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Editorial: Mine environmental governance

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Editorial on the Research Topic
Mine environmental governance

Introduction

Mining activities are one of the main causes of heavy metal pollution, and therefore mine environmental governance is of great importance to protect human health and improve ecological sustainability. Mine environmental governance refers to a series of practices to protect the environment and natural resources and promote sustainable development while undertaking mineral industrial activities. The research of mine environmental governance includes, but is not limited to, environmental risk assessment, environmental protection and remediation, and ecological effects of pollution (Chaney, 2015; He et al., 2015).

Mine environmental governance has become an important research area in the field of environmental sciences. This research topic is focused on the latest research progress and practical applications in this field, and has six published articles. Of them, two articles are in the area of environmental risk assessment, three are focused on the remediation of heavy metals in mines or affected areas, and one investigates ecological effects of mining pollution. These studies advance our understanding of environmental risk assessment, environmental remediation, and ecological effects of mining activities.

Mine environmental risk assessment

Risk assessment describes the status and toxicity of pollutants, such as heavy metals in the mining area. Methods such as single factors, Nemerow integrated pollution index, geo-accumulation index, potential ecological risk, Positive matrix factorization (PMF) and human health risk are commonly used to carry out environmental risk assessment (Zhang et al., 2018).

To assess the environmental risk of waste rock heaps, Tong et al. Collected 119 soil samples from 35 waste rock heaps at twelve mining sites in an abandoned pyrite mining area. The levels of potentially toxic elements (PTEs) were analyzed in waste rock, soil, and acid rock drainage (ARD) samples. The ARD had high pollution loads of PTEs, continuously exporting pollutants to the surrounding soils. The concentration of bulk As in 17 soil surface samples exceeded the risk control limit specified in China (60 mg/kg), while the leached concentrations of As and other PTEs in soil were far below the regulatory limits. The residual fraction of As, Cr, Cu, Zn, and Ni in the soil accounted for over 90% of the total, indicating these metals were possibly retained by the silicate matrix. Considering the relatively low bioavailability of PTEs and limited exposure routes, the human health risk of the soil surrounding the waste heap is generally acceptable.

In order to fully understand the pollution level and source of heavy metals, Su et al. carried out a risk assessment in agricultural soil. Cadmium (Cd), lead (Pb), arsenic (As), and mercury (Hg) from pharmaceutical production caused potential risk to surrounding farmland soil. As and Cd were observed to have higher pollution levels. The accumulated Cd and As contributed to a series of risks, including comprehensive pollution risk, geo-accumulation risk, potential ecological risk, and carcinogenic and non-carcinogenic risk. PMF source analysis combined with the geographic distribution of heavy metals surrounding pharmaceutical manufacturing confirmed that there were three main heavy metal pollution sources, including pharmaceutical wastewater, traffic, and agricultural chemicals, which had contributions of 52.37%, 16.49%, and 31.14%, respectively.

The studies provide comprehensive understanding of the risks caused by mining and other activities, which is conducive to the development of a sustainable control strategy of environmental pollution in various mining regions.

Mine environmental remediation

Green and sustainable remediation approaches are urgently needed for mining environmental governance. Microbial bioremediation has been widely studied as a potential sustainable technique for mine environmental remediation (Meng et al., 2019; Tan et al., 2022).

In this research topic, Wang et al. developed a green, sustainable, and effective strategy for Pb(II) bio-immobilization combining clay minerals and microorganisms. Liu et al. investigated the effect of isomorphous substitution of Co on the physiochemical properties of goethite and the atomic-level mechanisms of lead sorption. Chen et al. proposed a tailings backfill technology to mitigate surface subsidence and provided an alternative disposal method for tailings generated during ore extraction.

Wang et al. employed microalgae, *Chlorella sorokiniana* FK for biomineralization of Pb(II), and revealed the mechanism of Pb(II) immobilization induced by Chlorella in the presence of Ca(II). Mmontmorillonite (MMT) created a low-biotoxicity environment that lowers the Pb(II) bio-adsorption capacity of individual Chlorella and makes mineralization proceed more effectively. Batch experiments demonstrated that MMT as the formation site of bio-minerals resulted in dispersed minerals on the surface of Chlorella and Chlorella-MMT composite, which was beneficial to the survival of Chlorella. Pb(II)-bearing phosphate minerals tended to form in the presence of Ca(II) rather than without Ca(II).

Liu et al. showed that Co-substitution reduced the unit cell parameters and crystallinity of goethite, leading to the exposure of more Fe-OH groups on the surface. DFT calculations further revealed that the valence band was shortened and the total density of states was more biased towards the Fermi level in Co-substituted goethite, making the surface electrons more active. Additionally, both Pb^{2+} and $Pb(OH)^{+}$ were adsorbed by goethite through forming a tridentate complex with three oxygen atoms, and sp3 hybridization mainly occurred in this process. These results provide a new perspective for studying the properties of Co-goethite and its reaction with lead, and help expand the application of DFT calculations to simulate and predict the fixation and mobilization of heavy metals in goethite-rich soils/sediments.

The tailings backfill technology used by Chen et al. can significantly reduce tailings discharge or even achieve no discharge. A leaching test for heavy metal element classification of the backfill sample was carried out, and the results show that the heavy metal detection indicators meet the environmental protection standard requirements and would not cause secondary environmental pollution.

Ecological effects of pollution

Zhang et al. investigated the ecological effects of heavy metals at the gene level. They detected viral genes involved in detoxifying heavy metals in viromes from contaminated soil samples in mining areas. The genes included tellurite resistance genes (*terC* and terD), copper resistance genes (copC and *copA*), and arsenate resistance genes (*arsC*). Viral proteins involved in nutrient uptake and metabolism, cellular function, polysaccharides production, and biomineralization were detected. Viruses helped their hosts acquire novel metal-resistance abilities through horizontal gene transfer during adaptation to metal-rich environments.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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