Biostimulation of Iron Reduction and Uranium Immobilization: Microbial and Mineralogical Controls

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Abstract

The overall objective of our project is to understand the microbial and mineralogical mechanisms controlling the reduction and immobilization of radionuclides, such as uranium (U(VI)), during biostimulation of FRC subsurface materials present at the Field Research Center (FRC). This focus is on the activity and community composition of iron-reducing bacteria in FRC sediments. Reduction of iron (II) and uranium (VI) in FRC sediments is critical to the fate of uranium during in situ bioremediation.

We conducted microcosm experiments using near-in situ conditions with FRC subsurface materials containing high levels of U(VI) and Fe(II). Rates of electron acceptor/donor utilization were measured in sterile iron-metabolizing pure cultures (siderite and nitrate-reducing bacteria) and iron microcosms which are likely to make strong contributions to the fate of uranium during in situ bioremediation. The microbial activity was enumerated using PCR, cultivation, and rRNA gene approach to study U(VI) and Fe(II) reduction in FRC sediments. In all experiments, we observed that iron (II) reduction and uranium (VI) immobilization were very rapid.

Conclusions

Rates of substrate utilization were among the most rapid reported for aquatic environments. Activity correlated closely with the rates of microbial activity and the potential for uranium (VI) reduction. The microbial assemblages responsible for U(VI) reduction were dominated by a high proportion of Archaea, which are well adapted to the high-iron environment of FRC sediments. The microbial community was dominated by iron-reducing bacteria, which are known to be key players in the biogeochemical cycling of uranium.

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Microbial Community Analysis

Metallogenic Activity

Iron Mineralogy

Microcosm/Community Analysis

Microbial community analysis showed that the microbial assemblages responsible for U(VI) reduction were dominated by a high proportion of Archaea, which are well adapted to the high-iron environment of FRC sediments. The microbial community was dominated by iron-reducing bacteria, which are known to be key players in the biogeochemical cycling of uranium.

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