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Physicochemical characterization of drinking water of selected regions in Bangladesh

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Abstract

Water, the most vital resources for the survival of life is of major importance not only to have an adequate and accessible supply, but also to have quality water that is considered safe for human consumption. The study was designed with a view to investigating water quality by assessing physicochemical properties of drinking water collected from selected regions and to compare the regional variation among the quality of water. The analysed physical properties were pH, electrical conductivity (EC), total dissolved solids (TDS) and the chemical properties were Iron (Fe) Lead (Pb), Sulphate (SO_4^{2-}) and Phosphate (PO_4^{3-}). Water samples were collected from separate point of tap water and tube well water and most of them were collected from restaurant, house hold and governmental office within the study areas. The result revealed:(a) the highest value for physical parameters pH, EC and TDS were 7.8, 723 µs/cm and535 mg/L respectively whereas for chemical parameters SO_4^{2-}, PO_4^{3-} and Fe it was 1.6, 0.53 and 1.1 mg/L respectively; (b) the lowest value for pH, EC and TDS were 6.9, 430 µs/cm and 180 mg/L respectively whereas for SO_4^{2-}, PO_4^{3-} and Fe it was 0.05, 0.04 and 0.05 mg/L respectively. All of them were present in water within the permissible limits except Fe (1.1 mg/L) and TDS (535 mg/L) as it exceeds WHO standards (0.3-1 mg/L) for Fe and (500 mg/L) for TDS (WHO, 2012). The result obtained for experimental parameters indicates that the water quality is slightly harmful for drinking purposes in terms of (Fe) household and (TDS) govt. office in some regions.

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Introduction

Drinking water quality has always been a major issue in many countries, especially in developing countries like Bangladesh (Islam *et al.*, 2018; Muhammad *et al.*, 2017; Moe and Rheingans, 2006). Although safe drinking water is a basic demand for the people of all over the world, a huge percentage of people around the world are deprived from the pure drinking water including Bangladesh (Chowdhury *et al*., 2014; Islam *et al.*, 2020; Islam *et al.,* 2018). In Bangladesh, there are various sources of drinking water such as surface water, ground water and rain water. Among these

surface and ground water are considered as the main sources of drinking water. Here, 90% of drinking water is supplied from groundwater source (Mridha, 1996; Islam *et al.*, 2018). But the quality of water resources is deteriorating rapidly due to contamination in case of surface water and excess withdrawal of ground water (Rahman *et al.*, 2016).

As it is well known that natural and safe drinking water is a prime need for good health, the importance of using safe water has become an international issue with

the ever increasing world population which eventually accelerates the water demand. Groundwater that represents the world's largest and most important source of fresh potable water (Howard, 1997) provides to an estimated 1.5 billion people worldwide daily (DFID, 2001) has proved to be the most reliable resource for meeting water demand (MacDonald, 2002; Harvey, 2004). But this scares and fragile resource is now under the risk of degradation in both quality and quantity in many parts of the world (Ambiga *et al.*, 2013). Naturally occurring contaminants are present in the rocks and sediments and as groundwater flows through the sediments, metals such as Fe and Mn are dissolved and may be found in high concentrations in the water (Moyo, 2013; Rahman *et al.*, 2016; Miah *et al.*, 2019). In addition, human activities can modify the natural composition of groundwater through the disposal or dissemination of chemicals and microbial matter on the land surface and into soils, or through injection of wastes directly into groundwater. But unfortunately once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the source. Therefore, it becomes very important to regulate and monitor the quality of groundwater and to device ways and means to protect it (Mufid, 2012).

In Bangladesh most of the people think that ground water or water from tube wells is free from contamination. For this reason, hand pumped tube-well water is used as primarily source of safe drinking water in Bangladesh. Almost 90% of the households use this Hand pumped tube-well technology in Bangladesh (Emch *et al*., 2010). In rural area, most of the people

are depended on untreated groundwater and tube wells. But there is an estimation that about 11% of all deaths in rural areas of Bangladesh are caused by diarrheal disease (Streatfield *et al*., 2001). It has been reported that about 80% of all diseases and over one third of deaths in developing countries are caused by the consumption of contaminated water (WHO, 2012). Recent studies also suggest that persistent levels of diarrheal disease are caused in part by drinking untreated groundwater (Escamilla *et al*., 2011; Wu *et al*., 2011; Escamilla *et al*., 2013). Giving a special concern on this issue the study was undertaken to investigate water quality of the different sources of water in study areas and to compare the regional variation among the quality of water.

Materials and Methods

Study area: To conduct the present study, four districts (Dhaka, Mymensingh, Gazipur and Rangpur) of Bangladesh were selected for water sampling.

Samples and measurement: A number of total 96 water samples, of which 32 form household, 32 from restaurant and 32 from governmental offices, were collected from the four study areas. The total 24 water samples were collected from each district and samples were collected from selected sampling points. Parameters of pH, electrical conductivity (EC), total dissolved solids (TDS), Iron (Fe^+), Lead (Pb), Phosphate (PO_4^{3-}), and Sulphate (SO_4^{2-}) were analysed using the standard water analysis methods (Table 1).

Table 1. Methods and Instruments for water quality measurement in the study.

Parameter	Analytical Methods	Instruments
pH		
EC	pH, EC and TDS Meter	Lutron WA-2015 PH/ORP,DO,CD/TDS METER
TDS		
Iron (Fe^+)	Atomic Absorption Spectrophotometric(Mono element hollow cathode lamp)	Atomic absorption spectrophotometer (AS-7000)
Lead (Pb)		
Phosphates (PO_4^{3-})	Spectrophotometric (PhosVer 3 and SulfaVer 4 method respectively; Powder Pillow Procedure)	Spectrophotometer (HITACHI U-2910)
Sulphates (SO_4^{2-})		

Note: Units for all parameters are mg^{-L} or ppm except pH and EC.

The parameters were measured in accordance with the standard methods.

Statistical analysis: To confirm the variability of data obtained and validity of results, all the data were subjected for the statistical analyses using software MS Excel 2016, SPSS. Geographical location was obtained with the help of GIS software. The obtained water quality was then compared with standard values which are prescribed in Bangladesh drinking water standard and World Health Organization (WHO) drinking water quality guidelines.

Results and Discussion

pH: The average values of pH obtained for household drinking water ranged from 7.2 to 7.5 whereas for water used in restaurant for drinking purpose ranged from 7.1 to 7.7 and for govt. office drinking water it was from 7.2 to 7.5 (Figure 1). In case of household drinking water, the pH values obtained for selected regions Dhaka, Mymensingh, Gazipur and Rangpur were 7.5, 7.5, 7.2 and 6.9 respectively among which the highest value was observed in Dhaka and Mymensingh. The highest value of pH found in drinking water used in restaurants of the selected region was obtained for Dhaka and it was 7.7. The values of pH for Mymensingh, Rangpur and Gazipur was 7.5, 7.4 and 7.1 respectively of which the lowest value was found in Gazipur. The figure also represents that, the pH value obtained for govt. office was highest in Dhaka district about 7.5 and for Gazipur, Mymensingh, and Rangpur the values were 7.3, 7.3, and 7.2, respectively.
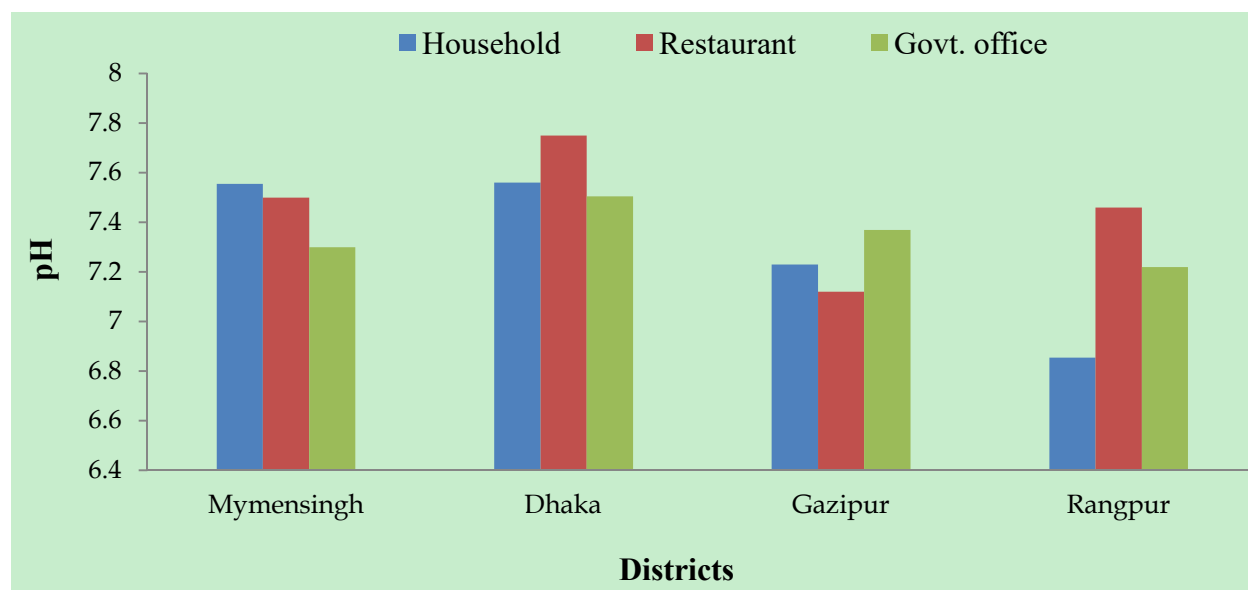

Figure 1. The average concentration of pH in different water sample of selected areas.

pH is most important in determining the corrosive nature of water. The lower the pH value higher is the corrosive nature of water. pH is also positively correlated with electrical conductance and total alkalinity (Gupta *et al*., 2009). In this study (Fig 2), the highest value of pH (7.8) was recorded in hotel and restaurant of Dhaka and the lowest value (6.9) was recorded in household drinking water of Rangpur. The highest, desirable and maximum permissible limit of pH for drinking water is ranged from 6.0 to 8.5 (EQS, 2004). So the pH obtained from all the tasted water samples were within the standard and suitable for drinking, however these were slightly falling under basic or alkaline range.

***Electrical conductivity (EC)*:** The following figure (Figure 2) represents the average values of Electrical Conductivity found in different water samples of different region selected for this present study. For household drinking water the highest concentration of EC was found in Rangpur district and it's about 723 μs/cm. The concentrations of EC found in household drinking water of other study region Dhaka, Mymensingh and Gazipur were 465, 680 and 572μs/cm

respectively. Similarly, the values of EC obtained from restaurant water was 430 μs/cm for Dhaka whereas for restaurant of Mymensingh, Gazipur and Rangpur it was 678, 554 and 612 μs/cm respectively among which the highest value was found for Mymensingh. In case of water of govt. office, the concentration found for EC was almost similar in Mymensingh and Rangpur and it was 680 μs/cm and for Gazipur and Dhaka the concentration was 573 and 465 μs/cm respectively.
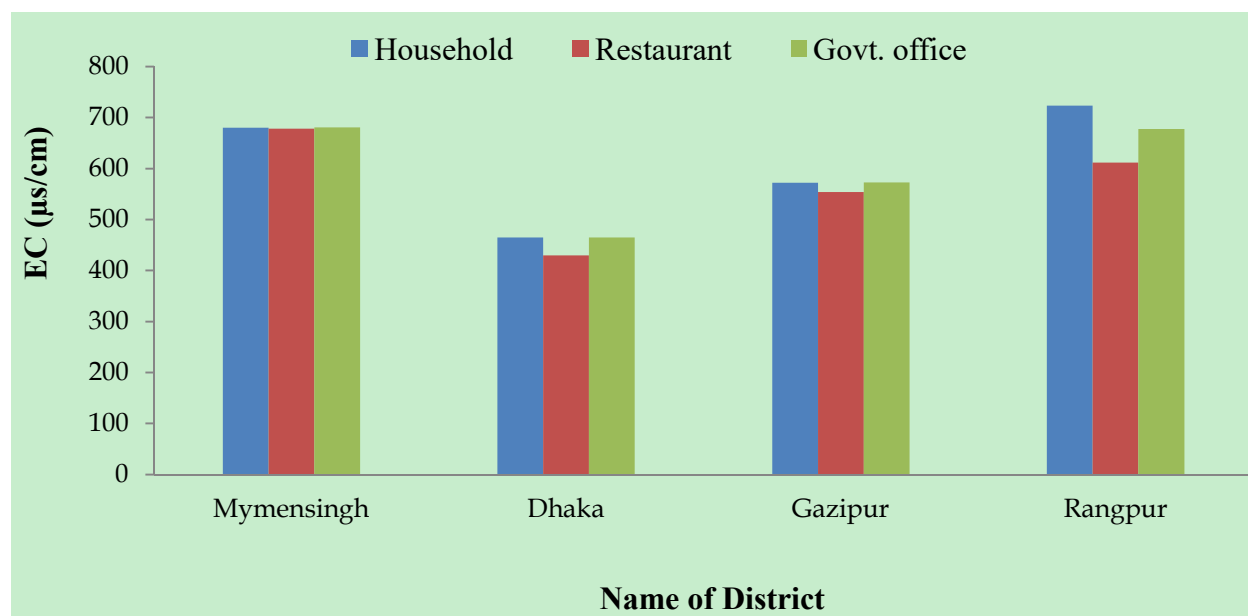

Figure 2. The average concentration of electrical conductivity (EC) of water collected from different districts.

Generally, the amount of Dissolved solids in water determines the electrical conductivity and an increase in ions concentration enhances the EC of water. It is reported that the water is soft, having a low electrical conductivity of 20-329 ms/cm (Alagbe, 2002). It is also reported that depth of the water table had a moderate negative geo statistical correlation with electrical conductivity (Losinno *et al*., 2002). In this study, the highest value of Electrical conductivity (723 μs/cm) was found at the household water sample in Rangpur and the lowest value (430μs/cm) was found at the Restaurant in Dhaka which was less than the maximum

acceptable limit, indicating the suitability for drinking purposes.

***Total dissolved solid (TDS)*:** In this study the maximum concentration of Total Dissolved Solid was 535 mg/L and the minimum of that was 180 mg/L (Figure 3). In case of household water, the highest concentration of TDS was found in Rangpur 462 mg/L whereas in Dhaka and Gazipur the concentration was almost similar around 430 mg/L and the lowest concentration was obtained from water samples of Mymensingh which was 201 mg/L. Similarly, for restaurant water the highest concentration was obtained in Dhaka 473 mg/L and the lowest was in Mymensingh

200 mg/L whereas for other district Gazipur and Rangpur it was 438 and 432 mg/L respectively. In govt. office the highest concentration of TDS in drinking water was observed in Rangpur 535 mg/L whereas the lowest was in Mymensingh 180 mg/L and in Gazipur and Dhaka the concentration was 458 and 450 mg/L, respectively. It is reported that the standard value of TDS for drinking water is 500 mg/L (ADB, 2004). The TDS values obtained from the tested water samples were within the standard except ones (Govt. office in Rangpur), indicating better quality of water for drinking. The study also supported by previous studies (Rahman *et al.*, 2016; Rahaman *et al*., 2004).
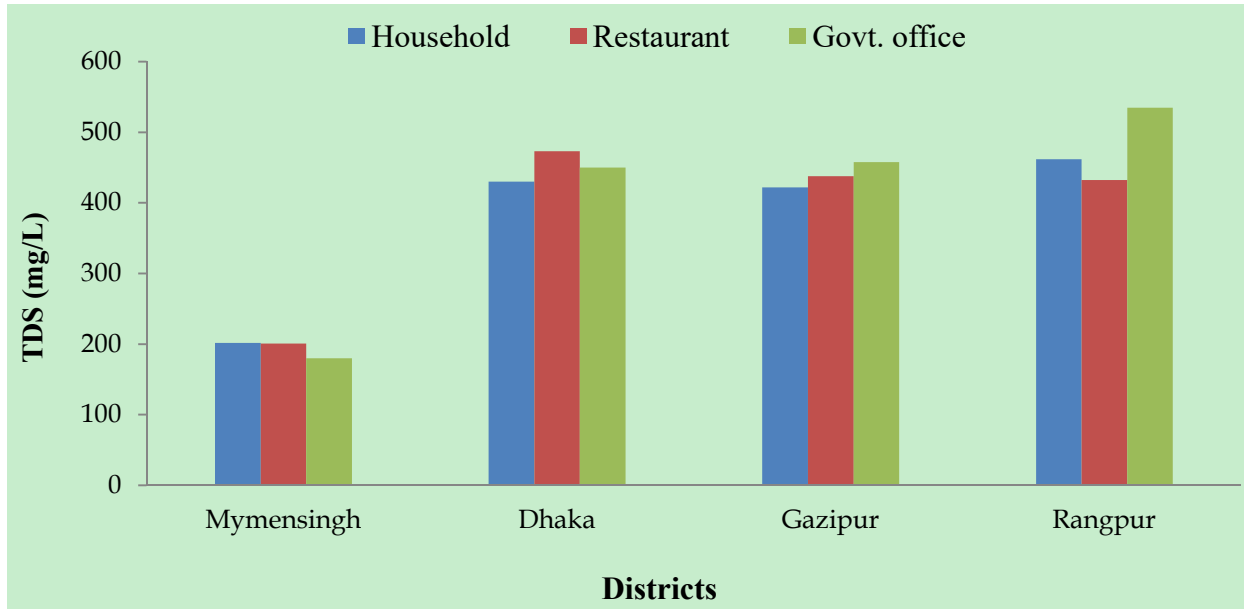

Figure 3. The average Total Dissolved Solid (TDS) concentration in different water sample of selected areas.

Metals quantification and other chemical assessment: In this study the presence of different chemical parameters including Iron, Sulphate, Phosphate and Lead in different water samples were analysed. Concentration of different chemical parameters obtained from the analyses of different water samples collected from selected regions are represented in Table 2.

Iron (Fe): Iron, familiar chemical elements found in almost all drinking water sources. The iron concentration obtained for different water samples ranged from 0.05 mg/L to 1.13 mg/L. In case of household water, the maximum concentration was found in Gazipur 0.84 mg/L and the lowest was in Dhaka whereas in Rangpur and Mymensingh the concentration was 0.75 and 0.57 mg/L respectively. Not only in water, Fe was also detected and determined in household dusts also in many research reports (Rahman *et al.*, 2016; Miah *et al.*, 2019). The concentrations of iron found in drinking water at restaurant of Dhaka, Mymensingh, Gazipur and Rangpur were 0.09, 0.63, 0.61 and 0.44 mg/L respectively the highest of which was observed in Mymensingh whereas for govt. office the concentration was 0.05, 0.31, 1.13 and 0.05 mg/L found in Dhaka, Myensingh, Gazipur and Rangpur, respectively. It is reported that the recommended concentration of iron for drinking water was 0.30 mg/L (Islam *et al.,* 2020; Rahman *et al.*, 2016). In this study the concentration recorded for iron (0.05 to 1.1 mg/L) was within BDS permissible limit but exceed the WHO guideline and

was similar to the concentration reported for iron at all sample sites in Bijoynagar in Bangladesh (Akter *et al.*, 2016). The BDS drinking water quality standard of iron 1.0 mg/L, but in this study the highest value of iron 1.1 mg/L which can be negligible. But it was mentioned that a value of about 1 mg/L can be derived from the provisional maximum tolerable daily intake established in 2010 WHO guideline as a precaution against storage in the body of excessive iron. So the water samples that contained iron higher than 1.0 mg/L is slightly harmful for drinking purposes.

Sulphate (SO$_4^{2-}$): The sulphate ion concentration was ranged from 0.05 to 1.6 mg/L in the present study. The highest concentration of sulphate for household drinking water was found in Gazipur 0.69 mg/L

whereas the concentration found in Dhaka, Mymensingh and Rangpur was 0.5, 0.09 and 0.62 mg/L respectively. In case of restaurant water the concentrations of sulphate found in Dhaka, Mymensingh, Gazipur and Rangpurwere 1.6, 0.12, 0.45 and 0.37 mg/L respectively, the highest of which was found in Dhaka whereas for govt. office the highest concentration was obtained from Dhaka and the lowest was in Mymensingh. According to the BSTI the standard limit of drinking water for sulphate is 4.00 mg/L. The sulphate concentrations found in all water samples in this study were within the BSTI standards and also within the WHO (2.50 mg/L) and EQS (4.00 mg/L) standards (WHO, 2012; EQS, 2004) indicating that it may not be harmful for human health and also use for drinking purposes.

Table 2. Chemical parameters of water samples collected from selected areas.

Drinking Water Sources	Selected Regions	Chemical Parameters			
		Iron (Fe)	Sulphate (SO$_4^{2-}$)	Phosphate (PO$_4^{3-}$)	Lead (Pb)
Household	Dhaka	0.05	0.5	0.46	-
	Mymensingh	0.57	0.09	0.4	-
	Gazipur	0.84	0.69	0.29	-
	Rangpur	0.75	0.62	0.04	-
Restaurant	Dhaka	0.09	1.6	0.40	-
	Mymensingh	0.63	0.12	0.3	-
	Gazipur	0.61	0.45	0.52	-
	Rangpur	0.44	0.37	0.07	-
Govt. office	Dhaka	0.05	1.05	0.45	-
	Mymensingh	0.31	0.05	0.45	-
	Gazipur	1.13	0.79	0.50	-
	Rangpur	0.50	0.62	0.06	-

Note: Units for all parameters are mg/L.

Phosphate (PO$_4^{3-}$): The concentration obtained for another parameters phosphate was different for different water samples of different region. In household water the highest concentration of phosphate was found in Dhaka (0.46 mg/L) and the lowest was in Rangpur (0.04 mg/L) and it other two region

Mymensingh and Gazipur it was 0.4 and 0.29 mg/L respectively whereas for restaurant water the highest concentration was observed in Gazipur (0.52 mg/L) and the lowest was in Rangpur (0.07 mg/L). Similarly, in govt. office the highest concentration was found in Gazipur (0.50 mg/L) which was very close to that of

Dhaka and Mymensingh (0.45 mg/L) and the lowest was found in Rangpur (0.06 mg/L). In Bangladesh the standard value of phosphate in drinking water is 1.96 mg/L. In this study the obtaining highest concentration was 0.53 mg/L and the lowest was 0.04 mg/L which is similar to that of phosphate found in different part of Bangladesh (Ghosh *et al*., 2015). So, the study revealed that the water quality is suitable for drinking purposes.

Lead (Pb): In case of lead, the acceptable limit for drinking water is 0.05 mg/L and the maximum allowable limit is 0.01 mg/L (WHO, 1972). But in this study, no value is obtained for lead from different water samples indicates the absence of the element. Pb also did not reported in drinking water by different studies (Rahman *et al.*, 2016; Islam *et al.*, 2018; Islam *et al.*, 2020).

Conclusion

This study was conducted to assess the physical and chemical properties of the drinking water collected from different selected area Dhaka, Mymensingh, Gazipur, and Rangpur district. It will help us in selection of right options to manage water sources also to find out the drinking water quality of selected area. In this study, physical properties of water such as pH, EC, TDS and chemical properties as Iron (Fe), Lead (Pb), Sulphate (SO_4^{2-}) and Phosphate (PO_4^{3-}) were analyzed. The experimental results reveals that pH values recorded at different sampling sites ranged from 6.9 to 7.8 and EC values ranged from 430 µs/cm to 723 µs/cm whereas the values of TDS ranged from 180 mg/L to 535 mg/L. In terms of chemical parameters, concentration of Fe found in water samples were ranged from 0.05 to 1.1 mg/L. Similarly the concentration of sulphate (SO_4^{2-}) ranged from 0.05 to 1.6 mg/L and for phosphate (PO_4^{3-}) concentration it was from 0.04 to 0.53 mg/L whereas Pb was totally absent in all analysed water samples. In this present study, the values reported for all of those parameters, found in analyzed water samples were within permissible limits except household drinking water of

Gazipur (excessive Fe) and drinking water used in Govt. office of Rangpur (high TDS). So, it can be concluded that the water used in these selected region is overall suitable for drinking purpose.

Acknowledgements

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