Pond alga could help scientists design effective method for cleaning up nuclear waste

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Researchers from Northwestern University and Argonne National Laboratory have an enhanced understanding of a common freshwater alga and its remarkable ability to remove strontium from water. Insight into this mechanism ultimately could help scientists design methods to remove radioactive strontium from existing nuclear waste.

Strontium 90, a major waste component, is one of the more dangerous radioactive fission materials created within a nuclear reactor. It is present in the approximately 80 million gallons of radioactive waste sludge stored in the United States alone.

The researchers are the first to show quantitatively how Closterium moniliferum, one of the bright green algae often seen in ponds, sequesters strontium (in the form of barium-strontium-sulfate crystals). They are using this understanding to think about a practical sequestration system for nuclear waste that maximizes strontium removal. The possibilities include using the algae for direct bioremediation of waste or accidental spills in the environment or designing a new process for waste treatment inspired by how the algae work.

The results are published by the journal *ChemSusChem*, a sister journal of *Angewandte Chemie*.

"Nuclear waste cleanup is a problem we have to solve," said senior author Derk Joester, who experienced Chernobyl's radioactive fallout when he was a teenager living in southern Germany. "Even if all the nuclear reactors were to shut down tomorrow, the existing volume of waste is great, and it is costly to store. We need to isolate highly radioactive 'high-level' waste from 'low-level' waste. The algae offer a mechanism for doing this, which we would like to understand and optimize."

Even though strontium 90 doesn't appear to be a significant environmental threat following the nuclear accident in Japan, the radioactive isotope will need to be dealt with during the power plant and nuclear waste cleanup, Joester said.

Joester is the Morris E. Fine Junior Professor in Materials and Manufacturing at Northwestern's McCormick School of Engineering and Applied Science.

Strontium 90 has a half-life of about 30 years, is chemically very similar to calcium and thus is drawn to bone. The cumulative cancer risk from strontium 90 exposure when strontium is bound in bones for many years is very high.

The crescent-shaped, single-celled organism studied by Joester and his colleagues naturally makes biominerals that include non-radioactive strontium, and it can differentiate strontium from calcium -- a rare feat. The researchers want to learn more about this selectivity because calcium is present in far greater abundance than strontium in nuclear waste, but calcium is harmless. By concentrating the radioactive strontium (Sr-90) in the form of solid crystals with very low solubility, the dangerous high-level waste could be isolated from the rest and dealt with separately.

"Using the algae for direct bioremediation of waste is one approach," said Joester, who began the research years ago with his graduate student Minna Krejci, "but we also are looking at the basic mechanisms of how the algae sequester strontium so we can engineer a more selective process for waste treatment. We want to isolate and concentrate in the crystals the most strontium possible."

The algae's ability to separate strontium from calcium occurs when the crystals are formed inside the cells. The algae first soak up barium, strontium and calcium from their watery environment. Strontium then is sequestered along with barium in the crystals, which remain in the cells, while the calcium is excreted from the cells. (Barium must be present for the organisms to take up strontium.)

Joester and Krejci teamed up with Lydia Finney and Stefan Vogt at the Advanced Photon Source at Argonne National Laboratory to produce maps showing the distribution of barium, strontium, calcium and several other elements in the cells. At the same time, the composition of the crystals made by the cells was determined. (The crystals are located in the organism's vacuoles, at the tips of the cells.)

The researchers varied the amount of barium and strontium in the algae's environment and then measured the amount of strontium taken up into the cell. They found the ratio of barium to strontium in the water affected the amount of strontium incorporated into each crystal. Depending on the medium's composition, the strontium measured in a crystal ranged from less than 1 percent up to 45 percent. This gives the researchers an avenue for making the process more strontium-selective.

"The synchrotron X-ray microscopy available at the Advanced Photon Source was absolutely critical to this study," Joester said. "It allowed us to visualize where calcium, strontium and barium go inside the cells." These sorts of experiments, he noted, are only possible at three synchrotron radiation facilities in the world: the Advanced Photon

Source, the European Synchrotron Radiation Facility in France and the SPring-8 in Japan.

Nonradioactive strontium, which is chemically identical to the radioactive version, was used in the experiments. The researchers do not know how well the algae would survive in a radioactive environment, although the organisms have proven resistant in other harsh environments.

More information: Joester, Krejci, Finney and Vogt all are authors of the paper, titled "Selective Sequestration of Strontium in Desmid Green Algae by Biogenic Co-precipitation with Barite." It can be viewed at onlinelibrary.wiley.com/doi/10 … c.201000448/abstract

Provided by Northwestern University

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