ARSENIC

In Search of the Roots of a Scourge

In Bangladesh as many as 57 million people drink water with arsenic levels that exceed the 10-ppb limit set by the World Health Organization. Arsenic occurs naturally in high concentrations in groundwater in Bangladesh. Researchers at the Massachusetts Institute of Technology (MIT) in Cambridge and Bangladesh University of Engineering and Technology in Dhaka now report that ponds resulting from land excavation to build up villages may worsen arsenic contamination in local drinking water, whereas irrigated rice fields appear to remove arsenic.

Land use in Bangladesh has changed dramatically over the past few decades. Population growth has spurred land excavations to elevate homes and roadways for protection against monsoon floodwaters. The resulting pits fill with water and become fish ponds, which are rich in organic carbon that percolates downward. Iron-reducing bacteria such as *Geobacter* species transform solid-phase iron into soluble ferrous iron. Solid-phase iron binds arsenic; however, when bacteria transform the metal ions into ferrous iron, the bound arsenic is released into groundwater. Study leader Charles Harvey, an associate professor of civil and environmental engineering at MIT, believes these fish ponds may be a major contributor to the arsenic poisoning that is now endemic to Bangladesh.

People in Bangladesh once drank stagnant surface pond water and, as a result, were plagued by gastrointestinal infections. About 40 years ago, they switched to drilling shallow tube wells to obtain cleaner drinking water, with the number of wells doubling roughly every 5 years, according to Alexander van Geen, a geochemist at Columbia University who also has studied the Bangladeshi situation. Symptoms of arsenic poisoning, such as characteristic skin lesions, started showing up about 20 years ago.

In the current study, Harvey and colleagues monitored the hydrology and chemical composition of water from ponds and rice fields that recharge underground aquifers in a 9-km^2 test site in the Munshiganj district of Bangladesh. Their measurements over 7 years included concentrations of arsenic, pH, oxygen, and organic carbon in water samples collected at different sites and water depths. They created a three-dimensional model to track water movement underground.

The team discovered that arsenic levels peaked about 30 m below ground level—the same depth to which many tube wells are drilled for drinking water. Moreover, when water was pumped out of aquifers to irrigate rice fields, the pond water was drawn down to about this same depth of 30 m, gaining arsenic as it passed downward through sediment layers. Atmospheric oxygen as well as that produced by algae in rice fields oxidized iron, causing it "to coagulate and settle out," explains Harvey, absorbing arsenic as it did so. Chemical fingerprints of water samples collected at different locations confirmed that water with the highest arsenic content originated from human-built ponds while water coming from irrigated rice fields had the lowest arsenic content. The results were reported online 15 November 2009 ahead of print in *Nature Geoscience*.

The study was carefully conducted and is a valuable contribution, says van Geen. He is less certain that the organic matter transported into the aquifer through the bottom of ponds drives the reducing conditions that produce the arsenic peak in Bangladesh. "My colleagues and I believe organic matter buried in the sediment is a more likely source, although no one can really claim this has been demonstrated," he says. "We believe the arsenic problem predates any significant human intervention—what has changed is that people didn't drink a lot of groundwater in the area more before thirty years ago."

Harvey next plans to dig 150-m wells for several families to share. If the water proves arsenic-free, he and colleagues will study whether drinking clean water flushes arsenic from the body or reduces skin lesions and other toxicity symptoms. "Most studies look at how arsenic causes health problems," he says, "but this will be the reverse situation."

Carol Potera, based in Montana, has written for *EHP* since 1996. She also writes for *Microbe*, *Genetic Engineering News*, and the *American Journal of Nursing*.

The Beat
by Erin E. Dooley

Persistent Contaminants in Newborns

In December 2009 the Environmental Working Group (EWG) released *Pollution in People: Cord Blood Contaminants in Minority Newborns*, which presents data on chemicals found in the cord blood of 10 newborns. The report includes what the authors call the first reported detection of 21 synthetic compounds in cord blood, including bisphenol A in 9 of the babies. The goal of this and similar EWG reports is to quantify the number of pollutants found in people, with 414 chemicals detected to date. The report is available at http://www.ewg.org/.

Outdoor Smoking: Minor Respite

As more jurisdictions around the world implement bans on smoking in indoor settings, many bars and restaurants are accommodating smoking patrons with outdoor smoking areas. Now a report in the November 2009 issue of the *Journal of Occupational and Environmental Hygiene* says exposure to secondhand smoke (SHS) in outdoor seating areas may affect the health of waitstaff and bouncers who may be exposed for several hours a day. Luke Naeher and colleagues stationed nonsmoking volunteers for 6 hours in outdoor bar or restaurant seating or outside a college library and found their salivary levels of cotinine increased over baseline by 162%, 102%, and 16%, respectively. Although cotinine levels were relatively low compared with levels following indoor exposure to SHS, the U.S. Surgeon General has determined there is no safe level of exposure to cigarette smoke.

Relegating smoking areas to outdoors may not fully prevent SHS exposure

On-the-Job Exposure to Endocrine Disruptors

Martijn M. Brouwers and colleagues have revised an existing job exposure matrix to more accurately assess potential occupational exposures to endocrine disruptors. As outlined in the September 2009 issue of *Occupational and Environmental Medicine*, the updated matrix can be adjusted to allow for more widespread use with specific jobs and tasks. Among other changes, the authors incorporated information on recently identified endocrine disruptors and converted dichotomous exposures scores (yes versus no) with exposure probabilities of low, medium, and high.

Sick Schools Revisited

In December 2009, the National Coalition for Healthier Schools released an updated report on environmental health factors in

INNOVATIVE TECHNOLOGIES

Microscopy Not to Dye For

Users of confocal microscopes now have access to a relatively inexpensive module that can be readily installed to dramatically increase the capabilities of these instruments. Members of Canada's National Research Council (NRC) initiated the commercial development of this technology, hoping to provide researchers with cost-effective access to imaging strategies with distinct advantages for some applications.

The price tag for the new system will be about US$57,000, a fraction of what it takes to acquire such a microscope. This new investment makes it possible to create detailed images of fatty structures that are typically nonfluorescent, such as the fibrous caps responsible for atherosclerosis and the myelin sheath surrounding nerve structures. Importantly, the method is label-free, meaning it does not rely on any dyes or stains. Moreover, images can be created in seconds rather than hours, offering real-time *in-vivo* representation of such complex processes as a virus infecting cells.

The technology is called coherent anti-Stokes Raman scattering, or CARS. Developed in the mid-1960s as a spectroscopic tool by materials engineers at the Ford Motor Company, in the late 1990s the concept was extended to include microscopy. The technique builds on the same hardware used in confocal imaging, consisting of two lasers plus an elaborate array of lenses and mirrors. When this bright light reaches a specimen, it fluoresces to a significant depth, and with the proper resolution, yields a detailed three-dimensional image.

Taking advantage of these same two lasers, CARS adds another light field based on a difference in frequency between these light sources, a difference that precisely matches a target molecule's vibrational resonance. The resulting image can be obtained even as the rest of the microscope generates a standard confocal image.

In 2007 NRC researcher Albert Stolow and his colleagues demonstrated that CARS images could be obtained using the same laser technology already found in confocal microscopes. The work taking place at the NRC also caught the attention of optics giant Olympus, which saw the prospect of a new product that would build on an established market of microscope users without asking them to convert exclusively to unfamiliar methodology or acquire another expensive, specialized piece of equipment. The company subsequently partnered with Stolow's team to come up with the design for an add-on device that would mate seamlessly with the company's existing confocal systems.

The enhanced 300-nm spatial resolution of CARS is achieved without dyes or stains to provide the necessary contrast. This feature makes it easier to work with living tissue that might diffuse or react with these agents and compromise the outcome.

That is a big selling point for Michael Sowa, an NRC researcher specializing in biodiagnostic spectroscopy and heart disease. CARS allows him to visualize fibrous patches of plaque building up inside veins and arteries; specifically, he can look for lesions that could burst and release material that could cause a stroke. "It's a really powerful tool for investigating vascular walls, and atherosclerosis in particular," he says.

NRC investigator John Pezacki was one of the first to adopt CARS almost a decade ago. Before then, he would have relied primarily on fixed cell staining, which amounted to taking a handful of snapshots portraying a complex chemical interaction while whatever might be happening in between each picture remained unknown. "It's the equivalent of doing very good quality photography versus cinematography," he explains. "It allows us to do kinetic measurements, answering the question of when [events] happen during the viral life cycle."

And while the CARS system currently performs optimally with the molecules making up lipids, Pezacki envisions potential for this technology in environmental analysis. "The holy grail of this area going forward is to be able to do lower-abundance materials, such as peptides, proteins, and nucleic acids," he says. "If you can . . . look at the unique CARS signals from [natural products or drugs] and get a label-free contrast image of where those things are in the cell or in a tissue, then you have the opportunity to do that with environmental toxicants as well."

Tim Lougheed has worked as a freelance writer in Ottawa, Canada, since 1991. A past president of the Canadian Science Writers' Association, he covers a broad range of topics in science, technology, medicine, and education.

Science class storage: what not to do

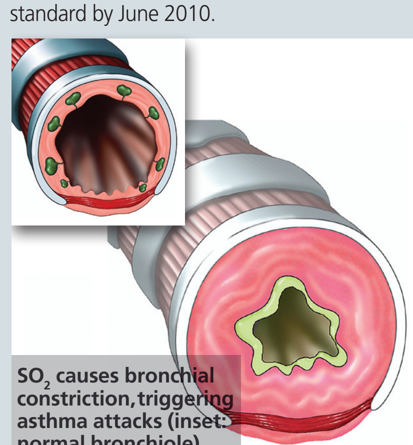
U.S. schools. *Sick Schools 2009*, available at http://www.healthyschools.org/, gives a state-by-state illustratration of how poor air quality in some schools increases health care costs and absenteeism while negatively impacting test scores. Overall, the report estimates 57% of U.S. public school students attend schools with at least one "unsatisfactory environmental factor." The authors recommend full staffing and resources for the U.S. EPA and other federal agencies to address healthy school environments.

Scandinavian Cell Phone Study: No Brain Tumor Association

A 30-year Scandinavian study by Isabelle Deltour and colleagues published online 3 December 2009 in the *Journal of the National Cancer Institute* found no change in brain tumor incidence trends between 1998 and 2003. Widespread cell phone use began in Scandinavia in the mid 1990s; the authors write that changes in brain tumor rates after 1998 "would be informative about an induction period of 5–10 years." They add the caveat that it may take longer than that for tumors caused by cell phone use to be detected.

EPA Proposes 1-Hr SO_2 Standard

Short-term exposures to sulfur dioxide can cause a variety of respiratory symptoms and increased hospital admissions. The EPA's current sulfur dioxide 24-hr primary standard of 140 ppb and annual average standard of 30 ppb have been on the books since 1971. The agency is now accepting comments to develop a more protective 1-hr primary standard of between 50 and 100 ppb, which would replace the existing standards. The EPA is also discussing changes to monitoring and reporting requirements for the pollutant, two-thirds of which comes from coal-fired power plants. The EPA expects to issue the final standard by June 2010.



SO_2 causes bronchial constriction, triggering asthma attacks (inset: normal bronchiole)