Cleaning contaminated groundwater more effectively

Sometimes, very harsh, dangerous chemicals are spilled, thrown or leaked into important drinking water sources. They are hard to remove from water, especially groundwater, and they can be deadly.

BY KATHLEEN KEARNS

A good example of these dangers was chronicled in the book (and movie) *A Civil Action*, which was based on a spill of the chemical trichloroethylene (TCE) that contaminated groundwater in Woburn, Mass., and caused a cluster of leukemia cases.

Cleaning up subsurface systems contaminated with chlorinated solvents, such as TCE, is one of the most difficult problems in the environmental sciences field, says Dr. Cass Miller, professor of environmental sciences and engineering at the UNC School of Public Health. "Such compounds are long-lived in the environment, of health concern at very low concentrations and devilishly difficult to remove once released into the subsurface." Miller and colleagues have developed patented processes to remove chlorinated solvents like TCE and perchloroethylene (PCE) more effectively than current approaches can. During the last several years, they've been working to advance, improve and better understand this technology.

More than half of all Superfund sites are contaminated with TCE, Miller points out. (In 1980, Congress created the Superfund program to clean up the nation's hazardous waste sites.) Many Department of Defense installations, including North Carolina's Camp Lejeune, have groundwater contaminated with such chlorinated solvents. Cleaning up this kind of contamination presents a host of challenges. One is the nature of the solvents themselves: they're heavier than water and tend to move downward because of gravity. "They tend to sink below the water table," Miller says. "These contaminants can reach significant depths below the subsurface."

Because they move through groundwater and spread through a variety of subsurface conditions and materials that can't be seen or completely characterized—various mixtures of sand, silt, clay and rock—their flow patterns are very complicated. Solvents leave some of their mass behind in clays and silts, and they can pond up on the surface of impermeable substances in the earth.

"This is what makes it so difficult to remediate," Miller says. "Solvents trapped in porous materials such as sands, silts and clays beneath the earth's surface can be a source of groundwater contamination and a threat to public health for over a hundred years if left unremediated."

As water moves through a contaminated region, some toxins are dissolved into it and become threats to public health. "The common technology to remove such contaminants is called 'pump and treat,'" Miller says. "A well is established between the contaminated region and any source of supply that you want to protect. As you pump that well, the idea is that you'll remove water and contaminants from the source region. This hasn't worked very well."

Miller's solution is to use brine, in this case, a calcium bromide mixture that is denser than both the solvents and water, to remediate a contaminated system. "We inject brine into the system, and because it's denser, it can displace some of the contaminants upward and

TIP: Dispose of household contaminants safely to avoid polluting groundwater. Collect old batteries, used antifreeze, paint and chlorinated solvents and take them to the landfill.

Dr. Cass Miller

provide a barrier to prevent further vertical migration downward. If we mobilize these contaminants and move them downward, and we have a brine layer as a barrier, then they'll stop at the barrier. Then we can remove them with an extraction well." The method uses a food-grade surfactant (a wetting agent) to move the contaminants downward.

Miller's team recently tested the process in a field study at Dover Air Force Base in Delaware. "Nature is complicated," he says, "and though we try to make complicated systems in the laboratory, the size and the complexity of those can never really mimic what's in nature." The Dover facility had an impermeable clay layer 40 feet beneath the surface, and the test area had double-steel barriers to prevent groundwater contamination outside of the test region.

Funding was obtained from the National Institute of Environmental Health Sciences through UNC's Superfund Basic Research Program; RETEC, a national environmental consulting firm; and the Dead Sea Bromide Group, an international partner. Miller's team then deliberately contaminated the Dover site with PCE and attempted to remove it. This field study was instrumental in helping to mature their understanding and move them in the direction of further refinements to the process.

"We learned we were able to add brine to the system, achieve the densities we wanted to achieve, and were therefore able to control any mobilized PCE," Miller says. "Importantly, we were able to recover the brine from the system efficiently and in economical concentrations. Unfortunately, we didn't remove all the PCE. We're doing follow-up work in the laboratory to further improve the process, understand the economics of the method through mathematical modeling and, along with our two partners, prepare for another field application." ■