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Editorial

Special Issue on Potentially Toxic Trace Elements in Contaminated Sites: Fate, Risk and Remediation

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The occurrence of potentially toxic elements (PTEs, including As, Cd, Hg and Pb) of both anthropogenic and natural origin in the environment represents an issue of global concern, leading to a general decline in environmental quality in both continental and aquatic systems. These contaminants are easily accumulated in soil and sediment compartments, which may represent both a sink and a potential secondary source of contamination. Indeed, physical and biogeochemical processes may promote the release and mobility of bioavailable forms of PTEs, affecting water quality, biota and human health.

Relevant investigations focused on PTE sources, mobility, and fate are extremely important for assessing the geochemical status of the environment, and for providing valuable mitigation and management strategies for contaminated sites. This Special Issue aims to examine the occurrence, distribution, and fate of PTEs of both natural and anthropogenic origin in the environment, as well as management and remediation approaches to assess and mitigate potential ecological and health risks. Six research articles have been collected, and focus on PTE occurrence, mobility, and fate in both continental and aquatic systems, along with the risk assessment, management and potential remediation strategies of PTE-contaminated sites.

Ghezzi et al. [1] investigated the distribution of As in several environmental matrices (soil, groundwater and vegetables) in a densely populated area of Versilia (Tuscany, Italy). The region is characterized by rich mineralization, and falls within an abandoned mining area once exploited for pyrite extraction and now feeding a natural stream catchment, with acid drainages highly contaminated by PTEs, including As. The investigation consists of a risk analysis for both adults and children, and based on surface soil ingestion, dermal contact and soil dust inhalation, as well as exposure through the consumption of vegetables. The authors found that although As concentrations in soil are below the threshold imposed by Italian regulations, health risk assessments indicate that direct exposure to soil is a potential harmful exposure route to As.

Arsenic (As), as a priority PTE, is also the focus of the study of Min et al. [2]. Here, As encapsulation into plant phytoliths (silicon deposits within the cell walls of the plant endodermis and epidermis) was investigated, as it could represent an efficient mechanism for reducing As translocation, at the same time stimulating the plant's antioxidant system. To improve the current knowledge regarding this mechanism, the authors selected two phytolith accumulators (*Pteris multifida* and *Pteris australis*) and compared their behavior for different soil water contents. The high As content in the phytoliths of *P. multifida*, which increased with soil water content, suggests that this plant may play as the role of a hyperaccumulator, thus affecting the fate of As in soil.

The occurrence of PTEs as nanoparticles in the environment was addressed by Fellet et al. [3], who studied the capacity of biochar to retain CeO_2 nanoparticles (CeO_2NPs) in soil. The authors hypothesized that the quenching process at the end of pyrolysis might

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influence the effects of biochar on the nanoparticles' mobility. As quenching with water results in biochar having a higher porosity, in this study, CeO_2NPs leaching from a soil amended with two biochars, obtained after dry and wet quenching, respectively, was evaluated. The authors found that the biochar had an effect on the amount of the mobile fraction of CeO_2NPs, and that dry quenching can reduce CeO_2NP leaching.

Mining activity and decommissioned mining districts represent one of the major anthropogenic sources of PTEs in the environment, as the result of the accumulation and dispersion of mining wastes enriched in PTEs. Barago et al. [4] investigated the use of portable X-ray fluorescence (pXRF) as a geochemical technique in multi-elemental screening analysis for the management of contaminated sites. This technique was employed to analyze soils and mining wastes from two different decommissioned mining sites in NE Italy, and its results were compared with those obtained via a traditional destructive approach and analysis, through inductively coupled plasma mass spectrometry (ICP-MS). The authors found that pXRF represents an effective and accurate tool for identifying the location of the most critical sources of contamination, which are characterized by the highest PTE concentrations.

The accumulation of PTEs and their potential mobility represent two of the main environmental issues facing coastal environments. The study of Mangas-Suarez et al. [5] is focused on PTE occurrence, sources, and potential environmental risk in surface sediments from the Avilés estuary and the nearby coastal area (north of Spain), which has been highly affected by anthropogenic activities. The authors provided a preliminary scenario of the geochemical status of both coastal and estuarine sediments, identifying the main estuary channel as the most critical area. There, sediments showed notable concentrations of Cd, Hg, Pb and Zn, with subsequent significant ecological risk due to PTE mobility and potential bioaccumulation.

Among the PTEs found in aquatic systems, mercury (Hg) is a focus of global concern due to its high toxicity and the bioaccumulation potential of its most toxic form, methylmercury (MeHg), in the aquatic food chain. Bettoso et al. [6] reported the results of a long-term survey within the framework of the WFD/2000/60/CE, focused on sediments, water and biota in the Marano and Grado Lagoon (northern Adriatic Sea, Italy). The authors found that this environment represents one of the most contaminated areas of the Mediterranean Sea, showing Hg concentrations in sediment which exceeded both the threshold limit for good quality, and that for potential eco-toxicological effects. Although speciation analyses testified to the scarce mobility of Hg from the sediment to the overlying water column, the Hg-contaminated sediments still represent an environmental issue of concern in terms of MeHg production and its bioaccumulation in fish, mostly in the most contaminated sector of the lagoon. This was especially evident in the case of detritivore feeding species, showing a significant correlation between edible parts and the total Hg concentration in sediment.

Although submissions for this Special Issue have been closed, current research focused on the impact of PTEs and other contaminants in the environment will continue to address new challenges in order to provide useful management and remediation strategies for contaminated sites.

Conflicts of Interest: The authors declare no conflict of interest.

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