New research may help to clean drainage from abandoned mines

December 16 2009, by Erin Spanier

Acid mine drainage forms "yellow-boy" iron precipitates as it travels downstream through the KL-1 site. Photo: Rachel Brennan

(PhysOrg.com) -- In a quiet green glen near Ashville, Pa., lies a rust-colored pond. A deep, rectangular hole in the ground, it somewhat resembles an Olympic-sized pool. Few people, however, would make the mistake of swimming laps there. And fewer -- human or animal -- would stop to drink.

Rachel Brennan, assistant professor of environmental engineering at Penn State, brings her students here. They crouch by the pond cautiously, carefully collecting water samples and searching for signs of life. The site, known as KL-1, is one of two water-treatment ponds installed by the Clearfield Creek Watershed Association in November 2007 to remediate pollution caused by the long-abandoned Klondike coal mine. But while its nearby sister site, KL-2, has proven effective at normalizing pH and extracting dissolved metals, the challenge at KL-1 is far more grave.

Each liter of water at KL-1 contains 137 milligrams of iron and 382 milligrams of acidity. At 3.3, the pH is far too acidic to sustain most life. The color of the water -- reminiscent of rusted metal -- is a symptom of the underlying problem: acid mine drainage.

Pyrite, a highly reactive rock commonly found in coal seams, is relatively harmless when undisturbed, Brennan explained. But when pyrite (also known as fool’s gold) is exposed to air and water, it leaches sulfuric acid, which in turn causes metals in the adjacent rocks and soil to be released. In Pennsylvania, that means iron, which is part of the pyrite itself, and aluminum and manganese, which are present in the soil. In other mining regions, the metals released can be even more dangerous -- chromium, arsenic, even lead.

Acidic drainage from abandoned mines -- and no one seems to know exactly how many such mines exist -- continues to contaminate tens of thousands of miles of streams in the United States, including more than 5,000 miles in Pennsylvania. That makes Pennsylvania an ideal testing ground for innovative treatment technologies. Brennan currently is testing one of the more promising of these options: crab shell chitin, a waste product of the crabbing industry. One of the most abundant natural materials in the world, chitin is used to make paper, fabrics, weight-loss pills and joint care supplements, among other products. In crustaceans like crab and shrimp, chitin combines with calcium carbonate, the same chemical that’s in limestone. And Brennan’s research suggests that this combination may be extremely effective at cleaning up acid mine drainage.

In preliminary testing in her lab in 2006, Brennan added crab shell chitin to mine-water samples and found that pH rose to near-normal levels in just six days while dissolved metals like iron and aluminum were reduced by over 99 percent. After nine days, even manganese, a metal that passive treatment systems have historically failed to remove, was reduced by 81 percent, and sulfate concentrations decreased from 489 to 303 milligrams per liter, confirming the activity of sulfate reducing bacteria, which are critical in biological treatment systems. Subsequent testing has yielded even greater contaminant reductions.

“We’re seeing simultaneous physical, chemical and biological treatment with just one substrate,” Brennan said.

In recent field tests at two mine-drainage sites in Colorado, she has achieved similar results. Still, Brennan has been anxious to test chitin at a site where other remedies have failed -- a site like KL-1.

“These kinds of water-quality problems could be easily fixed with active treatment,” Brennan said. “Build a little water treatment plant at each discharge point and you’d clean it up quickly. But there are so many of them in so many remote locations, it would cost billions of dollars. There’s just no money to do it.”

Passive treatment options like limestone and spent mushroom compost, on the other hand, while they work relatively well in low and moderate acidity, have not been effective in high-acidity, high-metal-content conditions. Brennan is hoping that chitin can fill the void.

The National Science Foundation is hoping so, too. In February 2007, NSF recognized Brennan with a prestigious Faculty Early Career Development (CAREER) Award. In addition to supporting fundamental research, the $413,000, multi-year award is intended to cover the cost of field testing chitin at the KL-1 site.

This fall members of Brennan’s research team, together with her CE

497B class, visited KL-1 to collect and analyze water samples. They then worked together to design an inexpensive remediation system to test chitin against spent mushroom compost and limestone controls.

"It's not the holy grail of bioremediation," Brennan said, but for cleaning acidic, metal-laden water in areas with limited financial resources, it may prove an affordable alternative to active chemical remediation.

Provided by Pennsylvania State University

Citation: New research may help to clean drainage from abandoned mines (2009, December 16) retrieved 5 May 2024 from https://phys.org/news/2009-12-drainage-abandoned.html