Nailing it

CEE student researchers find household biosand filters + iron nails = virus-free drinking water

By Joyce Mast

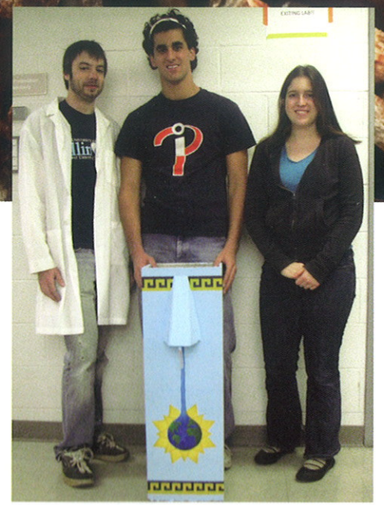
Socorro, a Mayan community of 450 in the highlands of southwestern Guatemala, is afflicted with acute and chronic diarrheal illnesses, soil-transmitted helminthes (worm) infections, and subsequent malnutrition. During the first months of winter rains, diarrheal rates in the children of Socorro exceed 75 percent. In 2007, Socorro called the University of Illinois branch of Engineers Without Borders (EWB-UIUC) for help. The response? An innovative project that will likely bring clean water to every Socorro household by fall 2010.

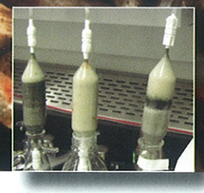
A team of U of I students, including CEE student leaders Sheila Markazi and Billy Nichols, went to Socorro for initial site assessments in December 2008 and spring 2009. The team designed a centralized system, but unfortunately the required land could not be purchased. In summer 2009, the community and the team, with help from a local, culturally sensitive non-governmental organization (NGO), decided to pursue household-scale water treatment. Five CEE EWB-UIUC undergraduates—Kimberly Parker and Peter Maraccini (project leads) with Alyssa Sohn, Emily Van Dam, and Ofelia Romero—will travel to Socorro during the 2009-2010 winter break. Working with the NGO, they will teach the small community team how to construct, operate, and maintain 150 (one for each family group) $30 concrete, iron-amended biosand filters (BSFs). After about 30 weeks, at a rate of five per week, Socorro could have its first reliable source of safe drinking water and no waterborne bacterial and viral diseases.

Visit the CEE website to read the students' blog about their work in Guatemala.

For 15 years, BSFs have been used effectively to strain out bacterial pathogens, protozoa, and helminthes from drinking water, but viruses, which are approximately 100 times smaller than bacteria, slip through. Enter EWB-UIUC undergraduates Parker, Maraccini, Markazi, Kevin Swanson and graduate researcher Ian Bradley, with their research adviser, Professor Thanh (Helen) Nguyen, who all found a great research opportunity in Socorro's waterborne diseases. Could the low-virus-removal problem be solved with rusty nails? Iron nails (zerovalent iron) added to the BSF sand layer, will rust, producing iron oxide and hydroxides. These positively charged oxides efficiently adsorb virus particles, removing them from the water. As the adsorption sites are filled, the iron oxides fall off the nails and expose new iron material, which rusts and creates new iron oxide adsorption sites to remove still more viruses. The process passively regenerates itself to indefinitely remove viruses. The iron oxides are caught in the sand once they fall off the nails and do not enter the filtered drinking water.

The few existing studies that have tested virus reduction using zerovalent iron-amended BSFs have considered only a particular virus or aspect of filtration. In April 2009, the CEE team was awarded a $10,000 grant from an Environmental Protection Agency program called P-3 (People, Prosperity, Planet) - Promising Research Ideas, one of only 20 nationwide, to examine multiple aspects of virus reduction using zerovalent iron-amended BSFs, in both small- and large-scale experiments with model organisms (MS-2) and human pathogenic viruses (rotavirus). They began in May. On the small scale, the team pumped water containing model viruses through glass columns filled with sand mixed with 10 percent iron filings and saw a 99.99 percent virus removal—the World Health Organization standard. As the experiment has continued and the iron has corroded further, more iron oxides have formed, with a 99.9999 percent removal rate.





◀*Left to right: Ian Bradley, graduate researcher, Peter Maraccini and Kimberly Parker, undergrad co-project leads, standing behind a concrete filter painted with Mayan designs. It can produce approximately 20 liters of clean water every use.*
▲*Test columns: Left, iron filings throughout the sand; middle, control; right, iron filings in a discrete layer.*

Such promising results raise more questions: What is the optimal number of nails and placement—concentrated in a layer or spread throughout the sand? How long do they need to be in contact with the water? Does local contaminated water contain enough oxygen for nails to rust, or do its microorganisms remove too much oxygen for the rusty-nail idea to work? Will Guatemalan nails remove viruses without affecting the water's pH, color, or taste? The CEE team is addressing these questions. Best responses could solve the waterborne disease problem in Socorro and developing communities around the world.

"First and foremost, we want to help Socorro," Maraccini says. "But we also want them to help us to demonstrate that our idea will be effective in real world situations."

The team will be flown to Washington, D.C., sometime this spring to compete for the $75,000 EPA-Phase II-Implementation grant. A follow-up trip to Socorro to evaluate filtered water quality and community response is planned for May 2010.

Peter Maraccini, Kimberly Parker, and Ian Bradley contributed to this story. Professors Nguyen and Bruce Litchfield supported the EPA P-3 grant application. More than 50 EWB-UIUC members volunteered their time, donated, and raised almost $24,000 through fundraisers, the University of Illinois, EWB, Wuqu' Kawoq and St. John's Catholic Chapel. This money, together with the $10,000 EPA P-3 grant, will fund the 150 zerovalent iron-amended BSFs for Socorro.

Nail photo:©klaumar/istockphoto.com

Working in traffic

Two CEE alumni work with the Illinois Center for Transportation for safer moving lane closures

Above: A mobile lane closure on the Reagan Memorial Tollway (I-88). Trucks with arrow boards and crash attenuators closed the right lane of the interstate for workers to do short-duration work in the lane.
Inset: A mobile lane closure at night on I-90 near Barrington Rd. Trucks with arrow boards and crash attenuators closed two left lanes of the three-lane interstate to perform maintenance on the pavement markings. The work crew is near the bright white light and the use of that light is based on recommendations from an earlier ICT project. Driver behavior was evaluated around these closures with a goal of making these closures safer.

By Leslie Sweet Myrick

Routine road maintenance is a rare sight during an Illinois winter, but two CEE alums are using this year's off season to wrap up their research towards safer work zones for the future. Through research funded by the Illinois Center for Transportation (ICT), Douglas Steele (BS 91, MS 92) and William Vavrik (BS 96, MS 97, PhD 00), both of Applied Research Associates Inc., are finalizing recommendations to improve the safety of moving lane closures.

Moving lane closures are a common traffic control technique in work zones. They consist of a convoy of traffic protection vehicles equipped with warning lights and arrow boards that alert drivers to the presence of work crews and guide them to the adjacent lane until they have safely passed the work zone. Moving lane closures allow the work crews to close lanes for shorter durations, thereby minimizing disruption for the traveling public and increasing the efficiency of maintenance work. However, they can also be dangerous because their mobile nature does not allow for the placement of barricades between the work crew and the adjacent open traffic lane. Additionally, many motorists do not view moving lane closures as "real work zones" and therefore don't exercise proper precautions in these zones.

This project was proposed to ICT after an Applied Research Associates Inc. (ARA) worker was killed while working at night in a closure similar to the one shown in the inset. About 18 months before the ARA accident, a tollway worker was killed while performing road work in another closure. These tragedies were the genesis of this research, the goal of which is to save lives.

In Phase I of this project, Steele and Vavrik studied the factors that affect driver behavior around moving work zones through a series of field tests. They observed driver behavior through videotapes and through the help of the Illinois State Police, who in an unmarked vehicle, monitored and recorded traffic speeds approaching and passing through the work zones. Also with the help of the Illinois State Toll Highway Authority, the researchers were able to test four locations for two to three days each. Specifically, they studied pertinent safety parameters that include traveling speed, number and spacing of trucks, buffer distances, and visibility of work crews. They also used energy absorption calculations to predict the typical roll-ahead distances of protection vehicles when they are impacted by vehicles of varying sizes and speeds.

After reviewing driver behavior and analyzing the video and speed data, Steele and Vavrik published their research and initial recommendations (posted on the ICT website's publications page at http://ict.illinois.edu). This initial research resulted in an improved understanding of traffic patterns and driver behavior near and around rolling lane closures.

The project has since expanded into Phase II that included a series of meetings with a diverse group of professionals who are involved with moving lane closures. Using the feedback gained from these meetings, Steele and Vavrik will submit specific recommendations for revised standards for moving lane closures in Illinois to the Illinois Department of Transportation (IDOT).

"Taking our field study results, presenting them to practitioners and experts, and getting their feedback adds tremendous insight for our final recommendations," says Vavrik.

The implementation of the recommendations could help reduce the thousands of accidents and numerous fatalities that occur in highway work zones each year. Aaron Weatherholt, the IDOT Technical Review Panel chairperson who oversees this research sums up the project's impact: "The value of this research is very simple, to reduce crashes and save lives."

ILLINOIS CENTER FOR TRANSPORTATION

The Illinois Center for Transportation is an innovative research partnership between the Illinois Department of Transportation and the University of Illinois. The ICT research team includes 64 investigators from a diverse array of universities, private consulting firms, and governmental agencies. ICT accepts research ideas twice annually.

http://ict.illinois.edu