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Research Article

A Survey for Risk Assessment of Groundwater Arsenic Intoxication in Certain Regions of Western up

Priya Bajaj[1] and Baby Tabassum[2]*

[1]Department of Zoology, Govt. P.G. College, Noida, Rampur, Utter Pradesh, India

[2]Toxicology Laboratory, Department of Zoology, Govt. Raza P.G. College, Rampur, Utter Pradesh, India

***Corresponding Author:** Baby Tabassum, Toxicology Laboratory, Department of Zoology, Govt. Raza P.G. College, Rampur, Utter Pradesh, India.

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Abstract

Heavy metal toxicity is a global health concern. Arsenic is a top ranked toxic metalloid occurring naturally but exposed unavailingly because of human interference. Groundwater arsenic contamination is a serious health issue in West Bengal and other states of India. The present study is designed to find out the toxicity status of arsenic in groundwater of three districts in Western Uttar Pradesh viz. Moradabad, Rampur and Bareilly. For this purpose, samples were collected from different depths of marked sites in selected districts at various times of the year using the prescribed protocols and subjected to AAS analysis. Thus obtained numerical results were tabulated and analysed statistically to calculate the average arsenic content and contamination factor of selected districts.

The results indicate a high level of arsenic content as compared to the WHO permissible limit which is just 0.01mg/L. Although all the three districts are at potential risk, but district Bareilly is on the verge. These results may be due to excessive industrialization, unwise e-waste disposal and extensive agricultural application of arsenic compounds. It is now suggested to control the reckless discharge of industrial and agricultural effluents and maintain strict regulation on illegal e-waste disposal in western Uttar Pradesh.

Keywords: Arsenic Toxicity; Western UP; WHO permissible limit

Introduction

Heavy metals are the naturally occurring, mostly toxic elements of high density and a molecular weight that received paramount attention over other pollutants. Heavy metals like zinc, cobalt, chromium, mercury, nickel, cadmium, lead and arsenic are highly toxic even in very low concentrations in water bodies and groundwater [12]. Only 3 % of total water present on earth is fresh water, out of which only 30% is available for drinking purpose in ponds, rivers and as groundwater while 70% of water is locked up in glaciers and ice caps on poles [1]. Adequate water supply is the major factor deciding the residence pattern of the human population. Most of inland zones of India utilize groundwater for domestic to industrial purpose. Because of undue anthropogenic activities, the water necessary for our survival is becoming hazardous every day [20].

Globally more than 200 million people, especially in developing countries like India, Bangladesh, China and Mexico are at health risks due to various methods of arsenic exposure. Arsenic is naturally present in the environment in both organic and inorganic forms and variable oxidation states. Inorganic arsenic is of major concern that occur either in the trivalent or pentavalent state. Arsenic ranks second in the list of the twenty most hazardous substances prepared by ATSDR (Agency for Toxic Substances and Disease Registry) under CERCLA (Comprehensive, Environmental, Response, Compensation and Liability Act). Anthropogenic interferences have increased the arsenic exposure to vulnerable limits and it has entered to our air, drinking water, food and soil. Thus we are exposed to arsenic without choice, since a number of routine life products are made up of arsenic [11,13].

Groundwater arsenic contamination is the primary concern, since water is necessary for survival. In certain parts arsenic concentration in groundwater exceeds 3 mg/l, while the WHO (World Health Organization) permissible limit is 0.01 mg/l. only [7]. Although this guideline value is transient and various national agencies allow more arsenic content because of difficulties in making drinking water arsenic-free. UNICEF (United Nations Children's Fund), 2015 report describes liver and kidney problems even cancers as the potential risk of groundwater arsenic contamination attributing 21.4% fatality [24]. Therefore the public health priority should be to reduce groundwater arsenic exposure with consideration of local availability of water sources and environmental conditions [15].

India, because of its large population drew the attention of international agencies regarding groundwater arsenic intoxication. In West Bengal, dated back in 1984, reporting of arsenic induced skin-lesions led to a discussion about the safe levels of arsenic in drinking water [10]. Since then, Arsenic contamination has been reported in the states adjoining the upper, middle, and lower Ganga and Brahmaputra plains that include Uttar Pradesh, Bihar and Jharkhand [17]. Ramganga and Kosi rivers, the subsidiaries of Ganga, flowing through the Moradabad, Rampur and Bareilly Districts of Uttar Pradesh might also pursue the higher levels of arsenic than WHO permissible limits. Thus these three districts from fertile plains were selected to survey for their groundwater arsenic content. These districts represent an industrially rich belt of western Uttar Pradesh and get flooded every year, so have the possibility of groundwater arsenic contamination.

Materials and Methods

Since our results were survey based, so a water survey was performed in certain regions of western UP following the protocols

Places and parameters of Collection

Three districts (Rampur, Bareilly, Moradabad) representing to the industrially rich belt of Western Uttar Pradesh were selected for the study to collect the water samples from Rāmgangā and Kosi River drainage and ground water from adjoining areas. The samples were collected at four different months (January, April, July and October) of year to consider seasonal ambiguity in water flow, if any. Flooding periods were not chosen for the collection because freshwater is much diluted during this period. The selection of sample collection place was made according to the distance from Source Rivers i.e. Ramganga & Kosi. The Samples were collected from various depth levels sorting into two categories- Group- I (40-70 feet depth; Normal areas adjoining the rivers) and Group-II (70-120 feet depth; Industrial areas adjoining the River). The details of places chosen for the survey and collections of water samples are listed in table-1.

Districts	Sample Number	Places of collection	Depth of collection (feet)	Month of collection
Rampur	S1	LalPur	50	July
	S2		55	October
	S3	Sehzadnagar	40	January
	S4		110	April
	S5	Milak	45	July
	S6		45	October
	S7	Panbadhiya	70	January
	S8		80	April
	S9	Jila Panchayat	120	July
	S10		80	October
	S11	Gandhi Samadhi	60	January
	S12		45	April
	S13	Ghatampur	35	July
	S14		45	October

Moradabad	S15	Budhbazar	70	January
	S16		90	April
	S17	Railway Station	110	July
	S18		50	October
	S19	Pakbarha	70	January
	S20		65	April
	S21	Bhojpur	40	July
	S22		60	October
	S23	Pipalsana	40	January
	S24		45	April
	S25	Katghar Bridge	65	July
	S26		50	October
	S27	Sagar Sarai	60	January
	S28		45	April
Bareilly	S29	Maolaganj	40	July
	S30		45	October
	S31	Teekur	35	January
	S32		40	April
	S33	Lodhapur	70	July
	S34		120	October
	S35	Bathua	40	January
	S36		50	April
	S37	Sikandarpur	65	July
	S38		40	October
	S39	Udaipur Bhoora	45	January
	S40		80	April
	S41	Kola Sota	110	July
	S42		55	October

Table 1: Places and parameters of Water sample Collection.

Method of collection

Water samples were collected from the tap and hand pumps of different boring depths areas (30 – 160 feet below ground level) in double- capped glass bottles. The bottles were prewashed with detergent followed by HNO_3 and double deionised distilled water. Prior to collection, the water was allowed to run for 05 minute**.** The sample was acidified to 1% with nitric acid and then stored in 100 ml double-capped glass bottle that had been prewashed in the previously described manner. Further the samples for subjected to AAS (Atomic Absorption Spectroscopy) analysis for determination of arsenic [2,5,14].

Physiochemical parameters of water

Before subjecting to AAS analysis the water quality was tested on the basis of following physiochemical parameters

- Temperature- Checked by digital thermometer
- pH- estimated by digital pH meter
- Electrical conductivity- recorded by digital EC meter
- BOD (Biological Oxygen Demand)- determined by digital BOD meter

- COD (Chemical Oxygen Demand)- estimated by Potassium dichromate open reflex method [16].

Analytical methods

The data is statistically presented in the form of Mean ± SD and subjected to calculate Contamination factor [8].

$$\text{Contamination factor (CF)} = \frac{Ci}{Cb}$$

Where.

Ci = Mean Concentration of arsenic in water

Cb = WHO Permissible limit of arsenic in water

Results and Discussion

Table 2 indicates the range of various physicochemical parameters of water samples collected from different areas, these results rely on that they fall within the permissible limits. Table 3, 4 and 5 shows the concentration of arsenic in groundwater of three selected district of western Uttar Pradesh (Rampur, Moradabad and Bareilly) analysed by AAS with their respective Mean, Standard deviation, Standard Error of Mean (SEM) and contamination factors. The results show these three districts are at an alarming stage as compared to the WHO permissible limit i.e., 0.01 mg/L in drinking water [25]. The graph shown in figure 1 gives a comparison of the mean arsenic concentration and contamination factor among three districts showing that district - Bareilly is at a much more frightening stage.

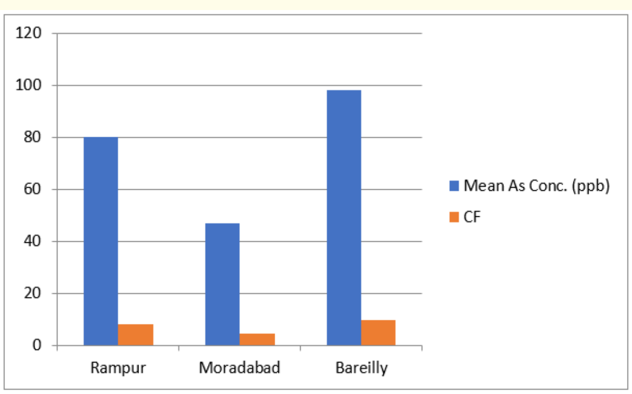

Figure 1: A comparison of mean arsenic concentration (ppb) and contamination factor in groundwater of three districts.

S.N.	Parameters	Range
1	Temperature	28 - 30 °C
2	pH	7.2 - 7.8
3	TDS	350 - 380 mg/L
4	BOD	37 - 39 mg/L
5	COD	150 - 160 mg/L
6	Conductivity	460 - 470 µmho/cm

Table 2: Physicochemical parameters of water samples.

As shown in table 3, samples from Rampur have an average arsenic concentration 0.08 ± 0.133 mg/L and contamination factor of 8. Table 4 shows the average arsenic concentrations in groundwater samples from district Moradabad, which is 0.047 ± 0.009 mg/L and contamination factor 4.7only. For district Bareilly average arsenic concentration in groundwater is 0.098 ± 0.138 mg/L and CF 9.8 (Table 5). Mean arsenic concentration in three districts is much higher than WHO permissible limit and follows the order-Bareilly>Rampur>Moradabad. These results reveal that the water is not recommended for drinking purpose due to high arsenic stress, and may cause problems in various metabolic organs like the liver, kidneys, blood and brain etc. Long term exposure to arsenic contaminated water leads to potential health hazards including skin lesions, hyperkeratosis, cancers, diabetes, hypertension, cardiovascular diseases, reproductive disorder and reduced cognitive development [26].

Physiochemical parameters play a significant role in acid base reactions and ion chemistry of water. In large water bodies most of cationic metals like arsenic and others acquire soluble phase as higher hydrogen ions occupies maximum anions [8]. This soluble form of arsenic is more hazardous because of its ready availability, high reactivity and easy movement in aquatic environment. Studies have shown a positive linear correlation between temperature and groundwater arsenic concentration. A slight increase of temperature fairly increases arsenic mobility from sediments to groundwater, thus increasing its accessibility [6]. Higher COD and BOD values represent highly polluted water by the industrial and other hazardous activities in the western Uttar Pradesh [19].

The increasing ground water levels and high industrial use of arsenic and its related compounds increase the risk of exposure to human beings and animals. The general population is exposed to arsenic via contaminants found in drinking water and food [4], whereas occupational exposure to arsenic usually takes place during mining and smelting operations or manufacturing of arsenic-containing compounds in semiconductor, paper, and glass industries. Currently, arsenic is being used in agriculture as pesticides (lead arsenate, calcium arsenate, and sodium arsenite), herbicides (monosodium arsenate and cacodylic acid; dimethyl arsenic acid), cotton desiccants (arsenic acid), and wood preservatives (zinc and chromium arsenate). Arsenic is also used in the smelting of gold and copper, glass manufacture and semiconductor industries [23].

SN	Sample No.	Arsenic concentration (mg/L)	Means ±SD	SEM	Contamination Factor
1.	S-1	0.035	0.08 ± 0.133	0.035	8
2.	S-2	0.047			
3.	S-3	0.540			
4.	S-4	0.051			
5.	S-5	0.041			
6.	S-6	0.045			
7.	S-7	0.041			
8.	S-8	0.044			
9.	S-9	0.042			
10.	S-10	0.053			
11.	S-11	0.043			
12.	S-12	0.038			
13.	S-13	0.047			
14.	S-14	0.052			

Table 3: Arsenic concentrations in water samples collected from Rampur.

SN	Sample No.	Arsenic concentration (mg/L)	Means ± SD	SEM	Contamination Factor
1.	S15	0.053	0.047 ± 0.009	0.002	4.7
2.	S16	0.035			
3.	S17	0.044			
4.	S18	0.045			
5.	S19	0.049			
6.	S20	0.062			
7.	S21	0.043			
8.	S22	0.055			
9.	S23	0.043			
10.	S24	0.043			
11.	S25	0.033			
12.	S26	0.041			
13.	S27	0.043			
14.	S28	0.062			

Table 4: Arsenic concentrations in water samples collected from Moradabad.

SN	Sample No.	Arsenic concentration (mg/L)	Means ± SD	SEM	Contamination Factor
1.	S29	0.048	0.098 ± 0.138	0.037	9.8
2.	S30	0.046			
3.	S31	0.042			
4.	S32	0.053			
5.	S33	0.055			
6.	S34	0.047			
7.	S35	0.041			
8.	S36	0.430			
9.	S37	0.042			
10.	S38	0.420			
11.	S39	0.035			
12.	S40	0.044			
13.	S41	0.042			
14.	S42	0.033			

Table 5: Arsenic concentrations in water samples collected from Bareilly.

Groundwater Arsenic contamination has been reported throughout Asia including West Bengal in India. However, its occurrence in groundwater is not considered a major source of toxicity in North India [3]. Although the higher concentration in studied districts may be because these areas are subjectively populated, developed, very fertile, agriculture rich and industrialized which is expanded to nearby towns and villages while, arsenic is widely used in electronic goods and pesticides, although pesticidal applications are declining now a day [21]. These districts are hubs of electronic wastes, so the probability of the illegal use and disposal of electronic waste is high within these areas. The authors have already run a research project regarding electronic waste disposal in these areas. District Bareilly found to be most contaminated among the three studied districts because it is more industrially developed than other two. A number of industries such as J.K Sugar mills, Coca-cola industry, Katha factory, Rubber factory, distilleries, IFFCO etc. are situated within the 30 km radius of Bareilly city [22]. Various industries effluents their discharge in to the Ramganga and Kosi River, so the quality of water has declined greatly, it is contaminated with heavy metals, arsenic is one of them and this water is used for agriculture, domestic and drinking purposes.

The criterion for selecting sampling sites was based on the population density, areas of industrial or anthropogenic activities such as minerals and mining activities, and the river catchment. These sites have rigorous industrial activities, illegal e-waste processing factories, and open burning sites of municipal solid waste. In these areas, illegal incineration and dumping of e-waste have been noticed percolating toxic heavy metals in the river and groundwater table. These areas also pose illegal and disused tin-mining areas which pose potential health hazards due to the high amount of inorganic arsenic and other heavy metals.

Conclusion

The results are awful indicating that a major proportion of the population is at a significant risk of arsenic toxicity. People may suffer serious health risks due to contamination of a vital resource, the drinking water. It is necessary to regularly monitor the quality and toxicity indices of drinking water. To achieve WHO standards, arsenic removal techniques should be applied. However, the focus should be to reduce contamination through anthropogenic sources. The most common arsenic-mitigation strategies include replacement of arsenic-contaminated sources by less-contaminated ones, and removal of arsenic from contaminated water before consumption by optimization and control of conventional treatment methods like coagulation. Recycling treatment of wastewater before discharging to water bodies should be followed strictly. Innovative eco-friendly practices like rainwater harvesting and watershed management should be promoted to hold the situation.

This will not only reduce water stress but also ensure arsenic free supply of water either naturally or through filtration. Now this is the high time to implement proper heavy metals product uses and waste management regulations in western Uttar Pradesh.

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