Characterization of archaeal diversity associated with planktonic and biofilm subsurface communities from the Snake River Plain aquifer

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Background

Trichloroethylene (TCE) contamination of groundwater is a serious environmental concern at the Test Area North (TAN) site of the Idaho National Laboratory in southeast Idaho where a TCE plume contaminates the fractured basalt Snake River Plain Aquifer (SRPA) that underlies the site. The concentration of dissolved TCE at the site is decreasing by natural attenuation and consequently has significant positive economic impact for remediation of the site. To further investigate this, we are characterizing the microbial diversity of planktonic and biofilm communities within the TAN aquifer. As part of this effort, archaeal diversity was examined.

Methods

Archaea present in a pristine deep-water well from the SRPA were investigated. Planktonic microorganisms were collected using hollow fiber filtration while biofilms were obtained by suspending sterile substrate columns containing basalt chips into the aquifer for 6 months of colonization. DNA prepared from the planktonic and biofilm communities was used as template for PCR-based amplification of 16S rDNA sequences. The resultant amplicons were cloned and restriction enzyme digests of the purified plasmid DNA containing amplified 16S inserts was analyzed by agarose gel electrophoresis. Clones were grouped according to their restriction patterns. Amplicons from representative clones of each group were sequenced.

Results

Not surprisingly, the planktonic- and biofilm-communities within the SRP aquifer are comprised of many previously undescribed and uncultured archaea.

Conclusions

The identification of the archaea present in the SRPA will aid in elucidation of the roles that archaea play in intrinsic bioremediation when chlorinated solvents contaminate deep basalt aquifers. In addition, this work contributes to the knowledge base of archaeal diversity.

Micro-spectroscopic investigation of selenium speciation in reclaimed mine soils from southeastern Idaho

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Introduction

Approximately 40% of the United States phosphate reserves are located in southeastern Idaho, northern Utah, and western Wyoming in an area known as the Western Phosphate Resource Area (WPRA). Past reclamation practices of mined sites consisted of the surface application of mine-wastes. However, some of the rocks in the waste material (e.g., middle waste shale) have elevated levels of Se, resulting in reclaimed soils with higher than normal Se concentrations. The weathering occurring in these soils causes changes in the Se speciation (i.e., mineralogy, oxidation state, and aqueous species), therefore changing its availability for biological uptake and transport into surface and groundwater. In this study we used microscopically focused synchrotron based X-ray fluorescence (XRF) and X-ray absorption spectroscopy (XAS) to characterize Se species in the rocks, soils, and plants.

Results

Total selenium concentration in the soils ranged from 0.31 to 70 mg kg^{-1}. In the unweathered middle waste shale micro-X-ray absorption near edge structure (XANES) analysis indicated that three unique Se-bearing species were present. Using the XANES data together with *ab-initio* fitting of the extended X-ray absorption fine structure region (micro-EXAFS) the three Se-bearing species were identified as dzharkenite, a di-selenide carbon compound, and Se-substituted pyrite. In the soils micro-XANES revealed that multiple oxidation states were present, with peaks indicative of Se(-II/0), Se(IV), and Se(VI) species. Of these species, Se(-II/0) and Se(IV) were present in greater concentrations than Se(VI). XANES analyses of the plants indicated that the primary forms of Se were organic selenides and Se(VI) species.

Conclusions

Selenium specaition in the soils of the WPRA indicates that the environment is generally oxidative. Selenium is introduced into the system as reduced Se(-II) species, and through weathering is transformed to Se(IV) and Se(VI). These oxidative transformations enhance the availability of Se for biouptake and transport into surface waters. Better understanding of the species and processes occurring will lead to improved management and remediation strategies to prevent Se exposure and toxicity on WPRA reclaimed sites.