ENVIRONMENT

Mitigating Microbes

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– Former graduate student Evan Walters

By **Tim Crosby**

When you go to the butcher, you don't ask for the whole cow. Instead, you want a choice cut or juicy, well-blended hamburger.

The same can be said for natural microbes that turn pollutants into more benign substances.

Researchers at SIU Carbondale recently proved that concept en route to helping clean up the water at a polluted site in Southern Illinois. The idea, supported by more than a year's worth of research, helped state officials design better methods to mitigate the pollution.

The work centers on a concept called a "bioreactor." A bioreactor uses living organisms and natural substances such as bacteria and organic material to break down or stabilize harmful substances. The various substances used inside the reactor – the substrates – determine how well it works, based on whatever hazards one is trying to mitigate.

Former graduate student Evan Walters, of Wheaton, found that herbaceous material, such as grass clippings and leaves, help the microbes thrive and subsequently improved the bioreactor's performance at the abandoned Tab-Simco mine site on Carbondale's east side.

The mine, which operated on and off since the late 1800s, contains leftover coal deposits that send pollutants into the nearby Cypress Creek. When the Illinois Department of Natural Resources recently refurbished the bioreactor at the site, it incorporated Walters' research into its design.

Working under the supervision of Liliana Lefticariu, associate professor of geology, Walters' experiments were aimed at improving the efficiency of a bioreactor the state originally put in place at the site.

Coal deposits at this particular site contain large amounts of iron oxide and pyrite, which, when exposed to water, release additional inorganic elements such as nickel, cadmium, cobalt and arsenic, among others. The high acidity of the water tends to keep those elements in solution, which allows them to move off the site with water.

IDNR, working through the Office of Surface Mines, originally constructed a bioreactor at the site in 2007. That reactor consisted of a small pond with a liner containing layers of limestone, woodchips and manure.

As water from the area drained into the pond, the limestone lowered the acidity of the water, causing the other substances to leave solution. At the same time, microbes from the manure and wood chips changed iron sulfate into sulfite, taking it back toward its original, less harmful state of pyrite.

Lefticariu's previous graduate student, Yosief Segid, worked on that reactor for three years, publishing his results in scientific journals as well. The bioreactor worked well, but after several years, its effectiveness began to wane.

"The first bioreactor was wearing out. It just wasn't big enough for the volume of water it needed to process," Lefticiairu said. "Every site like this is unique, and so the bioreactor you devise for it has to be customized. And so Evan had to try to find what materials would work best, improving on the first design if possible."

So Walters set out to determine the optimal mixture. To do this, he built five small test reactors, filled with various materials, including limestone and several different types of organic materials such as grass clippings, leaves, woodchips, spent brewing grains and others. He also had one control reactor containing only limestone.

Eventually, running the experiment would mean spending thousands of hours in the field, which ended up being a major challenge, Walters said. But it also meant more reliable results.

"Since the study lasted over a year the variations in weather made it difficult to organize sampling events and maintain operating integrity of the reactors," Walters said. "Not to mention each sampling day typically meant spending 14 plus hours of non-stop work.

"To tell you the truth every asset of this study would have been much easier if it had been performed in a laboratory setting. But our results depicted the responses of the reactors to environmental conditions that cannot be replicated properly in the lab. This made it possible to obtain genuine data that is representative of an actual abandoned mine land in the Midwestern United States."

Walters said the goal of his experiment was finding the best mixture of organic material to act as a food source that would enhance microbial activity, which in turn would increase the bioreactor's effectiveness. Herbaceous material such as grass is very malleable compared to wood chips. This difference, which goes down to the very molecular composition of the materials, makes herbaceous material much more susceptible to degradation by microbes than woody material, meaning herbaceous substrate is a much better food source for these reactors.

"To put it in human terms, when one goes to the butcher to buy meat for hamburgers, asking for the whole cow instead of ground beef would be similar to giving microbes woody material instead of herbaceous," Walters said. "Not to say that the cow or wood could not be used as a food source, it would just take more time to break down into utilizable material."

As a new scientist, Walters said he was careful not to draw conclusions until all his data were complete.

"Having an experiment last over a year made it very tempting to try to speculate at every point within the experiment, and trust me I did just that," he said. "But it was not until all that data were in that I really had a full picture of what had occurred within these reactors."

The breakthrough came, he said, when he saw answers to his hypotheses and he grew confident that he had found a real solution to making the reactors function more efficiently.

PHOTO BY RUSSELL BAILEY

Mine clean-up – Former SIU Carbondale graduate student Evan Walters adjusts some piping used in an experiment he designed aimed at cleaning the water at the abandoned Tab-Simco mine site on Carbondale's east side last year. Working under the supervision of Liliana Lefticariu, associate professor of geology, Walters' experiments improved the efficiency of a bioreactor the state recently refurbished at the site.

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Mine clean-up – Charles Pugh, a research assistant in the Department of Microbiology (left), and former SIU Carbondale graduate student Evan Walters, take samples of water from one of Walters' experimental bioreactors.

PHOTO BY RUSSELL BAILEY

Mine clean-up – Evan Walters stands near the pond at the abandoned Tab-Simco mine site on Carbondale's east side last year. The orange coloring in the water is from the iron and other pollutants left behind at the site.

WORTH KNOWING

SIU is increasingly active in the field of technology transfer and commercialization. Since 1996, the university has disclosed 354 inventions, issued 82 licenses/options, filed 183 patent applications with a resulting 56 issued patents, and received $6.5 million in royalties.

"To accomplish this was a feeling that cannot be captured with words," he sad. "Still, something else happened to me throughout this experiment. It turned out that many conclusions brought about more questions and possibilities that I had not yet considered. I had finally realized that this study was more than an experiment; it was what turned me into a living, breathing scientist."

Walters said he came to see that SIU is a committed partner in the overall Southern Illinois community.

"Through my experience, I believe SIU and the community are one and the same entity," he said. "The harsh reality of this project was that it is a site located in Carbondale that threatens the natural ecosystem and water. I could remember going to the site and speaking with the landowners about the contamination and how it had affected the aquatic life in the area. This is when I knew that it was not just an experiment; it was something real that would impact the livelihood of our community. We definitely felt committed to finding the best solution to the problem because we knew that our results could impact the local community in such a positive way."

Walters said working in the environmental sector will be an exciting challenge, and he feels well prepared by his experience at SIU.

"I feel as though I have both the knowledge and the passion to make a positive impact," he said. "Water is an essential component of our lives and therefore it is our responsibility to protect our natural water systems. I hope to be at the forefront of ensuring our most precious natural resource is secured for future generations to come."