

A Review of Arsenic in Drinking Water : Indian Scenario (2007-2017)

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ABSTRACT

Arsenic is considered to be a major environmental pollutant and its exposure occurs through environmental, occupational and medical sources. Arsenic contaminated drinking water is the main source for arsenic exposure especially in the South Asian regions. It is highly toxic and carcinogenic in nature. Therefore, high concentration of arsenic present in the drinking water is considered as a danger to human health. From the past few years, the contamination of drinking water because of arsenic is increasing especially in the northern and north eastern region of India. The ground water was previously considered as safe for drinking but now due to increasing amount of arsenic in it has lead to contamination of the groundwater and hence is harmful for humans. This amount has crossed the permissible amount of arsenic in drinking water that is 10 µg/l. Long term exposures to arsenic contaminated drinking water leads to Arsenicosis, also cancer of skin, bladder, liver, kidney and skin diseases. In this review paper we have reported most of the studies/ research where quantity of arsenic in drinking water has been reported for the Indian sub-continent after the year 2007.

Keywords: Arsenic, Groundwater, Contamination, Drinking Water.

I. INTRODUCTION

Arsenic and its Properties

Arsenic is a semi-metallic or a metalloid element. It is tasteless and odorless and is found in nature in the earth's crust as sulfide ores. Arsenic is found in soil, water and air due to its release from volcanoes or industrial processes and also by combustion of fossil fuels. [33] Occurrence of arsenic in a particular area depends on its geographical location. It is found in organic, inorganic and gaseous (arsine gas) form in the environment. It is toxic and carcinogenic in nature. [38] Inorganic arsenic is stable in oxidation states (-3, 0, +3, +5) but is naturally found in its trivalent and pentavalent state. Inorganic arsenic is mostly found in industry and in private well water in some parts of the country. [15] Arsine is a potent hemolytic poison in cases of both acute and chronic poisoning. The toxicity level of an arsenic compound depends on its valence state, solubility, physical properties, rate of absorption and

elimination, etc. [31] Inorganic trivalent compounds of arsenic are most toxic whereas elemental arsenic is the least toxic. Arsine gas is considered to be the most toxic in acute cases. [38]

Arsenic is considered as group 1 carcinogen i.e. it is well known as fatal to humans. Acute and chronic poisoning are the two types of arsenic poisoning. Usually acute arsenic poisoning occurs when the arsenic is accidentally ingested i.e. as pesticides or insecticides and sometimes for suicide. [43] Doses less than 5mg causes diarrhoea and vomiting and can be resolved within 12 hours with or without treatment. However, doses in the range of 100mg to 300mg are considered as lethal and can cause death within 24 hours to 4 days after consumption of arsenic. [38] Arsenicosis is the term used to refer to long term or chronic poisoning of arsenic. Arsenic absorbed in the body is accumulated in liver, lungs, kidney, nervous system, heart, spleen, hair, nails and skin. This leads to multiple organ failure and hence malignance. [6]

II. METHODS AND MATERIAL

Essentiality of Arsenic in the Human Body

Arsenic is essential in trace amounts in animals as well as humans. A very minute amount of arsenic 0.00001% is needed to be present in the human body for proper growth and healthy nervous system. Decreased serum arsenic concentration may lead to disease in central nervous system and cancer. It is a major clinical nutritional concern in humans as both low ($< 12 \mu\text{g}/\text{day}$) or high (more than $250 \mu\text{g}/\text{day}$) intake can possibly induce susceptibility to cancer of urinary bladder, kidney, liver, skin, lung. Human serum arsenic levels are measured by atomic absorption spectroscopy and the normal amount is $0.02 \mu\text{g}/\text{ml}$. The normal urinary excretion of arsenic is $2\text{-}25 \mu\text{g}/\text{ml}$. The concentration of arsenic in hair is $0.15\text{-}0.35 \text{ mg}/\text{kg}$ and in nails it is $0.25\text{-}0.34 \text{ mg}/\text{kg}$. The permissible amount of arsenic in drinking water is $10 \mu\text{g}/\text{l}$.^[15]

Arsenic Exposure and its Effects

Human Exposure to arsenic can be through food, water or air. Arsenic enters the food web from plants which are sprayed with arsenic containing pesticides or insecticides. Inhalation of arsenic or exposure to arsenic through air is seen in areas where mining is done or in industrial places where arsine is released in a large amount. Mostly human exposure to arsenic is due to intake of water containing arsenic in trace amounts for a long period of time or intake of water containing excess amount of arsenic beyond its permissible value. Presence of arsenic in drinking water can be due to various sources which mostly include the industrial effluents which are let out into the rivers or lakes, erosion of rocks, mining and due to contact of groundwater with insecticides or pesticides.^[43] Arsenic can cause damage to internal organs without any external symptoms and hence arsenic poisoning detection is very difficult to identify. Symptoms are seen only after 10 years of exposure and in some cases it may take 20 years also.^[1]

WORLD SCENARIO

Arsenic contamination is an issue of concern worldwide and it is a considerable risk factor in various countries including Bangladesh, Taiwan, India, Mexico, China,

Chile, Argentina, and USA.^[2] Over the past decade concentration of arsenic in drinking water is increasing and hence the risk to human health is also increasing and is now considered as a threat to the human health. WHO has set the minimum amount of arsenic in drinking water to be 10ppb .^[31]

Most of the tube wells from all the countries contained more than $10 \mu\text{g}/\text{l}$ arsenic and also in some of the countries in South Asia, the arsenic content was $2,500 \mu\text{g}/\text{l}$. In countries like Argentina and Cordoba province, the levels of arsenic in water are found to be very high, i.e. $5000 \mu\text{g}/\text{l}$ and $11,500 \mu\text{g}/\text{l}$ respectively.^[3]

WHO in 2010 gave a report on exposure to arsenic. This report concentrated on the effects of inorganic arsenic as a toxic substance and active carcinogen to the human body. The groundwater contains arsenic in large amounts and hence the risk to human health has increased. Most of the countries like Argentina, Bangladesh, Chile, China, India, Mexico and USA have arsenic in their tube wells. WHO gave another report in 2011 which said that the maximum amount of naturally occurring arsenic in ground water is $25 \text{mg}/\text{l}$.

The amount of arsenic present in the drinking water of some of the countries was estimated. The countries like America, European countries and the African countries follow $10 \mu\text{g}/\text{l}$ to be the permissible value. It was found out that Australia has set up the most severe value of $7 \mu\text{g}/\text{l}$ as the minimum permissible value of arsenic in drinking water.^[24]

INDIAN SCENARIO

The water of the rivers like Ganga and Brahmaputra are highly contaminated by arsenic and hence the states which are situated on the basin of these rivers like West Bengal, Bihar, Uttarakhand, Uttar Pradesh and some of the north eastern states are highly affected. The first case regarding the arsenic contamination in drinking water was reported in Chandigarh in the 20th century.

In 2007, Mazumder reported that Arsenic content in the drinking water in the state of West Bengal was found to be $330 \mu\text{g}/\text{l}$. In his further study in 2010, he reported that the amount of arsenic in drinking water has increased to $1362 \mu\text{g}/\text{l}$.^[1]

According to the North Eastern Regional Institute of Water and Land Management, concentration of arsenic in water in the North Eastern states like Assam, Tripura,

Manipur, Nagaland and Arunachal Pradesh is 300ppb. Arsenic is a virulent poison. Its ingestion if 76mg in acute dose is considered to be fatal.^[9]

In India, arsenic contamination is seen in the northern and north eastern states. The approximate range of arsenic found in these states is 50-3200 µg/L.^[34]

The contamination of arsenic in the basins of the rivers Ganga and Brahmaputra was reported. The states in which these rivers flow are West Bengal, Assam, Jharkhand, Bihar, Uttar Pradesh and Manipur. Most of the drinking water in these states is obtained by the rivers or ground waters of the above rivers which leads to arsenic exposure. The water of these regions contains arsenic in more than 10µg/L. The mean or the average amount of arsenic in the basin of these rivers is 200 mg/l.^[12]

A study was conducted on the effects of arsenic and its increasing concentration in the Gangetic plain, Bihar, India. It was reported that arsenic concentration in Bihar is 1654µg/L. Some of the highly contaminated districts in Bihar are Buxar, Bhojpur, Patna, etc.^[33]

In the state of Uttar Pradesh, India it was observed that the range of arsenic in the water was 2.0-1310ppb but most of the samples had arsenic more than 50 ppb. 50ppb is considered as the permissible value of arsenic in drinking water.^[19] The districts like Ballia and Kheri have highest amount of arsenic in their drinking waters. The range of arsenic was found to be very high i.e. 4800-6300 ppb which has increased significantly from the past few years in the district Ballia in the state of Uttar Pradesh.^[41]

Concentration of arsenic in drinking water (India)

| Name of the state | Source of arsenic | Concentration (µg/L) | Reference |
|--------------------------|-------------------|----------------------|-------------------------------------|
| West Bengal | Ground water | ≥ 500 | Chakraborti <i>et al</i> (2009) and |
| - Paraganas | | 1321 | |
| - Murshidabad | | 2037 | |
| - Howrah | | 50-155 | |
| - Hugli | | 510 | |
| Uttar Pradesh | Ground water | ≥1300 | Kunar <i>et al</i> (2009) |
| - Ballia | | 1310 | |
| - Mathura | | 520 | |
| Bihar | Ground water | ≥1800 | Kunar <i>et al</i> (2009) |
| - Patna | | 1810 | |
| - Buxar | | 1222-1400 | |
| - Bhojpur | | 1630 | |
| - Samastipur | | 626 | |
| Chattisgarh | Ground water | 50-1890 | Kunar <i>et al</i> (2009) |
| Assam | Ground water | 100-200 | Devi <i>et al</i> (2009) |
| Manipur | Ground water | 798-986 | Devi <i>et al</i> (2009) |
| Arunachal Pradesh | Ground water | 618 | Devi <i>et al</i> (2009) |

III. RESULTS AND DISCUSSION

The WHO and ISO have given the permissible value of arsenic in the drinking water as 10µg/L.^[6] The BIS has given the permissible value of arsenic in the drinking

water 50µg/L but later it was changed to 10µg/L. The drinking water containing arsenic beyond this limit becomes toxic. The arsenic content in West Bengal, India is 3200µg/l.^[3] It has led to multisystem diseases, cardiovascular diseases, reproductive failures and

different types of cancers. The North Eastern states of India also have high amount of arsenic i.e. more than 300µg/L which has caused deaths of half of the people living in these villages.^[9] The techniques used for detection of arsenic in drinking water are HG-AAS; Hydride Generation Atomic Absorption Spectroscopy.^[4] Arsenic less than 10µg/L is very essential in the human body as it plays a major role in proper growth and healthy nervous system but excess amount can lead to arsenic poisoning^[15] After West Bengal, the state of Uttar Pradesh is considered to be containing high amounts of arsenic in ground water i.e. 1310µg/L. The Ballia district is highly affected by arsenic contamination.^[19] The rivers like Ganga and Brahmaputra are highly contaminated with arsenic and contain 300µg/L of arsenic approximately.^[27] The state of Bihar is found to be having 1654 µg/L arsenic in water.^[33] The state of Uttar Pradesh has concentration of arsenic as 4800-6300 µg/L which has led to increased deaths of children and some adults.^[41] In order to reduce the level of arsenic to the permissible level different types of programmes were started by the government and have been implemented also. Awareness Programmes^[23], Rain water Harvesting programme in order to divert the excessive use of arsenic contaminated ground water, etc. have been implemented.^[13]

IV. CONCLUSION

From the above discussion it is clear that arsenic level has increased highly from the past few years. The states like West Bengal, Uttar Pradesh, Bihar and Assam are the highly polluted states in India. The major reason for presence of arsenic in the ground water is the entry on industrial effluents containing arsenic into the rivers and lakes. These rivers and lakes the source of drinking water to majority of India's population. Another reason is that excess digging of the tube wells has led to naturally occurring arsenic in the soil to enter into the water and hence into the food chain of humans. Therefore it has become necessary now to implement some measures in order to resolve this issue. Various techniques like rain water harvesting have been implemented in order to divert the people from using ground water for drinking and other household purposes which lead to exposure to arsenic.

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VI. REFERENCES

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