Operational Paper

Strategy to mitigate As exposure from drinking water

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ABSTRACT

One of the worst health hazards in Bangladesh is arsenic contamination of drinking water, which demands immediate and urgent remedial measures. The common strategy to control environmental health problems is to erect interventions at three levels: control at source, avoid ingestion and provide heath care The source of arsenic contamination is absolutely geological and almost any method can be applied to control it at source. There is little proven treatment for acute arsenic toxicity, but drinking water free of arsenic can aid the affected people at their initial stage of illness to get rid of the symptoms of arsenic toxicity. Hence, provision of safe drinking water is the foremost element of the arsenic mitigation plan. Identification of affected people and the population at risk of toxicity from arsenic, establishment of a standard value for the presence of arsenic in drinking water, provision of medical and health care and establishment of appropriate research work and study programmes are important elements of the plan. Finally, international, interdisciplinary and inter-organizational co-operation and collaboration have been highly emphasized in the mitigation plan.

Key words | microgram-per-litre level, safe drinking water, standard value, strategic mitigation plan

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INTRODUCTION

In the context of high prevalence of diarrhoeal diseases in Bangladesh, bacteriological quality has received priority as a criterion for drinking water supply. Groundwater is free from pathogenic microorganisms and available in adequate quantity in shallow aquifers for the development of cost effective water supply systems for a scattered rural population. As a result, groundwater abstracted by shallow tubewell was found to be the best option for rural water supply. Bangladesh, except in coastal and hilly areas, has achieved remarkable success by providing 97% of the rural population with tubewell water (BGS 1999). As people have become aware of the importance of avoiding diarrhoeal diseases, they have developed the habit of drinking tubewell water. Unfortunately, arsenic in excess of acceptable limits has been found in shallow tubewell water in most parts of the country. Water is a universal solvent and capable of dissolving almost everything to a certain extent but the possibility of arsenic occurring at high concentrations in drinking water had never been considered seriously before 1995 in Bangladesh (EPA 1994). Without determining its arsenic content, shallow tubewell water can no longer be considered safe for drinking and cooking purposes. As a result, the groundwater arsenic contamination problem in Bangladesh is the worst in the world (Fazal *et al.* 2001).

The magnitude of the problem is increasing as more information about arsenic contamination is pouring in. Arsenic in shallow tubewell water has been detected in almost all districts in Bangladesh. According to the study conducted by the Department of Public Health Engineering and British Geological Survey (DPHE & BGS 2000), the arsenic content of water from 46% of the shallow tubewells exceeds 0.01 mg l^{-1} (WHO Guideline value) and that of 27% of the shallow tubewells exceeds 0.05 mg l^{-1} (Bangladesh Standard). In the acute arsenic problem areas, more than 90% of the shallow tubewells have been found to produce contaminated water exceeding 0.05 mg l^{-1} of arsenic. Arsenic content higher than 0.5 mg l^{-1} has been reported in about 2% of shallow tubewells in Bangladesh. The population exposed to arsenic from drinking water exceeding the Bangladesh Standard has been estimated to be 25–36 million (DPHE & BGS 2000; EES & DCH 2000). More than 7,000 arsenicosis patients have so far been identified in arsenic affected areas in Bangladesh (Rahaman *et al.* 2000).

In Bangladesh, a number of institutions, universities, government and non-government organizations and donor agencies are working on various aspects of arsenic contamination of groundwater. Several projects have been undertaken to understand the magnitude of the problem and adopt mitigation measures but this is only the beginning of addressing the problem nationwide (Hussain & Iftikher 1998). Extensive works would be required to understand the sources, causes, occurrences and distribution of arsenic contamination, health effects and health management, communication of health impacts and finally development and implementation of safe water supply options in arsenic affected areas. Coordination of all initiatives in resolving this gigantic problem is needed for effective and efficient utilization of resources to attain the common goal. This coordinated plan is intended to provide a basis for collaboration of the actors in the field and mobilize efforts in the right direction.

STRATEGIC MITIGATION PLAN

Establishment of standard values for arsenic in groundwater

Since arsenic is found in all natural waters, guideline values are needed to delineate safe water and unsafe water for water supply. Considering the widespread occurrence of arsenic, scarcity of alternative safe water sources and technical capabilities in measurement and arsenic removal, the guideline values for Bangladesh may be recommended as follows:

- desirable concentration: < 0.01 mg l^{-1} (WHO 1999)
- maximum allowable concentration (MAC): 0.05 mg l^{-1}
- unsafe water: > 0.05 mg l^{-1}

In view of the higher risk associated with the maximum allowable concentration, the standard for arsenic needs to be reviewed as technological capabilities and economic conditions improve to afford water of better quality.

National survey

The extent of the arsenic problem is yet to be assessed. A national survey is required to understand the magnitude of the problem. A nationwide survey should be conducted to achieve the following goals:

- Examination of the quality of water of all tubewells, starting with those in vulnerable areas in Bangladesh and identification of the tubewells producing water with a high concentration of arsenic exceeding the Bangladesh Standard and WHO Guideline value.
- Delineation of the population exposed to arsenic contamination. The population served by the tubewells producing arsenic in excess of an acceptable limit may be considered as the population at higher risk.
- Identification of all arsenic-affected people in the high-risk area by qualified doctors and health workers.
- Preparation of maps showing the hot spots in respect of contamination of groundwater and prevalence of arsenic-affected patients. In this case, the application of GIS tools will have an immense impact (Quadiruzaman & Khan 1998).

Provision of safe drinking water

Supply of safe drinking water in the arsenic-affected areas is urgently required to avoid further ingestion of arsenic and arsenic-related diseases and to help recovery of affected patients. The possible options for the provision of safe drinking water include:

- Identification of safe and unsafe tubewells by green and red marks, respectively. People should be urged to use water from green marked tubewells for drinking and cooking. However, water from red marked tubewells can be used for purposes other than drinking and cooking.
- Installation of tubewells in alternative aquifers producing water with low arsenic content. Sinking of deep

tubewells is a promising option for water supply from uncontaminated deep aquifers with a protective overlying impermeable clay layer which is common in stratified aquifers in Bangladesh.

- Installation of community type treatment plants for the treatment of surface water for water supply in the absence of good quality groundwater. Protected ponds may provide safe water with minimal treatment.
- Rainwater harvesting should be greatly encouraged as an alternative as well as supplementary water supply system in arsenic-affected areas.
- Dug wells with adequate sanitary protection may be constructed for domestic water supply where aquifer and groundwater conditions permit such construction.
- Installation of community type arsenic removal plants attached or close to the tubewell to produce good quality water. Since iron is prevalent widely in groundwater in Bangladesh, installation of community type iron-cum-arsenic removal plants attached to the tubewell has good potential for safe water supply in Bangladesh.
- Development and installation of household level arsenic removal units are encouraged. The use of unknown chemicals and processes without adequate information is discouraged.
- Relatively large diameter production wells installed in deep aquifers for urban water supply usually produce safe water free of arsenic contamination. Medium sized arsenic removal plants may be installed in the case of production wells yielding arsenic contaminated water.

Provision of treatment and medical care

There is no known effective treatment for arsenic poisoning. In order to relieve the arsenic-affected people of a painful illness, it is essential to:

- provide medical and health care for seriously affected patients in health centres and hospitals;
- organize symptomatic treatment such as skin care, and providing vitamins and nutritious food.

Awareness building

Awareness of the people about arsenic contamination of groundwater and related diseases is essential to combat the arsenic problem in Bangladesh. People are to be made aware of:

- the possible health effects of drinking arsenic contaminated water as well as unsafe water from unprotected sources;
- symptoms of arsenic contamination and possible places to seek help;
- the necessity of having the source of drinking water tested for arsenic and pathogens by a laboratory;
- alternative sources of safe water and good hygienic practices to preserve the quality of drinking water.

Awareness and equal participation of both men and women are important in the sustainability of alternative technologies for safe water supply in the arsenic problem areas.

Strengthening water quality surveillance and monitoring capabilities

Arsenic contamination of groundwater appears to be in dynamic state and may propagate over long distances within a short time in aquifers with high transmissibility and under conditions of regular abstraction of water through production wells. The quality of water of a tubewell may change within a short time-span and a safe tubewell identified by water quality tests may not remain safe in future. Hence, regular examination of water quality following the national water quality survey is needed through strengthening of the local/regional water quality monitoring and surveillance capabilities.

Building of capacity through training

Appropriate and comprehensive training programmes are to be developed with the following targets:

- Development of the skills of doctors and health workers to diagnose cases of arsenic poisoning.
- Enhancement of the knowledge and skills of the engineers, hydrogeologists, and NGO workers, among others, to develop alternative safe water supply systems.
- Strengthening implementation capacity of the organizations involved in the planning and implementation of a water supply system free of arsenic contamination.
- Capacity building at the local level for technology selection, implementation, operation and maintenance

of conventional and alternative technologies for water supplies free of arsenic contamination.

Establishment of National Database and Information Centre (NDIC)

There are no long term monitoring data for arsenic in tubewells anywhere in Bangladesh and so the probable future changes in groundwater quality are largely unknown. The careful monitoring of a network of wells over a broad range of timescales is important (Adel 2000). There are very few data for this at present, even for short timescales. Such monitoring is difficult to do because of the relatively small changes expected. There appears to be some short-term variation (over weeks and days) in the arsenic contamination of tubewells. The reasons for this are uncertain but probably reflect changes in the flow paths of the pumped water as the water table or pumping regime changes, combined with a strong stratification of water quality within the aquifer itself. In this context, establishment of a national database and information centre for arsenic contamination of drinking water and resulting arsenic toxicity through proper documentation is essential. This is considered as an effective tool for planning, designing and implementation of arsenic mitigation programmes.

Strengthening of arsenic removal and measurement capabilities

Aside from the mitigation technology *per se*, probably the single greatest contribution that science and technology can make to solving the arsenic problem would be the development of reliable, sensitive and affordable arsenic analysis at the microgram-per-litre level. From previous studies (Jekel 1994; Edwards 1994; Cheng *et al.* 1994; Hering *et al.* 1996), it is already known that coagulation–precipitation is a very effective and most frequently applied technique in arsenic removal. In this technique, addition of coagulant facilitates the conversion of soluble arsenic species into insoluble products through coprecipitation and adsorption Arsenic removal by iron hydroxides, produced by enhanced corrosion of iron is also an effective way of removing arsenic from drinking water (Karschunke & Jekel 2002). But the most effective method is the application of a field-test kit, which combines all the technologies of removing arsenic from drinking water especially in the context of Bangladesh. Combining any unavoidable short-term variability from the aquifer itself with the inevitable sampling and analytical errors means that samples close to the adopted arsenic standard will have quite a high probability of changing from 'acceptable' to 'unacceptable', or vice versa, with time. A three-tier classification would therefore be 'definitely acceptable', 'maybe acceptable' and 'definitely unacceptable'. Several improved field-test kits are currently being developed which offer semi-quantitative visual measurements, e.g. 0, 10, 30, 50, 70, 300 and 500 $\mu g\,l^{-1}$.This will eventually improve the acceptability of measurement technology of arsenic in drinking water.

The following steps can be also implemented in Bangladesh:

- Establishment of a network of laboratories on a regional basis with arsenic measurement capabilities. Vehicle mounted mobile laboratories equipped with arsenic measurement facilities can help to extend arsenic testing services closer to the communities.
- Laboratory analysis of arsenic is the preferred option but field measurements cannot be avoided considering the huge number of tests to be conducted in nationwide survey, surveillance and monitoring programmes. Development of reliable field-test kits and standardization of test procedures are essential for uniformity and greater accuracy in field measurement of arsenic in water.
- Establishment of national reference laboratories for undertaking validation, review and evaluation of analytical techniques adopted to ensure quality of data.

Establishment of appropriate research study programmes

The following research programmes may be launched:

- Establishment of relationship between arsenic ingestion and manifestation of symptoms of arsenic-related diseases through extensive study in the affected areas.
- Assessment of clinical manifestations of chronic arsenic-related diseases.
- Efficacy of drugs and other methods of treatment of arsenic-related diseases.
- Development of techniques for reliable arsenic detection and measurement, and improvement of existing technologies for better performance under Bangladesh conditions.

- Identification of source of contamination, mode of propagation and hydrogeological conditions influencing arsenic contamination.
- Hydrogeological and water quality studies to explore safe groundwater reservoirs for water supply free of arsenic contamination.
- Arsenic removal technologies and their cost-effectiveness, efficiency and social acceptability.
- Alternative surface-water based water supply options: technological issues, people's perception and participation.
- Rainwater harvesting, storage and safe uses.

International, interdisciplinary and inter-organizational co-operation

Arsenic contamination of groundwater is a complex interdisciplinary problem that requires:

- international collaboration and co-operation to exchange experience and support implementation of programmes in addressing arsenic problems;
- co-operation among the government organizations and ministries related to arsenic mitigation;
- collaboration and co-operation among professional groups involved in various activities related to arsenic contamination;
- close co-operation among government and non-government organizations and the research and training institutions to combat arsenic problems in Bangladesh.

CONCLUSION

Many of the activities described in this arsenic mitigation plan are being implemented by the government and NGOs, universities, research and training institutions and donor agencies under their own programmes. Mobilization of concerted effort is needed to combat this public health problem of unprecedented magnitude. The Government of Bangladesh is yet to prepare a coordinated action plan and implement it for mitigation of arsenic problems in the country and the actions discussed in this paper can be a basis for the development of such a plan.

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