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Research Article

ANALYSIS OF ARSENIC TOXICITY AND RELATED HEALTH HAZARDS IN VARIOUS BLOCKS OF MURSHIDABAD DISTRICT

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ABSTRACT

Arsenic contamination in soil and groundwater is one of the serious health hazards from a global perspective. Nine districts of West Bengal are affected by arsenic toxicity. The regions in the eastern side of Bhagirathi River are severely affected. We have analyzed the level of arsenic toxicity in nine blocks of Murshidabad district. The situation in these blocks are extremely alarming as seven of the nine blocks have 30 - 50 % groundwater samples containing arsenic > 50 µg/l, a concentration declared unsafe by World Health Organization in absence of alternative source of drinking water. If we consider all the blocks, minimum 36% of the tested water samples contain arsenic > 10 µg/l (the permissible limit prescribed by U. S. Environmental Protection Agency). There are blocks where 78% of the water samples contain arsenic > 10 µg/l. Exposure to arsenic at this level for considerable period of time would lead to cardiovascular, respiratory and gastrointestinal disorders. It will have neurological, haematological and dermal effects. Also, it will affect the renal and hepatic systems. The other potential health effects faced by residents of these blocks could be chromosomal aberrations and genetic mutations, leading to cancers of bladder, kidney, intestine, lung and liver. Although arsenic poisoning could be treated with drugs, the only remedy is to switch over to uncontaminated sources of drinking water and food. For this purpose, innovative technologies like bioremediation, phytoremediation, rhizoremediation and inhibition of biomagnification could be used.

INTRODUCTION

Arsenic is a toxic metal and a major contaminant of soil and water. It has a cosmopolitan distribution and affects the healthy lives of huge number of individuals in the globe. Although natural processes deposit arsenic in soil and groundwater, anthropogenic activities have elevated its level to such an extent that it has become the cause for one of the major health concerns throughout the globe. These anthropogenic activities include use of arsenic in disinfectants, weedicides, pesticides etc., from which it can easily find its way in the soil and groundwater, and gets magnified as its moves up in a food chain (Pais IJ and Benton Jons JR, 1997). Biomagnification of arsenic is one of the major concerns related to contamination of food materials. Arsenic is found in rice and also in cow's milk (Huq Imamul SM *et al*., 2006, Chen Y *et al*., 2017). The major concern is the menace of arsenic contamination which could not be completely eradicated. However, it could be mitigated to a great extent. Arsenic occurs in nature in two predominant forms- Arsenite (III) +3 and Arsenate (V) +5 (Dey U *et al*., 2016). Also, Arsenide (-3) occurs in some inter-metallic alloys. Arsenic also occurs in organic forms as Arsenobetaine and Arsenocholine and as arsine gas. The organic forms of arsenic are comparatively less toxic compared to the inorganic forms. Further, within the body arsenic is converted to less toxic forms like Monomethylarsonic acid (MMA) and Dimethylarsonic acid (DMA), predominantly in liver and subsequently, excreted from the body. Arsenic toxicity is related to health issues like

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skin lesions, respiratory and cardiovascular diseases and cancers of kidney, liver, intestine, skin etc. (Smith AH *et al.,* 1992, Ratnaike RN, 2003, Hendryx M, 2009). The early symptoms include general weakness, fatigue, headache and subsequent appearance of spots in the skin.

U.S. Environmental Protection Agency and WHO have set the permissible limit of arsenic to 10 µg/l in drinking water (EPA, 2006, WHO, 2011). In India, in absence of alternative source of drinking water the permissible limit is 50 µg/l, as prescribed by WHO (WHO, 2011). In the lower Gangetic plain in West Bengal and in the Ganga-Brahmaputra delta in Bangladesh arsenic contamination in soil and groundwater has reached alarming levels. In West Bengal nine districts are affected by arsenic. North 24-Pargana, Nadia, Malda and Murshidabad are amongst the severely affected districts of West Bengal. South 24- Pargana is moderately affected by arsenic contamination. Barddhaman, Howrah, Hooghly and Kolkata are amongst the less affected districts. There are 26 blocks in Murshidabad districts which include 2414 villages and wards. The district is separated from Bangladesh by river Ganga. River Bhagirathi divides the district into two parts. Blocks situated in the western and eastern side of Bhagirathi river are differentially affected. Only 11.7% and 30.1% of blocks situated in the western side of the Bhagirathi river are contaminated with arsenic at a concentration above 50 µg/l and 10 µg/l, respectively. The blocks located on the eastern side of Bhagirathi river are more contaminated (64.7% above 10 ug/l and 32.5% above 50 ug/l) (Rahman MM *et al*., 2005). The major point of concern is a major portion of the population in Murshidabad district uses groundwater as a source of drinking water and for cooking purposes. Also, the groundwater of some regions precisely the hand tube wells, which are safe according to WHO standards are currently becoming unsafe. In our study we have concentrated on a few blocks of on a few blocks of Murshidabad district and the level of arsenic toxicity in these blocks, potential health hazards faced by the population of these blocks and some remedial measures that could be undertaken.

METHODS

Analysis of surveys, reports and data from PHED (Public Health Engineering Department), SWID (State Water Investigator Directorate) and SOES (School of Environmental Science, Jadavpur University, West Bengal)

In depth study of Medical effects of arsenic toxicity in a dose dependent manner from Medical Books and Research Papers

RESULTS

Status of various blocks of Murshidabad district with respect to Arsenic contamination

We have analyzed the groundwater contamination by arsenic in Berhampore, Harihapara, Domkal, Beldanga I, Beldanga II, Lalgola, Bhagobangola I, Bhagobangola II and Jalangi blocks. According to the guideline of U.S. Environmental Protection Agency, the permissible limit of arsenic in groundwater used for consumption should be within 10 µg/l. The situation is extremely alarming in Jalangi, Lalgola and Bhagobangola II, where the percentages of water samples containing arsenic greater than 10 µg/l are 77.8%, 73.0% and 71.6%, respectively. In Domkal, Hariharpara, Bhagobangola I and Beldanga I, the percentages of water samples having > 10µg/l arsenic is high and correspond to 69.6%, 63.2%, 61.2%, and 61.1%, respectively. Comparatively, the same percentage is slightly on the lower side for the groundwater of Berhampore (46.3%) and Beldanga II (36.5%). WHO provided a guideline according to which, in absence of any alternative source of drinking water, the maximum permissible limit of arsenic could be 50 µg/l. In the blocks of Jalangi and Bhagobangola II 50.9% and 43.0%, respectively, of the tested water samples contain arsenic greater than 50µg/l, which could have disastrous consequences on the residents of these blocks. The situation is equally alarming for the residents of Domkal, Beldanga I, Lalgola, Hariharpara and Bhagobangola I, where 35.0%, 34.7%, 34.5%, 33.4%, and 30.6%, respectively, of the tested water samples posses arsenic greater than 50 µg/l. Again the situation is slightly better in Berhampore and Beldanga II where 15.6% and 12.5%, respectively, of the water samples contain arsenic above 50 µg/l. A similar trend was observed with respect to the maximum concentration of arsenic in groundwater, where Jalangi, Bhagobangola II and Beldanga I showed 2040 µg/l, 1852 µg/l and 1700 µg/l, respectively, of arsenic in the tested samples. Domkal, Bhagobangola I, Hariharpara and Lalgola showed arsenic concentration of 1300 µg/l, 1285 µg/l, 1160 µg/l and 1028 µg/l, respectively, as the maximum concentration of arsenic in the tested samples. If these sources of groundwater were used for drinking and cooking purposes, it would result in acute arsenic toxicity symptoms and would be fatal if consumed for substantial period of time. Berhampore and Beldanga II showed the maximum arsenic concentration in the tested samples as 635 µg/l and 345 µg/l, respectively (EPA, 2006, WHO, 2011, SOES, 2006).

Potential health hazards encountered by residents of aforesaid blocks of Murshidabad district

The initial symptoms of arsenic poisoning are rather non-specific. It include general weakness, fatigue, headache, nausea, vomiting etc. However, the high levels of arsenic to which the residents of aforesaid blocks of Murshidabad district were exposed, would result in serious health consequences. Thickening of arteries and myocardial infarction could be observed in children of all blocks other than Beldanga II and Berhampore based on the level of arsenic consumption. The effects of arsenic toxicity on the respiratory system could be due to occupational exposure or consumption of arsenic through drinking water. However, bronchial asthma is caused by intake of arsenic through drinking water. The residents of all the blocks are susceptible to respiratory system disorders. Also, except for Beldanga II and Berhampore, in all the other blocks conditions like cyanosis of fingers and toes could be observed. Gastrointestinal system is affected in case of acute arsenic poisoning leading to nausea, vomiting and diarrhoea. Consumption of drinking water containing more than 0.6 µg/l arsenic could lead to gastrointestinal effects. The maximum arsenic concentration of all the districts other than Berhampore and Beldanga II are above this level.

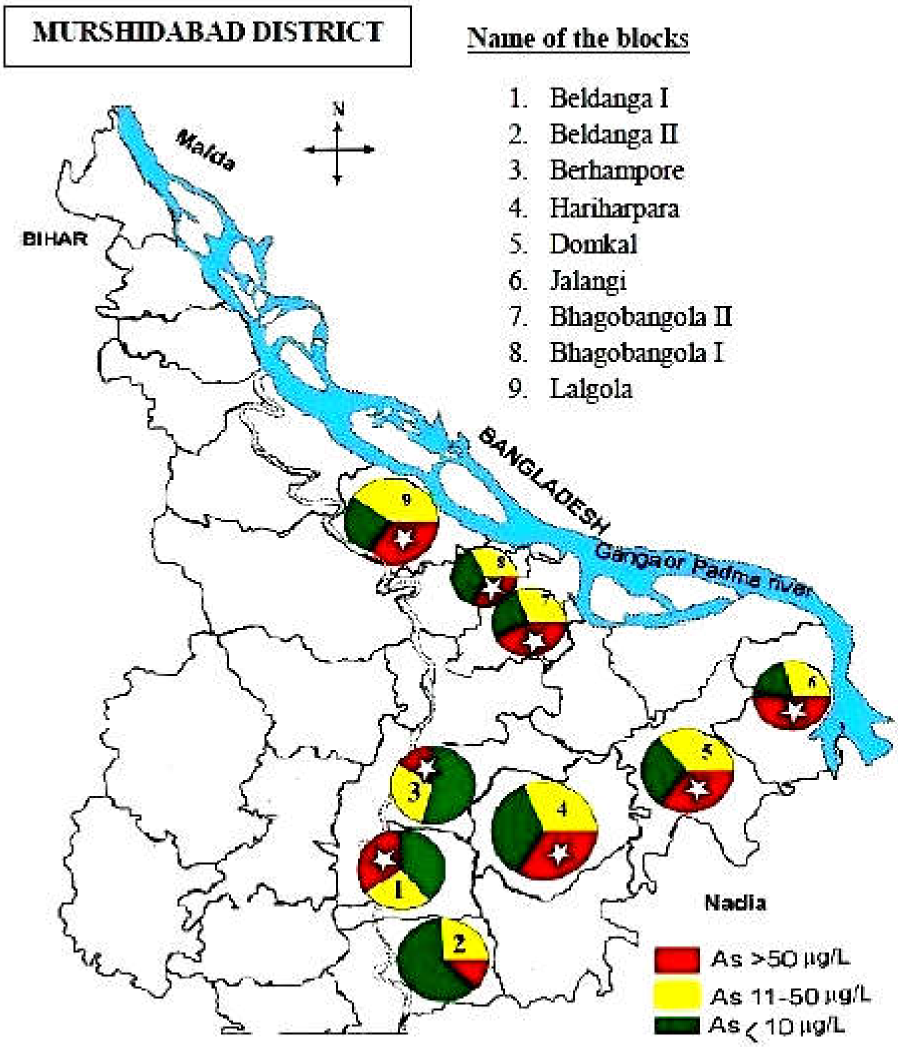

Figure 1. Various blocks of Murshidabad district and the corresponding levels of arsenic found in groundwater samples (SOES, 2006)

Since, the elimination of arsenic requires its conversion to less toxic form and excretion through urine, both hepatic system (liver) and renal system (kidney) are affected by even low level exposure to arsenic over a considerable period of time.

Therefore, residents of all the blocks are susceptible to these effects. Exposure to arsenic poisoning at higher levels could lead to haematological disorders like anaemia and leucopenia. Hence, the residents of Jalangi and Bhagobangola II are especially susceptible to these kinds of pathological conditions. Skin disorders like warts, corns on soles and palms, general hyperkeratosis, hyperpigmentation followed by hypopigmentation could be observed if arsenic is consumed at the level of 0.01 mg - 0.1 mg/Kg/day or more. Skin lesions could develop at advanced stages of arsenic poisoning. Therefore, residents of all the blocks are susceptible to dermal effects of arsenic poisoning. Besides this, the residents of all the aforesaid blocks are susceptible to the neurological effects which include headache, lethargy, mental confusion etc. Arsenic poisoning also leads to chromosomal aberration and genetic mutations. Therefore, consumption of arsenic at the level found in the above mentioned blocks over prolonged period of time could lead to the cancers of skin, lung, bladder, kidney, liver, intestine etc. (Saha JC *et al*., 1999, Yoshida T *et al*., 2004, Rahman MM *et al*., 2009).

Remedial measures to combat arsenic toxicity in the blocks of Murshidabad district

Chronic arsenic toxicity could be treated by using penicillamine, however, treatment with BAL (British Antilewisite) is a better option. DMSA/DMPS could also be used for cleaning melanosis. Another promising drug which could be orally administered to treat arsenic toxicity is Captosuccinic acid. Urea and Salicylate ointments could be used for treating the skin (Saha JC *et al*., 1999). However, once the complication has developed, no medicine is found to be effective. The only remedial measure to combat arsenic toxicity is to reduce the concentration of arsenic in the drinking water and food and bring it within the permissible limit. Rice, one of the staple food crops in Ganga- Brahmaputra plain could easily be contaminated with arsenic, when grown in the soil containing large concentration of arsenic. So, food samples grown in the affected regions should be tested for arsenic concentration before consumption. The water samples must also be tested accordingly. The tube wells should be clearly marked as safe and unsafe with respect to arsenic levels. The tube wells should have the depth to reach the aquifer, where the arsenic concentration is minimum. A knowledge regarding the groundwater resources and corresponding geology of region is essential for this purpose. Also, the tube wells established by

Public Health Engineering Department of West Bengal and the tube wells fitted with arsenic filters should only be used. Periodic examination of safe tube wells should be done to ensure the quality of the water and arsenic filters should be replaced with time. Water processing plants could be established at the block level to supply purified drinking water. Lastly, innovative strategies like bioremediation, rhizoremediation and phytoremediation should be considered where bacteria, fungi, algae and plants are used to reduce the levels of toxic forms of arsenic in soil and groundwater (Silver S and Phung L Te, 2005, Tangahu BV *et al*., 2011, Majumdar A *et al*., 2013, Chang JS, 2015, Dey U *et al*., 2016, Pyne S and Santra SC, 2017). With further advancement genetically engineered varieties of food crops can be used, which are modified in such a manner that the uptake of arsenic by the food crops and biomagnification of arsenic within the food chain is prevented.

DISCUSSION

Arsenic poisoning of soil and groundwater is one of the menace faced by the modern world. Increase in the concentration of arsenic in the soil and groundwater could be due to natural processes. However, the levels of arsenic contamination, which would pose potential threats to the lives of humans, have mainly occurred due to the anthropogenic activities. The uncontrolled use of arsenic in disinfectants, weedicides, pesticides etc. has led to its accumulation in soil and groundwater at fatal levels (Pais IJ and Benton Jons JR, 1997). The contamination of groundwater by arsenic is a serious problem in the plains of Ganga- Brahmaputra river system (SOES, 2006). Bangladesh and the state of West Bengal in India are severely affected by this. In West Bengal nine districts are affected by arsenic toxicity. The regions lying in the eastern bank of river Bhagirathi has alarmingly high concentration of arsenic (Rahman MM *et al*., 2005). Murshidabad is one of the most arsenic affected districts of West Bengal. We have concentrated our study on nine blocks of Murshidabad district. According to U.S. Environmental Protection Agency and WHO, the permissible limit of arsenic concentration in consumable water is 10 µg/l (EPA, 2006, WHO, 2011). However, in absence of any alternate source of drinking water WHO recommended 50 µg/l as the limit of arsenic in drinking water (WHO, 2011). Interestingly, in countries like Canada and Australia the permissible limit is 5 µg/l and 7 µg/l, respectively, which indicates that arsenic consumption at 10 µg/l or 50 µg/l could have health consequences (Kapaj S *et al*., 2006).

Our analysis showed seven of the nine blocks have more than 50% of water samples tested with arsenic concentration > 10 µg/l. In a similar manner, seven out of the nine blocks have more than 30% of water samples tested with arsenic concentration > 50 µg/l. Also, seven blocks have more than 1000 µg/l arsenic concentration as the maximum concentration of arsenic in the tested samples. In a nutshell, blocks like Jalangi, Bhagobangola II, Lalgola and Domkal are severely affected by arsenic toxicity. Hariharpara, Bhagobangola I and Beldanga I are moderately affected, whereas, Berhampore and Beldanga II are somewhat less affected. Most importantly, the groundwater sources once considered safe are progressively becoming arsenic contaminated. Staple food crops like rice is also showing arsenic contamination leading to biomagnification of arsenic in the food chain. The health hazards faced by the residents of these blocks depend upon the doses of arsenic consumed i.e. mg/kg/day, over a substantive period of time. However, in the generalized form, the residents of these blocks could potentially develop respiratory, cardiovascular and gastrointestinal disorders due to arsenic toxicity. The toxic arsenic would also have effects on hepatic and renal systems, along with dermal, neurological and haematological effects. Further, chromosomal aberrations and genetic mutations due to arsenic poisoning would be a potential threat for various types of cancers, like cancer of liver, kidney, bladder, lung, intestine etc. (Saha JC *et al*., 1999, Yoshida T *et al*., 2004). Although drugs like penicillamine and BAL could be used in case of arsenic poisoning, the clinical studies showed that the only remedial measure for arsenic poisoning is to consume uncontaminated water and food stuffs. Once the complications of arsenic toxicity sets in, no medicine is found to be effective. Therefore, tube wells harvesting water from deeper aquifers, uncontaminated with arsenic should be used. This requires knowledge of groundwater resources and the geology of the region. Further, tube wells established by PHED and other government initiatives and the sources of drinking water containing arsenic filters should be used. Also, a paradigm shift could be made with respect to the sources of drinking water. Surface water sources should be used after filtration and innovative strategies like rain water harvesting could be implemented. Also, bioremediation, phytoremediation and rhizoremediation could be used as biotechnological tools to mitigate the concentration of arsenic in soil and sub soil water (Silver S and Phung L Te, 2005, Tangahu BV *et al*., 2011, Majumdar A *et al*., 2013, Chang JS, 2015, Dey U *et al*., 2016, Pyne S and Santra SC. 2017). Genetic engineering could generate mutant varieties of food crops resistant to arsenic uptake (Chen Y *et al*., 2017). To combat the toxic effects of arsenic use of state of the art technology and biotechnology is the need of the hour.

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