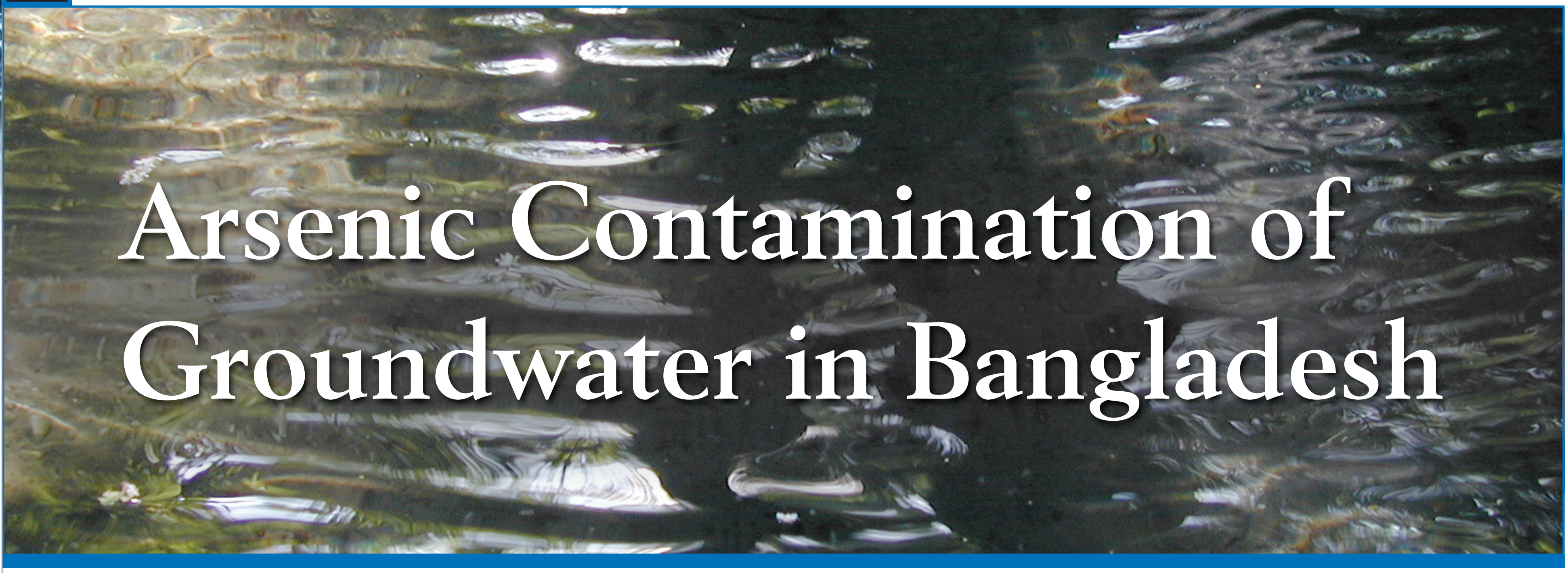

Arsenic Contamination of Groundwater in Bangladesh

The contamination of groundwater by arsenic is a vast and urgent public health issue for Bangladesh and West Bengal. The problem began approximately 30 years ago when well-intentioned international aid organisations made a strong financial push to install tube wells across much of rural Bangladesh. These efforts were motivated by the desire to reduce the outbreak of waterborne illnesses, such as diarrhoea, amebiasis, and typhoid. In addition to these public health goals, the installation of tube wells also reduced the daily and domestic workload of the households in the regions. Tube wells saved time and labour spent to capture water at more distant sources and then transport the water to the home. Since the 1970s and 1980s, the deployment of these tube wells has been linked to several positive public health outcomes, including reductions in the outbreaks of waterborne disease epidemics and reductions in infant mortality rates.

> *"Exposure to arsenic can lead to a number of harmful effects on an individual's health."*

In spite of these improvements, during the time when tube wells were being installed across Bangladesh, the presence and the extent of arsenic-contamination in the groundwater was not known. By the early 1990s, more than a decade after the first tube wells were installed, the first cases of arcenicosis were diagnosed and linked to arsenic-contamination of groundwater.

Recent estimates of the scale of the arsenic contamination problem suggest that as many as 35 million individuals are exposed to arsenic contamination levels that exceed Bangladeshi standard for arsenic of 50µg/L. As many as 57 million individuals may be exposed to levels that exceed the arsenic guideline established by the World Health Organization level of 10µg/L. As much as 13% of the population of Bangladesh may be currently relying on water supplies contaminated with arsenic. In addition to causing human health problems from direct exposure to arsenic-contaminated waters, arsenic has been detected in soils that are irrigated with contaminated water as well as in agricultural products such as rice and leafy vegetables.

While isolated occurrences of the arsenic-contamination in Bangladesh and West Bengal may be due to anthropogenic activities, the large geographic scope of the problem suggests that the most probable source is more likely to be geological. Sediments deposited during the Holocene era about 12,000 years ago contain Arsenic, which then leached into and contaminated the water of the aquifer. Once in the aquifer, the contaminated water was extracted using tube wells and then put to use extensively for domestic and agricultural purposes.

Health impacts of arsenic

Exposure to arsenic can lead to a number of harmful effects on an individual's health. Arsenic contamination has been linked to skin cancer and a list of internal cancers that includes liver, lungs and bladder cancers. In addition to being linked to cancers, arsenic has also been linked to problems of the respiratory system, cardiovascular disease, strokes, diabetes, skin pigmentation abnormalities, and keratosis.

The full scope of the public health impacts in Bangladesh associated with this arsenic-contamination event is unknown and may remain so for many years. Cancers linked to arsenic-contamination may be latent for up 20 years. Other impacts from ongoing arsenic exposure may also take time to manifest themselves as observable and recorded health impacts. Most studies agree that the outlook for this environmental tragedy is grim.

Map of Bangladesh

Monitoring arsenic

Efforts to monitor the arsenic concentration are important for at least two primary reasons. First, these efforts, when conducted on existing wells, give perspective to the arsenic-contamination problem and can provide guidance for the targeted implementation of contamination mitigation strategies, such as the installation of arsenic-removing filters. Secondly, when monitoring efforts are applied to wells sites that are under consideration or under construction, the public health problems caused by exposure to arsenic may be reduced or forgone entirely.

Several water quality tests are available for use in the laboratory to estimate the level of arsenic in a water sample. In addition to proper laboratory procedures, proper sample collection and transportation are important for any of the laboratory tests to generate reliable results. Several mobile water quality testing kits are available, but the development of even more reliable and user-friendly field testing techniques are an ongoing enterprise. Relative to laboratory tests, some of the advantages of field testing include the ability to avoid problems

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encountered when transporting samples to laboratories and the ability to quickly generate and distribute contamination information at remote well locations.

The authors of one study recommend handheld global positioning satellite (GPS) devices be distributed to locals who are already actively engaged in testing tube wells for arsenic levels. By integrating the results from water quality tests along with basic tube well information into a larger geographic information system (GIS) database, the spatial and geological distribution of the arsenic contamination problem can be put into greater context. This would allow water treatment projects to be targeted to the regions and villages where the arsenic contamination problem is the greatest.

Possible solutions

Several potential solutions exist to the arsenic problem. Some of these potential solutions include: (1) switching households from contaminated wells to surface water sources, such as ponds or rivers, (2) switching households from contaminated wells to non-contaminated wells, (3) installing arsenic-removal filters on contaminated wells. Each of these potential solutions carries costs and benefits that are unique to the solution and to the specific site, household, and community under consideration.

Switching households from well water to treated surface water has encountered several challenges. Households do not always trust that the treated surface water is any more free from contamination than the well water. In some cases, surface water treatment facilities are not properly maintained. This can lead to contamination by microbiological agents and pathogens, which may lead to a return of some of the public health problems that initially motivated the move towards groundwater in the 1970s and 1980s. Relative to using ponds and lakes as sources of surface water, treatment problems may be arguably even more challenging for rivers used as a source of drinking and household water. Rivers are likely to carry industrial and municipal waste and pollutants as the urban economies of Bangladesh and surrounding areas continues to rapidly expand and grow.

Switching households from contaminated wells to non-contaminated wells has been found to be problematic because of local customs and costs incurred on the household. In some cases, local customs discourage women from travelling beyond their home communities, without an escort. This makes acquisition of safe water more challenging if the nearest non-contaminated tube well lies outside the home community. In other cases, switching wells may just not be practical. One study found that households that changed wells increased their time spent acquiring water by a factor of fifteen.

Arsenic-removal water treatment technologies posses a lot of potential to address this problem, as such technologies do not require affected households to completely shift to a new source of water. However, such technologies are not cheap and nor are they permanent. Initial cost of installation and continuing costs of repair, maintenance, and replacement are among the reasons given that these filters are not more prevalent among affected households. In one study, approximately 25% of arsenic-removal filters had fallen into disuse after one to two years.

One potential solution suggested to deal with single households incurring unmanageable maintenance costs is to develop a community-based model of filtered-water supply. In such a case, one or two individuals would be responsible for the upkeep of the community's filter and would be compensated for their efforts.

For any of these potential solutions, a water quality monitoring program is likely to play an important role. In addition to identifying contaminated wells, a thorough monitoring program may identify the nearest uncontaminated well, thereby reducing travel and transportation burden of those households that choose to switch wells. For wells equipped with arsenic removal devices, the ongoing monitoring of those wells may be used to evaluate the need for equipment maintenance or replacement, and, in general, indicate the effectiveness of the arsenic removal technology.

More on arsenic removal technologies

Within the strategy of applying water treatment technologies to remove arsenic at contaminated wells, an array of choices exist, each with particular costs and benefits. These technologies can be generally divided into four categories: (1) Oxidation/Precipitation, (2) Coagulation Coprecipitation, (3) Sorption Techniques, and (4) Membrane Techniques.

Oxidation technologies are characterized by simple and low cost operations, but are slow and remove only a partial component of the arsenic contamination. Coagulation technologies are also relatively simple, but may produce toxic sludge and may remove all species of arsenic. Sorption technologies are relatively more common and well known, but maintenance and replacement costs can be high. Membrane technologies similarly can incur large operation and maintenance costs.

Progress is being made with all types of water treatment to make the technology more effective at removing arsenic, reducing system costs, and making the technologies appeal in all possible ways to the rural residents of the affected regions. However, the scope of the problem is still unknown and potentially so vast that even as technologies progress and improve, years may pass before the problem is completely resolved and in-hand.

This particular case of arsenic contamination in groundwater makes a fairly strong case about the potential value and importance of thorough water quality monitoring. Testing the water quality of a well prior to full installation and periodically during the useful life of the well can support the management and, in some cases, the prevention of potentially serious health issues related to contaminated water. The water industry has a viable opportunity improve the lives of those affected by this very tragic example of large-scale groundwater contamination.

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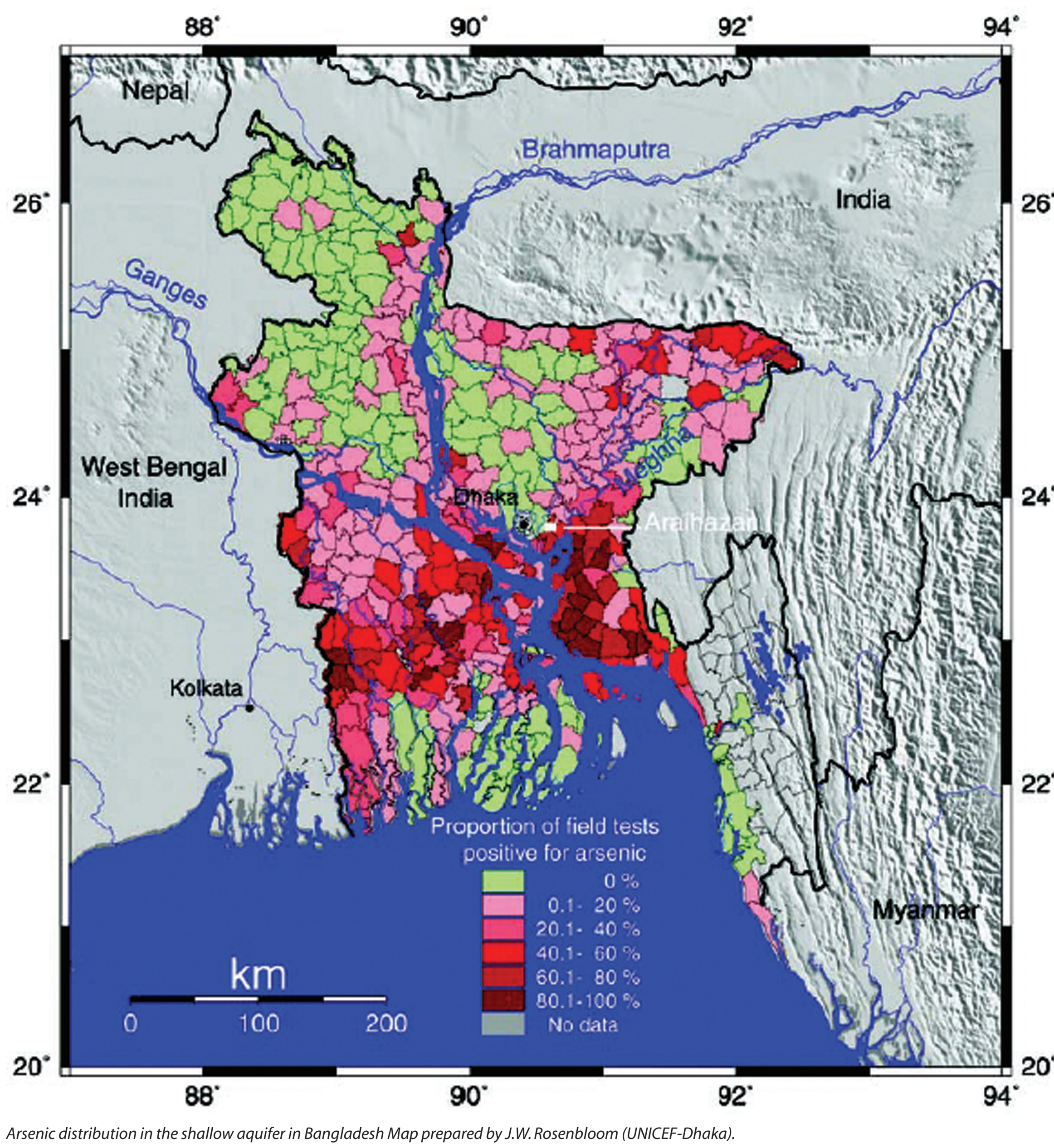

Arsenic distribution in the shallow aquifer in Bangladesh Map prepared by J.W. Rosenbloom (UNICEF-Dhaka).