

Extent of Arsenic Contamination in the Groundwater of Thuwal and Bishnupur Districts of Manipur (India)

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ABSTRACT

Groundwater plays an important role in shaping the economic and social health of urban and rural population throughout the globe, but the distribution of good quality groundwater is quite uneven. In many parts of the world, especially in the South and South-East Asian nations, many fold higher concentrations of various elements (e.g. arsenic, fluoride and selenium etc.) than their respective WHO permissible limits have been reported. A systematic study has thus been undertaken to evaluate the groundwater quality of Thuwal and Bishnupur district of Manipur. For this 26 water samples were collected and analyzed for various elements, including arsenic. More than 45% of collected water samples show arsenic concentration well above the permissible limit (10µg/L) prescribed by WHO for drinking water. The highest concentration of arsenic (535 µg/L) was registered from Ngangkha Lawai Mamang Leikai area of Bishnupur district which is fifty fold higher than the WHO limit for arsenic and ten fold of Indian permissible limit (50µg/L).

INTRODUCTION

The access of safe drinking water is one of the prime necessities for the survival of mankind. However, in many regions of the world, especially in many undeveloped and under-developed countries, this primary requirement is not fulfilled and a significantly large population is forced to drink contaminated water, which ultimately causes many waterborne diseases (Fewtrell et al., 2005). Apart from anthropogenic sources, many inorganic and organic pollutants from natural sources are also contaminating the groundwater. As in case of India, many pollutants such as arsenic (Farooq et al., 2010, 2012; Berg et al., 2008), fluoride (Hema et al., 2005) and selenium (Bajaj et al., 2011) etc., are contaminating the groundwater due to natural causes, on intra-basin and inter-basin scale. Though, a lot of research has been done on the problem of arsenic contamination in different basins of India but still many basins are left unexplored. India being a vast country with different hydrogeological and geological conditions, the outcome of one basin cannot be interpolated for the other basin, thus, there seems a need to investigate every single basin individually. The study has thus been taken with an aim to investigate the extent of arsenic contamination in parts of Imphal valley region of Manipur.

STUDY AREA

Manipur (north eastern state of India) is high structurally deformed province, consisting of younger sediment of quaternary age (Singh, L.D., 2007). It is located between N: 23°50' - 25°42' latitudes and E: 92°58' - 94°45' longitudes in the extreme eastern part of the country. The total surface area of the state is 22,327 sq. km, of which around 90% is covered by hills and the remaining 10% consists of central oval shaped valley surrounded by hills from all sides.

Barak river basin and the Manipur river basin are two major river basins within the state of Manipur. The rivers draining both the basins originate from the surrounding northern hilly region, thus are comparatively young while in valley area they shows some degree of maturity.

METHOD OF STUDY

To investigate the extent of arsenic contamination, 26 water samples were collected on a random basis. Out of the 26 samples, 21 were actively used domestic wells (tube wells/hand pumps), 2 river water samples, 1 spring water, 1 lake water and 1 pond water sample. Collection of all water samples involved collection of: (1) filtered samples (0.45 µm cellulose nitrate filter) for analyses of major anions; and (2) filtered (0.45 µm cellulose nitrate filter) and acidified (with 5 mL 14 M ultrapure HNO₃/L) samples for major cations and trace elements analyses. All samples were tightly sealed and stored at low temperature until further analyses. Analysis for all major (cations) and trace elements was done by ICP-OES (Perkin-Elmer, France). Sulphate (SO₄²⁻) concentrations were measured by spectrophotometer (Shimadzu UV-Visible spectrophotometer 160), alkalinity by titration and chloride (Cl⁻) by Expandable Ionanalyzer 940A with a combination electrode Orion ionplus 9817 BN. Tube wells were operated at least 5 minutes before collection of samples, to flash out the stagnant water inside the tube and to get the water representing the aquifer.

RESULT AND DISCUSSION

The summary of the geochemical analyses of the groundwater samples is presented in Table 1. All the water samples show weakly alkaline character and the pH ranges between 7.2 - 8.9.

The major ions composition, plotted on piper diagram (Fig. 1), clearly differentiates the tube well water from the surface water. Tube well water is mainly of Na-HCO₃ type while the surface water (including river, lake, pond and spring) is Ca-Mg-HCO₃ type. In all water samples SO₄²⁻ concentrations are quite high (tube well: av. conc. 27.1 mg/L and surface water: av. conc. 30.5 mg/L) compared to other arsenic affected areas (Eiche et al. 2008; Smedley and Kinniburgh 2002), where they are frequently below the detection limit Bdl.

Table 1- Geochemical data of water samples.

	Tube well water	Surface waters*
pH	7.2 - 8.8	7.9 - 8.9
Na ⁺	17.9 - 211	4.06 - 16.6
K ⁺	0.68 - 24.3	0.84 - 8.32
Ca ⁺⁺	16.4 - 93.3	2.22-18.2
Mg ⁺⁺	10.7 - 46.3	0.9 - 11.4
Cl ⁻	4.38 - 296	7.12 - 22.2
So ₄ ²⁻	19.9 - 47.8	25.6 - 34.7
HCO ₃ ⁻	190 - 560	90 - 120
As (total)	Bdl - 535	Bdl

*Other waters include samples from river, pond lake and spring. All major ion concentrations in mg/L, Arsenic concentrations in µg/L.

Higher SO₄²⁻ concentration indicates that the arsenic mobilization in the study area is not controlled by the reduction mechanism, as proposed for arsenic mobilization in Bengal Delta (Bhattacharya et al. 1997).

All surface water samples falls within the safe limit of arsenic in drinking water and arsenic concentration in these samples remained Bdl. However, in 57% of tube well water samples, the arsenic concentration more than 10µg/L (WHO permissible limit) is registered.

The presence of arsenic free water on the surface and contaminated groundwater at deeper levels indicates the existence and operation of arsenic release mechanism within the aquifer sediments. Further studies on larger scale to evaluate the extent of arsenic problem and to estimate the affected population are required. Use of surface water (after appropriate treatment for biological contaminants) for drinking purposes is suggested, until a long term solution for providing safe drinking water can be put in place.

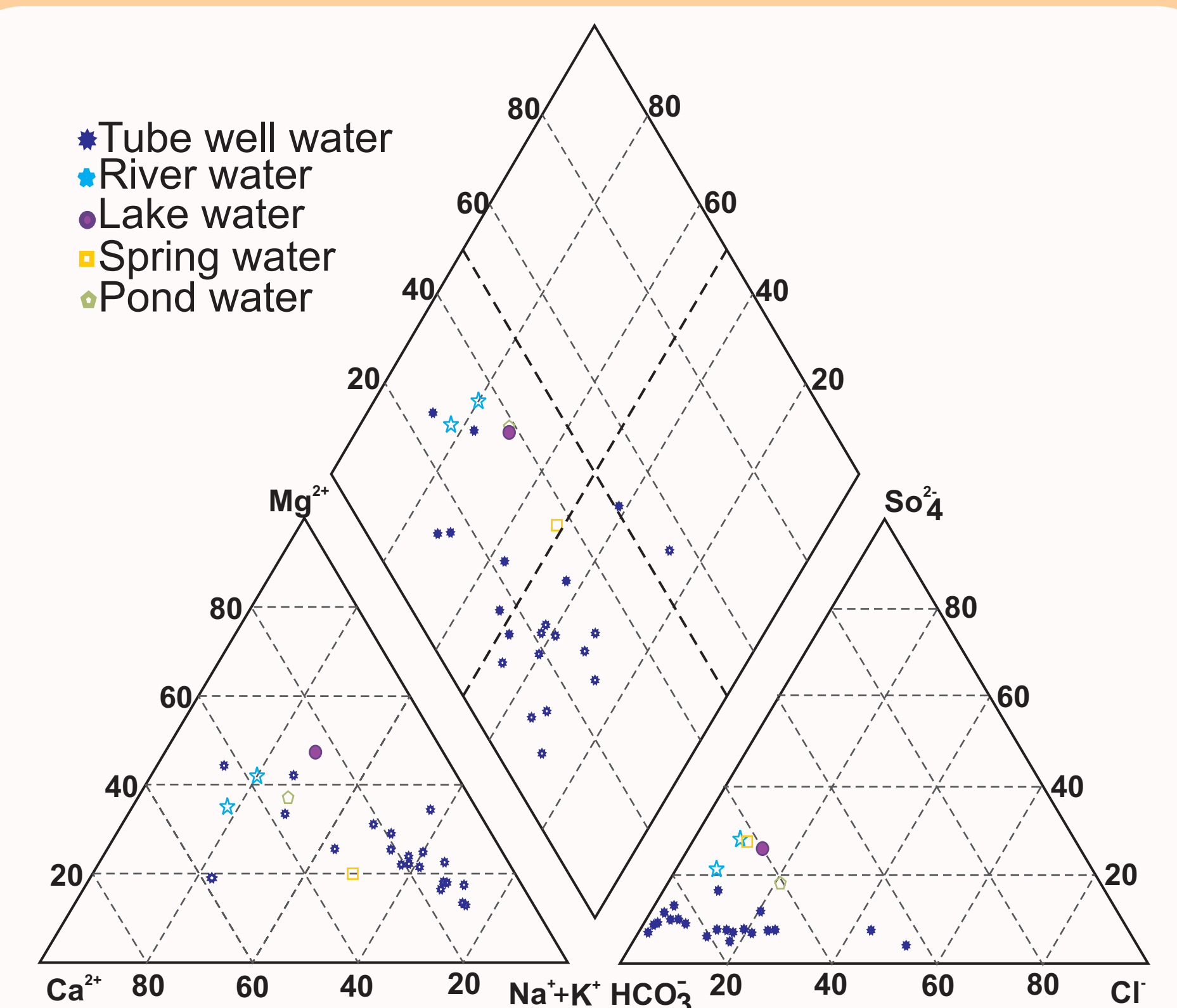


Figure 1 - Piper diagram showing the geochemical characteristics of water samples.

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