Enlisting Sedimentary Microbial Communities to Stabilize Long-Lived Contaminants in Mineral Phases

Extensive subsurface contamination remains at many former industrial and defense manufacturing sites, and effective remedial solutions are needed to slow or prevent its migration to groundwater. In this study, gaseous organic substrates were applied to stimulate microbial respiratory reduction of comingled radioisotopes and nitrate. Carbon dioxide was then injected in order to trap precipitated contaminants in calcite mineral phases as a long-term stabilization strategy. First, screening studies were performed to qualitatively measure the sediment respiratory response to gaseous or volatile organic substrates at various moisture contents. Volatile substrates produced the strongest respiratory response, among them were butyrate, pentane, butyl acetate. Sediments from three waste sites were tested in batch experiments and column studies under unsaturated and saturated conditions. Bio-reduction was a potent reductive treatment for combinations of Cr, U, and Tc-99; however, NO_3 concentration and a waste sites exposure history to NO_3 had a major controlling effect on the microbial response for remedial outcomes. Further, 88% to 91% of the bio-reduced Tc-99 was strongly co-precipitated or coated with calcite, which prevented re-oxidization and re-mobilization. These studies illustrate the importance of site-specific conditions in remedial design and process evaluation, though clearly waste site sediments maintain metabolic capacity that could be enlisted as part of an overall strategy to reduce the flux of long-lived radionuclides to groundwater at legacy waste sites.