

Groundwater Arsenic contamination in three blocks of Golaghat District of Assam

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Abstract

Contamination of Groundwater by arsenic and its adverse effect on human being have been reported in 20 countries in different parts of the world. The magnitude is considered highest in Bangladesh followed by India, Mangolia, China and Taiwan. Groundwater arsenic contamination has raised its ugly head recently in Assam, India, where people are thought to be at risk due to continuous consumption of arsenic rich water. Arsenic concentration in groundwater samples from the three blocks viz. Dergaon (Golaghat North), Kathalguri (Golaghat Central), Podumoni (Golaghat East) of Golaghat district of Assam is presented here to access their suitability for potable purpose.

Water samples from the above mentioned blocks of Golaghat district of Assam were analysed for arsenic, iron and pH. It was observed that arsenic content of these samples varied from 0.001ppm to 0.073 ppm or mg/L and arsenic content of about 39.72% samples were beyond the permissible limit (0.01ppm) for drinking use. Maximum concentration of arsenic was observed at 0.073 ppm from Podumoni block. pH of these samples varied from 5.9 to 8.1 and iron from 0.28 ppm to 5.88 ppm. Statistical analysis of data reveals that correlation between arsenic and iron content of analysed water samples non significant ($r=0.168$).

INTRODUCTION:

Arsenic has been classified as a human carcinogen with chronic ingestion associated with skin cancer while inhalation is associated with lung cancer (WHO,2000). The greatest health concern with regard to regular exposure to arsenic derives from drinking waters containing elevated concentrations. Studies have shown that ingestion of arsenic rich waters leads to skin lesions in exposed populations, which are also subjected to, increased incidence of cancer of the skin (Smedley and Kinniburge, 2002). It has also been suggested that cancer of internal organs may result from this exposure. In addition, it has been suggested that exposure to arsenic-rich water increases the risk of vascular diseases, hypertension and diabetes mellitus (Jain and Ali, 2000). Arsenic is a naturally occurring poisonous chemical element and is always present as compound in combination with oxygen, sulphur and iron (Brewster and Chatterjee, 1994). Arsenic occurs in the environment

as a result of several inputs that contain this element in organic and/or inorganic forms. Organic arsenic is generally less toxic than inorganic arsenic (Chatterjee et al., 1995). The commonly existing inorganic arsenic species in ground water are in the form of arsenate (As^{5+}) and arsenite (As^{3+}) (Chatterjee et al., 1995). The later being more mobile and toxic (40-60 times) in living organisms (Korte and Fernando, 1991). The presence of arsenic in natural water is related to the process of leaching from the arsenic containing sources such as rocks and sediments (Robertson, 1989, Hering and Elimelech, 1995). There are as many as 150 arsenic bearing minerals that exist in nature. But only three of them i.e. realgar or arsenic disulphide (As_4S_4), orpiment or arsenic trisulphide (As_2S_3) and arsenopyrite or ferrous arsenic sulphide ($FeAsS$) are considered as arsenic ores (Sneed and Brasted, 1956). Occurrences of arsenic in natural water depend on local geology, hydrology and geochemical characteristics of the aquifer materials (Bhattacharya et al., 1997) Furthermore, the

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geochemical characteristics of the aquifer material and their interactions with the aqueous media also play an important role in controlling retention and/or mobility of arsenic within the subsurface environment (Bhattacharya et al., 1995). From the different studies related to arsenic, it is known that arsenic originates in Himalayan head waters of Ganga and Brahmaputra rivers and arsenic contaminated groundwater is found within the sediments between 20 to 100 meters below ground level in Brahmaputra alluvial plain. Arsenic occurrence in Assam may be due to heavy deposition of sediments (Singh, 2004).

Groundwater is an important source of domestic water in Assam. Here most of the domestic water is harnessed from groundwater through shallow tube wells and dug wells, but it is now clear that much of the groundwater in this region is contaminated with arsenic. This contamination may have a significant impact on the health of rural population. The rural people of Assam are mostly dependent on hand operated tube wells for drinking water. Unfortunately, it is now established that this water contains arsenic at concentrations higher than the safe limit (0.01mg/L or 0.01 ppm) set by WHO (WHO, 1998) for drinking purpose. There are reports of arsenic contamination of ground water in North-Eastern India (Singh, 2004). This paper reports the present status of arsenic in groundwater of three blocks of Golaghat district of Assam. The groundwater samples were collected during the pre monsoon period from 87 locations of Dergaon (Golaghat North), Kathalguri (Golaghat Central) and Podumoni block (Golaghat East) of Golaghat district. The sources of these water samples were deep tube wells (mark tube well and tara pump), shallow tube wells, open wells and public water supply. The depth of the tube wells were in the range of 66 feet to 220 feet. Public water supply system of these blocks is also ground water dependent. Collected samples were analysed for arsenic, iron and pH.

MATERIAL AND METHOD:

Hydride Generation-Atomic Absorption Spectrometry (HG-AAS) was used for analysis of arsenic in water samples. A Perkin Elmer Model Aanalyst 200, atomic absorption spectrometer (USA) fitted with Mercury Hydride System (MHS-15), EDL System 2 arsenic lamp (lamp current 400 mA), HP printer and Wipro Computer was used. For determining iron concentration of samples

Perkin Elmer Model Aanalyst 200, atomic absorption spectrometer (USA) with hollow cathode lamp (HCL) was used.

Reagents and glassware

All reagents are of analytical grade and deionised water was used throughout for reagent preparation. Stock solution (1000 ppm) of arsenic was prepared by dissolving appropriate amount of As_2O_3 (Merck, USA) and kept refrigerated in glass bottle. Calibration standards were prepared fresh at the time of analysis. The solution for hydride generation were 1.5% $NaBH_4$ (E-Merck, India) in 0.5% $NaOH$ (E. Merck, India). Reducing solutions i.e. KI + ascorbic acid (Merck, India) and 5.0 M solution of HCl (E. Merck, India) were prepared at the time of analysis. Stock solution of iron (100 ppm) was prepared by dissolving $FeSO_4 \cdot NH_4SO_4 \cdot 6H_2O$ (Merck, India) and kept refrigerated in glass bottle. Calibration standards were prepared daily before analysis. Glassware used for arsenic analysis were soaked in 1:1 HNO_3 for 24 Hours and rinsed thoroughly with deionised water before use.

Sample collection

Water samples were collected from deep tube wells, shallow tube wells, open well and public water supply. Tube wells were operated at least 10 minutes before collection to flush out the stagnant water inside the tube and to get fresh ground water. The water samples were collected in 1 Poly propylene bottles and sealed. pH of the water samples were determined by using pocket pH meter (Merck, India) on the spot. After pH determination, 1:1 HNO_3 solution was added to the collected water samples as preservative (to pH less than 2).

Procedure for the determination of arsenic and iron in water samples

Arsenic: For better sensitivity, As^{5+} was pre-reduced to As^{3+} before analysis. Pre-reduction was carried out by adding 1 ml KI solution (KI + Ascorbic acid) and 10 ml 5 mol/L HCl solution and 10 ml water sample in 50 ml volumetric flask. Then volume is made up to the mark by adding 0.15 mol/L HCl solution. Time given for pre-reduction was 30 minutes. 10 ml of pre-reduced water sample was analyzed using atomic absorption spectrometer (Perkin Elmer, USA) with MHS-15

(Mercury Hydride System) at 193.7 analytical wavelengths and 0.7 nm slit width. Radiation source was electrode less discharge lamp for arsenic with 20 sec. pre reaction purge time and 10 sec. post reaction purge time. The argon gas and sodium borohydride were used for hydride generation. Oxy-acetylene flame was used for determination.

Iron: 10 ml water sample was analyzed for iron content by using atomic absorption spectrometer (Perkin Elmer, USA) at 372 analytical wave length and 0.2 nm slit width using oxy-acetylene flame.

RESULTS AND DISCUSSION:

Block map (NIC, Assam State Unit, 2007). of Golaghat district was given in figure 1. The results of arsenic iron and pH of groundwater samples from Dergaon (Golaghat North), Kathalguri (Golaghat Central) and Podumoni (Golaghat East) block of Golaghat district are presented in table 1. From the data of table 1, it can be seen that the arsenic content of water samples varied from 0.001 to 0.073 ppm. Podumoni block shows maximum (67.57%) groundwater contamination by arsenic followed by Kathalguri block (44.45%). In Dergaon block only (7.14%) groundwater samples have been found to be arsenic contaminated. Maximum arsenic content recorded is 0.073 ppm in Podumoni block. From the results it is observed that arsenic concentration in Dergaon block varied from 0.001 to 0.022 ppm. In Kathalguri block it varies from 0.001 to 0.051 ppm and in Podumoni block it varied from 0.001 to 0.073 ppm. The variation of arsenic concentration in the three blocks of Golaghat district is shown in figure 2.

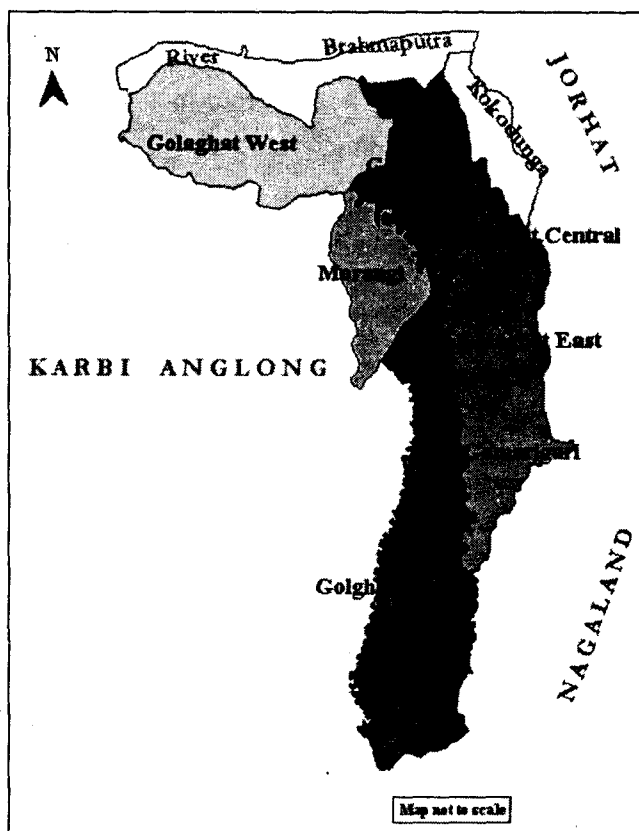


Figure 1: Golaghat District with Blocks

The variation of iron concentration in groundwater samples of the three blocks are Dergaon 0.434 to 5.47 ppm, Kathalguri 0.36 to 5.88 ppm and Podumoni 0.28 to 5.40 ppm respectively. The maximum concentration of iron was observed 5.88 ppm in Kathalguri block. From the data it is observed that 81.35% water samples have iron concentration above the permissible limit (1.0ppm) for drinking water. Graphical representation of iron content in water samples of different blocks are

TABLE 1: pH, iron and arsenic concentration in different water samples

District	Name of Block	No of samples collected and analyzed	pH (% of sample within the permissible limit)	Iron (ppm) (% of sample within the permissible limit)	Arsenic(ppm) (% of sample within the permissible limit)
Golaghat	Dergaon	14	5.9-7.7 (78.48)	0.434-5.47 (28.57)	0.001-0.022 (92.86)
	Kathalguri	36	6.2-8.1 (94.45)	0.36-5.88 (13.89)	0.001-0.051 (55.55)
	Podumoni	37	6.4-7.4 (94.60)	0.28-5.40 (13.51)	0.001-0.073 (32.43)

TABLE 2 : Arsenic concentration in water samples of different sources of three blocks

Blocks	No of samples analyzed	No. of Samples analyzed for Arsenic from different sources of water samples (minimum-maximum concentration of arsenic in ppm)		
		¹ DTW (min. - max.)	² STW (min. - max.)	³ OW (min. - max.)
Dergaon	14	5(0.002-0.006)	9(0.001-0.022)	—
Kathalguri	36	26(0.002-0.051)	9(0.001-0.035)	1(0.002)
Podumoni	37	24(0.001-0.073)	12(Tr-0.070)	1(0.006)

¹Deep Tube Well ²Shallow Tube Well ³Open Well

given in figure 3.

It is observed from table 1 that pH of water samples in Dergaon block varies from 5.9 to 7.7, in Kathalguri it varies from 6.2 to 8.1 and in Podumoni block it varies from 6.4 to 7.4. The pH of 89.21% samples is found within the permissible limit of 6.5 -8.5 for drinking water. The maximum value recorded was 8.1 in Kathalguri block. The variation of pH with different sampling points from the three blocks is shown in figure 4.

Data from table 2 indicates that groundwater samples of shallow tube well in Dergaon block have high arsenic content whereas samples from Kathalguri and Podumoni block have arsenic content higher in deep tube wells than the shallow tube wells. Samples from open wells have relatively low arsenic content than the other sources. Arsenic content of samples from deep tube wells of Dergaon block varied from 0.002 to 0.006 ppm where as arsenic in shallow tube wells of the same block varied from 0.001 to 0.022 ppm. In Kathalguri block arsenic concentration varied from 0.002 to 0.051 ppm in deep tube wells and in shallow tube wells it varied from 0.001 to 0.035 ppm. Similarly arsenic in water samples from deep tube wells of Podumoni block varied from 0.001 to 0.073 ppm, whereas in shallow tube wells it varied from traces to 0.070 ppm. The variation of arsenic concentration with different sampling points from different groundwater sources of the three blocks Dergaon, Kathalguri and Podumoni are shown in figure 5, figure 6 and figure 7 respectively. A negative correlation between arsenic and iron content in the three blocks was observed though the correlation coefficient value ($r=0.168$) is found to be non significant.

CONCLUSION:

The results reveal that out of three blocks of Golaghat district of Assam, Podumoni block shows maximum (67.57%) groundwater contamination by arsenic followed by Kathalguri block (44.45%). In Dergaon block only 7.14% ground water samples have been found to be arsenic contaminated. Results from table 2 shows that ground water samples of shallow tube wells of Dergaon block have high arsenic concentration compared to the deep tube wells. But in Kathalguri and Podumoni blocks, the ground water samples have high arsenic concentration in deep tube wells as compared to shallow tube wells. This may be due to the geological composition of those areas and so further study is needed for the same. Though the groundwater of the three blocks has been contaminated by arsenic, no symptoms of arsenic poisoning are observed till date. This is probably due to the presence of As^{5+} in ground water in high amount as compared to As^{3+} or due to some other reasons which are yet to be identified, but in near future, the problem of arsenicosis may arise. So a long term environmental planning is required to get rid of the ensuing danger of this pollution of groundwater.

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