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Arsenic pollution in India–An overview

Shanmugapriya S. P.[1*], Rohan J.[1] and Alagiyameenal D.[2]

[1]Mohamed Sathak Engineering College, Kilakarai, Ramanathapuram, Tamilnadu
[2]Department of Civil Engineering, MSEC, Kilakarai

ABSTRACT

There is general notion that most of the arsenic were from Himalayan Mountains and are then deposited in alluvial deposits. Higher proportions of arsenic are to be found in sedimentary rocks than that of igneous and volcanic rocks. Arsenic contamination has recently received worldwide attention because of the nature of its health effects Arsenic poisoning in India is more than 50 µg/L covering almost 7 states becoming the biggest natural groundwater calamity to the human beings. Exposure to arsenic through inhalation causes both acute and chronic problems resulting in severe damage of brain and nervous systems as well as peripheral nervous systems. Oral exposure to arsenic results in skin related disorders or even liver and kidney disorders. This paper discusses the multiple sources and effects of arsenic compounds in eastern parts of India, where the impacts on water quality and public health are seen in disastrous proportions. They are 6 of 17 districts in West Bengal, 20 of 70 districts in Uttra Pradesh, 13 districts in Bihar, 20 of 24 districts in Assam, 3 of 4 districts in Tripura, 6 of 13 districts in Arunachal Pradesh, 2 of 8 districts in Nagaland and 1 of 9 districts in Manipur.

Key words: Arsenic Compounds. Pollution effects, sources, contamination, India

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INTRODUCTION

Arsenic's history in science, medicine, and technology has been overshadowed by its notoriety as a poison in homicides. It is viewed as being synonymous with toxicity. Arsenic contamination in water supplies continues to increase in many countries, especially in developing nations, thereby creating both environmental and health hazard and often referred to as a 20th, 21 st century calamities. High arsenic concentrations have been reported recently from China, Chile, Bangladesh, India, Taiwan, Mexico, Argentina, Poland, Canada, Hungary and Japan. Among 21 countries in different parts of world affected by ground water arsenic contamination, the largest population at risk is in Bangladesh followed by west Bengal in India.

Arsenic and its forms in environment:
Arsenic is a metalloid widely distributed in the earth's crust at an average concentration of 2 mg/kg and appears in Group 15 (V) of the periodic table, below nitrogen and phosphorus. Elemental arsenic, which is also referred to as metallic arsenic, (As 0)) normally, occurs as the α-crystalline metallic form, which is a steel gray and brittle solid. The β-form is a dark gray amorphous solid. Other allotropic forms of arsenic may also exist. In compounds, arsenic typically exists in one of three oxidation states, -3, +3, and +5 . Arsenic compounds can be categorized as inorganic, compounds without an arsenic-carbon bond, and organic, compounds with an arsenic-carbon bond. Over 200 arsenic-containing minerals have been identified, with approximately 60 per cent being arsenates, 20 per cent sulphides and sulphosalts, and the remaining 20 per cent including arsenides, arsenates and oxides. The most commonly occurring form is arseno pyrite, an iron arsenic sulphide associated with many types of mineral deposits and especially those including sulphide mineralization

1.1 Sources of arsenic:
Arsenic can be released into the atmosphere and water in the following ways:
1. natural activities, such as volcanic activity, dissolution of minerals (particularly into groundwater), exudates from vegetation and wind-blown dusts;
2. human activities, such as mining, metal smelting, combustion of fossil fuels, agricultural pesticide production and use, and timber treatment with preservatives;
3. remobilization of historic sources, such as mine drainage water;
4. Mobilization into drinking-water from geological deposits by drilling of tube wells.

It has been estimated that about one-third of the atmospheric flux of arsenic is of natural origin. Volcanic action is the most important natural source of arsenic, followed by low-temperature volatilization. Inorganic arsenic of geological origin is found in groundwater used as drinking-water in several parts of the world, for example Bangladesh. Organic arsenic compounds such as arsenobetaine, arseno- choline, tetramethylarsonium salts, arsenosugars and arsenic- containing lipids are mainly found in marine organisms although some of these compounds have also been found in terrestrial species. Elemental arsenic is produced commercially from arsenic trioxide. Arsenic trioxide is a by-product of metal smelting operations. It has been estimated that 70% of the world arsenic production is used in timber treatment as copper chrome arsenate (CCA), 22% in agricultural chemicals like pesticides, and the remainder in glass, pharmaceuticals and non-ferrous alloys

1.2 Applications of arsenic compounds:
Arsenic was used in some medicinal applications until the 1970s. Inorganic arsenic was used in the treatment of leukaemia, psoriasis, and chronic bronchial asthma, and organic arsenic was used in antibiotics for the treatment of spiro- chetal and protozoal disease (ATSDR, 2007).after that Arsenic compounds are used in making special types of glass, as a wood preservative and, lately, in the semiconductor gallium arsenade, which has the ability to convert electric current to laser light. .Because of its high electron mobility, as well as light-emitting, electromagnetic and photovoltaic properties, gallium arsenide is used in high-speed semiconductor devices, high- power microwave and millimetre-wave devices, and opto-electronic devices, including fibre- optic sources and detectors .Arsine gas AsH3, has become an important dopant gas in the microchip industry, although it requires strict guidelines regarding its use because it is extremely toxic. During 1990– 2002, approximately 4% of arsenic produced was used in the manufacture of glass, and 1–4% was used in the production of non-ferrous alloys.

1.3 Effects of arsenic on human health
There are different pathways through which arsenic enters human systems: drinking water, inhalation and dermal uptake. . The problem is severe in South Asia, particularly in Bangladesh and eastern parts of India, where the impacts on water quality and public health are seen in disastrous proportions. While the World Health Organization (WHO) suggest a standard of 50 micrograms per litre (mg l-1) (WHO, 1993), scientific studies advise a much lower value of 10 ppb (WHO, 1999).

The order of toxicity of arsenicals is :

MMA (lll) > Arsenite (lll) > Arsenate (V) > MMA (V) = DMA (V)

Several studies have also shown that inorganic arsenic can increase the risk of lung, skin, bladder, liver, kidney and prostate cancers. Arsenic can cause cancer, blindness and fetal malformations in other mammals and amphibians. Various adverse health effects including cancer have been reported from the districts in West Bengal which are associated with prolonged arsenic exposure. Blackfoot disease is more prevalent in developing countries, particularly among the poor, because the process of detoxification of arsenic may not take place in their bodies as a result of nutritional inadequacies.

Arsenic is also associated with the growth retardation in children. The height of children might be affected by the arsenic in drinking water. The children who have high arsenic concentration in their hair had less height than the children with low arsenic.(Nrashant Singh,2007)

2. ARSENIC PERIL IN INDIA

In India seven states have so far been reported by arsenic contamination in ground water above the permissible limit of 10 microgram per litre. As of 2008, West Bengal, Jharkhand, Bihar, Uttar Pradesh in flood plain of Ganga River; Assam and Manipur in flood plain of Brahamaputra and Imphal rivers, and Rajnandgaon village in Chhattisgarh state have so far been exposed to drinking arsenic contaminated hand tube-wells water. The area and population of these states are 529674 km2 & approx. 360 million respectively, in which 88688 km2 and approximately 50 million people have been projected vulnerable to groundwater arsenic contamination. Almost all the identified arsenic affected areas in the Gangetic plains except areas in Chhattisgarh and 3 districts in Bihar namely, Darbhanga, Purnea and Kishanganj, are in a linear tract on either side of the River Ganga in UP, Bihar They are 6 of 17 districts in West Bengal, 20 of 70 districts in Uttra Pradesh, 13 districts in Bihar, 20 of 24 districts in Assam, 3 of 4 districts in Tripura, 6 of 13 districts in Arunachal Pradesh, 2 of 8 districts in Nagaland and 1 of 9 districts in Manipur.

2.1 West Bengal:

Since groundwater arsenic contamination was first reported in year 1983 from 33 affected villages in four districts in West-Bengal, the number of villages has increased to 3417 in 111 blocks in nine districts till 2008 in West Bengal alone. There can be several other lists of arsenic affected areas prepared by different organizations, which may differ from one to another, because of number of reasons, e.g.,(i) number of samples analyzed, and different sampling locations (ii) compilation of information may be different, etc. However, the fact is that during last 25 years, with every additional survey, an increasing number of contaminated villages and more affected people have been identified. In the last 18 years of survey, we analyzed 140,150 water samples from hand-tube wells in West Bengal and found that 48.2% had arsenic concentrations of >10 µg/L and 23.9% had >50 µg/L. Nine of 19 districts were severely affected (50 µg/L), five each were in the mildly-affected (most of them had concentrations of <50 µg/L) and safe categories (<10 µg/L). We found that 3,500 villages from 90 blocks were arsenic-affected. The area and population of the nine arsenic-affected districts are 38,865 sq km and 50 mil- lion respectively.

2.2 Bihar

In 2002, groundwater arsenic contamination first surfaced in two villages, Barisban and Semaria Ojhapatti in the Bhojpur district of Bihar in the Middle Ganga Plain. The area is located in the flood-prone belt of Sone-Ganga inter-fluve region. Investigations by Central Ground Water Board and Public Health Engineering Department, Bihar indicated contamination as high as .178 µg/L in the surrounding villages, affecting the hand pumps, which are generally at 20-40 m below ground surface. With ongoing study, more and more contaminated districts have surfaced. It was reported (CGWB, 2008) that by the year 2008, out of 38 districts, 15 districts covering 57 blocks are exposed to groundwater arsenic contamination above 50 µg/L. These districts are: i) Buxar ii) Bhojpur, iii) Patna, iv) Lakhisarai v) Saran, vi) Vaishali vii) Begusarai, Samastipur, ix) Munger, x) Khagaria, xi) Bhagalpur xii) Darbhanga, xiii) Purnea xiv) Katihar xv) Kishanganj (Figure-2.7). These districts are mostly distributed along the course of the river Ganga in Bihar except three; (i) Darbhanga, (ii) Purnea and (iii) Kishanganj, which are in isolated and scattered places showing no distinct routes of connection to one-another gravel, etc.

2.3 Uttra Pradesh

Groundwater arsenic contamination in UP was first exposed in 2003 by SOES from survey of 25 villages in Ballia district. Thereafter, with continued survey two more districts, Gazipur and Varanasi were detected for arsenic groundwater contamination. As of 2008, 3 districts covering 69 villages in 7 blocks in Uttar Pradesh were found affected by arsenic groundwater contamination and people suffering from arsenical skin lesions. The used to drink water of hand pump operated tube wells. All those tube wells tap groundwater from shallow aquifer below about 20-30 m.

2.4 Jharkhand

During 2003-2004, groundwater arsenic contamination above 50 µg/L was first reported by SOES in the Sahibganj district of the Jharkhand, in the middle Ganga plain. Later on (2006-07), it was confirmed by CGWB through detailed investigation. Arsenic contamination is close to the Ganga River and in those areas from where the Ganga River shifted during recent past. The hand pump tube-wells of depth range 25-50 m were reported to be contaminated, and the affected areas had similar geological formations as in adjacent Bihar and West Bengal

2.5 Assam & Manipur in North Eastern Hill states

There are seven states in North Eastern Hills. They are Manipur, Mizoram, Assam, Tripura, Arunachal Pradesh, Nagaland, and Meghalaya. Groundwater arsenic contamination was reported from Assam and Manipur states. A preliminary survey indicated that hand tube-well water in flood plains of these two states had some arsenic contamination above 50 µg/ L and the magnitude was much less compared to Ganga-Padma- Meghna plain. Recently UNICEF reported arsenic contamination from Assam and found arsenic contamination in 18 out of 23 districts of Assam above 50 µg/L.Recently SOES reported groundwater arsenic contamination situation from Manipur state. Mainly valley districts of Manipur are arsenic contaminated. These districts are Kakching, Imphal east, Imphal west, Bishnupur. The area of these 4 districts is 10% of total area of Manipur but about 70% of total population lives in these 4 districts. In Manipur at present people are not using hand tube- wells water for drinking, cooking and agricultural purposes.

Analysis of 1, 69,698 hand tube-well water samples from all these 7 states for arsenic detection by School of Environmental Studies, Jadavpur University (SOES, JU) reported presence of arsenic in 45.96% and 22.94% of the water samples more than 10 µg/L (WHO guideline value of arsenic in drinking water) and 50µg/L (Indian standard of arsenic in drinking water), respectively. Importantly, 3.3% of the analyzed tube-wells had been found arsenic concentrations above 300µg/L, the concentration predicting overt arsenical skin lesions.

3. REMEDIATION

Technological options to combat arsenic menace, in groundwater, to ensure supply of arsenic free water, in the affected areas, can be one of the followings or a combination of all:

I. In-situ remediation of arsenic from aquifer system,
II. Ex-situ remediation of arsenic from tapped groundwater by arsenic removal technologies like chemical coagulation,reverse osmosis ,membrane filtration etc.
III. Use of surface water source as an alternative to the contaminated groundwater source,
IV. Tapping alternate safe aquifers for supply of arsenic free groundwater.
V. Innovative technologies, such as permeable reactive barriers, phytoremediation, biological treatment and electrokinetic treatment, are also being used to treat arsenic- water, waste water and soil

Instead of this, point-of-entry (POE) or point-of-use (POU) treatment options may be acceptable treatment alternatives, which offer ease of installation, simplify operation and maintenance, and generally have lower capital costs (Fox, 1989).Location- specific research, combined with a combination of technology, incentive and self-protection policies could be used to address the problem of arsenic contamination worldwide.

CONCLUSION

Arsenic sources and effects are multiple and diffused in nature and it requires detailed assessment and policy. Innovation in low cost technologies offers possibilities for reducing abatement cost and for economic efficiency. To reduce arsenic in water resources, incentive policies such as taxing and subsidizing can be used to reduce arsenic levels in point sources through creation of appropriate incentives. Creating awareness among the people in the arsenic affected states in India will decrease the contamination level in water resources.

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