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Der Chemica Sinica, 2012, 3(6):1500-1504

Pelagia Research Library
ISSN: 0976-8505
CODEN (USA) CSHIA5

Assessment of arsenic content in groundwater samples collected from four districts of Northern Rajasthan, India

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ABSTRACT

Arsenic contamination of drinking water is a global problem. Groundwater is the primary source of drinking water for the population in Northern Rajasthan, India. This study consisted of the determination of arsenic content in 39 groundwater samples collected from Hanumangarh, SriGanganagar, Churu and Sikar districts of Northern Rajasthan, where drinking water samples are not treated before it is consumed. The water samples were collected from hand pumps. The arsenic in the drinking water samples were analyzed by using inductively coupled plasma mass spectrometry (ICPMS). The arsenic concentration in drinking water samples ranges from 1.48 µg L^{-1} in village 3H to 45.10 µg L^{-1} in village Rajgarh with a mean value of 7.31 µg L^{-1}. The arsenic concentration in 18% of the water samples has been found to be higher than the safe limit of 10 µg L^{-1} recommended by World Health Organization and United States Environmental Protection Agency.

Key words: Arsenic, Drinking water, Hand pumps, ICPMS

INTRODUCTION

Arsenic is a naturally occurring element widely distributed in the earth's crust. Arsenic (As), a potentially toxic element can exist in inorganic and organic form, inorganic arsenic being generally considered more toxic. Analysis of the toxic effects of arsenic is complicated by the fact that arsenic can exist in general different valence states and many different inorganic and organic compounds. The International Agency for Research on Cancer has concluded that arsenic is carcinogenic to humans [1]. Ingesting very high levels of inorganic arsenic can results in death. Exposure to lower levels can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels. Ingesting of inorganic arsenic can increase the risk of skin cancer and cancer in the liver, bladder, and lungs [2]. Arsenic in drinking water can impact human health and is considered to be one of the prominent environmental causes of cancer mortality in the world [3-4]. Arsenic has been known to cause a variety of adverse health effects [5-7]. Many studies have been conducted worldwide to determine the arsenic level in water [8-11]. The World Health Organization and US Environmental Protection Agency recently established a new maximum contamination level of 10 µg L^{-1} for arsenic in drinking water [12-13].

Geology of Study Area

Rajasthan is located in northwest of India. It lies between latitude 27° 00' N and longitude 74° 00' E. Fig. 1 Shows the geographic location of the state of Rajasthan in India, as well as the location of the sampling sites in Rajasthan. The studied area is bounded on the western side by Pakistan, on the northeast side by Haryana and Punjab to the north. Sriganganagar and Hanumangarh districts have plain surface covered with thick layer of alluvium and windblown sand. The Ghaggar River is an ephemeral one and has northeast to southeast course near Hanumangarh

and divide the Ganganagar district into two halves. Churu district is a part of the Thar desert soil of Churu district are pale brown, single grained, deep and well drained. The soils of the Sikar district are predominantly light textured, weak structured well drained alluvial & eolian in nature. The Khandela village of Sikar district in studied area is known for radioactive mineralization and is also known as copper belt. Most of the area of Rajasthan exposes wide variety of hard rock's including various types of metamorphic rocks like schist, quartzite, marble and gneisses of Precambrian age with associated acid basic intrusive rocks.

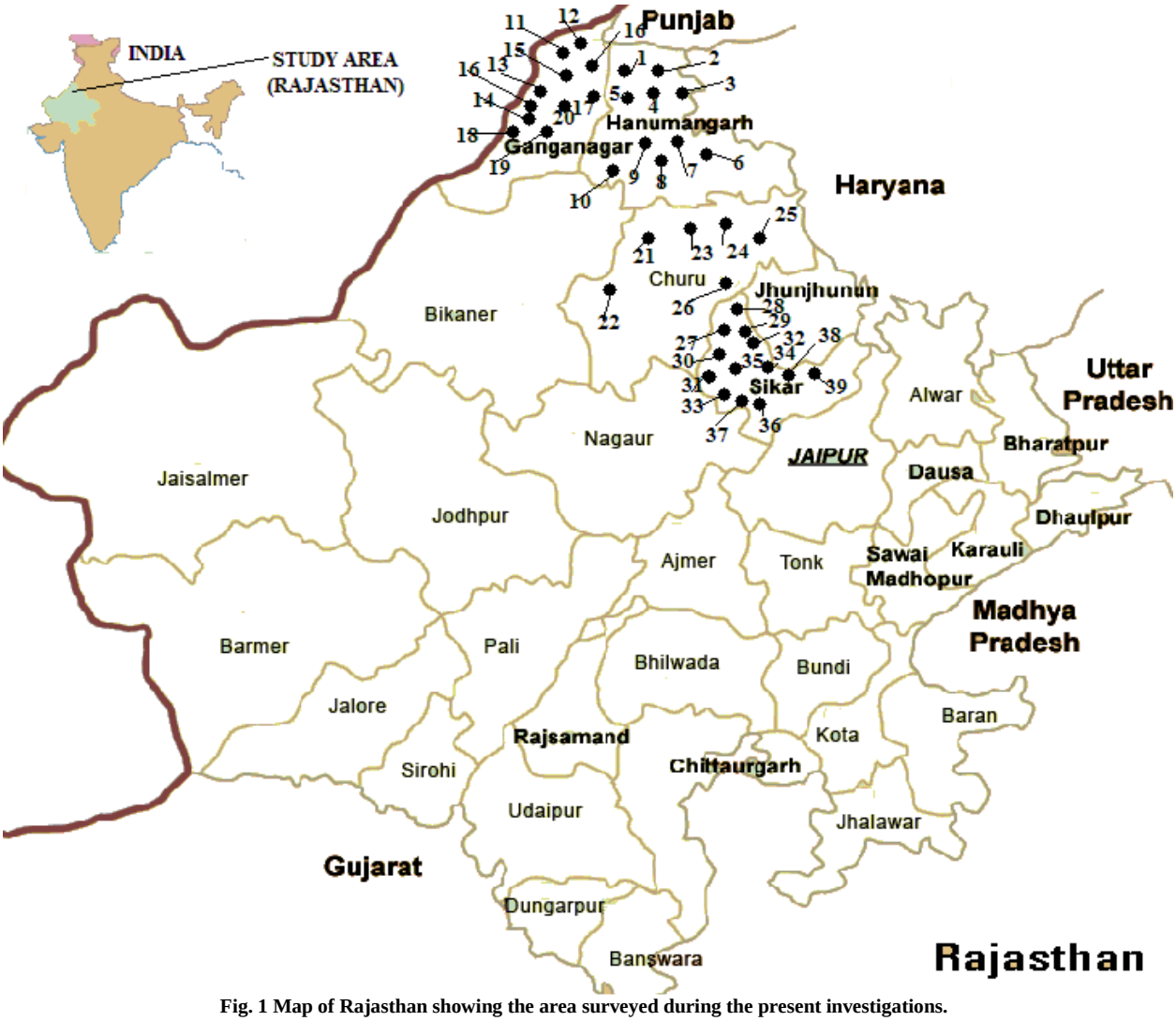

Fig. 1 Map of Rajasthan showing the area surveyed during the present investigations.

MATERIALS AND METHOD

In present study, arsenic concentration has been measured in 39 groundwater samples collected from four districts of Northern Rajasthan, India. The water samples were collected from individual home wells normally operated with hand pumps. The water directly from the tap is used by the residents. Before the samples were taken, the water was pumped out 5–10 min until fresh water comes from deep in the well. New polyethylene sample bottles were washed out with filtered water to be sampled. The sampled water was acidified immediately with nitric acid, and arsenic analyses were carried out in the Geochemistry Division ICP-MS Lab, National Geophysical Research Institute (NGRI), Hyderabad, India. Calibration was performed using NIST 1640a (National Institute of Standards and technology, USA), which is a reference material for trace elements in a natural water, to minimize matrix and other associated interference effects and to check the precision and accuracy of the analysis. The precisions achieved were <5% RSD with comparable levels of accuracy; in most cases suggesting that the data obtained by ICP-MS are best suited for high precision geochemical studies. In the present investigations, pH value has also been determined in collected groundwater samples using analytical kit-362D.

RESULTS AND DISCUSSION

The results for arsenic concentration in 39 groundwater samples collected from 39 villages of Hanumangarh, SriGanganagar, Churu and Sikar districts of Northern Rajasthan, India are reported in Table 1. The values in samples from Hanumangarh district were in the range 1.60 µg L^{-1} (Pilibanga) to 13.65 µg L^{-1} (Amar Singh wala) with an average of 6.42 µg L^{-1}. In the SriGanganagar district these values were in the range from 1.48 µg L^{-1} (3-H) to 13.40 µg L^{-1} (Gulabawala) with an average value of 4.45 µg L^{-1} and the values for the Churu district were in the range from 2.90 µg L^{-1} (Ratangarh) to 45.10 µg L^{-1} (Rajgarh) with an average value of 12.44 µg L^{-1}. These values for the Sikar district were in the range from 1.58 µg L^{-1} (Goria) to 9.74 µg L^{-1} (Khandela sample 2) with an average value of 5.20 µg L^{-1}. The arsenic concentration in water samples for whole of the studied area ranged from 1.48 µg L^{-1} (3-H) to 45.10 µg L^{-1} (Rajgarh) with an average value of 7.31 µg L^{-1}. The World Health Organization and US Environmental Protection Agency recently established a new maximum contamination level of 10 µg L^{-1} for arsenic in drinking water [12-13]. The resulting values were compared with the safe limit values. The measured arsenic content in 18 % water samples has been found to be higher than the recommended safe limit of 10 µg L^{-1} [12-13]. Figure 2 shows the variation of arsenic concentration in groundwater samples. On the basis of safe arsenic limit (10 µg L^{-1}), water samples collected from Rasuwala, Amar Singh wala, Gulabawala, Rajgarh, Seowa, Churu city and Chimnpura villages are not fit for human consumption.

Table 1. Concentration of arsenic in water samples collected from some areas of Northern Rajasthan

Sr. No.	Sample Location	Depth (m)	pH	Arsenic Concentration (µg L^{-1})
	District Hanumangarh			
H-1	Rawatsar	19.5	8.15	2.90
H-2	Nukera	28.5	7.27	4.80
H-3	Rasuwala	21.6	7.56	10.55
H-4	Shahpini	33.0	7.40	8.65
H-5	Pilibanga	24.0	7.41	3.16
H-6	Sangaryia	21.0	7.45	1.60
H-7	Amarpura jallu Khatt	23.4	7.25	7.75
H-8	Morjand Sikhan	22.5	7.57	9.50
H-9	Amar Singh Wala	24.0	7.95	13.65
H-10	Hanumangarh city	22.5	6.97	1.68
	District SriGanganagar			
G-1	3H	22.8	7.64	1.48
G-2	Gulabawala	22.5	7.75	13.40
G-3	14Q	22.5	6.91	2.88
G-4	Sangatpura	20.4	7.04	3.76
G-5	SriGnganagar city	24.0	7.56	1.94
G-6	Karanpur	24.0	7.21	2.56
G-7	Radewala	30.0	7.19	2.70
G-8	Kalian	24.6	8.40	1.78
G-9	23Z	25.5	7.00	6.40
G-10	Malkana Kalan	23.4	7.33	7.65
	District Churu			
C-1	Rajgarh	21.6	7.10	45.10
C-2	Ratangarh	21.0	8.45	2.90
C-3	Seowa	22.5	7.32	18.15
C-4	Chimnpura	21.0	7.82	41.50
C-5	Taranagar	27.0	8.02	2.92
C-6	Churu city	25.5	7.85	13.80
	District Sikar			
S-1	Goria	51.0	7.74	1.58
S-2	Fatehpur	60.1	8.76	4.08
S-3	Palthana	57.1	8.08	4.42
S-4	Sikar city	60.1	8.11	2.86
S-5	Ranoli	54.0	8.10	1.98
S-6	Khandela sample 1	45.0	6.90	6.80
S-7	Khandela sample 2	48.0	8.24	9.74
S-8	Raseedpura	75.1	7.21	4.68
S-9	Kotri	48.0	7.19	2.10
S-10	Khandela Gokul	42.0	7.47	2.88
S-11	Laxmangarh	54.0	8.68	4.04
S-12	Kotri Lalasar	51.0	7.14	2.50
S-13	Dadhia	67.6	7.88	4.30

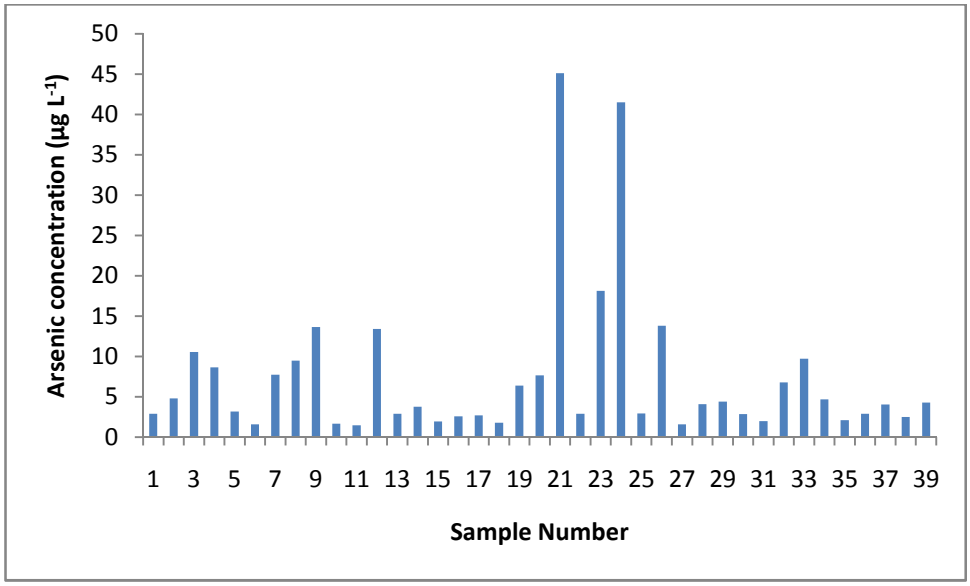

Fig 2. Bar Graph showing the variation of Arsenic concentration in groundwater samples

In the present investigation, value of arsenic concentration obtained in drinking water samples are lower as compared to the value reported for Punjab (8-85 µg L^{-1}) [8]. From table 1, it is evident that most of the water samples from the study area are fit for human consumption. The pH value of the water samples ranges between 6.90 and 8.76. The safe limit recommended by US Environment Protection Agency is 6.5-8.5 [13]. All the water samples except two (Fatehpur, pH value 8.76 and Laxmangarh, pH value 8.68) have a pH value within the safe limit.

CONCLUSION

The arsenic concentration in 7 out of 39 water samples from Northern Rajasthan crosses the safety limit and is therefore unsafe for drinking purposes. On the basis of safe arsenic limit (10 µg L^{-1}), water samples collected from Rasuwala, Amar Singh wala, Gulabawala, Rajgarh, Seowa, Churu city and Chimnpura villages are not fit for human consumption. All the water samples except two (Fatehpur, pH value 8.76 and Laxmangarh, pH value 8.68) have a pH value within the safe limit. Most of the water samples from the study area are fit for human consumption.

Acknowledgements
The authors are thankful to the residents of the study area for their cooperation during the fieldwork and National Geophysical Research Institute, Hyderabad for providing experimental facilities.

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