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Assessment of Arsenic Concentration in Ground Water of Tube Wells in Selected Primary Schools' at Palashbari Upazila of Gaibanda District

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Abstract
Arsenic contamination has been recognized as an acute national problem in Bangladesh. Tube wells, one of the most important source of drinking water in Bangladesh, are contaminated by arsenic in 61 districts out of a total of 64. Children who are exposed to high levels of arsenic in their drinking water are 7 to 12 times susceptible then adult. This study was conducted to know the arsenic concentration level in primary schools' tube wells. Twenty seven schools were selected at Palashbari upazila of Gaibandha district under Rangpur division. Econo Quick test kit was used to measure arsenic concentration. Global Positioning System (GPS) was used to indicate the geographic location. Fifteen were Sallow Tube Well no. 06 and eleven were Deep Tube Well no. 06 among the examined tube wells. Arsenic concentration of these studied tube wells were ranged between 0 to 200μg/L. Except two all are below (0 to 10μg/L) the WHO maximum permissible level (50μg/L). Among these two one lies marginal level (50μg/L) and another crosses the level (200μg/L). Arsenic concentrations of these tube wells were not high. So, there could be considered as a safe source of drinking water for the pupils of these primary schools.
Key Word: Arsenic, Concentration, Contamination, Drinking water, Primary School

Introduction

Bangladesh is fighting with the largest mass poisoning of a population in history because groundwater used for drinking has been contaminated with naturally occurring inorganic arsenic (Smith *et al.* 2000). Arsenic contamination of groundwater in Bangladesh was first detected in 1993 (Khan *et al.* 1997). Recent findings of the British Geological Survey (BGS,1999) show that groundwater of 61 surveyed districts, out of a total of 64, is contaminated with arsenic (BGS, 1999). However, survey results of the School of Environmental Studies (SOES) and Dhaka Community Hospital (DCH) show that 47 districts are contaminated (SOESDCH, 2000).
Tube wells are the single-most important source of fluid (drinking water) in Bangladesh (Asadullah and Chaudhury, 2008). Tube-wells have been used in Bangladesh since the 1940s (UNICEF, 1999). According to 2001 population census, 88% of rural households use tube wells as the main source of drinking water. Even in the early 1970s drinking from open water bodies was a common practice. However, surface water is often contaminated with bacteria and a major cause for waterborne diseases such as cholera, dysentery, typhoid, and diarrhoea. Unsurprisingly, these water-related illnesses in young children were the leading cause of morbidity and mortality (Asadullah and Chaudhury, 2008).
Infants and children suffered from acute gastro-intestinal disease resulting from bacterial contamination of stagnant pond water (Smith *et al.* 2000). Consequently, during the 1970s the United Nations Children's Fund (UNICEF) worked with the Department of Public Health Engineering to install tube-wells to provide what was presumably a safe source of drinking-water for the population. These wells consist of tubes with 5 cm in diameter and are inserted into the ground at depths of usually less than 200 m. The tubes are then capped with a cast. Bangladesh had surpassed its goal of providing 80% of the population by 2000 with access to ''safe'' drinking-water in the form of tube-wells, ring-wells and taps (UNICEF, 1998).
Tube well construction strongly accelerated in the 1980s. Around 11 million tube wells were installed during the period, a vast majority being in private ownership (Geen *et al.* 2005). This initiative has helped control water-born diseases, but in many areas it has had the unintended side-effect of exposing the population to another health problem – toxic arsenic in ground water. However, the problem of arsenic contaminated water has only recently come to light due to the increasing number of tube-wells used over the past 20 years and the subsequent increase in the number of individuals drinking from them (Smith *et al.* 2000) .
Arsenic toxicity has been recognized as an acute national problem. The World Health Organization (WHO) maximum permissible level is less than 50 (μg/L) of arsenic. Intake of arsenic over the permissible level over a period of several years leaves a person at risk of developing arsenic related diseases. So far, 40,000-100,000 people have already developed visible pigmentation of skin, skin lesions, swollen limbs, warts, gangrene, and cancer and/or invisible damage to lungs, kidneys, and other internal organs, loss of feeling in the hands and legs. Prolonged exposure to inorganic arsenic can lead to hallucinations, agitation, emotional lability, memory loss, gangrene and skin as well as internal (lungs, bladder and kidneys) cancer (ATSDR, 2005).

No affordable technology exists that can either remove arsenic from drinking water or at least reduce it to a level at which it has no adverse effect on human well-being (Asadullah and Chaudhury, 2008). Therefore, majority of the affected population continues to remain exposed to the crisis. There are a number of studies documenting the adverse effect of arsenicosis on physical wellbeing of adults (Asadullah and Chaudhury, 2008). While the adverse effect of arsenicosis on adult health is well-documented, little is known on the consequences of the catastrophic health crisis caused by drinking metal-contaminated groundwater.

Children who are exposed to high levels of arsenic in their drinking water are seven to 12 times more likely to die of lung cancer and other lung diseases in young adulthood (Smith et al. 2006). There are at least four reasons why educational development of children is likely to be hampered owing to exposure to arsenicosis. First, children who have continuously drank from Arsenic contaminated tube-wells are likely to have worse health status and under-perform in schools compared to the peers who have grown up in arsenic unaffected households. Second, arsenicosis at home may cause adverse income shocks. Third, there is an emerging body of medical evidence documenting a direct impact of arsenic exposure on the intellectual development of children. Lastly there is evidence that, when exposed to arsenic at early ages, children can develop visible symptoms such as pigmentation and arsenical skin lesions by the time they reach secondary school age (Asadullah and Chaudhury, 2008).

Most children are exposed to arsenic largely through fluid intake at home and in school. School performance of children from affected households could be undermined for an additional reason. With nearly-complete awareness regarding the health implications of arsenicosis, affected households are increasingly seeking access to arsenic-free tube wells. Traditionally, children are sent to fetch water which cuts into study hours at home would adversely affect school performance of children.

This study therefore aims to test for the water of tube wells to know the arsenic concentration level in selected primary schools at Palashbari upazila of Gaibandha district which was supported by United Nations Children's Fund (UNICEF)

Materials and Methods

Study area

Palashbari upazila of Gaibandha district under Rangpur division is located at $25^0 11^/$N to $25^0 19^/$N latitude and $89^0 14^/$E to $89^0 35^/$E longitude. It is bounded by Pirganj (Rangpur), Sadullapur and Gaibandha sadar upazilas on the north, Gobindaganj upazila on the south, Gaibandha sadar and Sughatta upazila on the east and Ghoraghat upazila on the west with an area of 190.67 sq km.

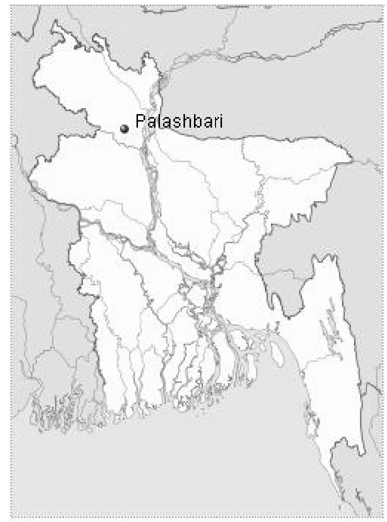

Figure 1: Showing the study area, Palashbari upazila of Gaibandha district in Bangladesh

Data collection

Selected twenty seven schools were visited during September to October, 2011 and data of Water Point Type, Water Point Depth (feet), Water Point Status, Arsenic concentration (µg/l) etc. was recorded. Water samples of these schools were tested by Econo Quick test kit. GPS (Global Positioning System) machine was used to indicate the geographic location of the study area. Every school's geographic locations (Latitude and Longitude) were set up by the GPS machine.

Arsenic Test KIT Components

- Two reaction bottles
- Two white caps with white turrets for holding test strips
- Three plastic spoons (one large pink spoon for reagent 1, one smaller red spoon for reagent 2, and one smaller spoon for reagent 3)
- Arsenic test strips
- Reagent #1 (tartaric acid with rate enhancers)
- Reagent #2 (an oxidizer)
- Reagent #3 (zinc powder)
- Two red caps for mixing
- Easy read color chart

Arsenic Test Procedure

The analysis was performed in a closed reaction plastic bottle. The reaction bottle was rinsed two times by the sample water to be tested, and then the sample water was poured up slowly to the marked line on the bottle (50 ml). First, the water sample was mixed in the supplied reaction vessel with Reagent #1 (tartaric acid with rate enhancers), red cap securely was sealed and shake vigorously, and the bottle was positioned upright for 15 seconds to acidify the water sample. Uncapped the reaction bottle and then Reagent #2, an oxidizer, was added to remove hydrogen sulfide interference. Again recapped securely with the red cap and shake vigorously with the upright position of the bottle for 15 seconds. The reaction bottle was uncapped again and finally Reagent #3, Zinc powder, was added in the sample. Then the red cap was sealed securely and shake vigorously in a upright position the bottle uprights for 5 seconds again. Test strip was inserted into the turret and left 10 minutes for the reaction to occur. With the addition of Zinc powder, inorganic arsenic compounds (As^{+3} and As^{+5}) were reduced to arsine gas. After 10 minutes wait, as arsine gas was generated and comes in contact with the test strip, the mercuric bromide indicator on the test strip changed in color from white to shades of yellow or brown. Once the reaction was completed, the test strip was removed carefully and matched to a calibrated color chart to obtain a quantitative measure of arsenic in the tested sample. A light yellow to brown color change indicates the presence of arsenic. The color intensity is proportionately related to the concentration of arsenic in the sample. The reduction in this kit utilizes zinc and includes the following reactions:

$$As_4o_6 + 12Zn + 24H^+ \rightarrow 4AsH_2(gas) + Zn^{+2} + 6H_2O$$
(pH>1.6) and
$$Zn + 2H^+ \rightarrow Zn^{+2} + H_2\ (gas)$$

The color chart was used to match the test strip pad color within the next 30 seconds. For the best color matching direct sun-light was avoided direct sunlight. The reacted test strip pad was positioned behind the punch holes (to view the centre of the test strip pad through the hole) to confirm precise color match and to direct arsenic level.

Data analysis

Collected data were analyzed using MS Excel 2007 package.

Results and Discussions

Among the selected twenty seven primary schools only six are Government Primary School and rest twenty one are Non Government Primary Schools. These schools located $25^0 13^/ 02.1^{//}$ N to $25^0 18^/ 18.5^{//}$ N latitude and $89^0 16^/ 23.0^{//}$ E to $89^0 28^/ 27.6^{//}$ E longitude (Table 1).

Table 1: Sampling information of different tube wells of selected primary schools

Sl. No.	Name of School	Latitude	Longitude	Water Point Type	Water Point Depth (Feet)	Arsenic (µg/L)	Water Point Status
1.	Shaindha Reg. Non-Government Primary School	$25^0 14^/ 12.7^{//}$	$89^0 19^/ 25.7^{//}$	STW6	30	0	Running
2.	Salmara Reg. Non-Government Primary School	$25^0 13^/ 48.2^{//}$	$89^0 20^/ 22.5^{//}$	STW6	38	10	Running
3.	Kariata Reg. Non-Government Primary School	$25^0 13^/ 02.1^{//}$	$89^0 20^/ 14.8^{//}$	STW6	60	0	Running
4.	Konabori Reg. Primary School	$25^0 13^/ 06.6^{//}$	$89^0 21^/ 22.7^{//}$	STW6	45	0	Choked Up
5.	Jalingi Reg. Non-Government Primary School	$25^0 18^/ 00.7^{//}$	$89^0 25^/ 00.2^{//}$	STW6	77	0	Running
6.	KittarPara Reg. Non-Government Primary School	$25^0 17^/ 24.1^{//}$	$89^0 24^/ 19.6^{//}$	DTW6	145	0	Running
7.	Laxmimari Government Primary School	$25^0 17^/ 19.9^{//}$	$89^0 24^/ 38.1^{//}$	DTW6	160	0	Running
8.	Forkondapur Reg. Primary School	$25^0 18^/ 02.2^{//}$	$89^0 24^/ 24.0^{//}$	DTW6	180	0	Choked Up

9.	Shampur Reg. Primary School	$25^{0}18^{/}18.5^{//}$	$89^{0}24^{/}06.7^{//}$	STW6	35	10	Choked Up
10.	Bujruk Bishnowpur Government Primary School	$25^{0}16^{/}04.3^{//}$	$89^{0}23^{/}22.1^{//}$	DTW6	155	50	Running
11.	Chondipur Reg. Non-Government Primary School	$25^{0}18^{/}08.1^{//}$	$89^{0}22^{/}45.6^{//}$	DTW6	110	0	N/A
12.	KyarPara GovernmentPrimary School	$25^{0}15^{/}29.4^{//}$	$89^{0}24^{/}19.7^{//}$	STW6	70	0	Running
13.	Balabomonia Ideal Reg. Non-Government Primary School	$25^{0}14^{/}38.5^{//}$	$89^{0}26^{/}27.9^{//}$	DTW6	120	10	Running
14.	Balabomonia ProdhanPara Reg. Primary School	$25^{0}14^{/}37.2^{//}$	$89^{0}27^{/}13.0^{//}$	STW6	65	200	Running
15.	Ghorabandha Purbopara Government Primary School	$25^{0}15^{/}38.8^{//}$	$89^{0}28^{/}27.6^{//}$	DTW6	135	0	Running
16.	Ghorabandha Pocchimpara Reg. Primary School	$25^{0}15^{/}20.1^{//}$	$89^{0}27^{/}28.1^{//}$	STW6	45	10	Running
17.	Chalkbala Reg. Primary School	$25^{0}16^{/}37.3^{//}$	$89^{0}16^{/}23.0^{//}$	DTW6	80	0	Choked Up
18.	Pacchim Ramchondrapor Non-Government Primary School	$25^{0}16^{/}17.0^{//}$	$89^{0}16^{/}50.9^{//}$	DTW6	90	0	Running
19.	Pacchim Ramchondrapor Pacchimpara Reg. Primary School	$25^{0}16^{/}09.6^{//}$	$89^{0}16^{/}29.8^{//}$	STW6	26	0	Running
20.	Sultanpur Bariapara Reg. Primary School	$25^{0}17^{/}03.1^{//}$	$89^{0}19^{/}09.4^{//}$	STW6	25	10	Running
21.	North Sultanpur Bariapara Reg. Primary School	$25^{0}17^{/}24.6^{//}$	$89^{0}18^{/}47.2^{//}$	STW6	77	0	Running
22.	Beradanga Reg. Non-Government Primary School	$25^{0}15^{/}57.7^{//}$	$89^{0}18^{/}28.1^{//}$	DTW6	85	0	Running
23.	Nowana Nowda Reg. Primary School	$25^{0}16^{/}21.8^{//}$	$89^{0}19^{/}33.5^{//}$	STW6	70	0	Running
24.	Karatua Para Reg. Primary School	$25^{0}14^{/}17.1^{//}$	$89^{0}17^{/}55.3^{//}$	STW6	55	10	Running
25.	Hasbari Model Government Primary School	$25^{0}13^{/}55.5^{//}$	$89^{0}21^{/}03.2^{//}$	STW6	45	0	Choked Up
26.	Rangamati Government Primary School	$25^{0}18^{/}08.5^{//}$	$89^{0}20^{/}09.1^{//}$	Motor Pump	170	0	Running
27.	Durgapur Fazoria Reg. Primary School	$25^{0}15^{/}57.7^{//}$	$89^{0}22^{/}25.6^{//}$	DTW6	120	0	Running

STW6: Sallow Tube Well no. 06; DTW6: Deep Tube Well no. 06

Most of the (15) tube wells are Sallow Tube Well no. 06 (STW6) with a range of water depth 25 to 77 feet, one is motor pump with a water depth of 170 feet and rests of the (11) tube wells are Deep Tube Well no. 06 (DTW6) with a range of water depth 80 to 180 feet. Most of these tube wells are running and few are chocked up (Table 1).

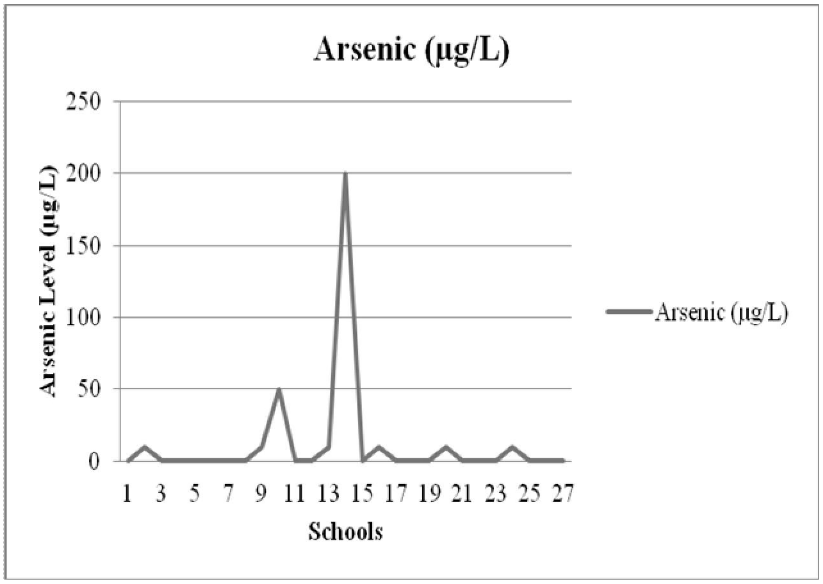

Figure 2: Showing the arsenic concentration (µg/L) in selected primary schools' tube wells

Arsenic concentration of these study tube wells ranges between 0 to 200µg/L. Most of the tube wells contain zero (0µg/L) arsenic concentration (Figure 2). Only one tube well's arsenic concentration (200µg/L) crosses the WHO maximum permissible level which is 50µg/L for Bangladesh and one tube wells lies on marginal level (50µg/L).

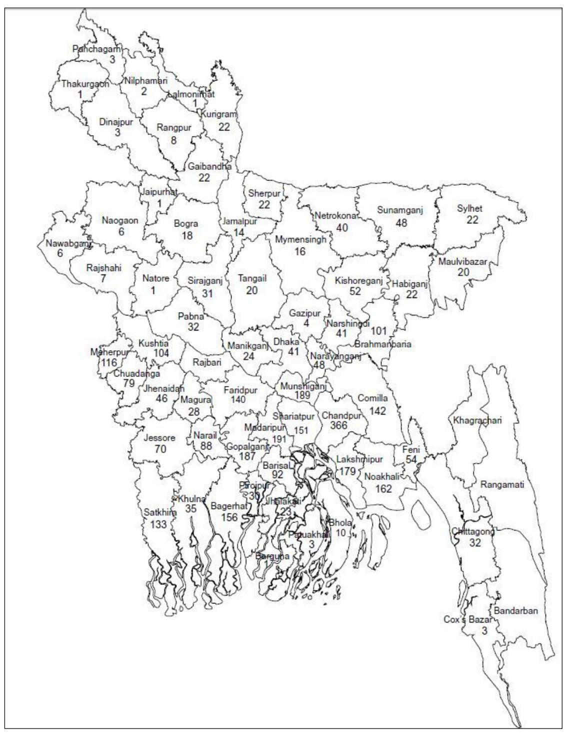

Figure 3: District wise arsenic concentration (in µg/L)
Source: BGS and DPHE 2001

Arsenic concentration of these study tube wells were lower because there is a distinct regional pattern of arsenic contamination with the greatest contamination in the south and south-east of the country and the least contamination in the north-west and in the uplifted areas in the north-central Bangladesh. The young (Holocene) alluvial and deltaic deposits are most affected whereas the older alluvial sediments in the north-west and the Pleistocene sediments of the uplifted Madhupur and Barind Tracts normally provides low arsenic level (BGS and DPHE, 2001).

Gaibanda is the least affected district, the average arsenic concentration is 22µg/L (Figure 3). Even in areas of generally low arsenic concentrations, there are occasionally 'hot spots' where a cluster of wells with unusually high concentration (200 µg/L) of arsenic are found (BGS and DPHE 2001), (Figure 2).

Conclusion and Recommendation

Arsenic concentration of these studied tube wells was not high enough. It should be considered as a safe drinking water source for the pupils of these primary schools except two wells. The high concentrations in these two wells have to ban for drinking purpose but may be use for bathing, washing and toilet purpose.

To achieve the suitable quality of drinking water as well as the development of school's children following steps should be taken-

- From a worldwide perspective, drinking water derived from aquifers showing similar characteristics to those of the Bengal Basin should be considered 'at risk' and need to be systematically tested for arsenic.
- Future studies therefore should aim at collecting additional data on past exposure at all levels of schooling.
- Furthermore, these studies should also involve collection of urine/blood samples from pupils to measure actual levels of arsenic exposure and their health status.

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References

Asadullah, M. N. and Chaudhury, N. 2008. Poisoning the Mind: Arsenic Contamination and Cognitive Achievement of Children, The World Bank South Asia Region Human Development Unit, pp:2-7

ATSDR. 2005. Toxicological Profile for Arsenic, Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Department of Health and Human Services, Atlanta, GA.

BGS and DPHE. 2001. Arsenic contamination of ground water in Bangladesh, volume – 1: summary, British Geological Survey Report WC/00/19, British Geological Survey, Keyworth.

BGS. 1999. Groundwater Studies for Arsenic Contamination in Bangladesh, Main Report and Supplemental Volumes 1–3, British Geological Survey Dhaka, Bangladesh and Mott MacDonald International Ltd., United Kingdom: Government of the Peoples Republic of Bangladesh, Ministry of Local Government Rural Development and Cooperatives Department of Public Health Engineering.

Geen, A. V.; Ahmed, K. M. and Madajewicz M. 2005. The Lethal Water Wells of Bangladesh, New York Times, July 30.

Khan, A. W. *et al*., 1997. Arsenic contamination in groundwater and its effect on human health with particular reference to Bangladesh, *Journal of Preventive and Social Medicine*, **16**(1):65–73.

Smith, A. H.; Lingas, E. O. and Rahman, M. 2000. Contamination of drinking-water by arsenic in Bangladesh: a public health emergency, *Bulletin of the World Health Organization*, **78**(9):1093 – 1103.

Smith, A. H.; Marshall, G.; Yuan, Y.; Ferreccio, C.; Liaw, J.; Ehrenstein, O. V.; Steinmaus, C.; Bates, M. N. and Selvin, S. 2006. Increased Mortality from Lung Cancer and Bronchiectasis in Young Adults Following Exposure to Arsenic In Utero and Early Childhood, *Environmental Health Perspectives*, 114.

SOES-DCH. 2000. Groundwater Arsenic Contamination in Bangladesh: A. Summary of 239 days field survey from August 1995 to February 2000, B. Twenty-seven days detailed field survey information from April 1999 to February 2000, School of Environmental Studies, Jadavpur University, Calcutta 700 032, India and Dhaka Community Hospital, Dhaka 1217, Bangladesh.

UNICEF. 1998. Progotir pathey, on the road to progress; achieving the goals for children in Bangladesh, Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh with United Nations Children's Fund.

UNICEF. 1999. Arsenic mitigation in Bangladesh, United Nations Children's Fund (Internet communication, 14 December 1999, available at http://www.unicef.org/arsenic).