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Original Article

Arsenic in Surface Water of Murshidabad, West Bengal, India: An Unprecedented Situation

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Abstract

Arsenic contamination in groundwater in the Ganga- Brahmaputra basin in India and Padma-Meghna basin in Bangladesh and its consequences to the human health have been reported as one of the world's biggest natural groundwater calamities to the mankind. In India, seven states namely- West Bengal, Jharkhand, Bihar, Uttar Pradesh, Assam and Manipur and some parts in Chhattisgarh state have so far been reported affected by Arsenic contamination in groundwater above the permissible limit of 10 μg/L. People in these affected states have chronically been exposed to drinking Arsenic contaminated hand tube-wells water. With every new survey, more Arsenic affected villages and people suffering from Arsenic related diseases are being reported, and the issues are getting complicated by a number of unknown factors. Arsenic is said to be absent in the surface water like rivers, lakes, ponds etc. A recent survey in Murshidabad district, West Bengal, India reveals that arsenic contamination is also available in Ganga water and other surface water bodies. In river Ganga, at upper Murshibad region it is 0.0006 to 0.0013 mg/L, in its lower part the amount varies from 0.0008 to 0.0182 mg/L. The surface water bodies are also contaminated in varying degree (0.0014 to 0.0188 mg/L). The water supplies by the Berhampore municipality also contain 0.001 to 0.0444 mg/L. The probable source of contamination is the ground water. Huge amount of ground water is taken out by pumps for household purposes, this water is drained in the river without any treatment. In a study, it is found that the sewage falling in Ganga contain 0.0010 to 0.0444 mg/L arsenic. When arsenic is found in the surface water, it will definitely enter the food chain through plants and animals. The biological magnification poses greater threat to human being.

Keywords: Arsenic; Ganga; Murshidabad; Surface Water; Food Chain.

Introduction

Source of Arsenic in Water

Arsenic pollution is a menace to all of us. A major part of India is affected by arsenic pollution. The impact of arsenic pollution on human being, plants, other animals and environment is alarming. In West Bengal several district such as 24 Parganas (North & South), Nadia, Burdwan, Malda and Murshidabad are being affected very badly. Arsenic is found widely in nature and most abundantly in sulphide ores. The arsenic loaded iron particles are then flushed into the sand layer below (Acharyya *et al,* 1993, 1999). Arsenic is generally found in the ground water. This is known to be absent in surface water because it is thought to be oxidized and sediment. Other sources of arsenic are-

1. Some rodenticides used in the agricultural field and urban area contain arsenic.
2. Factories in India, where copper is melted, in one step of the process, arsenic is obtained as a byproduct and the factory dump this without proper safety measures.
3. In some regions, in some layer of soil, arsenic may be there. Arsenic released through some chemical process and dissolved in the water of that layer. If the tube well pumps out water from the layer, arsenic may be present above the permissible limit.
4. High arsenic concentration in ground water is generally associated with the geochemical

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environments.

5. The principle sources of arsenic are from arsenic bearing geologic material. The presence of sulphide mineral deposits in the field and the association of arsenic with such types of minerals suggest very strongly that these are the origin for the near field arsenic sources.
6. Reports indicate that high concentrations of arsenic are grounded primarily in the upper 150 meters of the alluvial sediments (Acharyya *et al,* 1993, 1999).

Arsenic Toxicity

Acute poisoning may occur due to accidental ingestion of inorganic arsenic compounds (e.g. arsenic trioxide). Cases of poisoning are characterized by profound gastrointestinal damage, resulting in severe vomiting and diarrhea which may result in shock and subsequent oliguria and albuminuia. Other acute symptoms may occur within a few minutes following exposure to the poison in solution out may be delayed for several hours if the arsenic compound is solid form or if it is taken with a meal. When ingested as a particulate, toxicity is also dependent on solubility and particle size of the ingested compound. The fatal dose of ingested arsenic trioxide has been reported to range from 70 to 180 mg./lit. Death may occur within 24 hours but the usual course runs from 3 to 7 days. Acute intoxication with arsenic compounds is usually accompanied by anemia and leucopenia especially granulocyopenia. In survivors these effects are usually reversible within 2 or 3 weeks. Reversible enlargement of the liver is also seen in acute poisoning. Exposure to irritant arsenic compounds in air, such as arsenic trioxide can causes acute damage to mucous membranes of the respiratory systems and can cause acute symptoms from exposed skin. Severe irritation of the nasal mucosa, larynx and bronchi as well as conjunctivitis and dermatitis occur in such cases (WHO, 1993).

Chronic arsenic poisoning may occurs in worker exposed for a long time to excessive concentration of airborne arsenic compounds. Local effects in the mucous membranes of the respiratory tract and skin effects are prominent features. Involvement of the nervous and circulatory systems and the liver may also occur as well as cancer of the respiratory tract. With long term exposure to arsenic via ingestion in food, drinking water or medications, symptoms are partly different from those after inhalation exposure. Vague abdominal symptoms–diarrhoea or constipation, flushing of the skin, pigmentation and hyperkeratosis–dominate the clinical picture. Anaemia and lucocytopenia often occur in chronic arsenic poisoning. Liver involvement has been more commonly seen in persons exposed for a long time via oral ingestion than in those exposed via inhalation. Arsenical skin lesions are some what different depending on the type of exposure. Eczematous symptoms of varying degrees of severity do occur. Two types of dermatological disorders may occur (WHO, 1993).

1. An eczematous type with erythema, swelling and papules or vesicles ; and

2. A follicular type with erythema and follicular swelling or follicular pustules.

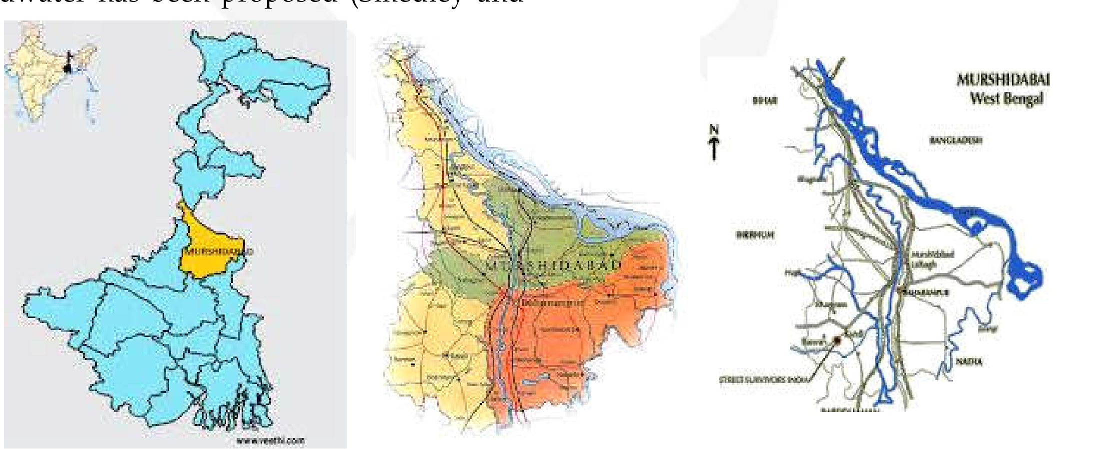
Dermatitis is primarily localized on the most heavily exposed areas such as the face, back of the neck, forearms, wrists and hands. Chromic dermal lesions may occur depending on the concentration and duration of exposure. These chronic lesions may occur after many years of environmental exposure. Hyperkeratosis, warts and nekabisus of the skin and the conspicuous signs in chronic skin lesions poisoning depigmentation , i.e. Leukoderma, especially on the pigmented areas, commonly called 'raindrop' pigmentation also occurs. These chronic skin lesions, particularly the hyperkeratosis may develop into precancerous and cancerous lesions. Mucous membrane lesions in chronic arsenic exposure are most classically reported as perforation of the nasal septum after inhalation exposure. This lesion is a result of irritation of the mucous membranes of the nose (WHO, 1993).

Arsenic in Water

In most studied areas it was seen that high-arsenic groundwater was not related to areas of high arsenic concentration in the source rock. Two key factors were identified: first, there should be very specific biogeochemical triggers to mobilize arsenic from the solid/sorbed phase to groundwater, and second, the mobilized arsenic should have sufficient time to accumulate and not be flushed away, that is, it should be retained in the aquifer (Smedley and Kinniburgh, 2002). In other words, arsenic released from the source should be quick, relative to the rate of groundwater flushing. There are number of processes for mobilization of arsenic in groundwater namely, (i) mineral dissolution, (ii) desorption of arsenic under alkaline and oxidizing conditions, (iii) desorption and dissolution of arsenic under reducing conditions, (iv) reduction of oxide mineral surface area, and (v) reduction in bond strength between arsenic and holt mineral surface (Smedley and Kinniburgh, 2002).

Oxidation of sulphide minerals (pyrite-FeS_2) was advocated strongly by many investigators in West Bengal as the cause of groundwater arsenic contamination (Das et al., 1994). According to this hypothesis, arsenic is released from the sulfide minerals (arseno-pyrite) in the shallow aquifer due to oxidation (Mandal et al., 1998). The lowering of water table owing to over exploitation of groundwater for irrigation is the cause of release of arsenic. A recent research study explained that desorption or dissolution of arsenic from iron oxides could be the process on regional distributions of arsenic in water (Smedley, 2004). Broadly, it can be stated that some critical reactions to transform to reducing conditions and subsequent arsenic release are likely to take place to reduce arsenic from its oxidized As (V) form to its reduced As(III) form. Under many conditions, As (III) is less strongly adsorbed to iron oxides than As(V). Dissolution of the iron oxides themselves under reducing conditions is another potentially important process. Some investigators explained that excessive use of water for irrigation and use of fertilizers have caused mobilization of phosphate from fertilizers down below the shallow aquifers, which have resulted in the mobilization of Arsenic due to anion exchange onto the reactive mineral surfaces. Sikdar and Chakraborty (2008) attributed that the combined processes of recharge of groundwater from rainfall, sediment water interaction, groundwater flow, infiltration of irrigation return water (which is arsenic rich due to the use of arsenic-bearing pesticides, wood preservatives, etc. and the pumping of arsenic-rich groundwater for agriculture purpose), oxidation of natural or anthropogenic organic matter and the reductive dissolution of ferric iron and manganese oxides, played a key role in the evolution of groundwater arsenic contamination in the area. Recently, a new hypothesis based on displacement of arsenic by dissolved bicarbonate as an alternative mechanism for the genesis of high-arsenic groundwater has been proposed (Smedley and Kinniburgh, 2002). The occurrence of arsnic in groundwater is well studied in West Bengal, the major problem is that it is coming in the food chain through water used for irrigation purpose (Bhattacharya *et al*, 2009, 2010; Iva *et al* , 2015). It is a convention that Arsenic is never found in surface water because surface water is rainfed mainly, thus surface water is safe for drinking and other purpose (Mukherjee-Goswami *et al*, 2008). During survey of Icthyofauna in Murshidabad district a number of water bodies were encountered. As per guidelines the water quality parameters have to be measured. It was also observed that all the major towns in Murshidabad do not have any sewage water treatment plant. They are directly disposing waste water in Ganga or the water bodies nearby. Moreover most of the households are dependent on ground water, use tube wells or pumps. The waste water produced by each and every house drains outside in municipality drains. These drains created a network, collect all the waste water and directly dispose water in Ganga or in 'Beels'. As we know, Murshidabad is highly contaminated with Arsenic, out of curiosity the surface water were tested in the laboratory. Arsenic was found and then the water samples were sent to PWD (Irrigation Laboratory), Government of West Bengal for confirmation (Sevabrata, Murshidabad, 742134).

Murshidabad is a district of West Bengal in eastern India. Situated on the left bank of the river Ganges, the district is very fertile. Covering an area of 5,341 km² (2,062 sq mi) and having a population 5.863m (according to 2001 census) it is a densely populated district and the ninth most populous in India (out of 640). It borders Malda district to the north, Jharkhand's Sahebganj district and Pakur district to the north-west, Birbhum to the west, Bardhaman to the south-west and Nadia district due south. The international border with Bangladesh's Rajshahi division is on the east. Berhampore is the headquarters of the district.



Map and location of the Major Rivers in Murshidabaad

Landscape, Rivers and Vegetation

The district comprises two distinct regions separated by the Bhagirathi River. To the west lies the Rarh, a high, undulating continuation of the Chota Nagpur plateau. The eastern portion, the Bagri, is a fertile, low-lying alluvial tract, part of the Ganges Delta. The district is drained by the Bhagirathi and Jalangi rivers and their tributaries. Bhagirathi is a branch of the Ganges, and flows southwards from Farakka barrage where it originates from the Ganges. It flows southwards through the district and divides it into more or less equal halves.

Materials and Methods

The sample water collected fixed with conc. HCl (2% of sample volume). Arsenic is measured in Spectrophotometer compared with standard curve after proper procedure. The procedure was taken from Narayan *et al*, 2006. Fe(Iron) content was also measured in the laboratory of some selected sample because arsenic is found associated with Fe frequently. The Ganga water was collected at different points at 100 Km stretch in pre-monsoon and post monsoon period. The collection point included urban and rural areas. Water sample from 'Beels' in and around Berhampore were also collected in pre-monsoon (March-April) and post-monsoon (Sepetember-October) period. The photograph of the Municipality outlet pouring directly in Ganga were also taken. The sample water was also collected from 3 major outlets of Berhampore municipality. Two of these channels are directly connected with Ganga and one is with Chaltia 'Beel'. The drinking water supplied in the houses is measured for Arsenic.

Observation

The following results were obtained in the laboratory and confirmed by PWD laboratory

Table 1: Arsenic content of surface water in berhampore municipality area

Sample Water	**Post Monsoon (As mg/L ± SD)**	**Pre Monsoon (As mg/L ± SD)**	Pre Monsoon (Fe mg/L)	Post Monsoon (Fe mg/L)
Ganga (Farasdanga Ghat)	0.0041 ± 0.0007	0.0112 ± 0.00004	Not measured	0.11
Ganga (Kandi Bus Stand)	0.0108 ± 0.0003	0.0118 ± 0.0002	1.00	0.22
Ganga (Haridas mati)	0.0005 ± 0.0001	0.0005 ± 0.0006	Not measured	0.1
Outlet 1 falling in Ganga (Kandi Bus Stand)	0.0079± 0.0002	0.0212 ± 0.0009	0.48	0.42
Outlet 2 falling in Ganga (Gorabazar)	0.0010 ± 0.0007	0.0444± 0.0005	0.49	0.40
Main Drain of Berhampore Munisapality (going to Chaltia Beel)	0.0118 ± 0.0007	0.0364 ± 0.0004	0.31	0.12
Chaltia Beel	0.0024 ± 0.0003	0.0048± 0.0008	Not measured	0.07
Bishnupur Wetland (Beel)	0.0087 ± 0.0003	0.0133 ± 0.0008	0.1	0.27
Indraprastha Beel	0.007 ± 0.0001	0.0118± 0.0008	Not measured	0.45
Dhupghati Beel	0.0122± 0.0004	0.0188 ± 0.0006	Not measured	0.38
Laldighi (Control Wetland)	0.0014±0.0001	0.0018 ± 0.0001	Not measured	0.16
Tap Water (Municipality Supplied)	0.0208± 0.0002	0.0512 ± 0.0002	0.39	0.92

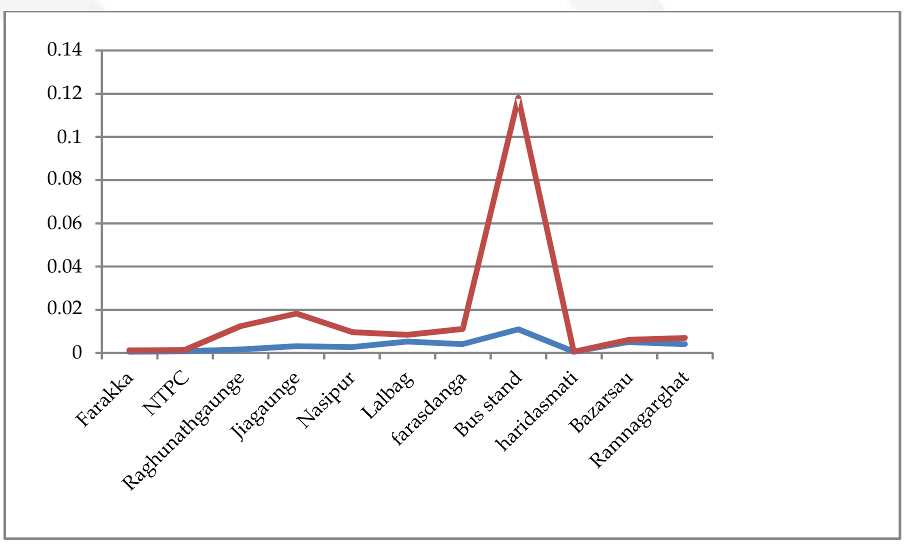


Fig. 1: Arsenic occurance in 100 km stretch in Ganga of Murshidabad. The blue is Pre-monsoon and red indicate Pre-monsoon occurrence of Arsenic in water

Table 2: Arsenic content of ganga water in murshidabad district

Sample site	Post monsoon (mg/L ± SD)	Pre monsoon (mg/L ± SD)
Farkka Feeder Canal	0.0006 ± 0.0001	0.0013± 0.0004
NTPC	0.0008 ± 0.0001	0.0014 ± 0.0005
Raghunathgaunge/Jangipur	0.0017 ± 0.0007	0.0124 ± 0.0009
Jiagaunge/Azimgaunge	0.0032 ± 0.0006	0.0182 ± 0.0008
Nasipur	0.0027 ± 0.0001	0.0096 ± 0.0003
Murshidabad/Lalbag	0.0053 ± 0.0003	0.0084 ± 0.0006
Bazarsau	0.0050 ± 0.0004	0.0061 ± 0.0004
Ranmnagar Ghat	0.0041 ± 0.0004	0.0069 ± 0.0007

Sewage water falling in Ganga

Gorabazar, Berhampore

Murshidabad

Kandi Bus Stand Bazar, Berhampore

Gopalghat, Berhampore

Raghunathgaunge

NTPC, Farakka

Jiagaunge

Discussion

It is a myth that arsenic is never obtained in surface water, so drinking surface water is safe. From the above observations, it is evident that arsenic is found in surface water in Murshidabad district of West Bengal and in some cases it is above WHO recommended level. It is much more alarming because arsenic will magnify biologically through aquatic food chain. Arsenic will be absorbed by plants, enter in the herbivore aquatic animals, herbivore consumed by carnivore and we take both the herbivore and carnivore fish. Occurrence of arsenic in food chain is already known in the terrestrial ecosystem. The source of arsenic in ground water is well studied but the source in river water is not known. It may enter from the bedrock. But the presence of arsenic in lentic system can not be explained. The probable reason of arsenic contamination is sewage water discharge from locality directly in the surface water bodies. It this study it is found that the sewage water going directly in various water bodies in and around Berhampore, Murshidabad, Jangipur, Raghunathgaunge and other places. As the people of these townships are using ground water, the contamination is going in the surface water through drainage systems. All the 'Beels" are contaminated. The sample from Ganga is collected at 100 km stretch, all these sample contain arsenic. The amount is highest near Municipality outlet. The arsenic contaminated Ganga water is taken back in Berhampore Municipality, purified in JNURM project and supplied as drinking water, that contain even more amount of arsenic. As all the sewage water sample contain high amount of arsenic, the sewage is definitely the source of arsenic in surface water. All the "Beels" are land locked, rainfed so there should not be any arsenic contamination in the 'Beels". The drains that are carrying arsenic are contaminating the 'Beels". The post-monsoon amount is low but the pre-monsoon amount of arsenic is high. The amount of arsenic in Ganga is high near the urban areas (Raghunathgaunge, Jiagaunge, Murshidabad, Berhampore) in comparison to rural areas (Hridasmati, Nasipur, Bazasau, Ramnagar Ghat). There is a need for water treatment as well as sewage treatment plant in large scale. Only then the treated sewage water can be released in Ganga or other water bodies. This type of sustainable development can only make us arsenic free.

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