Removing arsenic from water: Methods, problems and prospects

M F Islam

THE problem of presence of high arsenic content in tubewell water of Bangladesh was not even imagined thirty years back when UNICEF undertook sponsoring the sinking of large number of tubewells in the rural areas for the provision of safe water. By the time the presence of arsenic was detected the rural people had become habituated to the tube well water , abandoning the age old dug wells and pond water for drinking and cooking purposes.. The ponds and the dug wells , though supplied water for drinking and other purposes, were the primary cause of diarrhea and cholera thirty years back.

However the diagnosis of peculiar unknown type of skin diseases in some parts of Bangladesh pointed to something wrong in the environment somewhere. It became evident after painstaking investigation by government and non-government organizations that the disease was caused by the unsuspected germ free water from the underground. The culprit is the very powerful poison Arsenic in water from the tube well. Now it is surmised that an overwhelming percentage of tube wells is pumping out arsenic contaminated water from the underground and about 30 to 40 million people are at risk for the future.

The genesis of the arsenic poisoning is a serious scientifically debated question. The actual reason for the arsenic contamination will not be solved in the near future. However it is interesting to note that the major affected areas are the lower delta regions of Jamuna, Padma and Meghna rivers.

The discovery of arsenic in ground water over wide regions of Bangladesh has aroused serious concern. The pure water thought to be inexpensive for drinking and cooking purpose may no longer be true for many parts of the country. There are many regions of Bangladesh where arsenic free drinking water is difficult to get. Different mass media ,NGOs and GOs are constantly advising people not to use contaminated water for cooking and drinking. It has been found in many areas that even the simple villagers are conscious of the dangers from long time use of arsenic contaminated water.

Many older people know the existence of a virulent poison known as *"seko bish"* . This is nothing but arsenic used to kill people. The tasteless odorless sekobish was mixed with the food and drink of the unsuspecting victim, who may die after developing cholera type symptoms. The amount of arsenic in tubewell water will not cause immediate death of the drinker but will cause serious metabolic defects which, if not treated, may cause his/her premature death over a period of time.

The scientific truth that arsenic exists in ground water and that it is geologic in origin essentially means that we are living with arsenic for thousands of years without ever knowing it.. This was due to the fact that our forefathers were habituated to the use of dug well, pond and river water for almost all purposes. Where necessary they used simple earthen ware filters made of sand and charcoal for clarification of water . As the surface water was arsenic free , the problem of arsenic poisoning did not arise. However it may be possible that arsenic related diseases may have existed in the past as it is now known that some dug well water tested positive for arsenic. Fortunately such phenomenon was not widespread.

Though the sinking of large number of tube wells has dramatically reduced the water borne epidemics like cholera and typhoid and averted premature death, arsenic contaminated tubewell water has undone it for many. It is unlikely we can again ask our people to use pond, dug well and river water without any inexpensive methods for germ freeing. Moreover all the big rivers and waterbodies are subjected to pollution from industries both inside and out side the border.

Need of the hour

Now we have to seek water that is not only germ-free but also arsenic free, a task very difficult indeed for a very poor, highly overpopulated country with seasonal rainfall. The undertakers of the task have to keep in mind the following pertinent questions:

! The arsenic free water has to be supplied free of cost to the overwhelmingly poor villagers who may not be able to pay for the cost of the process.

! The process of making water arsenic free should be universally accessible.

! The process should be such as can be easily run by the villagers.

! The process should be environment- friendly.

The meeting of all these conditions are very difficult. The methods that are simple from the stand point of technology are (i) boiling and sand filtration of pond and river water (ii) rain water collection and preservation for year round use. Boiling 20 30 litres of water every day involves large fuel cost and may damage the village environment if wood and other combustibles are daily used by the villagers for large amount of surface water. Rain water collection will involve construction of large reservoirs involving large amount of money for the poor. Moreover rain is also seasonal.

Arsenic will stay with us for many generations in the future . By that time maybe the different aspects of the arsenic problem will also be solved. It even so happen that the arsenic problem may be a driving force for the development of some chemical industries in Bangladesh. Man cannot live without pure drinking and cooking water. Pure water production is a big chemical industry.

I am enumerating below the fundamental chemical processes now used for removing arsenic from water.. One has likened the work of these processes to search for a small sewing needle lost in a large stack of hey ! The arsenic has to be removed from few tenths of a million or few billionths of a part of water. Really an incredible operation. The operation of arsenic removal now centers on the following chemical processes.

! Precipitation of arsenic as insoluble residue.

! Co precipitation and adsorption with suitable reagents.

! Ion- exchange process.

! Membrane Filtration Techniques.

! Adsorption by active materials.

All the processes have their merits and demerits. The precipitation processes may be completely depending on the water quality and may introduce further unwanted species in water. The water matrix will influence the arsenic removal. Almost same remark may be applied for co-precipitation technique where the minute amounts of the arsenic are trapped or adsorbed by the generated precipitation by a chemical reaction. The ion-exchange process works on the well known principle of exchanging one species in a solid with another in water. It requires specialized costly materials for proper operation . The membrane filtration involves the use of membranes of substances of proper pore size allowing the passage of a species of a proper size and precludes over sizes. This is a sophisticated technique and requires sophisticated appliances. In adsorbent processes the unwanted species is simply adsorbed by the material from water.

Out of these processes co-precipitation technique with suitable coagulants has been practiced on a large scale for water clarification. The chemicals used are mainly aluminum and iron salts. Aluminum sulfate is used for this purpose. Nowadays ferrous sulfate and ferric chloride are also used in water works.

All these processes have one common constraint . The water quality has to be constantly monitored and the appropriate dosage for the use of chemicals and operating parameters changed, if necessary. This requires well trained chemists.

In view of cost consideration and difficulty of operation and maintenance, the high technology of ion-exchange and membrane filtration cannot be considered for rural application in Bangladesh. As a corollary only the co-precipitation and adsorption processes can be considered as low cost methods for wide scale rural application.

Many organizations are trying different types of arsenic filters in Bangladesh basically performing on the principles of co-precipitation and adsorption. Stevens institute and DPHE/ DANIDA 2- Bucket system use coagulation and adsorption method using ferric chloride and aluminum sulfate, with subsequent filtration. Alcan and BUET method use aluminum oxide as the adsorbent medium. The Sono -3- Kolshi is basically an adsorption method for arsenic removal by slowly formed iron hydroxides from large amounts of iron chips used.

Difficulties

As pointed out earlier, all the processes use known principles. However, very little information is available on the effects of various other species usually present . The contaminant arsenic is present in ground water in almost negligible amounts compared to other elements normally present in water such as sulfate , chloride, nitrates , sodium , potassium ,calcium, iron, manganese, silica, phosphate etc and even dissolved organic substances from the decaying plants (humic and fulvic acids). For these reasons the laboratory type performance of a particular method may be different from the performance of the same method with actual water from tubewells. It is already known that the ground water of different regions vary widely in composition.

Types of adsorbents

It has been reported that many surface substances adsorb arsenic from water . The reported materials are varied, such as water hyacinth, wood, charcoal, banana pith, coal ash, spent tealeaf, mushroom, sawdust, rice husk, activated carbon, bauxite, laterite, iron oxide coated sand, activated aluminas, hydrous ferric oxides and composites of oxides.

The organic materials will decompose on long time contact with water, making water unusable. The inorganic materials are stable and suitable for long time use. Other very pertinent considerations in the selection of materials are (a) the efficiency of arsenic removal , (b) cost of the materials, (c) availability of raw materials for large scale manufacturing, (d) disposal of arsenic loaded waste materials, (e) amount of arsenic free water (< 0.05 ppm As) produced per unit of the material used and (d) desirable water quality parameters of the arsenic free water. All these are conflicting considerations; very effective materials may be costly and out of reach of the poor villagers. The technology of production may also be complicated and costly , not suitable for a poor country. Imported materials will make the country dependent on others.

Disposal of adsorbed materials

Any organic adsorbents will decompose very fast in the environment and release large concentrations of arsenical compounds in the environment, though there is the possibility of formation of organic arsenic compounds considered much less harmful. In contrast the inorganic substances may form surface compound of much greater stability. However different inorganic compounds will have variable strengths of attachments for arsenic species from water. Iron oxides / hydroxides may attach arsenic in a different way from that with aluminum oxide. Iron as a transitional metal may form secondary bond with arsenic species even in the oxide or hydroxide form, making strong attachments.

The most desirable characteristic of an arsenic adsorbent is the very slow release of the adsorbed arsenic from the used adsorbent. In such cases the disposal of the used materials is not a problem. The arsenic is essentially bound in the adsorbent as in the soil. Bangladesh soil is actually the reservoir of arsenic, as all soils contain arsenic minerals, from which arsenic is transferred to the aquifers . The mechanism of this transfer is little understood.

Whenever we use arsenic contaminated ground water for any purpose other than drinking, such as bathing, washing and irrigation, we are simply returning the same arsenic to the ground and ultimately to the aquifers. This process will go on as long as we use ground water in the contaminated areas. For drinking and cooking we consume a very small portion of water withdrawn from the underground. We will never be able to get rid of arsenic from our aquifer in the affected areas. From chemical point of view we are in an Arsenic cycle just as there is Nitrogen, Oxygen, Phosphorus or Carbon cycle. But this cycle is localized in Bangladesh. We have to see how best we can manage this cycle. One way to get out of this cycle is not to use the ground water for any purpose at all, but it is doubtful if it is possible now.

Some have suggested we may immobilize the waste solid arsenic adsorbed materials in concrete blocks for use in the construction of culverts , roads and railways incorporating the waste materials in the concrete mix. However this remains to be tested in the field for possible applications.

Adsorbents on test

Various organizations and researchers are trying to develop arsenic removal techniques suitable for Bangladesh situation. As noted earlier imported activated alumina is being tested in both the laboratory and field level. Some methods use composites(Shafi). This writer also discovered a method for activating ordinary brick sand for arsenic removal. This method is now being field tested on a large scale by an international NGO specializing in the water field (IDE) for possible applicability in collaboration with local NGOs and international donors (UNICEF and DANIDA),in the name of Shapla Filter.

Conclusion

Arsenic will stay with us for many generations in the future . By that time maybe the different aspects of the arsenic problem will also be solved. It may even so happen that the arsenic problem can be a driving force for the development of some chemical industries in Bangladesh. Man cannot live without pure drinking and cooking water. Pure water production is a big chemical industry. The industry requires many chemical inputs and well trained people to run it. Moreover the arsenic may have other uses discovered in future. Such discoveries may make arsenic not a bane but a boon for Bangladesh. Researches should also be acting in this direction.

M F Islam is Professor, Department of Applied Chemistry and Chemical Technology, Rajshahi University

Water logging and salinity of the southwest

Needed more action for reclamation

AKM Sanowar Hossain

It may not be possible to bring back the innumerable rivers, creeks, khals (canals) and estuaries to their pre-embankment conditions but it is technically feasible to gradually arrest and improve the deteriorating environment.

IN the last few decades there has been a gradual decrease of the tidal 'prism' of the southwest region of Bangladesh in general and the Pussur-Sibsa River system in particular. For many years, the tidal rivers and estuaries of the region were stable; salinity was low and favourable to the environment. Interference with the existing condition began in the early 1960s when construction of coastal embankments was started. By the mid-sixties empoldering of water bodies in the southwest was almost complete. These extensive works were built to the Master Plan prepared by the then International Engineering Company (widely known as IECO) of the USA. The objective was to increase paddy production and to create local infrastructure for road communication. Rapid silting at downstream of the regulators blocked the drainage channels, leading to water logging and increase in salinity. The effect on environment and ecology was disastrous. The devastation of waterlogged barren fields hit the farmers within a few years of the project's completion.

The authors of the Master Plan did not fully appreciate the potential post-implementation neglect in maintenance of the projects. The required extensive flushing of the poldered areas was not ensured. The sluice gates in the embankments were reduced to inoperative condition for lack of maintenance, resulting in severe downstream silting. The quantum of tidal water that could enter the region through the rivers was extensively obstructed and, therefore, decreased. The depth of the rivers started decreasing gradually and simultaneously the tidal range in the region increased by 1-1.5m. Before the construction of the present coastal embankments, tidal water could spread and drop off its silt in the fields and low-lying areas. During ebb tide silt-free water returned to the rivers. Thus for many years the depth of rivers in the region remained stable. Coastal embankments are also attributed to be the main cause of declining navigability of the Pussur channel and at the Mongla Port.

While the paddy production lay in ruin, the trapped saline water in the polders provided an ideal opportunity for commercial cultivation of shrimps. With the rapid spread of shrimp farming, vast new areas came under saline inundation, thus further worsening the environment and ecology. The lucrative cash crop has attracted powerful interest groups to shrimp farming who now wield a mafia-style grip on the local community and successfully manipulate, and at times have physically thwarted, attempts to drain the affected areas. The economic benefit from shrimp farming has mostly bypassed the common people. Instead, it has brought about misery and health hazard for them and complicates any exercise to remove the expanding water logging and salinity problem.

It may not be possible to bring back the innumerable rivers, creeks, khals (canals) and estuaries to their pre-embankment conditions but it is technically feasible to gradually arrest and improve the deteriorating environment. The reclamation of Beel Dakatia in Khulna is a case in point from where stagnant water was drained out by the Water Development Board. The reclamation was carried out under a Taka 38 million emergency action plan based on the recommendations of an ADB funded technical assistance by an association of Haskoning and BCL in 1992. Some 6,000 ha of submerged land were brought back under the plough in 1994 after about 12 years under water and smile was back on the face of the community.

AKM Sanowar Hossain is a former chief engineer of Mongla Port.