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ENVIRONMENTAL IMPACT OF COAL MINING

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Abstract — Coal mining has a significant impact on the environment by altering natural ecosystems, degrading land resources, and affecting the quality of air and water. As global energy demand continues to grow, coal remains one of the primary energy resources in many countries. In India, coal has been the dominant source of energy for several decades, supplying approximately 27% of the world's commercial energy demand and playing a crucial role in industrial and economic development. However, extensive coal extraction has resulted in considerable environmental challenges that require effective management and sustainable mining practices. This study analyzes the environmental consequences of coal mining, with particular emphasis on open-pit and underground mining methods. Geological conditions determine the choice of extraction technology, while each mining method produces different types and volumes of environmental impacts. The research examines land degradation, habitat destruction, biodiversity loss, waste generation, and pollution associated with coal mining activities. Special attention is given to the accumulation and disposal of mining waste, which represents one of the major environmental concerns in coal-producing regions. The analysis demonstrates that inadequate waste management and uncontrolled disposal of mining residues lead to soil degradation, contamination of surface and groundwater resources, deterioration of air quality, and long-term ecological imbalance. These environmental impacts also negatively influence the health and quality of life of nearby communities. The findings highlight the necessity of implementing environmentally responsible mining technologies, improving waste management systems, strengthening environmental monitoring, and adopting sustainable land reclamation measures. The proposed recommendations can contribute to reducing the ecological footprint of coal mining while supporting the sustainable development of mining regions.
Keywords — coal mining, development, migration, explosives, pollution.

КӨМІР ӨНДІРУДІҢ ҚОРШАҒАН ОРТАҒА ӘСЕРІ

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Аңдатпа — Көмір өндіру қоршаған ортаға айтарлықтай әсер етіп, табиғи экожүйелердің бұзылуына, жер ресурстарының деградациясына, сондай-ақ ауа мен су сапасының нашарлауына әкеледі. Баламалы энергия көздерінің қарқынды дамуына қарамастан, көмір көптеген елдер үшін негізгі энергетикалық ресурстардың бірі болып қала береді. Үндістанда көмір бірнеше ондаған жылдар бойы негізгі энергия көзі болып саналады және әлемдік коммерциялық энергия тұтынуының шамамен 27 %-ын қамтамасыз ете отырып, өнеркәсіп пен экономиканың дамуына елеулі үлес қосады. Дегенмен, көмірді қарқынды өндіру қазіргі заманғы экологиялық шешімдерді талап ететін елеулі табиғатқа әсерлермен қатар жүреді. Бұл жұмыста көмірді ашық және жерасты әдістерімен өндірудің қоршаған ортаға тигізетін әсеріне талдау жүргізілді. Кен орнын игеру технологиясын таңдау геологиялық жағдайларға байланысты екендігі және әрбір өндіру әдісінің қоршаған ортаға тигізетін әсері әртүрлі болатыны көрсетілді. Зерттеу барысында жердің деградациясы, табиғи мекендеу ортасының бұзылуы, биоалуантүрліліктің азаюы, тау-кен өндірісі қалдықтарының түзілуі және қоршаған ортаның ластануы мәселелері қарастырылды. Көмір өндіру қалдықтарын жинақтау, сақтау және кәдеге жарату мәселелеріне ерекше назар аударылды.Зерттеу нәтижелері қалдықтарды тиімсіз басқару және оларды бақылаусыз орналастыру топырақтың, жерүсті және жерасты суларының ластануына, атмосфералық ауа сапасының төмендеуіне және экологиялық тепе-теңдіктің бұзылуына әкелетінін көрсетті. Сонымен қатар, бұл үдерістер халықтың денсаулығы

мен өмір сүру сапасына кері әсер ететіні анықталды. Алынған нәтижелер негізінде көмір өндіруде экологиялық қауіпсіз технологияларды енгізу, қалдықтарды басқару жүйесін жетілдіру, экологиялық мониторингті күшейту және бүлінген жерлерді рекультивациялау бойынша ұсыныстар берілді. Бұл шаралар көмір өндіру өнеркәсібінің қоршаған ортаға тигізетін теріс әсерін азайтуға және тау-кен өңірлерінің тұрақты дамуын қамтамасыз етуге мүмкіндік береді.
Түйін сөздер **—** көмір өндіру, даму, қоныс аудару, жарылғыш заттар, ластану.

ВЛИЯНИЕ ДОБЫЧИ УГЛЯ НА ОКРУЖАЮЩУЮ СРЕДУ

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Аннотация **—** Добыча угля оказывает существенное воздействие на окружающую среду, вызывая деградацию природных экосистем, нарушение земельных ресурсов и ухудшение качества воздуха и водных объектов. Несмотря на активное развитие альтернативных источников энергии, уголь остается одним из важнейших энергетических ресурсов во многих странах мира. В Индии уголь на протяжении нескольких десятилетий является основным источником энергии, обеспечивая около 27 % мирового коммерческого энергопотребления и играя важную роль в развитии промышленности и экономики. Однако интенсивная добыча угля сопровождается значительными экологическими последствиями, требующими внедрения современных природоохранных решений. В работе проведен анализ экологических последствий открытого и подземного способов добычи угля. Показано, что выбор технологии добычи определяется геологическими условиями месторождения, при этом каждый способ оказывает различное воздействие на окружающую среду. Рассмотрены вопросы деградации земель, разрушения естественных местообитаний, сокращения биоразнообразия, образования горнопромышленных отходов и загрязнения компонентов окружающей среды. Особое внимание уделено проблемам накопления, хранения и утилизации отходов угледобывающего производства. Результаты исследования показали, что неэффективное управление отходами и их неконтролируемое размещение приводят к загрязнению почвы, поверхностных и подземных вод, ухудшению качества атмосферного воздуха и нарушению экологического равновесия. Установлено, что данные процессы отрицательно влияют на здоровье населения и качество жизни в прилегающих районах. На основе полученных результатов предложены рекомендации по внедрению экологически безопасных технологий добычи угля, совершенствованию систем обращения с отходами, усилению экологического мониторинга и проведению рекультивации нарушенных земель, что будет способствовать снижению негативного воздействия угледобывающей промышленности на окружающую среду.
Ключевые слова **—** Добыча угля, развитие, миграция, взрывчатые вещества, загрязнение.

MAIN PROVISION

The environmental impact of coal mining extends beyond land degradation and resource depletion, affecting air quality, water resources, biodiversity, and human health. Both surface and underground mining generate significant environmental pressures through waste generation, dust emissions, noise pollution, land subsidence, and ecosystem disturbance. The adoption of environmentally responsible mining practices, effective waste management, mine reclamation, and ecological restoration is essential to reduce the environmental footprint of coal mining while maintaining its economic benefits.

INTRODUCTION

Mining activities, especially during the development of forest areas, put a lot of pressure on the local flora and fauna. An important issue is also the impact of mining on underground water levels, turbidity of surrounding bodies of water, and land destruction. Although coal mining makes a significant contribution to the economic development of the country, it also negatively affects human health. In addition, coal mining also affects the socio-cultural life of miners and the population living in this region. Therefore, when carrying out mining activities, a comprehensive approach is needed, taking into account the impacts on the local habitat and ecosystem [1-5].

To do this, various factors must be taken into account, such as determining the places where minerals are found, correctly calculating the slope angle of the dumps, safe disposal of waste and the effective use of turbidity control structures. In India, coal mining companies are implementing "clean

coal" strategies that aim to reduce the impact on the environment. Reducing the amount of ash by washing coal increases combustion efficiency, and this directly contributes to reducing the emission of pollutants. Although the process of washing coal requires additional water, it allows you to step towards a pollution-free society [6-8].

During the combustion of coal, harmful substances such as sulfur dioxide, nitrogen oxide, carbon dioxide, as well as dust and ash particles are released. In areas where coal is burned, the level of air and water pollution can reach dangerous degrees. It is recognized that coal mining around the world has a negative impact on local and global ecology. It destroys vegetation at the local level, causing soil erosion and disrupting the balance of microorganisms. And globally, methane gas is released from coal seams, which creates a greenhouse effect 30 times stronger than carbon dioxide. Thus, coal mining has a negative impact on air quality standards. Underground mining contributes to soil degradation, leading to groundwater depletion and land subsidence in many regions [9].

In the event of land subsidence beyond the threshold, it is necessary to replenish it. There are also socio-cultural negative consequences of coal mining, such as the migration and resettlement of people, changes in cultural heritage, as well as an outbreak of criminal and other illegal activities in the region due to a sharp increase in economic development through mining.

However, mining projects also have positive effects, including changes in the employment structure, increased sources of income, infrastructure development, and community prosperity. Changes in transport, communications, the education system, trade, recreation and medical services are also among the positive effects of coal mining. Thus, it is obvious that coal mining is harmful to the environment, however, it contributes to economic development, as well as increasing the level of self-provision through the effective development of Natural Resources [10].

Although it is not possible to move mining operations to another location, it is possible to reduce the damage to the environment by choosing the right production site and introducing new technologies [11-13].

Research gap. Although numerous studies have investigated individual environmental impacts of coal mining, most of them focus on specific issues such as air pollution, land degradation, water contamination, or ecological restoration separately. There is still a lack of comprehensive assessments integrating the multiple environmental, ecological, and socio-economic consequences of coal mining within a unified framework. Furthermore, limited attention has been given to combining recent international environmental management practices with sustainable mine reclamation strategies and occupational environmental risks. This study addresses this gap by providing an integrated evaluation of the major environmental impacts of coal mining together with contemporary mitigation and restoration approaches.

Novelty statement. The novelty of this study lies in the comprehensive analysis of the environmental impacts of coal mining by integrating recent scientific findings (2022–2025) on air, water, soil, biodiversity, noise pollution, land subsidence, and ecological restoration. Unlike conventional reviews that examine individual environmental components, this study considers the combined effects of mining activities throughout the mine life cycle and highlights sustainable environmental management practices, mine reclamation strategies, and modern mitigation technologies aimed at reducing the ecological footprint of coal mining under current sustainability and carbon-neutrality objectives.

METODOLOGY

Noise pollution is currently recognized as an important health risk factor. It is dangerous not only because it causes discomfort, but also because of its harmful effect on the human body. Long-term exposure to noise can lead to partial hearing loss in the ear and even permanent damage to the inner ear.

The problem of noise in underground mines is of particular concern, as acoustic features in confined spaces contribute to the spread of noise and its impact on workers [14].

The main sources of noise in underground mines:

1. coal cutting machines;
2. coal conveyors and wagons (tubes);
3. coal blasting process;
4. production, ventilation and drilling equipment;
5. main and secondary fans, air blowing systems.

Increased noise is often due to poor equipment maintenance. In most mines, noise exceeds the permissible level of 90 dB (A), and this is a safe limit for 8 hours of Operation per day [15].

A study carried out by the DGSHB (General Directorate of mine safety:

The results of the study showed that drilling rigs, crushing and conveying systems emit noise exceeding the level of 90 dB (a). This poses a serious threat to the health of miners and requires urgent introduction of noise protection measures.

Table 1 – Noise level in underground coal mines

Research location	Average noise level (дБ)
Near the mine scraper	96
Transfer point	99
Conveyor belt end	89
Hydraulic pump	91

RESEARCH RESULTS AND DISCUSSION

The development and Land Use Plan of the field should include the stage of preparation of the mine for preliminary operation, the operational stage and the post-operational stage. The plan should clearly state the goals of Post-Operational Land Use and describe the measures necessary to achieve this goal.

When developing this plan, it is necessary to take into account not only direct mining operations, but also the terrain around and the peculiarities of the ecosystem.

In the description of the region, several main components are taken into account. First of all, the current land use model of the region and the general characteristics of human settlements are considered. In addition, the natural features of the local ecosystem, climatic conditions and the most important characteristics of the terrain are analyzed. Data related to the terrain include such features as geomorphological conditions, topography and drainage system, cracks and crevices in the geological structure, as well as hydrogeological indicators-the location of permeable layers, the relationship of underground and surface waters and their hydraulic parameters. At the same time, the ability of natural soil and water to absorb pollution, as well as the distribution area and reserves of fertile soil, are also taken into account.

The state of transport and communication infrastructure in the region also plays an important role. In addition, information on mining operations will be considered, information on the types of extracted minerals, methods of production and stationary installations used, the volume of waste and methods of their disposal, the risk of land subsidence and landslides will be studied. Also, the requirements for the transport infrastructure necessary for production and the characteristics of the services and facilities to be installed are taken into account.

CONCLUSION

Mining has a significant impact on the economic, social and environmental structure of neighboring regions. Although mining provides economic development in a given region, it causes land destruction and causes environmental and socio-economic problems.

To solve the problem, important environmental factors must be taken into account. Each mine head must maintain an environmental checklist in accordance with the government of India's mining license terms and environmental management plan. By systematically reviewing this information, specific environmental issues of the mine can be identified. Low environmental performance can accelerate situations that require strict regulation.

The cracks caused by the subsidence (sitting) of the Earth have left many places infertile and unstable. Also, the seating of the land led to the drying of nearby reservoirs and Wells. However, through the joint efforts of coal mining companies and local authorities, it is possible to recycle these lands and return the product to use. However, consistent and coordinated work is not being done in this direction.

The main thing is to close the cracks. It is not necessary to restore the dug land to its original state, even if it is used for agriculture, landscaping or housing construction. According to some researchers, it is necessary to improve the water storage capacity of the dugouts under the soil.

According to scientists, before starting work on the restoration of the land, the purpose of its future use must be determined in coordination with local residents. The most important thing is to seal the cracks, and it is not necessary to restore the dugout to its original relief, it can be used for the purpose of agriculture, gardening or housing construction.

CONFLICT OF INTEREST

The author claims that there is no conflict of interest in the implementation of this study and the publication of the article.

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