Arsenic Contamination of Tube Well Water in Chittagong City, Bangladesh- A Case Study

M.A. Malek[1], M.N. Uddin[2], M. Atiquzzaman[3], A.H.M.G. Hyder[4], S.K. Palit[5]

Abstract— Arsenic, a semi-metal, colourless, tasteless and odourless toxic element, is known as the "King of Poison" at present. Arsenicosis is a well-known chronic disease which occurs due to drinking of arsenic contaminated tube well water having arsenic level exceeding the normal level for a prolonged period. It is likely to create a significant health impact ranging from skin lesions to cancer culminating in death. In 2008, Chittagong University of Engineering and Technology (CUET) and the Institution of Engineers Bangladesh, Chittagong Centre (IEBC) have been jointly conducted a sample survey in 41 Wards, administrative sub-divisions, of the Chittagong city in Bangladesh. From the research, arsenic has been found in shallow tube well water in 13 city wards which exceeds WHO guideline value of 0.01 mg/l for drinking water. In the present work, South Bakalia-a city ward in Chittagong has been taken as the study area for detailed investigation where arsenic concentration was found as 0.3 mg/l to 0.4 mg/l in sample survey. All the tube wells of the ward were tested for measuring arsenic concentration in the field by collecting water sample from tube wells using Wagtech Arsenic Field Test Kit (UK). Arsenic contaminated tube-wells have been marked with red colour paint for future reference and to create public awareness. A total number of 45 deep tube well's water were also tested randomly throughout the ward and found free from arsenic. Arsenic contamination has been found only in shallow tube wells and clustered in particular areas. Considering the result, arsenic contaminated prone areas within the ward have been identified so that people of the area consume water for drinking purpose from alternate sources.

Index Terms—Arsenic, Arsenicosis, Contamination, Shallow tube-well, Deep tube-well, Public awareness, Arsenic prone area, Chittagong city.

1 INTRODUCTION

1.1 Background

Bangladesh is facing perhaps the largest mass poisoning regarding arsenic in history. Though the shallow tube wells are free from pathogens but most of the shallow tube well's water in Bangladesh is found to be contaminated with arsenic. Once these tube wells were lauded for saving lives by preventing or reducing the intensity of water borne diseases but at present these tube wells are expected to be responsible for a slow and painful death of lives for providing arsenic contaminated drinking water [1].

British Geological Survey(BGS) and Department of Public Health Engineering (DPHE), Bangladesh conducted a national hydrochemical survey of well water in Bangladesh in the year 1998 and 1999 and found alarming amount of arsenic contamination in ground water of Bangladesh[2]. Considering the Bangladesh standard limit of arsenic in drinking water (0.05 mg/l), about 27% of all shallow tube wells installed in 61 plain districts of Bangladesh could be remarked as contaminated with arsenic. The Corresponding figures for deep tube wells sunk to a depth of 150 meters and above, were 5% and 1% for arsenic contamination of 0.01 mg/l and 0.05 mg/l, respectively. It is widely believed that Bangladeshi peoples are getting exposure to arsenic because of the extensive use of arsenic contaminated groundwater for drinking and irrigation purposes since the 1960s[2]. But the two major cities in Bangladesh such as Chittagong were not covered by the survey, though groundwater is extensively used in these cities [2]. Consequently, in 2008, Chittagong University of Engineering & Technology (CUET) and the Institution of Engineers Bangladesh, Chittagong Centre (IEBC) jointly conducted a samples survey in Chittagong City Corporation (CCC) area where 41 numbers of ward (administrative sub-divisions) are located.

Arsenic contamination is due to natural geological setting caused by Holocene sea level rise and Ganga-Brahmaputra deltaic sedimentation [3]. The mobility of arsenic from the sedimentary pyrite layer into the aquifers due to large-scale withdrawal of groundwater for agriculture and drinking purposes is due to the green revolution and outbreak of cholera in the 1960s in South Bengal. This followed rapid intake of O_2 (oxygen) within the pore spaces of the sediments and are believed to be due to the following geochemical processes:

$$FeS_2+2H_2O+5O_2 = FeSO_4+2H_2SO_4 \ldots\ldots (1)$$
$$4FeSO_4+O_2+2H_2SO_4=2Fe(SO_4)_3+2H_2O \ldots\ldots.. (2)$$
$$FeS_2 + 7Fe_2(SO_4)_3 + 8H_2O = 15\ FeSO_4 + 8H_2SO_4 \ldots\ldots. (3)$$

Prof. Khalilur Rahman, Chemical Engineering Department, BUET, Bangladesh (1992) reveals: a much serious problem is the disposal of highly toxic waste sludge from HFFG that has accumulated in the factory from carbon dioxide absorption tower. It was estimated that well over 22000 CFT of packing material along with sludge containing arsenic has piled up. The arsenic control in the sludge is about 40%. The process has since been modified and arsenic is not used in the absorbing solution, but large quantity of solid material remains dumped in concrete pit and in the open area.

- *Lecturer, Department of Civil Engineering, World University of Bangladesh, Dhaka, Bangladesh, E-mail: amalek.ce@gmail.com*
- *Ex Student, Department of Civil Engineering, Chittagong University of Engineering & Technology, Bangladesh, E-mail: nymebd@gmail.com*
- *Lecturer, Department of Civil Engineering, World University of Bangladesh, Dhaka, Bangladesh, E-mail: atique_kuet@yahoo.com*
- *Lecturer, Department of Civil Engineering, World University of Bangladesh, Dhaka, Bangladesh, E-mail: 82hyder@gmail.com*
- *Professor, Department of Civil Engineering, Chittagong University of Engineering & Technology, Bangladesh, E-mail:*

1.2 Findings of the CUET- IEBC Study 2008

The main objective of the CUET and IEBC jointly conducted research project was to investigate the level of arsenic in groundwater in Chittagong city corporation area. As 10 samples were collected from each ward, a total of 410 samples were tested instantly on the spot. 7 samples out of 10 were collected from shallow tube wells and 3 samples were collected from deep tube wells. The water samples obtained from the investigated deep tube wells did not contain traceable amount of arsenic. About 32% of the water samples collected from different city wards was found to contain arsenic concentration above the WHO guideline value. Water samples collected from 7 out of total 42 investigated words were contaminated with arsenic above the Bangladeshi standards. Arsenic was not found in the deep tube wells above 45m depth. In contrary, 10.99% of all the shallow tube wells (282 tube wells) investigated was found to be contaminated with arsenic. Summary of that research have been shown in Fig. 1 and Table 1. Wards coloured red in Fig. 1, are the worst affected areas where Arsenic concentration exceeds Bangladesh standard limiting value of 0.05 mg/l [6].

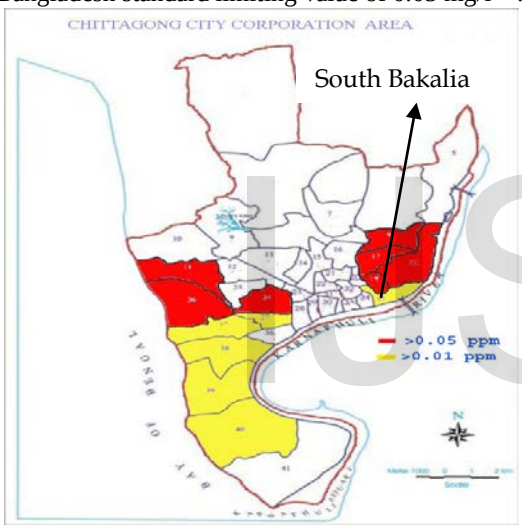

Fig. 1. City wards affected with arsenic contamination [5].

TABLE 1
WARDS EXCEEDING WHO GUIDELINE VALUE OF 0.01mg/l [4]

Ward no	Ward name	Concentration (mg/l)
6	East Sholashahar	0.50
11	South Kattali	0.20
17	West Bakalia	0.40
18	East Bakalia	0.08
19	South Bakalia	0.40
24	North Agrabad	0.08
26	North Halishahar	0.50
27	South Agrabad	0.05
35	Boxir Hat	0.05
37	NorthMiddle Halishahar	0.04
38	South Middle Halishahar	0.04
39	South Halishahar	0.04
40	North patenga	0.04

1.3 Objectives of the Present Study

From the above discussion ward 19, South Bakalia is one of the worst arsenic contaminated wards having the contamination in the range of thirty to forty times of WHO limiting value of 0.01 mg/l. Thus the present study aims to fulfil the following objectives for screening arsenic concentration within the ward 19. Location of the ward comprising the study area illustrated in Fig. 1. The specific objectives of this study are:

- To determine arsenic concentration in all shallow tube well's water in the studied area.
- To compare the results of arsenic concentration level with WHO guide line value and Bangladesh standard.
- To identify existing arsenic contaminated zones in the studied area.
- To take proper measure for creating public awareness among the people living in the studied area.
- To paint arsenic detected tube wells with red colour.

1.4 Study Area

The Study area comprises of ward no19, named as South Bakalia, which is one of the arsenic affected wards among 41 wards. It is surrounded by East Bakalia (No.18), West Bakalia (No.17), Boxir Hat (No.35), and Dewanbazar (No.20). It is located besides Raja Khali Khal. The ward has an area of 2.28 square kilometers (.88 square miles) where approximately 89 thousand inhabitants are living and the literacy rate of the inhabitants is about 63%. Location of the ward comprising the study area has been illustrated in Fig. 1.Considering a huge number of people using water from shallow tube well, assessing quality of water become very important.

2 METHODOLOGY

2.1 Shallow and Deep Tube wells

Local people, in general, consider a shallow tube well as tube well when the well diameter is about 38 mm and the well depth is less so that water from aquifer can be extracted manually by hand pump. On the other hand, tube wells sunk in deep aquifer, having a well diameter greater than 38 mm, well depth greater than the average depth of tube well, and using motorized pumps for extracting water are termed as deep tulle well [7]. In Chittagong, generally shallow tube wells find water within a maximum depth of 200 ft. (about 60 meters). In contrary, Deep tube wells are sunk in deep aquifer having a depth of above 200 feet (above 60m) [8].

2.2 Safe Distance Between Tube Well and Latrine

There should be a minimum distance in between tube well and latrine location in order to allow sufficient residence time for the pathogens of latrine to be eliminated. Since, the information of ground water flow in horizontal direction is unknown, a safe or minimum distance of at least 10 m would have been provided in between tube well and latrine location.

2.3 Field Testing of Tube Well Water

Though testing of water samples from all the tube wells in the Ward South Bakalia were aimed at, it is possible that some of the tube wells might have been left out of this survey. From 110 shallow tube wells, about 33% were found contaminated with arsenic *i.e.* 1/3 of shallow tube wells water of the ward have arsenic. Water samples were collected from 110 tube wells, both shallow and deep, located in the ward 19 (south Bakalia) in 500 mL plastic bottles. The used bottles were washed with deionized water before collection of the samples. The tube well owners without approval generally avoid disclosing their identity for fear of retaliation by CWASA. Moreover, a few locations of shallow tube wells may have gone unnoticed during the field survey.

Like earlier CUET-IEBC study, Wagtech Arsenic field test kit as shown in Fig. 2 was used in this study for field testing of water samples collected from the 110 tube wells (shallow and deep).

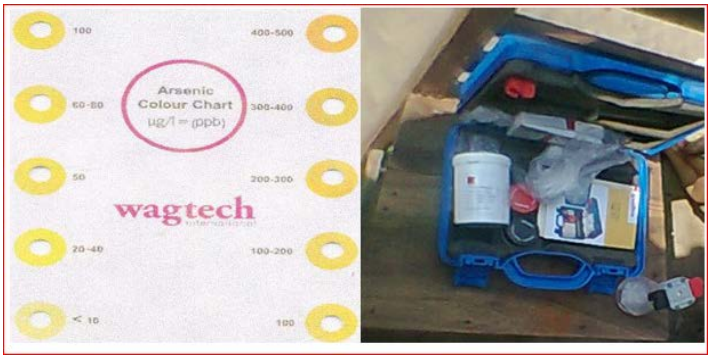

Fig. 2. Wagtech Arsenic kit box with colour chart.

The Wagtech arsenic test kit was operated according to the procedures and instructions of the manual provided by the manufacturer. Arsenic detected tube well were marked by painting with red color in the field.The field test and painting of tube well have been shown in Fig. 3.

Fig. 3. Testing of smaples on the field and painting of arsenic detected tube wells with red color.

3 RESULTS AND DISCUSSIONS

The results of the field investigations of 110 tube wells have been shown in Table-2.Among all the investigated tube wells, around 33% were found to be arsenic contaminated. In particular, 18.18% tube wells were contaminated with arsenic above the Bangladesh standard value of 0.05 mg/L whereas 32.73% tube wells were contaminated with arsenic above the WHO standard value of 0.01 mg/L.

TABLE 2
RESULTS OF THE ARSENIC SCREENING FROM THE TUBE WELLS LOCATED IN WARD NO. 19

No of tube wells tested	No of tube wells As >0.05 mg/l (Bangladesh standard)		No of tube wells As>0.01 mg/l (WHO guide line value)		Remark
	No. of tube wells	%	No. of tube wells	%	
110	20	18.18	36	32.73	Most of the affected tube wells are having depth within 15-30 m.

Some tube wells were found to be arsenic contaminated in the range of six to eight times than the Bangladesh limiting value. The worst arsenic affected locations in the ward were detected as the surrounding areas of Mia khan Lane, Moidar Mill, Belagazir Bari Road, Abdul Karim Road, Abu Jafor Road etc.

which are shown in Fig. 4. There are pockets of uninhabited low lying areas in the Ward. The areas found to be contaminated with arsenic remains submerged under water for a few days for several times in every year. Deep tube wells were not found to be contaminated with arsenic above the allowable limit.

According to the CUET-IEB study in 2008, arsenic contamination was found in 20% of all the tube wells located in the South Bakalia in that year. Whereas in the present study conducted in March and April in 2012, and around 32 % of all the tube wells located in the ward was found to be contaminated with Arsenic. As a result it is noticed that South Bakalia area is getting severely affected with arsenic contamination day by day.

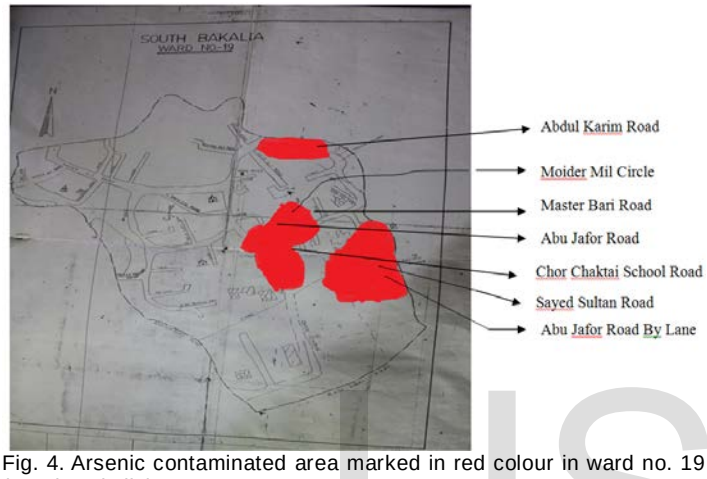

Fig. 4. Arsenic contaminated area marked in red colour in ward no. 19 (South Bakalia).

4 AWARENESS PROGRAM

Awareness campaigns about arsenic contamination could reduce the risk of many arsenic-related problems. Different types of awareness programmes such as public meeting, education, messages through posters, banners, leaflets, stickers, flip charts, Newspaper, Television, and Radio have been conducted in Bangladesh since 1995 (reference). As an objective of this study, an awareness seminar was organized at the councilor office of South Bakalia (Ward-19) at the initial stage of field survey to educate the local people**.** Furthermore, electronic media was used to convey the awareness messages. All the awareness programmes conducted have been shown in Fig. 5. Arsenic contaminated tube wells were marked with red colour for future references.

Fig. 5. Rising awareness through campaign and electronic media.

5 CONCLUSIONS AND RECOMMENDATIONS

During field investigation, high level of arsenic has been detected in 20 out of 110 shallow tube wells which exceed Bangladesh standard (0.05 mg/l). If the WHO provisional guideline value of 0.01 mg/l is considered, 36 tube wells exceed the limit out of 110 shallow tube wells. Most of the affected tube wells are having depth within 15-30 m. The arsenic affected areas such as Mia khan Lane, Moidar mill, Belagazirbari and Abdul karim road are low laying area which are often flooded during monsoon period as located near the Rajakhali khal. During flood the water remain stagnant for two to three days in those areas which may contains arsenic sediments. The reducing environment in organic matters could take place in the area during flooded period. The reducing soil environment in the deeply flooded areas appears to be conductive to the release of arsenic in groundwater [9]. That could be one of the possible reasons of arsenic contamination in South Bakalia. In addition Rajakhali khal located in Bakalia carry and deposit various industrial wastes containing arsenic compounds which could increase arsenic contamination in ground water. In the field investigation it was observed that most of the tube wells were situated beside the latrine which may lead to pathogen contamination in the ground water. It was clearly observed that people of the affected area were not fully aware about arsenic related health hazards, and safe distance between tube well and latrine.

Considering the gravity of the problem, all the tube wells in the remaining wards identified as arsenic affected in the CUET-IEBC study in 2008, have to be screened again to know the updated Arsenic contents. Chittagong City Corporation (CCC), Chittagong Water & Sewerage Authority, and NGOs working in the environmental sector could provide the necessary financial assistance for conducting the proposed study in the remaining arsenic affected Wards. The local people who were drinking the arsenic contaminated water for five years or more may get affected with arsenicosis. These affected people have to be identified and their medical assistance should be provided. Because of the close proximity of latrines with the water source in the studied area, tube well water may get contaminated with faecal content and bacteria. The tube well waters could be screened for bacteria and faecal content. Consequently, screening of tube well water to know the content of arsenic and other drinking parameters of water could be an immediate necessity for whole Chittagong city.

6 Limitations

During field investigation in some places, all the peoples were not always helpful. In some case, some owner denied to give permission to test their tube wells. In addition, few owner or user of tube well gave wrong information that is why it was impossible to test few numbers of tube wells.

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