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IODINE BIOTRANSFORMATION: A HANFORD PERSPECTIVE

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Radioiodine (129I), a waste product from nuclear fission, is of environmental concern due to its long half-life (˜16 million years), mobility, and hazardous potential to humans through bioaccumulation in the thyroid gland. The Hanford Site in Richland, Washington, contains two separate iodine-129 contaminant plumes over 1,500 acres with concentrations of ˜3.5 pCi/L in groundwater samples, exceeding the federal drinking water standard of <1pCi/L. Although, iodide (I-) is thermodynamically favored, based on current pH and Eh ranges measured in the groundwater, the dominant species is iodate (IO3-) (70.6%) while organo-iodine (25.8%) and iodide (3.6%) were found in far lower quantities. Enrichments of Lower Ringgold sediment from the 200 West Hanford site allowed the isolation of microbial species capable of iodine biotransformation. Through a series of batch studies and spectrophotometric assays, isolates were found to couple nitrate (NO3) reduction with iodate (IO3), where iodate reduction was not observed in the absence of nitrate. Additionally, isolates able to oxidize iodide were also identified. Currently, analytical technics are being developed to further understand the kinetics and enzymatic activity for both of these redox reactions. Ongoing research involves these isolates and their influence on iodine speciation in the presence of organics such as humic acid or lignocellulose.

1. INTRODUCTION

From the 1940s through the early 1990s, liquid wastes from materials used and produced at the Hanford Site were disposed to the ground through cribs, ditches, ponds, and trenches. Waste containing carbon tetrachloride, uranium, nitrate, chromium (total and hexavalent), I-129, Tc-99, and tritium infiltrated the subsurface contaminating soil and groundwater [1]. Iodine-129 is one of the primary risk drivers for the site. Hydraulic containment is the currently selected remedy for I-129 in the groundwater, and there is currently no remedy selected for controlling migration of I-129 from the vadose zone to the groundwater. A number of biogeochemical processes have been shown to cycle iodine between different aqueous, as well as volatile and solid phase species (Figure 1) [2]. The effect to microbes on iodine transformation by Hanford isolates will be discussed.

2. METHODS

Batch microcosm studies were performed to look at the ability of bacteria isolated from the Hanford subsurface to transform different iodine species when supplied with an external carbon source. In separate studies, bacteria were supplied with lactate, nitrate and iodate, and bacterial growth and iodate disappearance were monitored with time. In a similar manner, bacterial isolates were supplied with either an organic acid or sugar with iodide and iodine concentration was monitored with time. All analytes were measured using colorimetric methods.

3. RESULTS

Molecular characterization of the microbial community in iodine-impacted groundwater showed a number of bacterial families with genera that have previously demonstrated iodine biotransformation capabilities. Results from sediment traps incubated in locations in the plume with background, low, and high levels of 129I show the presence of families that include Pseudomonads and Actinobacteria, taxa that have shown the ability to both oxidize I- and reduce IO3-.

Sediments from traps incubated in iodine-contaminated groundwater at the Hanford Site have yielded a number of bacterial isolates that can oxidize or reduce different iodine species. Since the dominant iodine species in 200-UP-1 groundwater has been shown to be IO3-, experiments were performed to determine the ability of various Hanford isolates to reduce IO3- in the presence of nitrate, a common co-contaminant in the 200-UP-1 groundwater. One isolate designated AD35, which is most closely related to Agrobacterium tumefaciens, has been shown to reduce IO3- to I- in the presence of nitrate. Iodate reduction occurred under both anaerobic and microaerobic conditions. When the culture was spiked with nitrate, IO3- concentrations continued to decrease in the culture medium.

Microbial oxidation of I- to I2 and IO3- is another important process that could affect iodine speciation in the Hanford groundwater. While I- concentrations in Hanford groundwater are below 5% of the total iodine, the potential for biological I- oxidation will provide insight into current speciation, and prevalence of IO3-, in the 200 West Area groundwater. A number of bacterial isolates from the Hanford groundwater have been shown

to oxidize to I- to I2.
4. CONCLUSIONS
Bacteria isolated from Hanford sediments were shown to be capable of iodine cycling in the subsurface. These results are important because: 1) bacteria capable of iodide oxidation show that microbes may be responsible for the current iodine speciation in the Hanford subsurface; 2) bacteria can change the speciation of iodine; thereby, affecting fate and transport of iodine in the subsurface; and 3) bacteria could be used as part of remedial strategies for future cleanup of iodine in the Hanford vadose zone and underlying groundwater.

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