L 334, 17.12.2010, pp. 17–119. https://eur-lex.europa.eu/legal-content/EN/ TXT/?uri= celex%3A32010L0075

EUROSTAT (2022) Air emissions accounts by NACE Rev. 2 activity, Online data code: NV_AC_ AINAH_ R2__custom_5742847 last update:20/12/2022, https:// ec. europa.eu/eurostat/databrowser/view/ENV_AC_AI NAH_R2__custom_5742847/default/map?lang=en

EUROSTAT (2024) Businesses in the mining and qaurrying sector. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Businesses_in_the_mining_and _quarrying_sector, 2024

EZTER S., SÁNDOR G., ISTVÁN B., LÁSZLÓ B., ALEXANDRU S., CSILLA. S., VIKTOR W. (2021): Evolution of surface deformation related to salt-extraction-caused sinkholes in Solotvyno (Ukraine) revealed by Sentinel-1radar interferometry. https://doi.org/10.5194/nhess-21-977-2021, 2021

FERNANDEZ G.J., BARAHONA E., IRIARTE A., MINGORANCE M.D. (2007) A simple methodology for the evaluation of groundwater pollution risks, http://dx doi.org/10.1016/j.scitotenv.2007.01.015

FERNÁNDEZ-REMOLAR D.C., MORRIS R.V., GRUENER J.E., AMILS R.; KNOLL A.H. (2005) The Río Tinto Basin, Spain: Mineralogy, sedimentary geobiology, and implications for interpretation of outcrop rocks at Meridiani Planum, Mars. Earth and Planetary Science Letters. 240 (1): 149–167. doi:10.1016/j.epsl.2005.09.043,

FRANKS D.M., BOGER D.V., COTE C.M., MULLILIGAN D.R. (2011) Sustainable Development Principles for the Disposal of Mining and Mineral Processing Wastes. Resources Policy. 36 (2): 114–122. https://doi. org/10.1016/j.resourpol.2010.12.001

GERHARDT A., JANSSENS DE BISTHOVEN L., SOARES A.M.V.M (2004) Macroinvertebrate response to acid mine drainage: community metrics and on-line behavioral toxicity bioassay. Environmental Pollution. 130(2): 263-274. https://doi.org/10.1016/j.envpol.2003.11.016

GLOBAL DATA (2021) Five Largest Surface Mines in 2021. https://www.globaldata.com/data-insights/mining/europe--five-largest-surface-mines-in-2090657/

HIT HORIZONS (2024) Breakdown of Mining Industry in Europe, https://www.hithorizons.com/eu/analyses/industry-statistics/mining

HOXHA E. (2004) Mbrojtja dhe rehabilitimi i ambientit të dëmtuar nga shfrytëzimi minerar. First Edition, ILAR, pg.20-21, ISBN 99943-622-9-1.

HOXHA E. (2023) Albania's Challenges and Risks on Climate Neutrality, in: Climate Change and the Future of Europe, edited by: Kaeding, M., Pollak, J., Schmidt, P. Springer, Cham. https://doi.org/10.1007/978-3-031-23328-9_28

HOBBS S.L., GUNN J. (1988) The hydrogeological effect of quarrying karstified limestone: options for prediction and mitigation. Journal of Engineering Geology and Hydrogeology, 31(1):147-157. https://doi .org /10.1144/GSL.QJEG.1998.031.P2.10

HUANG X., SILLANPÄÄ M., GJESSING E.T., PERÄNIEMI S., VOGT R.D. (2010) Environmental impact of mining activities on the surface water quality in Tibet: Gyama valley. The Science of the Total Environment. 408 (19):4177–4184. https://doi.org/10.1016/j.scitotenv.2010.05.015, 2010

HUANG Y., TIAN F., WANG Y., WANG M., HU Z.H. (2014) Effect of coal mining on vegetation disturbance and associated carbon loss. Environmental Earth Sciences. 73 (5): 2329–2342. https://doi.org/10.1007/s12665-014-3584-z, 2014

JIMENEZ P.N. (2018) https://commons.wikimedia.org/w/index.php?curid=45716075 https://panonikaso jenice.ba/ wp-content/uploads/2018/08/panonikatuzla.jpg,

JUNG M.C., THORNTON I. (1996) Heavy metals contamination of soils and plants in the vicinity of a lead-zinc mine, Korea. Applied Geochemistry. 11 (1–2): 53–59. https://doi.org/10.1016/0883-2927(95)00075-5

KAVOURIDIS K., AGIOUTANTIS Z.G. (2006) The impact of a large-scale failure of the external waste dump to the operations at the South Field Mine, Ptolemais, Greece. Conference: 2nd International Conference on: Advances in Mineral Resources Management and Environmental Geotechnology, Chania, Greece August 2006. https://www.researchgate.net/publication/311372710The_impact_of_a_large-scale_failure_of_the_external ùwaste_dump_to_the_operations_at_the_South_Field_M inePtolemais_Greece

KIMURA S., BRYAN C.G., HALLBERG K.B., JOHNSON D.B. (2011) Biodiversity and geochemistry of

DOI: 10.6092/issn.2281-4485/20521

an extremely acidic, low-temperature subterranean environment sustained by chemolithotrophy. Environmental Microbiology. 13(8):2092–2104. https://doi.org/10.1111/j.1462-2920. 2011.02434.x

KOÇO M., HOXHA E. (2019) Environmental damages caused by open cast mines exploitation in the touristic area of Kruja, Albania. CISET - 2nd Cilicia International Symposium on Engineering and Technology 10-12 October, 2019, Mersin / TURKEY Proceedings ISBN 978-605-184-196-0 (177-180)

KRAMER M.., KIND-RIEPER T.., MUNAYER. R., GILJUM S., MASSELINK R.., VAN ACKERN P., MAUS V.., LUCKENEDER S.., KUSCHNI N., COSTA F.., RÜTTINGER L. (2023) WWF Report: Extracted Forest. https://wwf.panda.org/discover/knowledge_hub/?8455466/Mining-impacts-affect-up-to-13-of-global-forest-ecosystems-and-tipped-to-rise-with-increased-demand-for-metals

LARROCEA M.P.O., CÁZARES B.X., MENDOZA I.E.M., GONZÁLEZ R.C., HERNÁNDEZ J.H., GARDUÑO M.D., MEYER. M.L., FLORES L.G., CHÁVEZ M.C.A.G. (2010) Plant and fungal biodiversity from metal mine wastes under remediation at Zimapan, Hidalgo, Mexico. Environmental Pollution. 158 (5): 1922–1931. doi:10.1016/j.envpol.2009.10.034, 2010

MALMQVIST B., HOFFSTEN P.O. (1999) Influence of drainage from old mine deposits on benthic macroinvertebrate communities in central Swedish streams. Water Research, 33(10):2415-2423. https://doi.org/10.1016/S0043-1354(98)00462-X

MAUS V., GILJUM S., DA SILVA D.M. (2022) An update on global mining land use. Science Data 9:433, https://doi.org/10.1038/s41597-022-01547-4, 2022

MAYTE R.G.B., SALGUEIRO R., DIEZ-HERRERO A., HENRIQUE PEREIRA H. (2008) Reported tailings dam failures. A review of the European incidents in the world-wide context. Journal of Hazardous Materials, 151(2)846-852). http://dx.doi.org/10.1016/j.jhazmat.2007.07.050,

MONONEN T., KIVIEN S., KOTILAINEN M.J., LEINO J. (2022) Social and environmental impacts of mining activities in the EU. European Parliament. Policy Department for Citizens' Rights and Constitutional Affairs Directorate-General for Internal Policies PE 729.156-83, https://www.europarl.europa.eu/thinktank/en/document/IPOL_STU(2022)729156

MORENO-DE LAS HERAS M. (2009) Development of soil physical structure and biological functionality in mining spoils affected by soil erosion in a Mediterranean-Continental environment. Geoderma. 149(3–4):249–256. https://doi.org/10.1016/j.geoderma. 2008.12.00

MUMMEY D.L., STAHL P.D., BUYER J.S. (2002) Soil microbiological properties 20 years after surface mine reclamation: spatial analysis of reclaimed and undisturbed sites. Soil Biology and Biochemistry. 34(11):1717-1725. https://doi.org/10.1016/s0038-0717(02)00158-x

NAUMAN S., NOEBEL R., GAUDILLAT Z., STEIN U., RÖSCHEL L., ITTNER S., DAVIS M.C.K.., STANEVA A., RUTHERFORD C. (2020) State of Nature in the EU. EU Publications, European Environment Agency, https://www.eea.europa.eu/publications/state-of-nature-in-the-eu-2020 https://doi.org/10.2800/705440

NIYOGI D.K., LEWIS W.M..; McKNIGHT D.M. (2002) Effects of stress from mine drainage on diver-sity, biomass, and function of primary producers in mountain streams. Ecosystems. 6(5):554–567. https://doi.org/10.1007/s10021-002-0182-9

NUNATSIAQ NEWS (2013).: As the mines goes, so does this Arctic town, https://nunatsiaq.com/stories/article/65674astheminegoessodoesthisarcticminingtown

ORJI O.U., IBIAM U.A., AWOKE J.N., OBASI O.D., URAKU A.J., ALUM E.U., EZE A.G. (2021) Assessment of Levels and Health Risks of Trace Metals in Soils and Food Crops Cultivated on Farmlands Near Enyigba Mining Sites, Ebonyi State, Nigeria. Journal of Food Protection. 84(8):1288–1294. doi:10.4315/JFP-20-295

ORTEGA-LARROCEA M. del P., XOCONOSTLE-CÁZARES B., MALDONADO-MENDOZA I.E., CARRILLO-GONZÁLEZ R., HERNÁNDEZ-HERNÁNDEZ J., GARDUÑO M.D., LÓPEZ-MEYER M., GÓMEZ-FLORES L., GONZÁLEZ-CHÁVEZ M. del C. (2010) Plant and fungal biodiversity from metal mine wastes under remediation at Zimapan, Hidalgo, Mexico. Environment Pollution, 158(5):1922-1931 https://doi.org/10.1016/j.envpol.2009.10.034

PRASAD S.D., BYRAGI T.R., VADDE. R. (2015) Environmental Aspects and Impacts Its Mitigation Measures of Corporate Coal Mining. https://doi.org/10.1016/j.proeps. 2015.06.002

PRIKRYL I., ŠPAČEK J., KOZA V (2011) First large mine lake successfully filled up in Czech Republic. 11th International Mine Water Association Congress 2011, Aachen, Germany 4-11 September 2011. Proceeding 539-543, http://toc.proceedings.com/13389webtoc.pdf

PRIYA S. (2022) Mining Processes: Ambient Air pollution emissions, and the Solution. https://www.devic-earth.com/blog/mining-processes-ambient-air-pollution-emissions-and-the-solution

PYATT F.B., GILMORE G., GRATTAN J.P., HUNT C. O., McLAREN S. (2000) An imperial legacy? An

DOI: 10.6092/issn.2281-4485/20521

exploration of the environmental impact of ancient metal mining and smelting in Southern Jordan. Journal of Archaeological Science, 27(9):771–778. https://doi.org/10.1006/jasc.1999.0580, 2000

RASHER T., VAN SCHALKWYK A. (2000) The environmental impact gold mine tailings footprints in the Johannesburg region, South Africa. Bulletin of Engineering Geology and the Environment, 59(2):137–148. https://doi.org/10.1007/s100640000037

RICHARDS I.G., PALMER J.P., BARRAT P.A. (1993) The Reclamation of Former Coal Mines and Steelworks. Studies in Environmental Science. ScienceDirect, 56:213–223, https://doi.org/10.1016/S0166-1116(08)70744-1

ROSE C.W., YU B., WARD D.P., SAXTON N.E., OLLE Y J.M., TEWS E.K. (2014) The erosive growth of hillside gullies, Earth Surface Processes Landforms, 39(15):1989–2001, https://doi.org/10.1002/esp.3593

SINGH K.B. (1997) Sinkhole subsidence due to mining. Geotechnical & Geological Engineering, 15(4):327–341. https://doi.org/10.1007/BF00880712

SOLEILLE S., ANN KONG M., PLANCHON M., SAIDI N., PETAVRATZI E., GUNN G., BROWN T., SHAW R., LEFEBVRE G., LE GLEUHER M., RIETVELD E., DE JONG J., NIJLAND T., BASTEIN T. (2017) European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Study on the review of the list of critical raw materials: final report, Publications Office, 2017, https://data.europa.eu/doi/10.2873/876644

SONTER L.J.; DADE M.C.; WATSON J.E.M., VALENTA R.K. (2020) Renewable energy production will exacerbate mining threats to biodiversity. Nature Communications. 11 (1):4174. doi:10.1038/s41467-020-17928-5

STEINHAUSER G., ADLASSNIG W., LENDL T., PEROUTKA M,, WEIDINGER M.L., LICHTSCHEIDL I.K.; BICHLER M. (2009) Metalloid contamined microhabitats and their biodiversity at a former Antimony mining site in Schlaining. Austria. Open Environmental Sciences. 3:26–41. doi:10.2174/1876325100903010026

SYMOCHKO L., DEMYANYUK O., SYMOCHKO V., GRULOVA,D., FEJER,J., MARIYCHUK R. (2023) The Spreading of Antibiotic-Resistant Bacteria in Terrestrial Ecosystems and the Formation of Soil Resistome. Land, 12(4):769. https://doi.org/10.3390/land12040769

SYMOCHKO L., HOXHA E., HAMUDA H.B. (2021) Mapping hot spots of soil microbiome using GIS technology. Agriculture and Forestry, .67(1):191-203. http://dx.doi.org/10.17707/AgricultForest.67.1.16

SHIBATA Y., and others.: (2010) The study for the Master Plan for promoting mining industry in Albania – Final report, Japan International Cooperation Agency (JICA), Albania, IDD JR 10-151. https://openjicareport.jica.go.jp/pdf/12010138_01.pdf

TAILINGS. INFO.: Highland Valley Copper Mine, Logan Lake, BC, Canada, Photo courtesy of TECK, https://www.tailings.info/casestudies/highland.htm

UNCE (2018) Albania Environmental Performance Reviews. https://unece.org/DAM/env/epr/epr_studies/Leaflet/Booklet_3rdEPRAlbania.pdf

VEGA R.J.M., GÓMEZ V.A., GONZÁLEZ S.J., GUTIERREZ G.R.B., MARTÍNEZ A.J. (2017) Changes in land use due to mining in the north-western mountains of Spain during the previous 50 years. Catena, 149(3): 844-856. https://doi.org/10.1016/j.catena.2016.03.017,

WANTZEN K., MOL J. (2013) Soil erosion from agriculture and mining: a threat to tropical stream ecosystems. 3(4):660–683. doi:10.3390/agriculture3040660

WEBER J., TINGEY D., ANDERSEN C. (2021) Plant response to air pollution. U.S. Environmental Protection Agency, Washington, DC, EPA/600/A-93/050 (NTIS PB93167260). https://cfpub.epa.gov/si/si.public.record/Report.cfm?Lab=NHEERL&dirEntryId=50437

WIKIMEDIA COMMONS. (2009) Wolkenkratzer, Heringen Monte Kali. https://commons.wikimedia.org/w/ index.php?curid=24409219

WIKIMEDIA COMMONS (2015a) Chinchón dolina. https://commons.wikimedia.org/w/index.php?curid=45303372

WIKIMEDIA COMMONS (2015b) Luis Fernández García L.: File:Chinchón dolina c1991.jpg. https://commons.wikimedia.org/w/index.php?curid=45303372

WIKIMEDIA COMMONS (2018) Garzweiler surface mine. Martin Falbisoner, https://commons.wikimedia.org/w/ index.php?curid=73602131

WIKIMEDIA COMMONS (2003) Tzorn, Aitik coopar mine. https://commons.wikimedia.org/w/index.php?Curid=22651690, 2003

WONG H.K.T., GAUTHIER A., NRIAGU J.O. (1999) Dispersion and toxicity of metals from abandoned gold mine tailings at Goldenville, Nova Scotia, Canada. Science of the Total Environment. 228(1):35–47. https://doi.org/10.1016/S0048-9697(99)00021-2

WORLD MINE TAILINGS (2020) State of World Mine Tailings Portofolio 2020 https://worldminetailingsfailures.org/

ZHANG, LING; WANG, JINMAN; BAI, ZHONGKE; LV, CHUNJUAN (2015) Effects of vegetation on runoff and soil erosion on reclaimed land in an opencast coal-mine dump in a loess area. Catena, 128:44–53. https://doi.org/10.1016/j.catena.2015.01.016