"The Microbes Underground: A Look at Subsurface Nitrogen-Cycling Microbial Communities at Uranium Contaminated Sites in the Colorado River Basin"

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Abstract

Throughout the upper Colorado River Basin (CRB), uranium persists as a relic contaminant of former ore processing activities. Elevated solid-phase uranium levels exist in fine-grained, organic-rich sediments intermittently found within the floodplain alluvium of the following Department of Energy-Legacy Management sites: Rifle, CO; Naturita, CO; and Grand Junction, CO. Coupled with seasonal groundwater fluctuations that alter the subsurface redox conditions, previous evidence from Rifle, CO suggests this resupply of uranium may be controlled by biologically-produced nitrite and nitrate. Known as nitrification, the two-step process of archaeal and bacterial ammonia-oxidation is followed by bacterial nitrite oxidation, generating nitrate under oxic conditions. Our hypothesis is that when seasonally elevated groundwater levels recede and the subsurface system becomes anoxic, the nitrate diffuses into the reduced interiors of organic-rich sediments and becomes readily available for denitrification, the stepwise anaerobic reduction of nitrate/nitrite to dinitrogen gas. Denitrification may then be coupled to the oxidation of sediment-bound U(IV) forming mobile U(VI), allowing it to resupply uranium into local groundwater supplies. One key step in substantiating this hypothesis is to demonstrate nitrogen-cycling organisms are present in the organic-rich sediments.

Here we investigate how the diversity and abundances of nitrifying and denitrifying microbial populations change throughout the organic-rich, fine-grained sediments of the subsurface by using functional gene markers for ammonia-oxidation (*amoA*, encoding the α-subunit of ammonia monooxygenase) and denitrification (*nirK*, *nirS*, encoding nitrite reductase). Abundances of these key nitrogen cycling functional genes are specifically targeted and determined through quantitative polymerase chain reaction (qPCR), elucidating how relative numbers of nitrifiers (*amoA*) and denitrifiers (*nirK*, *nirS*) vary with depth, vary with location, and relate to uranium release in sediment cores spanning the upper CRB. Early findings at Rifle, CO indicate subsurface archaeal *amoA* diversity spans Group 1.1b, and includes soil, freshwater, and estuarine relatives. These results suggest a robust community of ammonia-oxidizing archaea are present and their products may participate in uranium mobilization.