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Assessment of Surface Water Quality in an Arsenic Contaminated Village

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ABSTRACT

Arsenic contamination of ground water has occurred in various parts of the world, becoming a menace in the Ganga-Meghna-Brahmaputra basin (West Bengal and Assam in India and Bangladesh). Recently arsenic has been detected in Cachar and Karimganj districts of barak valley, Assam, bordering Bangladesh. In this area coli form contamination comprises the major constraint towards utilization of its otherwise ample surface water resources. The local water management exploited ground water sources using a centralized piped water delivery scheme without taking into account the geologically arsenic-prone nature of the sediments and aquifers in this area. Thus surface water was the suggestive alternative for drinking water in this area. The present study investigated surface water quality and availability in a village of Karimganj district, Assam, India contaminated with arsenic for identifying the potential problems of surface water quality maintenance so that with effective management safe drinking water could be provided. The study revealed that the area was rich in freshwater ecosystems which had all physico-chemical variables such as water temperature, pH, DO, total alkalinity, free CO_2, heavy metals like lead, chromium and cadmium within WHO standards. In contrast, coli form bacteria count was found far beyond permissible limit in all the sources. Around 60% people of the village preferred ground water for drinking and only 6% were aware of arsenic related problems. The problem of bacterial contamination could be controlled by implementing some ameliorative measures so that people can safely use surface water. Inhabitants of the two districts should be given proper education regarding arsenic contamination and associated health risk. Effluents should be treated to acceptable levels and standards before discharging them into natural streams.

Keywords: Arsenic Contamination, Surface Water, Ground Water, World Health Organization, Water Temperature (WT), Carbon Dioxide, Total Alkalinity (TA), Dissolved Oxygen (DO), Electrical Conductivity (EC)

1. INTRODUCTION

The World Health Organization (WHO, 2002) estimates 1.7 million deaths and 54.2 million Disability Adjusted Life Years (DALYs) lost worldwide per year due to unsafe water, hygiene and sanitation. In India more than a million child deaths per year results from waterborne diseases like diarrhea (Parikh *et al*., 1999). According to NWP (2002), drinking water needs of human beings and animals should be the first priority on any available water. The availability of safe and reliable sources of water is an essential pre-requisite for the establishment of a stable community. The hydrobiological cycle stores about 0.6% of water as ground water and accounts for 25% of our fresh water (Mahapatra and Mishra, 2005). Due to several anthropogenic activities ground water is found to be contaminated with heavy metals like arsenic, fluoride.

In the north eastern part of India, surface water from ponds and rivers comprised the traditional water supply source. In recent years, these systems were contaminated by high densities of pathogenic micro-organisms which caused various waterborne diseases, such as diarrhoea, gastroenteritis, typhoid and cholera. This was mostly accompanied by high turbidity that rendered the aesthetical quality of this water poor. For avoiding these problems the water providers decided to exploit ground water sources in the centralized piped

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water supply schemes without taking into account the geologically arsenic-prone nature of the sediments and aquifers in this area. Ground water became very popular because of its convenience and crystal clear nature However, within less than a decade arsenic was detected in number of wells of NE India.

Arsenic contamination in ground water is a major problem in more than 20 countries all over the world which includes Asian countries (Thailand, Taiwan, mainland China, Vietnam and the Ganges Delta of Bangladesh and West Bengal, India). In North East India, arsenic has been detected in 21 districts of Assam, three districts of Tripura, six of Arunachal Pradesh, four of Manipur and two of Nagaland (Singh, 2004). Prolonged exposure to water contaminated with arsenic is highly toxic to humans causing skin and bladder cancer, melanosis and keratosis. Ground water contamination with heavy metals like As, F. is generally irreversible. Water-management decisions are very much important as they have environmental, physical,social and economic impacts. It is, therefore, necessary to have the most relevant information for arriving at rational decisions that will result in the maximum amount of benefit to most people (Gupta and Deshpande, 2004). The key role of a Government should be to maintain and ensure an adequate supply of chemically and microbiologically safe drinking water which is acceptable to the people. This makes chemical and microbiological monitoring of surface and ground water sources mandatory. According to Smith *et al*. (2000) the fundamental intervention is the immediate identification and provision of arsenic-free drinking water.

The Karimganj district (92°C15'-92°C35' east and 24°C15'-25°C55' north.) is one of the 21 arsenic affected district of Assam where arsenic concentration exceeded the permissible limit 50 μgL^{-1}. It is bounded on the North and west by Bangladesh (**Fig. 1**). Hence it was thought that a preliminary study on some dimensions of surface and ground water quality of Bidyanagar village of Karimganj district would be of value for developing management strategies for maintaining potable water quality.

2. MATERIALS AND METHODS

Three replicate water samples were collected from the sub-surface layer in PVC and BOD bottles (for estimating dissolved oxygen) from ten sites of different water sources (four ponds, four handpumps and two sites of River Longai) of Bidyanagar Village. Water Temperature (WT), pH and Electrical Conductivity (EC) were measured by mercury bulb thermometer, pH meter and Conductivity-TDS Meter, respectively.

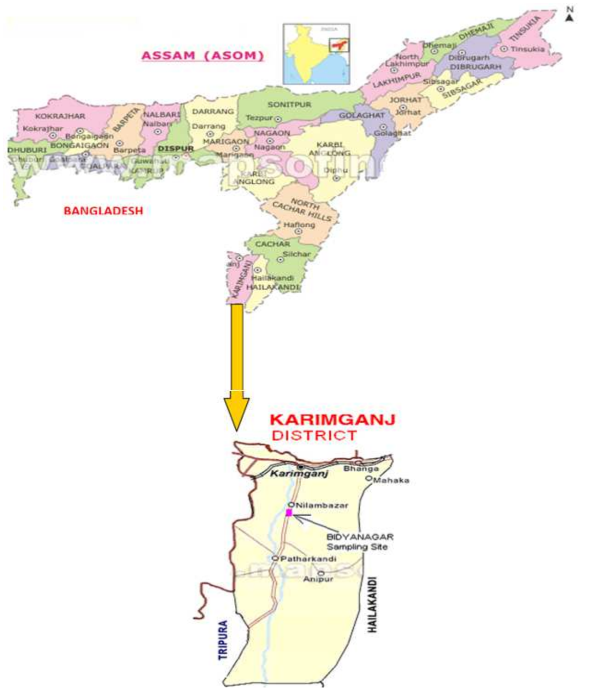

Fig. 1. Map showing the location of the Bidyanagar village of Karimganj district, Assam

Dissolved Oxygen (DO), Total Alkalinity (TA) and free Carbon Dioxide (CO_2) were analyzed by standard methods (Eaton and Franson, 2005). Cadmium (Cd), Chromium (Cr) and Lead (Pb) of water samples were estimated in a Perkin-Elmer 2380 flame atomic absorption spectrophotometer.

For microbiological analysis three replicate water samples were collected in sterilized bottles from all the sites. *E.coli* and other coli form analysis was done using membrane-filter technique with MS-Endo broth (Eaton and Franson, 2005) and expressed as $MPN100ml^{-1}$. For collecting various information regarding socioeconomic condition, surface and ground water usage, related health risk. a structured and semi-structured questionnaire containing both open and close-ended questions was used (Murdock *et al*., 1986).

3. RESULTS

Physico-chemical and biological properties of water samples of different sites are shown in **Table 1**.

The WT of the surface water sources ranged from 29.5-32.33°C. The range of DO (5.8-8.81 mg L^{-1}), free CO2 (1.1-4.77 mg L^{-1}), EC (98.13-216.77) and TA (45-90 mg L^{-1}) was within the permissible limit of WHO (2004). The pH ranged from 5.98-8.12.

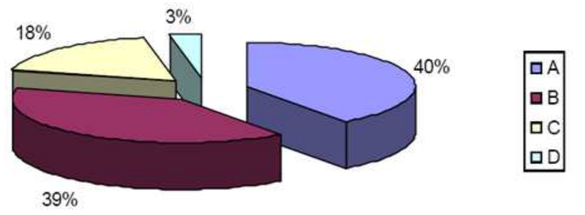

Fig. 2. Educational status of the people of Bidyanagar village. A-Below 10th standard, B- Above 10th standard, C- Above 12th standard, D- Graduate

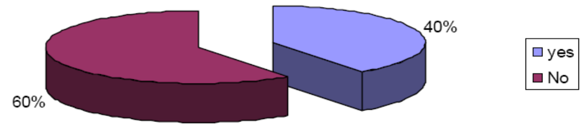

Fig. 3. Awareness level of Arsenic contamination of water in Bidyanagar village

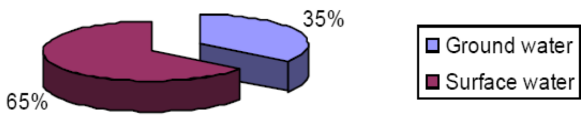

Fig. 4. Preference for drinking water source by the people of Bidyanagar

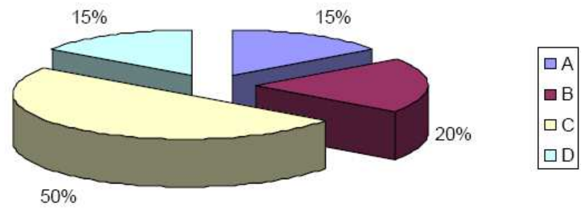

Fig. 5. Employment status of the people of Bidyanagar village. A-Govt. job, B- Private Job, C- Cultivator, D- Unemployed

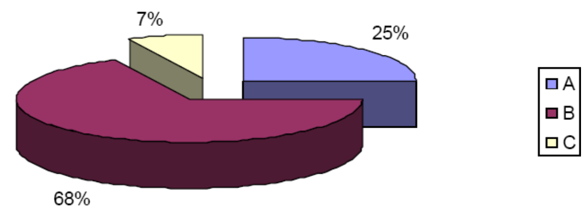

Fig. 6. Monthly expenditure of the people of Bidyanagar village. A- Rs.3000 and more, B- Rs. 5000 and more, C- Rs.6000 and more

The concentration of Cr, Cd and Pb in all the drinking water sources ranged from 8.6-22.3, 1.7-4.3, 6.6-22.6 μgL^{-1}, respectively. The number of *E.coli* in different drinking water sources varied from 3.3-50 MPN $100ml^{-1}$. The number of other fecal coliform ranged from 573.3-8856.7 MPN100 mL^{-1} **Table 1**. While 60% of households were aware of arsenic contaminated water, the remaining 40% of families 101 were limitedly informed. In the village 40% people were below 10th standard, 39% above, 18% passed 12th standard and 3% were graduate. 35% people of the village preferred ground water for drinking, 65% people preferred surface water. 15% of the total population was employed by the government, 20% in private sector and 50% was engaged in cultivation. The remaining 15% were unemployed. Only 7% household of the village belonged to the expenditure category of Rs.> 6000. 68% household belonged to the category of Rs.> 5000 and 25% belonged to Rs.> 3000 (**Fig. 2-6**).

3. DISCUSSION

The importance of adequate water quantity for human health has been recognized for many years and there has been an extensive debate about the relative importance of water quantity, water quality, sanitation and hygiene in protecting and improving health (Esrey *et al*., 1985). Study revealed that in the Bidyanagar village surface water availability is not a problem; however, water quality is. The highest temperature in river water might be due to the fact that river receives effluent from various sources which increases the temperature. The range of DO conformed to the previous studies on the ponds of Cachar district of Assam (Gupta, 2004; Bhuiyan and Gupta, 2007; Gupta *et al*., 2008). However, record of very low concentration of free CO2 did not agree with the previous studies. A study on the water quality of Tamparaparani river of Tamil Nadu (Martin *et al*., 2000) revealed similar low concentration of free CO2. Except pond 2, pH of all the sites were also well within the permissible range of WHO (2004). The acidic nature of water of Pond 2 could be due to the contamination by sewage and domestic wastes in the water sources (Dwivedi and Pandey, 2002).

The problem of environmental pollution due to toxic metals has begun to cause concern on account of geoaccumulation, bioaccumulation and biomagnifications (Naik and Wanganeo, 2008). Iron among other trace elements is known to play a significant role in human health for example, a deficiency of Fe causes anemia. On the other hand, an excess of Fe may cause gastrointestinal irritation. In the present study, other important metals having specific role in water quality such as Cr, Cd and Pb were found to be well within permissible limits of WHO.

Table 1. Variation of chemical, physical and biological parameters in water of ponds (P1-P4) handpumps (H1-H4) and river of Bidyanagar village (R1 and R2) (Values in parenthesis are ± SD of three replicate samples)

	Pond				Handpump				River	
Variables	P1	P2	P3	P4	H1	H2	H3	H4	R1	R2
WT (°C)	31.66 (0.58)	30.83 (0.29)	31.66 (0.29)	30.83 (0.58)	29.83 (0.29)	30.16 (0.29)	31.33 (0.00)	29.5 (0.29)	32.33 (0.29)	31.66 (0.29)
DO mgL^{-1}	6.77 (0.34)	7.54 (0.29)	5.81 (0.58)	7.44 (0.44)	7.83 (0.58)	8.81 (0.16)	7.04 (0.62)	6.53 (0.51)	7.42 (0.42)	7.22 (0.27)
Free CO2 (MgL^{-1})	1.83 (0.64)	2.2 (0.0)	4.76 (0.64)	1.1 (0.00)	2.2 (0.00)	2.93 (1.29)	2.56 (0.64)	4.03 (0.64)	3.3 (0.00)	4.4 (0.00)
TA (mgL^{-1})	53.33 (2.89)	83.33 (2.89)	45 (5)	75 (5)	81.67 (2.89)	78.57 (7.15)	61.66 (2.89)	68.33 (2.89)	90 (5)	83.33 (2.89)
pH	6.88 (0.02)	5.98 (0.02)	7.18 (0.01)	7.24 (0.03)	7.95 (0.05)	6.88 (0.02)	7.52 (0.02)	8.12 (0.01)	6.84 (0.02)	7.82 (0.01)
EC ($\mu S\ cm^{-1}$)	186.0 (2.22)	216.77 (1.46)	115.0 (2.37)	98.13 (7.06)	112.1 (3.20)	98.9 (4.22)	142.0 (2.69)	119.6 (4.99)	185.4 (1.4)	174.7 (1.42)
Cd ($\mu g\ L^{-1}$)	4.0	3.5	1.7	2.5	1.8	4.3	1.5	0.6	4.1	3.2
Cr ($\mu g\ L^{-1}$)	20.1	15.0	19.0	11.7	22.3	21.6	8.6	11.0	10.4	13.8
Pb ($\mu g\ L^{-1}$)	10.8	13.4	10.4	10.2	22.6	15.0	20.1	12.1	6.6	11.8
E.coli (MPN 100 mL^{-1})	26 (3.57)	33.3 (2.08)	40 (7.49)	40 (6.94)	3.3 (0.57)	20 (3.43)	3.3 (0.57)	10 (7.28)	50 (9.25)	50 (11.08)
Other faecal Coli form (MPN 100 mL^{-1})	7543.3 (5.13)	7716.7 (6.1)	7946.7 (8.6)	5110 (3.54)	573.3 (3.97)	993.3 (4.04)	983.3 (9.45)	843.3 (7.53)	8856.7 (8.0)	8406.7 (4.04)

Typical Enter Pathogenic *E. Coli* (EPEC) strains are a leading cause of infantile diarrhea in developing countries (Ashbolt, 2004). In the present investigation, coli form bacteria count was found far beyond permissible limit in all the sources. According to permissible standards, if one or more than one *E.coli* per 100 mL of water is detected, the water is considered to be unsafe for drinking purposes. The number of *E.coli* and other fecal coli form in different drinking water sources of the village was recorded very high except in hand pumps. Highest number was recorded in river sources and lowest in hand pumps (**Table 1**). These results were corroborated with previous studies made in ponds of Catcher district, Assam and ponds, wells and natural reservoirs in and around Guwahati city, Assam (Sharma *et al*., 1995; Gupta *et al*., 2008). Microbiological properties of water of five Nigerian rivers also revealed similar results (Oluwande *et al*., 1980). It was observed that water samples of ponds situated near septic tanks, bathrooms and urinals showed higher values of coli forms. This showed lack of proper management practices in sanitary condition around the sources. Sharma *et al*. (1995) and Ayse *et al*. (2008) reported that surface water of river and pond frequently exposed to contaminated soil, sewage, domestic waste, untreated wastewater favored high bacterial load. Comparatively less bacterial count in hand pumps could be due to the filtering action of the earth which removes not only most of the bacteria but also much of their food material (Begum *et al*., 2004).

In a given situation with poor sanitation and poor-quality drinking water, the beneficial impact of improving only the sanitation will be larger than that of improving only the quality of drinking water (Esrey, 1996). In the study area, with arsenic contaminated ground water, surface water is the only option available to the inhabitants of arsenic effected villages. Hence for water borne diseases, people living in and around the surface water source. Need to be educated on hygiene practices and aware of their environmental impact on the drinking water. Public awareness programmes on simple and economical water treatment methods like filtration, boiling and SODIS (solar disinfection with UV plus heat in clear bottles for sunlight penetration) would prove beneficial. In developing countries, the availability of clean air, potable water, sanitation and safe food is often presumed to be low due to poverty. Individuals often lack the necessary information to make good decisions about environmental hazards in their day-to-day lives. Two most important factors operative in potable water quality conservation and management are education and economic condition of the population. A study on public perception of drinking water quality in Quebec region, Canada confirmed the importance of socio-economic characteristics of consumers on their perception of drinking water quality (Turgeon *et al*., 2004). Hence, a survey made for identifying the potential problems of surface water quality maintenance in the present study area revealed 60% of the population above 10th standard were aware of the arsenic problem because of their education. This knowledge is observed in their preference for water sources as 35% of people preferred ground water and 65% of people preferred surface water for drinking and treated water before use. The fate of 102 those 35% who have been using arsenic contaminated ground water is at risk to developing arsenocosis after prolonged exposure to the metal. Since the village has nearby surface water sources like river and ponds, water providers should take some ameliorative measures to control the microbial contamination of the aquatic systems in order to avoid the use of ground water. A study made on the socioeconomic impact of arsenic hazard on the poor people of rural society of Bangladesh showed that it caused social crisis and break up of social ties (Chowdhury *et al*., 2006). Risk of being affected by arsenic toxicity is increased and more prevalent among poor families. In the village, more than three fourth of the population are not in a position to have nutritious diet. Fortunately, there is no report of arsenocosis yet and ameliorative measures to lower arsenic concentrations in ground water can still be effective to protect human health in this area.

4. CONCLUSION

This study finds that a phased water quality monitoring programme should be undertaken for improvements in water quality. Effluents should be treated to acceptable levels and standards before discharging them into natural streams. Allocation of funds under the water resources sector should be re-prioritized to ensure that the needs for development as well as operation and maintenance of the facilities are met. Structures and systems created through massive investments should be properly maintained in good health.

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