

Mining and its Effects on Carbon Emission: An Analysis

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Abstract: *The mining industry has made a substantial contribution to global carbon emissions in recent years. This research article seeks to examine the mining process and the activities involved and, the influence of mining activities on carbon emissions with a specific focus on the direct and indirect consequences of this process. In addition, the study explores the possibility of decreasing carbon emissions by implementing cleaner technology and practices in the mining industry and offer possible remedies. The contents of this study offer important knowledge for policymakers, industry executives, and researchers, emphasizing the necessity of implementing sustainable practices in mining to reduce its environmental impact.*

Keywords: Mining, Carbon Emission, Environment

1. Introduction

The mining industry facilitates carbon emissions to a large extent globally, having a notable impact on the environment. According to a study published in Communications Earth & Environment, all mining industry products exhibit a uniquely high value per tonne of CO₂ emissions compared to other sectors like energy, construction, and agriculture (Cox et al., 2022). This underscores the significant carbon footprint associated with mining activities. Furthermore, research highlighted in Frontiers emphasizes the importance of decoupling carbon emissions from economic development in the mining sector, particularly focusing on China's efforts to achieve carbon peaking (Ren et al., 2023). The environmental repercussions of mining extend beyond land clearing and ecosystem degradation to include substantial greenhouse gas emissions that have a negative impact on climate change ("Mining's Climate Accountability," 2020). As the demand for minerals increases with technological advancements and industrial growth, it becomes imperative to address the carbon emissions associated with mining activities (Sun et al., 2022). A holistic comprehension of mining and its effects on climate change is essential for developing sustainable practices and mitigating the environmental impact of this vital industry.

Mining has been a chief source of global carbon emissions, particularly in the extraction of fossil fuels. According to a report by the International Energy Agency (IEA), the mining sector accounted for approximately 25% of global energy-related carbon dioxide (CO₂) emissions in 2019 (Fleming et al., 2023). This figure is expected to increase as global energy demand continues to grow, driven by population growth, urbanization, and industrialization. The environmental impact of mining is a critical concern, as it contributes to climate change and other environmental issues ("Mining's Climate Accountability," 2020). The Intergovernmental Panel on Climate Change (IPCC) has identified the mining sector as a major contributor to greenhouse gas (GHG) emissions, that are also accepted as a chief source for causing global warming. The IPCC also emphasizes the need for immediate action to reduce GHG emissions, particularly from the mining sector, to mitigate the negative effects of climate change.

Recent studies have highlighted the urgent need for the mining industry to address its carbon emissions and adopt sustainable practices. A report by the World Economic Forum emphasizes the importance of transitioning to low-carbon mining to reduce environmental impact and meet global climate goals (Cox et al., 2022). The mining sector's contribution to carbon emissions is a pressing concern, as evidenced by research in Resources Policy that discusses the challenges of reducing emissions while meeting growing mineral demand ("Mining's Climate Accountability," 2020). Sustainable mining practices are crucial for mitigating climate change as well as for ensuring a sustainable viability of the industry in a carbon-constrained world (Cox et al., 2022). Efforts to reduce carbon emissions in mining are gaining traction, with initiatives such as the Mining Association of Canada's Towards Sustainable Mining program focusing on environmental stewardship and responsible resource development. Additionally, advancements in technology, such as automation and electrification, offer opportunities to lower carbon intensity in mining operations. Addressing carbon emissions in mining requires a multi-faceted approach that considers not only operational efficiency but also regulatory frameworks, stakeholder engagement, and innovation in clean energy solutions. This research seeks to provide useful insights to the continuing discussion on sustainable mining practices by examining the effects of mining on carbon emissions and investigating methods to reduce the environmental impact. Understanding the complexities of carbon emissions in mining is essential for fostering a more environmentally conscious industry that can thrive in a carbon-constrained future. By fostering collaboration among stakeholders, politicians, and industry leaders, we may effectively promote positive transformation towards a mining sector that is both sustainable and environmentally responsible.

2. Analysis the mining processes

The mining process involves several stages that contribute to carbon emissions within the industry. These stages include:

- Mining Operations: The extraction of minerals and ores involves heavy machinery and equipment that consume

significant amounts of energy, leading to carbon emissions. The mining industry generates between 1.9 and 5.1 gigatons of CO₂ equivalent (CO₂e) of greenhouse gas (GHG) emissions annually, with a substantial portion originating from fugitive coal-bed methane released during coal mining (Delevingne et al., 2020).

- **Processing and Refining:** Smelting and refining processes in metal production are energy-intensive operations that generate substantial carbon emissions. For example, the processing stages of smelting and refining typically produce the most carbon emissions in the production of energy transition metals like nickel, dysprosium, and cobalt (The Carbon Emissions of Producing Energy Transition Metals: Charted, 2022). The carbon intensity of copper cathode production is influenced by the mining of copper ore and subsequent processing into cathodes, with energy-efficient technologies playing a role in reducing emissions (Understand Your Copper Emissions, n.d.).
- **Coal Mining:** Coal mining is a significant source of GHG emissions due to activities such as machine use, electricity consumption, and fugitive emissions. Coal extraction and utilization throughout the production process contribute to carbon emissions, highlighting the need for decarbonization efforts within the coal mining sector (Иванова et al., 2022).
- **Fully Mechanized Processes:** In underground fully mechanized mining processes, various stages such as coal breaking, loading, transportation, roof support, and treatment of mine gob areas generate substantial carbon dioxide emissions. The use of machinery, electricity, lubricants, and construction activities all contribute to carbon emissions in these processes (Li et al., 2022).
- **Decarbonization Efforts:** To reduce carbon emissions in mining processes, companies are exploring strategies such as transitioning to renewable energy sources, improving energy efficiency through automation technologies, and promoting recycling to reduce the environmental impact of metal production (Understand Your Copper Emissions).

Understanding the different stages of the mining process that contribute to carbon emissions is crucial for developing sustainable practices and mitigating the environmental impact of mining activities. Efforts to reduce carbon emissions in mining operations are essential for achieving global climate goals and promoting environmental stewardship within the industry.

3. Direct and Indirect environmental consequences of carbon emissions from mining

The carbon emissions from mining activities have direct and indirect environmental consequences that impact the climate and ecosystems. These consequences include:

3.1 Direct Effects

Ali et al. (2020) list the direct effects as following:

- **Global Warming:** Carbon emissions from mining contribute to global warming by releasing greenhouse

gases that enter the atmosphere, leading to rising temperatures and climate change

- **Air Pollution:** The release of carbon dioxide and other pollutants during mining operations contributes to air pollution, affecting air quality and human health.
- **Water Contamination:** Mining activities can lead to water contamination through the release of pollutants, including heavy metals, affecting aquatic ecosystems and water quality.

Indirect Effects:

(Consequences of Climate Change) describes the indirect effects as following:

- **Habitat Fragmentation:** Mining activities can result in habitat fragmentation and loss, disrupting ecosystems and biodiversity.
- **Over-Exploitation:** The extraction of minerals through mining can lead to over-exploitation of natural resources, impacting ecosystems and biodiversity.
- **Invasive Species:** Mining operations can introduce invasive species into ecosystems, disrupting native flora and fauna
- **Soil Pollution:** The pollution of soil from mining activities can have long-lasting effects on soil health and fertility, impacting agricultural productivity and ecosystem stability

These direct and indirect consequences of carbon emissions from mining highlight the need for sustainable practices, environmental stewardship, and mitigation strategies to minimize the environmental impact of mining activities on climate change and ecosystems. Efforts to reduce carbon emissions in mining processes are essential for promoting environmental sustainability and mitigating the adverse effects on the environment.

4. Potential solutions to minimize carbon emissions throughout the mining life cycle

To minimize carbon emissions throughout the whole process of mining, several potential solutions and strategies can be implemented. These solutions aim to reduce the negative environmental impact caused by mining activities and promote sustainability within the industry. Here are some key solutions based on the provided search results:

4.1 Decoupling Carbon Emissions from Economic Development:

Strengthening digitalization, intelligence, and automation in mining processes is crucial for promoting safety, efficiency, and sustainable development while reducing carbon emissions. (Sun et al., 2022). Analyzing the factors influencing carbon emissions from mining activities and decoupling them from economic development can help in achieving low-carbon transformation within the industry

4.2 Decarbonization Efforts:

Improving operational efficiency by upgrading equipment and processes can help reduce carbon emissions within mining operations (Legge et al., 2021). Transitioning to

sustainable fuels and drivetrains, such as liquid sustainable fuels (biofuels or synfuels) and electric vehicles, can significantly decrease carbon emissions in mining activities.

4.3 Land Rehabilitation and Eco-Friendly Equipment:

Implementing land rehabilitation strategies post-mining to repurpose mined land and accelerate natural ecosystem recovery can mitigate environmental damage caused by mining activities (Abc-Dust, 2022). Upgrading to more environmentally friendly machinery, renewable energy sources, and electric equipment can help reduce carbon emissions in mining operations.

4.4 Energy Efficiency and Sustainable Practices:

Investing in energy-efficient technologies, such as renewable energy sources like solar or wind power, can reduce the carbon footprint of mining operations (Abc-Dust, 2022). Promoting sustainable practices like using electric vehicles, improving equipment durability, and upgrading to eco-friendly technologies can contribute to lowering carbon emissions in the mining industry.

By implementing these solutions and adopting sustainable practices throughout the mining life cycle, the industry can work towards minimizing carbon emissions, reducing its environmental impact, and promoting a more sustainable approach to resource extraction.

5. Conclusion

In conclusion, the findings of this research underscore the significant impact of the mining industry on global carbon emissions and the environment. By examining the mining process and its activities, this study has highlighted the direct and indirect consequences of mining activities on carbon emissions. The exploration of cleaner technologies and practices in the mining industry presents a promising avenue for reducing carbon emissions and mitigating environmental damage. The potential remedies identified in this study offer actionable solutions for policymakers, industry executives, and researchers to address the environmental challenges posed by mining activities. Implementing sustainable practices in the mining sector is imperative to minimize its carbon footprint and promote environmental stewardship. By embracing cleaner technologies, enhancing operational efficiency, and prioritizing land rehabilitation, the mining industry can transition towards a more sustainable future. The insights provided in this study serve as a valuable resource for decision-makers seeking to balance economic development with environmental conservation. It is essential for stakeholders to collaborate and prioritize sustainability in mining operations to safeguard ecosystems, mitigate climate change, and ensure a more environmentally responsible approach to resource extraction. It is imperative to make a focused and determined attempt to include sustainable practices in the mining industry in order to decrease its environmental footprint and promote a more environmentally friendly and sustainable future for future generations.

Acknowledgements

Acknowledgements and Reference heading should be left justified, bold, with the first letter capitalized but have no numbers. Text below continues as normal.

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