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ASSESSMENT OF WATER QUALITY PARAMETERS FOR SAFE DRINKING WATER SUPPLY FROM IRRIGATED DEEP TUBE WELLS IN DINAJPUR DISTRICT OF BANGLADESH

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ABSTRACT

Analysis of physic-chemical, microbiological and hydrological properties is very essential for human health concern. Due to use of contaminated unhygienic water, peoples in north western region of Bangladesh suffer from various water borne diseases. So it is essential to know the water quality parameters for its safe use as drinking purpose. Water samples collected from different sites (deep tube wells) were analyzed for physic-chemical, biological and hydrological parameters with standard methods and the obtained results were then compared with national standards and WHO guidelines. Total 81 water samples were collected and tested in BMDA laboratory. Among the considered parameters, concentrations of arsenic, chloride, pH, total hardness and dissolved oxygen were found within the permissible limits for potable water. But iron contents, in majority cases, were slightly higher according to the Bangladesh and WHO standards. No e. coli bacteria was found in the studied samples. Other parameters like calcium, magnesium, electrical conductivity etc. were also determined and found lower than the permissible limits, but safe for drinking purpose. In a very few cases of hydrogen ion concentration (pH), the values of tested samples were slightly deviated and lowered than the permissible limits. Except those, the quality of drinking water supply system from BMDA's deep tube wells in the study area is safe for drinking purpose and other domestic uses.

Key words: Drinking Water Supply, Ground Water, Water Quality Assessment and Irrigated Deep Tube Well.

I. INTRODUCTION

Groundwater provides a year-round drinking water supply to 97% population in our country. Dug wells, ponds, rivers were commonly used for drinking purpose in many parts of the country except in coastal areas. During the late 1970s and early 1980s, in order to avoid surface water sources, which were mostly contaminated with pathogenic micro-organisms, the use of groundwater was introduced in Bangladesh. Thousands of hand-operated tube wells were installed in rural areas of Bangladesh by the government, aided by international donor agencies to provide drinking water supply. During 1980 - 1990 several millions of such hand-operated tube wells were installed for domestic usage.

During past two decades, there is a slight declining trend in ground water level. This information and analysis of groundwater level, its intensive use, fluctuations, recharge conditions and quality indicate that the declining groundwater level is a threat to both irrigation and drinking water supplies in Barind areas at present and will be in the future. The quality of groundwater, in particularly arsenic, salinity, iron and manganese, is a major threat to safe drinking water supplies in these areas. In water supply, the quality of drinking water is undermined by the safety issues. About 20 million people are currently exposed to water having arsenic contamination. About 85% people have access to safe water and 57% people use hygienic sanitation facilities [1]. According to WHO, about 80% of all diseases in human beings are caused due to unhygienic water use.

Barind Multipurpose Development Authority (BMDA) was established with the concept of area development mostly in agricultural sector. Major activities of this organization are relating to irrigation through installation of deep tube wells. Later on BMDA has taken drinking water supply system with piped water networks from deep tube wells to provide rural households with improved water supply as they have poor access to potable water.

Before starting BMDA's activities, there was a crisis of safe drinking water for the rural people in the north-western area of Bangladesh. After starting BMDA activities, they used to collect drinking water from nearby BMDA's deep tube wells. In this situation, BMDA has taken step to meet up drinking water demand for the rural people and BMDA has connected drinking water supply system with deep tube wells located near the villages in rural areas. And around 2500 piped water installation are constructed till now to ensure drinking water supply for such villages round the year. Besides irrigation water, the authority also supplies drinking water to many parts of its working areas.

The present study intends to assess the physic-chemical, microbiological and hydrological quality of deep tube well water for the use of drinking purpose and other domestic uses. The aims of BMDA drinking water supply concept are to: 1. Supply potable water to every household in rural areas round the year. 2. Ensure the people in this area have access to arsenic-free water. 3. Eradicate diseases caused by arsenic and shortage of potable water. 4. Improve the health of the people living in the rural villages and 5. Create a reliable drinking water supply in the rural villages.

And The goal and corresponding target of SDG (Sustainable Development Goal) which is of interest for the conservation strategy as follows- Goal 6: Ensure access to water and sanitation to all, i,e. By 2030, to achieve universal and equitable access to safe and affordable drinking water for all, and by 2030, to achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.

II. LITERATURE REVIEW

Bangladesh depends mainly on groundwater sources to meet its domestic demand for potable water. Most parts of the north-west region of the country are flood-free zones and the main source of groundwater recharge is rainfall. Groundwater use in the Barind area has exceeded recharge and GWTs have been successively falling over the years, with increasing withdrawal of groundwater for irrigation [2, 3]. Out of 16 districts of Rajshahi and Rangpur division, some part of Dinajpur district was identified as the water depleted areas. Ground Water Tables (GWTs) at many areas in the NW region fall below 8 m during March–May in each year, causing water scarcity for domestic supply [4], agriculture, and secured livelihood [5]. Here, water scarcity implies the lack of access to adequate quantity of water for human, animal, and environmental requirements.

Deep aquifers separated from shallow contaminated aquifers by impermeable layers are generally considered as a dependable source of arsenic-safe water. The chances of contamination of such deep aquifers are very low [6]. However, the deeper aquifers without any separating aquiclude are vulnerable to contamination in the long run, although they may initially produce arsenic-safe water [7].

About 27% of the tube wells installed in shallow aquifer were found to be arsenic contaminated above the Bangladesh standard for arsenic in drinking water (50μg/L) in a national hydro-chemical quality survey [8]. A total of 77 million people of Bangladesh are exposed to toxic levels of As (WHO Standard of (10 μg/L) in their drinking water [9] that primarily comes from shallow ground waters.

Microbial contamination of drinking water quality is the second leading risk factor for diarrheal diseases which are the fifth leading cause of death in children under five years old worldwide [10]. In an effort to reduce the diarrheal disease burden, public health efforts during the past 40 years in Bangladesh have led the majority of rural Bangladeshis to consume drinking water from groundwater aquifers using shallow tube wells rather than surface water.

The low arsenic concentrations in deep tube wells have been shown to be stable over time, except when poorly constructed [11, 12, 13]. Deep tube wells have also demonstrated better microbial quality at source compared to shallow tube wells as E. coli and fecal coliform levels decrease with increased depth [14, 15]. DTWs are found to be the most sustainable suitable technology. DTWs are also highly resilient under most expected climate change conditions [16]. Drinking water has been the main focus of attention since the early 1990's when widespread contamination of groundwater by Arsenic (As) was discovered in shallow aquifers of Bangladesh [17].

However, As contamination in groundwater has implications for agricultural as well as potable water supplies. With a view to identify and solve the above problems, the present study was done. The aims of the present study were to:

- Supply potable water to every household in rural areas round the year.
- Ensure the people in this area have access to arsenic-free water.
- Eradicate diseases caused by Arsenic and shortage of potable water.

- Improve the health of the people living in the rural villages
- Create a reliable drinking water supply in the rural villages.

III. MATERIALS AND METHODS

A. Study Area and sample collection

The selected study areas were located at Birganj and Kaharol upazilas of Dinajpur district in Bangladesh. Piped-water network system for drinking purpose and domestic uses in these areas was designed and built by BMDA in several deep tube wells in the study area. The survey data used in this analysis was obtained from the deep tube wells directly prior to installation of the drinking water supply schemes. Preliminary survey has been done before selection of a scheme by arranging meeting with the water users in the respective villages or the communities involved. The total 81 deep tube well schemes have been selected for the study. 55 and 26 numbers of water samples from different deep tube wells of Birganj and Kaharol upazilas respectively were collected and analyzed in BMDA's chemical laboratory.

B. Methods/Instruments used for Testing Water Quality Parameters

The water quality parameters were tested using the following testing machines/processes shown in Table 1:

Table-1: Water quality parameters and related testing machines /processes.

Name of parameters and symbols	Unit	Testing machines/processes
Arsenic (As)	ppm	Automatic Absorption Spectrometer /Arsenetor
Iron (Fe)	ppm	Automatic Absorption Spectrometer/Spectrophotometer
Calcium (Ca)	ppm	Automatic Absorption Spectrometer/Titration
Magnesium (Mg)	ppm	Automatic Absorption Spectrometer/Titration
Total Hardness (TH)	ppm	Titration
Chloride (Cl)	ppm	Spectrophotometer/Arsenetor
Total Dissolved Solid (TDS)	ppm	TDS meter
Dissolved Oxygen (DO)	ppm	DO meter
Hydrogen Ion Concentration (pH)	-	pH meter
Electrical Conductivity (EC)	µs/cm	Electrical Conductivity meter
Turbidity	NTU	Turbidity meter (Nephelometer)

After testing, confirmation of the quality of water samples identifying the above parameters; the respective schemes were approved for drinking purpose and other domestic uses.

C. Design and Layout

An additional RCC overhead water tank is constructed with the irrigated deep tube well of BMDA. Normally the water tank is constructed in rectangular shape from 33 feet above the ground level. Water holding capacity of each tank was around 25000 liter (Figure 1). For each scheme, around 7500 -8000 feet underground water distribution line with uPVC (unplasticized Poly Vinyl Chloride) pipe of different diameters (1 inch to 4 inch) was laid down for proper and safe distribution of drinking water to the households. Approximately 50 numbers of faucets were constructed to collect drinking water smoothly (Figure 2).

Fig.-1: Drinking water supply scheme

Fig.-2: A villager uses drinking water from faucet/water tap.

IV. ANALYSIS OF RESULTS AND DISCUSSION

Normally in surface and ground water, some elements and characters are found like Arsenic(As), Iron(Fe), Calcium(Ca), Chloride(Cl), Magnesium(Mg), Total Hardness(TH), Phosphorus(P), Temperature, Electrical Conductivity(EC), Total Dissolved Solid(TDS), Hydrogen Ion Concentration(pH), Zinc(Zn), Boron(B), Alkalinity, Turbidity, Nitrate(NO_3), Nitrogen(N), Sulfate (SO_4), Dissolved Oxygen(DO), etc. To know the quality of water, many parameters need to be tested. Country basis the acceptance limits of water for drinking purpose may vary. In Bangladesh, the parameters have separate ranges, whereas WHO declared ranges are different from that. An analysis of some tested parameters of water samples collected from BMDA deep tube wells in the study area is described here.

A. Tested Parameters and Results

This study was conducted for the acceptance of drinking water supply schemes in north-west part of Bangladesh. Irrigated deep tube wells were installed earlier through BMDA management. Total 81 water samples from different deep tube wells were collected and tested for physic-chemical and hydrological properties of groundwater. The corresponding depth of aquifer was around 25 to 50 meters.

The quality of water for drinking purpose and domestic uses from different deep tube wells in the study area were compared with Bangladesh drinking water quality standards [18] and World Health Organization (WHO) standards[19, 20]. All the samples were collected from the ground water sources. The tested results are presented in Table 2.

Table-2: Comparison of tested results according to Bangladesh and WHO standards.

Water quality parameters (unit)	Mean values	Standard Deviation (SD)	Minimum Values	Maximum values	Bangladesh standard values	WHO standard. values
As (ppm)	0.002	0.0001	0.00	0.015	≤ 0.05	≤0.01
Ca (ppm)	9.917	4.453	5.126	32.60	71-75	
Mg (ppm)	1.739	0.863	0.237	5.219	30-35	
Fe (ppm)	0.740	1.068	0.000	5.832	0.30-1.00	≤0.30
Cl (ppm)	10.15	5.352	3.340	33.50	150-600	≤250

pH	6.703	0.627	5.720	7.390	6.50-8.50	
EC (µs/cm)	133.10	43.683	61.00	255.0	600-1000	≤250(1993)
TH (ppm)	31.51	12.758	16.00	98.00	200-500	
Turbidity(NTU)*1	- (< 5)	- (< 5)	-	-	≤10	≤5
DO (ppm)	5.581	0.687	4.100	6.970	≤6	
E.coli bacteria (ppm)	NES*2	NES*2	NES*2	NES*2		

*1NTU= Nephelometric Turbidity Units, *2NES=No Evidence Seen

Normally Arsenic, iron, chloride, pH , some others harmful chemicals dissolved in water have the adverse effect on the public health. So it is essential to assess and compare the water quality parameters with standard values for drinking purpose and domestic uses. In this study, 81 water samples from different deep tube well schemes were taken. Out of 81 samples, all deep tube wells were found to be safe for drinking purpose according to Bangladesh standard with respect to arsenic content. The maximum Arsenic content of 0.015 ppm was found in Kaharol upazila. The location of deep tube well was at Mauza- Panigao and JL/Dag No – 64/761. Total 50 deep tube wells were found zero values of Arsenic content. According to WHO standard, 3 nos. of DTW were out of Arsenic rangeof WHO standard and 78 deep tube wells were in safe limit. The mean value and standard deviation of Arsenic shown that the water quality of the study area was quite safe for drinking purpose.

Iron content of 24 samples was not in safe limit and 57 samples were safe as Bangladesh Standard for drinking purpose. But according to WHO standard, 43 samples were in safe limit. The maximum value of iron content was 5.832 ppm (Upazila: Birgonj, Mauza: Nijpara, JL/Dag: 145/1664) and the minimum was zero ppm. 7 numbers of deep tube wells were found no iron content.

Chloride can be an indicator of pollution. It is one of the most important parameter in assessing the water quality and higher concentration of chloride indicates higher degree of organic pollution. Normally high concentration of chloride combined with nitrate can contaminate water which is harmful for domestic uses. In respect to chloride concentration, all of the samples in this study were beyond acceptable limit as Bangladesh standard, chloride contents were very low, but all the samples were almost safe for drinking purpose according to Bangladesh and WHO standards..

The water having pH less than 6.5 may cause corrosion of metallic substances and higher than 8.0 can adversely affect the disinfection process. In the study area, the ranges of pH were from 5.72 to 7.39.The maximum values were found within the range of Bangladesh and WHO standards. Maximum water samples were slightly acidic in nature. But these were quite safe for drinking purpose except a few.

In the study areas, there was no *E. coli* found in the studied samples. Here it is noted that *e. coli* test is also done in BMDA chemical laboratory as periodical basis. From the analysis of water from the above samples, the results indicated that the other parameters were quite safe for drinking purpose and domestic uses according to Bangladesh and WHO standards.

Findings from the results, it is clear that the quality of water in the study area is better than other modes. The average quality of drinking water was found to be quite safe for drinking and domestic purposes.

B. Beneficiary groups, their participation and its impact

The operation and maintenance of such a drinking water supply scheme is normally conducted by the nearby villagers/beneficiaries. Each scheme has a separate management committee and the committee is generally formed by nine members of whom seven members are from water users association (WUA) and two members are included from BMDA officials. Any person or farmer associated with the scheme may be a member of the management committee.

The farmers use drinking water from the scheme without bearing any cost (money). If any unwanted situation arises among the water users, the committee solves the problem immediately by arranging a meeting (Figure 3). They also create a fund for future expenditure as maintenance cost by collecting a certain amount of money in each month from the farmers.

In each scheme there were around 950 beneficiary families involved. The villagers located in the study area are getting Arsenic free safe drinking water round the year. They are now free from waterborne diseases due to use of safe drinking water.

Fig.-3: A meeting of Water Users Group

V. CONCLUSION

Major activities of BMDA are relating to irrigation through installation of deep tube well. Later on BMDA has taken up drinking water supply system with piped water distribution networks from deep tube wells to provide improved and safe water supply to the rural households as they have poor access to potable water. Emphasis has been given in this study on the impacts of safe drinking water supply, water quality parameters with safe limits for drinking purpose, hygiene and health outcomes of marginalized rural households in north-western part of Bangladesh using BMDA's irrigated deep tube wells. This study found that BMDA's piped water infrastructures have a positive impact on access to improved and safe drinking water supply and significantly reduced the distance traveled for and time spent on collecting safe drinking water.

Concluding Remarks

We can say, in a word, that deep tube wells may provide safer and better quality of drinking water as compared to shallow tube wells and manually operated pumps or others indigenous equipment. Hence, it is recommended that BMDA's drinking water supply system from irrigated deep tube wells is more suitable and sustainable for drinking purpose and other domestic uses in this study area.

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