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GEOLOGY-BASED ENVIRONMENTAL MANAGEMENT FOR SUSTAINABLE MINING PRACTICES

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ABSTRACT: Geological characterization is essential for environmental management in mining operations, since it illustrates how rock type, structural features, and mineral composition influence mining impacts and risks. Differences in lithology and ore body geometry dictate excavation methods and the extent of land disturbance. Structural geology influences slope stability, fault-determined fluid conduits, and ground control techniques. Hydrogeological considerations govern groundwater flow, the necessity for water extraction, and the movement of contaminants. The presence of sulfide-bearing minerals increases the likelihood of acid mine drainage and metal leaching. The geotechnical characteristics of the host rocks influence the stability of landfills and the construction of tailings dams. The mineral composition of a substance influences its dust production and associated hazards. Comprehensive geological mapping facilitates waste segregation and optimal mine planning. Incorporating geological models into environmental impact assessments enhances their precision. Predictive geochemical modeling assists in selecting optimal strategies to mitigate damage. Early assessment of geological risk mitigates long-term environmental liabilities.

Keywords: *Ground water management, Environment, geology.*

1. INTRODUCTION

The effects of global warming are becoming more worrying, so people are trying to use less energy that releases carbon into the air. As a result, the nuclear sector has seen a modest upturn. Rising demand for commodities whose extraction was once unprofitable has driven up the price of uranium. Metals and minerals will be required by humans for a variety of purposes, including housing and food production, in the long run. Obtaining these basic commodities relies heavily on the mining sector.

Mining is becoming increasingly important to modern society's ability to sustain itself. A consistent supply can only be achieved by steadily adding new mines to the system. Because of the unrelenting industrialization in Latin America, Asia, and China, the world's demand for metals and minerals is skyrocketing. A world without minerals would be an impossibility in this highly linked universe. Their hope for society's future lies in the integration of economic, social, and cultural institutions. Mineral resource extraction affects mineral resource consumption, and vice versa. Middle- and upper-class nations are increasingly using these resources, which show this trend. Rapid economic development in low-income nations ensures a steady supply of the natural resources that are fundamental to global progress.

Mining for minerals now does not have to mean sacrificing their rights for generations to come. Businesses rely on readily available natural resources since they are an integral part of the world economy. Environmental, economic, and societal considerations must be considered when evaluating this. Technological advancement, scientific investigation, and progress can prevent the potential social and environmental disasters caused by extraction. Additionally, this trend is made easier by open trade laws, the shifting of private wealth, and the occasional donations from rich people. In Figure 1, we can see the mining procedure.

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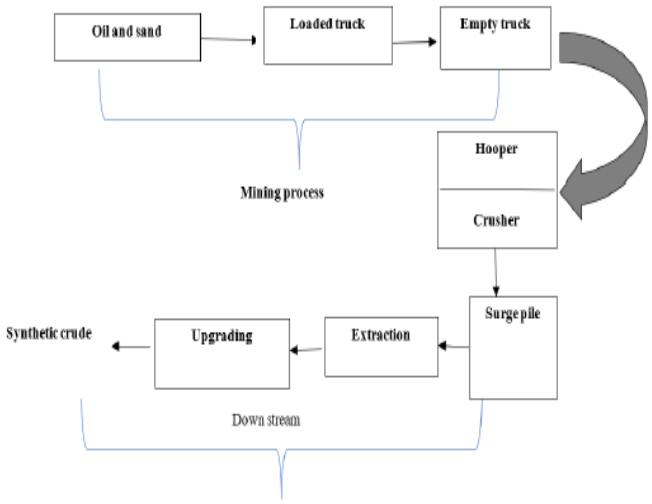

Figure 1. Mining process

The expansion and development of numerous sectors can be attributed to enterprises. The mining industries are seeing a dramatic upturn in activity, which is having a negative effect on both society and the environment. Still, other industries rely on them for the minerals that are vital to their operations. It is possible that this played a role. This impeded economic and development cooperation since environmental values and economic expansion were incompatible. In his critique of "business as usual," the profit-driven tactics of corporations supported by liberal productive and neoclassical economics, Welford (1997) highlights the dangers these practices pose.

The social and environmental stability of the planet is at risk due to these acts. He argues that future generations may be able to seize some of the non-renewable resources that are largely responsible for modern society's prosperity and success. The mining sector's negative impacts on its current and future responsibilities and activities are the source of political threats. As a result, the achievement of future mining objectives will depend on how well the current and past operations have performed. Therefore, when people talk about social and environmental responsibility, the mining industry is a hot topic. Much like any other industry, the extractive sector has been the subject of media interest. The increased focus on sustainability and social responsibility in the workplace makes this particularly relevant in many nations and sectors.

2. LITERATURE REVIEW

The mining industry has a detrimental effect on local populations and their cultural traditions, according to studies. The county's environmental regulations have been relaxed since mining requires a large amount of land. Poverty, land erosion, and starvation have resulted from this. Not only are local residents marginalized, discriminated against, and forced to leave their homes, but mineworkers and adjacent communities also face threats to their health and safety. Erosion of soil, extinction of species, fissure formation, and chemical pollution of water and land are all consequences of mining. Mining also pollutes the air, disturbances, and terrain.

The mining industry is a never-ending financial cycle that starts with the search for new mineral resources, continues through their extraction and processing, and ends with the cleanup of any regions affected by unethical methods. The specific mining procedures used are determined on the type of mineral. These technologies have a wide range of effects on the environment. Quarrying, open pit, open cast, and drilling are the four main surface mining processes.

One component of underground mining is the removal of surface-level mineral deposits through the use of shafts and tunnels. Included in this as well are borehole mining and mining that takes place under the surface. The process of mining entails removing minerals from the ground. Countries, communities, and businesses all benefit from mining in some ways. Prostitution, drug abuse, gambling, and inbreeding are just a few of the social ills that have been on the rise recently. As a result, there is less stability within families and more difficulty in sharing resources.

Mining has a negative effect on the economy because it destroys natural ecosystems, causes harm to local residents and organizations, produces a lot of trash and pollution, and leaves a legacy of poisonous mine

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seepage. Inadequate water, soil, and environmental factors lead to habitat instability and deterioration, which in turn leads to flora and fauna extinction and other noticeable consequences. Some of climate change's negative consequences can linger for quite some time. Pollution from mining has an impact on farms, animals, plants, marine habitats, and farming methods, all of which have an effect on food security. Sometimes, mining takes people away from farming and other productive activities, which lowers the value of important land resources. These changes are voluntary, but they have a negative impact on the environment and put people's livelihoods in serious danger .

Land that has been mined is currently not suitable for farming or manufacturing. Mining has a significant impact on the local ecosystem, including the woods, rivers, and streams. Disease and death in people and other animals might result from the removal of polluted soil, water, or plants. Even if lakes would help collect excess water, the problem would still be there. This article takes a look at the long-term effects that mining can have on our world. The disposal of garbage in the area is the cause of this. Ancient, deep mines that could rise or fall uniformly could have a harmful effect on residential areas, roads, and farmland. In addition, they can change the process that generates surface detritus.

3. ENVIRONMENTAL IMPACT ON MINING

The surroundings are impacted when a mine is in close proximity. Location, weather, and terrain all have a role in how mining affects the surrounding human habitat. Environmental concerns about mining are more likely to surface in a city that extracts 50,000 tonnes per year than to a barren island that extracts 5 million tonnes per year. As the number of affected persons rises, so does the level of environmental destruction. The local climate and terrain have a significant impact on the mining environment. In the level area, the river's speed drops, making it easier to pull the silt out of the water. Particulate matter and loud noises, however, can have a major impact on conditions up high.

The nation and its geomorphological features were symbolized by the undulating hills. The machinery set up in the valley can only be seen from quite a height and a short distance. The nearby hills create a strong barrier that limits the spread of both dust and noise. Because of its elevated placement, the gadget is more noticeable.

The rapid stream of the elevated river causes it to deposit a large amount of silt in a relatively flat region. In addition, the pace at which mine contamination spreads into the surrounding area is highly dependent on weather factors such as temperature, humidity, precipitation, and wind. The amount of pollution is thus affected by the weather. The dispersal of liquid waste is heavily influenced by precipitation, whereas the main components of gaseous waste, particulate matter, contaminants, and air are released into the atmosphere.

In environmental geology, geological information is used to identify issues and determine the best ways to prevent failures and losses. It opens up opportunities for people to take part in things going on in the neighborhood. All things considered, these methods and damage introduction functions aid national administrators and lawmakers in sustainable development by revealing the best courses of action to take. Both above and below ground, water is preserved, as it is essential to human survival. Having this in place is crucial.

Toxic substances pose a much greater threat because they can cause illness if misused. Drive carefully around rivers, lakes, seas, and subterranean aquifers that may be contaminated. In environmental studies, the ability to detect and control contamination is vital. Included in this set are the dynamic precipitation processes of evaporation, rain, and snow. It is critical to assess the harmful effects of soil and granite on underground water and air. Investigating the permeability of lithological units and the presence of hazardous elements inside them is, hence, a primary objective of environmental studies. Mineral residues and other industrial and domestic contaminants are examples of materials that might be adversely affected by human activity [16]. One of the most important factors impacted by several factors is the oxygen atmosphere. Other factors won't compare to how dangerous it will be. Pollutants are mainly released into the environment as a result of industrial operations and harmful compounds.

4. ENVIRONMENTAL GEOLOGY

Geology is the branch of science concerned with the study of the structure, dynamics, and composition of our planet. How do humans influence Earth's natural processes and resources? That's the big question that environmental geologists try to answer. According to environmental geologists, human activities have the greatest impact on the planet. Among the various cornerstones of environmental geology are the following:

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- Human actions have a direct impact on the processes that comprise nature's feature and structure generation mechanisms.
- The fundamental composition and operations of the Earth have not altered over time.
- Natural structures and processes are frequently negatively affected by human actions. Oils and other man-made substances can be used by humans to contaminate natural formations.
- Climate change is just one of many disastrous trends and occurrences brought about by human activity.

Importance of Environmental Geology

Transportation, food production, and disaster preparedness are just a few areas where environmental geology plays an important role in people's daily lives. This field studies the positive and negative effects that humans have on the environment. Learning about environmental geology teaches people how to lessen their influence on the planet. The widespread use of synthetic materials, the continuous advancement of industry, and the widespread adoption of ecologically hazardous activities and goods make this research vital. It could seem to some that environmental geologists are completely fixated on human activities, as shown in Figure 2.

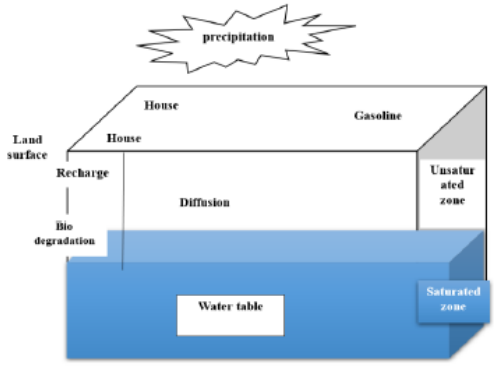

Figure 2. Environmental geology (web)

A fundamental comprehension of the natural world's regular functioning is necessary to comprehend how human activities alter these patterns. Nearly all geologists agree that minerals can be degraded when they come into contact with water. The granite cliffs that line the shore and riverbanks are gradually worn down by the water's erosion. As a rule, these processes are uncontrollable by humans. On the other hand, these processes can be accelerated by human activity.

The presence of contaminants in water that contains synthetic waste can amplify erosion. It is also possible for humans to alter the soil composition that is erodible by water. It is possible for people to introduce harmful substances, such as metals and lubricants, into the natural world through the production of synthetic materials. Pollutants in the environment can stunt a tree's development and cause it to change shape. Greater harm to the topsoil can be inflicted by industrial agriculture. As a whole, environmental geologists make up the bulk of the field's researchers. A master's degree, preferably a Ph.D., is required to work in this area. In environmental geology, understanding past events can help with forecasting what's to come. For environmental geologists, time is the most important factor. Some examples of these priorities are as follows:

- Harmful behaviors and the potential damage to the environment. To lessen the negative effects of human waste on the ecosystem, environmental geologists can persuade policymakers and bureaucrats to handle human waste properly. Experts in environmental geology may advise governments to dig wells to collect and store wastewater. In addition, they are able to establish rules or guidelines that dictate what people should do in the event of a natural catastrophe, like a flood or tornado.
- Resolving environmental concerns with immediate action. Damage to the geological formations disturbed by mining operations is substantial. By developing rules and tactics for specific parts of the mining process, environmental geologists can help shed light on mining activities. Environmental geologists typically devise a plan to evaluate the local soil and groundwater when they supervise subterranean operations like mining.
- Reducing the adverse effects of pre-existing environmental degradation. The consulting services of environmental geologists are frequently sought after by individuals who pollute the environment. After natural catastrophes, such as oil spills, environmental geologists may analyze the soil's chemical makeup

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using scientific equipment. Using these evaluations, they can determine the extent of the damage, the nature of the injury, and the best ways to prevent more harm.

5. DISCUSSION ANALYTICS

Table1. Mean and Standard Deviation area-wise and for full scale (N=100)

The distinct stages of mining include; preparing for and building the mine; exploring for mineral deposits; processing minerals for usefulness; and producing basic materials. Every single one of these stages is connected to one another in some way. As can be seen in Table 1, mines are often situated in areas that are rich in a high concentration of valuable minerals. The shutdown of the mining industry will have far-reaching effects for both the economy and society as a whole due to the fact that mining is a transient industry. In light of this, it is of the utmost importance to consider the possibility of isolating the mining region and then restoring it thereafter.

In addition, we need to evaluate these options because, according to the evidence, the state is the only institution that is capable of protecting the environment. Several different types of waste products from mining have the potential to contaminate the environment, including the air, water, soil, vegetation, and fauna. The illustration illustrates that mining can have a detrimental effect on the environment due to the dust, noise, and vibrations that are often produced during excavation, blasting, and transportation. These components are necessary for mining to function properly.

Area	Experience	Automation	Innovation	Individuality	New business model	Agility	Full scale
Mean	19.49	8.43	11.97	10.07	8.05	35.84	106.09
S.D.	2.949	0.879	1.755	2.085	1.167	4.211	11.217

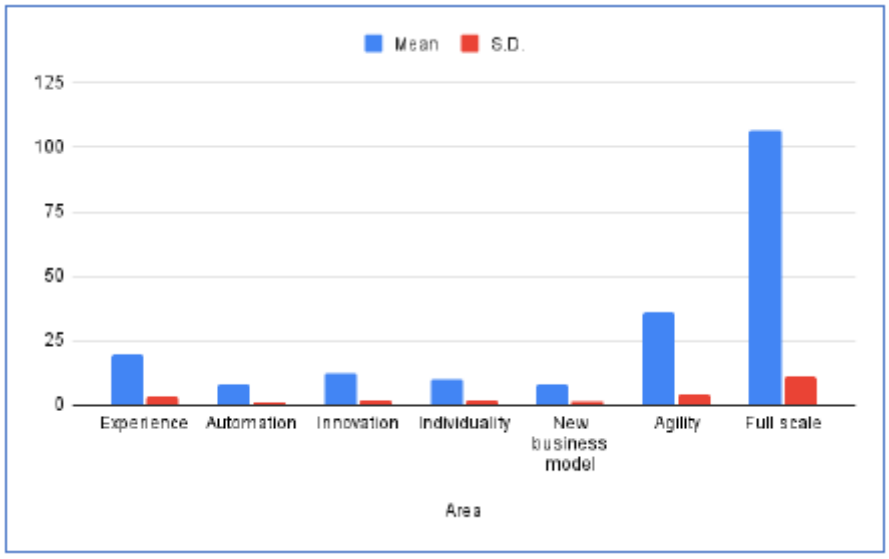

Figure 4. Mean and Standard Deviation plot

5. CONCLUSION

The potential long-term effects of a project on the environment can be predicted with the help of an EIA. In order to safeguard both the environment and public health, it is crucial to conduct an environmental impact assessment before beginning any project. Therefore, it is an essential first step in any mining operation, according to 75% of those who took the study. Geologists specializing in environmental issues help us understand and control the damage that humans cause to the environment. Geological hazards, such as earthquakes, polluted groundwater, and landslides, can be better understood and mitigated with their help. In

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order to improve sustainability, environmental geologists conduct research and provide recommendations about the management of waste, land use planning, and resource acquisition. If we want to keep our environment habitable for generations to come, we need their help.

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