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Groundwater contamination — monitoring, risk assessment and restoration

title: **Human risk assessment of arsenic contaminated groundwater in India**

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ABSTRACT

The profound impact of our environment on the human body is apparent in understanding the cause of disease. Human survival is dependent on the environment and therefore, environmental protection should be a major issue in modern society. Additionally, the significance of acclimatizing to the surrounding environment is crucial for human health and survival. Arsenic contamination in water is a major human health concern worldwide. The greatest threat to human health arises from arsenic in drinking water because millions of people are at risk of drinking water contaminated with the metalloid. In India arsenic human exposure is mainly by ingestion of drinking water naturally contaminated with inorganic arsenic from geogenic sources. Presently public attention is focused in many states e.g. New Delhi, West – Bengal, Uttar Pradesh, Bihar, Jharkhand and Chhattisgarh where level of arsenic in drinking water are often higher than W.H.O. permissible limits. Many persons of either sex died of cancer and millions are suffering from arsenicosis, melanosis, keratosis, and gangrene and skin cancer which is believed to have been triggered by their prolonged use of arsenic laced drinking water. The arseniferous belt is mainly characterized by complete or truncated cycles of fining upward sequences dominated by course of medium sands, silt and clay sediment. A geochemical and hydrogeological characteristic of this alluvial sediment influences the mobility of arsenic in groundwater. Arsenic poisoning or arsenicosis is emerging as the world's biggest environmental health disaster. So far about a 60 million people spread over an area of about 85,000 Sq. Km. have been found to be affected by poisoning. Finally, we have to evaluate and identify potential prevention and mitigation strategies to reduce arsenic exposure and its fatal and non-fatal consequences. These findings have important public health, socio-economic and policy implication for large number of arsenic exposed population of the world.

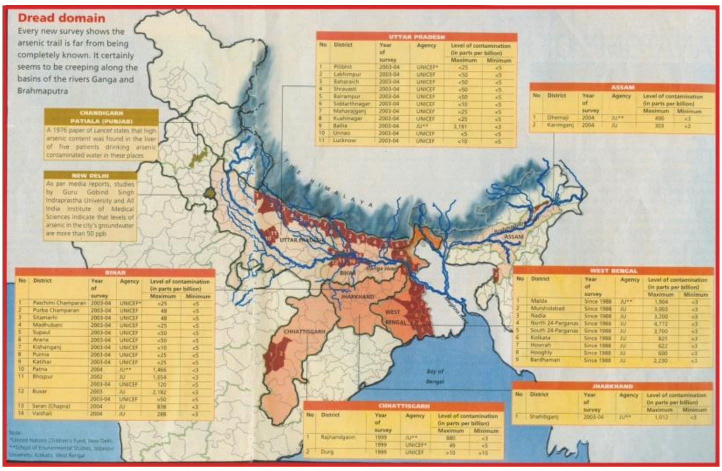


Figure 1. Location map No. 1.

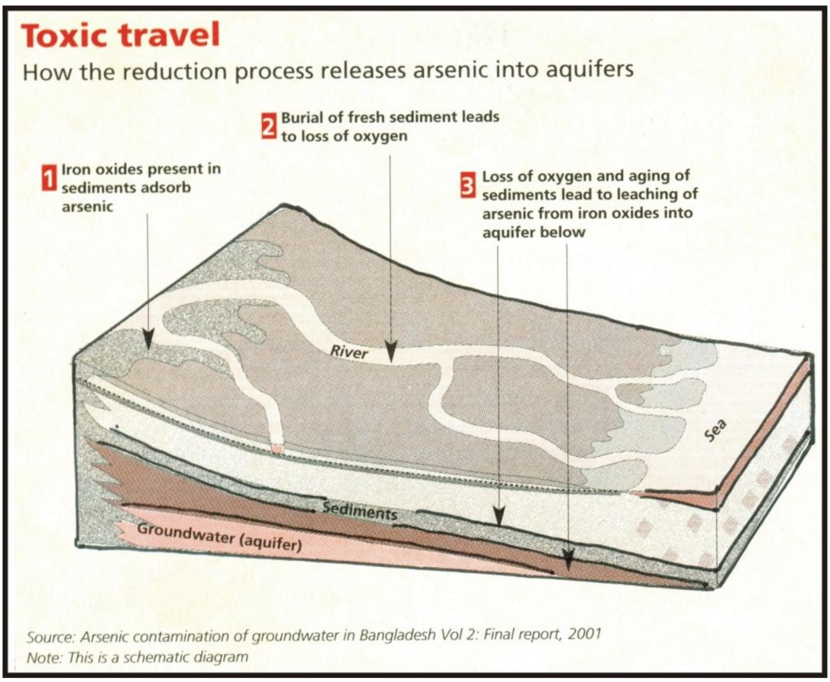
METHODS AND MATERIALS

The Reduction Theory

According to the reduction theory, arsenic is adsorbed by iron oxides, which form a part of fine-grained sediments. These sediments are rapidly "reducing" (losing oxygen) because the rich organic matter. When the sediments reduced (lose oxygen), a series of geochemical reactions occur leading to the release of arsenic into the groundwater. The exact processes involved are not yet well understood. But as per BGS researchers, they are likely to involve one or more of the following processes:

- reduction of strongly adsorbed arsenic to less strongly bound arsenic, which leads to the release of arsenic from iron oxides;
- iron oxides partially dissolve and release iron as well as the adsorbed arsenic;
- the iron oxides undergo changes leading to the desorption (release) of arsenic.

Acharya (2001) explains that "arsenic gets preferentially entrapped in the organic-rich clayey floodplain and delta sediments and therefore any delta or floodplain that developed into marsh-land or swamp is prone to contain arsenic contaminated groundwater". A 2004 paper in the British journal Nature supports this theory, arguing that anaerobic-metal reducing bacteria can play a key role in the mobilization of arsenic in the sediments. According to this research, arsenic release takes place after iron reduction – release of iron in anaerobic conditions –rather than occurring simultaneously with changes in the iron oxides.



The oxidation theory

The other set of researchers believes that the oxidation of iron releases the arsenic in the sediments. These researchers hold that arsenic is present in pyrites – iron-containing rocks – that are deposited in the aquifer sediments. When the iron is exposed to oxygen, its capacity to adsorb arsenic reduces, and therefore the toxic chemical starts leaching into the aquifers,. This hypothesis is called the pyrite oxidation thesis. Chakraborti (2003) propose that oxygen enters the aquifer because of heavy groundwater withdrawal, favoring the oxidation of arsenic-rich iron sulphide, which in turn mobilizes the toxic element into the water. The oxidation theory fails to explain arsenic contamination in deep aquifers, where oxygen cannot reach. The organic carbon reduction theory explain contamination in these aquifers: dissolved carbon in the waters of some regions combines with iron hydroxides rich in arsenic. When these oxides embrace carbon, they simultaneously liberate arsenic, which in turn contaminates the aquifers.

RESULTS AND DISCUSSION

One of the highest arsenic concentrations in the world appears to be in the bengal deltaic alluvial aquifers generally at depth 20–50 m. A working hypothesis for the release of the arsenic has been oxidation of pyrite/arsenopyrite in clay or peat interbeds. However, the deltaic alluvial aquifers hold reducing iron rich in alkaline low sulphate groundwater and the reduction of arsenic bearing iron-oxyhydroxides may be the cause ascribed to reductive dissolution reaction is mediated by anaerobic heterotopic Fe (III) reducing bacteria. It may occur due to some geochemical changes. These alluvial tracks contain high contents of pyrites which are rich in arsenic. Due to increased population and their need to meet their food requirements, three or more crops are harvested each year. As a result, excessive groundwater is used. Million of bore holes are installed for agriculture and drinking purposes and due to the fluctuation of water table from pre-monsoon to post-monsoon; the ground water aquifers are aerated. Thus, the pyrites are decomposed and As (arsenic) acids ($H_3 ASO_4$, $H_3 ASO_3$) are released from sediments.

Evidences suggest that the ingestion of arsenic can cause several different types of cancers. The clinical representation of arsenicosis is initially dermatological, including melanosis, leukomelanosis, keratosis, hyperkeratosis and progresses to gangrene or skin cancer. Prognoses for people exhibiting these symptoms are poor. There is no cure of arseniocosis as yet. Patients are advised to drink arsenic free water, and to maintain a diet of nutritious foods, which is often not possible because the inhabitants are neither health conscious nor can afford the suggested line of treatment because of extreme poverty. The gravity of the problem may be ascertained with the report that only a small fraction of groundwater of the affected area was tested and reported to have more than 0.05 ppm arsenic. The WHO specifies a limit of 0.05 ppm arsenic and less than 0.01 ppm is desirable in drinking water (WHO Guidelines for Drinking Water, 1993).

CONCLUSION

There is no doubt that arsenic content of groundwater situation in India is very grave. Patients are suffering, relatives are desperate and physicians are frustrated. We are optimistic that with joint efforts with national and international agencies and scientific communities, some solution will be obtained which will bring smile on the faced of the distressed. To mobilize and organized efforts of the international community toward this goal is the prime target of this work.

Figure 2. Lesions on the Face of baby, caused by drinking contaminated water.

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