Scientists offer solutions to arsenic groundwater poisoning in southern Asia

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An estimated 60 million people in Bangladesh are exposed to unsafe levels of arsenic in their drinking water, dramatically raising their risk for cancer and other serious diseases, according to the World Health Organization (WHO).

Because most of the contaminated water is near the surface, many people in Bangladesh have installed deep wells to tap into groundwater that's relatively free of arsenic.

In recent years, farmers have begun using the deep, uncontaminated aquifers for irrigation - a practice that could compromise access to clean drinking water across the country, according to a report in the May 27 issue of journal *Science*.

The report is co-authored by groundwater experts Scott Fendorf (Stanford University), Holly A. Michael (University of Delaware) and Alexander van Geen (Columbia University).

"Every effort should be made to prevent irrigation by pumping from deeper aquifers that are low in arsenic," the authors wrote. "This precious resource must be preserved for drinking."

Every day, more than 100 million people are exposed to arsenic-contaminated drinking water in Bangladesh, Cambodia, China, India, Myanmar, Nepal, Pakistan and Vietnam.

Over the last 10 years, Fendorf, Michael and van Geen have conducted long-term groundwater studies throughout southern Asia with the goal of finding low-cost solutions to what the WHO calls the largest mass poisoning in history.

"Our Science report presents an overview of the scientific consensus and continuing uncertainty about the root causes of the arsenic calamity," said Fendorf, a professor of environmental Earth system science at Stanford.

Crisis in southern Asia

Unlike most countries in the region, India and Bangladesh have very deep aquifers that typically have low levels of arsenic. In Bangladesh, one of the poorest and most densely populated countries in the world, concerns about arsenic-contaminated rice crops have led farmers to look for safer sources of water deep underground.

"People in Bangladesh want to sink irrigation wells to the deeper aquifers where the water is clean," said Fendorf, a senior fellow at Stanford's Woods Institute for the Environment. "The problem is that irrigation wells pump high enough volumes to pull down arsenic-contaminated water from the surface and jeopardize the quality of the groundwater below."

Arsenic poisoning was first identified in the early 1980s in West Bengal, India, where health officials linked an outbreak of skin lesions to groundwater pumped from shallow wells. Today, the WHO estimates that thousands of people from Pakistan to Vietnam die of cancer each year from long-term arsenic exposure. Groundwater containing arsenic also causes cardiovascular disease and inhibits the mental development of children.

In the 1990s, scientists identified the source of the arsenic contamination: the Himalaya mountain range, where arsenic-laden rocks and sediments are carried downstream along four major river systems - Ganges-Brahmaputra, Mekong, Irrawaddy and Red.

This naturally occurring arsenic is harmless until it reaches the river basins. There, bacteria in surface and subsurface sediments release arsenic from the solids to a soluble, toxic form that slowly works its way into the shallow aquifers below. This process has been occurring for millennia - a discovery made by Fendorf and colleagues in Cambodia in 2008 - but had little impact on human health until recently when people began tapping groundwater to avoid pathogen-laden surface water.

That same year, co-author Holly Michael demonstrated that in Bangladesh, an uncontaminated domestic well more than 500 feet (150 meters) deep could remain arsenic-free for at least 1,000 years. But Michael projected an entirely different scenario for deep irrigation wells, which use mechanized pumps instead of hand pumps to bring groundwater to the surface.

"Holly showed that if you start drawing high volumes of water from an irrigation well, you create flow conditions that bring arsenic-contaminated water from above into the deep aquifer below,"

While many Bangladeshis are justifiably concerned about the accumulation of arsenic in rice paddies, the amount that actually ends up inside a rice grain is small compared to exposure from drinking water, he added. "For that reason, we recommend that deeper wells only be used by individual households for drinking water and not for crop irrigation."

In 1999, Bangladesh launched a major nationwide campaign to test well water quality. Since then, thousands of households have drilled deeper wells, some reaching depths of 1,500 feet (350 meters).

"Most people would say that deep wells are a good option," Fendorf said. "They're not that expensive, and the water often has a similar temperature and taste. For all intents and purposes, it's the same water, except deep aquifers aren't poisonous."

However, because water-flow patterns below ground are constantly altered by irrigation and other land-use changes, the authors recommended that all existing deep wells in Bangladesh be retested on a regular basis.

Other solutions

Aside from Bangladesh and India, the majority of affected countries have aquifers that only reach depths of 300 feet (100 meters) . Therefore, deep-water wells are not an option. In Cambodia, people have turned to filtration to remove arsenic from shallow groundwater.

"Many arsenic filters are quite effective at removing arsenic over the short term," Fendorf said. "However, they should be tested regularly, which doesn't always happen, and replaced when they begin to fail from disturbance or exhaustion."

Some governments in the region recommend piping water directly to villages or homes, but that solution raises other health issues, Fendorf said. "Piped water usually comes from a surface source, like a river," he explained. "The problem is that it often contains bacteria and other pathogens. It might go through a sand filtration system, but that's often ineffective.

"We need to be thinking broadly about water options that are available and not focus on a single solution," he added. "In one village, a deep well might work great, in another village maybe it's rainwater harvesting or water filtration. As scientists studying groundwater, we can help people most by predicting where wells should be placed, and whether those wells will remain clean over time, particularly as a result of irrigation and other land-use changes."

Provided by Stanford University

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