Team finds Yellowstone alga that detoxifies arsenic

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Arsenic may be tough, but scientists have found a Yellowstone National Park alga that's tougher.

The alga -- a simple one-celled algae called *Cyanidioschyzon* -- thrives in extremely toxic conditions and chemically modifies arsenic that occurs naturally around hot springs, said Tim McDermott, professor in the Department of Land Resources and Environmental Sciences at Montana State University.

Cyanidioschyzon could someday help reclaim arsenic-laden mine waste and aid in everything from space exploration to creating safer foods and herbicides, the scientists said.

The alga and how it detoxifies arsenic are described in a paper that's posted this week (week of March 9) in the online edition of Proceedings of the National Academy of Sciences, or *PNAS*. Lead authors are McDermott and Barry Rosen, of Florida International University. Among the four co-authors is Corinne Lehr, who formerly worked with McDermott as a postdoctoral scientist at MSU and is now a faculty member at California Polytechnic State University.

Arsenic is the most common toxic substance in the environment, ranking first on the Superfund list of hazardous substances, the researchers wrote in their paper. McDermott said arsenic is very common in the hot, acidic waters of Yellowstone and presents real challenges for microorganisms living in these conditions. Indeed, there are challenges for the

researchers. McDermott said the acid in the soil and water are strong enough that it sometimes eats holes through his jeans when he kneels to collect samples.

McDermott has worked in Yellowstone for more than a decade and travels year-round to the Norris Geyser Basin to study the microbial mats that grow in acidic springs. Over the years, he noticed thick algae mats that were so lush and green in December that they looked like Astro-Turf, McDermott said. By June, they were practically gone. While investigating the change, McDermott and his collaborators learned about the *Cyanidiales* alga and its ability to reduce arsenic to a less dangerous form.

"These algae are such a dominant member of the microbiology community that they can't escape notice, but for some reason they have not attracted much attention," McDermott said.

The *Cyanidioschyzon* algae grow all over Yellowstone, but the researchers concentrated on the Norris Geyser Basin, McDermott said. The alga thrives in water up to 135 degrees Fahrenheit (too hot to shower) with a very acidic pH factor ranging from 0.5 to 3.5. Creeks are considered acidic if their pH factor is less than 7.

"These algae live in areas of Yellowstone that are extremely toxic with respect to arsenic," McDermott said. "You couldn't drink these waters even if you changed their pH."

The scientists cloned genes from the alga, then studied the enzymes to figure out how they transformed arsenic. They learned that the alga oxidizes, reduces and converts arsenic to several forms that are less toxic than the original.

Rosen said one significant form is a gas that can evaporate, especially at

the high temperatures of the Yellowstone springs. That allows life to exist in "really deadly concentrations of arsenic," he said.

"It gives us insight into how life adapts to extreme environments," Rosen added. "If life can grow at high temperatures and high concentrations of heavy metals like arsenic, life might be able to evolve on other planets or moons such as Titan or Enceladus."

McDermott said the scientists conducted basic research that may have implications someday for acid mine drainage and acid rock drainage remediation efforts.

"Any time you learn anything about eukaryotic algae and their potential application for bioremediation, that's always good," he said.

Eukaryotic refers to microorganisms that have cells with membranes enclosing complex structures. *Cyanidioschyzon* is a simple one-celled organism classified as a red algae.

Rosen added that the alga they studied is a primitive plant, so it might shed light on how plants can tolerate arsenic, which is used in several types of herbicides. The knowledge they gained could also be used someday to help create a new type of rice.

"Some plants, such as rice, accumulate high concentrations of arsenic. This endangers our food supply," Rosen explained. "Rice with high amounts of arsenic won't kill anyone quickly, but does increase the risk of cancers such as bladder cancer."

McDermott said when he first thought about investigating the changing colors in the Yellowstone algae mats, he figured that something more than photosynthesis had to be involved. He thought altitude and latitude played a role. Some of the hot springs have no trees around them, so he

wondered if the intense June sun was hammering the algae.

Molecular evidence suggests that the algae in these springs are comprised of two different population groups, McDermott said. One flourishes in the winter and the other in the summer. The algae that dominates in the summer can apparently tolerate high levels of ultraviolet rays.

Source: Montana State University