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Editorial: Soil pollution, risk assessment and remediation

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Editorial on the Research Topic
Soil pollution, risk assessment and remediation

Soil pollution is a global issue that poses serious threats to human and ecosystem health (Singh and Singh, 2020). Soils are crucial in providing numerous ecosystem services essential for sustaining life on Earth. However, the alarming reality is that we have been witnessing a rapid loss of the quality of our soils and the invaluable benefits they offer (Jie et al., 2002). For example, it has been estimated that 16.1% of soils are contaminated in China, as reported by the Chinese Ministry of Environmental Protection (MEP, 2014). Similar findings have been reported in the United States, where an estimated 294,000 sites require cleanup (USEPA, 2004), and in the United Kingdom, where it is estimated that 2% of the land area of England and Wales is contaminated (Environment Agency, 2009). These figures highlight the widespread nature of soil contamination and the urgent need for action to address this critical problem.

Anthropogenic activities are the primary source of soil contaminants. Both organic and inorganic pollutants can enter the soil matrix through various pathways, including the application of fertilizers and pesticides, improper disposal of wastewater, pharmaceuticals, plastics, and the burning of fossil fuels (Peña, 2022; Gautam et al., 2023). Once these pollutants have infiltrated the soil matrix, remediation becomes extremely challenging and costly. Moreover, they can pose significant health risks through the food chain. For instance, studies have demonstrated that heavy metals such as arsenic and cadmium reduce crop yields and severely impede crop quality and food security (Djahed et al., 2018; Yuan et al., 2021). Additionally, these organic and inorganic pollutants have been linked to serious illnesses in humans. Trace toxic metals like arsenic, lead, and cadmium have been associated with various types of cancers, while organic substances like polychlorinated biphenyls, polycyclic aromatic hydrocarbons, insecticides, and herbicides have been linked to various human diseases (Rahman et al., 2015).

To date, numerous studies have been conducted to address the soil pollution crisis by developing feasible risk assessment and remediation methods. Researchers have explored both biological and non-biological approaches to tackle this problem. The methods can be categorized as physical, chemical, and biological. Physical methods involve the physical removal, washing, encapsulation, and electrokinetic extraction contaminates in soil (Liu et al., 2018). Chemical methods include soil precipitation and solidification to immobilize and reduce pollutants bioavailability (Jiang et al., 2023). On the other hand, biological

methods utilize plants and microorganisms to remove or transform pollutants into less toxic species. Among these approaches, biological methods are considered the most promising due to their ability to mitigate pollutants without generating secondary contaminants and their relative cost-effectiveness compared to physical methods (Gustave et al., 2022). Moreover, other techniques, such as the use of bioreporters, have focused on accurately assessing the risk posed by these contaminants (Zhang et al., 2022; Zhang et al., 2023).

Despite the significant amount of work that has been done on soil pollutant risk assessment and remediation, there is still a pressing need for further research in this field. Many existing methods are still in their infancy stages, and only a few have been implemented in real-world field settings. Additionally, there is a crucial requirement for more investigation into the risk assessment of soil and crop contamination resulting from these polluted soils. Recognizing this pressing need, a special focus was placed on this Research Topic, aiming to gather the latest studies that describe results pertaining to various areas, including but not limited to 1) Whole-cell bioreporter and biotic ligand model technology, 2) Bioavailability-based soil pollution risk assessment, 3) Utilization of biochar for soil remediation, 4) Investigation of biogeochemical behaviors of heavy metal(loid)s in soils, 5) Study of degradation, transformation, and immobilization of emerging organic pollutants in soils, and 6) Assessment of the impact of organic and/or inorganic soil amendments on the fate and transport of heavy metal(loid)s in agricultural soils.

A total of nine articles made significant contributions to the Research Topic, consisting of seven Original Research papers, one Brief Research Report, and one Review article. Xu et al. conducted a field study to investigate the effects of biochar and biochar-based fertilizers on soil properties, cadmium availability, and translocation in rice plants grown in cadmium-contaminated rice paddies. Similarly, Antonangelo et al. explored the potential of switchgrass and poultry litter biochar to immobilize and restrict the accumulation of heavy metals in ryegrass. Zhang et al. examined the use of various types of biochar, applied at low rates in the field, to mitigate cadmium contamination in *Brassica campestris* L. He et al. assessed the prevalence and risk of polycyclic aromatic hydrocarbons in top soils across China. Similarly, Maurin et al. presented a standardized extraction and analysis method to detect organic pollutants using samples from France. Dong et al. reported on the aggregation of organic amendments on bauxite residue particles and the associated mechanisms. Duan et al. focused on the effects of *Paenibacillus sabinae* and *Leptolyngbya* sp. RBD05 on the nutrient and chemical properties of saline-alkali soil. Lastly, Watson and Gustave assessed the potential risks associated with arsenic exposure from consuming market rice in The Bahamas, while Song et al. provided a review on the use of microalgae for wastewater remediation, soil improvement, and enhancement of crop quality.

Collectively, these studies greatly contribute to our understanding of soil pollution, its effects, and potential remediation strategies. Notably, the studies conducted by Xu et al., Zhang et al., and Antonangelo et al. provide valuable insights into the latest use of soil amendment, such as biochar, for effectively remediating cadmium and other trace toxic heavy metals. This is particularly crucial considering cadmium's ranking as the foremost heavy metal contaminant in Chinese soils (Zhao et al., 2015). Furthermore, the review by Song et al. and the studies by Duan et al. and Dong et al. shed further light on how microorganisms can play a vital role in bioremediation, establishing it as the most promising method. Additionally, other articles within this Research Topic present innovative standardized approaches for detecting organic pollutants, addressing a challenging issue that obstructs the accurate assessment of organic pollutants in soils. Lastly, the paper by Watson and Gustave unveils the extent of arsenic contamination in the market rice available in the Bahamas, a Small Island Developing State. While these articles have made significant contributions to our understanding of the subject, it is crucial to emphasize that substantial further research is required to tackle the pressing issue of soil pollution, mitigate associated human and ecological risks, and pave the way for effective solutions.

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.

Publisher's note

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