EASTERN

Glimpses of Biological Research in Upper Brahmaputra Basin

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Preface

Biological research has achieved a unique chair in the entire research arena. It is now recognized as an indispensable field of research with immense awaited possibilities in multiple areas of human interest. The legacy of exciting and groundbreaking discoveries in biology is still nascent. Dramatic improvement in medicine, agriculture, and forestry is perceived to be endured through the new biological findings. It will be praiseworthy to probe the cure of many threatening diseases like cancer amongst the vast biological resources. At the same time, a major chunk of the population is dependent on bioresources for their livelihood. With burgeoning population and subsequent pressure on limited bioresources, adoption of technology and up-gradation of traditional knowledge systems will help increase agricultural production including fish production. In this context, biologically enriched regions need to play a crucial role in such strategic endeavors. Being a hotbed of biodiversity, northeast India has immense capability to become a key contributor for biological data which may fill up some of the knowledge gap prevailing in biological fields. It is indeed the need of the hour to capitalize on these biological resources of the northeast region through scientific exploration. This book is intended to draw the participation of young minds in the process of biological investigation and to cast their ideas regarding various avenues of this majestic field of knowledge. We deeply believe the notion of exposing the scientific minds to such a platform to encourage their endeavor of knowledge hunt. The mantra behind this book is to reflect the various facet of biological research effort and to capture a snapshot of the ongoing voyage of inquiry, especially in northeast India. This book envisions the idea of accepting a wide range of ideas and works which will impart a holistic outlook to this piece of chore. We also strongly believe that researchers will get a chance to improve their scientific writing skills which is indeed an unavoidable aspect of research.

Dr. Akash Kachari
Dr. Shyama Prasad Biswas
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Arsenic and Iron Content in Water Sources of Lakhimpur District, Assam, India

Bhaba Kumar Pegu
Dipmoni Gogoi
Mridul Buragohain

Abstract

The present study was carried out to investigate the spatial assessment of arsenic and iron content in water sources of Lakhimpur district of Assam (India), and the adjoining region of the West Bengal and Bangladesh borders. For this study, 54 water samples were collected from tube wells, ring wells, hand pumps, public water supply and rivers during July 2018 using GIS technique covering the study area. Study revealed that 11.11% of the analyzed water sample was contaminated by arsenic (WHO; 10μg/L for potable water). The most badly affected areas were Ghilamara and Boginodi development blocks. The highest arsenic concentration was recorded at 12.46μg/L at the sampling point, H-1. With respect to iron, the water samples of the study area were highly contaminated by iron as 74% of analyzed water samples exceed the WHO drinking water standard (0.3 mg/L).

Keywords: *Arsenic, iron, GIS, Lakhimpur, Assam*

Introduction

Heavy metals are major toxicants found in industrial wastewater and may adversely affect the biological treatment of wastewater. Its specific weight is more than 5.0 g/cm3 (Volesky, 1990; Li and Bishop, 2002). Arsenic is the 20th most abundant element in the Earth's crust 14th in the seawater and 12th in the human body (Woolson, 1975) and is widely distributed throughout nature as a result of weathering, dissolution, fire, volcanic activity and anthropogenic input (Cullen and Reimer, 1989). The last includes the use of arsenic in pesticides, herbicides, wood preservatives, and dye as well as the production of arsenic-containing wastes during smelting and mining operations. In arsenic-enriched environments, a major concern is the potential for mobilization and transport of this toxic element to groundwater and drinking water supplies. In Bangladesh, an estimated 57 million people have been exposed to arsenic through contaminated wells. This incident serves as an unfortunate reminder of the toxic consequences of arsenic mobilization and underscores the need to understand the factors controlling the mobility and solubility of arsenic in aquatic systems (Newman *et al.*, 1997). In northeastern India, arsenic has been detected in some districts of Assam, Tripura, Arunachal Pradesh, Manipur, and Nagaland. The extent, distribution, origin, and mobilization process of arsenic and iron in the aquifers of river Brahmaputra basin, mostly located in the Indian state of Assam, has been largely undocumented, and unexplored. Brahmaputra River (also known as Tsang Po in Tibet and China), the fourth largest fluvial system in the world, is the largest river that flows in the southeastern Tibet and northeastern parts of India and is mostly responsible for landscape evolutions of associated region. Originated in the Trans-Himalayas, the river enters the Indian state of the Assam through the deep Tsang Po gorge and flows as a wide and deep braided river system. The Brahmaputra river valley is mainly a Quaternary valley-fill with a few isolated pre-Cretaceous residual hills. In the Brahmaputra river basin, arsenic and iron-enriched aquifers are located mostly in alluvial deposits by the Brahmaputra river channel and its tributaries (Chetia *et al.*, 2011). The present study revealed the present status of arsenic and iron toxicity, spatial distribution in the Lakhimpur district of Assam. The study would help to fling light on the water quality concerning arsenic and iron in one of the most important areas of northeast India.

Materials and Methods

Profile of the study area: Lakhimpur district lies on the North East corner of Assam and at the North Bank of the mighty river Brahmaputra. The district lies between 27.597' Northern latitude and 94.737' Eastern longitude and covers an area of 2,277 sq km out of which 2257 sq km is rural and 20 sq km is urban. It is bounded on the north by Siang and Papumpare district of Arunachal Pradesh and on the East by Dhemaji District and Subansiri River. The river Brahmaputra along with the Majuli district stands on the southern side and the Gahpur subdivision of Biswanath district is on the West. The area is characterized by a temperature range of 24°C -33°C and with an average humidity of 82%. The annual rainfall of the district is 1551.3mm per year.

Table 2.1: Blockwise physical location of sampling stations in the study area

Block Name	Sample No.	Sample Source	Geographical Location		Block Name	Sample No.	Sample Source	Geographical Location	
			North (N)	East (E)				North (N)	East (E)
NARAYANPUR	A-1	RW	27.024	93.872	LAKHIMPUR	E-4	TW	27°15'4"	94.0550
	A-2	TW	27.041	93.834		E-5	TW	27.171	94.0530
	A-3	TW	27.062	93.81		E-6	TW	27.142	94.043
	A-4	TW	27.092	93.796	TELAHI	F-1	RW	27.179	94.132
	A-5	TW	27.115	93.774		F-2	TW	27.112	94.073
	A-6	TW	27.145	93.786		F-3	TW	27.09	94.062
BIHPURIA	B-1	RW	26.998	93.927		F-4	TW	27.133	94.061
	B-2	TW	26.977	93.954		F-5	TW	27.111	94.074
	B-3	TW	27.004	93.91		F-6	TW	27.175	94.023
	B-4	PWS	26.9523	93.96	BOGINODI	G-1	TW	27.333	94.164
	B-5	TW	27.015	93.916		G-2	RW	27.298	94.148
	B-6	TW	27.098	93.827		G-3	R	27.447	94.257
KARUNABARI	C-1	TW	27.098	93.827		G-4	PWS	27.449	94.248
	C-2	TW	27.102	93.943		G-5	TW	27.41	94.194
	C-3	TW	27.122	93.932		G-6	TW	27.315	94.157
	C-4	TW	27.123	93.853	GHILAMARA	H-1	HP	27.285	94.295
	C-5	R	27.112	93.826		H-2	TW	27.201	94.357
	C-6	TW	27.054	93.952		H-3	PWS	27.189	94.389
NOWBOICHA	D-1	TW	27.162	93.997		H-4	R	27.33	94.343
	D-2	TW	27.174	94.024		H-5	TW	27.306	94.301
	D-3	PWS	27.203	94.056		H-6	TW	27.218	94.335
	D-4	R	27.205	94.06	DHAKUWAKHANA	I-1	TW	27.198	94.424
	D-5	R	27.163	94.007		I-2	TW	27.202	94.442
	D-6	TW	27.151	94.022		I-3	TW	27.306	94.442
LAKHIMPUR	E-1	TW	27.114	94.052		I-4	TW	27.114	94.255
	E-2	TW	27.141	94.056		I-5	TW	27.121	94.255
	E-3	TW	27.133	94.035		I-6	TW	27.125	94.243

Sampling information and analysis: For the study, 54 samples were collected randomly from nine development blocks of Lakhimpur district (Fig. 2.1 and Fig. 2.2). Samples were collected by random selection and combined in clean and sterile one-liter polythene cans to obtain a composite sample, 1:1 HNO3 solution was added to each of the water samples (to make pH <2.0) and stored in an icebox which were carried to the laboratory for arsenic analysis (Laxen *et al.*, 1981). Water temperatures were measured at the source by using a digital thermometer. The locations of the sampling points were obtained with a handheld global positioning system (GPS, Germin 72 model) with a position accuracy of less than 10m (Table 2.1). 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. The water pH was measured using a digital pH meter (Model-802, Systronics, India). In regards to this study analysis of arsenic and iron content of the water samples were done by using Atomic Absorption Spectroscopy (model-240AA by Agilent Technologies) with Flow Injection Analyze Mercury Hydride Generation System (Model–FIAS-100) at 193.7 nm (detection limit 0.02 ig/L) as per the standard procedure (Eatson *et al.*, 2005).

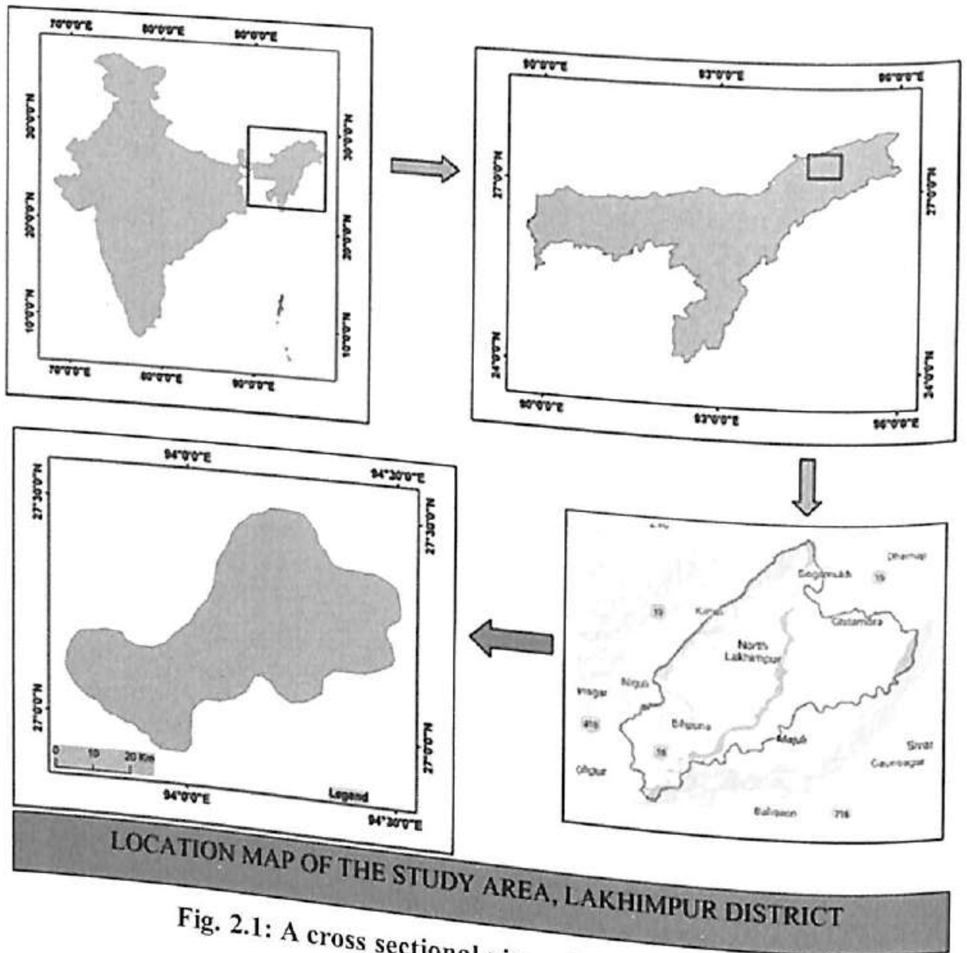

Fig. 2.1: A cross sectional view of the study area

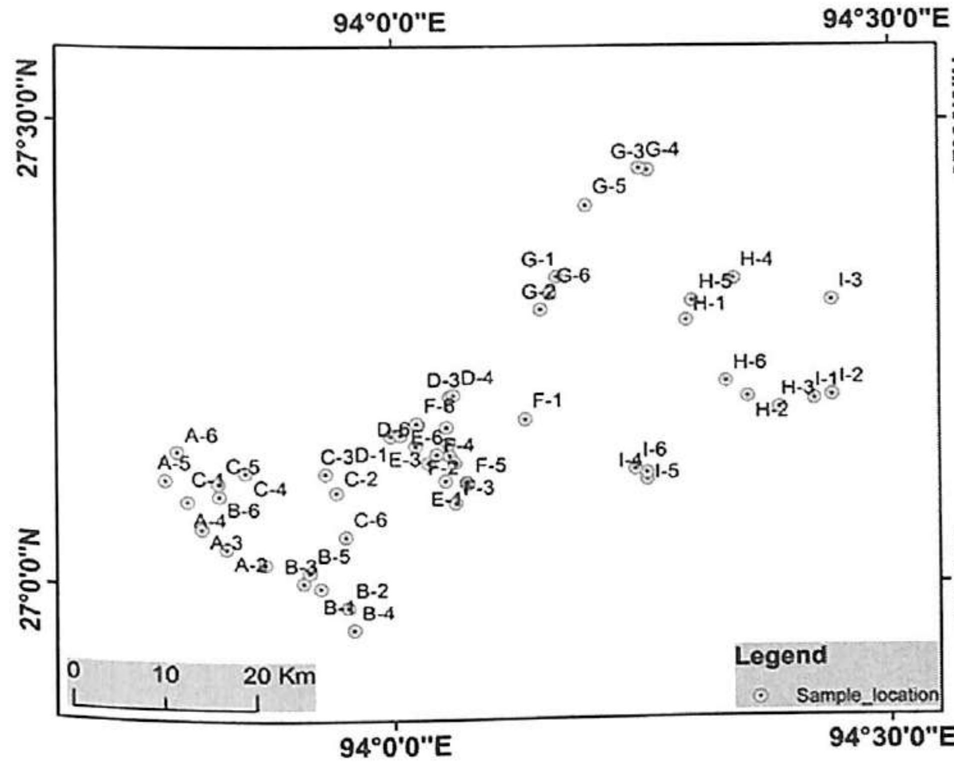

Fig. 2.2: Map showing the block-wise distribution of 54 sampling stations

Results

The experimental findings of the experimental data are summarized in Table 2.2. The spatial distribution map for arsenic and iron had been presented in Fig. 2.3 and 2.4. To find the accuracy of the content in the water samples, the data were exposed to several statistical analyses (Table 2.3).

Table 2.2: Distribution of the metal content in sampled water

Sample No.	Temp (°C)	pH	Fe (ppm)	As (µg/L)	Sample No.	Temp (°C)	pH	Fe (ppm)	As (µg/L)
A-1	26.8	6.2	0.298	0.030	E-4	25.8	7.3	1.940	0.450
A-2	27.0	7.1	0.137	0.020	E-5	28.0	6.6	1.003	0.112
A-3	25.0	6.8	0.213	0.290	E-6	30.1	7.4	0.784	0.390
A-4	25.5	7.2	0.332	0.320	F-1	30.0	6.8	0.290	0.320
A-5	27.3	8.3	0.339	0.030	F-2	26.0	8.1	0.949	0.450
A-6	26.3	7.8	1.800	0.200	F-3	28.9	7.5	1.003	0.340
B-1	29.7	7.5	1.003	0.040	F-4	28.0	7.4	1.204	0.456

B-2	27.7	7.0	1.006	0.210	F-5	27.0	7.3	0.098	0.567
B-3	25.0	7.7	0.987	0.079	F-6	28.5	7.6	1.006	0.435
B-4	26.8	6.7	0.189	0.060	G-1	25.5	8.4	0.357	12.300
B-5	26.2	6.5	0.454	11.980	G-2	27.0	7.6	0.441	11.290
B-6	25.7	8.1	0.339	0.200	G-3	25.5	6.8	0.910	4.300
C-1	26.5	8.4	1.232	0.290	G-4	30.0	7.9	1.870	0.342
C-2	25.5	6.3	1.859	0.980	G-5	25.7	6.8	0.562	0.320
C-3	28.5	6.9	0.567	0.006	G-6	27.8	7.5	2.552	11.860
C-4	29.0	7.2	1.580	0.580	H-1	27.5	7.3	1.935	12.460
C-5	30.5	7.2	2.456	0.456	H-2	26.5	6.8	0.989	0.322
C-6	31.5	7.9	1.223	0.060	H-3	28.0	7.3	1.990	0.474
D-1	30.0	7.3	0.463	1.280	H-4	26.8	6.4	1.980	0.383
D-2	29.5	8.3	0.574	0.260	H-5	31.5	7.1	0.943	0.433
D-3	27.0	6.8	1.889	0.445	H-6	30.0	7.3	0.434	0.324
D-4	30.6	7.4	0.878	0.051	I-1	27.0	8.4	1.434	0.343
D-5	31.0	7.3	1.994	0.334	I-2	28.0	8.3	0.544	0.003
D-6	29.5	7.2	1.395	0.995	I-3	25.5	7.4	1.800	0.394
E-1	26.4	6.7	0.394	0.030	I-4	27.5	6.3	0.888	0.230
E-2	31.0	8.4	6.230	1.310	I-5	29.0	6.7	1.849	11.345
E-3	32.5	7.1	0.985	0.121	I-6	26.0	6.7	0.637	0.998

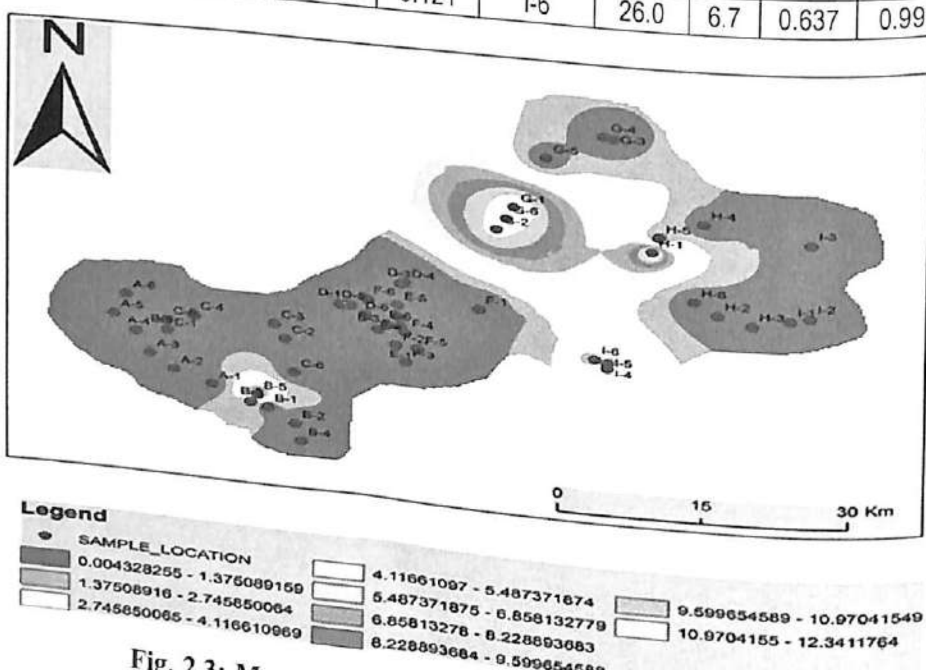

Fig. 2.3: Map showing the locations of arsenic content

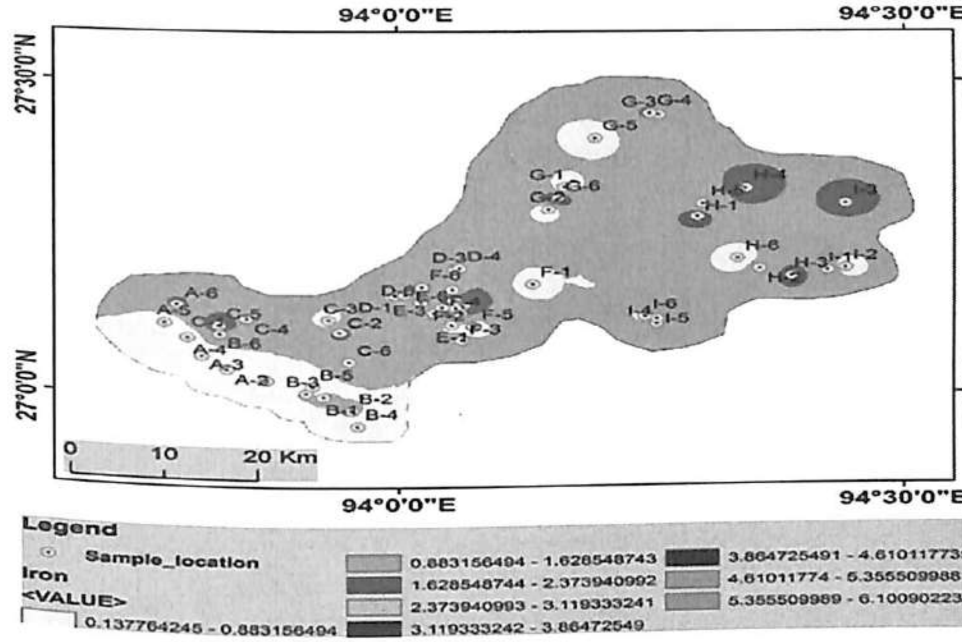

Fig. 2.4: Map showing the location of iron content

Discussion

The study reveals that drinking water samples of Lakhimpur district falls under alert categories concerning arsenic as 11.11% of analyzed water sample exceeds above WHO guideline value (10µg/L). The elevated arsenic concentration of the water samples ranged from 12.46 µg/L in hand pump (H-1, Ghilamara) to 12.3 µg/L in tube well (G-1, Boginodi). From the statistical analysis, it was observed that significant positive skewness and kurtosis value point towards sharp arsenic distribution with a long right tail. It is observed that groundwater samples of Lakhimpur district fall under toxic and alert categories concerning arsenic as some of the samples exceed and some are approaching the WHO guideline value was found high than compared to As (V) in groundwater samples of Ballia district, Uttar Pradesh, India. The study revealed that reductive termination of FeOOH was responsible for arsenic release (Chauhan *et al.*, 2009). Groundwater of Barpeta district, Assam, India was highly contaminated with arsenic. The quality of the water was found to be alkaline with an elevated amount of iron, manganese, and lead (Jain *et al.*, 2018). Zinc, cadmium, manganese, lead, and arsenic in water samples of tube wells, deep tube wells and ring wells of Kamrup district, Assam (India) were estimated and found that the arsenic content did not exceed the WHO limit but was relatively found to be high (Chakraborty and Sarma, 2010). The iron contamination of the tea garden belt of Darrang district of Assam, India was found to be higher in concentration in tube wells of the area. The arsenic content was found below or at the WHO limit and showed positive kurtosis and skewness value (Borah *et al.*, 2010). The contamination of metals like aluminium, lead, cadmium, and arsenic with respect to seasonal variations was found in groundwater samples of Dhemaji district of Assam (Buragohain *et al.*, 2009).

Table 2.3: Statistical enumeration of some physical and chemical parameters

Statistics	Temperature (°C)	pH	Iron	Arsenic
Mean	27.87	7.30	1.13	1.64
Std.deviation	1.93	0.59	0.95	3.63
Median	27.50	7.30	0.98	0.34
Mode	27.00	7.30	1.00	0.03
Standard Error of Mean	0.26	0.08	0.12	0.49
Variance	3.74	0.35	0.90	13.19
Skewness	0.47	0.29	2.94	2.52
Standard Error of Skewness	0.33	0.33	0.33	0.33
Kurtosis	-0.73	-0.61	14.07	4.61
Standard Error of the Kurtosis	0.66	0.66	0.66	0.66
Range	7.50	2.20	6.13	12.45
Maximum	32.50	8.40	6.23	12.46
Minimum	25.00	6.20	0.09	0.00
Percentile (25)	26.32	6.80	0.45	0.20
Percentile (50)	27.50	7.30	0.98	0.34
Percentile (75)	29.50	7.60	1.74	0.54

The stressed zone of arsenic concentration can be seen in Boginodi, Ghilamara, Bihpuria, and Dhakuakhana development block. In the present study meets or falls below the current standard l for arsenic, which is 0.05ppm (WHO, 2004). The arsenic contamination in the water samples may be due to the use of various insecticides, herbicides, pesticides and fungicides which allow the source of water to be xenobiotic contamination (Das *et al.*, 2003). In addition to this the uses of arsenical compounds and additive in livestock feed, particularly for poultry may be a demerit. The mobilization of arsenic might be due to the reductive dissolution of As-Fe bearing minerals in the sediments reduced by oxygen-deficient

groundwater (Huq *et al.*, 2018). Moreover, several agricultural practices, industrial debris, and households' sewages can be strong evidence of arsenic contamination in the water sources. Available literature shows that groundwater in different districts of Assam are highly contaminated with iron in the form of fluorosis (Susheela, 2007; Kotoky *et al.*, 2008). A high level of iron distribution in groundwater sources of certain districts of Assam has also been observed (Aowal, 1981; Baruah *et al.*, 1995). The study area falls under alert categories regarding iron also as 74% of analyzed water samples exceed the WHO drinking water standard (0.3 mg/L). The elevated concentration of iron content analyzed is found to be 6.230 ppm in Tube well (E-2, Lakhimpur development block). A similar result found a strong correlation of arsenic and iron was observed in groundwater samples of the Golaghat district of Assam (India) and the study suggested that arsenic mobilization in groundwater may be due to As-Fe bearing minerals (Chetia *et al.*, 2011). The statistical analysis is supported by positive skewness and kurtosis value which is the point towards sharp iron distribution with a long right tail in the study area. The major hotspot of iron concentration is traced in Lakhimpur and Ghilamara block. Higher concentrations of iron in tube wells of the area may be due to the soil origin and uses of old rotten iron pipes.

Conclusion

The study area, Lakhimpur district is covered with alluvial soil. They are all recent soils of Oligocene to Miocene age. This is a part of the Assam-Arakan basin and soil younger than Cretaceous age. There are certain minerals such as arsenopyrite, Nicolette, gresdorfite, skutterdite which contain arsenic. These minerals are rich in igneous rocks or sedimentary exhalative sulphides in reducing conditions. They are generally leached out by groundwater in the dissolved phase. There must be some continuous supply of arsenic, some bedrocks beneath where arsenic is being uprighted to shallow aquifers from deep wells. Moreover, Lakhimpur district has blundy of tea gardens and paddy fields where a huge amount of fertilizers and pesticides are being used. The arsenic forms weak bonds with certain organic material, helps the arsenic to precipitate which may lead to arsenic contamination in groundwater and further decomposed in the same land and concentrating it. Drinking water quality assessment is nowadays a prime awareness for public health. Most regions are not validated under WHO guidelines values that are unsafe as potable water. The study is a fact survey to convey the study area as an alert region for arsenic and iron. The unsafe water resources should be sealed by Govt. and other agencies to avoid the upcoming hazardous health risk. The water sources of the study area should be treated indigenously with proper management before its use. Arsenicosis due to arsenic contamination in drinking water is a major public health crisis in India. Since the identification of arsenic-contaminated tube wells and arsenic patients, government and nongovernment organizations undertook several activities to stop the arsenic exposure through drinking water by providing alternate sources of arsenic-safe water, identification of arsenicosis patients and their management, and mass awareness programs. These activities could only bring about a little sustainable significant positive impact. The lagging of sustainable arsenic-safe water supply and effective arsenicosis management program is apparent, and surveillance for complications particularly cancers among arsenicosis patients and arsenic-exposed populations is lacking.

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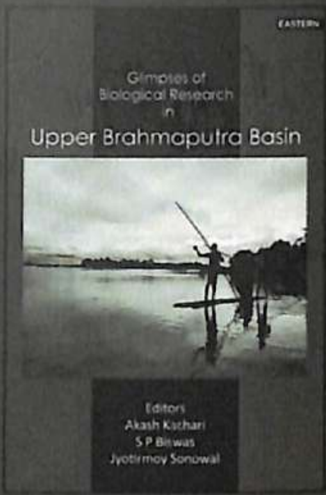
The book



Although in the global context, emphasis of research is given more on molecular biology and biotechnology; the importance of basic research cannot be overestimated. This is more so in the case of India's northeast region. The region is well known for its rich biodiversity and a good number of research papers in plant and animal sciences were published in the last few decades. However, it is also a fact that documentation of bioresources of the region is far from complete. Little is known about the distribution and current status of many of the endemic and rare species of the region. It is also necessary to have a scientific information on the traditional usage and active ingredients available in the edible/medicinal plants, animals and microbes, and also how to maintain habitat ecology and formulation of strategies for sustainable utilization of bioresources of the region. The book gives an overview of the present trend of research in biological sciences in the north-east India.

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