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Poisoned Waters

by David H. Kinley III and Zabed Hossain

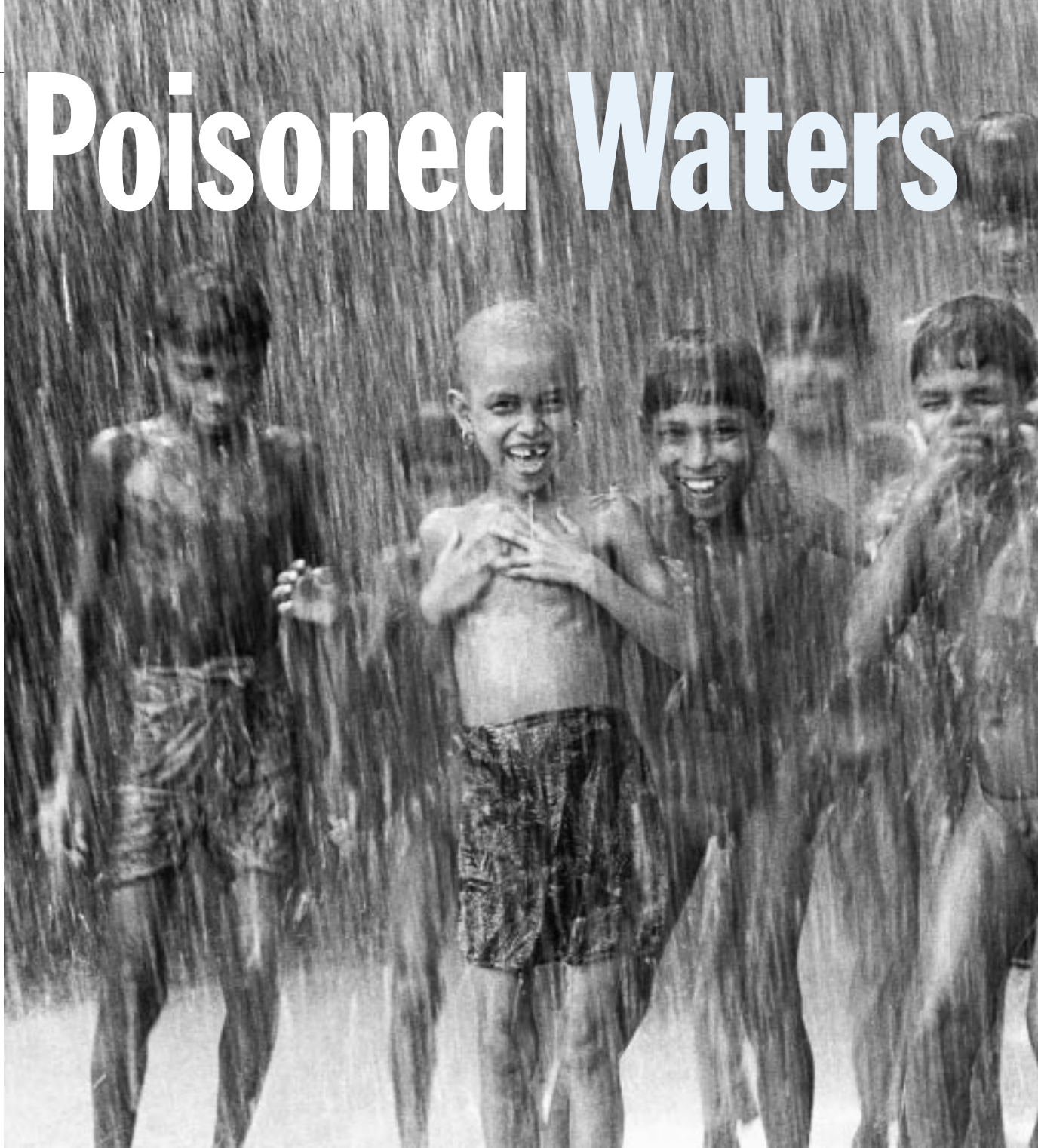
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Poisoned Waters



Bangladesh, Desperately Seeking Solutions

by David H. Kinley III and Zabed Hossain

Bangladesh has both too much water and not enough of it. On the one hand, this poor and densely packed nation—130 million people in an area the size of New York state—is laced with the great Ganges and Jamuna rivers and countless lesser streams. Rainfall totals about 80 inches a year. The country is largely flat, and immense

tracts of floodplain become lakes during the monsoon season. Water is nothing if not abundant.

Finding water that is safe to drink is another story, however. It has long been a constant challenge for millions, especially the isolated rural poor. Now, drinking water is the villain in what CBS television once called



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“the greatest poisoning in human history.”

In Nilkanda village, in the Sonargaon subdistrict about two hours from the capital, Dhaka, housewife Monwara Begum tells how her tragedy began to unfold. “Hand pumps helped us to avoid the diseases in the pond,” she says, referring to the contamination of surface waters by human and animal waste. “But after drinking from the hand pump over many years, my husband fell ill with arsenic poisoning. We use a filter system now for all we drink, but I’m not convinced it is safe.”

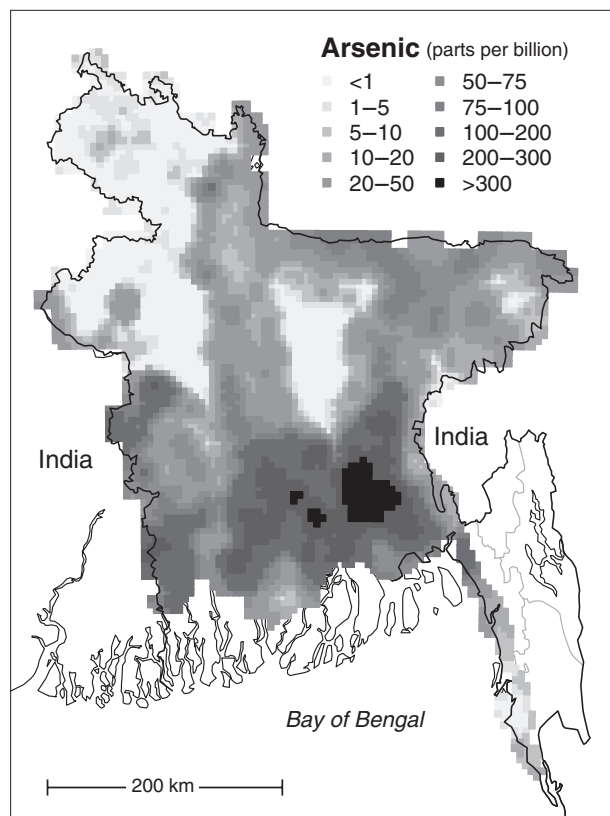
“More than 60 percent of the wells in this subdistrict are contaminated with arsenic and unsafe to drink

from,” explains Sayed Ershad, a development worker who has spent the last several years grappling with the disaster. “Many people still drink the poison water from the wells. The alternatives cost them time and money, and people here face extreme poverty.”

Across the village, a thin and listless middle-aged man sits quietly in his ramshackle bamboo and thatch home. His skin is discolored and his hands and feet are pocked with callous-like growths, telltale signs of arsenicosis. “He continues to drink from the contaminated well,” says Ershad. “He doesn’t use a filter because he’s convinced he doesn’t have many more days to live.”

The Best of Intentions

Bangladesh's high population density and lack of sanitation infrastructure keeps surface waters perpetually contaminated, and waterborne diarrheal diseases have long been a leading cause of widespread illness and premature infant death. In response, the government began installing shallow tubewells (sealed pipes extending down into the groundwater and equipped with simple hand pumps) when Bangladesh was still East Pakistan.



The regional distribution of arsenic in groundwater in Bangladesh. Nearly 60 million people are exposed to arsenic concentrations above the World Health Organization standard.

Following the independence struggle and subsequent famine in 1971, international aid agencies (UNICEF, the World Bank, the UN Development Programme) and private interests joined the effort. Since then several million tubewells have been sunk into the shallow water table, and hand pumps have become an icon of a better life for the rural poor. World Health Organization (WHO) reports suggest that the tubewells helped slash infant and child mortality by half over the last 40 years.

The discovery of high concentrations of naturally occurring arsenic in the groundwater is thus a bitter irony. Heavy-metal contamination was not even considered in

Bangladesh until evidence of arsenicosis began to emerge in the neighboring Indian state of West Bengal in the late 1980s. Arsenic-contaminated wells were first confirmed in Bangladesh in 1993 and it wasn't until 2000 that the first comprehensive program of well testing was completed, when the British Geological Survey (BGS) surveyed a sample of about 3,500 wells nationwide.

The results were shocking. Of the BGS-estimated 6 to 11 million shallow tubewells in Bangladesh (those less than 150 meters deep), at least 1.5 million are heavily contaminated, with concentrations exceeding the national drinking-water standard of 50 parts per billion. Some 35 million people are believed to be exposed beyond the national standard, and 57 million are exposed to arsenic concentrations above the WHO standard of 10 parts per billion.

Local patterns of contamination and resulting sickness are more difficult to circumscribe. Neighboring villages and even households may be consuming well water with vastly different levels of contamination. Some villages with high levels of contamination do not show much evidence of widespread arsenicosis, which generally reveals itself first as dark spots on the skin and nodules on the palms and soles of the feet. Over 5 to 10 years or more, these symptoms become more pronounced. In many cases, internal organs, including the liver, kidneys, and lungs, are also affected. Strong evidence links arsenic poisoning with cancer, but it remains difficult to ascertain how heavy and prolonged the exposure must be to trigger the disease.

The potential human toll in Bangladesh is thus uncertain, because some cancers take as long as 20 years to emerge. According to a recent report from the WHO, in parts of southern Bangladesh where arsenic concentrations are very high, one in ten adult deaths could be due to some form of arsenic-induced cancer of internal organs stemming from long-term exposure. These risks fall heavily on the rural poor, who are rendered more vulnerable to illness by malnutrition and the large volumes of water they drink. They may also ingest additional arsenic by eating rice irrigated with poisoned water and then boiled in it. (The relatively few city dwellers get their water from largely arsenic-free deep aquifers.)

Getting to the Bottom of the Problem?

With almost half the country's population under threat, it is crucial to understand the root causes and patterns of contamination. But there are other dimensions to the problem besides the geographic distribution of arsenic. For instance, "we know it's not the depth of the well alone that determines its safety now or in the future," says M. Khaliqzaman, an environmental scientist working with the World Bank. Moreover, "tapping a deep well may supply sufficient water for a village, but is it

safe and sustainable for a city of a million? That's what we still don't know." And in any case it is still necessary to find ways to quickly, cheaply, and repeatedly test water quality in millions of specific locations.

One major initiative for addressing the arsenic problem is the Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP), run by the government and backed by over \$35 million from the World Bank and the Swiss Agency for International Development. Launched in 1998, BAMWSP sought to provide water supply relief for large numbers of rural people and to enhance scientific analysis of the scope of contamination. The project was deliberately set up to be independent of existing government institutions, but its work has nevertheless been delayed by bureaucratic mismanagement, lack of coordination with other water sector efforts, and insufficient scientific and technical information.

"Finding solutions to the contamination that can be implemented at the community level has been a complex process," explains the former BAMWSP director, Abdul Quader Choudhary. "It took nearly 30 years to get universal coverage of drinking water supplies using hand pumps. Now we've identified mitigation technologies that can work and are affordable by the poor. But we've still got a long way to go in solving the problem in a systematic way." Indeed, four years after launching its project with much public relations fanfare, the World Bank may be ending its participation in the BAMWSP. If so, nearly 80 percent of the total project budget would be left unspent.

Technology Gap

Politics and bureaucracies aside, at least one part of the overall problem remains technical: determining arsenic concentrations in water at the village level. Test kits produced by the U.S. drug giant Merck began to be used to measure village well contamination in the mid-1990s, but these kits only provide a rough, and sometimes misleading, measure of contamination levels. "Testing and analysis of arsenic contamination is technically complex, difficult, and expensive," explains Dr. Abul Hasnat Milton, chief of the arsenic unit of the NGO Forum for Drinking Water Supply and Sanitation. With assistance from the Danish Embassy, Dr. Milton's water quality testing laboratory in Dhaka has become one of the country's most sophisticated, and has analyzed more than 25,000 samples for the government and aid organizations.

Unfortunately, that standard of excellence is difficult to reproduce everywhere. "There is still a great need to improve arsenic testing," says Mr. Khaliqzaman. "There are 26 laboratories doing tests across the country, but only a third of them are capable of delivering

results of an acceptable standard." To address this obstacle, the WHO and the International Atomic Energy Agency (IAEA) have been providing vital technical help through a laboratory quality assurance program over the past two years.

Compounding uncertainties in the measurement of arsenic levels is a lack of basic knowledge about the movement of groundwater, and the location and mobilization of arsenic in water supplies. "The geology and hydrology of Bangladesh are very complicated due to



Courtesy David H. Kinley III

Tubewell hand pump. The "safe" ones are painted green, the "dangerous" ones red. But the crude tests often used to tell one from the other yield many false results.

the nature of its underground structures," explains M. Nazrul Islam, director general of the Geological Survey of Bangladesh. "Try to imagine multiple layers of Himalayan sediments deposited over tens of millions of years by shifting rivers, tides, and floods. The sediment layer is up to 20 kilometers thick near the Bay of Bengal. Aquifer movements within these layers remain poorly understood."

According to S.K.M. Abdullah, who chairs a national expert committee advising the government, "the Bengal Delta is more complex than the Mississippi, the Rhine, or the Senegal River deltas. It's really a composite of three deltas in one. We know that water older

than 20,000 years is largely uncontaminated with arsenic, but you can't just drill down to a certain depth and assume it is arsenic-free."

Science, Deep and Wide

Bangladesh clearly needs more and better science for identifying water supply solutions. "What's really called for is analysis of deep aquifers on a country-wide basis," says Mr. Khaliqzaman. Because of its potential for

groundwater, where an aquifer is being recharged, how it connects and mixes with other groundwater bodies, and how vulnerable it is to contamination.

Since 1999, IAEA has been working with the World Bank's team to deploy isotope hydrology techniques in constructing a complete model of groundwater and aquifer dynamics and arsenic mobilization. The investigators are trying to understand whether deep aquifers will remain arsenic-free over the long term if they are developed as alternative sources, and how other deep aquifers may have been contaminated through mixing of deep and shallow reservoirs.

"Until very recently, the hydrogeological characterization in Bangladesh was being conducted through multiple institutions and agencies using primarily non-isotopic techniques," explains Pradeep Aggarwal, head of isotope hydrology for the IAEA in Vienna, Austria. "The integration of isotope techniques has provided the required information rapidly and at a much lower cost than previously possible. Now we are expanding the application of isotopic techniques countrywide." In particular, Dr. Allen Welch of the U.S. Geological Survey is using isotopic and conventional tools to investigate deep aquifer samples in the most heavily affected regions of the country. The results are expected in early 2003.

Meanwhile, the people of Bangladesh desperately need safe drinking water. The earliest response, initiated by the United Nations Development Programme in the mid-1990s, was an emergency initiative covering 500 of the most heavily affected villages. It screened all water sources for arsenic contamination and all the villagers for arsenicosis, and conducted a community awareness program.

More recently, UNICEF has supported the country's largest development NGO, the Bangladesh Rural Advancement Committee (BRAC), and seven other NGOs in evaluating more than 161,000 tubewells supplying several million people. Contaminated wells and pumps have been marked with danger-signifying red paint. BRAC has also been field-testing low-cost water treatment systems and supply alternatives in Sonargaon and eight other subdistricts. These include arsenic filtration devices, rooftop rainwater harvesting, hand-dug ring wells, and deep tubewells. Each technology



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A young Bangladeshi man and his grandmother, both arsenicosis victims. The symptoms can appear as early as age 2. Arsenicosis affects millions, but victims nonetheless often experience social rejection as well as illness.

quickly and accurately enhancing this knowledge, "isotopic analysis can play a critical role in understanding and addressing the arsenic contamination problem." This technique takes advantage of the fact that most elements are mixtures of isotopes distinguished by differing numbers of neutrons in the atoms' nuclei. The oxygen in water, for instance, is about 98 percent O^{16} (atoms with 16 neutrons each), but trace amounts are in the form of O^{17} and O^{18} . The isotope mixture varies in known ways, allowing water to be "fingerprinted" and tracked through the hydrological cycle. Isotopic analysis can be used to determine the movement of

offers partial relief. Filtration systems, for example, lose their effectiveness over time as the filtering mechanism is saturated, and the captured arsenic then must be suitably disposed of without environmental contamination. Deep wells that have been tested and found safe offer an alternative source, although the associated piped water distribution systems are quite expensive. Catching the rain offers some promise during the wet season, but even simple capture and storage systems are unaffordable by many villagers.

of arsenic poisoning in India, China, and other Asian countries,” says Heijnen. “The contamination could reach 100 million people in Asia—more than the numbers affected by HIV-AIDS.”

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The efforts of BRAC, UNDP, and other bilateral, private, and international aid organizations are slowly mitigating this public-health calamity. But far more extensive and effective aid will be required to find a lasting solution to the poisoned water and bring an end to the widespread suffering. “Arsenicosis is hard to diagnose and there is no known cure or treatment,” says Han Heijnen, a WHO environmental health advisor in Dhaka. “We know that continuous exposure is a sure cause of early death. Arsenic poisoning at the levels we’re seeing in Bangladesh will take 10 or 20 years off a person’s life, without any doubt.”

Moreover, arsenic-contaminated water is not limited to Bangladesh, and the scientific work now under way—if it is allowed to continue—could be a critical investment for both Bangladesh and the Asia-Pacific region. “We are only now uncovering the true extent

Frequent flooding contributes to fecal contamination of Bangladesh’s rivers and streams and makes them risky sources of potable water.

For additional information:

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