ARSENIC CONTAMINATION OF GROUND WATER IN BANGLADESH
A BRIEFING PAPER
Ministry of Health and Family Welfare
Bangladesh

Introduction

Bangladesh is a tropical riverine country of about 120 million people, out of which 51.5% are male and 48.5% are female. The population density of this country is the highest in the world which is 755 persons per square kilometer. The country's economy is largely agrarian but 53% of the population are landless. Situated in the largest deltaic region of the world, Bangladesh is richly endowed with natural resources. People of Bangladesh are made up of an ethnically mixed society with a vibrant and living heritage descending from the 3000 year old Indo-Aryan civilization.

The country has a common land boarder with India on all three sides - the east, the west and north, barring a 194 km adjoining with Myanmar on the south-east. To the south is the Bay of Bengal.

Bangladesh comprises approximately 147,570 sq. km. but now deltaic growth in the costal areas keep adding to its land area unceasingly. It is one of the least developed countries in the world with a per capita GNP equivalent to US $253. The literacy rate is only 43% with the female literacy rate being even lower at 25%.

Land and Climate

Bangladesh, most of which is at low elevations, is divided into five physical regions: the ganges delta proper to the southwest, the paradelta to the northwest, the east-central plains, the Sylhet hills in the northeast, and the southeast Chittagong region.

The Ganges delta is geologically the most recently formed of the regions which is flooded by fresh and tidal water. The soil base is new alluvium. The Paradelta, like the delta proper, is a plain, but its elevations are higher, 100 to 300 feet (30 to 90 meters) above sea level. Its soils are varied: silt and sandy clays and old alluvium.

The east-central plain consists of plains and active floodplains in which the main rivers, including the Brahmaputra, have altered their channels in the past. To the northeast is the Meghna depression, part of which is only 10 feet (3 meters) above sea level; during the rainy season it turns into a huge lake, covering most of its 2,800-square-mile (7,250-square-kilometer) basin.The Sylhet hills and ranges are a small extension of the foothills of India's Meghalaya Plateau. Its highest peak (Harargaj) reaches 1,103 feet (336 meters).

The Chittagong region primarily consists of coastal plains and islands. It also includes the Matamori River delta and parts of the Karnaphuli River valley to the west and ridges and valleys to the east.

The extensive river systems of Bangladesh are fundamental to the nation's economy and way of life. The rivers flow into the Bay of Bengal. About three fourths of the water emptied into the bay is carried during the rainy season, especially June through September.

Bangladesh has a tropical monsoon type of climate, with heavy summer rain and high summer temperatures. These heavy rains prevail for two to three months. Winters are dry and cool.

Environmental Problems

Extremely high population density in Bangladesh is a factor contributing to the intense use of land, forest, and fisheries and to the water resources. This leads the country to severe environmental pressure such as intense cultivation that threatens soil fertility and swamps the country with agrochemical; excessive extraction of

water for irrigation that depress the water table; flood control measures that block fish migration paths and commercial fish farming that floods agricultural land with salt water. Added to this pollution, fecal pollution is by far the most serious water contamination problem, while water and air pollution is causing increasing concern in the rapidly growing urban areas. A recent incident of pollution of ground water by arsenic creates an alarming situation for the country's public health.

Arsenic Contamination of Ground Water Related Problems

Of the three main sources of water, namely, surface water, ground water and rain water, the later two sources generally meet the most important criteria of drinking water in their natural condition. These waters are usually consumed directly without treatment. Harness of ground water is cheaper and safer in comparison with rainwater. On the other hand, surface water is plentiful during monsoon but scarce in dry season and it is highly polluted. Thus, it can not be consumed without prior treatment. Treatment of surface water is relatively complicated and expensive.

In view of the fact that ground water is safe for drinking and its harness is cheaper and sustainable, public, as well as private, water supplies are heavily dependent on these sources. Unfortunately, when most of the people have developed the habit of drinking tubewell water (ground water), being aware of its importance to avoid an attack of diarrheal diseases and, when almost 97 percent of population have got the access to safe water through more than 4 millions tubewells, arsenic has been found in unacceptable concentrations in tubewell waters in many parts of Bangladesh.

Hundreds of tubewells in rural Bangladesh have been identified with high arsenic concentrations and many more are feared to have been contaminated with the same. So far 50,000 tubewells were tested and 63 percent of them were found to be contaminated by unacceptable concentrations of arsenic. Bangladesh has recognized the acceptable limit of arsenic concentration in water at 0.05 milligram/liter. Many people are suffering from arsenicosis and many more are at risk. The government is conducting surveys to identify arsenicosis patients. To date, 4000 cases of arsenicosis patients have been identified. The cause of arsenic contamination in ground water is not yet known. Extensive research has yet to be conducted in this regard to accentuate the knowledge base. However, natural geological changes are presumed to be the primary reason for arsenic contamination. The basis for such belief lies with the studies conducted in West Bengal, India, having similar alluvial deposits. Arsenic contamination in groundwater is due to the various natural geological processes that exist in the geological environment.

The source of arsenic in sediments is mainly the parent rock materials from which it is derived. Arsenic associated with sediment particles can be a major source of arsenic contamination when particles are detached and carried as sediments during erosion. Sediments can contain substantial amounts of total arsenic. During the formation of sedimentary rocks, arsenic is carried down by precipitation of iron hydroxides and sulphides. In a moist climate, arsenic sulphides are easily oxidized, become water-soluble, are washed out of the sediment particles by meteoric precipitation, and are transported with run off.

Arsenic undergoes reactions of oxidation -reduction, precipitation-dissolution, absorption- desorption, and organic and biochemical methylation. All of these reactions control mobilization and accumulation of arsenic in the environment. A biotic reaction between arsenic species and the substrates on the species and the substrates on the sediment surface, as well as physical disturbance of sediments, all play very important roles in controlling the mobilization of arsenic.

In nature, arsenic bearing minerals undergo oxidation and release arsenic to water. The problems of arsenic in Bangladesh in its Ganges delta region, however, because of the complexity and the size of the problems, the geological studies are yet to come to a conclusive finding. The following conceptual hypotheses have been put forward by many research workers based on various direct findings as well as indirect supporting evidence on arsenic contamination in the Ganges delta.

a) oxidation of pyrite and arsenopyrite due to excessive withdrawal and lowering of ground water is responsible for arsenic contamination in ground water,

b) reduction of oxyhydroxides is the source for arsenic contamination in ground water,

c) unconfined aquifers subjected to oxidation and reduction, and underlain by peaty clay and/ or clay layer is responsible for arsenic contamination. Mine wastes, especially carbonaceous shale, dumped to the surface from coal mining in the Rajmahal basins are transported and deposited along with the river and flood-born sediments may be responsible for the formation of the peaty clay layer in the deltaic domain. The continued abstraction of water from unconfined aquifer releases pentavatent arsenic and is transformed into trivatent arsenic on reduction to become soluble and mobile in water.

However, all three hypotheses may be operative in the Ganges delta region and responsible for arsenic contamination.

Health Hazards from Drinking Arsenic Contaminated Ground Water

Although arsenic contamination in ground water has been reported from various regions of the world viz. Taiwan, Argentina, Alaska, Chile, Mexico, China, Mongolia, Ghana and Hungary, the single largest contamination so far has occurred in the lower Ganges delta region bounded by the rivers Bhagirathi, Ganges/ Padma - lower Meghna. The people of this vast region are continuously being exposed to arsenic toxicity causing serious health hazards which is very alarming by engulfing this vast delta region. At this moment the contamination of the underground water has become a great challenge for providing safe drinking water to the majority of the population. The health hazard due to this contamination has raised the serious concern for public health. Arsenicosis, a disease born by drinking arsenic contaminated water which can lead to a very painful death. Arsenite and arsenate are known as carcinogens and have an affinity to deposit in hair, nail, bone etc. Arsenic is found in high concentration in liver, spleen, kidney and lungs as well.

Toxic effects of arsenic involve these organs. Toxicity of arsenic depends on its accumulation in the body. The time taken to develop symptoms in the human depends on the exposure, body defense mechanism, nutritional status etc. It is thought that it may take 2-20 years to develop symptoms.

The arsenic poisoning from the contamination of ground water is very chronic in nature. Most of the time the victims do not complain of the above symptoms until they are detected through screening. The above symptoms are also very difficult to identify from other clinical conditions. The present experience to identify the arsenic cases are by external manifestations specially with the presentation on the skin called melanosis (blackening of skin) and keratosis (hardening of palms and soles) with the history of consuming arsenic contaminated source water.

Gangrene of peripheral organs and ulceration due to toxic effect on the small blood vessels may also be found. Cancer of the skin along with cancer of some internal organs - liver, kidney, bladder is not uncommon. The stage of keratosis is known as potentially malignant. It is also observed that even if a person having no manifestations after consuming contaminated water the chance of having cancer cannot be ruled out.

Management

It is very difficult to differentiate the arsenical manifestation in stages. A person without external manifestations may face serious consequences of arsenicosis leading to cancer or acute renal failure. This is very simple to classify the arsenicosis as subclinical and clinical form. Clinically the earliest sign in the skin may be the melanosis then the keratosis and others. The systemic involvement is variable and may appear before and after the melanosis or keratosis. Subclinical cases deserve early identification and follow-up.

Experiences from the observation suggest that at least some stages of arsenicosis (melanosis) are reversible if

the contaminated water consumption is stopped. The use of arsenic free water may probably stop the deterioration of the symptoms but information of complete recovery is not yet known. The supportive treatment for nutrition improvement may play some role to diminish symptoms and may help to reverse some cases of the melanosis stage.

The Challenges

The main challenge is how to provide the millions of people at risk with arsenic free, bacteriologically as well as chemically safe, and aesthetically acceptable alternative source of drinking water. The factors remain in this challenge are:

- Identification of arsenic free tubewells in the known affected areas
- Identification of arsenicosis patients
- Treatment of the patients with arsenicosis
- Treatment of arsenic contaminated water where no other safe source exists
- Identification of arsenic free aquifersExtent of the potential alternative sources, namely, surface water and rain water
- Habit, culture and custom of the people
- Economic condition of the people, and their willingness and ability to pay for the service
- Community motivation to face the challenge collectively
- Technologies
- Cost
- Monitoring
- Research and Development
- Institutional support

It has been observed that tubewells, public and private, exist in several numbers in any cluster or community. It has also been found that generally not all tubewells in an area are affected by arsenic. Therefore, the immediate challenge is to find out the unaffected ones in the affected areas and commence routine monitoring in order to stop using the currently affected tubewells as soon as arsenic is detected.

The government of Bangladesh has formed a national steering committee for arsenic contamination mitigation activities headed by the Honorable Minister for Health & Family Welfare under which one scientific committee and a technical committee are doing their respective jobs under specific terms of references. Both committees send their activity reports to the national steering committee which regularly meet at three months intervals. This committee consists of all agencies working in the field of arsenic related problems. The government has so far taken three major strategies.

Phase one

To identify the number of arsenic contaminated tubewells, label them with the color red for dangerous ones and green for safe ones. Conduct surveys for arsenicosis patients.

Phase two

To provide deep tubewells as an emergency measure in those locations where most of the tubewells are found to be contaminated by arsenic (as aquifers at the level below 800 feet are found arsenic free).

Phase three

To provide treated safe surface water through pipes to the people. Simultaneously efforts are taken to alert the people regarding the danger of arsenic contamination of groundwater and what they should do in such situation.

Conclusion

The environmental initiatives undertaken by Bangladesh demonstrates the commendable efforts made to deal with priority problems related to the physical environment. An action plan on Health and Environment has been formulated to identify the areas of concern and pertinent issues to determine the causes and define possible solutions. The arsenic contamination of the groundwater problem is a newer one and it is impossible for a developing country like Bangladesh to mitigate through its own resources. The Bangladesh government has already mobilized its own resources for this program. Three projects under the Ministry of Health & Family Welfare have just completed the first phase to identify contaminated tubewells, color marking, identifying patients, and patient treatment were done. These activities will be continued in the next phases. UNDP is providing continuous support to one of these projects.Besides these, a GOB-World Bank supported Arsenic Mitigation Water Supply Project has started its function under Department of Public Health Engineering.

Some donor partners have extended their desire to support the governments' initiatives. A few donor-supported projects are in progress. But these are too little to combat this public health problem. It is not a question of which country's peoples are suffering, it is the suffering of mankind. Everybody should come forward to save these sufferers.

Published by Dr. A Z M Iftikhar Hussain,
Project Director
Arsenic Contamination Mitigation Projects
Ministry of Health & Family Welfare
Government of the People's Republic of Bangladesh
NIPSOM Building, (Room NO 324), Mohakhali, Dhaka-1212
Bangladesh
e-mail: iftikhar@bdonline.com