Trace metals and metalloids in the environment

RUBEN KRETZSCHMAR[1]

[1]Institute of Biogeochemistry and Pollutant Dynamics, Department of Environmental Systems Science, CHN, ETH Zurich, Switzerland (kretzschmar@env.ethz.ch)

Trace metals and metalloids (TM) occur ubiquitously in rocks, soils, sediments, and aquatic environments. Some TMs are essential for normal growth of plants and/or animals and humans (e.g., Zn, Cu, Ni, Mo, Se, V, Co, Cr), and deficiency is an important issue. On the other hand, most TMs can be toxic and/or cancerogenous upon acute or chronic exposure above certain critical levels. As, $Cr^{(VI)}$, Cd, Pb, and Hg are among the most toxic TMs of environmental relevance.

Trace metals and metalloids have been utilized by mankind for thousands of years, leading to several historic contamination peaks detectable in lake sediments and ice cores. Today, massive amounts of TMs are mined and processed every year, resulting in metal contamination of soils, sediments, and aquatic environments.

Understanding the geochemical behavior, biological effects, and biogeochemical cycling of TMs at local to global scales involves many challenges for geochemical research. Two of our recent studies will be used to highlight some of these challenges. The first study investigated the speciation and geochemical behavior of arsenic (As) in organic wetland soils, revealing the important role of natural organic matter (NOM) as sorbent for As. Using synchrotron X-ray absorption spectroscopy (XAS), we found that reduced organic sulfur groups in peat form strong complexes with As(III), leading to low As mobility in peat under reducing conditions and slow oxidation of As(III) to As(V) upon aeration of the peat [1-3]. The second study aimed at understanding the dynamics of TMs (As, Cu, Cd, Zn, Hg) in contaminated river floodplain soils affected by periodic flooding. Soil microcosm experiments using XAS, electron microscopy, and microbiological techniques revealed the formation of TM-bearing nanoparticles (metallic Cu(Hg), metal sulfides) by bacteria suspended in the pore water during soil reduction, which may render the TMs more mobile under sulfate reducing conditions than previously assumed [4,5].

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