

Heavy metals in soils: Distribution, forms, bioavailability and their impacts on soil biota (Uzbekistan, Angren-Almalik mining industrial area)

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The knowledge of chemical mobility of heavy metals in soils is fundamental to understanding their toxicity, bioavailability, and geochemical behavior. The soil samples, which are heavily impacted by aerial emissions from the coal burning and metal-processing industry of the Angren-Almalik mining industrial area, were the main subject of our intensive investigation. Accumulation and persistence of heavy metals in surface soil layers, their bioavailability and potential toxicity were the main reasons for conducted research. The obtained data demonstrate that the Angren Power Plant and Almalik Mining Metallurgical Combine are major sources for Pb, Zn, Cu, Cd, and As enrichment in soils of study area. Highest contents above mentioned metals were determined in the upper soil layer near the sources of pollution. The concentrations and forms of Cr, Ni, and Co in contrast suggest that the concentrations of these metals in soil were derived from the lithogenic background. The influences of heavy metals on soil microbial and nematode population characteristics along the pollution gradient in Angren-Almalik industrial area was investigated in detail. Results on the influences of heavy metals to soil microorganisms along the deposition gradient illustrate their negative response to heavy metal pollution. Studies on the relationship between soil biota and pollution levels have raised the question regarding the importance of natural soil abiotic properties, stressing the importance of background data of environmental conditions, and elucidating the importance of further studies on this subject. Obtained data on nematode population and community structure, ecological indices and other indicators including microbial biomass, metabolic quotient in soils of study area show bright future of these techniques as tools for environmental biomonitoring and bioremediation measures.

Actinide adsorption onto hematite (001) surface

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Actinide-containing species are an environmental and health risk due to their radioactivity and toxicity in combination with their mobility as aqueous species. Adsorption onto common mineral surfaces, such as Fe-oxide surfaces, may limit the transport of aqueous actinides. Flow-through experiments have shown that Pu-species sorb more strongly to mineral surfaces than Np-species. One possible explanation is that Pu⁵⁺ is more likely to reduce to Pu⁴⁺ than Np⁵⁺ to Np⁴⁺, and subsequently precipitate as a solid actinide oxide. For reduction to occur, a reducing agent is necessary. Some Fe-oxide minerals, such as hematite, do not contain reducing cations; thus, electron transfer can only be facilitated from a reducing agent through the mineral surface. Using quantum-mechanical density functional theory (DFT) calculations, we have studied electron transfer from different reducing agents through the hematite near-surface region to the actinide cations in their 4+, 5+, and 6+ oxidation states. Differences in adsorption energies and reduction potential as a function of actinide element, oxidation state, and reductant increases the understanding of processes that may retard the transport of actinides. Preliminary results indicate the actinide species with higher atomic number favor adsorption distances that are further from the hematite surface than the Fe lattice sites. Also, the arrangement of the actinide adsorbed on the hematite surface influences the success of the calculations, as well as the final adsorption energy. For example, the aqueous uranyl ion (UO₂²⁺) is a linear ion with U-O bond lengths of 1.8Å; however, several chemical and geometric conditions are considered for the DFT calculations. The system must be charge neutral; therefore, adsorption of UO₂²⁺ onto the hematite surface must have an extra O²⁻ for charge balance. Our initial geometry for the adsorption model has the U⁶⁺ in the hematite-Fe³⁺ position, and the three charge-balancing O²⁻ in the position of the next hematite O-layer. Calculations on U⁶⁺ adsorption resulted in the formation of peroxide molecules bonded to the adsorbed U⁶⁺, indicating a surface analogue of the uranyl peroxide mineral studtite.