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Mining bacteria's appetite for toxic waste
Researchers try to clean nuclear sites with microbes

Monday, July 14, 2003
San Francisco Chronicle
CHRONICLE SECTIONS

David Perlman, Chronicle Science Editor

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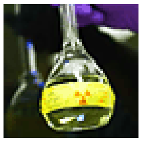
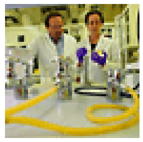

Scientists are experimenting with some unusual species of bacteria that can thrive by cleaning up radioactive wastes left over from the Cold War when nuclear weapons plants across the country were running full blast.

The problem exists wherever uranium has been mined, processed and made into nuclear bombs. Almost 500 billion gallons of groundwater -- enough to supply 1. 5 million homes for a year -- remain contaminated with uranium and other toxic chemicals in 36 states, the U.S. Department of Energy estimates.

Another 800 million gallons of waste from uranium mines and weapons plants lie buried in landfills, trenches and unlined tanks. More than 2 billion cubic feet of contaminated sediments remain to be cleaned -- a mountain of radioactive and toxic dirt 2,000 times larger than Egypt's Great Pyramid at Giza.

For many years, scientists have known about the unusual appetites of some microbes, including the ability of certain strains to consume uranium and other deadly poisons. Now researchers are starting to exploit that ability as a way to clean up nuclear sites, a process called "bioremediation."

STANFORD ENGINEER'S STUDIES

Among the experimenters is Craig Criddle, a Stanford University environmental engineer. He is working with several classes of microbes that he believes can turn a soluble form of uranium into an insoluble form. The uranium can precipitate out of the water like sand and be gathered like a common mineral, he believes.

Next week, Criddle will pursue an experiment at the Oak Ridge National Laboratory in Tennessee, which produced the uranium for the infamous atom bomb dropped on Hiroshima, killing almost 80,000 people.

The lab has another legacy. "The nitric acid and uranium oxide waste, a witch's brew, was dumped into unlined pits there for 31 years and then covered by a parking lot," Criddle said.

The waste ate its way down into layers of saprolite, a claylike rock, so that more than 99 percent of it is deep in the soil, he said. The remaining uranium has contaminated groundwater, a long-term threat to human health, because the uranium is soluble and moving steadily toward nearby Bear Creek, which flows through the area.

A complex community of microorganisms thrives by "breathing" oxides of sulfur, iron, aluminum and even more hazardous compounds like the uranium and other radioactive elements. As the microbes obtain their oxygen from soluble uranium oxide, for example, they transform it into a highly insoluble form called uraninite.

At Oak Ridge, Criddle will be working with several bacteria, including members of a genus called Desulfovibrio, which numbers more than 30 distinct species.

Heavy metals such as chromium that were used during the bomb-making era also pose a human health problem. Similar techniques mobilizing bacteria to remove chromium, a cancer-causing metal, are also being tested in the Oak Ridge experiments by a team from UC San Diego's Scripps Institution of Oceanography, led by marine biologist Bradley Tebo.

Criddle's uranium experiments involve lowering the acidity of the microbes' environment and nourishing them with ethanol to "get them all happy," as Criddle says. Doing so encourages them to go to work on the uranium by reducing oxides of the radioactive uranium and thereby rendering them insoluble.

Like other researchers in bioremediation, Criddle has support from the Department of Energy. The agency's program manager, microbiologist Anna Palmisano, is a former member of the astrobiology group at NASA's Ames Research Center in Mountain View, seeking microbial analogues on Earth for possible life on other planets.

"There are wonderful microbes that could be able to help us," Palmisano said. "But the radioactive elements that are moving into the water are soluble,

and to get them out, they must be made insoluble."

URANIUM DRIFTING TOWARD RIVER

Along the Colorado River, about 200 miles west of Denver, is the small town of Rifle, whose two mines and mills produced almost 17 million tons of uranium oxide, known as "yellowcake." When the mines shut down about 30 years ago, they left almost 3 million tons of contaminated uranium tailings. Uranium dissolved in the water beneath the tailings is moving gradually toward the Colorado River. Internet maps warn of the Rifle mill site: "No well drilling or use of groundwater."

After more than a decade of laboratory work, microbiologist Derek Lovley of the University of Massachusetts at Amherst has built a field site for testing the ability of a class of microbes, called Geobacters, to attack the uranium waste problem at the old Rifle mines. Two weeks ago, he began new and large- scale tests there.

In effect, Lovley and his colleagues have discovered that the Geobacter bacteria can live or "breathe" in environments where uranium oxides dominate. They are focusing on the old Rifle mill site to see if they can reduce the uranium-polluted water to radioactivity levels well below the government's safety standards.

The genes of Lovley's Geobacter species already have been sequenced by the Institute for Genomic Research in Rockville, Md., founded by famed scientist Craig Venter, who raced government scientists to sequence the entire human genome, and at the Energy Department's Joint Genome Institute, operated in Walnut Creek by the University of California.

Understanding those genes, according to Lovley, could enable scientists to engineer new strains of Geobacter even more capable of transforming the water- soluble forms of uranium into insoluble forms that could be filtered from streams and underground aquifers.

OTHER MICROBES IN SPOTLIGHT

Still other strains of microbes are under investigation.

One unique bacterium bears the intriguing name of Deinococcus radiodurans, meaning "strange berry that withstands radiation." It was discovered by Oregon radiation researchers in 1956 in a can of meat that had spoiled even after the meat was sterilized experimentally by intense radiation beams, and it is by far the most radiation-resistant organism in the world.

Gene-splicers are experimenting to see if the genes of D. radiodurans can be engineered to produce a new "superbug" that could decontaminate the most intensely radioactive wastes on Earth -- wastes much more deadly than the uranium that scientists such as Criddle and Lovley are hoping to clean up.

E-mail David Perlman at dperlman@sfchronicle.com.

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