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Conference Abstract

Nitrate stimulated microbial and viral activity and the subsequent influence on uranium mobility in sedimentary systems

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Abstract

Mobilization of naturally-occurring uranium(U) has been recognized to give rise to geogenic U groundwater contamination in aquifers. In addition to carbonate ligand complexation, nitrate has been demonstrated to play a role in controlling U mobility by altering uranium solubility through redox reactions. Nitrate is a common anthropogenic contaminant often prevalent at high concentrations in alluvial aquifers overlaying managed land. Alluvial deposition processes that form these aquifers create a lithologically heterogeneous subsurface with defined contacts between sands, silts, and clays. This leads to deposition of organic carbon and accumulation of reduced metals/radionuclides, including U(IV), in the finer grained silts and clays. The addition of high nitrate porewater into uranium-bearing alluvial aquifer silt sediments stimulated a nitrate reducing microbial community capable of catalyzing U(IV) oxidation and mobilization of U into porewaters. However, metadata from an aquifer wide study and a subsequent experiment revealed that this result is concentration dependent. Low concentrations of nitrate bearing pore-water added into organic-rich, uranium bearing sediments and resulted in a decrease in dissolved U(VI), consistent with reduction. XANES analysis of sediments supported U(VI) reduction with the precipitation of U(IV). U(VI) reduction activity occurred concurrent with an increase in dissolved organic carbon (DOC) and cell and virus abundance and activity. Metagenome assembled genomes from the microbial community revealed the metabolic potential indicating complex carbon degradation, fermentation, mineralization as well as the potential for anaerobic respiration of nitrate, metal/radionuclides, and sulfate. The virome recovered from the samples indicated a change in viral community in response to nitrate amendments and viral-encoded carbohydrate active enzymes were upregulated indicating a coupled response of both viral and microbial community regulating nitrate stimulated carbon biogeochemical cycling. These data together suggest that the addition of an electron acceptor in to organic carbon reduced sediments stimulates not only microbial but also viral activity leading to upregulation of genes associated with carbon biogeochemical cycling in sedimentary systems. While genes associated with metal oxidation are observed, net reduction of uranium prevails leading to uranium immobilization at low nitrate concentrations. Thus together these data indicate a tipping point whereby the influx of nitrate into the reduced environment can influence uranium mobility in DOC and carbon cycling supporting microbial activity and reducing conditions subsurface systems.

Keywords

nitrate, uranium, bacteria, virus, carbon cycling

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Conflicts of interest

The authors have declared that no competing interests exist.