Arsenic poisoning in Bangladesh
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"Bangladesh is grappling with the largest mass poisoning of a population in history because groundwater used for drinking has been contaminated with naturally occurring inorganic arsenic", the World Health Organisation (WHO) reported in September 2000.

Allan H. Smith, professor of epidemiology at the University of California at Berkeley has said that between 33 and 77 millions of Bangladesh's 125 million population are at risk. In 2002, after a long debate, United States congress adopted the WHO recommendation of 10 micrograms per liter as the maximum contaminant level for safe drinking water. In many areas in Bangladesh concentrations are above 3000 micrograms per liter and even up to 10 000. Some experts warn that it is a matter of time before contaminated water seeps through the entire country.

Arsenic contamination of ground water is a world wide health problem

Also in large areas of the Indian state of West Bengal, groundwater contains arsenic several hundred times the level recommended by WHO. Some 45 million people live in the inflicted areas in West Bengal, and there are villages where as many as 40 per cent of the people have visible symptoms of arsenic poisoning. Since Arsenic is the twentieth most common element in nature it is no wonder that dangerous levels of arsenic in drinking water has this far been observed in: Argentina, Australia, Canada, Chile, China, Greece, Hungary, India, Japan, Mexico, Mongolia, New Zealand, South Africa, The Philippines, Taiwan, Thailand, USA and USSR. As awareness of the menace spreads, new sources are discovered. The frightening Arsenic poisoning in Bangladesh is only the most spectacular example.

The World Bank has recognised the problem

The World Bank has allocated US$ 44.4 million to find a remedy in Bangladesh. According to independent experts the cost for implementing the remedy itself may run into billions of dollars, and that, of course, is much to pay for getting rid of one single contamination. There are ways to avoid the contaminated water - by transporting well water from non-afflicted sources, by drilling new wells that hopefully, do not go into the arsenic carrying sediment, by using purified surface water, and by supplying bottled water for drinking.
Considering the continued spread of arsenic, purifying the water is however the best long run options. However, another report from WHO titled 'Arsenic in Drinking Water', May 2001, states that: "There are no proven technologies for the removal of arsenic at water collections points such as wells, hand-pumps and springs."

Characteristics of Arsenic

Organic arsenic compounds that are found in foods pass through the body quickly and are therefore quite harmless. Inorganic arsenic is deposited in the body and concentrated over time and therefore causes long-term damage. Arsenic is difficult to detect. It is tasteless, odourless and colourless, and: a person can absorb significant doses without immediate harm. A well-nourished and otherwise healthy person will withstand the poison for a long time while an undernourished will perish quickly. Babies and children are especially sensitive. Inorganic arsenic forms ions, which are trivalent or pentavalent. Trivalent Arsenic (As+3) is considered up to 60 times more toxic than pentavalent (As+5). As+3 is also much more difficult to detect and few arsenic detection instruments can distinguish between As+3 and As+5. Most of the technologies that have been recommended this far for combating arsenic do a good job at removing As+5 but not As+3.

Safe limits

There is debate on how much arsenic the human body can handle without being harmed. A common figure is 12 micrograms per day. A generally agreed maximum contaminant level for safe drinking water has earlier been 50 micrograms per liter. This is obviously too high compared to the 12 micrograms per day assumption.

In the 1960's, a large poisoning in Taiwan, involving 20,000 people, allowed detailed study, the analysis of which eventually led the WHO to lower the recommended maximum level to 10 micrograms per liter. Although WHO found that for health reasons a level of 2 would have been preferable, difficulties in measuring at those levels at that time prevented such ruling.
Diseases caused by arsenic poisoning

The following diseases are suspected to be caused or aggravated by arsenic in drinking water according to EPA in Arsenic Rule Benefit Analysis, August 9, 2001: Cancer of the Lung, Bladder, Skin, Prostate, Kidney, Nose and Liver, Stillbirths, Postneonatal mortality, Ischemic heart disease (heart attack), Diabetes mellitus, Nephritis (chronic inflammation of the kidneys), Nephrosis (degenerative kidney diseases), Hypertension, Hypertensive heart disease, Emphysema, Bronchitis, Chronic airway obstruction, Lymphoma (tumours in the lymph), Black-foot disease and Developmental deficits.

In other literature, the following additional conditions suspected to be caused by arsenic in drinking water are cited: Bowen's disease, Basal cell carcinoma, Squamous cell carcinoma, Enlargement of liver, Jaundice, Cirrhosis, Non-cirrhotic portal hypertension, Hearing loss, Acrocyanosis, Raynaud's Phenomenon, Megablastosis, Goiter and it is suspected to contribute to various other cardiovascular, pulmonary, immunological, neurological, peripheral vascular and endocrine diseases.

However, the epidemiological study of diseases caused by arsenic poisoning is only in its infancy. For instance, a report from the United States National Academy of Sciences (NAS) from September 12, 2001, says EPA has this far greatly underestimated the cancer risks of arsenic in drinking water. In addition, in April 19, 2001, a team of EPA scientists at EPA's Office of Research and Development laboratory in North Carolina also reported that arsenic may cause genetic damage.

Sources of arsenic in water

Arsenic is and has been used in many activities throughout human history, as medicine, as poison, and in industry. Ever since industrialisation, millions of tons of arsenic have been poured out as waste from industrial processing, from livestock farming, from cotton and wool processing, from wood preservation and from mining and metal industry.

Arsenic is also used for killing weeds, insects and rats. Run off from such activities has contaminated surface and groundwater in many parts of the world, like lake Yangebup in Australia, or the Ogallala aquifer in Texas, USA. In West Bengal and Bangladesh. as in many other areas, the contamination in the water is from natural arsenic sources in the ground.

Technologies for arsenic removal

In large-scale applications, such as municipal or industrial treatment plants, there are established technologies for achieving reliable separation of arsenic. To remove As+3 in a large plant, it is first oxidised into As+5. This oxidation is usually accomplished with chlorine or hydrogen peroxide. The second step is precipitation with lime or coagulation/flocculation with some salt while controlling water's pH. Then follows filtration. Activated alumina is often recommended as a complementary adsorptive media in the filtration process.
EPA's report from December 2000, mentioned above, shows that As+3, no doubt, is the most difficult substance ever encountered in the water purification business. When I first heard of the arsenic disaster in 1996 as a request for information on behalf of an Indian Development Bank in West Bengal, my immediate advise was to try reverse osmosis, RO, which, as far as I knew then, removes all ions to a high degree.

When it was reported back that RO did not accomplish desired results I was full of disbelief. Later I have seen results from tests made for EPA in 1998 where the RO equipment tested removes 96% of As+5. but, surprisingly enough, only 5% of As+3.
It is however possible to achieve good removal with RO, if combined with pre-oxidation and then some form of after-treatment such as an ion exchange or activated alumina adsorption/filtration. The large number of steps makes operation complicated. It is also difficult to monitor the result.

Lately, several different absorption and adsorption technologies have been proposed. Arsenic will simply stick to a certain media when the arsenic containing water is poured through. These are attractive systems since capital costs are generally very low - a simple container and a first batch of the appropriate media. Long term costs are however high since media will have to be replaced at intervals. Disposal of used media may also present a problem since it must be classified as hazardous waste.

There are thus several possible technologies for removing arsenic from the contaminated wells. However, spending billions of initial cost and then large open ended recurring costs for just removing arsenic will make any community poor. Even in a rich country like the United States the authorities have concluded that the cost of adding arsenic removal technology to existing technology may be possible in large water utilities, but entirely unfeasible in small water utilities. In October 2002, a small private utility in Alamosa, Colorado is the first to be forced to sell its operation to the State because as the owner of Price Water District, Mr Price said: "As a private utility, I can't stand the expense."

A new method holds promise

Because of these findings, a Swedish company, Scarab Development AB, has set out to design equipment for arsenic removal based on a new technology, membrane distillation, (MD), which actually removes arsenic completely in a simple and reliable way. Laboratory tests certify that the technology removes As+3 as well as As+5 to below the detection level (< 3 micrograms per liter) of state-of-the art measuring instruments (AAS Graphite), i.e. more than 99.97% removal of both As+5 and As+3.

The technology does not require expert monitoring; and is easy to maintain and service and therefore could be used in small plants, at wellheads and in individual households. And it does not create hazardous waste.

An opportunity to leap-frog in development

There might be an efficient way to combat arsenic poisoning in an economical way, especially in areas where water infrastructure is still in an underdeveloped stage. And that is to leap-frog from no utilities to distributed utilities, by-passing the large utilities that have been built in industrialised countries and now: create insurmountable problems. What is proposed is to integrate the arsenic remediation into the wider connect of general welfare development. The greatest advantage of the proposed technology is that it not only removes arsenic completely, but any other possible contaminant. And another great advantage is that when waste heat is available, it produces perfect water for drinking at a minimal cost.