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Microorganism Cleans Up Toxic Groundwater

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for National Geographic News
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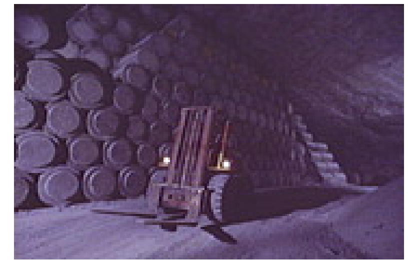

Researchers believe a tiny microorganism may help the U.S. Department of Energy to clean up uranium that has leaked into groundwater. Above: a radioactive waste storage facility.

Photograph by Emory Kristof, copyright National Geographic Society

A microorganism too small to see with the naked eye may be the answer to one of the U.S. Department of Energy's largest environmental problems: hundreds of billions of gallons of groundwater contaminated with uranium and other toxic chemicals.

The microorganism, called *Geobacter sulferreducens*, has a unique metabolism—it passes electrons onto metals to get energy from its food in the same way that we humans breathe in oxygen to break down our food.

In the electron transfer process, the microorganism changes the metals from their dissolved, or soluble, form to a solid, or insoluble, form. This causes the metal to fall out of the groundwater.

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"Basically what that allows us to do is to take uranium dispersed in a large area, filter it out from the water, and capture it in a discreet zone so that it is easy to excavate or otherwise extract," said Derek Lovley, a microbiologist at the University of Massachusetts Amherst.

In 1987, Lovley discovered that *Geobacter* uses iron oxide—essentially rust—to survive. He has since found some 30 different species of the organism and learned they can be coaxed to "breathe" all kinds of metals.

Working with the U.S. Department of Energy, Lovley and his colleagues are in the third year of a project designed to coax *Geobacter* to thrive on uranium in contaminated groundwater.

Teresa Fryberger, director of the U.S. Department of Energy's Environmental Remediation Sciences Division, said approaches like *Geobacter* to cleanup contaminated groundwater are needed to overcome the limitations of current technologies.

Currently the department pumps contaminated groundwater to the surface, treats it to remove contaminants, and then re-injects it to the ground.

"In most cases it cannot completely remove the contamination and is not capable of resolving groundwater contamination problems such as those resulting from uranium contamination at many DOE [Department of Energy] sites," Fryberger said.

Uranium Contamination

The problem of uranium-contaminated groundwater dates back to the Cold War when mines and mills throughout the United States produced millions of tons of uranium oxide, or yellowcake, to build nuclear bombs.

When the mills shut down in the 1970s, radioactive wastes were left behind. Today this waste is seeping into and contaminating the nation's groundwater. People who drink the water are at risk of kidney damage and cancer.

"Within the DOE complex, uranium contamination of soils and groundwater is widespread because it was mined, milled, refined, purified, enriched, fabricated, and reprocessed with each step typically taking place at a different location," Fryberger said.

According to Lovley, exact figures on the extent of uranium-contaminated groundwater are difficult to come by, but he said, "It's massive."

"To try to clean up all existing uranium contaminated sites with current technology—the non-biological things—it would basically bankrupt the country," Lovley said. "The costs are too much. That's why we're looking for simpler and cheaper methods."

Is *Geobacter* the cheap and simple answer? The researchers are testing the microorganism at an abandoned uranium mining and mill site near the town of Rifle in western Colorado.

Field Tests

Geobacter are naturally present in the groundwater at the Rifle site, but they

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thrive mostly on iron oxide and their populations are relatively small.

From previous work Lovley and his colleagues know that *Geobacter*'s favorite food is acetate—essentially vinegar. When acetate is abundant, *Geobacter* populations explode.

So the researchers drilled a few pipes into the ground at the Rifle test site and let the acetate slowly drip into the groundwater to encourage a population explosion. According to the scientists' theory, if the population explodes, the microbes will exhaust the iron oxide supply and turn their attention to the dissolved uranium.

To test this hypothesis, the researchers drilled a series of wells downstream from where they dripped the acetate and periodically took water samples. By the end of the 2003 field session, the scientists had refined their technique to the point of removing about 90 percent of the uranium from the groundwater.

Instead of digging down and removing the solid uranium, the scientists allow the solid, immobile form to stay in the ground. "As long as we stabilize these uranium-contaminated environments that are near a river, as long as it won't be carried to the river, people are going to be very happy," Lovley said.

To ramp up the technology, Lovley and his team are now developing a computer model that describes the way the microbes respond to different conditions in the environment. The team also recently sequenced the genome of *Geobacter sulferreducens*, which has provided insight to the way the microbe functions.

Fryberger, the DOE research director, said that she and her colleagues are

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"excited about Dr. Lovley's results from the old Rifle site. This work has shown that microbial immobilization of uranium can be accomplished outside of the laboratory."

One question for the Department of Energy going forward is the long-term stability of the immobilized uranium created by the microbial interactions.

Another concern raised by Arjun Makhijani, president of the Institute for Energy and Environmental Research in Takoma Park, Maryland, is the long-term effect of wide-scale applications of the microbes.

"We are not attending to unforeseen consequences of long-term changes in the organisms and what damage that might cause to the ecosystems," Makhijani said.

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