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Use of surface water for drinking purpose in Golaghat district of Assam, India

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Abstract: Safe drinking water is a basic need of every human being despite of any socio-economic status. Groundwater extracted from the deep aquifers in flood plain areas of Golaghat district, a region of Brahmaputra river basin in North East India, can no longer be considered safe for drinking. Report says that, the residents of the area have been chronically exposed to low to moderate levels of heavy metals like arsenic and iron. Therefore the identification and utilization of arsenic free safe surface water sources as an alternative to groundwater for drinking purpose, is a great concern nowadays in Golaghat district of Assam, India. A total of 90 water samples of different surface water sources like open well, ring well and river water, collected from different locations of Golaghat district, were analyzed for arsenic as well as other heavy metals like iron, manganese, cadmium, copper, zinc and some other water quality parameters. Analysis shows that, concentration levels of arsenic and other water quality parameters except iron (25% of total collection) in surface water sources are all within the safe limits of WHO standards for drinking.
Key Words: surface water, arsenic, BIS, Golaghat District, Assam .

Introduction

The presence of arsenic in drinking water and its toxic effect is one of the most awesome environmental health challenges nowadays threatening the wellbeing and livelihood of more than a hundred million people worldwide[1]. The groundwater arsenic contamination has been reported extensively in recent years from different parts of the world, including countries in North America and Latin America (viz. USA, Canada, Mexico, Argentina, Bolivia, Brazil, Nicaragua), Australia, and Southeast Asia (viz. Bangladesh, China, Nepal, Vietnam, Cambodia and India)[2,3,4,5,6]. However, the environmental problem of arsenic toxicity in groundwater of entire Bengal delta of Ganga-Padma-Meghna-Brahmaputra (GPMB) river plain, covering several districts of West Bengal and Bangladesh creates apprehension towards the scientific community and considered as the worst arsenic affected alluvial basin[2,7]. The magnitude of the severity in respect with arsenic toxicity in the region, where sub-surface water is primarily used as a source of drinking water, is very high. In Bangladesh, 28-77 million people drink arsenic-contaminated water without having alternative resources. According to the report of world health organization (WHO), chronic consumption of such toxic water, in future, may lead to death of 1 in every 10 adults caused by arsenic related cancers[8,9,10]. A report from WHO predicts that, within a few years, death across much of southern Bangladesh (1 in 10 adults) could be from cancers triggered by arsenic[11]. It was also reported that arsenic disaster of Bangladesh is greater than the disasters at Bhopal, India in 1984 and

Chernobyl, Ukraine in 1986[7]. The U. S. National Research Council (NRC) stated that exposure to 0.05ppm arsenic may create cancer in 1 in 100[12]. It was also been reported that 1 in 100 who drink water containing 0.5 ppm arsenic may ultimately die in lung, bladder and skin cancer[7]. Another study highlighted that many people living in the affected areas of West Bengal and Bangladesh, drinking arsenic contaminated water may not exhibit skin lesions but could be subclinically affected[13]. Arsenic problem in groundwater in West Bengal, India was first recognized in early 1980s[14] and the health effects are now reasonably well documented. In fact, more than 50 million people are undoubtedly at risk in the Bengal delta plain[2, 15]. More recently, the scale of the problem in other states adjoining the West Bengal with similar hydro geological pattern like Assam, Tripura, Manipur, Arunachal Pradesh (AP), Nagaland, Bihar and Uttar Pradesh, has also been reported[5]. In North-Eastern India, the presence of arsenic has been identified in 21 districts of Assam, three districts in Tripura, six in Arunachal Pradesh, one in Manipur and two in Nagaland[2,5,16]. However, the problem of arsenic in groundwater in Assam is yet to get enough systematic attention having sparse review reports[10,16,17].

Along with arsenic, problem of iron in water is another major issue in the region[16,18]. Chronic and excess iron consumption is toxic for the health that might cause genetic disorders like haemochromatosis. This redox flexible element produces oxygen free radicals that are toxic to the cells. Moreover, iron hydroxides in water are supposed to help in the generation of arsenic species[19]. Recently, problem of manganese has also come up in some parts of Assam (unpublished observation).

Now-a-days in Assam, the family and/or community based groundwater tube wells have become more popular. Groundwater is an important source of domestic water in Golaghat district of Central Assam. Here most of the domestic water is harnessed from groundwater through shallow tube wells and deep tube wells[20]. About 80% of the total rural population (about 8,65,141) of the region use tube well water for drinking purposes whereas only 20 % of the total populations consume surface water for the same[20]. Similarly almost 50% of the total urban population (about 81,138) consumes surface water (river water) for drinking purposes in the municipality water supply scheme, where as same percent of people uses water from their own tube well sources. The schematic diagram of the percentage wise population distribution using groundwater and surface water sources for drinking purpose is given in figure 1. The main cause of using groundwater from shallow and deep tube wells by about 65% people of total population (about 9,46,279) in Golaghat district is due to the reasons that the groundwater sources are totally free from bacteriological contamination and waters are available in adequate quantity in aquifers. At the same time tube well waters are less expensive and easy to operate. The installation requires less time and effort. However, recent studies suggest that 67% of the groundwater in this region have arsenic concentration above the WHO guideline value (0.01 ppm) for drinking. 76.4% groundwater samples have iron content beyond the permissible limit of WHO guideline. In few samples, the concentrations of lead, mercury, cadmium, copper etc are found beyond the permissible values. But is interesting to note that except iron in few samples (25% of total collection), all other samples collected from open well, ring well and river of this region have arsenic and trace metal concentrations below the WHO guideline values of drinking water. Table 1 shows the analysis of arsenic and some other water quality parameters of surface water samples. Source wise arsenic distribution of surface water samples has been shown in Table 2. In this study, a rigorous survey was undertaken to access the surface water quality for drinking purpose of Golaghat district with special reference to Arsenic.

The objective of the present detailed survey based study was to investigate the surface water quality Golaghat district, (26.0ºN to 27.1ºN and 93.0ºE to 94.18ºE) located in the central part of state Assam. Along with arsenic (As), the work also includes the examination of concentration levels of other key parameters, namely, iron (Fe), manganese (Mn), sodium (Na), potassium (K), calcium (Ca), magnesium (Mg) with pH, and total hardness (TH). Thus, the current article would help to fling light on the surface water quality with special reference to arsenic and hence its future prospect as alternative source of drinking water in the groundwater arsenic contaminated Golaghat district, a region of Brahmaputra river basin.

Experimetal

Study Area

The district Golaghat, the study area, is located in the north east part of Assam, India. The total area of Golaghat district is 3502 sq. kms. and lies 100 meter above the mean sea level[21]. It is surrounded by Brahmaputra River in north, Nagaon and Karbi Anglong district in the west, Jorhat district and Nagaland in the east and Karbi Anglong and Nagaland in the South. Golaghat district is located longitudinally from 93°16/E to 94°10/E and latitudinally from 25°50/N to 26°47/N[22]. It is 290 kms far from the state capital Dispur[23]. Dhansiri, the main river originating from 'Laisang peak' of Nagaland is flowing through a distance of 352 km from south to north before joining the Brahmaputra. Its catchment area is 1220 sq.km[24]. Doyang, Nambor, Doigrung and Kalioni are the four rivulets of Dhansiri. Doyang originates from 'Maw' of

Nagaland and joins with Dhansiri at the South point of Golaghat town. The other rivulets originate from Karbi-Anglong and flow in a west to east direction. The river Kakodonga marks the border of Golaghat and Jorhat district. It also originates in Nagaland and flows in a south-north direction. The climate is tropical with a hot and humid weather prevailing most of the summer and monsoon months. Total average annual rainfall is 1300 mm[24]. The location map of Golaghat district is shown in Figure2.

Sampling methodology

A total of 90 water samples were collected from different surface water sources of six blocks of Golaghat district. Equal numbers (30 nos) of water samples from three surface water sources viz. open well (OW), ring well (RW) and river were collected for the analysis of arsenic and other elements like iron, manganese, lead, zinc, copper, cadmium, sodium, potassium, calcium, magnesium, pH and TH etc. The samples were collected in polystyrene bottles having 500 ml and 1000 ml capacities as per requirement of the test. The standard procedures of sampling were adopted and preservatives were added as per nature of analysis during the collection of the samples[25]. pH of the water samples were determined by using calibrated pocket pH meter (Merck, India) on the spot. After pH determination, 1:1 HNO_3 solution was added to the collected water samples as preservative[7] (to pH less than 2).

Sample analysis

Collected samples were analyzed for the parameters viz. As, Fe, Mn, Cd, Cu, Zn, Ca, Na, K, Mg, pH, and TH. pH of the samples was measured at the site of collection by using Pocket pH meter (Merck, India), previously standardized by pH 4, 7 & 9 standard buffer solutions respectively. After determination of pH, 1:1 HNO_3 solution was added to each of the water samples collected (to make pH<2.0) and were carried to the laboratory for further analysis. The analyses of TH, Na, K, Ca, and Mg were determined following standard methods[26]. The instruments were calibrated and standardized before carring out the analysis. Na and K in the water samples were determined by flame photometer (Systronics, Germany) whereas TH, Ca and Mg were determined by EDTA titrametric methods. The concentration of the heavy metals namely Fe, Mn, Cd, Cu and Zn were determined using atomic absorption spectrometry (AAS; model Perkin Elmer 200, USA) at their respective wave length and slit width. Hydride Generation-Atomic Absorption Spectrometry (HG-AAS) was used for analysis of As in water samples. All the reagents and standards were prepared freshly at the time of analysis. For better sensitivity, As^{5+} was pre-reduced to As^{3+} before analysis. Pre-reduction was carried out following the user guide of AAS[26]. Briefly, a mixture of 5 ml of potassium iodide & ascorbic acid solution, 10 ml of 5 mol/L HCl solution and 10 ml of water sample was added in 50 ml volumetric flask. The volume was made up to the mark of the flask with 0.15 mol/L HCl solution. Time given for pre-reduction was 30 minutes. 10 ml of pre-reduced water sample was analyzed using AAS with MHS-15 (Mercury Hydride System) at 193.7 analytical wavelengths and 0.7 nm slit width. Radiation source was electrode less discharge lamp (EDL) for arsenic with 20 sec. pre reaction purge time and 10 sec. post reaction purge time. The argon gas and sodium borohydrate were used for hydride generation. Oxy-acetylene flame was used for determination of heavy metals.

Results and discussion

Table 1 shows the concentration of different water quality parameters of samples collected from surface water sources of the study area. Analysis of surface water samples (Table 1) of different sources like open wells, ring wells and river, shows that except iron, all other parameters are within the safe limit of drinking water standard. Analysis reveals that 25% samples of surface water have iron content above the permissible limit 1ppm of WHO/BIS for drinking water. Only 2% samples have manganese concentration above the safe limit 0.3 ppm. Table 2 shows the source wise distribution of arsenic concentration in different surface water sources of the study area. The concentration of arsenic present in different surface water sources were ranges from trace to 0.002, trace to 0.003 and trace to 0.006 respectively for open well, ring well and river water. Analysis reveals that the surface water of the region is totally safe from arsenic and other heavy metal contamination except iron. All the samples collected from open well, ring well and river has arsenic concentration below the permissible limit of WHO for drinking water.

River water is the main source of drinking water, supplied to the 50% urban population of Golaghat district whereas open wells and ring wells supplies drinking water to 20% of the total rural population[6]. The water of these sources has been found to be free from arsenic as well as from trace elements even in locations where tube wells are contaminated. The explanations may be attributed to the low arsenic content of surface water[27] are (i) the oxidation of As (III) to As (V) of surface water due to its exposure to open air and agitation during water withdrawal can cause precipitation of dissolved arsenic and iron, (ii) ring wells accumulates groundwater from top layer of water table which is replenished each year by arsenic free rain and surface waters by percolation through aerated zone of the soil. The fresh recharges also have diluting effects on contaminated groundwater, (iii) the presence of air and aerated water in well can oxidize the soils around ring wells and infiltration of water into wells through this oxidized soil can significantly reduce the concentration of arsenic in the well water. Analysis also showed that pH, TH and other trace element concentrations of the surface water samples were all within the drinking water guideline values of WHO.

Utilization of Surface water to reduce the As problem in near future in Golaghat district

The water quality of Golaghat district of Assam, situated on the bank of the river Brahmaputra, is considered as an important issue for health reasons in regard to arsenic contamination in tube well waters of the region. The presence of arsenic in groundwater of Golaghat district was first reported in the year 2004 [10]. For a long period of time, people of the region were not aware of the presence of arsenic in groundwater and its health effects, which may be due to lack of knowledge about arsenic and its toxic effects or may be due to some other reasons like media etc. Nowadays, most of the people of this region are aware of the problems related to arsenic toxicity. Therefore nowadays most of the local people in the groundwater arsenic affected region are taking interest in using surface water of the region for drinking purposes rather than groundwater. Therefore, the options available for water supply in the arsenic effected areas of Golaghat district is to identify the alternative arsenic free surface water sources. Water resources of the region as a whole are substantial. Open well, ring well and river are considered as the main sources of surface water in Golaghat district. River Dhansiri and Kakodonga are the two perennial rivers of Golaghat district of Assam which have continuous flow in parts of its bed all year round during years of normal rainfall[28]. About 446.179 sq. km. which is about 13% of the total geographical area of the district is occupied by surface water bodies[29]. Of this about 225 sq. km is occupied by the river systems and 135.07sq. km by natural wetlands including seasonal and permanent waterlogged and marshy areas and man-made reservoirs and tanks.

Problems related to the surface water

The main problems of using the surface water for drinking and cooking purposes are related to the bacteriological contamination which can cause cholera, typhoid, shigella, polio, meningitis, and hepatitis A and E[30]. These water borne diseases caused by water has been contaminated by human, animal, or chemical wastes. Worldwide, the lack of sanitary waste disposal and of clean water for drinking, cooking, and washing is to blame for over 12 million deaths a year[31]. Some 60% of all infant mortality is linked to infectious and parasitic diseases, most of them water-related. In some countries water-related diseases make up a high proportion of all illnesses among both adults and children. In Bangladesh, for example, estimated three-quarters of all diseases are related to unsafe water and inadequate sanitation facilities. Water-borne diseases include human beings and animals can act as hosts to the bacterial, viral, or protozoal organisms that cause these diseases. Millions of people have little access to sanitary waste disposal or to clean water for personal hygiene. Where proper sanitation facilities are lacking, water-borne diseases can spread rapidly. Untreated excreta carrying disease organisms wash or leach into freshwater sources, contaminating drinking water and food. The extent to which disease organisms occur in specific freshwater sources depends on the amount of human and animal excreta that they contain. Diarrheal disease, the major water-borne disease, is prevalent in many countries where sewage treatment is inadequate. Instead, human wastes are disposed of in open latrines, ditches, canals, and water courses, or they are spread on cropland. An estimated 4 billion cases of diarrheal disease occur every year, causing 3 million to 4 million deaths, mostly among children. Providing clean water and sanitation greatly reduces child mortality. According to a review of 144 studies from the 1980s, infant and child deaths fell by an average of 55% as a result of providing clean water and sanitation.

Sanitation programme at Golaghat district

The low cost rural sanitation programme in Golaghat district of central Assam, India, plays an important role in both the health of the human population and the environment. To ensure safe drinking water and good human health, a joint programme of state government, PHED, Golaghat, Govt. of Assam and NGOs on total sanitation was implemented in the rural areas of Golaghat district of Assam. Under the scheme a total of 79,743 households of BPL (below poverty line) & 27031 households of APL (above poverty line) covering 102 GP will be benefited. A total 24772 households of BPL and 8205 households of APL have already been covered by the TSC in the year 2009. Presently1014 numbers of schools have also been covered by the scheme. At the same time the district Golaghat is achieving 100% success in the field of installation of baby friendly toilets in the Angangbadi centres.

Role of treatment plants on the drinking water quality in Golaghat district

The surface water treatment plants play a key role for the assessment of water quality from the bacteriological point of view. The success of such treatment plants depends on identification, selection of raw water intake points and per capita water consumption daily. Following the norms prescribed by Govt. of India, general per capita rate 40 lpcd is proposed. Considering 5% production loss and 10% transmission and distribution loss, the daily requirement of water for design population of district Golaghat at initial stage was proposed to be 55 liters in the year 2009. Studies were made to identify a suitable common intake point for tapping raw water from the above mentioned perennial rivers of Golaghat district and to identify a treatment plant location within the effected area with consideration for easiness and convenience of lying raw water pumping main from the intake to the treatment plant location, availability of electric power and overall economy. At the same time due consideration should be made for convenience of laying clear water main to the respective constituent piped water supply schemes for which reconnaissance survey might be made along the bank of the rivers for a considerable length.

Water from rivers can be tapped by various means, viz. by providing a floating barge and installing the raw water pumps in it; through a jack well; by installing infiltration gallery; by providing a grid chamber; creating a impounding reservoir by constructing dam; off take canal from the river etc. every different types of intake system requires different river bank condition and flow characteristics. In case of river with considerable fluctuation of discharge during lean period and flood condition, intake floating barge and intake wells are technically feasible and economically viable. In this particular case, as the river bank at proposed intake location is steady and horizontal fluctuation of water level between lean period and high flood condition is not very high, it is proposed to provide a fabricated M.S. floating barge as intake station for installation the raw water pumps and other accessories. As the surface water of the above three mentioned perennial rivers of Golaghat district have high turbidity (750 NTU in high flood condition and 45 NTU in dry season), in addition to presence of harmful pathogenic bacteria, the norms and methods prescribed in the “Manual on Water Supply and Treatment” should be followed according to which full fledged treatment process having the facility for aeration-coagulation-clariflocculation-filtration followed by disinfection is required.

Conclusion

For almost last two decades, research on Arsenic has gained a significant momentum as a response to the harmful health effects of the element. The recognition of the scale of Arsenic enrichments in groundwater of West Bengal, India and Bangladesh and elsewhere has opened up serious apprehension in the scientific community. Groundwater provides drinking water to more than 1.5 billion people daily and to many more in times of surface water. However, new reports are coming from different areas regarding the Arsenic contamination. Several factors involved for 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 high priority toxic substance like Arsenic in newly reported region is early survey based detection of the pollution and identification of the affected sources to remediate the crisis. From the study it was revealed that, the residents of Golaghat district had been chronically exposed to low to moderate levels of heavy metals like As and Fe, in comparison with highly exposed populations in West Bengal, India, Bangladesh , Taiwan , Chile and Argentina. Understanding the groundwater movements requires in depth characterization and routine verification of physical hydrogeology. Moreover, community participation to make understand the signs and symptoms of chronic Arsenic toxicity to the villagers of the affected regions is of utmost necessary. There is no medicine to cure chronic arsenic toxicity except healthy diet and safe water. Therefore investigation of new alternative water sources for drinking is very much essential in Golaghat district, the region of the Brahmaputra river basin of North East India. It is interesting to note that the surface water resources viz. open wells (pond), ring wells, river water etc. of Golaghat district are almost safe in terms of arsenic, other trace elements and sodium, potassium, magnesium, calcium, total hardness, pH except few samples for iron and manganese. But these surface water sources are needed to be implemented with controls for bacterial contamination. Providing safe drinking water to the rural habitations and schools has been accepted as the most challenging and priority task by the government of Assam. Public Health Engineering Department is the nodal Government Department for the rural water supply programmes in the state. Recently the PHED, Golaghat district has planed for arsenic mitigation programme by providing surface water, mainly river water to the rural people of Golaghat district, for drinking purposes. The PHED, Golaghat have selected the three rivers Dhansiri, Doiang and Kakodonga for their water supply schemes. About 20,000 people will be benefited by this scheme where consumption will be about 55 liters. per capita per day. By proper planning and management, surface water of the region can be used as alternative source of drinking water in the badly arsenic affected areas of the region in the Brahmaputra river basin.

Table 1: Analysis of surface water samples for arsenic and other water parameters

Parameters	Surface water (ppm)	WHO/BIS guideline value (ppm) Desirable-Permissible
As	Trace-0.006	0.01-No relaxation
Fe	0.654-2.81	0.3-1.0
Pb	Trace-0.009	0.05-No relaxation
Mn	Trace-0.120	0.1-0.3
Zn	Trace-2.5	5-15
Cu	Trace-0.03	0.05-1.5
Cd	Trace-0.007	0.01-No relaxation
Na	1.5-144	230
K	1.7- 33.0	----
Ca	5.0- 110	75-200
Mg	2.8-45.0	30-100
pH	6.4-7.2	6.5-8.5
TH	10.0-295.0	300-600

Table 2: Arsenic concentration ranges in water samples from different surface water sources

Water Sources	No of sample analyzed	% of Sample within safe limit	Conc. Range Min.-Max (ppm)
Pond	30	100	Trace- 0.002
Ring well	30	100	Trace-0.003
River	30	100	Trace-0.006

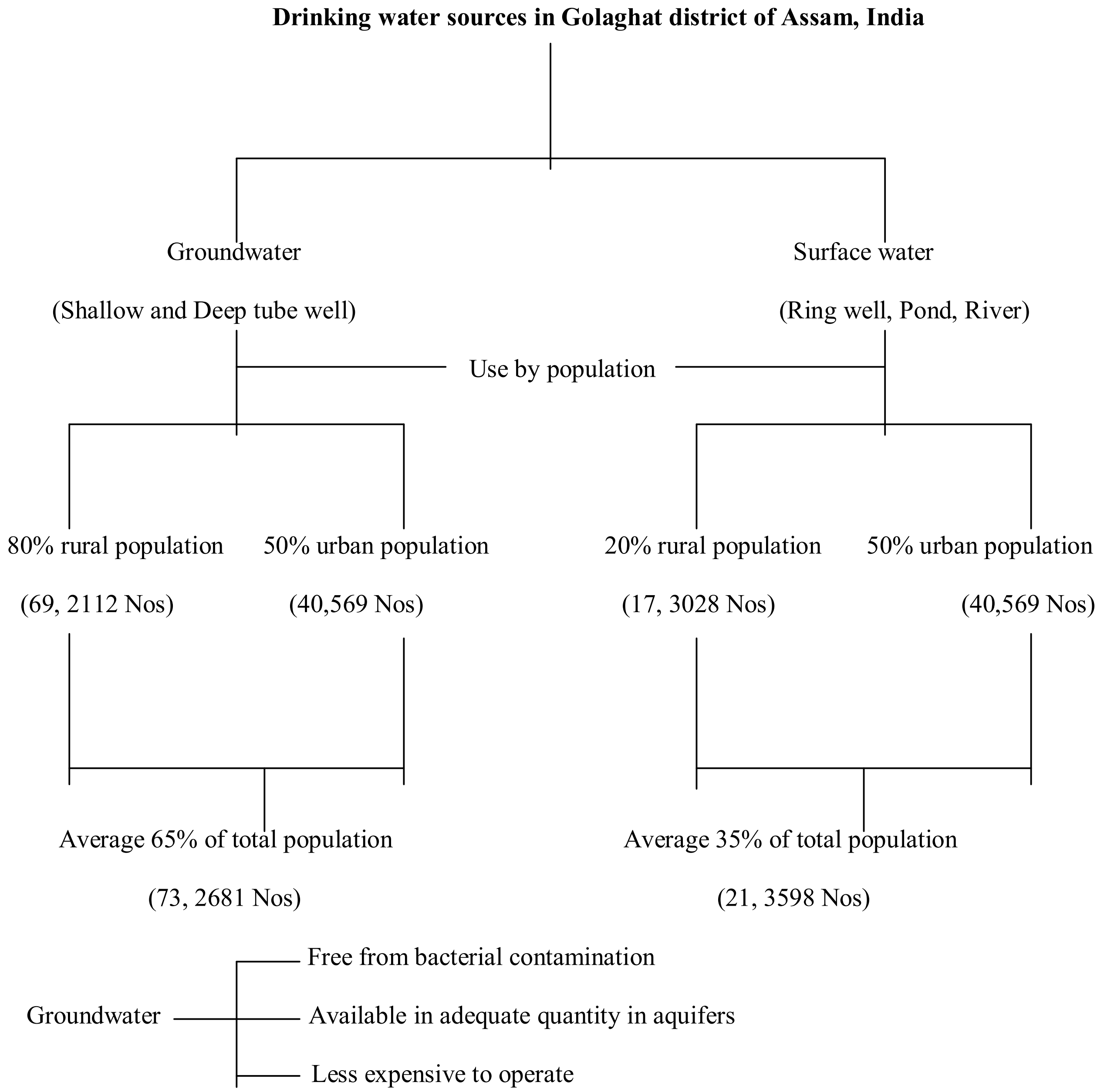

Figure1. Schematic diagram of percentage wise consumption of water for drinking purpose from different water sources

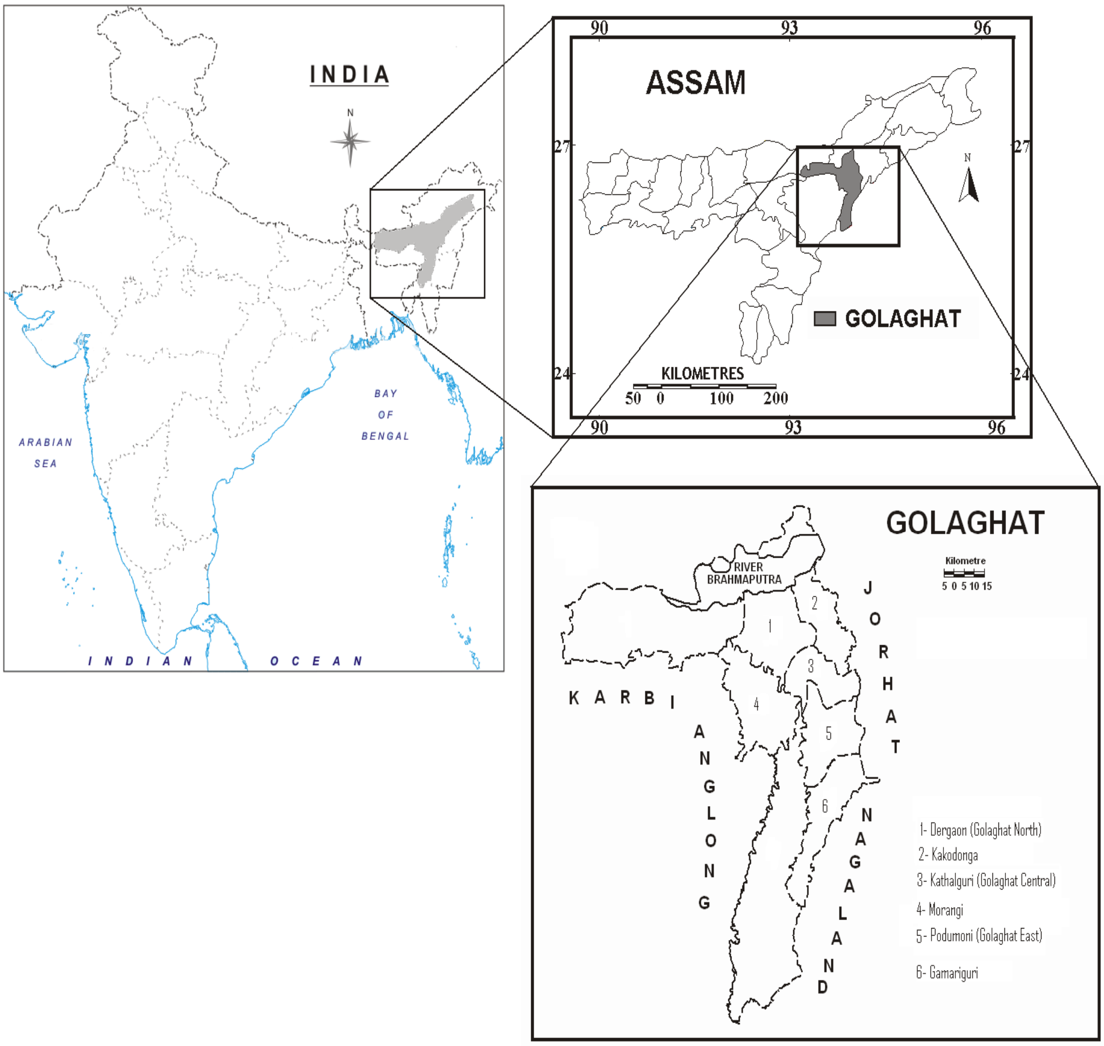

Figure 2. Location map of Golaghat district

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