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Status of arsenic contamination in potable water in Chawngte, Lawngtlai district, Mizoram

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Abstract

Arsenic is a naturally occurring element found primarily in rocks, soil, water, and plants in the Indian sub-continent. Natural events, such as infiltration to water, dissolution of minerals from clay, and erosion of rocks, can release arsenic into water. Arsenic is usually found in inorganic forms in water, the most predominant form being arsenate [As (V)], with arsenite [As (III)] under some conditions. In organism, it bonds with carbon and hydrogen, forming organic arsenic. The contamination of groundwater by arsenic in Chawngte, Mizoram, India is likely to happen due to its sharing of a common land border with Bangladesh. Groundwater and rainwater are the most important supplementary sources of drinking water in region. Hence, residents of Chawngte are relying on tuikhurs (spring) and other natural sources. It has been observed that several number of tube wells, tuikhurs and hand pumps, exist in any cluster or community. Generally, not all tube wells and hand pumps in an area are affected by arsenic. Therefore, the immediate challenge is to find out the unaffected ones in the affected areas and commence routine monitoring in order to stop using the currently affected tube wells as soon as arsenic is detected. The physico-chemical parameters like pH, EC, TDS, total hardness, total chlorides, iron and free chlorine are well within the acceptable limits for drinking water. Arsenic and turbidity are slightly higher than the acceptable limits but still within the permissible limit of 0.05 mg/l and 5 NTU respectively.

Key words: Arsenic; Chawngte; dissolution; water.

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INTRODUCTION

Arsenic is the 20th most common element in the earth's crust, and is associated with igneous and sedimentary rocks, particularly sulfidic ores. Arsenic compounds are found in rock, soil, water and air as well as in plant and animal tissues. Although elemental arsenic is not soluble in water, arsenic salts exhibit a wide range of solubility depending on pH and the ionic environment. Arsenic can exist in four valency states: –3, 0, +3 and +5. Under reducing conditions, the +3 valency state as arsenite (As^{III}) is the dominant form; the +5 valency state as arsenate (As^{V}) is generally the more stable form in oxygenized environments.[1,2] From the available reports[3,4] it has been noticed that most of the arsenic affected floodplains in Asia are by the side of the rivers that originate in the Himalayas or Tibet Plateau. Thus it is considered that Himalayas and surrounding mountains are potential sources of arsenic bearing minerals. Because the north-eastern hill states are part of the Himalayan mountain range, we anticipated finding groundwater arsenic contamination in the Newer Alluvium (Holocene) of the Surma.

The quality of water has been continuously declining globally in general and in developing countries in particular, due to natural and anthropogenic processes.[5,6] Drinking water is derived from a variety of sources depending on local availability: surface water (rivers, lakes, reservoirs and ponds), groundwater (hand pumps and seepage) and rain water. Amongst the three, rain water is the purest and ready to use. As it contains no mineral impurities etc. may not be recommended for domestic use. The surface and sub-surface water in fact get time to interact with the rocks, soils, organisms and all possible means on the earth as well as below the earth surface. As a result, the water becomes good enough with inclusion of requisite minerals required and good for health to human beings. In this process, sometimes water is also being recipient of some toxic content in form of heavy metals such as *viz.* cadmium, arsenic, nickel, etc. Presence of arsenic as major toxic components in groundwater has been established in the neighboring states of Assam, Tripura, Manipur and also in Bangladesh. However, it is first time reporting of arsenic from the territory of Mizoram from the localities bordering Tripura and Bangladesh.

Our drinking water today, far from being pure, contains some two hundred deadly commercial chemicals. Therefore, the demand of fresh water has to be fulfilled from its indigenous resources. Agricultural activities in the past decade have shown presence of toxic biochemical, pesticides and insecticides for agricultural productivity. This has led to the problem of Arsenic contamination, endosulfan and various water borne diseases. Hence, a township at remote location in Mizoram has been selected for present study which is situated at neighboring of Bangladesh.

The study area 'Chawngte' lies in the western parts of Lawngtlai district and its exact location is 22°37'10'' N and 92°38'11'' E. It is situated on international border with Bangladesh and having a distance of 34 km towards west from district headquarters Lawngtlai. Under these circumstances, it seems mandatory to explore various potable sources in the state for their suitability to potable water standards established by Bureau of Indian Standards (BIS) and World Health Organization (WHO). The objectives of the present work are to establish physico-chemical characterization of all possible potable water sources and to demarcate water sources which are not within recommendation of BIS and WHO in order to optimize the health condition of the resident of the study area.

MATERIAL AND METHOD

The studies were conducted at Chawngte, Lawngtlai District, Mizoram, India (Fig. 1). The samples were collected in the post-monsoon season from the selected locations. These samples have been taken for detailed hydrological and hydro geochemical investigations. Out of 10 samples, 4 samples are from tuikhur, 3 samples are from well and 3 samples are from hand

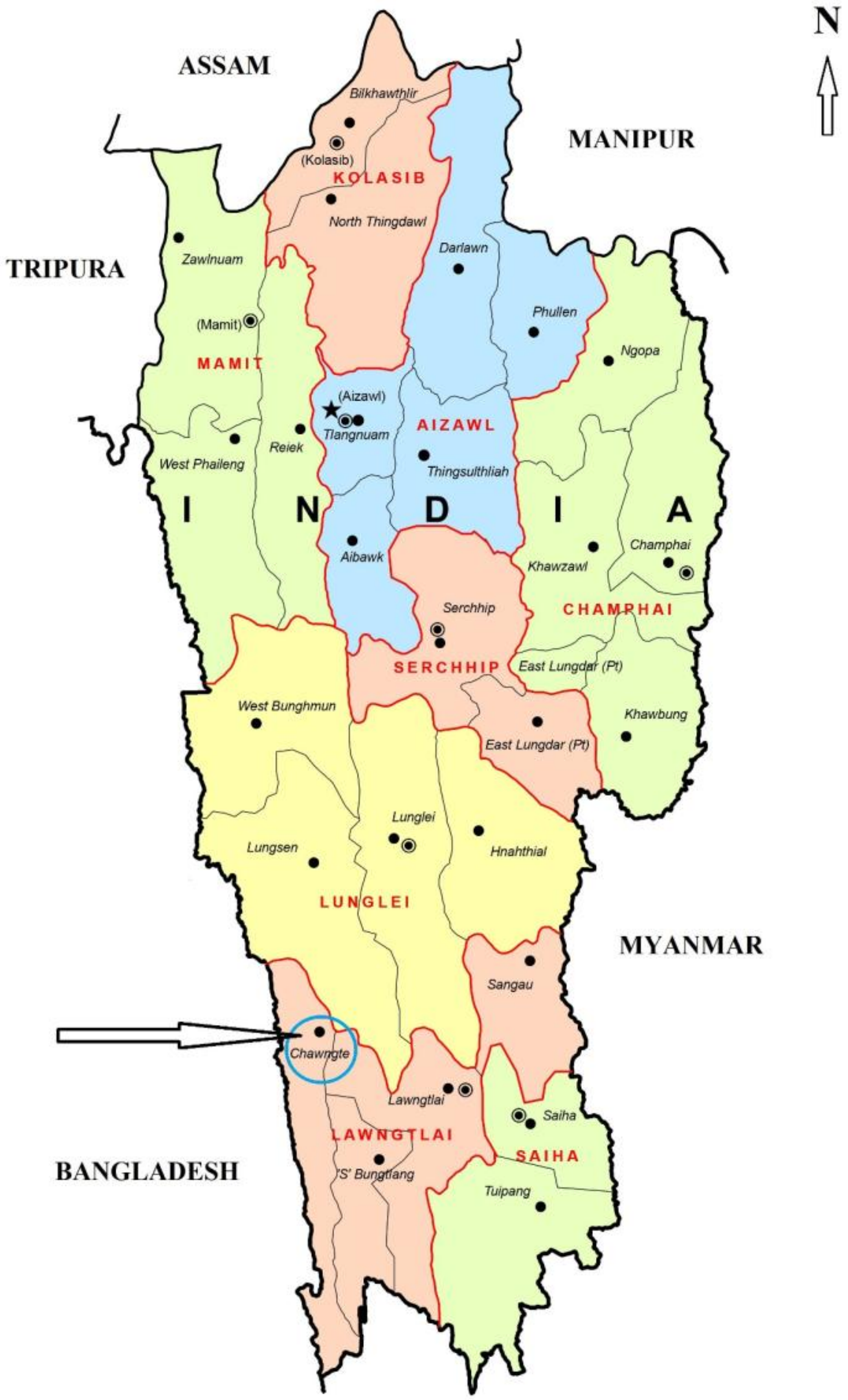

Figure 1. Map of Mizoram showing the study area (arrow head).

pumps. Sampling was performed according to the recommendations of the APHA, AWWA and WEF.[7] Various sources of potable water were identified during the survey of study area. Water samples were collected in a wide mouth bottle (tarson bottle), washed with distilled water and again rinsed with representative water samples. Water samples were analyzed in situ to find out the physico-chemical properties like pH, turbidity, total dissolved solids (TDS), electrical conductivity (EC), total hardness (TH), total chlorides (TC), total iron (Fe), free chlorine (FC), nitrate and arsenic. Digital instruments made by 'Eutech Instruments' were used to test pH, total dissolved solids and electrical conductivity. Total hardness, total chlorides, total iron, total chlorine and nitrate were measured using the water testing kit made by Transchem Agritech Limited. Turbidity values of the samples were measured using the Digital Nephelo Turbidity Meter-132 (systronics) using formazine as standard. Arsenic concentration was measured using an arsenic test kit made by Merckoquant Chemicals, Germany.

RESULT AND DISCUSSION

Results of all the potable sources in the study area have been classified into physical and chemical properties and presented in the Table 1 and table 2 respectively. It can be seen that the pH varies from 6.0-7.2 (Fig. 2A), which are found to be well within the acceptance limit for drinking water (6.5-8.5) as specified by the BIS[8] and WHO.[9] Electrical conductivity varies from a minimum of 110 μS/cm to a maximum 220 μS/cm. The EC values are generally higher for Tuikhur water in comparison to the hand pump. Conductivity can be regarded as a crude indicator of water quality for many purposes, since it is related to the sum of all ionized solutes or total dissolved solid (TDS) content. The Total Dissolved Solids varies from a minimum of 80 mg/l to a maximum of 360 mg/l. Higher values of TDS may be attributed mainly to geochemical rock-water intercalation in the area, which adds a number of electrolytes to the water bodies.[10] The desirable limit of TDS in drinking water is 500 mg/l. For turbidity, it is observed that all the values of the stations have slightly higher than the desirable limit but still within the permissible limit of 5NTU. The total hardness varies from 60 to 110 mg/l (Fig. 2B). Its desirable limit is 200 mg/l and permissible limit is 600 mg/l. Depending on pH and alkalinity, hardness above about 200 mg/l can result in scale deposition, particularly on heating. Soft waters with a hardness of less than about 100 mg/l have a low buffering capacity and may be more corrosive (WHO 2003).

The concentration of chloride in all the stations (Fig. 2B) – TKW, WLW and HPW samples are much lower (40-100) than the desirable limits value of 250 mg/l prescribed by BIS as well as WHO. Chloride concentration above 250 mg/l can produce a distinct taste in drinking water. Where chloride content is known to be low, a noticeable increase in chloride concentrations may indicate pollution from sewage sources.

The amount of free chlorine present in various stations varies from 0.1-0.3 mg/l. Low values of Free Chlorine are obtained in TKW-4, WLW-7 and HPW-9, high values are in TKW-1 and HPW-8. However, the values are found to be well within the desirable limit. The free chlorine, which is the chlorine available to inactivate disease-causing organisms, and is thus a measure used to determine the potability of water. The total iron content for various stations varies from trace to 3 mg/l. The Environmental Protection Agency (EPA) considers iron as a secondary contaminant, which means it does not have a direct impact on health. The Secondary Maximum Contaminant Level set out by the EPA is 0.3 mg/l, but this is merely a guideline and not a federal standard. Typically around 15 mg/L, Idaho's well water does contain quite high amounts of iron, but the level is still not enough to cause physical harm.[11] Trace/no nitrate is present in all the stations. The low concentration of nitrate is mainly due to less use of nitrogenous fertilizers as it is derived mostly from residual chemical fertilizers applied to agricultural land

Table 1. Water analyses results (physical characteristics).

Location	pH	EC	TDS	Turbidity
TKW-1 Kamalanagar South	6.4	160	130	4
TKW-2 Kamalanagar-I	6.0	220	140	5
TKW-3 Chawngte-L	7.1	180	80	5
TKW-4 Santinagar Village	6.0	190	190	4
WLW-5 Chawngte-C	6.0	180	240	3
WLW-6 Kamalanagar-II	6.2	170	360	4
WLW-7 Kamalanagar-III Rest House	7.1	140	360	5
HPW-8 Chawngte-L	6.5	180	290	5
HPW-9 Chawngte, S.D.O 0ffice	7.2	110	170	3
HPW-10 Chawngte-P	6.7	130	350	4
Permissible limits	6.5-8.5	600	500	--
Permissible limits	6.5-8.5	2000	2000	5

*TKW= Tuikhur; *WLW= Dug well; *HPW= Hand pump

Table 2. Water analyses results (chemical characteristics).

Location	Total Hardness mg/l	Total Chlorides mg/l	Free Chlorine mg/l	Total Iron mg/l	Nitrate mg/l	Arsenic mg/l
TKW-1 Kamalanagar South	105	80	0.3	0.1	Trace	0.03
TKW-2 Kamalanagar-I	90	80	0.2	Trace	Trace	0.02
TKW-3 Chawngte-L	90	40	0.2	0.1	Trace	0.01
TKW-4 Santinagar Village	110	60	0.1	0.2	Trace	0.05
WLW-5 Chawngte-C	105	80	0.2	Trace	Trace	0.05
WLW-6 Kamalanagar-II	60	100	0.2	0.1	Trace	0.03
WLW-7 Kamalanagar-III Rest House	75	85	0.1	0.2	Trace	0.02
HPW-8 Chawngte-L	90	80	0.3	0.5	Trace	0.01
HPW-9 Chawngte, S.D.O 0ffice	75	60	0.1	2	Trace	0.02
HPW-10 Chawngte-P	90	80	0.2	3	Trace	0.01
WHO Permissible limits	500	200	--	0.1	50	0.05
BIS Permissible limits	600	1000	1.0	0.3	45	0.05

*TKW= Tuikhur; *WLW= Dug well; *HPW= Hand pump

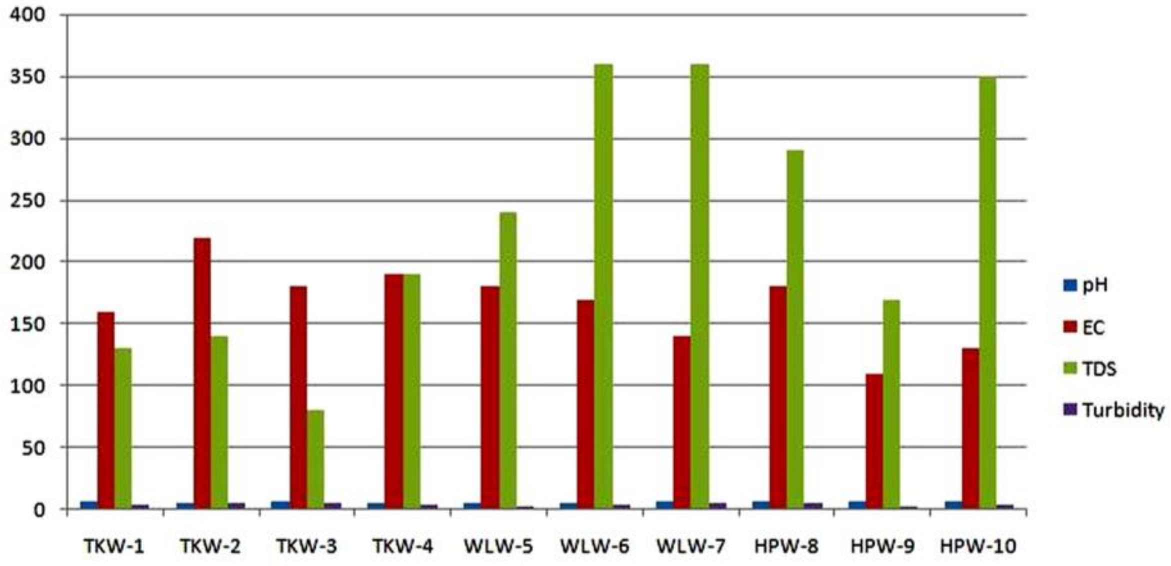

Figure 2A. Plot of physical data (pH, electrical conductivity, total dissolved solids & turbidity).

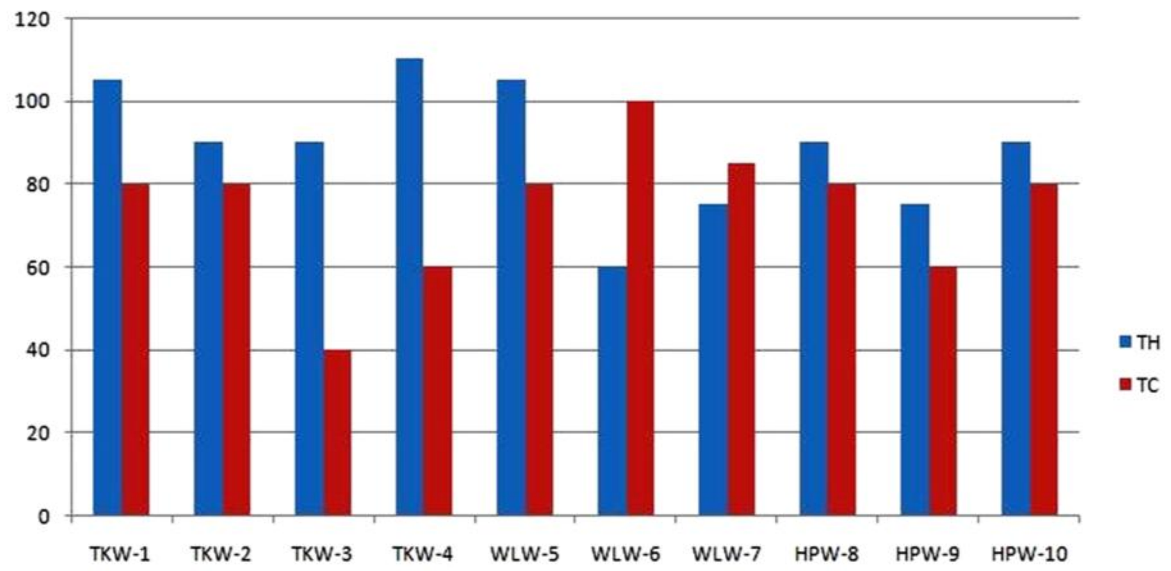

Figure 2B. Total hardness vs total chlorides.

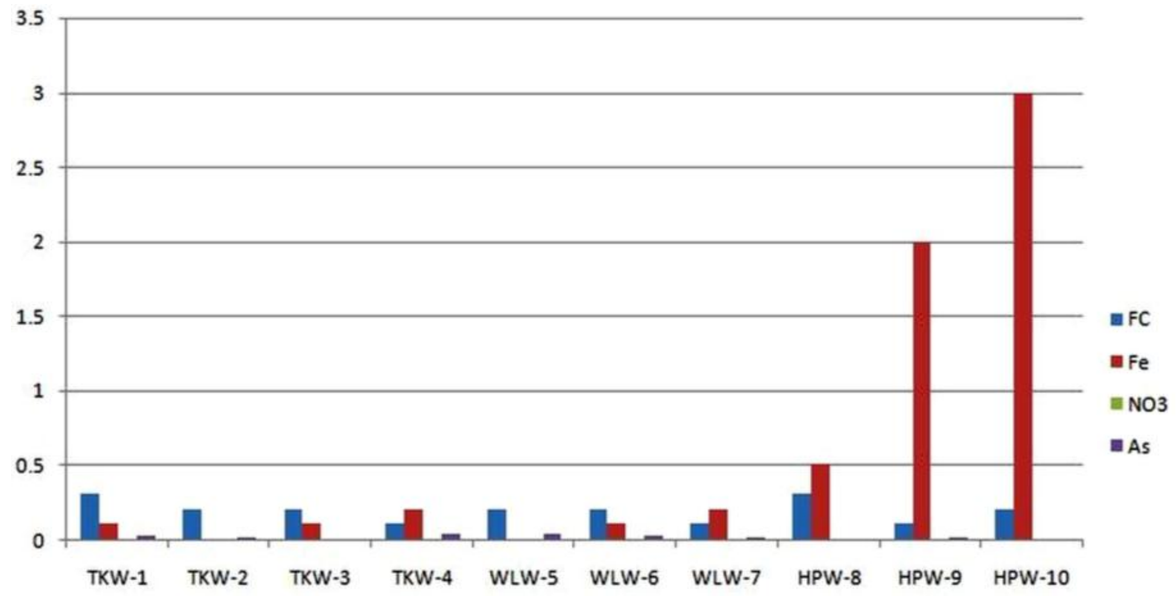

Figure 3. Plot of chemical data (free chlorine, iron, nitrate & arsenic).

to increase productivity.[12,13] The amount of As concentration of 0.01 mg/l (acceptance limit) is obtained in three stations viz. TKW-3, HPW-8 and HPW-10, while in TKW-4 and WLW-5 it exceeds the acceptance limit obtaining a value of 0.05 mg/l (Fig. 3). Drinking water can be contaminated with inorganic arsenic by either through wind-blown dust in mining areas, leaching of or run off from soil, dissolution of rocks, minerals and ores during rock-water interaction.

Conclusion

Based on the norms of the Bureau of Indian Standards (BIS) IS 10500-2012 and WHO, the physico-chemical parameters like pH, electrical conductivity, total dissolved solids, total hardness, total chlorides, iron and free chlorine are well within the acceptable limits for drinking water. Arsenic and turbidity are slightly higher than the acceptable limits but still within the permissible limit of 0.05 mg/l and 5 NTU respectively. From the above parameters, all the tuikhur, hand pumps and well are fit to serve as water source for domestic purposes.

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