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Assessment of drinking water quality using physico-chemical parameters around Islamic University, Kushtia, Bangladesh

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Abstract

The quality of surface water is a very sensitive issue and it is a great environmental concern worldwide. In recent years, there has been an increase in awareness and concern about water pollution across the globe. In order to ascertain water quality for human consumption, some physico-chemical properties were evaluated of the drinking water of ten villages around Islamic University, Kushtia, Bangladesh. Standard methods were used for determining physical and chemical characteristics of the water samples. As, Fe and Mn contents of the drinking water samples were also analyzed by atomic absorption spectrophotometer. The data showed the variation of the investigated parameter in water samples as follows: pH 7.65 to 8.76, Electrical Conductivity (EC) 280 to 750 µS/cm, hardness 120 to 550 mg/l as CaCO3, Total Dissolved Solids (TDS) 210 to 1380 mg/l, As 0.0 to 0.082 mg/l, Fe 0.039 to 2.03 mg/l and Mn 0.0 to 0.41 mg/l. The concentrations of testing parameters of all the drinking water samples were not keeping up the World Health Organization drinking water quality guideline and the Bangladesh Drinking Water Quality Standards.

Keywords: Drinking water; Physico-chemical parameters; Atomic absorption spectrophotometer; Metal ions; Water quality assessment

1. Introduction

Water is the most vital element among the natural resources, and is crucial for the survival of all living organisms [1]. Despite this fact, water pollution and freshwater depletion are the two main environmental problems in Asian region [2]. The economic burden of environmental degradation owing to water pollution is very huge in the Asia–Pacific region when it comes to restoring the quality of life and installing controls [3]. The surface water of the country is polluted from untreated industrial effluents and municipal wastewater, run off pollution from chemical fertilizers and pesticides, and oil and lube spillage in the coastal area from the operation of sea and river ports [4]. Water quality also depends on effluent types and discharge quantity from different type of industries, agrochemicals used in agriculture, and seasonal water flow and dilution capability by the river system [5–7]. Pollution control issues are relatively recent in Bangladesh. With few exceptions, the industries are not equipped with pollution control systems. With the advancement of industrialization, untreated wastes and highly toxic effluents, especially heavy metals and organic pollutants are discharged directly into the natural systems regularly that impair the quality of water, soil and sediments. The ministry of Environment and Forest reported that these effluents contain 10 to 100 times the allowable levels of pollutants permissible for human health [8]. They pollute our soils as well as groundwater. Once the ground water is polluted, it is virtually impossible to purify even for a highly technologically advanced industrial country and thereby endangering human health, aquatic lives and crop production. The effluents may contain heavy metal like Ni, Pb, Cr, Cu, Hg, Mn, Zn or Fe. Some of these are toxic to plants and some are toxic to both plants and animals [9]. Therefore, chemical properties of water carried great importance for assessing the quality of water and its suitability for drinking and any other purposes.

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According to our literature review, no report has been published concerning the trace metal ions of these areas. Therefore, the main objectives of this study are to present the current physico-chemical properties and metal status of the drinking water of ten villages around Islamic University, Kushtia, Bangladesh.

2. Material and methods

2.1. Sample Collection

The drinking water samples were collected in prewashed (with detergent, doubly de-ionized distilled water, diluted HNO_3 and doubly de-ionized distilled water, respectively) high density polyethylene (HDPE) bottles from ten different villages around Islamic University campus, Kushtia, Bangladesh. pH and electric conductivity (EC) of the samples were measured while collecting the samples. Two liters (one liter for the determinations of main ions and one liter for metal determinations) of each water sample was taken in duplicate at two different sampling periods approximately 1 month apart. The determinations of the major ions of the water samples were performed within one week after sample collection.

The samples were obtained directly from the water pump after allowing the water to run for at least 10 minutes. The samples for metal determinations were filtered through a Millipore cellulose membrane of 0.45 μm pore size and were stored in 1 liter HDPE bottles and acidified to 1% with nitric acid. These samples were subsequently stored at 4°C for as short a time as possible before analysis to minimize physicochemical changes.

2.2. Reagent and Solutions

Analytical grade reagent chemicals were employed for the preparation of all solutions. Freshly prepared double de-ionized distilled water, from a quartz still, was used in all experiments. Hydrochloric acid (5M), Sodium Borohydride reagent (0.6% $NaBH_4$ solution), Potassium Iodide (20%KI) solution as a reductant, Inert gas Argon (as a carrier gas) for HVG system (determination of As), Air-Acetylene as a fuel gas for direct flame system (determination of Fe and Mn), Commercial grade Standard solutions (CRM) of As, Fe, Mn solutions were used throughout the experiments.

2.3. Apparatus

Prior to analysis, all instruments were calibrated according to manufacturer's recommendations. pH was measured by using SensION™-MM340 digital meter. Conductivity was determined using an Electrical Conductivity meter CM-21 P. The meter was calibrated by using standard EC=1214 μs/cm. Determination of hardness was done by EDTA titrimetric methods. Atomic absorption spectrometer (Shimadzu-AA7000) equipped with deuterium background correction, double beam system were used for the analysis of Arsenic (Hydride Vapour Generated Method), Iron and Manganese (direct flame method).

2.4. Analysis for TDS and metal ions

Total Dissolved Solids were analyzed by the use of multimeter using respective standards solutions. Arsenic, Iron and Manganese were analyzed by Atomic Absorption Spectrophotometric Method. As(V) is reduced to As(III) using potassium iodide and sodium borohydride reagent to form arsine vapour and detect the total arsenic. Here inert gas argon is used as a carrier gas. On the other hand iron and manganese is analyzed by atomization process creating a flame by the combustion of air and acetylene gas (flame temperature nearly about 2200°C).

3. Results and discussion

3.1. Physical and Chemical Properties of the Samples

The main physical and chemical properties of the drinking water samples including pH, electrical conductivity, hardness and Total Dissolved Solids (TDS) from different water samples were given in Table-1. For drinking water to be considered of good quality, the pH level should be in the 6.5 to 8.5 range, as advised by the WHO (2017) [10], and the Bangladesh drinking water standard (BDWS) [11] (Table 3). Therefore, compatible drinking water should have approximately neutral characteristics. In this study, the pH values in the range of 7.65 to 8.76 (lowest in Shekhpara and highest in Bashantopur).

Electrical conductivity is the indication of the total dissolved substituent in water. The compounds that are dissolved into ions are called electrolytes, whereas different salts, organic and inorganic materials such as alkalis, chlorides, sulfides, and carbonates provide these ions with the ability to carry electric conductivity. The EC differs from pH in that it represents all active ions (negative and positive) in the water, while pH measures only the hydrogen (H^+) and hydroxyl (OH^-) ions. Pure and standard water indicates very low EC, i.e., low dissolved contaminated ions [12]. However, in this investigation, all samples exceeded the recommended EC value of 250 µS/cm (Table 3), where the highest and lowest values were 750 µS/cm (Ananda Nagar) and 280 µS/cm (Bashantopur), respectively. These high values meant that the water was not of good quality and contained many dissolved impurities.

The hardness of water is due to Ca and Mg ions, originating from the soil, rock, sediment, and minerals. Both low and high values of hardness are harmful to the human body. A low value may cause colon carcinogens and rectal cancer [13] and cardiovascular disease [14] to appear since Ca and Mg can bind bile acid and fatty acid, thus affecting the creation of colon mucosa [13]. However, several years ago, the WHO demonstrated that a high value may cause kidney stones and skin diseases such as eczema [15]. The provisional limits of hardness are 200 and 500 mg/L provided by the WHO [10] and the BDWS [11], respectively. Only four samples fell within the WHO-recommended limit of 200 mg/L, while six samples exceeded the safe level. In addition, the hardness of water in the villages ranged between 120 and 550 mg/L. TDS indicates the wide range of inorganic and organic minerals or various salts such as K, Ca, Mg, Na, Al, HCO_3^-, Cl^-, and SO_4^{2-} and several trace metals that are dissolved in water. High TDS could cause kidney stones, gall stones, blockage of arteries, heart disease, either a laxative or constipation effect, and potentially cancer [16]. The Total Dissolved Solids (TDS) of the samples were in the range of 210 to 1380 mg/L. Here approximately 80% of water samples were in the range of the prescribed value by the WHO (600–1000 mg/L) and the BDWS (1000 mg/L) (Table 3).

Table 1 The physical and chemical properties of drinking water samples

Sampling Location	pH	EC (µS/cm)	Hardness (mg $CaCO_3$/l)	TDS (mg/l)
Shekhpara	7.65	300	550	1380
Corpara	8.41	456	250	350
Ananda Nagar	8.03	750	200	443
Ramchandapur	8.52	475	210	330
Tribeni	8.70	467	210	391
Choto Boyalia	8.62	442	120	210
Jontu Nagar	8.53	650	150	590
Bashantopur	8.76	280	130	378
Modondanga	8.15	520	450	1250
Shantidanga	8.30	450	250	557

3.2. Trace metal ions

Table 2 The concentrations of trace metal ions in drinking water samples

Sampling Location	As (mg/L)	Fe (mg/L)	Mn (mg/L)
Shekhpara	0.07	1.28	0.30
Corpara	0.01	0.069	0.0
Ananda Nagar	0.03	2.03	0.15
Ramchandapur	0.041	0.039	0.09
Tribeni	0.0	0.97	0.41
Choto Boyalia	0.082	0.22	0.06
Jontu Nagar	0.051	0.21	0.0
Bashantopur	0.025	0.12	0.12
Modondanga	0.039	1.25	0.20
Shantidanga	0.0	0.29	0.10

The drinking water samples collected from the ten water points around Islamic University campus, Kushtia, Bangladesh were analyzed by atomic absorption spectrometry in triplicate to determine arsenic, iron and manganese. The concentrations are given in Table-2.

The lowest level of Arsenic was detected in Tribeni and Shantidanga (0.0 mg/L) while the highest level in Choto Boyalia as 0.082 mg/L. Bangladesh standards for drinking water quality of arsenic is 0.05 mg/L but WHO guideline is 0.01 mg/L. So, as it can be seen in Table-3, in the locations Ananda Nagar, Ramchandapur, Bashantopur and Modondanga permitted the Bangladesh standards for drinking water guideline but do not WHO guideline.

Table 3 Comparison of observed value with its standard value provided by different organizations

Parameters (unit)	This study	Water quality standard	
		WHO (WHO 2017)	BDWS (ECR 1997)
pH	7.65 – 8.76	6.5 – 8.5	6.5 – 8.5
EC (µS/cm)	280 – 750	250	-
Hardness (mg CaCO3/l)	120 – 550	200	500
TDS (mg/l)	210 – 1380	600 – 1000	1000
As (mg/l)	0.0 – 0.082	0.01	0.05
Fe (mg/l)	0.039 – 2.03	0.3	0.3 – 1.0
Mn (mg/l)	0.0 – 0.41	0.4	0.1

WHO, World Health Organization; BDWS, Bangladesh drinking water standard

The highest iron level was found in Ananda Nagar as 2.03 mg/L and lowest in Ramchandapur as 0.039 mg/L. Regarding iron, it can be seen that four water points out of ten exceeded the Bangladesh Drinking Standards as well as WHO Standards (Table-3).The highest manganese concentration was detected in Tribeni as 0.41 mg/L and lowest in Corpara as 0.0 mg/L. The acceptable limit of Manganese in Bangladesh is 0.1 mg/l. So, five water points out of ten containing higher than the BDS guideline value.

4. Conclusion

From the above discussion we can conclude that the people of Bangladesh are living with a danger of drinking water. Hence we need to adapt steps to cope the problems. Being a responsible citizen of Bangladesh we should make awareness to the people about harmfulness of heavy metals present in drinking water and inspire community people about sharing of safe drinking water.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that no conflict of interest exists.

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