

Ecological Environment Protection and Restoration of Mines based on International Experience and Insights

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Abstract

This paper explores the ecological environment protection and restoration of mines based on international experience and insights. The article emphasizes the increasing global concern over the impact of mining activities on the ecological environment, making the protection and restoration of mining ecological environments an urgent issue for countries to address. By drawing on successful international cases and strengthening international exchanges and cooperation, we can better promote the implementation of ecological environment protection and restoration of mines in China and achieve sustainable development of the mining industry. The paper highlights the importance of international experience in China's mining ecological environment governance, and calls for collaborative efforts to advance the protection and restoration of mining ecological environments. Moreover, by learning from successful international cases, valuable insights can be gained to facilitate the green and sustainable development of the mining industry.

Keywords

Heavy Metal Pollution; Mine Environment; Cooperation and Exchange.

1. Introduction

In today's global context, the impact of mining activities on the ecological environment is increasingly attracting widespread attention and concern. As global mineral resources gradually deplete, and environmental issues become more pronounced, the protection and restoration of mining ecosystems have become urgent challenges for governments and societies worldwide (Figure 1)[1-3]. The process of mining often leads to a series of environmental problems, such as land degradation, water pollution, and atmospheric emissions, severely affecting the surrounding ecosystems and the quality of life for local communities. These issues not only create tremendous pressures on the local environment but may also result in ecological imbalances, loss of biodiversity, and even trigger a range of socio-economic problems[4,5]. In this context, the protection and restoration of mining ecological environments have become a global focus.

By drawing on international experience and insights, countries can jointly explore and share successful experiences and effective approaches to governance. Across the globe, some countries and regions have undertaken successful practices in the protection and restoration of mining ecological environments, forming a series of replicable and scalable governance models and technological measures[7]. In the current context of increasingly prominent global environmental issues, the importance of protecting and restoring mining ecological environments cannot be ignored[8]. Only by strengthening international cooperation and communication and drawing on international experience and insights can we better address global challenges and collectively build an eco-friendly mining industry to achieve sustainable development of the mining industry.

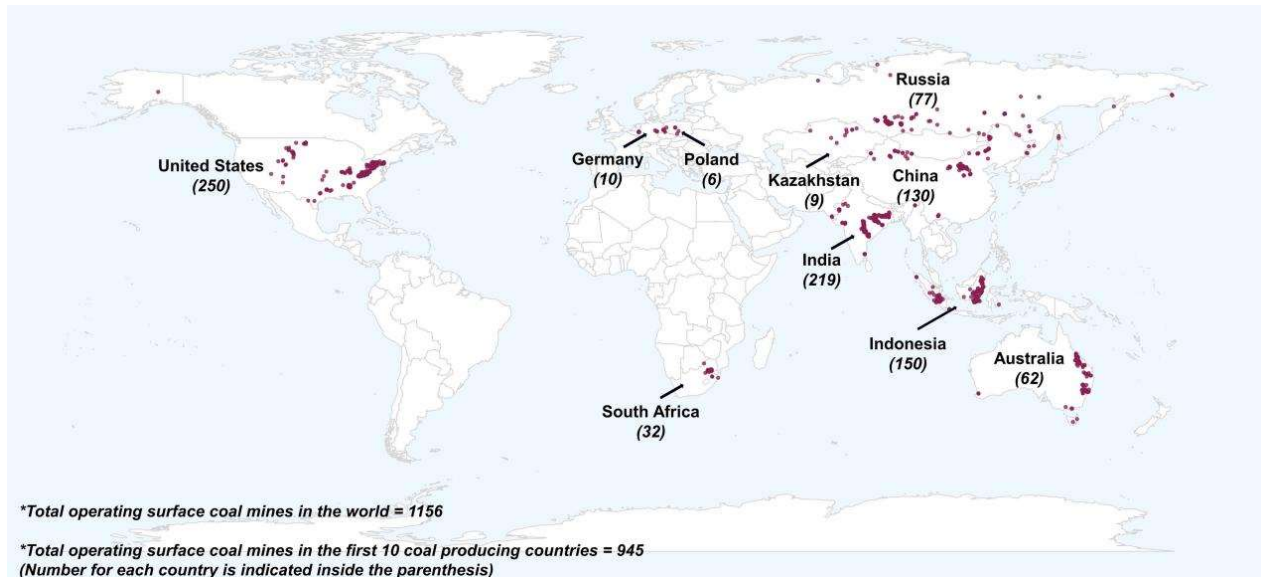


Figure 1. World map representing current operating surface coal mines of the top 10 coal producing countries [6]

2. Case Studies of Mine Rehabilitation in Different Countries

Ok Tedi Mine Rehabilitation Project (Papua New Guinea): The Ok Tedi copper and gold mine is located in the western region of Papua New Guinea, and long-term mining activities have resulted in severe environmental damage and social issues[9]. The Ok Tedi Mine Rehabilitation Project was initiated in 2001. The project adopted comprehensive measures, including vegetation restoration, soil conservation, and water resources management, to mitigate the extent of land and water damage and to assist local communities in achieving economic transformation and social stability.

Fairmont Mountains Gold Mine Rehabilitation Project (Canada): The Fairmont Mountains gold mine, situated in the Alberta province of Canada, suffered severe ecological damage due to years of mining activities. To achieve ecological restoration of the mining area, the Fairmont Mountains Gold Mine Rehabilitation Project was launched in 1992. The project employed various measures, such as afforestation, lake water quality improvement, and protection of wildlife, to successfully restore the natural ecosystem of the region[10].

Black Mountain Lead-Zinc Mine Rehabilitation Project (Australia): The Black Mountain lead-zinc mine is located in Queensland, Australia, and long-term mining activities have caused serious land degradation in the region. The project mainly focused on land reconstruction, vegetation restoration, and water resources protection, which helped restore some natural vegetation and ecological functions in the area.

Roslin Iron Mine Rehabilitation Project (United Kingdom): The Roslin iron mine is located in Scotland, United Kingdom, and years of mining activities have resulted in landscape and ecological damage in the region. The project implemented measures such as vegetation restoration, lake restoration, and land reclamation, gradually restoring the original ecological landscape of the area.

3. International Experience and Lessons

3.1. Importance of Interdepartmental Cooperation and Policy Coordination

The protection and restoration of the ecological environment in mines require the cooperation of multiple departments and stakeholders. International experience has shown that effective collaboration and coordination between governments, enterprises, and social organizations are

key to ensuring the effectiveness of governance[11]. We can draw on international cooperation models to establish interdepartmental collaboration mechanisms, form consensus, and jointly promote the protection of the ecological environment in mines.

3.2. Lessons from Public Participation and Community Governance

Public participation plays a crucial role in the governance of the ecological environment in mines. International experience has demonstrated that effective public participation can increase the transparency and fairness of governance and enhance the feasibility of governance schemes[12]. Additionally, the community governance model is worth learning from, as it allows local communities to participate in decision-making and supervision, better safeguarding the local ecological environment and social interests.

3.3. Scientific and Technological Innovation and the Direction of Green Mining Development

The development of green mining is a vital objective in the governance of the ecological environment in mines. International experience has indicated that scientific and technological innovation plays a critical role in achieving green mining[11]. By introducing advanced technologies and enhancing resource utilization efficiency and environmental management, we can propel the mining industry towards a green and sustainable direction[13].

3.4. Establishment of Long-term Monitoring and Evaluation Mechanisms

The protection and restoration of the ecological environment in mines are long-term processes that require sound monitoring and evaluation mechanisms. International experience has shown that establishing regular monitoring and evaluation mechanisms can promptly identify issues and implement effective measures[14], thereby enhancing the effectiveness of governance and the scientific basis of decision-making[3].

4. Lessons from International Experience in the Ecological Environment Governance of Mines in China

Mine Ecological Restoration Techniques: Internationally, various successful mine ecological restoration techniques have been implemented, including vegetation restoration (Figure 2), soil protection, and water resource management[8,9,15]. China can learn from these techniques and combine them with local conditions to innovate and apply them effectively for the restoration of the ecological environment in mines.

Community Participation and Communication: In international experience, close cooperation with local communities is often required for the governance of the ecological environment in mines, involving them in discussing governance plans and increasing community participation. China should also strengthen communication with local residents, listen to their opinions and suggestions, form a consensus, and facilitate the smooth progress of governance work.

Policy and Regulation Development: Some countries have established strict policies and regulations for the governance of the ecological environment in mines, imposing penalties for violations while providing incentives for ecological restoration. China can draw on this experience, strengthen the development and enforcement of relevant mining governance regulations, establish effective incentive mechanisms, and encourage companies to fulfill their ecological environmental responsibilities.

International Cooperation and Technical Exchange: International cooperation can help China introduce advanced governance technologies and management experience, accelerating the progress of ecological environment governance in mines. Engaging in technical exchanges and cooperation with other countries and international organizations can elevate China's level of mine governance.

Whole Life Cycle Management: International experience suggests that the governance of the ecological environment in mines should involve managing the entire life cycle, from mine planning and extraction to closure and abandoned mine stages, emphasizing the concept of whole life cycle management. China should also consider environmental protection and ecological restoration during mine planning and operation stages, minimizing the impact on the ecological environment.

In conclusion, learning from international experience can help China adopt more efficient and scientifically reasonable measures in the governance of the ecological environment in mines, speeding up ecological restoration and protection, and achieving the sustainable development of the mining industry. Through international cooperation, China can actively participate in global mine governance and environmental protection efforts, contributing to the construction of a global ecological civilization.

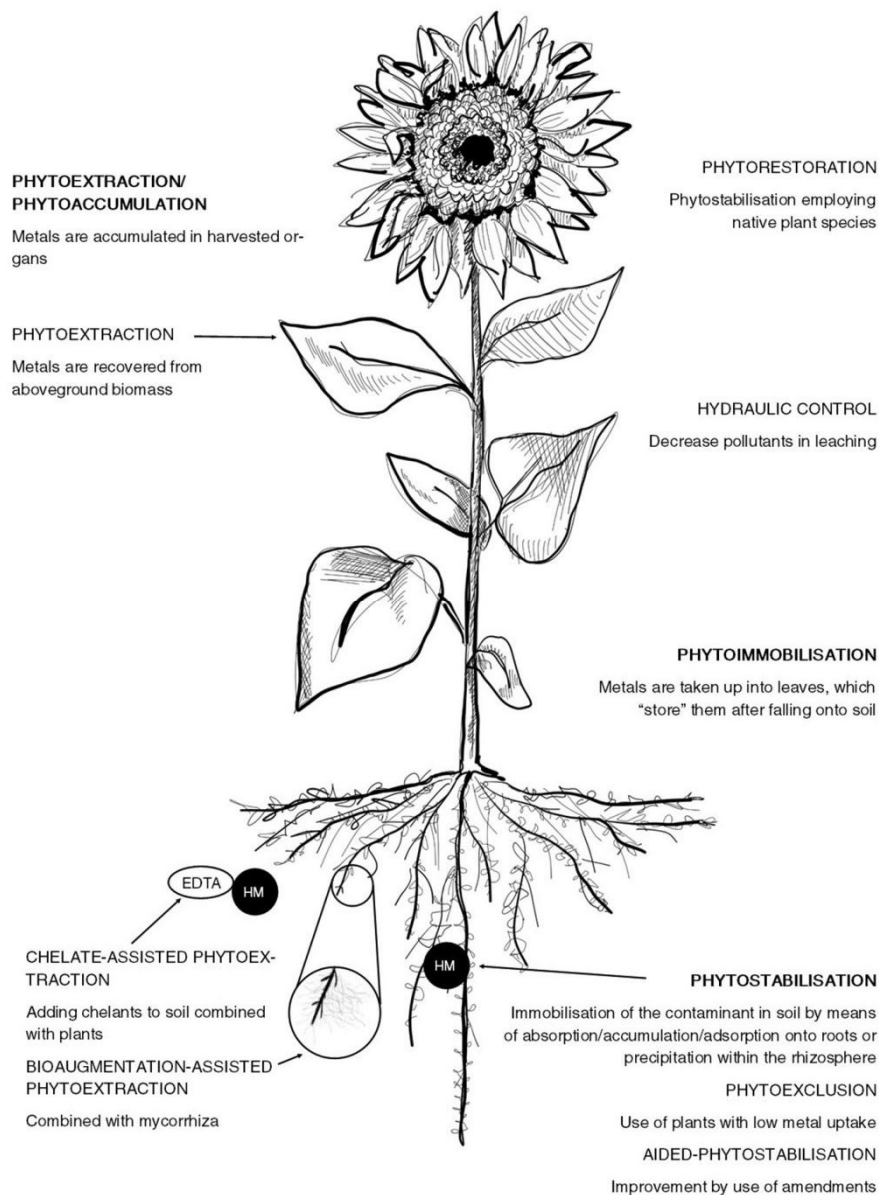


Figure 2. Overview of basic phytoremediation techniques used for metals. Higher concepts are written in bold font, and specific techniques with definitions are written in regular font[13]

5. Conclusion

In conclusion, drawing lessons from successful international cases allows us to identify effective governance measures and techniques for mine ecological restoration, such as vegetation recovery, soil remediation, and water resource management. For instance, in Canada's Alberta province, large-scale afforestation after mine closure has successfully restored the ecological environment and reconstructed the ecosystem. Australia has conducted extensive research and practices in mine ecological restoration, resulting in a series of mature governance technologies. China can combine its local conditions and learn from these successful international experiences to explore more effective methods for the governance of the ecological environment in mines.

Furthermore, strengthening international exchanges and cooperation is essential for China's mine ecological protection and restoration governance. International cooperation can help China introduce advanced governance technologies and management experiences, promoting the enhancement of mine ecological environment governance levels. We should also innovate governance models based on China's specific circumstances, leverage technological innovations, and collaboratively drive the global mining industry towards a greener and more sustainable direction. By doing so, we can actively contribute to the construction of an ecological civilization and a sustainable future.

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