INDIVIDUAL ASSIGNMENT ON MODULE -5

SEMINAR PAPER

ON

USE OF THE ALTERNATIVE SOURCES OF DRINKING WATER: A CASE STUDY ON AN ARSENIC PRONE AREA, BANGLADESH

SUBMITTED TO

DR. MD. MIZANUR RAHMAN

MODULE DIRECTOR, MODULE -5

&

DIRECTOR

BPATC, SAVAR, DHAKA

SUBMITTED BY

ARSHAD HOSSAIN KHAN

DEPUTY SECRETARY

ROLL NO: 119

130TH ACAD COURSE

BANGLADESH PUBLIC ADMINISTRATION TRAINING CENTRE

SAVAR, DHAKA

14 DECEMBER, 2020

Abbreviations

APSU: Arsenic Policy Support Unit

BAMWSP: Bangladesh Arsenic Mitigation Water Supply Project

BGS: British Geological Survey

CART: Community Arsenic Removal Technologies

DTW: Deep Tube Well

DPHE: Department of Public Health Engineering

GoB: Government of Bangladesh

HART: Household Arsenic Removal Technologies

L: Litre

NB: Neighbor

PSF: Pond Sand Filter

PWS: Piped Water Supply

RSF: River Sand Filter

STW: Shallow Tube Well

RWH: Rain Water Harvesting

µg: Micro Gram

ABSTRACT

Arsenic contamination of drinking water has serious public health threat. There are eight alternative sources of drinking water in Bangladesh such as deep tube well, piped water supply, rain water harvesting, pond sand filters, household arsenic removal technologies, community arsenic removal technologies, dug well, and well-sharing. It is not clear how these options are accepted and used by the population. Very few systemic studies were carried out on this crucial issue. To know the use of alternative sources of drinking water by the villagers, to identify the safe water options in an arsenic prone area, Bangladesh which is more accepted than others and to know about the awareness of the people in that area are objectives of this study. Primary data had been collected from personal interview with semi-structured questionnaire randomly. A total of 23 responses were recorded.

The results revealed that 100% of 23 respondents had not used red painted shallow tube wells after painting these tube wells red. At present, 34.78% of 23 respondents are collecting water from their own deep tube wells, whereas, 21.74% of 23 respondents are collecting water from the green painted shallow tube wells of neighbors and 43.48% of them are collection water from the respective deep tube wells of neighbors,

Deep tube well is the most favored (100%) option, piped water supply is the second highest favored option (78.26%), and rain water harvesting is the third highest favored option (65.22%). Unfortunately, pond sand filters, household arsenic removal technologies, community arsenic removal technologies, dug well and well-sharing have no acceptance. All the 23 respondents are aware of arsenic contamination and associated health complications.

1. Introduction:

1.1Background

Arsenic contamination in drinking water is a serious problem. It is a global health problem. Man suffers internal cancers due to chrome ingestion of arsenic (Smith and Steinmaus, 2009) and man dies from myocardial infarction (Yuan et al., 2007).

The problem of arsenic contamination was serious in Bangladesh. Bangladesh standard of arsenic concentration in drinking water is 50 micrograms per liter (μg/L). But World Health Organization (WHO) standard of arsenic concentration in drinking water is 10 micrograms per liter (BGS and DPHE, 2001).

From about 20 million to over 36 million people are affected from drinking water which has arsenic above the Bangladesh drinking water standard of 50μm/L (DPHE, BGS, and MML 1999 ,EES and DCH 2000; Begum 2001; BGS and DPHE (2001). According to the BGS and DPHE, 2001), by drinking arsenic contaminated water exceeding the national standard of 50 μm/L, thirty five million people are affected. If we consider the WHO standard of 10 μm/L, total number of affected people would be 57 million.

Some symptoms of chronic exposure to arsenic were observed in the affected people. The symptoms were dark spots on the skin, white spots on the skin, skin hardens. Skin diseases are commonly identified as melanosis. Skin cancer and internal cancers are the effects of arsenic contamination. Abdominal pain, nausea, vomiting, diarrhea, anemia are the results of chronic exposure to arsenic. People with skin lesions (melanosis and keratosis) in Bangladesh are most common.

Yu et al. (2003) estimated that if people drunk arsenic contaminated water, the outbreak of arsenic in Bangladesh annually would be two million cases. We would find one million patients of skin cancer and 3000 patients might die from arsenic induced cancers. A survey was conducted in 270 villages of Bangladesh in 2000. A nationwide screening program was carried out by the BAMWSP (2005) and a survey was carried out for arsenicosis patients over 66 million people in every household of 270 arsenic contaminated upazilas. It was revealed that there were 38430 arsenicosis patients. Results from previous survey conducted by BGS and DPHE, 2001

revealed poor correlation between the extent of arsenic contamination in a particular area and the availability of patients (BGS and DPHE, 2001).

In Bangladesh, arsenic contamination in ground water was first recognized in the 1990. A national survey was conducted and it showed that approximately 27% of shallow tube wells were over of Bangladesh permissible arsenic limit of 50 μg/L. That survey showed that 46% tube wells exceeded the WHO`s standard (DPHE, GoB, BGS and MML).

In cities and municipalities, water was supplied from deep, arsenic free acquifers. But in rural and peri urban areas, people get drinking water mostly from shallow tubewells. This shallow tube wells were privately owned. Mitigation efforts by raising awareness of the people in the arsenic prone area were taken. But it had challenges because arsenic has no taste or odor and it takes seveal years to develop symptoms. From 2000 to 2006, a massive tubewell screening campaign was conducted. Basic information was given to villagers. Nearly 5 million tubewells in arsenic prone areas in Bangladesh were tested. The tube wells which were over the national standard, were painted red and the tube wells which were within the national standards, were painted green (Johnston and Sarker, 2007).

There are many alternative sources of drinking water in an arsenic prone area. Steps had been taken to promote or install all alternative sources. The National Arsenic mitigation policy recommended that, wherever possible, necessary steps should be taken to promote piped water systems and that preference should be given to use of surface water over use of ground water (GoB, 2004). Emphasis had been given on promotion to various alternative sources in the implementation plan accompanying the policy. Improved dug wells (hand dug shallow wells, generally around1m in diameter and 10-20 m in depth with sanitary protection at the surface) and pond sand filters (small community slows and filters) should be given preference. Installing deep tube wells (drilled wells, generally 1.5 inches in diameter and 150m in depth, with sanitary protection and a hand pump at the surface) is a last resort . Providing water through piped water systems is the long term goal. Rainwater harvesting systems, large scale surface water treatment plants, household of community arsenic removal techniques are the alternative sources. These were described elaborately in the implementation plan of Bangladesh Government (GoB, 2004). Whether these alternative sources were technically suitable or not, it depended on hydro geologic and geographic conditions of that particular area. As a result, we saw different options were

promoted in different zones of the country. The local scale spatial distribution of arsenic was not same (Van, 2003). In many affected villages, there were enough green painted shallow tube wells to supply the entire population (Van et al., 2002). The people who had no safe shallow tube wells, they shared the safe tube wells of neighbors. Safe tube well sharing (sometimes referred to as well switching) was important in the tube well screeching program.

By 2006, it was estimated that more than 1,00,000 alternative sources had been installed in arsenic prone areas of Bangladesh. Though preference has been given on surface water in the policy, 70% of new installations were deep tube wells (Kabir, 2007). Localized studies showed that people were sharing tube wells in some areas (Johnston and Sarker, 2007; Opar et al., 2007).

By 2006, an expert review estimated that 29% of the population, who consumed arsenic contaminated water, had switched to arsenic safe shallow tube wells and that another 12% of the population had switched to deep tube wells (Ahmed et al., 2006). Use of the other alternative sources of drinking water was considered negligible.

Bangladesh National Policy for Arsenic Mitigation:

Identification of the nature and extent of the arsenic contamination, arsenic mitigation measures, institutional capacity, research and development, information, reference laboratory, collaboration and cooperation, and implementation issues in Bangladesh were addressed in the policy.

Screening and regular monitoring of all tube wells should be carried out including irrigation wells. Survey should be carried out to identity the arsenicosis patients. A measurement of arsenic levels should be carried out in soil and agricultural products.

National policy says that public awareness should be raised about arsenic contamination. Alternative sources of drinking water should be identified.

Proper diagnosis and treatment is essential for arsenicosis patients. Capacity building should be ensured. All have to know that arsenicosis is not contagious. Surface water should be given preference over ground water as alternative source of drinking water. National policy also says that piped water supply systems, wherever possible, should be promoted, proper diagnosis should be ensured for arsenicosis patients. Management of patients exposed to arsenic, training of health service providers and rehabilitation of arsenicosis patients should be ensured. Capacity

building at all levels (government, non -government organization, local community) for proper management of the arsenic contamination and its impact on health should be ensured. A network of modern, sophisticated, well-equipped laboratories at an appropriate level should be established.

Effective coordination among government ministries and agencies is essential. Role of local government institutes and local communities in planning and service delivery should be ensured. Involvement of non-governmental organizations and the private sector in service delivery should be ensured. Research and development works should be ensured so that impact of arsenic on health and environment can be easily understood. Better cooperation and coordination among the different organizations and institutes should be ensured to solve this problem. The policy emphasizes that an implementation plan will have to be prepared to mitigate arsenic within the framework of the policy. It is necessary to review and to update the policy to get a better policy.

Implementation plan for arsenic mitigation in Bangladesh:

Alternative sources of water in an arsenic prone area:

Implementation of alternative sources of water in an arsenic prone area will ensure safe water for drinking and cooking for all (GOB, 2004). Possible alternatives to arsenic contaminated ground water are alternative ground water sources, surface water sources, rain water harvesting and ground water treatment for arsenic removal. These are discussed elaborately as follows:

Alternative ground water sources:

Arsenic free deep tube well, piped water system and dug well are the alternative ground water sources of drinking water. Deep tube wells and dug wells have been installed in much arsenic prone areas to supply safe drinking water.

Arsenic free deep tube well:

We get arsenic free water in the deep aquifers in many parts of the country. This is a very suitable option to get arsenic free water. The presence and identification of aquifers, cost to install a deep tube well, possible cross aquifer contamination should be considered in this case.

The arsenic free deep aquifers separated from shallow, contaminated aquifers by relatively impermeable layers have to be identified first.

1851 Deep tube wells in the arsenic prone areas of Barisal, Chandpur , Gopalgonj, Jahalakhati, Jhenidah, Khulna, Laksmipur, Pirojpur and Satkhira mostly in the south and north eastern parts of Bangladesh had been installed by the BAMWAP. 8981 more deep tube wells would be installed possibly in other arsenic prone areas (BAMWSP, 2005).

Deep tube wells in other arsenic prone areas had been installed by DPHE- Danida and World Vision (APSU, 2004). BAMWSP installed 111 deep tube wells in the Hazigang upazila of Chandpur district. BAMWSP tested water samples, collected from 86 deep tube wells for arsenic and other water quality parameters. Results showed that all the deep tube wells were arsenic and fecal free (BAMWSP, 2005). Risk assessments of different arsenic instigations, such as deep tube well, dug well, pond sand filter, rain water harvesting were carried out by the Bangladesh Government's Arsenic Policy Support Unit (APSU) recently. Water samples were collected from deep tube wells from south and southeast parts of Bangladesh. These were tested for arsenic and other water quality parameters (APSU, 2004). Results showed that all the deep tube wells were arsenic free as per Bangladesh standard and WHO standards.

Dug well

The dug well is very common to withdraw ground water. To install a dug well, a tube is dug in the ground to a depth below the ground water table. From ground water table, water comes to well. It is very common in many countries to use dug for domestic water supply (Ahmed and Rahman, 2000). One can find many dug wells operating in Chittagong, Sylhet and northern parts of Bangladesh. It is difficult to construct a hand pump tube well due to adverse hydro geological conditions. It is difficult to install dug to a thick clayey soil layer. They are unable to produce enough water to fulfill requirements. About 1.3 million people in both urban and rural areas still depended on dug well water (GOB, 2002). It was not easy to save the water of a dug well from bacterial contamination.

Conventional open dug wells are easily polluted. The top of the covered dug wells is protected for better sanitary protection. A pipe is installed on the top of the cover slab for aeration. A hand pump is fixed either on the top of the slab or by the side of the well to withdraw well water.

There is a possibility of bad smell in some dug well water due to lack of aeration of the water. Recommendation of the government's national policy and implementation plan for arsenic removal was improved drug well. This is an option for arsenic mitigation (GOB, 2004). Such dug wells are covered upon a frame above the well.

Alternative surface water sources:

Pond, river, etc., are the examples of surface water sources. But these are generally microbiologically unsafe. Treatment steps are required to make them potable. There are many processes for treatment such as, use of a pond sand filter / river sand filter (PSF/RSF), household filters. Surface water was given preference over ground water for water supply in the national policy for arsenic initiation 2004. Using a PSF or RSF as an alternative water supply option in arsenic prone areas was the recommendation of the implementation plan. The details about PSF are described as follows.

Sand filter is used in the pond sand filter for the treatment of surface water for domestic water supply. People install a PSF on or near the bank of a pond. Usually, the pond does not dry up during dry season.

A manually operated hand tube well pumps the pond water to feed the sand filter bed. After filtration, the filtered water is collected through a tap.

It has some problems, such as low discharge of water and difficulties in washing the filter bed. Reduction of the turbidity of raw water to get hazard free operation of the filter chamber is another disadvantage. Roughing filtration is often introduced as a pretreatment unit. Community involvement in operation and maintenance is necessary to maintain a PSF operational. Although the PSF can remove bacteria, it may not remove 100 percent of pathogens from heavily contaminated surface water. The depth of the sand bed has to be sufficient thickness for complete removal of bacteria. Emphasis should be given on proper pond development and management to operate a PSF successfully. Steps should be taken to protect pond from external pollution, for appropriate filter operation. Restriction should be imposed to culture fishing, bathing or washing in the pond. If the pond is shallow or clay is deposited in the pond, re-excavation should be carried out. It is necessary to use algaecide to control algae growth. It is necessity to be involved

of the user groups. Regular monitoring, maintenance, and repair are essential for proper functioning of PSF.

According to available data, 458 PSFs in different arsenic prone areas had been installed by five different organizations such as BAMWSP, DPHE-UNICEF, DPHE-DANIDA, DPHE-GOB-IV and AAN. In a recent survey, water samples were collected from 42 PSFS, mostly in southern region of Bangladesh. Results showed that thermo-tolerant coliforms were detected in almost all water samples (APSU, 2005.b).PSF water samples are arsenic free. There are many reasons for bacterial contamination, such as high levels of contamination in pond water, insufficient filter depth, and poor maintenance.

Rain water harvesting

From the early civilizations of the Middle East and Asia, the Mediterranean region and North Africa, people have been used rain water for potable water. People used rain water widely in many parts of the world, particularly in the regions of Africa, Australia and Asia. Where water is not sufficient, in the coastal belt and hilly areas of our country, people collect rain water as an alternative water supply option. People are doing this before the exposure of arsenic contamination in ground water. This is an alternate water supply option in many arsenic prone areas. People of some areas are used rain water harvesting successfully. A catchment surface where the rain water run-off is collected, a storage reservoir where the rain water is stored, and a delivery system for transport of the water from the catchment to a reservoir are the components of a rain water harvesting system. People can use rain water as a supplementary, partial or backup supply system. If rain water is the only source of potable water, people do not rely on it fully. People consider total amount of supply and demand of rain water.

The quality of rain water is usually well. It lacks essential minerals (e.g., fluoride and calcium) necessary to human body. In a study carried out by the BAMWSP in 2002, it revealed that 34 percent of the respondents did not like drinking rain water as it possesses no taste (APSU, 2005).

According to available data, 2606 rain water harvesting units in different arsenic prone areas had been installed by two organizations, (DPHE-Unicef and DPHE- Danida). In a recent study, samples were collected from rain water harvesting units. Thermotolerant coliforms were detected in 42 percent of the samples during the rainy season and in 62.5 percent of the samples during

the dry season (APSU, 2005 b). If the roof top is unsanitary, contamination of rain water usually occurs. Poor handling of water is also responsible for contamination. The chemical quality of water samples collected from rain water harvesting units was found arsenic free.

Arsenic removal technologies

There are various technologies for removing arsenic in ground water. Co- precipitation with alum or iron, adsorptive filtration, ion exchange and membrane processes, such as reverse osmosis, are the common technologies.

1.2 Problem identification:

The shallow tube wells exceeding the arsenic concentration of Bangladesh standard were painted red, whereas, the shallow tube wells within the arsenic concentration of Bangladesh standard, were painted green. For red painted tube wells, people needed alternative sources of drinking water. A survey showed that nearly two thirds of households (62.1 %) were using the alternative sources of drinking water during survey period (Inauen et al., 2013). All safe water options needed more time or effort and money. Water collection from neighbor or community source had some difficulties. Operation, maintenance and management of community source are complicated. In a survey on 1000 arsenic sate water samples, Kabir found that 10% of deep tube wells, almost a quarter of dug well and pond sand filters, one third of rain water harvesting systems and 83% of arsenic removal technologic were not functional (Kabir and Howard, 2007). From this review, little information was available whether end user and family members were interested to use alternative sources of drinking water or not . Of the few studies in this area, emphasize had been given on people`s knowledge and awareness (Paul, 2004). Although getting awareness some people were not interested to use alternative sources of drinking water (Ahmed et al., 2006). Research had shown that distance was the key factor not for using alternative sources of drinking water (Hoque et al., 2004; Opar et al., 2007). The taste of drinking water was another factor (Severtson et al., 2006). Social barriers for women were also another factor (Hoque et al., 2004). There was a lack of data about long term sources of water. However, these studies focused on a very few possibly acceptance factors. Very few systemic studies were carried out on this crucial issue.

1.3 Rationale/ Justification of the present study:

To overcome these problems, a survey had been conducted in Khamarbari and Mohonpur villages of Majbari union of Kalukhali upazila, under the district of Rajbari. This study will provide information about the use of red and green painted shallow tube wells, and the use of alternative sources of drinking water. Psycological, social, and financial analysis had been carried out. This will help the policy makers for policy formulation and implementation. This will bridge the knowledge gap. It will enhance the knowledge. This will help to identify the challenges so that those challenges can be addressed rightly.

1.4 Objectives:

The aim of the present study is to provide update information on the use of alternative sources of drinking water. Three main questions are addressed:

a) to know the use of alternative sources of drinking water by the villagers in an arsenic prone area, Bangladesh
b) to identify the safe drinking water options in an arsenic prone area, Bangladesh which are more accepted than others
c) to know about the state of awareness of the people in that area

1.5 Limitations:

Bangladesh, as well as the whole world, has been suffering from covid-19 pandemic.

Actually, this type of study requires minimum of several months. In one month, I studied few books, journals. I made Questionnaire and talked with aged citizens living around the study field. But for fulfillment of this study, more time and exclusive study were needed.

This research was funded by none and no logistic support was provided.

2 . METHODOLOGY:

The study had been utilized both primary and secondary data. Primary data had been collected from an arsenic prone area, Bangladesh . Secondary data had been collected from websites, news papers, journals, books, web portals, official documents, magazines. The study had followed personal interviews.

Before hand, a semi-structured questionnaire had been prepared. The questionnaire had been prepared in English and it had been translated into Bengali. Households had been selected randomly. Descriptive and simple statistical analysis had been done.

A total of 23 respondents whose shallow tube wells were arsenic contaminated, were interviewed randomly. All of them are male. Their age ranges from 35 to 80 years. Out of 23 respondents, 19 respondents are peasants and 4 respondents are small businessmen.

3. RESULTS AND DISCUSSION:

Shallow tube wells of 23 respondents were arsenic contaminated and were painted red in 1997 by DPHE, Rajbari. After painting red, no households had been using these red painted shallow tube wells since 1997.

Out of 23 households, 8 households (34.78%) installed deep tube wells in their home within 2001 to 2007. They are using their deep tube wells from the installation time. Before installation of deep tube wells to their own homes, they used green painted tube wells of neighbors. Before installation of deep tube wells to the respective home of neighbors, they used green painted tube wells of distant neighbors. 5 households (21.74%) have been collecting water from the green painted shallow tube wells of neighbors since 1997. These tube wells were painted green by DPHE, Rajbari, in 1997. 10 households (43.48%) are collecting water from the deep tube wells of neighbors from installation time. These tube wells were installed within 2001 to 2007.

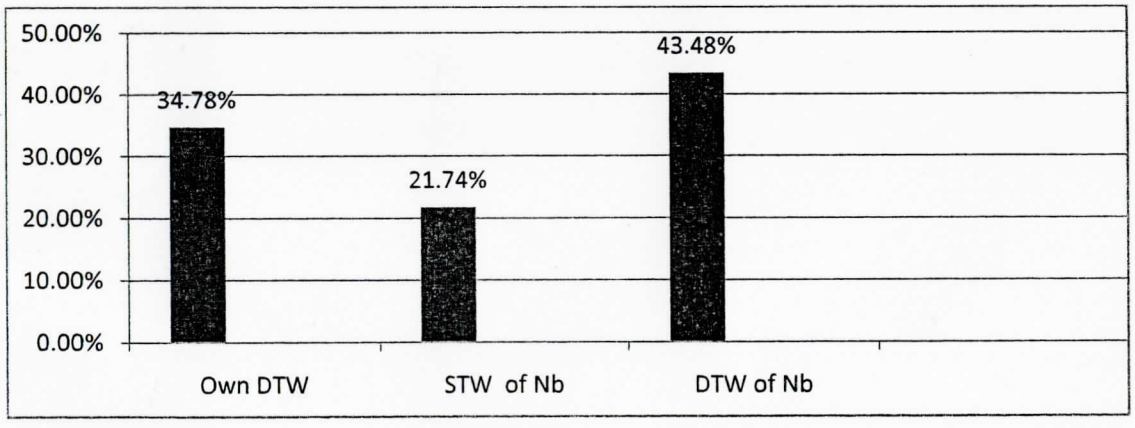

Figure 1: Use of arsenic free deep tube wells of own and neighbors, shallow tube wells of neighbors

Out of 23 respondents, all respondents support installation of deep tube wells in their homes. DPHE, Rajbari, had installed deep tube wells in 8 households in their respective homes. Rest of the 15 respondents has no financial ability to install deep tube wells. If the DPHE, Rajbari or NGOs or local government installs deep tube wells in their respective homes free of cost or at the subsidized cost of 7000 take, they will get deep tube wells. It is arsenic free, safe and hygienic. This is not dirty. It means 100% of 23 households support deep tube well.

Out of 23 households, 18 households support piped water supply. In their locality, piped water supply is absent. This is safe, pure, arsenic free and hygienic. It is tasteful too. Local government should take steps to install piped water supply. Out of 23 households, 5 households do not support piped water supply as they have to pay 100 or 200 taka per month for the service. Local administration has limited capacity. It means 78.26% of 23 households support piped water supply and 21.74% do not.

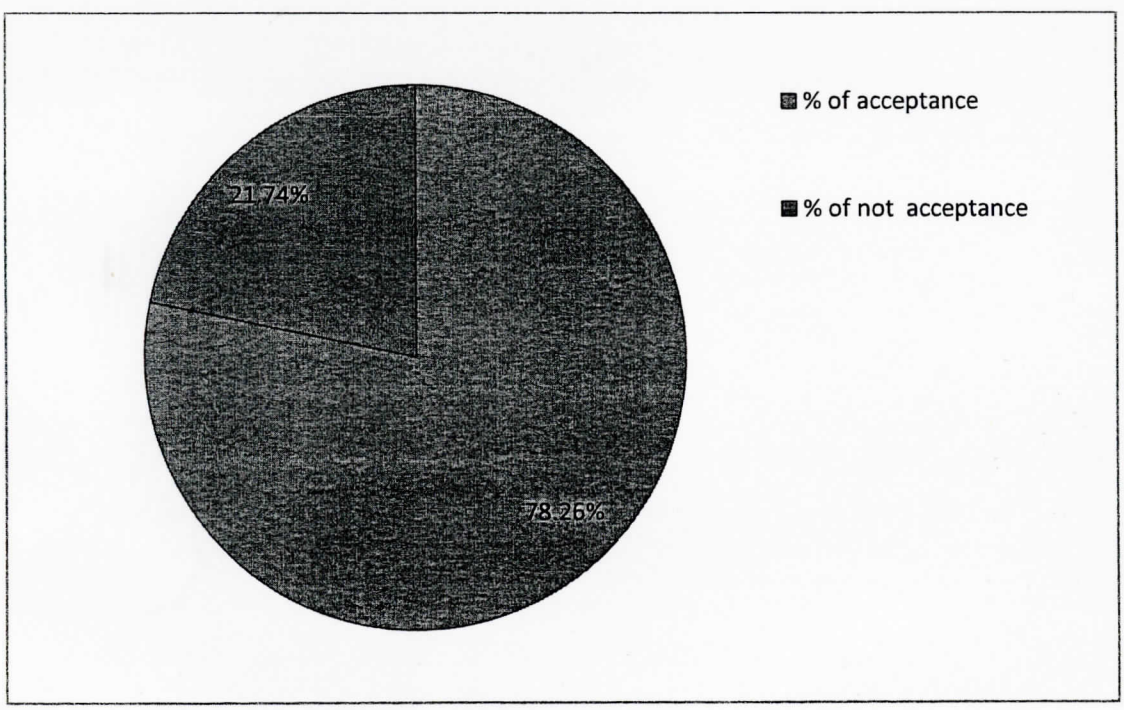

Figure 2: Acceptance of piped water supply

Out of 23 households, 15 households support rain water harvesting. If Government, NGOs or local government gives financial and technical support, they will harvest it as a backup source of

water. This is arsenic free and pure. They do not harvest rain water. Sometimes they use rain water to cook pulse and curry. Out of 23 households, 8 households do not support rain water harvesting. The taste of water is poor. They do not get sufficient water during winter and dry seasons. When rooftop is dirty, it becomes impure and unhygienic. It means 65.22% of 23 households support rain water harvesting as a back- up source of water and 34.78% do not.

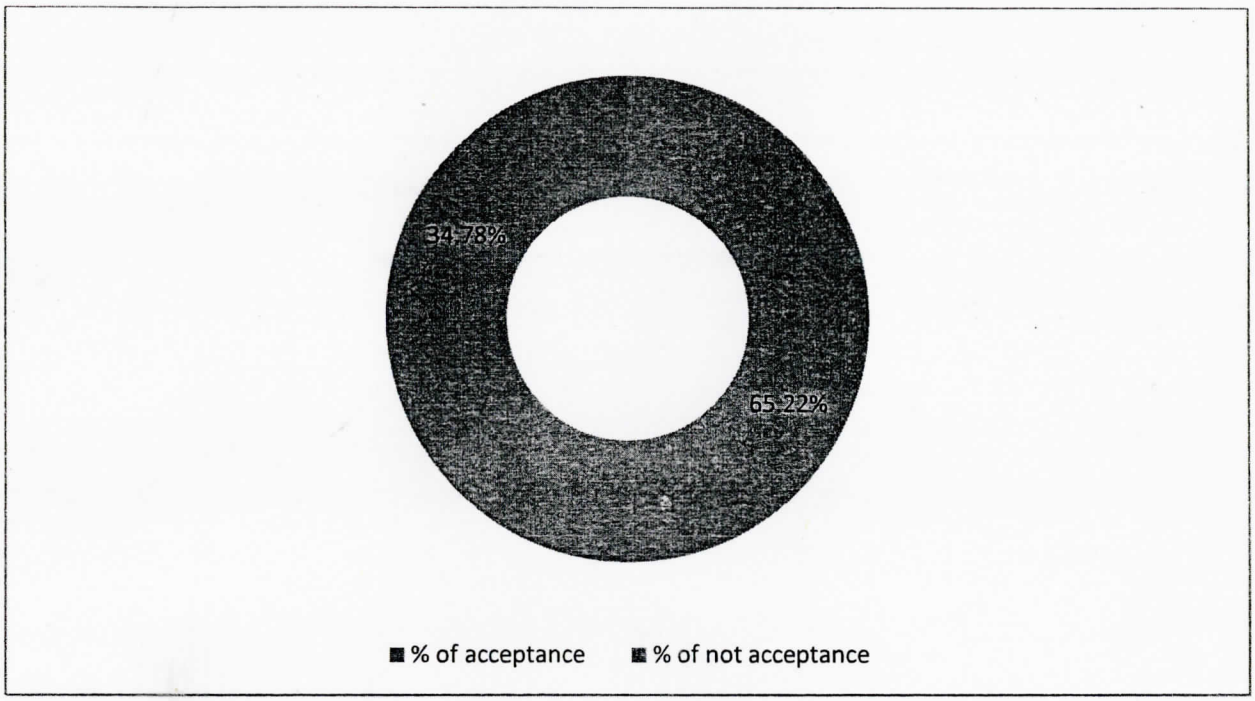

Figure 3: Acceptance of rain water harvesting

Out of 23 households, all households do not support pond sand filters. Pond is dirty and it is very difficult to be cleaned. The pond is not deep enough. The quantity of filtered water is not sufficient and the collection of filter water is time consuming too. It means 100% of 23 households do not support pond sand filters.

Out of 23 households, all households have no dug well in their homes. They do not support installation of dug wells in their homes. The taste of dug water is poor. Sometimes there is possibility of bad smell in the water. Although DPHE, Rajbari, installs dug well every year to the home of applicants at the subsidized cost of 7000 taka, they have no interest. It means 100% of 23 households do not support dug well.

Out of 23 households, all households do not support household arsenic removal technologies. Actually, by applying it, inhabitants do not get arsenic free water. The target will not be fulfilled justifiably. They have to pay money to purchase it. Generally, the filter has to be changed after one year. This is time consuming and laborious. Out of these concerns, 100% of 23 households do not support it.

Out of 23 households, all households do not support community arsenic removal technologies. Actually, by applying it, inhabitants do not get arsenic free water. The target will not be fulfilled justifiably. Collection of filtered water from community arsenic removal technologies has some difficulties. It means 100% of 23 households do not support it.

Out of 23 households, all households do not support well-sharing. They collect water from the deep tube wells or from the green painted shallow tube wells of neighbors. But, sometimes, the behavior and attitude of their neighbors are not good. This is laborious and time consuming too. If DPHE, Rajbari, installs deep tube well in their respective homes, at the subsidized cost of 7000 taka, they will get deep tube wells in their homes. This will minimize time, distance and labour. It means 100% of 23 households do not support well-sharing.

Deep tube wells show highest score in terms of acceptance and it is 100%. Piped water supply shows the second highest score in terms of acceptance and it is 78.26%. Rain water harvesting shows a medium level of acceptance and it is 65.22%. Rest of the alternative sources of drinking water show zero level of acceptance and it is 0%.

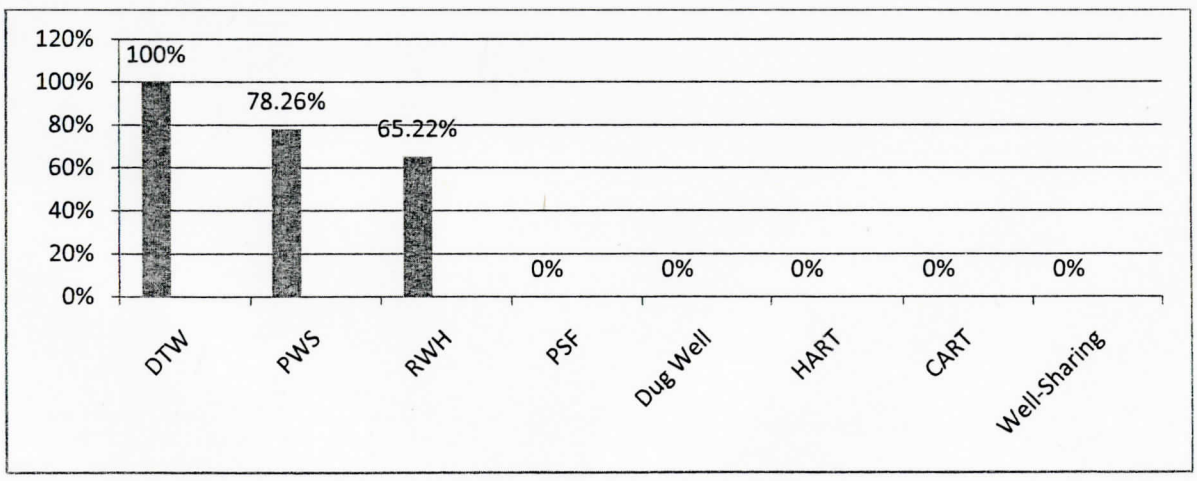

Figure 4: Acceptance of alternative sources of drinking water

Out of 23 respondents, 19 respondents are peasants and 4 respondents are small businessmen. Their age ranges from 35 to 80 years. All households have not been using red painted shallow tube wells since 1997, after painting red by the DPHE, Rajbari, in 1997. It shows that all respondents are aware of arsenic contamination.

4. RECOMMENDATIONS:

1. DPHE, Rajbari, and local government install deep tube wells every year, but the number of deep tube wells is not sufficient. People who have not got deep tube wells yet, collect drinking water from the deep tube wells or from the green painted shallow tube wells of neighbors.

   Government, NGOs, local government should take steps so that deep tube wells can be installed at their homes free of cost or at the subsidized cost.
2. Government, NGOs, local government all should give emphasis on rainwater harvesting in arsenic prone areas.
3. Shallow tube wells which were not arsenic contaminated, were painted green in 1997 in that area. But after painting a shallow tube well green, there is a possibility of arsenic contamination in that shallow tube well because the distance between red painted shallow tube well and green painted shallow tube well is short. So, the green painted shallow tube wells should be retested every year.

   People who drink the water of these green painted shallow tube wells, their medical checkup are essential. Their hair of head, skin of hand palm, foot palm and back side of the body to be examined periodically. Cancer test should be carried out.
4. Local government should take steps to install piped water supply.
5. To create awareness about the withdrawal of ground water, proper steps should be taken up. By using rain water as back- up source, we can reduce the withdrawal of ground water. By using pond and river water, i.e, surface water as other usages, we can reduce the withdrawal of groundwater.
6. Red color of the red painted shallow tube wells has already disappeared. As a result, the shallow tube wells should be painted red again by DPHE, Rajbari.

5. CONCLUSIONS:

Different people have different opinions about the acceptance of the alternative sources of drinking water in an arsenic prone area, Bangladesh. Psychological factors of the people of that area have been analyzed. Motivational training should be arranged to improve psychological factors. Steps should be taken to the installation of deep tube well, piped water supply and rain water harvesting, which are psychologically favored options. Nobody supports pond sand filters, dug well, house hold arsenic removal technologies, community arsenic removal technologies and well-sharing as alternative sources of drinking water in the studied area. This will not wise to take any step to install psychologically unfavored options. Although DPHE, Rajbari installs dug wells every year to the home of applicants, at the subsidized cost, it is psychologically unfavored option. Economic and social factors have also been identified.

References:

Ahmed F. M., and M. M. Rahman. 2000. Water supply and sanitation: Rural and low income urban communities. Dhaka: International Training Network (ITN)-Bangladesh

Ahmed MF, Ahuja S, Alauddin M, Hug SJ,Lioyd JR, et al. (2006) Ensuring safe drinking water in Bangladesh Science 314:1687-1688.

Argos M, Kalra T, Rathouz PJ Chen Y, Pierce B, et al.(2010) Arsenic exposure from drinking water, and all cause and chronic-disease mortalities in Bangladesh (HEALS):A prospective cohort study. The Lancet 376:252-258.

Arsenic Policy Support Unit (APSU). 2004. Risk assessment of arsenic mitigation options, phase-I (RAMMO-I). Dhaka: Arsenic Mitigation Policy Support Unit and ITB-Bangladesh Centre for Water Supply and Waste Management.

----2005b. Risk assessment of arsenic mitigation options, phase-II (RAMMO-II). Dhaka: Arsenic Mitigation Policy Support Unit and ITB-Bangladesh Centre for Water Supply and Waste Management

Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP). 2005. Bangladesh Arsenic Water Supply Project Web site: www.bamwsp.org

British Geological Survey (BGS) and Department of Public Health Engineering (DPHE). 2001. Arsenic contamination of groundwater in Bangladesh. Final report (February 2001). Dhaka: British Geological Survey and Department of Public Health Engineering

Department of Public Health Engineering (DPHE), British Geological Survey (BGS), and Mott MacDonald Ltd (MML). 1999. Groundwater studies for arsenic contamination in Bangladesh. Final report, phase 1 (January). Dhaka: DPHE, BGS, and MML

Department of public Health Engineering, Government of Bangladesh, British Geological Survey and Mott Mac Donald ltd (UK)

Flanagan SV, Johnston RB, Zheng Y (2010) Health and economic impact of arsenic in Bangladesh : Implications for mitigations for mitigation strategy and practice. Bulletin of the world Health organization 90:889-846.DPHE/BGS/MML (2000) Groundwater studies for arsenic contamination in Bangladesh. Phase 2: National Hydro chemical Survey Dhaka , Bangladesh:

Government of Bangladesh (2004) Implementation plan for arsenic mitigation. Dhaka. Available:

Government of Bangladesh (2004) National policy for arsenic mitigation. Dhaka. Available: http// www.dphe.gov.bd/pdf/National -Policy-for-Arsenic-Mitigation-2004 ,pdf

Hoque BA,Hoque MM Ahmed T, Islam S, Azad AK, et al (2004) Demand-Based water Options for arsenic mitigation : An Experience from rural Bangladesh . public Health 118:70-77

http://phys4.harvard.edu?~wilson/arsenic/countries/bangladesh/National%20Water%20policy%202003/ Arsenic%20IMPLEM%20FINAL-23-8-03.pdf.

Inauen J, Hossain M M, Johnston R B and Mosler H J (2013), Acceptance and Use of Eight Arsenic-Safe Drinking Water Options in Bangladesh, accessed to Google Chrome on 05 November.2020.

Johnston RB,Sarker MH (2007) Arsenic Mitigation in Bangladesh:National screening data and case studies in three upazilas. Journal of Environmental Science and Health , Part A: Environmental Science and Engineering 42:1889-1896

Kabi A, Howard G (2007) Sustainability of arsenic mitigation in Bangladesh : Results of a functionality survey. International Journal of Environmental Health Research 17:207-218.

Opar A,pfaff A, SeddiqueA, Ahmed K, GrazianoJ, al (2007) Responses of 6500 households to arsenic mitigation in Araihazar, Bangladesh, Health & place 13:164-172.

Paul BK (2004) Arsenic contamination awareness among the rural residents in Bangladesh . Social Science & Medicine 59:1741-1755.

Rahman, M., Q. Quamruzzaman et al. 2000. Arsenicosis—Yet to be cared. Paper presented at the International Conference on Bangladesh Environment, January 14–15, 2000, at Dhaka.

Severtson DJ,Baumann LC, Baumann LC, Brown RL (2006)Applying a health behavior theory to explore the influence of information and experience on arsenic risk representation, policy beliefs, and protective behavior, Risk Analysis 26:353-368.

Smith AH, Steinmaus Cm(2009) Health effects of arsenic and chromium in drinking water. Recent human finding . Annual Review of public Health pp.107-122.

Van geen A, Ahsan H, Homeman AH, Dhar RK, Zheng Y et al. (2002) promotion of well – switching to mitigate the current arsenic crisis in Bangladesh. Bulletin of the world Health organization 80:732-737.

Van Geen A (2003) Spatial variability of arsenic in 6000 tube wells in a 25 km2 area of Bangladesh. Water Resources Research 39:1140.

Yuan y, marshall G, ferreccio c, steinmaus C, selvin S, Et Al. (2007) Acute myocardial infarction mortality in comparison with lung and bladder cancer mortality in arsenic – ecposed region ll of Chile from 1950 to 2000. American journal of Epidemiology 166:1381-1391

Yu, W., C. M. Harvey, and C. F. Harvey. 2003. Arsenic in the groundwater in Bangladesh: A geostatistical and epidemiological framework for estimating health effects and evaluating remedies. Water Resources Research (2003) 39 (6): 1146.

Appendix:

Questionnaire

Personal information of the interviewee for this questionnaire:

1. What is your name?
2. What is your age?
3. What is your profession?

Research Questions:

1. Had your tube well been red painted due to exceed arsenic limit in it?
2. It had been red painted, in which year?
3. After painting red, did you (with family members) drink the water of that tube well?
4. Now do you drink the water of that tube well?
5. You had been drinking the water of that tube well from which your?
6. If you did not drink the water of that tube well, you drank water from which source?
7. What is the distance of that source of water from your home?
8. There is a possibility of suffering from diseases, due to drinking arsenic contaminated water. Do you know?
9. Have you faced any problem?
10. If yes, have you undergone treatment?
11. What is the shortest distance of green painted tube well from your home?
12. Is there any pond which can be purified in your locality?
13. If yes, what is the distance from your home?
14. Is there system of rain water harvesting in your home?
15. Do you (with family members) drink rain water?
16. Do you drink the water of your tube well by filtering?
17. If yes, from which year?
18. Have you installed deep tube well in your home?
19. Did you (with family members) drink water of that tube well?
20. Was the water of your tube well tested or not?

21. In which year, deep tube well had been installed?
22. What is your opinion about installation of deep tube well in your home?
23. What is your opinion about piped water supply?
24. What is your opinion about rain water harvesting in your home?
25. What is your opinion about pond sand filters to purify pond water?
26. What is your opinion about installation of dug well in your home?
27. What is your opinion about using household arsenic removal technologies?
28. What is your opinion about using community arsenic removal technologies in your locality?
29. What is your opinion about well- sharing?