ARSENIC AND IRON CONTAMINATION IN GROUND WATER IN LOWER BRAMHAPUTRA BASIN IN BONGAIGAON AND PART OF DHUBRI DISTRICTS OF ASSAM STATE, INDIA

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ABSTACT

The occurrence of arsenic as contamination in ground water has received national attention in recent years especially after arsenic pollution of ground water in West Bengal in early 80's. The serious ill-effects of its contamination in ground water have led to curiosity to discover of new areas having arsenic pollution. Its long exposure of higher concentration in ground water and food links to bladder and lung cancers in human beings. . Arsenic concentration is detected in various proportions from 0.3 to 14.3 ppb/l in ground water, surface water bodies and streams. Out of 50 samples, at three place viz., Charkola, Paglahat and Tamarhat, where its concentration exceeded permissible limit of 10 ppb/l. Except at three locations, where its concentration is below detection level, in rest of places the concentration of arsenic is in the range from 0.3 to 9.0 ppb/l, and at 2 locations viz Golakganj and Mazagaon, its concentration is recorded 9.1ppb/l. Iron, the second most abundant element by weight in the earth's crust, is normally present in ground water in the ferrous form (Fe^{++}), which is a soluble state and easily oxidized to trivalent ferric iron (Fe^{+++}). Aeration of iron can affect the quality of both ground water and surface water. The results of Iron and other parameters are yet to be received; however, previous results of 75 samples in the study area show that Iron concentration is in ground water varying from 0.03 to 15.1 mg/l. Its concentration is widely distributed with various proportions in the study area. In about 85% of samples Fe concentration is exceeded the permissible limit of 0.3 mg/l. The geologic and hydro geological factors play a prominent role for localization of As in the area. As might have derived from arsenic rich iron hydroxides on weathering of sulfide minerals- Pyrite and Arseno-pyrites. However the exact evidence of possible cause of localized concentration of As is yet to be ascertained. Ground water quality of phreatic aquifers is suitable for drinking, domestic, irrigation and industrial purposes. All the general chemical constituents like Ca, Na, K, Cl. Co3-HCo3, and sulfate are within permissible limits set by BIS except Iron and Arsenic at some places.

1.0 INTRODUCTION

As a part of Ground Water Management Studies during AAP 2009-10 an area of 3511.10 sq. km covered in Bongaigaon and part of Dhubri districts in western part of Assam State, which form lower part of Bramhaputra river basin, falling in Survey of India topo sheets of 78 F/15,16, 78 J/3,4,7,8,11,12 and 15, within the latitudes $26^0$00'00-$26^0$30'00 'and Longitudes 89^0 42' 00''-90^0 52' 00'' The study area has an international boundary with Bangladesh and West Bengal (India) on the west and southwest, Kokrajar and Chirang districts in the north, Barpet district in the east and Brahmaputra river in the south. Dhubri and Bongaigaon are the district headquarters of Dhubri and Bongaigaon districts respectively and are well connected with other parts of the districts and the State by National and State highways and rail network. The NH-31 and 37 are connecting Guwahati- New Jalpaiguri passes through the area. (Fig.1).

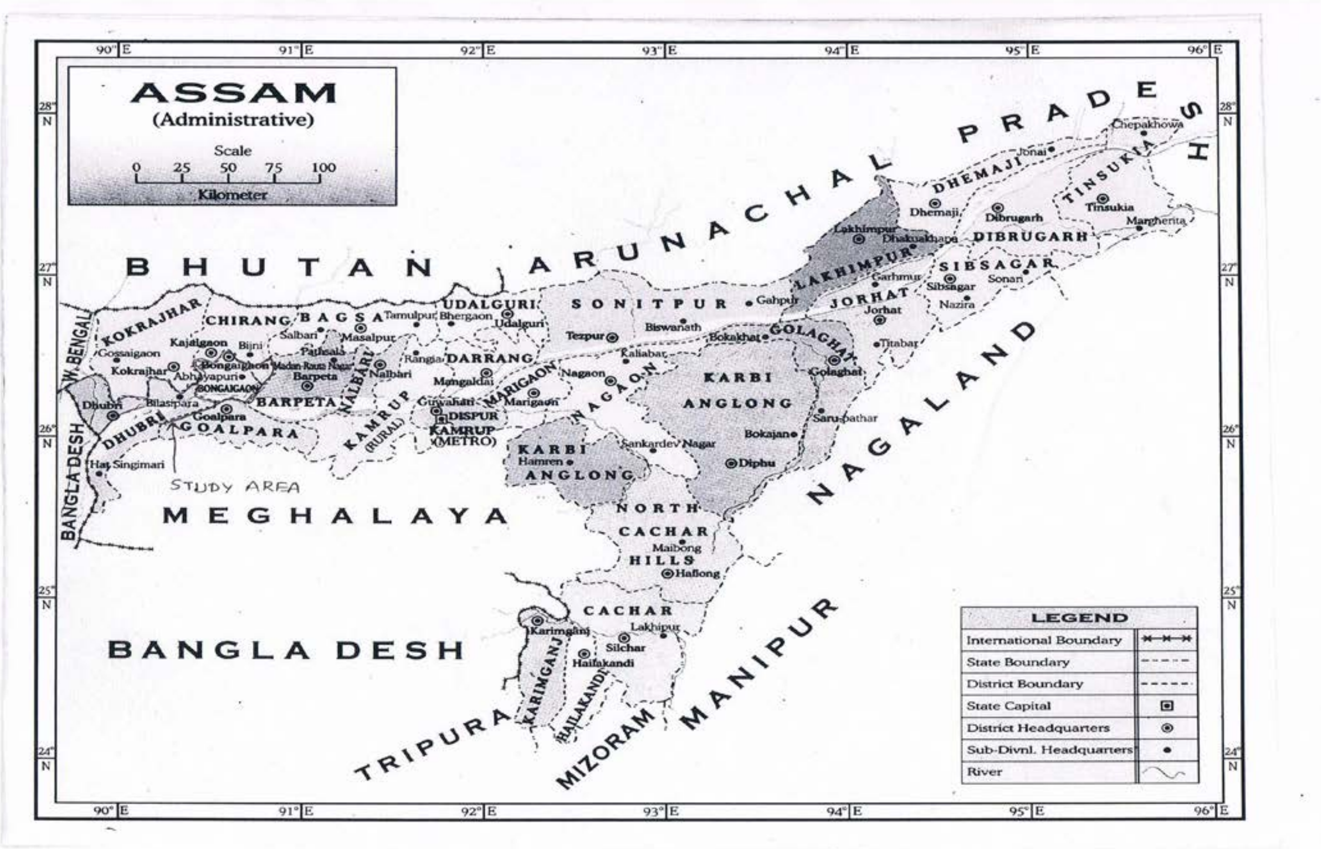

Fig.1. Map of Assam state with study area

The area experiences sub-tropical humid climate with pleasant winter and hot dry summer and receives a annual normal rainfall in the range from 2062.7mm (Dhubri) to 4021.7 mm (Bongaigaon). Forest covers 36.76% of total geographical area in Bongaigaon and 26.2% in Dhubri district. The net area sown covers 52% in Bongaigaon and 56% in Dhubri district. The total area irrigated by all sources is 4364 ha and 6765 ha in Bongaigaon and Dhubri districts respectively and there is no canal and tank irrigation. Agriculture is the main occupation of the people.

Physiographically, the area forms a part of a alluvial plain with flat topography with isolated hillocks and the general elevation varies from 25 to 455 m amsl. Five main geographic units- Flood plains, Younger Alluvial plains, Older Alluvial plains, Pediment complex and denudational hills of gneissic complex. Alluvial plains of Bramhaputra river system form a major part of the physiography. Archaean formations formed as inliers in the form of denudational hills in the eastern part of Dhubri and the western part of Bongaigaon districts especially east of Bhilaspur, These hills covered with thick lateritic cover occupied by mixed forests.

The area drained by a number of perennial streams flow from north to south and joins the Brahmaputra river. The major rivers are Champamati, Manas, Ai are flowing through Bongaigaon district, Gangadhar, Gadhadhar, Sonkosh and Gaurang rivers flow through Dhubri district. These rivers exhibit meandering courses and the extensive meandering indicates their mature stage. There are number of standing water bodies known locally as beels viz., Haldibari, Chaulikhoa, Mora chaulikhoa, Lungaichera located on the east of Abhyapuri are the cut off lakes from Manas river, now sustained by some minor streams emerging from inselberges and by shallow water table zones. There are no major irrigation projects. However minor irrigation structures likr lift irrigation, flow irrigation and at places under well irrigation and these irrigation facilities are not evenly distributed.

The area is part of foreland depression between the comparatively younger mountains chains of the Himalayas in the north and block Mountains of Shilling plateau in the south. The origin and the development of the area is connected with the different phases of upliftment due to tectonic movements, glaciations, and erosion of the Himalayas and sinking with sedimentation. Granitic gneisses of Archaean form the basement which is overlain by, Sub- Recent Laterites and Alluvium of Recent Age.

2. GEOLOGICAL CONDITIONS

Geologically, the area underlain by two distinct rock formations viz. Pre-cambrian granitic gneisses and Quaternary alluvial deposits. About 90% of the area covered by unconsolidated and 10% by consolidated formations. The oldest rock formations encountered in the area are granitic gneisses and granites of Achaean Age occurring as low and rounded hillocks and boulders.

The Archaean group of rocks comprising Biotite-Hornblende gneiss, granulites, Schists, which are intruded by granites and pegmatites, They have very sharp contact with the overlying unconsolidated formations. Hornblende-biotite-mica schists are intruded by acid and basic intrusions of pegmatites, quartz veins and amphibolites. The denudational hills of gneissic complex found to occur in the western and central part of Bongaigaon district, composed of gneissic rocks intrusions of pegmatites. The Archaean inselberge, which is an extension of Garo hills across Brahmaputra river. They are pinkish to grayish in color and are medium grained. They are extensively weathered and jointed. The depth of weathering varies from 3.0 to 12 m.

The unconsolidated alluvium of Quaternary Age is divided into Older and Younger types. The major part of the area is underlain by Younger plains consists of different grades of sand, gravel, pebble, silt and clay. The Older alluvium seen in the north and north-western part of Bongaigaon relatively at higher elevation than the younger alluvium, compact in nature, is mainly composed of unconsolidated to semi-consolidated weathered limonitic clay, unsorted boulders, pebbles, gravels and sands and are believed to be formed by the process of river aggradations and river migration.

Soils in the study area are broadly classified into 3 types, the soils on floodplain are sandy to silty loam, clayey loam and fertile in nature;. the soils on the Older Alluvium zones are also sandy, highly permeable, grayish brown observed in the forest area and the soils on inselberges are clayey, lateritic, and yellow to reddish in color. Topography, relief, climate and vegetation are the controlling factors for the formation of the soils. Shallow and light textured soils are generally seen in ridges and slopes, medium textured soils of moderate depth on gently sloping mid-up lands and very deep heavy textured soils on level to nearly level low-lying areas and along the banks of streams.

3. HYDROGEOLOGICAL CONDITIONS

The area underlain by two distinct rock formations viz. Precambrian granitic gneisses and Quaternary alluvial deposits. 90% of the area covered by unconsolidated formation and 10% by consolidated. Granitic gneisses form the basement in the area. Groundwater occurs under water table to semi-confined conditions in weathered zone and fracture rock formations. Groundwater in weathered zone, is developed through dug wells and shallow bore wells. The thickness of weathered mantle widely vary from <10.0 m near the hill slopes to as much as 20 m in valleys and topographic lows. Weathered layer forms an important zone for infiltration of water and as its thickness increases, the holding capacity of formation increases. The extent of weathering depends on several factors like, topography, texture, mineralogical composition and extent of fracturing and jointing.

Most of the entire area is occupied by alluvial sediments of Quaternary age. Piedmont deposits comprising of coarse clastic sediments like boulder, pebble, cobble, gravel associated with minor fraction of sand and silt are the main repository in the foothill zone. The piedmont zone extends up to 4 – 6 km from the foothills. The floodplain area comprising sand, silt, clay, gravel and pebble received from the rivers coming from the upper reaches are the main deposits next to the piedmont deposits. All these formations act as good reservoirs of ground water in the area. Aquifer horizon in the shallow zone comprises sand of various grades, pebble and boulder. Alluvium, mainly of fluvial origin, occurs along the Bramhaputra river and its tributaries. Their thickness often exceeds 200 m. and their areal extent is vast thus their development potential is not yet harnessed.

The shallow aquifer occurring within a depth of 50 m from the land surface consists of a mixture of sand, clay and silt. The thickness of aquifer is about 20 m and ground water occurs under unconfined condition. The water table is shallow and rests within 2-4 m bgl during pre-monsoon period and the general fluctuation of water table during pre and post monsoon period is about 2 m. The flow of ground water almost follows the general topography of the The aquifer occurring in the depth range of 50 to 200 m below ground level consists of fine to medium grained sand with clay intercalation. The exploration data revealed presence of four to five major aquifer zones. Ground water occurs under confined to semi-confined conditions. Highly silty nature of sediments prevails in shallow depth. Ground water in the floodplain area occurs under phreatic condition in the shallow aquifer zone and under semi-confined condition in the deeper aquifer. Flow of ground water is from north to south.

Groundwater occurs under phreatic, semi-confined to confined conditions. Depth to water levels during the pre-monsoon period varies from 4.45 to 17.80 mbgl and 3.00 to 17.20 mbgl during post monsoon period. Water table fluctuation varies from 0.20 to 3.20 m. From the data of water levels of network stations (10 NHS in Dhubri district and 9 in Bongaigaon district) it is observed that water levels rise from 0.008 to 0.135/year m and fall from 0.001 to 0.132 m/year. 17 Exploratory Wells were drilled by CGWBm and their depths vary from 25.4 to 299.20 m and the discharge observed was vary from 0.90 to 274.24 m^3/hr for the drawdown of 1.46 to 45 m. The Transmissivity (T) is varied from 1.47 to 9147 m^2/day. The Specific capacity computed varies from 2.66 to 1693.2 lpm/m and hydraulic Conductivity was from 1.39 to 176 m/d. The casing lowered in the bore wells was varied from 5.0 to 88.0 m and Static Water Level recorded was varying from 0.77 to 34.45 mbgl. The abstraction structures prevailing in the area are ring wells (10 m depth), shallow tube wells (25 m depth) fitted with hand pump, and deep tube wells (100 m depth).

4. GROUNDWATER QUALITY

Groundwater quality evolves through interaction of the recharge water with the host rocks in the zone of aeration and saturation. The chemical quality of groundwater varies considerably within short distances. It acquires chemical characteristics due to interplay of meteorological, geological, pedological and topographical conditions and anthropogenic influences such as irrigation practices, cropping methods and in the use of fertilizers and pesticides. The chemical analysis data of water samples collected from the observation wells not available yet; however the chemical data of the previous surveys is studied.

Ground Water in general is good and potable, while in some areas hardness, Arsenic and Fe contents are high. Ground water in shallow aquifer in alluvial tract show slightly alkaline in nature as the pH is in the range of 6.5 to 8.08. Most of the samples have a pH ranging between neutral to alkaline and pH is within the permissible limit for drinking water standards. The conductivity of groundwater samples varies from 67 to 612 micro-mhos/cm at 25^0 C in Bongaigaon district and from 54 to 519 micro-mhos/cm at 25^0 C in Dhubri district. The concentration of EC of all the samples is within the permissible range.

The contents of dissolved solids in groundwater decide its applicability for drinking, irrigation and industrial purposes. The hardness in groundwater is varied from 25 to 270 ppm in Bongaigaon district and 25 to 155 ppm in Dhubri district. About 11 % in Bongaigaon district and 7% ground water samples in Dhubri district are having total hardness ranging between 150 – 300 mg/l. The concentration of Ca in the groundwater in the area ranges from 6.0 to 72 mg/l. All samples are within the permissible limit (200 mg/l). The magnesium content in groundwater ranges from traces to a maximum of 16 mg/l. The concentration of Ca and K is in traces and is a minor constituent of cation group of ions. The primary source of CO_3 and HCO_3 ions in groundwater is the dissolved CO_2 in rainwater as it falls through the atmosphere and water flowing through the soil dissolves large amount. The concentration of carbonates in groundwater is nil and bicarbonate concentration in groundwater ranges from 31 to 439 mg/l.

The sulphate concentration of atmospheric precipitation is only about 2 ppm, but the sulphate content in groundwater varies widely due to oxidation and precipitation processes as the water traverse through rocks. Its concentration is nil to 5 ppm in Bongaigaon district and nil to 18 mg\l of sulphate, in Dhubri district. The chloride content in rainwater is usually less than 10 mg/l. Abnormal chloride concentration may be due to pollution of sewerage waste and leaching of saline residues in the soil. The chloride concentration in groundwater ranges from 11 to 234 mg/l. The maximum permissible limit is 1000 mg/l. Natural nitrate concentration in ground water ranges from 0.1 to 10 mg/l and its concentration in groundwater ranges from traces to 3.2 mg/l and its concentration is within the permissibility limit of 45 mg/l. Fluorine is the most electro-negative element. It occurs in water as fluoride. The fluoride concentration in groundwater ranges from 0.04 to 0.8 ppm. All the samples show the fluoride concentration less than 1.0 mg/l,

Iron concentration is more than the permissibility of 0.3 ppm in Bongaigaon and Dhubri districts. The iron distribution is shown in the table.1.

Except at a few locations, a majority of samples show excess iron content. Higher concentration of >1 ppm is recorded at Abyapuri, in Bongaigaon district and at Salkocha, Bhilaspura and at Tamarhat in Dhubri district (fig.2).

Table.: 1. Distribution of Iron concentration in groundwater

Sl. No	Iron concentration range	Bongaigaon district		Dhubri district	
		No. of samples	Percentage	No. of samples	Percentage
1	< 0.3	Nil	-	5	33.4
2.	>0.3	9	100	10	66.6

Arsenic: Randomly 50 nos. of water samples were collected and the analysis data has been presented in the table 3. Arsenic concentration varied from 0.30 to 14.3 µg/lit. At 2 locations its concentration is Below Detection

Level (BDL) in the study area. The spatial distribution of As concentration in Bongaigaon and in parts of Dhubri districts has been prepared (fig.2).

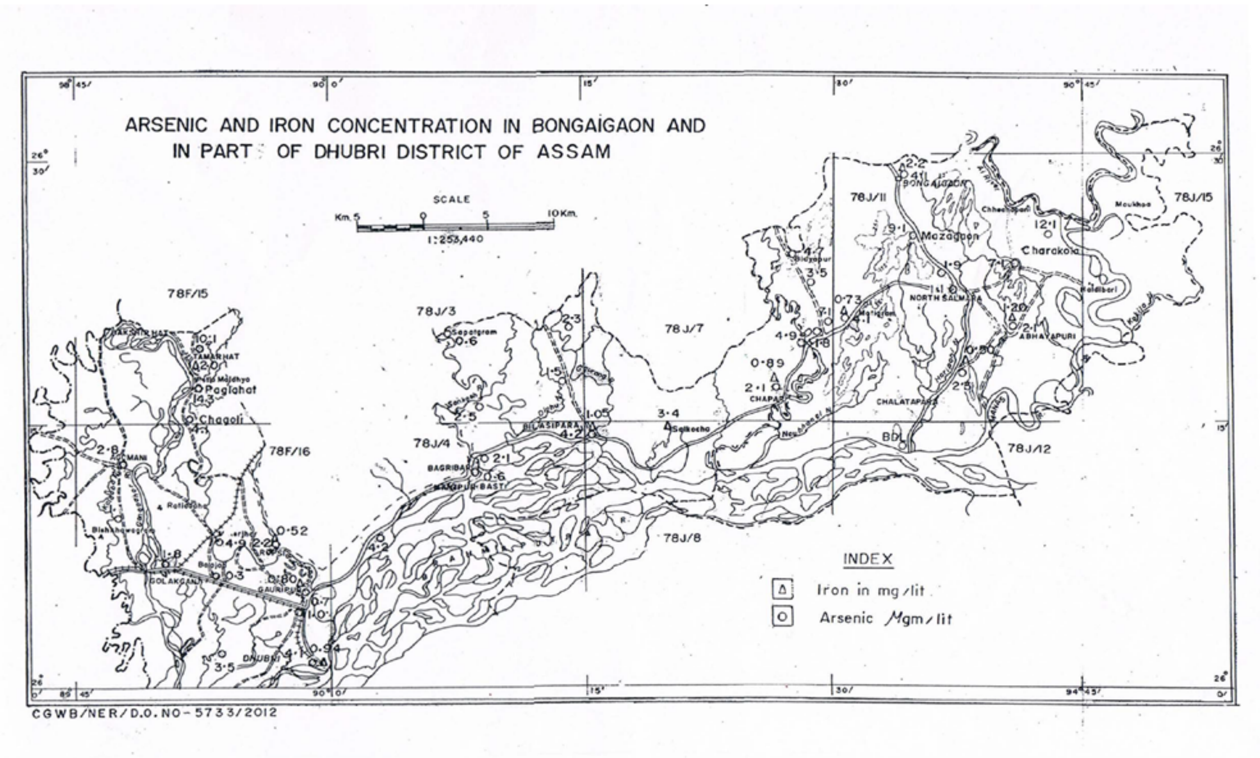

Fig.2. Arsenic and Iron concentration in Bongaigaon and Dhubri districts

Table: 2. Range of As concentration in Bongaigaon and Dhubri districts

Sl. No	Range of value (in µg/l)	No. of samples	%
1	<1.0	11	22
2	1.0 – 5.0	32	64
3	5.0 – 10.0	4	8
4	>10.0	3	6
	Total	50	100

Groundwater pollution by application of the various chemical fertilizers and pesticides in the field, may cause groundwater pollution.The fertilizers consumption in respect of N, P and K in Bongaiogaon and Dhubri districts respectively are 5526 and 24,921 metric tons during the year 2006-07 (table-3).

Table:3. Details of Fertilizers used for the fields in the area (in M tons)

Sl. No	Particular	Dhubri district			Bongaigaon district		
		Kharif	Rabi	Total	Kharif	Rabi	Total
1	Ammonia (Nitrogen)	5198	11690	16888	1085	1424	2509
2	Phosphorus	1695	5546	7241	690	872	1562
3	Potash	1918	7685	9603	746	709	1455
	Total	8811	24921	33732	2521	3005	5526

5. RESULTS & DISCUSSION

Ground water quality of shallow aquifers is suitable for drinking, domestic, irrigation and industrial purposes. All the general chemical constituents like Ca, Na. K, Cl. Co_3-HCo_3, sulfate are within permissible limits set by BIS except Iron and As at some places. The data of chemical quality of deeper aquifers is not available. It is observed that there is a correlation of occurrence of arsenic with iron in ground water. The widespread occurrence of iron in ground waters along with/without arsenic makes the water non potable without some sort of treatment. Arsenic being tasteless, colorless and odorless goes undetected and on the other hand the iron contamination is visible-red color, strong metallic smell and taste, discoloration of teeth, utensils, red sludge at the bottom of containers and chocks plumbing all these evils make presence of iron in water supply is highly objectionable. Constituents of Fluoride vary from below detection level to as high as 0.90 mg/l and at Salkocha where the concentration is beyond permissible limit (10.0) mg/l have been recorded. The available chemical data is inadequate to ascertain wider distribution and concentration of Fluoride in ground water.

Arsenic concentration at three places viz., Charkola in Bongaigaon district, and at Paglahat and Tamarhat in Dhubri district, where its concentration exceeded permissible limit of 10 ppb/l. Except at two locations, where its concentration is below detection level, in rest of places the concentration of arsenic is in the range from 0.3 to 9.0 ppb/l, and at 2 locations viz Golakganj and Mazagaon, its concentration is recorded 9.1 ppb/l. Two surface water samples from Gangadhara and Sankosh rivers, which are tributaries of Bramhaputra River flowing through the study area recorded arsenic concentration of 1.8 and 2.1 ppb/l respectively. Water sample from Chandakol Beel showed the arsenic concentration of 0.8 ppb/l. From the results, it is observed that arsenic concentration is widely distributed with various proportions in major part of the study area. The occurrence of As contamination in ground water has been reported in several parts of Assam State by several individuals\institutions and it is the first time that its pollution reported by CGWB in these districts. So for, the occurrence of As in ground water has been reported in Demaji, and Majuli islands of Jorhat districts of Assam. Arsenic contamination in groundwater has been first reported by Singh (2004) in Johrat (194-657 μg/L), Dhemaji (100-200 μg/L), Golaghat (100-200 μg/L) and Lakhimpur (50-550 μg/L), Assam. Based on the studies conducted in Darrang and Bongaigaon districts in Assam, Enmark and Nordborg (2007) have found that the concentration of arsenic in the two districts varied from 5 to 606 μg/L. There are no reports about arsenic causing health hazards in the region (UNESCO, 2005).

Arsenic is a toxic heavy mineral, constituent of a number of naturally occurring sulphide minerals such as pyrites and arsenopyrites. The Arsenic compounds are found both in tri and pentavalent forms in ground water, of which trivalent is more hazardous than the latter. The permissible limit of arsenic in drinking water is 0.01 mg/l (10 ppb/l) and if consumption exceeds this limit and exposed for a long period , it may lead to many health hazards like gastro intestinal tract ulcers, various skin ulcers and tumors. Arsenic is a naturally occurring trace element found in rocks, soils and the water in contact with them. It has been recognized as a toxic element and is considered a human health hazard. As per the BIS Standard for drinking water the maximum permissible limit of Arsenic concentration in ground water is 0.01 mg/l. Therefore, urgent need for an extensive monitoring of arsenic contaminated areas in the area along with studies pertaining to source, distribution and mobilization. The concentration of As ground water is attributed to the weathering of Sulphide associated with carbonaceous matter may have produced As-rich iron hydroxides, which in turn released As (after reduction) to the existing sedimentary environment. The concentration of As was found to be localized and not uniformly distributed. The As enrichment in ground water of flood plain region is significant and needs immediate attention.

The results of Iron and other parameters are yet to be received, however, previous results of 75 samples in the study area show that Iron concentration is in ground water varying from 0.03 to 15.1 mg/l. Its concentration is widely distributed with various proportions in the study area. In about 85% of samples Fe concentration is exceeded the permissible limit of 0.3 mg/l. Iron, the second most abundant element by weight in the earth's crust, is normally present in ground water in the ferrous form (Fe++), which is a soluble state and easily oxidized to trivalent ferric iron (Fe+++). Aeration of iron can affect the quality of both ground water and surface water. Use iron rich ground water would affect the soil drainage with the deposition of ferric hydroxide on the surface. Dissolution of iron occurs as a result of oxidation and decrease of pH. It is essential element in human nutrition but It imparts objectionable tastes and color to food. Iron is important micro-nutrient. The cause of high concentration of iron in ground water is attributed to the occurrence of high iron bearing minerals in the Pre-Cambrian and Tertiary geological formations.

The geologic and hydro geological factors play a prominent role for localization of As, which might have derived from arsenic rich iron hydroxides which derived from weathering of sulfide minerals-Pyrite and Arseopyrites. However the exact evidence of possible cause of localized concentration of As is yet to be ascertained. Studies conducted by Enmark and Nordborg (2005) in the Bongaigaon and Darrang district in Assam have revealed that the reductive dissolution mechanism may be the mechanism of arsenic mobilization in these areas. The concentrations of higher arsenic contents in the shallow aquifers are found to be localized and are not uniformly distributed. Industrialization is on spread of late, this does not appear to be a contributing source of Arsenic contamination in shallow ground water. Obviously, the most viable source of Arsenicin ground water is geogenic. High concentration of iron (Fe) and arsenic (As) content in the ground water is observed which is greater than permissible limit of BIS and WHO standards. Arsenic content in ground water in deeper aquifers could not be assessed because no deep tube well exist.

Concentration of arsenic has been found beyond permissible limit at aforesaid locations. However, physical manifestation of arsenic effect has not been reported. Some of the mitigating measures which may be abandoning high concentrated As water, blending and treatment to bring below permissible limit of Arsenic, Iron and Fluoride contamination in ground water of shallow aquifers are given below.

- As people largely depend on ground water for their needs then there is a great risk due to use of As contaminated water. All efforts are to be made to minimize dependence on potentially toxic ground water thereby preventing future health risks. Majority of sources are individual tube wells, deep tube wells and ring wells. Artificial recharge schemes are to be practiced where contaminates of iron and As within the shallow depth up to 50 m.
- Sporadic occurrence of Arsenic in ground water as reported by various state/central departments/institutes. Extensive groundwater monitoring is to be carried out to test all sources- dug wells, bore well water systematically to detect As, Fe and F concentration to understand the distribution and occurrence of these elements in ground water and work out strategies for their mitigation and management..
- Clinical monitoring and surveillance system to detect early sign of arsenicosis in the population. Assess the magnitude of the problem in high concentrated areas and take appropriate measures like generation of awareness about health problems associated with As water and providing safe drinking water. There is need to create community awareness, identification of symptoms of Arsenicoses through audio-visual means,
- Inter-departmental-institutional collaboration is needed to integrate the available data and information for addressing ground water quality problem. Constitution of a Task Force for mitigation of fluoride and arsenic contamination of ground water and which will act as nodal agency for proper coordination with state and central govt. agencies and other educational institutes engaged in the development of safe ground water resources.
- The available arsenic, iron and fluoride removal technologies like Domestic Iron removal Unit (DIRU) developed by NEERI, Low iron Filter, Indigenous iron filter of Assam are efficient in removal of iron from ground water. Iron Removable Unit (IRU), De-arsenification Unit (DU) and Integrated DRDO water testing kit developed by DRL, are to be used to reduce contaminated water below permissible level. As & Fe are removed from drinking water by Nalgonda technique (a mixture of Lime, Alum and bleaching in water) and is viable for common people. Iron is removed by sand filtration method after oxidation, which is done with air, Potassium permanganate and Chlorine. Low cost Tripura Filter is evaluated by the All India Institute of Hygiene & Public Health, Kolkata, is found to be capable of removing Iron and bacteriological contamination effectively may be adopted. Sand with charcoal bed infiltration method is more adoptable at individual level. Oxidation/aeration followed by filtration is far the best technique in removal of iron.
- Efforts should be made for identification of sources of contamination especially for arsenic in order to take appropriate preventive measures.
- The available arsenic, iron and fluoride removal technologies require refinement to make them suitable and sustainable for their large scale effective uses both at individual and community level.

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BIOGRAPHY

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CERTIFICATE

The author certify that the paper titled "ARSENIC AND IRON CONTAMINATION IN GROUND WATER IN LOWER BRAMHAPUTRA BASIN IN BONGAIGAON AND PART OF DHUBRI DISTRICTS OF ASSAM STATE, INDIA" and submitted for consideration for Conference on "India Water Week" to be held in New Delhi from 10-14 April 2012 is in original and has not been published or presented at any other forum.

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