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Assessment of Supplied Water Quality of Khulna WASA of Bangladesh

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Abstract

In Khulna region of Bangladesh, scarcity of drinking water is remarkable. To fulfill the crisis of potable water, Khulna Water Supply and Sewerage Authority (KWASA) is supplying water to the Khulna city dwellers through its distribution network from the groundwater source (GW). However, the quality of supplied water is not satisfactory. In order to identify such water contamination problems, water samples from different locations of the distribution network were analyzed in this study. Important water quality parameters include pH, color, turbidity, iron, chloride, arsenic, hardness, BOD_5, total solid (TS), total suspended solid (TSS), total dissolved solid (TDS), total coli form (TC) and Escherichia coli (EC) were tested. Microbial water quality parameters, TC and EC were found that about 66.67% and 100% of total sample exceeds permissible limit, respectively. Except very few cases, other water quality parameters of almost all samples satisfy the allowable limits recommended by WHO and BDS guidelines.

Keywords: *KWASA, Water Quality, Distribution Network, WHO, BDS*

1. Introduction

Water is one of the fundamental components of the physical environment. The quality of drinking water is closely associated with human health, and providing safe drinking water is one of important public health priorities. A wide range of water problems faces nations and individuals around the world. The assessment published in 2000 by the World Health Organization (WHO), 1.1 billion people around the world lacked access to improved water supply. About 80% of all diseases and over one third of deaths in developing countries are caused by the consumption of contaminated water, and on an average as much as one tenth of each person's productive time is sacrificed to water-related diseases [11]. The quality of drinking water in Khulna is also at high risk as well as Bangladesh. Bangladesh is largely dependent on GW source for drinking and other uses. Numerous water quality problems exist in GW systems in Bangladesh, especially in its southwestern coastal belt [5]. However, the southwest coastal belt of the country is facing enormous challenges in meeting the rising fresh water demand due to limited water supply from the available GW and SW sources as they are affected by the salinity and other water quality problems [8, 10]. Khulna is one of the densely populated urban areas with a population of about 1.5 million in Khulna City Corporation (KCC) area which has been suffering from inadequate supply of drinking water often associated with water quality problems too. KWASA, established in March, 2008, is the responsible body to supply water to this huge population. Water supply by Khulna WASA comes from deep tube wells without water treatment through its limited distribution network system of 268 km length to the city dwellers and is able to meet 47.5% of the total demand for water of the city. A variety of physical, chemical and biological transformations can happen once the water travels through a distribution system [13]. Water-borne diseases are caused by ingestion of contaminated water from pathogens contained in human or animal excreta. The available water treatment technologies for GW are costly. So, Khulna WASA is likely to not using this option. Since contaminated water can pose a potential source of health risk to Khulna city dwellers, the present investigation was undertaken with an objective to assess important water quality parameters of the KWASA's supply water. The study was undertaken as part of the under-graduate program of the Department of Civil Engineering of Khulna University of Engineering and Technology (KUET). Therefore, this study is an attempt to investigate some physical, chemical and bacteriological parameters of GW such as pH, Color, Turbidity, Iron, Chloride, Arsenic, Hardness, BOD_5, TS, TSS, TDS, TC and EC were tested in the central part of KCC area of Bangladesh.

2. The study area and Sample Collection

KCC, the study area, is an expanding center of southwestern Bangladesh, which is being directly influenced by tides. It currently covers an area of 46 sq. km and 1.5 million populations under the jurisdiction of KCC in 2012. The city along with its surrounding is bounded by the longitude 89°28'– 89°37' east and latitude 22°46'–22°58' north and its elevation is 1 to 2 m above mean sea level. The mean annual temperature from 2001 to 2007 was 26.7°C. Khulna receives a mean annual rainfall about 1620 mm. Out of 31 wards of KCC, 15 points were selected for the present study, which mainly covers the center part of the city. All sampling points are summarized in Table 1 and presented in Fig. 1. Meaningful and reliable sampling assures the validity of analytical findings. Therefore, utmost care was exercised to ensure that the analyses were representative of the actual composition of the water samples. The samples from different locations were collected in sterilized bottles and prior to filling the sample bottles were rinsed two to three times with the water to be collected. Collected samples were promptly carried to the Environmental Engineering laboratory of the Department of Civil Engineering of KUET and almost all the important water quality parameters were measured within four hours of collection. KWASA have interconnected water supply network. So, collection of water in several production tube wells and households were done.

Table 1. Sample no. and sampling location

Production Tube wells		Households	
Sample No.	Location	Sample No.	Location
1	Shekhpara Jame Mosque Pump	9	150 Baghmara Main Road
2	Bosupara Koboresthan Pump	10	10/1 Gagan Babu Road
3	Nirala Park Pump	11	Staff Quarter, Sadar Hospital
4	Mistripara Bazar Pump	12	Rokeya Villa, Banargati Bazar
5	Shipyard Pakarmatha Pump	13	29, Baro Boira Central Road.
6	Court Pump	14	180, Baghmara Main Road
7	Nur Nagar Fire Service Pump	15	North Khal Bank Road
8	Sher-e- Bangla Road Park Pump	-	-

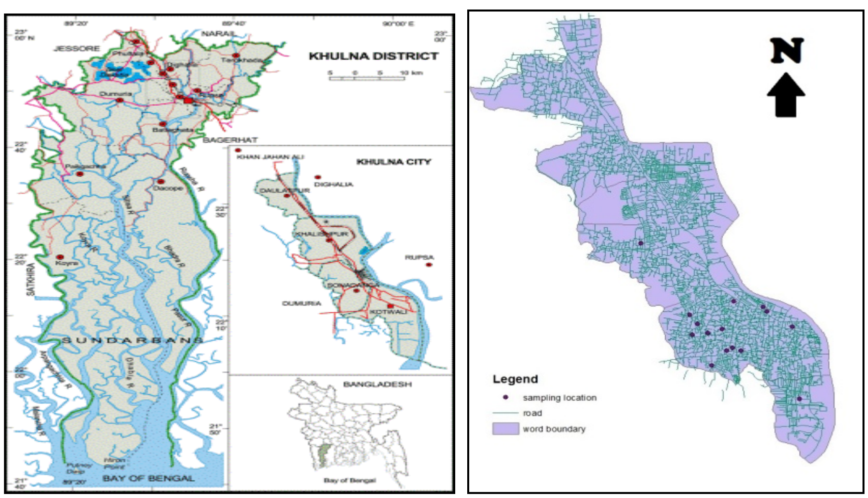


Fig. 1. Study area and Sampling point in KCC

3. Materials and methods

At first, field reconnaissance survey was conducted and the sampling locations are selected in such a way that it represents the entire area of distribution network of KWASA. It is performed by taking the water supply network map of KWASA. After finalizing the sampling points, samples were collected. Plastic bottles of one-liter capacity are used for this purpose. They are thoroughly cleaned by rinsing three to four times with sampling water. Before sampling from production tube well, sufficient amount of water is pumped out so that the sample represents the GW from which the well is fed [5]. Then the sampling bottles are filled up to the brim and are immediately sealed to avoid exposure to air [7]. The sampling containers are labeled including its station name, source, coordinate, identification number, date and time for identification. Collection and preservation of the samples are carried out according to standard methods [1]. The samples are immediately transferred to the Laboratory for subsequent laboratory testing and analysis. The collected GW samples are analyzed for pH, Color, Turbidity, Iron, Chloride, Arsenic, Hardness, BOD_5, TS, TSS, TDS, TC and EC. All physical, chemical and bacteriological analyses are performed according to the standard methods for the examination of water and wastewater [1]. TDS and pH were determined by TDS meter and pH meter respectively. Iron and color were determined by Spectrophotometer and turbidity is measured by Hellige turbid meter. Chloride and hardness are determined by titration method. For chloride test, 0.0141N $AgNO_3$ with $K_2Cr_2O_7$ indicator is used and standard soap solution is used for hardness test. The water quality parameters are assessed by comparing the test results with both Bangladesh Drinking Water Standard (BDS) [3] and WHO guidelines for drinking water quality [12].

4. Result and Discussion

pH

The pH value is an important index of and controlled value of pH is desired in water supplies, sewage treatment and chemical process plants. The pH values of all samples of different sampling location were found in permissible range of 6.5-8.5 according to WHO (2006) and ECR (1997) recommended values with a varying range 6.76 to 7.78. The variations of pH in collected samples are presented in Fig. 2. (a).

Turbidity and color

Turbid water is not suitable as it causes quick clogging of filtered. The maximum turbidity 9.09 NTU was found in Staff Quarter, Sadar Hospital and minimum 0.46 NTU value was found in Sher-e-Bangla Road Park Pump. Among the production tube wells, 100% samples did not exceed the permissible value of 5 NTU. In case of house hold samples, 71.43% samples were below 5 NTU and the remaining 28.57% exceeded 5 NTU but remained within the range of 10NTU WHO standard (Fig. 2. b). One the other hand, colored water does not cause so many health problems but it is aesthetically unacceptable. Color in water is primarily due to the presence of colored organic substances, metals such as Fe, Mn or highly industrial wastes. Color values vary within the range of 25 Pt.Co to 166 Pt.Co exceeding the limit of WHO and ECR. (Table 4).

Chloride

High chloride content in inland water distribution system usually indicates sewage pollution. At concentrations above 250 mg/L, chloride rich water gives a salty test causes various diseases such as high blood pressure, although it depends on individual adaptability. The maximum and minimum chloride concentrations were found about 550 mg/L at Staff Quarter Sadar Hospital and 72 mg/L 180, Baghmara Main Road (Table 1,2). High chloride concentration are quite may be due to the saline water intrusion problem, which is quite frequent in KCC area. Although, among household and production tube wells, no sample exceeds 600 mg/L (Fig. 3. a).

Iron and arsenic

Iron defects lead to anemia, causing tiredness, headaches and loss of concentration. Minimum value of iron (0.01 mg/L) is found in house hold sample of Banargati Bazar and maximum value (0.31 mg/L) found in production tube well of Nirala Park. Among all samples, no samples exceeds ECR (1997) recommended value and 6.67% samples exceeds WHO (2006) permissible value (0.3 mg/L) for drinking water. Arsenic enters drinking water supplies from natural deposits in the earth or from agricultural and industrial practices. To protect consumers served by public water systems from the effects of long-term, it is limited to 0.05 mg/L. All the collected samples are totally free from arsenic.

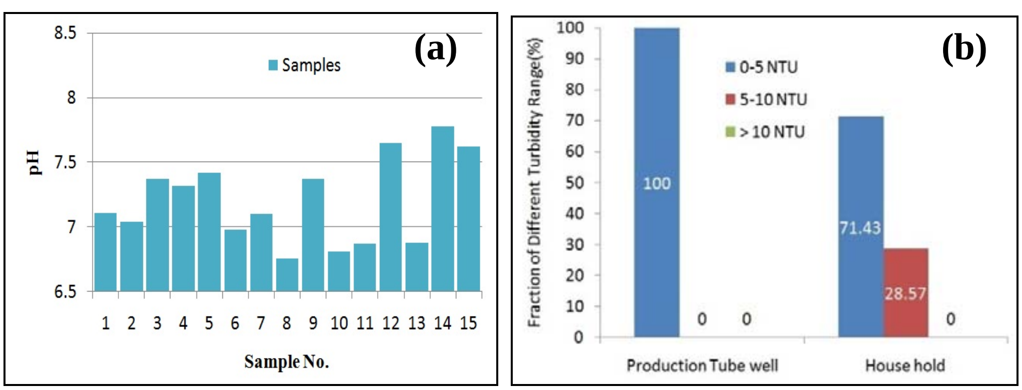


Fig. 2.a. Variation of pH of different samples, **b.** Turbidity of water samples in different ranges.

Table 2. Summary of measured water quality parameters in KWASA's supply.

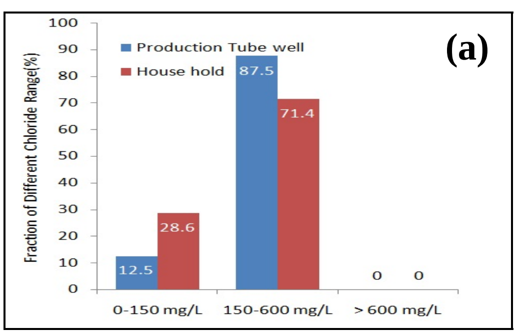
Water Quality Parameters	pH	Turbidity	Color	Iron	Cl	Hardness	TS	TDS	TSS	BOD_5
Units	-	NTU	PtCo	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
BDS (1997)	6.5-8.5	10	15	0.3-1.0	150-600	200-500	-	1000	10	0.2
WHO (2006)	6.5-8.5	5	15	0.3	250	500	-	1000	-	-
Sample No. 1	7.11	1.98	40	0.20	233.3	574.1	820	650	170	0.37
2	7.04	0.70	44	0.12	166.7	370.4	530	480	50	1.11
3	7.37	1.73	38	0.31	233.3	259.3	430	390	40	2.19
4	7.32	0.77	27	0.11	166.7	407.4	480	210	270	1.0
5	7.42	1.89	63	0.06	83.33	222.2	420	370	50	0.95
6	6.98	1.57	56	0.06	233.3	407.4	650	510	140	1.11
7	7.10	1.17	90	0.25	200.0	314.8	600	410	190	2.83
8	6.76	0.46	25	0.16	170	486.2	450	390	60	0.78
9	7.37	1.80	84	0.10	83.33	185.2	550	480	70	0.86
10	6.81	5.69	71	0.16	516.7	592.7	1300	920	380	1.5
11	6.87	9.09	166	0.11	550	1222	1920	1870	50	2.97
12	7.65	1.12	69	0.01	155	310.2	490	400	90	2.83
13	6.88	1.32	72	0.13	160	292.8	430	350	80	1.30
14	7.78	0.98	83	0.10	72	277.8	460	410	50	1.24
15	7.62	1.01	78	0.18	180	493.9	470	420	50	1.69

Hardness

The maximum (1222.32 mg/L) hardness was found in sample of household sample at Staff Quarter, Sadar Hospital and minimum (185.2 mg/L) value was found at 150 Baghmara Main Road. Based on the hardness value water may be classified as in Fig. 3. b. Soft and moderately soft water was not found in samples. Hard and very hard water was found 42.86% and 57.14%, respectively in household water samples where 100% of production tube well water was very hard. Test result demonstrates that about 20% samples exceeds BDS permissible limit (500 mg/L). Soap consumption by hard waters represents an economic loss to the water use.

Total dissolved solid (TDS)

The TDS value has been increased to an amount of 1870 mg/L in Staff Quarter, Sadar Hospital and its minimum value of 210 mg/L in Mistripara Bazar Pump. As being of coastal area, seawater intrusion is the main factor for the increased amount of TDS in GW, which was supported by a high value of sodium and chloride. 16% samples exceed the permissible limits (1000 mg/L) of WHO (2006) and ECR (1997). Depending on the TDS values, water is grouped as excellent, good, fair, poor and unacceptable. Most of the samples lies in good (300-600 mg/L) and 14.29% samples of households are unacceptable and there is no sample of household in excellent (<300 mg/L) class (Fig. 4. a).



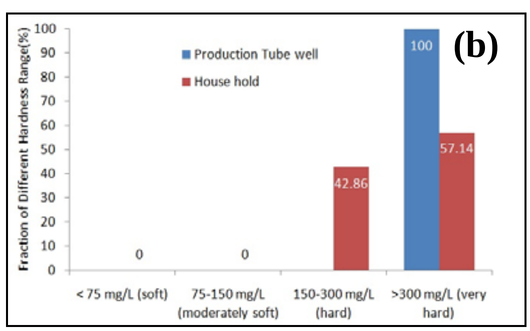


Fig. 3. a. Chloride of water samples in different ranges, **b.** Hardness of water samples in different ranges.

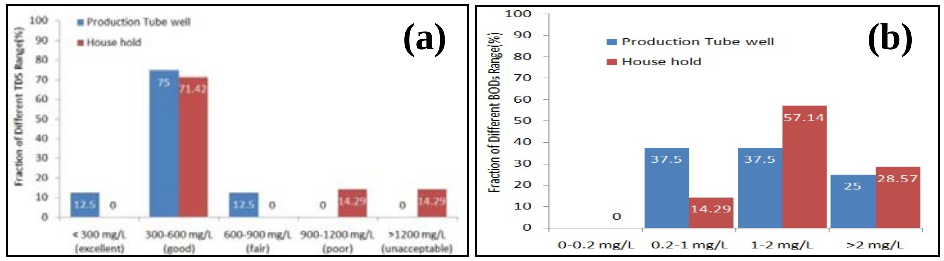


Fig. 4. a. TDS of water samples in different ranges, **b.** BOD_5 of water samples in different ranges.

BOD_5

All the collected water samples from different location of KCC had BOD_5 concentration greater than the permissible value of 0.20 mg/L of BDS. Fig. 4.b. shows the distribution of BOD_5 concentration in different ranges of household and production tube well samples. The maximum BOD_5 concentration was found 2.97 mg/L in Staff Quarter, Sadar Hospital and the minimum was 0.86 mg/L in Baghmara Main Road. Therefore, high BOD_5 concentration in the distribution system might be due to cross-contamination through leaking pipes, unauthorized connection, improper domestic storage facilities etc.

Total coli form (TC) and Escherichia coli (EC)

Test results for TC and EC are given in the following Table 3. Maximum TC was found in water sample collected from house hold (Staff quarter, Sadar Hospital). However, maximum EC was found in sample no 12 which is collected from house hold also at Banargati Bazar. Therefore, water supply in those areas may not be safe considering the microbiological water quality standard. The water passing through the distribution network in this area carries TC and EC which indicates that microbial contamination in the distribution system might happen due to cross contamination by leaking pipes, unauthorized connections, improper domestic storage etc.

Table 3. Coliform counts in water samples of KWASA in different production tube well & house hold

Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TC(nos/100 mL)	130	125	115	200	290	10	70	42	190	185	335	180	80	160	76
EC(nos/100 mL)	0	0	0	70	10	0	0	17	100	5	5	120	7	100	46

Table 4: Comparison of water samples with its recommend standard quality

Parameters	Units	Max	Min	Water Quality Standard		% of samples exceeding water quality	
				WHO (2006)	BDS (1997)	WHO (2006)	BDS (1997)
pH	-	7.78	6.76	6.5-8.5	6.5-8.5	0	0
Turbidity	NTU	9.09	0.46	5	10	13.33	0
Color	Pt.Co	166	25	15	15	100	100
Chloride	mg/L	550	72	250	150-600	13.33	0
Iron	mg/L	0.31	0.01	0.3	0.3-1.0	6.57	0
Hardness	mg/L	1222.32	185.2	-	200-500	-	20
TDS	mg/L	1870	220	1000	1000	6.67	6.67
BOD_5	mg/L	2.97	0.86	-	0.2	-	100
TC	Nos/100mL	335	10	0	0	100	100
EC	Nos/100mL	120	0	0	0	66.67	66.67

Overall assessment of the KWASA supply water and recommendation

Test results of water samples collected from the outlet of production tube well and household revealed that the water entering the distribution system was not meet the desired chemical and microbial quality except pH, turbidity, chloride and iron. However, this quality drinking water can suffer more serious contamination in distribution system because of breaches in the integrity of the pipe work. Although the researchers are currently unsure about the exact effect of bio film produced within a distribution system [13]. Though the concentration of water quality parameters in the outlet distribution networks (households) were higher than the level recorded at the outlet of production tube well and they were not still within the permissible range in some location. So, contamination occurs in the network. Therefore, it can be concluded from random tests of biological water quality that the people of Khulna city are at high risk due to contamination of drinking water.

One of the major tasks to ensure improved water quality is to find out possible point of sources of microbial contamination i.e., cross contamination by leaking pipes, unauthorized connection to the main at road sides, lack of maintenance of domestic storage and distribution system etc and to take necessary preventing measures. Current practice in many countries is to use disinfectant residuals to control the growth of microorganisms in distribution systems. In fact, proper system efficiency depends on quality monitoring which could be achieved by a program of frequent monitoring at service connection throughout the system. Besides, low cost treatment plants can be installed in the inlet of distribution network to provide standard quality water in the distribution network.

5. Conclusions

Khulna city dwellers are not only suffering from inadequate water supply but also are they posed to serious threat due to the scarcity of safe water. Water quality test results of random samples of KWASA's distribution system revealed that the water quality is not satisfactory in production tube well and deteriorated during its flow through the distribution system. KWASA's piped water supply systems are generally buried complex reticulations and they are difficult to operate and maintain. Nevertheless, they are as important as water resource and treatment facilities in ensuring the supply of safe drinking-water. The authority should conduct regular monitoring program to prevent possible contamination of water along its distribution. Public consciousness can also play an important role to help prevent such problems. The situation may exacerbate in near future if the authority does not pay attention and take immediate actions to restore water quality in the distribution system.

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