Subsurface bacteria to immobilize uranium

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In research that could help control contamination from the radioactive element uranium, scientists have discovered that some bacteria found in the soil and subsurface can release phosphate that converts uranium contamination into an insoluble and immobile form.

Based on laboratory studies, Georgia Institute of Technology researchers report promising results using bacterial species from three genera isolated from subsurface soils collected at a U.S. Department of Energy (DOE) Field Research Center site in Oak Ridge, Tenn. Researchers conducted preliminary screenings of many bacterial isolates and found several candidate strains that released inorganic phosphate after hydrolyzing an organo-phosphate source the researchers provided.

The bioremediation research project, funded for three years by DOE's Environmental Remediation Sciences Division, is in its early stages. Research team member Melanie Beazley, a Ph.D. student in the Georgia Tech School of Earth and Atmospheric Sciences, will present preliminary findings on March 30 at the 231st American Chemical Society National Meeting in Atlanta.

"These organisms release phosphate into the medium, but the precipitation (of uranium phosphate) occurs chemically," explained Assistant Professor of Earth and Atmospheric Sciences Martial Taillefert, co-director of the study. "That is the biomineralization of uranium and the novelty of this approach."

The process begins when the bacteria – from the genera Rhanella, Bacillus and possibly Arthrobacter– degrade an organo-phosphate compound such as glycerol-3-phosphate (G3P) or phytic acid (IP6), which can be present in subsurface soils.

"During their growth, the organisms liberate phosphate they derive from the organo-phosphate compound," said project co-director Patricia Sobecky, an associate professor of biology. "The free phosphate is released to the surrounding media, which is a solution in the lab. Then we conduct assays to see how much uranium is mineralized by the phosphate released by the bacteria."

The bacteria's role is crucial in this process because uranium cannot dissociate the organo-phosphate compound chemically, Taillefert explained. So uranium in the presence of organo-phosphate alone does not result in significant uranium precipitation.

Sobecky and her Ph.D. student Robert Martinez are conducting the microbiological and physiological component of the research, while Taillefert and Beazley study the uranium chemistry and analyze distribution of different forms of uranium during incubation in the lab.

"The devil's in the details with the chemistry of uranium: There are numerous forms of uranium in the environment, which are all influenced by the natural properties of soils and groundwater," Taillefert said.

Sobecky added, "What we're doing now is optimizing the assay conditions and the techniques to analyze the distribution of uranium species in the lab."

Traditionally, DOE has funded research investigating the chemical reduction of uranium contamination. But there are two approaches to immobilizing uranium. One strategy reduces uranium (VI) to uranium (IV), which is, in principle, immobile. But the uranium can re-oxidize even with traces of oxygen from rainwater seeping into the groundwater. The Georgia Tech approach biomineralizes uranium (VI) into an insoluble form of uranium via phosphate precipitation.

As they work toward a bioremediation strategy that will work in the field, researchers must design a mechanism to deal with competing organisms in the soil that might sequester the free phosphate, Sobecky noted. Though their current grant does not cover the cost of a field study, researchers hope to obtain funds in the future to test their strategy at Oak Ridge and potentially other DOE sites. Uranium contamination is a concern at DOE sites because it can migrate to groundwater in surrounding areas, Taillefert noted.

"At this point, we know the organisms we're studying are active in precipitating uranium phosphate," he said. "…. Now we need to determine how chemically stable it is."

Researchers also have learned that when the bacteria are releasing phosphate from G3P, the bacteria can tolerate the toxic uranium and can continue to grow once the uranium is precipitated by the released phosphate.

"Our challenge now is fine-tuning the conditions around the bacterium so eventually it can thrive and work chemically in a natural setting," Taillefert said.

Source: Georgia Institute of Technology