UW Extension Impact Report

Wisconsin Geological and Natural History Survey
Tracking and Regulating Natural Arsenic to Ensure Drinking Water Safety

Situation

In 2001, the U.S. Environmental Protection Agency (EPA) cut the arsenic allowed in drinking water from 50 parts per billion (ppb) to 10 ppb—a concentration similar to 10 drops of water in an Olympic-size swimming pool. EPA classifies arsenic as a carcinogen. Prolonged exposure increases risk of skin cancer and tumors of the kidney, prostate, bladder, liver and lungs. Ingesting arsenic also increases risk of blood vessel damage, nerve damage, hypertension, depression, diabetes, digestive disorders, anemia, and changes in skin color and texture. Well water containing high arsenic levels—100 to 1,000 ppb—commonly contains high levels of iron, sulfate and other toxic metals such as cobalt, molybdenum, vanadium, cadmium, chromium, copper, and nickel.

With less allowed, unacceptable levels of naturally occurring arsenic are found in wells statewide. Health studies found so many contaminated wells in the Fox River Valley that the Department of Natural Resources (DNR) declared Outagamie, Winnebago and the western half of Brown County as an Arsenic Advisory Area and set protective well construction guidelines. While public water supplies are regularly tested and treated to meet EPA safe drinking water standards, the 800,000 private rural wells are the owners' responsibility as legal custodian of their water system. Yet three-fourths of well owners responding to a Central Wisconsin Groundwater Center survey reported they had not tested their drinking water in the last five years. Water testing labs reported that even among those who did have their water tested for bacteria and nitrates, few paid the extra cost to test for arsenic and associated toxic metals. Likewise, Fox Valley well drillers were reluctant to follow DNR guidelines because of the added construction costs—in particular, the soaring cost of steel well casing.

Response

DNR staff worked in Southeast Wisconsin with UW-Extension outreach specialist Madeline B. Gotkowitz, hydrogeologist with the Wisconsin Geological and Natural History Survey (WGNHS), and UW-Madison assistant professor of environmental sciences. Gotkowitz conducted geochemical research to identify the source of arsenic contamination in an abandoned public well and locate safe drinking water for the Woods School near Lake Geneva in Walworth County. The DNR also called on her to identify arsenic sources contaminating private wells in the Fox River Valley for establishing specific well construction regulations.

A statewide group of experts convened to study the serious health, economic and regulatory issues of unsafe drinking water, develop strategies to manage arsenic contamination, protect wells and reduce health hazards. Led by the DNR Drinking Water and Groundwater Bureau, this partnership includes UW-Extension campus and county faculty such as Gotkowitz and her colleagues with WGNHS and the Central Wisconsin Groundwater Center at UW-Stevens Point, university researchers, county and tribal health departments, Wisconsin Department of Health and Family Services, National Institutes of Health, U.S. Geological Survey, and the Wisconsin Water Well Association. A joint DNR-UW Groundwater Coordinating Council reviews the group's educational materials to ensure that consistent messages reach the public.

With DNR funding, Gotkowitz studied Fox River Valley wells with J.A. Simo, UW-Madison professor of geology and geophysics, and Madeline E. Schreiber, hydrogeologist and assistant professor of geological sciences at Virginia Tech. A study of more than 3,300 private wells had found **1 well in 6** (17 percent) with arsenic levels above 10 ppb, and 3 percent of those well above 50 ppb. Armed with these findings, Gotkowitz set out to discover the geologic and geochemical controls that release both low and high levels of arsenic into wells. She examined drill cores and cuttings, sampled mineralized zones, analyzed key metals and minerals, recorded their geographic distribution in the St. Peter sandstone, and related that information to arsenic distribution in the aquifer (water-bearing formation). She evaluated regional groundwater geochemistry data for conditions that trigger chemical reactions releasing arsenic, and conducted a study of wells with high and low arsenic levels.

Gotkowitz found high arsenic levels—100 ppb—in drinking water where the well bore hole allows air to oxidize and dissolve sulfide minerals. Overall, high arsenic concentrations cluster from south to north along the Fox River Valley where wells are drilled through sulfide mineral pockets in the St. Peter sandstone aquifer. In the high arsenic comparison well, Gotkowitz found that microbes introduced through the well bore hole facilitate iron cycling and release arsenic. Although using chlorine to disinfect wells can oxidize iron sulfides in aquifer sediments and release arsenic, chlorination ridding the well of active microbiological communities may reduce arsenic levels in similar settings.

She found that two distinct geochemical mechanisms appear to contribute low to moderate arsenic levels (up to 50 ppb). First, oxidation of sulfide minerals may release arsenic to groundwater in confined portions of the St. Peter sandstone aquifer. Oxidation may have occurred in the geologic past, or current levels of oxygen dissolved in groundwater may permit slow oxidation. Second, domestic water use patterns, increasing water use per person and growing numbers of private wells in the aquifer (10,000 more in the past decade)—contribute to drawing down the water table about three feet per year. Strengthened by microbiological activity in the well bore hole, this geochemical environment becomes sufficiently reducing to dissolve arsenic-bearing iron oxides.

This research shows how conditions releasing arsenic in the St. Peter sandstone aquifer—as well as remedies for high-arsenic wells—differ sharply from those found deep in the sand and gravel aquifer of glaciated Southeast Wisconsin. In the Fox River Valley, arsenic is released when sulfide mineral deposits are exposed to oxygen, microbes and weathering. New or replacement wells must be constructed in aquifers above or below St. Peter sandstone bedrock, drilled without using air, and encased through bedrock layers. Because single wells are more at risk of contamination, Gotkowitz and her DNR colleagues recommend one common well—referred to as cluster wells—for those housing developments expanding outside of municipal wells.

In the relatively old water confined deep in the thick glacial deposits of Southeast Wisconsin, UW-Madison graduate student Tara Root and hydrogeologist Jean M. Bahr found that arsenic is bound to iron hydroxide minerals dispersed throughout the aquifer and released with very little oxygen. Although Gotkowitz successfully located safe drinking water for a replacement well near the Woods School, drilling deeper here would be both cost-prohibitive and unlikely to reach safer water. Many residents of this area must rely on bottled water or install an in-home treatment system. Gotkowitz is now conducting a two-year research project to inventory drinking water resources in unglaciated Southwest Wisconsin. She concludes that arsenic levels cannot easily be predicted in any given well, and urges all private well owners to have their water tested annually by a certified lab.

While Gotkowitz studies the geochemical conditions and hydrogeologic processes releasing arsenic in wells and aquifers, WGNHS geologists Bruce A. Brown, Thomas S. Hooyer and John W. Attig are mapping the bedrock and glacial deposits under the Fox River Valley. Hooyer secured research funding from the National Geologic Mapping Program to study the nature and distribution of Ice Age sediments through parts of 14 counties formerly occupied by glacial Lake Oshkosh. As their research progresses, WGNHS faculty prepare local maps and reports on geochemical environments and groundwater flow, and inventories of groundwater, non-metallic minerals, construction materials and other geologic resources for colleagues, regulators, homeowners, public officials and decision-makers charged with completing comprehensive plans by the end of the decade.

Outcomes

WGNHS provided the science supporting specific well construction requirements and methods for the Arsenic Advisory Area. Brown helped DNR staff write the new rules and Gotkowitz followed with technical review. Based on geological evidence and discussions with Gotkowitz and Brown, DNR Drinking Water and Groundwater Bureau staff created a special well casing depth area from five miles on either side through the St. Peter sandstone within Outagamie and Winnebago counties—the largest special casing area ever. The new rules guide well drillers to safe drinking water, regulate depth of casing for deep wells below arsenic bearing sandstone and require specific methods for drilling without air. Well drillers and DNR regional staff report the new rules are working, resulting in more arsenic-free wells. Local governments working with UW-Extension are learning how land use decisions affect public health, what DNR well-casing rules mean for new development, and how to work cooperatively across county lines to reduce public health risks from arsenic-contaminated drinking water.

Fox River Valley: Working with WGNHS researchers and Central Wisconsin Groundwater Center faculty at UW-Stevens Point, UW-Extension Winnebago County community resource development educator Catherine Neiswender coordinated educational programs in Outagamie and Winnebago counties on the DNR special well casing depth area rules for the Wisconsin Towns Association. At these meetings, WGNHS hydrogeologist Madeline Gotkowitz presented her arsenic research findings that explain and prescribe the new well construction requirements. In November 2005, the Winnebago County Planning and Zoning Committee approved a comprehensive land use plan incorporating safe drinking water as a criterion for future development, and forwarded the plan to the County Board of Supervisors for a public hearing and vote in 2006.

Southwest Wisconsin: Traditional lead mining in this unglaciated or "driftless" area gave Wisconsin its Badger State nickname, and associated arsenic and toxic metals show up in drinking water. During Iowa County's four-year comprehensive planning process, local planning commissions continually discussed groundwater as a criterion for siting new development, and regularly requested more groundwater data. When the Iowa County Board of Supervisors asked UW-Extension for help, community resource development educator Paul Ohlrogge contacted WGNHS, and Gotkowitz began a two-year research project to inventory groundwater resources for meeting water supply needs. Early in this research, citizen participation was identified as critical for successful public education.

With input from the fourteen town board chairs, Ohlrogge assembled a Groundwater Advisory Committee representing all 14 towns. As committee chair, he designed a series of educational sessions focusing on Iowa County groundwater data. He compiled the results of more than 900 well water tests, and published them online in English and Spanish. Groundwater advisory committee members learned about groundwater flow, the groundwater cycle, how geology determines water quality, and why some aquifers are vulnerable to contamination from stormwater runoff, landfills, pesticides, and nitrates from fertilizer or agriculture. The committee has been an asset to WGNHS geologists, locating abandoned wells and landowners who allow WGNHS mapping teams to enter their property and conduct specific research for the project.

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