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Filtering Water in Homes

UNC faculty and students travel to Cambodia and the Dominican Republic to study technologies to provide clean drinking water to those who need it most.

BY EMILY J. SMITH

In developing countries throughout Asia, Africa and Latin America, clean water can mean the difference between life and death. Worldwide, more than 1.8 million people — mostly children under five — die each year from diarrheal diseases, many of which are caused by unsafe water.

These are facts all too familiar to UNC School of Public Health researcher Dr. Mark Sobsey, Kenan Distinguished University Professor of environmental sciences and engineering. Sobsey works in the Dominican Republic, Cambodia, South Africa, Indonesia, Ghana and Honduras with a team of UNC graduate students and post-docs to test the efficacy of simple household water filtration devices in removing waterborne pathogens and reducing the incidence of diarrheal disease.

"Effective filtration technologies have the potential to bring safe drinking water to many people in developing countries around the world who don't have access to it now," says Sobsey, who also directs the School of Public Health's Environmental Virology and Microbiology Laboratory. "We can tremendously improve people's health and quality of life if we can help them get a reliable source of clean, safe drinking water."

Although point-of-use household water treatment filters have been used in developing countries since the 1990s, objective data on their effectiveness are scant. It's for this reason that Sobsey and his team have been conducting randomized controlled trials and other prospective cohort studies of the effectiveness of different filter designs: porous ceramic filters, and also biosand filters — concrete or plastic containers that filter water through layers of biologically-active gravel and sand. All are designed for use in even the most rudimentary of homes.

Results from studies of the ceramic and concrete biosand filters conducted by the UNC team last year in the Dominican Republic and Cambodia look promising. Both kinds of filters reduced the incidence of diarrhea by up to 40 percent in households that used them.

Dr. Joe Brown, who earned his doctoral degree in environmental sciences and engineering from UNC in August 2007, led the Cambodian studies on the ceramic filters.

Research was conducted in Prek Thmey, a rice-farming village on the Bassac River, 20 kilometers downstream from Phnom Penh — the country's capital — and also downstream from one of the main outfalls for Phnom Penh's open sewers. In this village — the name of which means "new water" in Cambodian — one in five children is sick with diarrhea at any given time.

One-hundred and eighty households in the community participated in the study, conducted in collaboration with Resource Development International, a Cambodian-

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A Cambodian man (left) transports clay water filters in a ceramic water filter factory near Phnom Penh run by Resource Development International (RDIC), a Cambodian-based nonprofit organization. UNC scientists are conducting research on the filters in collaboration with RDIC. Ceramic filters are designed so that water passes through them but bacteria and viruses do not. Each filter is tested and sold, at cost, for about $8, along with a plastic bucket to store filtered water and a lid to go over the filter/bucket unit. A Cambodian worker (above) operates a hydraulic press mold that takes wet clay mixture and forms it into a pot-shaped filter. Filters are used in Cambodian homes like the one shown here (right).

based nonprofit organization. Sixty received standard ceramic filters commonly distributed by nongovernmental organizations working in Cambodia; 60 received ceramic filters modified by UNC researchers to increase virus removal; and 60 households (the "control" group) didn't get filters.

"Technologies perform differently in the field than in the lab," says Brown. "For this reason, it's important to consider how they're used when evaluating their effectiveness."

Before distributing filters, UNC researchers collected baseline data from study participants on water quality and source, water sanitation and hygiene practices, and socioeconomic indicators. After the filters were distributed, they made bi-weekly visits to households for 22 weeks, collecting samples of treated and untreated water in each household and health data on family members.

Lab results from the study found that both ceramic-filter designs reduced *E. coli* bacteria by approximately 99 percent and MS2, a virus, by 90 to 99 percent. The presence of *E. coli* indicates the possible presence of fecal contaminants in a water sample and when ingested, pathogenic strains of it and similar pathogenic bacteria like *Salmonella*, *Campylobacter* and *Shigella* species are common causes of diarrhea.

Ceramic water filters are designed so that filtered water flows into an enclosed five-gallon plastic bucket with a side tap to dispense clean water.

"The filters are not as effective as boiling water, but because filtered water is stored securely, it is less likely than boiled water to get re-contaminated by people putting their hands or utensils into it," says Brown.

In fact, safe water storage is one of the bonuses of these household water treatment filters.

"Village-scale water systems are great, but if people don't have a tap in the house, they're going to be out collecting water in a bucket and bringing it back to be stored. That's where it gets contaminated," says Brown.

Brown has been intensely involved in researching filters. In 2006, he also conducted a study, funded by UNICEF and the World Bank, to explore the effectiveness of ceramic water filter use in households that had received one between 2002 and 2006 from development organizations working in that area.

PHOTO BY DR. JOE BROWN

"Two nongovernmental organizations in Cambodia have put tens of thousands of these filters into households over the past four years, and UNICEF said, well, we'd really like to invest in this technology, but we need to know how effective they've been," says Brown, explaining the reasoning for the study.

Brown started the project by getting a list of all households that had received ceramic water filters from these organizations over the past four years. From that list, he randomly selected 600 households across three provinces to participate in the study. Of these, 506 households were located, up to four years after receiving filters.

"People who had more of an awareness of water and sanitation issues were more likely to continue using the filters," says Brown. "Also, people who had bought their own filters were more likely to continue using them — they were more invested in the technology. A lot of people who had been given filters weren't using them."

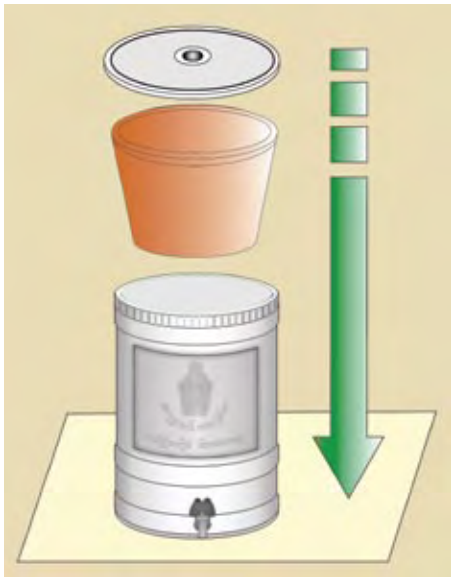

DIAGRAM BY MICKEY SAMPSON

Chhoun Bunnara (above, left) a Cambodian research colleague working with UNC scientists, shows a man how to use a ceramic filter. The man lives in the west-central Cambodian village of Kampong Lourng, a floating village on Tonle Sap Lake.

Water passes through the porous ceramic filter (diagram above) into a plastic receiving container, where it is dispensed via a tap to prevent re-contamination of the water.

In a second part to this study, 80 of the 506 participating households still using their filters were matched with 80 households in a control group living in similar circumstances who had never had filters. In comparing the two groups, the study found that the group using filters had about 50 percent fewer cases of diarrheal disease than those without filters.

A similar study of concrete biosand filter use in Cambodia is underway, directed by Kaida Liang, who earned her master's degree in environmental sciences and engineering from UNC in August 2007. Those study results are due later this year.

Biosand filter use in the Dominican Republic

UNC research on the efficacy of concrete biosand filters is also ongoing in the Dominican Republic.

An initial field study of their effectiveness began in 2005 when UNC School of Public Health researchers recruited approximately 180 households in two villages near Bonao, Dominican Republic, to participate in the project. They monitored households without filters for four months, assessing the rate of illness. Then, about half the houses (approximately 80) were given concrete biosand filters. All households then were monitored for another six months. The team's initial analysis showed the filters reduced diarrheal disease among household members by an estimated 47 percent, including among highly vulnerable young children less than 5 years old. Field analyses conducted on more than 100 household filters near Bonao also found that the filters reduced the amount of *E. coli* in the water by 93 percent.

"Effective filtration technologies can bring safe drinking water to many people in developing countries who don't have access to it now. We can tremendously improve people's health and quality of life if we can help them get a reliable source of clean, safe drinking water."

"Over time, as people use the filter, it gets better at filtering the water," says Dr. Christine Stauber, who earned her doctoral degree in environmental sciences and engineering from UNC in August 2007 and helped direct the project. "This is because with time, a 'biolayer' grows on the surface of the sand in the filter. As that biolayer gets thicker, it helps filter the water."

UNC School of Public Health researchers returned to Bonao in summer 2007 to learn whether people were still using the filters and whether the filters were still producing improved drinking water. Results are expected later this year.

Dr. Gloria Ortiz, a UNC postdoctoral fellow and native of the Dominican Republic who helped direct the project, said residents told her that the filters make a great difference in their lives.

"They told me they no longer worry about sick children who miss school, or about taking the children to the doctor or finding money to buy medications to treat diarrhea," she says. "Many told me that since they've been using the filters, no one in their house had gotten a single case of diarrhea. This is a tremendous step in improving their health and well-being."

UNC-based lab studies on the efficacy of biosand filters in removing *E. coli* bacteria and viruses found that when water is left in the sand filter for longer periods of time (10 to 20 hours), more bacteria and viruses are removed from the water.

"We're conducting studies now to find out how long the pause time should be

Plastic and metal containers (below) store unfiltered water in a Dominican Republic home. Water stored this way is prone to contamination. For this reason, biosand and ceramic water filters being tested by UNC researchers are designed so that filtered water flows into enclosed containers with side taps to dispense clean water.

PHOTO BY DR. GLORIA ORTIZ

UNC researchers have been conducting randomized controlled trials of the effectiveness of porous ceramic filters and biosand filters that filter water through layers of biologically-active gravel and sand. Both kinds of filters were found to reduce the incidence of diarrhea by up to 40 percent in households that used them.

to get improved performance and why the concentration of harmful microbes decreases when water is left in the filter for several hours," says Mark Elliott, a doctoral student in environmental sciences and engineering who is overseeing the research and has directed more than a half-dozen biosand-filter lab studies since 2004.

Elliott hypothesized that the *E. coli* bacteria may stick to the particles of sand in the filter or that the biolayer on the surface of the filter may contribute to the microbial reductions.

UNC-led research on the efficacy of plastic biosand filters is in developmental stages in Honduras, Ghana and Indonesia, says Sobsey. The projects are funded by International Aid, a nongovernmental organization based in Michigan. A sustainability study of the biosand filter is underway in the Dominican Republic. This project is funded by the U.S. Agency for International Development (USAID).

"USAID has become a big promoter of household water treatment technology. However, they're reluctant to support any technology that does not have the evidence of reducing diarrheal disease in the field," says Sobsey. "They're also interested in sustainable technologies. For this reason, we've conducted studies in places where they think they can most efficiently begin to introduce these filters and achieve large-scale coverage."

Sobsey notes that the ceramic and biosand water filters are "something of a status symbol" in developing countries. "People can point to the filters and say, 'Look, I have a water filter. It makes my water cleaner.' People have a sense that their families are healthier because they have a water filter."

The filters also empower people at a household level to take responsibility for their water, Sobsey says. ■

PHOTO BY DR. CHRISTINE STAUBER

Yakira Morillo and her daughter (above) standing next to their biosand filter in Jayaco, Bonao, Dominican Republic.

Lab worker Aideé Liranzo de Villar (below) processes water samples to detect bacterial contamination in the laboratory of Dr. Mirna Peña de Guerra in Bonao, Dominican Republic.

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