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Better Bioremediation at Uranium Mill Tailings Site

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Scientists find process that could enable sustained bioremediation of uranium

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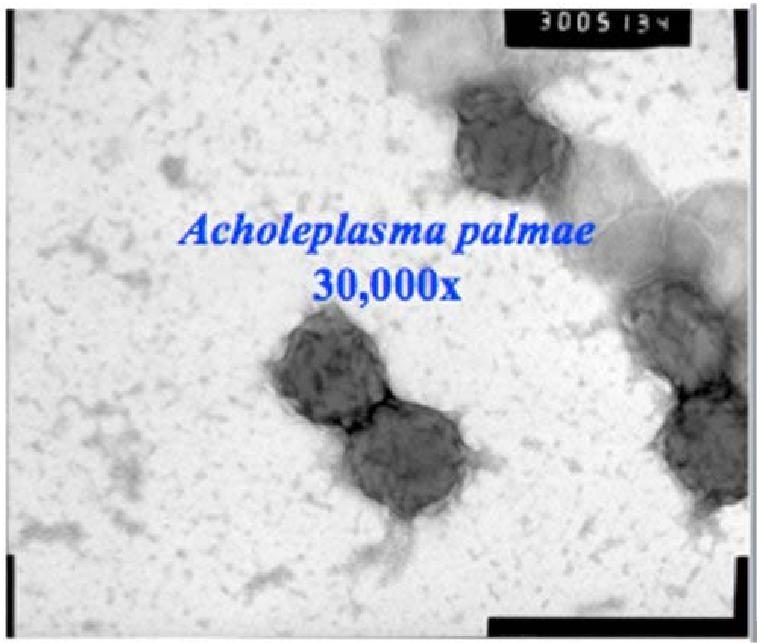
Results: At a former uranium mine site in Colorado, researchers have found a surprising process for immobilizing uranium that could lead to simpler, less-expensive remediation methods. In laboratory tests of subsurface sediment samples, they found that under certain conditions, mobile uranium, or U(VI), will adsorb on—or accumulate on the surface of—microbial communities in the subsurface, making it immobile. If those conditions can be duplicated at a contaminated site, the uranium will stay immobile for long periods of time. This eliminates the need for long-term treatments—specifically, adding acetate to the subsurface to stimulate microbes that reduce U(VI) to an immobile form, U(IV).

Why it matters: Uranium that was released to the environment as a result of ore milling, nuclear fuel fabrication or processing activities is found in the groundwater at many contaminated U.S. Department of Energy sites. Extensive efforts are currently under way to remediate these contaminated areas with physical, chemical and biological techniques. However, the high cost or limits to long-term sustainability of current methods limit their large-scale application.

For the past decade, researchers have studied prevention of further mobility of uranium in groundwater using native microbes. In recent field studies at DOE's Integrated Field Research Challenge Site in Rifle, Colorado, scientists added acetate to the site subsurface to stimulate *Geobacter*, a bacteria species capable of reducing U(VI) to U(IV).

However, in a study published in the April 2008 issue of *Environmental Science & Technology*, researchers from Pacific Northwest National Laboratory and the University of Massachusetts found that U(VI) continues to be removed from the groundwater even after acetate additions to the groundwater are discontinued. Further analysis suggests that uranium removal during this phase is associated with U(VI) adsorption to the biomass of the site's natural microbial community rather than reduction of mobile U(VI) to immobile U(IV), as was previously hypothesized.

Methods: In previous field experiments, researchers identified two distinct phases following the addition of acetate to stimulate microbial bioreduction of U(VI). In phase I, *Geobacter* species reduce U(VI) to U(IV), thus removing uranium from the groundwater. In phase II, sulfate-reducing bacteria predominate. However, long-term monitoring revealed an unexpected third phase during which U(VI) removal continues even after acetate additions are stopped.



This scanning electron microscope image is of the Mollicute Acholeplasma palmae. Mollicutes are a class of bacteria found in subsurface sediments at a uranium-contaminated site in Rifle, Colorado. Mollicutes could play a significant role in remediation by adsorbing mobile uranium.

In the current experiment, the PNNL team successfully reproduced all three phases in the sediment columns. When sediments from the third phase were gently heat-sterilized using pasteurization to remove the microorganisms, the capacity to remove U(VI) was lost. In the sediments with live microorganisms, U(VI) removed from the groundwater was recovered as U(VI) in the sediments. This contrasts to the recovery of U(IV) in sediments that resulted from the reduction of U(VI) to U(IV) in sediments where acetate was added.

In the sediments in which U(VI) was being adsorbed, members of the bacterial phylum *Firmicutes* and class *Mollicutes* were the predominant organisms, whereas no *Mollicutes* were detected in sediments having no capacity to sorb U(VI). This suggests that the U(VI) adsorption may be caused by the presence of these living organisms. This unexpected enhanced adsorption of U(VI) onto sediments following the stimulation of microbial growth in the subsurface could increase the cost effectiveness of in situ uranium bioremediation.

What's next: The research team's finding that even the gentle heat treatment of pasteurization eliminated the U(VI) adsorption capacity suggests that a living microbial community, or at least intact cell components such as membranes and/or proteins, are required for extended U(VI) removal in the absence of acetate. It's possible that the *Mollicutes* are responsible for this U(VI) adsorption, but to investigate this it, the researchers must first isolate and characterize these organisms from the sediments.

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Reference: N'Guessan AL, HA Vrionis, CT Resch, PE Long, and DR Lovley. 2008. "Sustained removal of uranium from contaminated groundwater following stimulation of dissimilatory metal reduction." *Environmental Science & Technology* 42(8):2999-3004.

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