

Role of microbial processes in the environmental fate of uranium

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Uranium (U) is a potential contaminant in soil, sediments, and water. In the environment, U is present mainly as hexavalent U (U(VI)), which is highly soluble and forms numerous aqueous complexes, or tetravalent U (U(IV)), which is sparingly soluble. A major microbially-mediated U transformation is the reduction of U(VI) to U(IV). It is often a non-metabolic process catalysed by numerous microorganisms and is typically due to the fortuitous activity of metal reductases. Pentavalent U (U(V)) has been invoked as an intermediate for U(VI) reduction to U(IV).

Because of its low solubility, the U(IV) product precipitates readily. There are several products of U(VI) reduction, including minerals such as UO_2 and ningyoite as well as non-crystalline products including U(IV) coordinated to carbonate and phosphate moieties. U(VI) released by natural or anthropogenic processes can be immobilized by microbial activity through direct (enzymatic) reduction or via indirect reduction. The latter involves the biological formation of reduced products such as ferrous iron- or sulfide-bearing minerals or aqueous species and the chemical reduction of U(VI) by these compounds. The remediation of aquifers contaminated with U is proposed through the stimulation of microbial activity in the subsurface and the subsequent reduction of U(VI) via enzymatic and indirect reduction. Immobilized uranium remains as an *in situ* waste form similar to naturally occurring uranium roll-front deposits.

It is challenging to differentiate microbial from abiotic reduction in the subsurface. New tools, such as U isotope fractionation, are being developed to delineate the contribution of each process to U immobilization in engineered and natural settings.