Complex interactions between metal ions, dissolved organic matter, and microbes on metal transformation and trafficking in the environment

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Naturally dissolved organic matter (DOM) consists of chemically heterogeneous, polyfunctional organic compounds that exist ubiquitously in aquatic and terrestrial environments. DOM forms strong complexes with metal ions affecting their mobility and reactivity and can also directly or indirectly participate electron transfer reactions in enhancing microbial reduction or oxidation of metals and radionuclides such as mercury (Hg), uranium (U), and technetium (Tc). In this presentation, we describe coupled chemical and biological reactions between metals, DOM, and microbes and their influences on metal speciation and transformation in the environment. DOM is found to enhance microbial reduction of U and Tc under anaerobic conditions, but DOM can also act as an electron acceptor and enhance oxidation of U and Tc under oxidizing conditions. More interestingly, DOM causes Hg reduction and oxidation simultaneously under anaerobic conditions, although this process is strongly influenced by the oxidation state of sulfur and the ratio of Hg to S in DOM. Quinones and semiquinones in DOM are the dominant redox reactive moieties leading to the oxidation or reduction of U and Tc, whereas Hg oxidation is caused by thiol-induced oxidative complexation. The reduced DOM converts Hg(II) to gaseous Hg(0) at a low DOM/Hg ratio but, at a high DOM/Hg ratio, this reaction is reversed. Similar to DOM, certain strains of microorganisms such as *G. sulfurreducens* PCA are able to reduce Hg(II) at relatively low cell biomass to Hg ratios, but reduction becomes inhibited at increasing cell to Hg ratios due to increased adsorption or Hg-thiol complexation on the cell envelope. Further, depending on specific surface functional properties and biochemical mechanisms, certain strains of microorganisms such as *D. desulfuricans* ND132 are incapable of reducing Hg(II) but are able to oxidize Hg(0) to Hg(II) under anaerobic incubations leading to increased Hg uptake and methylation. This research highlights the importance of the multifunctional roles of DOM and microbes and their coupled reactions with metals and radionuclides in determining metal speciation, species transformation, bioavailability, and transport in the environment.