Microbial Janitors: Enabling natural microbes to clean up uranium contamination

Oak Ridge, Tennessee is famously known as the base of the Manhattan Project in the 1940's which ultimately led to the development of the atomic bomb. Uranium enrichment activities on the Oak Ridge Reservation in the 1940s until the 1980s led to substantial contamination in nearby ponds that were used to dump waste. Since then the uranium and nitrate contamination has spread through the ground and now covers an area of about 7 km. This month we've interviewed Dr. Stefan Green, a research faculty member in the Oceanography Department at Florida State University who is working with Dr. Joel Kostka on developing microbial remediation solutions for this site. The overall project, known as the Oak Ridge Integrated Field Research Challenge, is headquartered at the Oak Ridge National Laboratory (Scott Brooks, Principal Investigator) and funded by the US Department of Energy's Environmental Remediation Sciences Program.

Q: How can uranium be removed or neutralized so it no longer poses a threat?

A: One key to this is uranium's oxidation state. When it is oxidized (hexavalent), uranium is soluble and can travel very easily with groundwater. However, when it is reduced to a tetravalent state, the uranium can form an insoluble precipitate, and become trapped in the subsurface. This is one viable approach to preventing the contamination from spreading beyond the existing contamination area. Some bacteria can catalyze the reduction of hexavalent uranium to tetravalent uranium, and we are looking for ways to identify and enrich these organisms in the field.

Q: ***Can microbes be deployed now at contamination sites to reduce uranium?***

A: Due to regulatory concerns, U.S. DOE programs do not favor augmenting the environment with uranium-reducing microbes. Rather, our goal is to stimulate the indigenous microbial community to reductively immobilize the uranium. Many indigenous microorganisms perform this reduction. However, the metabolism of these microbes may be inhibited in areas of high contamination and low pH. For example, as nitric acid was used during the uranium processing at Oak Ridge, this site has extremely high concentrations of nitrate and can be highly acidic. The pH of the soil is so low in some places that most bacteria can't grow at all. Our research is focused on finding new strains of bacteria that survive in the contaminated subsurface and engineering the subsurface environment to stimulate nitrate removal and uranium reduction.

Q: ***What success have you had in identifying new species that are capable of reducing uranium?***

A: The Kostka lab has isolated a new U(VI)- reducer, *Geobacter daltonii* strain FRC-32^T from the highly uranium-contaminated source zone. Aside from its significance as being one of the few U(VI)-reducers isolated from the contaminated subsurface of U.S. DOE sites, *G. daltonii* has also been shown to degrade organic contaminants under anaerobic conditions. A complete genome of this organism is available courtesy of the Joint Genome Institute, and a publication describing this species is available at the International Journal of Systematic and Evolutionary Microbiology.

Q: ***How have MO BIO's products enabled your work?***

A: The sediment and groundwater samples that we're working with have high concentrations of heavy metals and very low biomass. Together, these features make DNA recovery challenging. Very low recoveries are typical and this soil/sediment in particular has a higher than normal amount of inhibitors. Because we are using high-throughput sequencing technology to identify new bacterial strains, overcoming these two challenges is critical to our success. MO BIO's PowerSoil kits have been extremely helpful to our work, and have enabled us to extract genomic DNA from the most contaminated soils for use with high-throughput pyrosequencing analyses.

For more information please visit the Kostka Laboratory website: http://www.joelkostka.net/index.html