IOSR Journal of Applied Chemistry (IOSR-JAC)
e-ISSN: 2278-5736.Volume 14, Issue 8 Ser. I (August 2021), PP 38-45
www.iosrjournals.org

Quality Measurement of Drinking Water in Rajshahi City Corporation and Effectiveness of Different Water Purifiers

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Abstract
The study was carried out to assess some physical and chemical parameters of the water samples collected from different tube wells in the Rajshahi City Corporation Area, Bangladesh and justified the effectiveness of different water purifiers widely used in this area. Seven water samples from different locations were collected and analyzed for various physicochemical parameters. Besides, three water samples from three types of water purifiers were collected and analyzed to determine the effectiveness of those filters considering the drinking water quality. From this study, it was found that most of the parameters existed under the permissible limits of BD standards.

Keywords*: Rajshahi City; Bangladesh; Water Quality; Water Purifier; Physicochemical Parameters*

Date of Submission: 25-08-2021 Date of Acceptance: 09-09-2021

I. Introduction

Water is one of the most precious substances to life on earth. Access to safe drinking water plays a vital role in health and development issues and is essential for survival. Safe drinking water is necessary to maintain good health and protect from various diseases [1]. The deficiency of safe water may be responsible for many health related issues such as gastrointestinal disease and nervous system disorder [2-4]. Due to rapid population and industrial growth using natural resources like groundwater is increasing and recharging them is a big challenge as groundwater is used for both irrigation and drinking by millions of people every day [5-7]. Excessive pumping and continual withdrawal may lead to the deterioration of its quality and even depletion of groundwater [8,9]. So the quantity, as well as quality of resources of the groundwater, must be taken into full consideration [10,11].

In 2012, World Health Organization (WHO) and UNICEF combinedly conducted a joint monitoring program for water supply and sanitation and reported that about 783 million people in the world do not have access to safe drinking water and 84% of them are living in rural areas [12]. Different physicochemical parameters of drinking water such as hardness, pH, total dissolved solids (TDS), and levels of non-toxic compounds (iron, manganese) do not pose a health threat at normal levels found in groundwater. These parameters affect the acceptability of drinking water as they are responsible for the aesthetic and organoleptic quality of water [13]. After the incident of the presence of arsenic found in drinking water in Bangladesh, many countries started to perform some chemical testing [14]. A study in Bangladesh showed that low metallic content was observed for most water samples in Chittagong metropolitan area [15]. Another study conducted in some rural areas of Nigeria found higher levels of Pb and Cd above the WHO limits for drinking waters [16]. In this study, we evaluate some physicochemical parameters of drinking water collected from seven different locations of Rajshahi City Corporation area. A new inhabitant of Rajshahi City Corporation area often faces problems with water while drinking & bathing. So it seems that the water quality of this area is questionable. A study in this area regarding this issue indicated that high concentrations of iron and manganese and total hardness are the major constraints for drinking water supply in Rajshahi City Corporation area [17]. Another study mentioned that Rajshahi city householders are suffering from inadequate water supply as well as various water related diseases and the water quality test of targeted sample exhibited that water quality of samples is not satisfactory [18]. In these circumstances, different types of water purifiers are being used by the dwellers of this area. But none of these studies said about the necessity of using water purifiers in Rajshahi metropolitan area considering the water quality. The aim of the present study was to assess the quality of drinking water uplifted from hand tube wells in different locations of Rajshahi metropolitan area. The second objective of this study is to measure the effectiveness of three water purifier systems which are widely used in Rajshahi City Corporation area, Bangladesh.

II. Materials And Methods

2.1 Sample Collection

2-litre polythene bottles were used to collect water samples. Before usages, the bottles were washed with non-metallic detergents, rinsed several times with distilled water and dried properly. Seven water samples were collected from different Tube wells situated in Rajshahi City Corporation area. Water collected from Sopura was treated with three different types of water purifiers to determine the effectiveness of those purifiers.

2.2 Analysis of the samples

Acidified water samples were analyzed for As, Cr, Cu, Mn, and Na with the help of an atomic absorption spectrometer (SHIMAZU-6300). Fe was determined in the sample using a spectrophotometer (SHIMAZU-1601). Hanna Pocket-Sized pH meter and Aqua TDS meter (Model- AD 201) were used to read the pH and TDS value respectively. Hardness and chloride concentration of water samples were determined by titrimetric method. Every analysis was done following the standard methods for the examination of water.

III. Results And Discussion

Table 1 shows different parameters of seven water samples collected from different areas of Rajshahi City Corporation. According to WHO, there is no established guideline value for pH, TDS, hardness, iron, manganese, sodium and chloride but above the values marked with star (*) the taste of the drinking water is changed [19].

3.1 pH

The pH of a solution is the negative logarithm of the hydrogen ion activity. According to the WHO guideline for drinking water, there is no health-based guideline value which is proposed for pH. The Bd standards for pH in drinking water is 6.5-8 [19, 20]. pH values greater than 11 causes eye irritation and different skin disorders [21]. The highest value of pH among all the samples was 7.3 found in Sopura and the lowest value was 6.9 found in Horogram. So, pH values of all the samples were found within the BD standards value (Table 1).

3.2 TDS

TDS can be taken as an indicator of general water quality because it directly affects the aesthetic value of water quality [22]. Drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than 1000 mg/L [19]. There is no WHO guideline value of TDS for drinking water. Bd standards of TDS for drinking water is 1000 mg/L. The highest TDS value, 610 mg/L, was found in Horogram and the lowest value, 395 mg/L, was found in the Padma residential area. It was seen that TDS of all samples were within the permissible limits (Table 1).

3.3 Hardness

Hard water interferes with almost every cleaning task from laundering and dishwashing to bathing and personal care [23]. According to the WHO drinking water guidelines, there is no established guideline values for hardness because there is no health concern at levels found in drinking water. BD standards of hardness for drinking water is 200-500mg/L [20]. The lowest water hardness, 285 mg/L, was found in Horogram and highest value, 460.46 mg/L, was found in Rajshahi University of Engineering & Technology (RUET) campus. The obtained data showed that hardness content in water was within limits prescribed by BD standards (Table 1).

Table 1: Different parameters of seven water samples

Parameters	Place of Sample Collection							BD standards (mg/L)	WHO standards (mg/L)
	Sopura	Bongram	RUET	Laksmipur	Horogram	Padma	Binodpur		
pH	7.3	7.2	7.1	7.1	6.9	7.2	7.2	6.5-8.5	-
TDS	551	400	452	432	610	395	400	1000	1000*
Hardness	456	396.8	460.46	408.82	285	424	428.43	200-500	500*
Arsenic	0.007	<0.003	0.003	<0.003	0.086	0.004	<0.003	0.05	0.01
Chromium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	0.05
Copper	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1	2
Iron	0.26	0.08	0.48	<0.05	11.11	0.18	0.25	0.3-1.0	0.3*
Lead	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.01
Manganese	3.1	0.2	0.3	0.3	0.4	0.5	0.3	0.1	0.1*
Sodium (Na)	4.6	1.0	1.53	1.1	2.3	1.7	1.1	200	200*
Chloride (Cl)	5	31.91	36.87	28.71	22.33	38.28	35.09	150-600	250*
Nitrate (NO_3^-	3	<1	2	<1	15.5	0.5	<0.1	10	50

(Above the value, marked with star (*) the taste of the drinking water may be changed)

3.4 Copper (Cu)

Copper is both an essential nutrient and a drinking water contaminant. At normal concentration copper is a biologically important trace element; at elevated concentration, it is toxic for living organisms [21]. The permissible concentration of Cu in drinking water are 1 mg/L and 2 mg/L according to BD standards and WHO guideline respectively [19, 20]. The concentrations of Cu in all samples were less than 0.01 mg/L (Table 1).

3.5 Iron (Fe)

Severe problems can be caused in drinking water by the presence of iron although there is normally no harmful effect on persons consuming waters with significant amounts of iron but generally laundry becomes stained if washed in water with excessive iron, and vegetables likewise become discolored on cooking. Taste problems may also occur due to the excessive concentration of iron [24]. According to BD standards the allowable concentration of Fe in drinking water is 0.3-1 mg/L [20]. There is no established guideline value in WHO drinking water guideline for Fe but above 0.3 mg/L, iron stains laundry and plumbing fixtures [19]. All the samples had tolerable concentration of Fe except in the samples collected from Horogram where the Concentration of Fe was 11.11 mg/L (Table 1).

3.5 Manganese (Mn)

Higher level of manganese in drinking water may be responsible for undesirable taste [24]. The maximum allowable concentration of manganese in drinking water is 0.1 mg/L according to BD standards [20]. Although there is no WHO drinking water guideline value for manganese, but at levels exceeding 0.1 mg/L, manganese stains sanitary ware and laundry [19]. The concentrations of manganese in all samples were higher than 0.1 mg/L. The highest concentration of manganese was found in the sample of Sopura and that was 3.1 mg/L (Table1).

3.6 Chromium (Cr)

The maximum permissible limit of chromium in drinking water according to WHO and BD standards is 0.05 mg/L [19,20]. In all samples the concentrations of Cr were less than 0.02 mg/L (Table 1).

3.7 Lead (Pb)

Lead is a toxic cumulative poison because it accumulates in body tissue [24]. According to Bd standards the maximum permissible concentration of Pb in drinking water is 0.05mg/L [20]. In all samples the concentrations of Pd were less than 0.05 mg/L (Table 1).

3.8 Sodium (Na)

Sodium causes hypertension if taken in excess [24]. At room temperature, the average taste threshold for sodium is about 200 mg/L. The Bd standards for sodium in drinking water is 200mg/L [20]. The observed concentration of sodium in the samples were within the limit as mentioned in Bd standards (Table 1).

3.9 Chloride (Cl-)
The Bd standards for chloride is 150-600 mg/L [20]. Concentrations of chloride above 250 mg/L are increasingly likely to be detected by taste [19]. The concentration of chloride in the samples were found from 5 mg/L to 38.28 mg/L.

3.10 Nitrate (NO3-)
Standards for Nitrate in drinking water are 50 mg/L and 10 mg/L according to WHO and BD standards respectively [19,20]. The range of the concentration of nitrate were <1 mg/L to 15.5 mg/L. The highest concentration of Nitrate was found in the sample of Horogram which was permissible according to WHO standard but higher in the light of BD standards (Table 1).

3.11 Arsenic (As)
Higher level of arsenic in drinking water causes arsenicosis in human body which can lead to death. That's why amount of arsenic in drinking water is a major concern. WHO standards for arsenic in drinking water is not greater than 0.01 mg/L while the BD standards is 0.05 mg/L. All the samples except collected from Horogram were within both BD and WHO standards (Table 1).

IV. Effectiveness Of Different Water Purifiers

4.1 pH
Table 2 shows the effectiveness of three water filter systems in case of their ability to change different parameters which were considered in the light of the water quality of Rajshahi City Corporation area. The main sample having pH 7.3 was let go through three different types of filter systems and the water was treated individually. The filtrated water from the mineral pot ceramic filter showed the highest pH among the water samples. Mineral pot filter system contains filter cartridge in which silica sand is available. It removes acidic components from the water [25]. So the pH of the water filtrated from this system was increased. For the same reason, the Sand Charcoal & Granular system (homemade filter) also increased the pH value of the filtrated water (Figure 1).

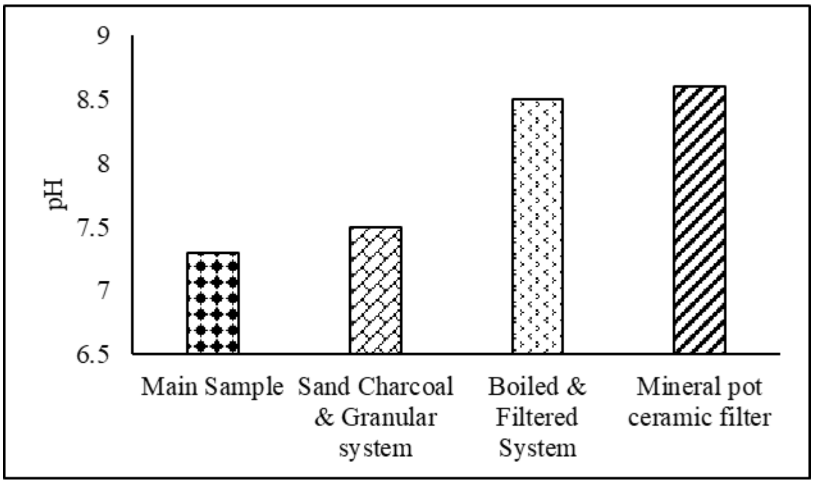

Figure 1: Effect of different filters on pH

Table 2: Effectiveness of three water filter system

Parameter	Main Sample (Sopura)	Parameter after treated by filtration System		
		Sand Charcoal & Granular system	Boiled & Filtered System	Mineral pot ceramic filter
pH	7.3	7.5	8.5	8.6
TDS (mg/mL)	551	471	419	489
Hardness	456	400	196	40
Arsenic	0.007	0.005	0.009	<0.003
Manganese	3.1	1.9	0.7	0.4
Nitrate	3	1.7	2.5	2.3

4.2 TDS

Sand Charcoal & Granular system (Homemade filter) removes Fe, Mn and decreases the hardness of the sample. So, the treated water using this filter has less TDS as compared with the main sample (Table 2). Mineral pot ceramic filter also decreases the value of TDS but to a lesser extent because sand is used in this filter and this sand releases minerals to the water [25]. Boiled and Filtered system showed the best performance for reducing TDS value (Figure 2).

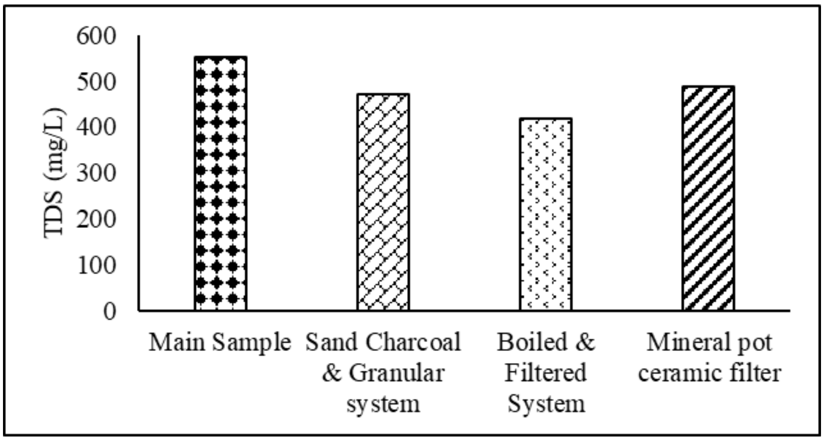

Figure 2: Effectiveness of Filters to change the concentration of TDS

4.5 Hardness

The performance of three water filter systems in case of reducing hardness from the samples were shown in Table 2. Mineral pot ceramic filter significantly reduced the hardness of water (Figure 3). It removed 91.2%, Sand Charcoal & Granular system 12.3% and Boiled & Filtered System 57% hardness from the samples.

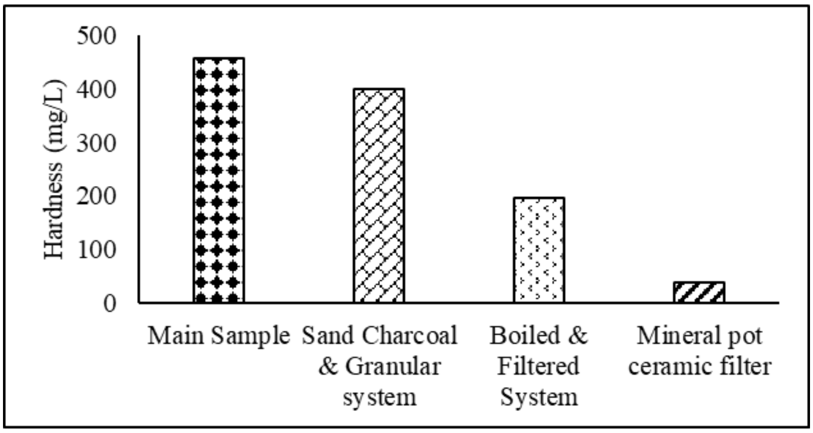

Figure 3: Effectiveness of Filters to change the concentration of Hardness

4.6 Manganese (Mn)

The result indicates the performance of three water filter systems in case of removing manganese from the samples (Table 2, Figure 4). Mineral pot ceramic filter removed 87.10%, Sand Charcoal & Granular system 38.9% and Boiled & Filtered System 77.4% manganese from the sample. But none was able to decrease the amount of manganese to the permissible BDS standard and WHO recommended value, 0.1 mg/L.

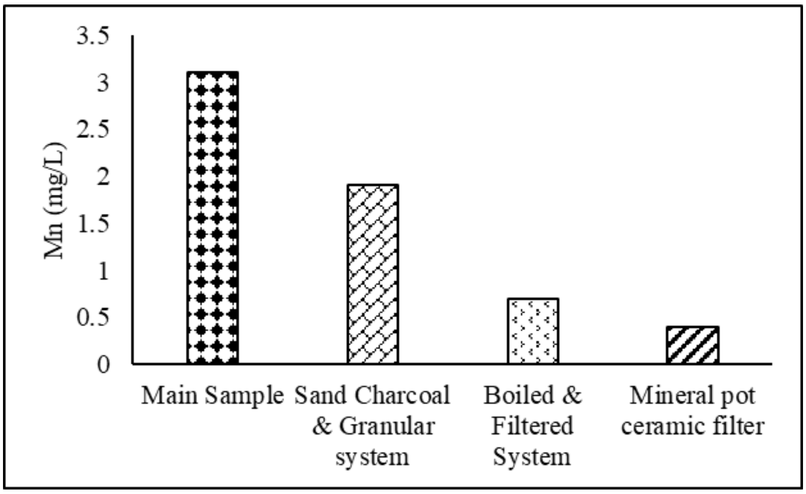

Figure 4: Effectiveness of Filters to change the concentration of Mn

4.7 Nitrate (NO_3^-)

Table 2 shows the effectiveness of three water filter systems in case of their ability to change different parameters which were considered in the light of the water quality of Rajshahi City Corporation area. Sand Charcoal & Granular filter system greatly reduced the amount of nitrate in drinking water (Figure 5). Mineral pot ceramic filter removed 23.33%, Sand Charcoal & Granular system 43.33% and Boiled & Filtered System 16.70% Nitrate (NO_3^-) from the samples.

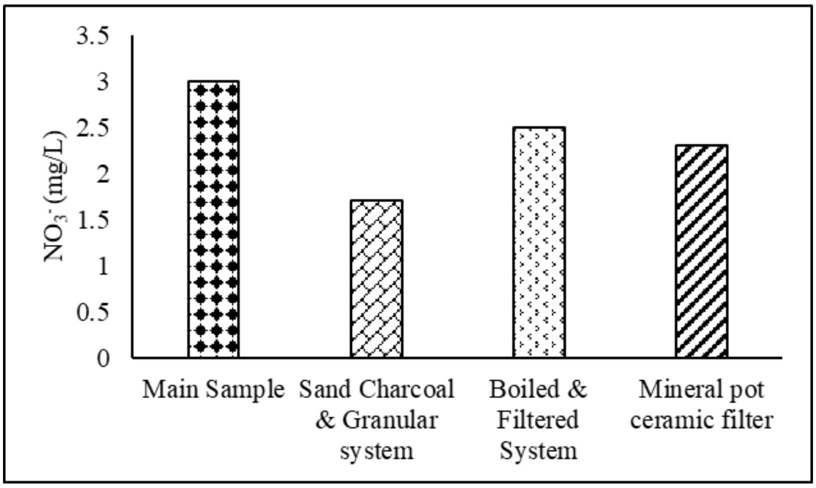

Figure 5: Effectiveness of Filters to change the concentration of NO_3^-

4.8 Arsenic (As)

Table 2 also illustrates the ability of three filters in case of removing arsenic from the sample. Mineral pot ceramic most effectively removed arsenic from the sample (Figure 6). The concentration of arsenic was increased in the boiled and filtered system. In this system filter paper was used. It seemed that water evaporated while water was being boiled and the concentration of arsenic was increased as the total volume of water was lessened.

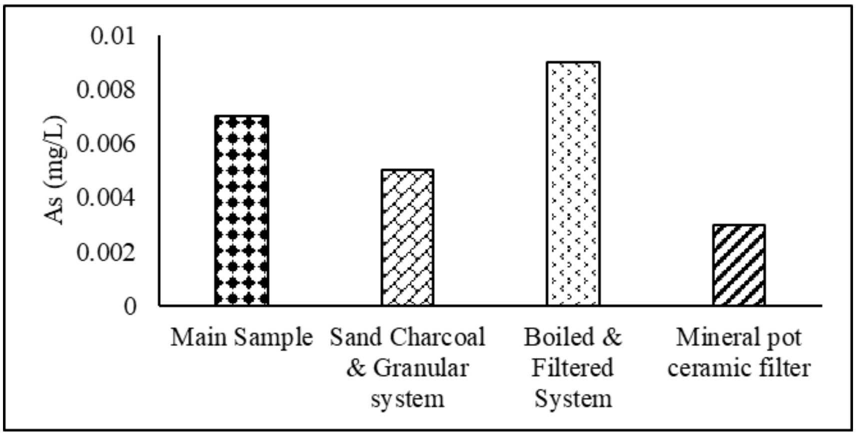

Figure 6: Effectiveness of Filters to change the concentration of As

V. Conclusion

The study evaluated the selected physical and chemical parameters in tube well water of Rajshahi City Corporation area, Bangladesh. The values of all the parameters were found to be within the Bangladesh standard and WHO standard limit except for manganese (Mn) in all samples, iron (Fe) in samples collected from Horogram and RUET campus, nitrate (NO_3^-) and arsenic (As) in sample collected from Horogram. It was also found that the hardness of all water samples was under permissible limits but still, the status of all the samples were hard water considering the value. It was seen in this study that three water purifiers effectively improved most of the parameters. They significantly removed manganese, hardness and nitrate from the water samples. Although the mineral pot ceramic filter and Sand Charcoal & Granular system were able to remove arsenic from the samples, Boiled & Filtered System was not that.

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