IJRCE

International Journal of
Research in Chemistry and Environment
Available online at: www.ijrce.org

ISSN 2248-9649

Research Paper

Groundwater Arsenic Contamination in Brahmaputra River Basin: A GIS Based Water Quality Assessment with Seasonal Variation in Dhemaji (Assam), India

Mridul Buragohain
Department of Chemistry, Lakhimpur Girls' College, North Lakhimpur, Assam, INDIA

(Received 05th February 2018, Accepted 23rd March 2018)

Abstract: *Distribution of arsenic and its compound and related toxicology are serious concerns nowadays. Millions of individuals worldwide are suffering from arsenic toxic effect due to drinking of arsenic -contaminated groundwater. The Bengal delta plain, which is formed by the Ganga–Padma–Meghna–Brahmaputra river basin, covering several districts of West Bengal, India, and Bangladesh is considered as the worst arsenic -affected alluvial basin. The present study was carried out to investigate the seasonal variations of arsenic in groundwater of Dhemaji district of Assam, an adjoining region of the West Bengal and Bangladesh borders. Sixty groundwater samples were collected from tubewells of five development blocks of dhemaji district (Assam) in one year period, during December 2016 to November 2017 using GIS technique. The present study showed that out of the 60 groundwater samples, 37%, were found contaminated with higher arsenic contents (WHO, arsenic 10 µg/L for potable water). The most badly affected area was the Sissiborgaon development block, where 75% of the samples had arsenic concentration above the WHO drinking water guideline values. In this block, the highest arsenic concentration was recorded 19.45 µg/L at sampling point, B-7. Significant variation was observed between pre-monsoon (October to April) and post-monsoon (May to September). Arsenic concentration is sufficiently higher in post-monsoon than in pre-monsoon season.*

Keywords: Arsenic, Seasonal variation, GIS, AAS, Groundwater, Brahmaputra river basin, Dhemaji, etc.

Introduction

Natural potable water resource is becoming exceedingly a limited reserve for the human race throughout the world. Furthermore, presence of varied numbers of pollutants including heavy metals in the water through natural and/or anthropogenic interventions imparts toxic and harmful effects to the environment and the individual[1]. Human and ecological use of in-stream water depends on ambient water quality. Human alteration of the landscape has an extensive influence on watershed hydrology[2,3] and heat budget[4] which subsequently increases water temperature[5] and modifies in-stream biogeochemical processes that drive oxygen, nutrient, and sediment cycling[6]. Therefore, identifying spatial and temporal changes in ground water quality has been a major focus of previous research. In West Bengal, India and Bangladesh, it is estimated that 100 million people in arsenic-affected areas are potentially at risk from groundwater arsenic contamination above the WHO guideline value of 10 µg/L[7,8]. Eroded sediments and varied inputs of human activities like mining, pesticides, pharmaceuticals, etc. are thought to be the common sources of arsenic. Chronic arsenic exposure is detrimental to human health being associated with cancer of the skin, lung, liver, urinary bladder, and kidney[9] and other diseases, including cardiovascular and peripheral vascular diseases, diabetes, peripheral neuropathies, portal fibrosis, and adverse birth outcomes[10].

Elevated level of arsenic in groundwater has been well documented in Chile, Mexico, China, Argentina, USA, and Hungary as well as in the Indian State of West

Bengal, Bangladesh, and Vietnam[11]. Five out of eight North-Eastern states are also affected by arsenic contamination. Manipur is ranked first and Assam as second followed by Arunachal Pradesh, Tripura and Nagaland. The GW in these regions is naturally arsenic enriched and therefore wide spatial distribution of As has been found in these areas. In North India, Punjab and Haryana and in South India, Andhra Pradesh and Karnataka are suffering with groundwater arsenic contamination. Low level of arsenic (up to 17 µg/L) has also been reported in Tamil Nadu from South India. Many of the states like Jammu and Kashmir, Uttarakhand, Odisha, Gujrat, Kerala, Telengana, Goa etc. are still unexplored for groundwater arsenic contamination. Thus, according to current reports out of 640 districts in India, 141 are As affected (As >10 µg/L), among them 120 are above 50 µg/L[12,13]. The present study revealed the present status of arsenic toxicity, spatial distribution in Dhemaji district of Assam and the trend of seasonal variations. The study would help to fling light on the water quality with respect to arsenic in one of the most important areas of northeast India.

Material and Methods

The study area Dhemaji district (Figure 1) is situated in the remote corner of north east India on the north bank of the river Brahmaputra. The district is located between $27^{0}\ 05^{/}\ 27^{//}$ and $27^{0}\ 57^{/}\ 16^{//}$ northern latitudes and $94^{0}\ 12^{/}18^{//}$ and $95^{0}\ 41^{/}\ 32^{//}$ eastern longitudes. The district is divided into two sub-divisions viz. Dhemaji and Jonai, comprising of five development blocks viz. Dhemaji, Sissiborgaon, Bordoloni, Machkhowa and Morkongselek (Tribal). The soil of the district is broadly classified into four groups, namely new alluvial, old alluvial, red loamy and lateritic soil. The new alluvial soil is found in the flood plain areas subjected to occasional flood and consequently receives annual silt deposit when the flood recedes. The old alluvial soils are developed at higher level and are not subjected to flooding. Red loamy soils are formed on hill slopes under high rainfall conditions [14]. For the present study, sixty groundwater samples were collected from shallow hand tubewells (~ 60 ± 10 ft deep) of five development blocks of the district during December 2016 to November 2017 to assess the qualitative changes in arsenic loads. Majority of the tubewells for the collection of samples were for community use. Samples were collected by random selection and combined together in clean and sterile one-litre polythene cans to obtain a composite sample, 1:1 HNO_3 solution was added to each of the water samples (to make pH < 2.0) and stored in an ice box which were carried to the laboratory for arsenic analysis[15]. The locations of the sampling points were obtained with a hand held global positioning system (GPS, Germin 72 model) with position accuracy of less than 10m. The sampling locations are shown in Figure 2 and block wise sample collection summary are given in Table 1. Samples were protected from direct sun light during transportation to the laboratory. All probable safety measures were taken at every stage, starting from sample collection, storage, transportation and final analysis of the samples to avoid or minimize contamination. Arsenic were analysed by using Atomic Absorption Spectrometer (Perkin Elmer AA- Analyst 200, USA) with Flow Injection Analyze Mercury Hydride Generation System (Model–FIAS-100) at 193.7 nm (detection limit 0.02 µg/L) as per the standard procedure[16].

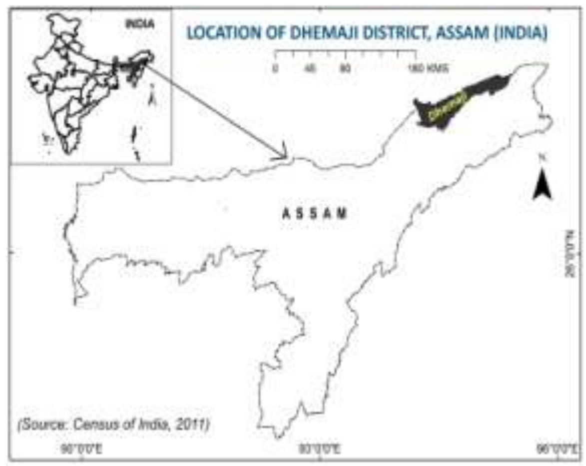

Figure 1: A cross sectional view of the study area, Dhemaji district in Assam, India

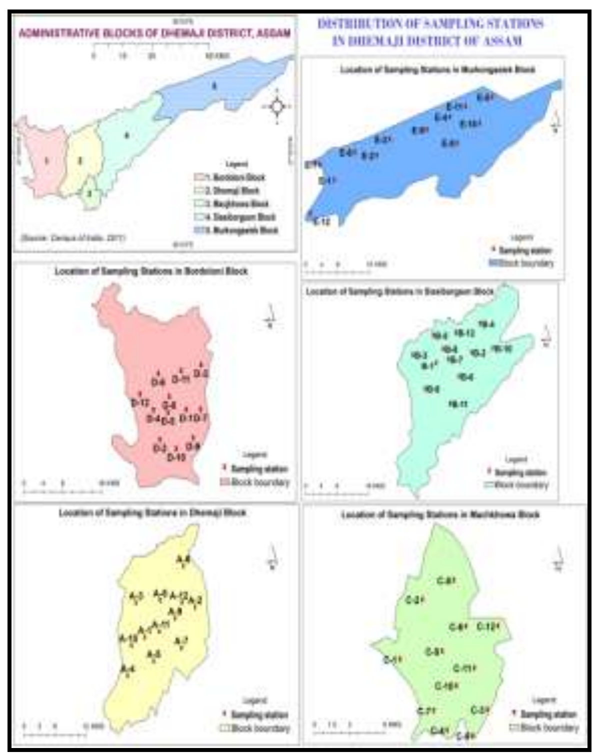

Figure 2: **Map showing the Block wise distribution of 60 sampling stations in the study area**

Table 1: Block wise physical location of sampling stations in the study area

Block Name	Sample No.	Geographical Location		Sample No.	Geographical Location	
		North (N)	East (E)		North (N)	East (E)
DHEMAJI	A-1	27° 27.240'	94° 30.125'	A-7	27° 26.242'	94° 34.430'
	A-2	27° 29.815'	94° 36.106'	A-8	27° 30.479'	94° 31.978'
	A-3	27° 30.290'	94° 29.132'	A-9	27° 28.867'	94° 33.725'
	A-4	27° 23.866'	94° 28.076'	A-10	27° 26.530'	94° 28.565'
	A-5	27° 25.113'	94° 31.145'	A-11	27° 27.735'	94° 31.840'
	A-6	27° 33.466'	94° 34.762'	A-12	27° 30.245'	94° 34.560'
SISIBORGAON	B-1	27° 34.870'	94° 41.540'	B-7	27° 35.245'	94° 43.456'
	B-2	27° 35.986'	94° 47.031'	B-8	27° 36.460'	94° 42.655'
	B-3	27° 35.821'	94° 37.930'	B-9	27° 31.887'	94° 39.777'
	B-4	27° 39.306'	94° 48.409'	B-10	27° 36.441'	94° 50.414'
	B-5	27° 38.037'	94° 41.128'	B-11	27° 30.082'	94° 43.608'
	B-6	27° 33.241'	94° 45.064'	B-12	27° 38.328'	94° 44.647'
MACHKHOWA	C-1	27° 19.240'	94° 31.730'	C-7	27° 17.224'	94° 33.454'
	C-2	27° 21.543'	94° 32.917'	C-8	27° 22.275'	94° 34.560'
	C-3	27° 17.230'	94° 36.225'	C-9	27° 16.226'	94° 35.450'
	C-4	27° 16.460'	94° 34.137'	C-10	27° 18.182'	94° 34.645'
	C-5	27° 19.528'	94° 33.913'	C-11	27° 18.860'	94° 35.577'
	C-6	27° 20.477'	94° 35.164'	C-12	27° 20.475'	94° 36.827'
BORDOLONI	D-1	27° 26.230'	94° 24.570'	D-7	27° 26.222'	94° 26.345'
	D-2	27° 23.450'	94° 21.225'	D-8	27° 27.466'	94° 22.450'
	D-3	27° 30.387'	94° 26.442'	D-9	27° 23.572'	94° 25.376'
	D-4	27° 26.240'	94° 20.450'	D-10	27° 22.573'	94° 23.252'
	D-5	27° 25.983'	94° 22.250'	D-11	27° 29.884'	94° 23.957'
	D-6	27° 29.631'	94° 21.097'	D-12	27° 27.760'	94° 18.780'
MORKONGSELEK (TRIBAL)	E-1	27° 41.713'	94° 55.991'	E-7	27° 43.510'	94° 53.888'
	E-2	27° 44.453'	95° 2.544'	E-8	27° 45.670'	95° 14.765'
	E-3	27° 46.225'	95° 4.560'	E-9	27° 47.225'	95° 10.225'
	E-4	27° 48.630'	95° 13.744'	E-10	27° 47.810'	95° 18.229'
	E-5	27° 50.778'	95° 20.261'	E-11	27° 49.786'	95° 16.159'
	E-6	27° 44.840'	94° 59.183'	E-12	27° 37.956'	94° 52.321'

Results and Discussion

The experimental findings of the experimental data are summarized in Table 2. The GIS map for block wise arsenic distribution in both pre and post – monsoon season have been presented in Figure 3 and 4.

Table 2: Block wise Arsenic concentrations in the study area

Block Name	Sample No.	Arsenic Concentration (in µg/L)		Sample No.	Arsenic Concentration (in µg/L)	
		Pre-Monsoon	Post-Monsoon		Pre-Monsoon	Post-Monsoon
DHEMAJI	A-1	3.05	5.20	A-7	12.25	14.20
	A-2	BDL*	3.25	A-8	6.20	10.50
	A-3	10.70	13.50	A-9	12.80	8.25
	A-4	4.80	5.75	A-10	3.12	9.50
	A-5	BDL*	4.60	A-11	7.10	9.10
	A-6	15.60	17.95	A-12	4.30	4.10
SISIBORGAON	B-1	12.40	11.20	B-7	10.30	19.45
	B-2	13.05	14.40	B-8	17.01	15.30
	B-3	10.57	8.04	B-9	12.60	12.10
	B-4	14.30	14.20	B-10	7.25	12.45
	B-5	12.15	10.05	B-11	7.18	8.25
	B-6	9.40	13.10	B-12	14.20	15.70
MACHKHOWA	C-1	5.20	5.45	C-7	7.30	9.20
	C-2	3.15	BDL*	C-8	7.20	9.50
	C-3	8.18	10.30	C-9	9.04	11.38
	C-4	7.50	9.70	C-10	8.14	5.80
	C-5	4.10	5.60	C-11	5.90	7.20
	C-6	5.40	6.30	C-12	9.10	11.74
BORDOLONI	D-1	6.30	7.50	D-7	7.30	8.40
	D-2	7.10	6.52	D-8	12.40	9.25
	D-3	8.14	5.80	D-9	10.40	11.70
	D-4	6.90	4.20	D-10	13.12	9.20
	D-5	8.10	10.74	D-11	10.30	9.55
	D-6	4.30	6.25	D-12	7.05	8.80
MORKONGSELEK (TRIBAL)	E-1	14.40	9.25	E-7	8.40	9.75
	E-2	17.40	18.70	E-8	4.20	4.95
	E-3	13.12	14.20	E-9	10.54	10.15
	E-4	12.30	9.55	E-10	7.50	5.55
	E-5	7.05	6.80	E-11	7.60	8.50
	E-6	9.40	9.75	E-12	5.30	7.45

*BDL: Below detection limit

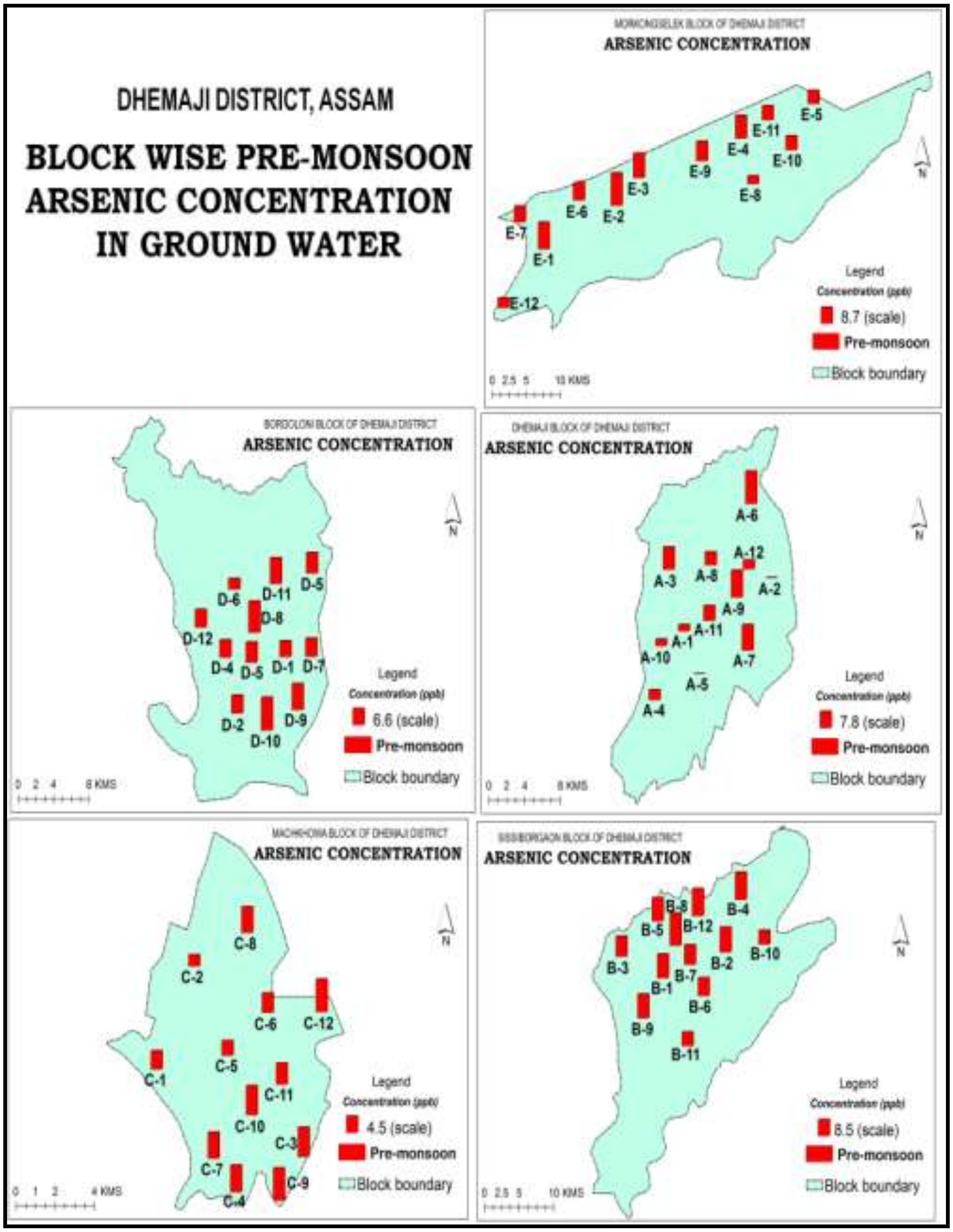

Figure 3: Pre- Monsoon season spatial distribution map for arsenic among the sampling stations

From analysis of water samples it is observed that the district fall under toxic and alert categories with respect to As as 37 % of the analysed samples exceed the permissible limit set by WHO/BIS (10 µg/L)[17,18]. The observed values of concentration for arsenic content in the water samples ranges from BDL to 19.45 µg/L. The highest arsenic concentration was recorded at sampling point, B-7 of Sissiborgaon development block. This block was most badly affected, where 75% of the samples had arsenic concentration above the WHO drinking water guideline values. Significant variation was observed between pre-monsoon (October to April) and post-monsoon (May to September). Arsenic concentration is sufficiently higher in post-monsoon than in pre-monsoon season. Long term exposure to As contaminated water may lead to various diseases such as conjunctivitis, hyperkeratosis, hyperpigmentation, cardiovascular diseases, disturbance in the peripheral vascular and nervous systems, cancer of the skin, lung, liver, urinary bladder and kidney skin, gangrene, leucomelonisis, nonpitting swelling, hepatomegaly and splenomegaly[19].

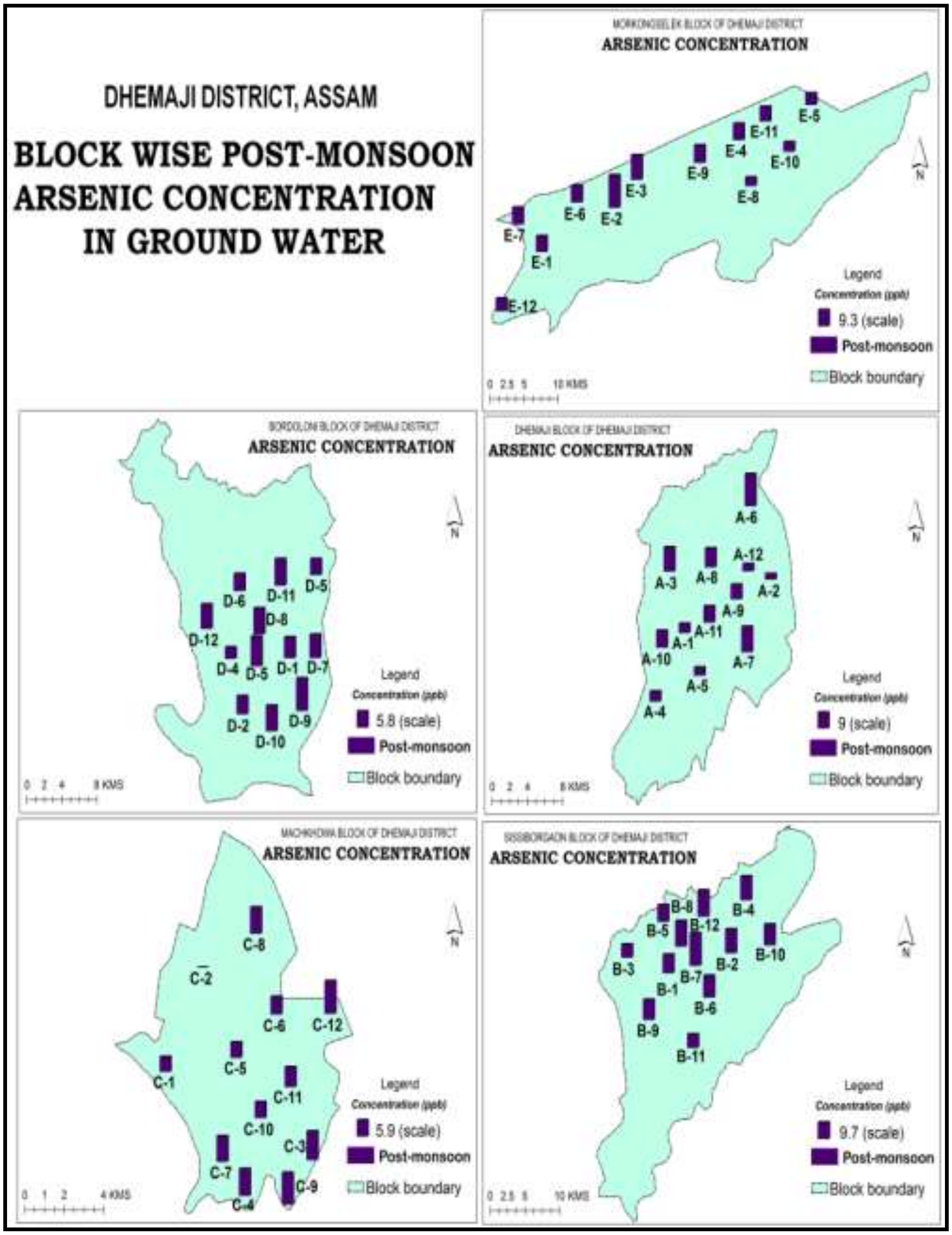

Figure 4: Post-Monsoon season spatial distribution map for arsenic the sampling stations

Conclusion

Arsenic contamination of groundwater is an alarming problem on a global scale. In several parts of the world, biogeochemical processes have resulted in dissolution of naturally occurring arsenic into groundwater. For almost two decades, research on arsenic has gained a considerable momentum as response arsenic to the detrimental health effects of the element. The recognition of the scale of arsenic enrichments in groundwater in West Bengal, India and Bangladesh and elsewhere has opened up a serious concern in the scientific community. Billions of people use to drink waters from aquifers daily however; new reports are coming from different areas regarding arsenic contamination. Several factors are involved in the ever expanding impure water tables throughout the world, involving new aquifers that are yet to be recognized. Therefore, the primary concern to counter the problem of groundwater contamination especially with a high-priority toxic substance like arsenic in a newly reported region is an early survey-based detection of the pollution and identification of the affected sources to remediate the crisis. The mitigation strategy for the problem in the area might be specific to the location, taking into considerations the geomorphological variations and socioeconomic conditions. Understanding the groundwater movements require in-depth characterization and routine verification of physical hydrogeology. Moreover, community participation to make the villagers of the affected regions of the district studied understand the signs and symptoms of the chronic arsenic toxic effects is of utmost necessary. Again, cost-effective, user friendly technologies providing pure water are required to counter the serious health hazards due to consumption of arsenic contaminated water. A long-term environmental planning and integrated research is essential to mitigate the danger of such poisoning. A wholistic approach involving medical practitioners, scientists, and social workers will need to work coherently to find out a solution that can lessen sufferings of the humanity and making a provision for safe drinking water.

Acknowledgement

This research was supported by a grant from University Grants Commission, New Delhi and Regional Office, Guwahati in the form of minor research project vide no. F. 5- 158/2015-16 (MRP/NERO)/418 dated 23rd Nov, 2016. Author is also thankful to Mr. Krishna Das, Research Fellow, Department of Geography, Gauhati University for his kind help in GIS analysis.

References

1. Chatterjee S., Chattopadhyay B. and Mukhopadhyay S.K., Elemental profile of abiotic components of the East Calcutta Wetlands, a Ramsar site in India. *Land Contamination & Reclamation,* **16(4)**, 365–379 (**2008**)

2. Claessens L., Hopkinson C., Rastetter E., Vallino J., Effect of historical changes in land use and climate on the water budget of an urbanizing watershed, *Water Resour. Res.*, **42** (**2006**)

3. Chang H.J., Comparative stream flow characteristics in urbanizing basins in the Portland Metropolitan Area, *Hydrol. Process*., **2**1, 211–222 (**2007**)

4. Oke T.R., Boundary Layer Climates, *Methuen*, New York (**1987**)

5. Nelson K.C., Palmer M.A., Stream temperature surges under urbanization and climate change: data, models, and responses, *J. Am. Water Resour. Assoc*. **43**, 440–452 (**2007**)

6. Baker A., Land use and water quality, *Hydrol. Proc.*, **17(12)**, 2499–2501 (**2003**)

7. Chakraborti D., Das B., Rahman M.M., Chowdhury U.K., Biswas B., Goswami A.B., Nayak B., Pal A., Sengupta M.K., Ahamed S., Hossain A., Basu G., Roychowdhury T. and Das D., Status of groundwater arsenic contamination in the state of West Bengal, India: A 20-year study report, *Mol. Food Res.*, **53**, 542-551 (**2009**)

8. Chakraborti D., Rahman M.M., Das B., Murrill M., Dey S., Mukherjee S.C., Dhar R.K., Biswas B.K., Chowdhury U.K., Roy S., Sorif S., Selim M., Rahman M. and Quamruzzaman Q., Status of groundwater arsenic contamination in Bangladesh: A 14-year study report, *Water research,* **44**, 5789-5802 (**2010**)

9. Bunnell J.E., Finkelman R.B., Centeno J.A., Selinus O., Medical geology:Aglobally emerging discipline. *Geologica Acta*, **5(3)**, 273–281, (**2007**)

10. Xia Y., Wade T.J., Wu K., Li Y., Ning Z., Le X. C., Well water arsenic exposure, arsenic induced skin-lesions and self-reported morbidity in inner Mongolia. *International Journal of Environment Resource Public Health,* **6**, 1010–1025 (**2009**)

11. Shankar S., Shanker U., Shikha, Arsenic Contamination of Groundwater: A Review of Sources, Prevalence, Health Risks, and Strategies for Mitigation, *The Scientific World Journal*, 2014 (**2014**), Article ID 304524, 18 pages, http://dx.doi.org/10.1155/2014/304524

12. Mishra S., Current Status of Ground Water Arsenic Contamination in India and Recent Advancements in Removal Techniques from Drinking Water, *International Journal of Plant and Environment*, ISSN: 2454-1117, (**2016**), DOI: https://doi.org/10.18811/ijpen.v2i1-2.6613.

13. Das S., Bora S.S., Lahan J.P., Barooah M., Yadav R.N.S., Chetia M., Groundwater arsenic contamination in North Eastern states of India, *Journal of Environmental Research And Development*, **9(3)**, 621-632, (**2015**)

14. Ground Water Information Booklet, Dhemaji District, Assam, Ministry of Water Resources, Guwahati, http://cgwb.gov.in/District_Profile/Assam/.pdf (**2008**)

15. Laxen D.P.H., Harrison R.M., Cleaning methods for polythene containers prior to the determination of trace metals in fresh water samples. *Analytical Chemistry*, **53,** 345-350 (**1981**)

16. Eatson A.D., Clesceri L.S., Rice E.W., Greenberg, A.E., *Standard methods for the examination of water and wastewater* (21st ed.), 4–138, Centennial Edition, USA (**2005**)

17. WHO, Guidelines for drinking water quality, World Health Organization, Geneva (**2008**)

18. BIS, Bureau of Indian Standards, 10500: Second Revision ICS No. 13.060.20, downloaded from: http://www.bis.org.in/sf/fad /FAD25(2047)C.pdf (**1991**)

19. Jack C.N.G., Wang J. and Shraim A., A global health problem caused by arsenic from natural sources, *Chemoshpere*, **52**, 1353-1359 (**2003)**