Food Research 8 (6) : 216 - 224 (December 2024)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

RESEARCH PAPER

Assessment of physicochemical quality and microbiological safety of jar drinking water marketed in Dhaka City, Bangladesh

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Article history:
Received: 8 October 2022
Received in revised form: 24 December 2022
Accepted: 28 February 2024
Available Online: 6 December 2024

Keywords:
Drinking water,
Physicochemical quality,
Microbial safety,
Escherichia coli,
Salmonella spp.,
Dhaka City

DOI:
https://doi.org/10.26656/fr.2017.8(6).496

Abstract

Safe drinking water is necessary for optimum health, but a sufficient supply of safe drinking water is challenging in the twentieth century, particularly in highly populated cities like Dhaka. Due to the lack of fresh natural resources of potable water and the higher price of the commercially marketed mineral water bottle, many consumers prefer relatively lower-cost jar drinking water. However, the physicochemical properties and the safety of these jar-drinking waters are largely unknown. This study aimed to assess the physicochemical characteristics and microbiological safety of jar drinking water marketed in Dhaka City. Water samples from fifty different jar water sellers were collected and examined for different chemical quality parameters and microbiological safety using standard procedures and all test results were compared to water quality standards provided by the World Health Organization (WHO) and Bangladesh Standard and Testing Institution (BSTI). Heterotrophic plate count and coliform count were performed on different agar media and biochemical experiments were performed for the characterization of bacterial isolates. This research found that the total hardness, pH, total dissolved solids, electrical conductivity, and chloride content of the majority of the water samples were determined to be within acceptable limits. However, a large number of samples (88%) were found to be above the acceptable range for calcium and magnesium hardness, and approximately 33% of samples had greater levels of inorganic iron than the recommended limit. A total of 34 (68%) out of 50 samples exceeded the safety limit of heterotrophic bacteria whereas a total of 18 (36%) samples were found contaminated with coliform bacteria (ranges 3 to 29 CFU/100 mL). Biochemical experiments revealed another concerning fact, 14% of water samples were found positive for *Escherichia coli* and 6% was *Salmonella* spp. The findings of the study showed that the majority of the jar drinking water samples obtained throughout Dhaka City was not safe as per the standard provided by the WHO and/or BSTI. Therefore, these jar drinking waters can be a source of significant public health threat.

1. Introduction

Water is a natural resource and the most essential fluid for sustaining life on the earth. As a most vital liquid, the oceans contain about 97% water and are not fit for drinking, and the remaining 3% of fresh water is suitable for drinking. Of 3%, about 2.97% is contained by ice caps in the high mountain and glaciers, and the rest of the small part of 0.3% is existing as underground and surface water for drinking purposes and human use (Mohsin *et al*., 2013). It is challenging to ensure safe drinking water for people all over the world. At present, groundwater is the main source of potable water in rural and urban areas, but due to the increase in population, the source of groundwater reduces drastically.

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eISSN: 2550-2166
Published by Rynnye Lyan Resources

Groundwater is also utilized for irrigation and industrial uses. But due to the increasing population and climate change, the physicochemical and other health hygienic properties of water become abnormal and make water unfit for drinking and other household and industrial use (Dhiviyaa *et al.*, 2011).

Due to the lack of fresh water, on a global scale, potable is one of the main sources of drinking water, especially in cities over the world. The groundwater represents the major source of potable water which is treated commercially for human consumption (Adeloju *et al.*, 2021). Therefore, about 1.5 billion people use potable groundwater worldwide daily (Palamuleni and Akoth, 2015). However, due to the cost-affecting factor, many consumers prefer jar drinking (relatively low cost) water from the ground or underground water source. Although the safety of jar drinking water which has been processed locally is still being investigated. Water containing chemical residue higher than the recommended safety value provided by the WHO as well as other local and international bodies is responsible for inducing different unfavorable physiological conditions for a person and even, sometimes, may cause abdominal irritability (Bharati and Bharati, 2013). A previous study showed that water with excessive dissolved solid content may cause constipation (Aichbichler *et al*., 1998). Among different physicochemical parameters of water quality pH, hardness, alkalinity, TDS (TDS), iron, magnesium, and residual nitrate play an important role in water acceptability. Not only physicochemical parameters but the microbiological quality of water is also very important. More people are dying from drinking contaminated water than from war and all forms of violence worldwide per year. WHO (2008) reported that contagious diseases caused by water-borne pathogenic bacteria result in about 26% of all deaths worldwide.

Moreover, drinking water-associated diseases such as diarrhea, cholera, typhoid fever, and dysentery is more common, especially in developing countries. These diseases pose a serious threat to the people WHO do not have access to potable water (Fenwick, 2006). In terms of the microbiological aspect, drinking water should be free from any kind of pathogens as well as opportunistic microflora. Water with physical, chemical, and microbial characteristics that comply with the WHO guidelines of the standard on drinking water quality is defined as safe drinking water (Cotruvo, 2017).

Safe drinking water is highly necessary for a healthy life. However, nowadays in Dhaka City, safe drinking water is somewhat scary, in particular, for people who drink from a roadside tea stall, restaurant, or tap water supplied by the local water supply authority. People, especially when they are away from home or eat out cannot rely on normal tap water and drink commercial mineral PET drinking water and/or jar drinking water. But in most cases, many people prefer jar drinking water rather than commercially available mineral PET drinking water considering the low price, affordability, and availability of jar water. The current study aimed to determine the safety and quality of jar drinking water around Dhaka City, Bangladesh.

2. Materials and methods

2.1 Sample collection

A total of fifty jar drinking water samples were randomly collected from different street vendor shops, tea stalls, food shops, and restaurants of both downtown/ Metropolis areas of Dhaka City. Samples were collected in a pre-sterilized screw cap test tube, and collected samples were labeled and transported to the laboratory (Sanders, 2012) of the Department of Food Technology and Nutritional Science, Mawlana Bhashani Science and Technology University for further physicochemical and microbial analysis.

2.2 Analytical method for determining physicochemical properties

The total dissolved solids (TDS), electrical conductivity (EC), and pH of the collected samples were determined at room temperature by using a digital pH meter (HANNA-HI-22091), EC/TDS meter (HANNA-HI-2300) by the direct method based on a previous study (Choure *et al.,* 2021). Total hardness (TH), calcium, and magnesium were analyzed by the direct titrimetric method provided by previous work (WHO, 1999). Spectrophotometric determination was used to determine the iron content in drinking water samples (Kassem and Amin, 2013). Total alkalinity, chlorine, nitrate content, and turbidity were analyzed according to the previous study (Kassem and Amin, 2013).

2.3 Analytical method for microbial analysis

2.3.1 Media and chemicals used in microbial analysis

Nutrient agar was used to determine the heterotrophic plate count (HPC), MacConkey agar was used to assess the total coliform count (TCC), and potato dextrose agar (PDA) was used to check the total fungal count of the collected jar drinking water samples (Environment Agency UK, 1992). Rappaport-Vassiliadis (RVS) broth and MacConkey broth were used for primary enrichment and isolation of *Salmonella* and *E. coli* respectively. *Salmonella Shigella* agar and Eosin Methylene Blue agar were used to detect and differentiate *Salmonella* and *E. coli* separately (Karim *et*

https://doi.org/10.26656/fr.2017.8(6).496

al., 2020).

2.3.2 Sterilization of media and equipment

To ensure effective sterilization, glassware was subjected to dry heat sterilization at 170-185℃ by using an oven (Model no: JSON-050, Korea). Growth media and other heat-sensitive equipment were sterilized by using an autoclave (Model no: JSAC- 50, Korea) at 121℃ for 15 mins.

2.3.3 Determination of heterotrophic plate count, total coliform, and total fungal count

Approximately 10 mL samples were ten-fold serially diluted in 0.9% lab-grade NaCl solution. Every 1 mL of the diluted homogenate was plated onto Petri-dish containing liquid nutrient, MacConkey, and potato dextrose agar (Mohammadi-Gouraji *et al*., 2019). The sample was uniformly distributed by a gentle clock and antilock-wise moving. Nutrient agar and MacConkey agar media were subjected to incubation at 37℃ for 24 hrs and PDA was incubated at 25℃ for 5 days. Separate and visible colonies were counted using a digital colony counter (SC6 Digital Colony Counter, Stuart) and results were expressed as CFU/mL (Nabi *et al*., 2016).

2.3.4 Biochemical test

The bacterial isolates from the water sample were characterized by their colony biochemical as well as morphological properties. In this study, different types of microorganisms present in water samples were also identified. For this purpose, different types of bacterial colonies were isolated in pure culture from the SS agar, MacConkey agar, EMB agar, and plate count agar (PCA) for their primary identification followed by the methods explained by the earlier researcher (Faruque *et al*., 2019). After that standard biochemical reactions were carried out for the final verification of presumptively identified bacterial isolate from the water sample according to Bergey's Manual Determinative Bacteriology. Different types of biochemical tests eg-Kligler Iron agar (KIA), citrate, Motility-Indole-Urease (MIU), mannitol, catalase, glucose, Voges Proskauer (VP), starch, Methyl Red (MR), oxidase, lactose, were performed for each well isolated particular colony of presumptive bacteria (Ali *et al.,* 2021).

2.4 Statistical analysis

The statistical package SPSS 20.0 (IBM, USA) was used for Pearson bivariate correlation analysis to evaluate the correlation among the physicochemical parameters of water. P-value < 0.05 was considered statistically significant.

3. Results and discussion

3.1 pH

Among other parameters of potable water, pH is the most relevant operative quality component. The WHO did not provide any direct health-based guideline value for pH in drinking water. However, extreme or lower pH can be corrosive to the equipment and distribution system, and hence failure to control corrosion has adverse effects on the taste and appearance of drinking water (Cotruvo, 2017). In the present study, 4 samples (8%) were found to be out of the acceptable limit according to Bangladesh Standard Specification for drinking water (Table 1). According to BDS 1240:2001 (Table 2), the local recommendation for pH in drinking water is 6.4-7.4 (Towhid, 2018). The PH of the water depends on the present hydrogen ions in the water. The PH level of water sometimes may vary (slightly high or low) due to the presence of other ions or salts that directly interact with H^+ ions. In our study, the reasons for slight PH variation were not directly investigated, but the obtained results (presence of different ions) suggested that the presence of some metal (Ca, Mg, Cl, Fe) or functional group (Nitrate) may affect the value of PH.

3.2 Total hardness

TH mainly expresses the aggregated ionic concentration of calcium (Ca^{2+}) and magnesium (Mg^{2+}) in the drinking water. Depending on the score of water hardness, water is classified as soft water (TH: < 75mg/L), moderately hard water (TH: 75-150 mg/L), hard water (TH: 150-300 mg/L), and very hard water (TH: > 300 mg/L) (Sawyer *et al.,* 2003). Very soft water is nearly flat in calcium, magnesium and other important minerals and this type of water is not beneficial for consumption. Prolonged consumption of very soft water detracts from the minerals that are already present in the body (Van Der Aa, 2003). Water containing extremely high minerals (Hardness > 500 mg/L) is not suitable for drinking, since a high concentration of minerals can be deposited inside the organ and can be a factor for kidney and gallbladder stones (Garzon and Eisenberg, 1998). In the present study, the minimum value of the TH of the jar drinking water sample is 41.03 mg/L whereas the maximum value is 112.03 mg/L. Among 50 jar drinking water samples, 24 samples (48%) were found to be soft and another 26 samples (52%) were found to be moderately hard (Table 1). Department of Public Health and Engineering, Government of Bangladesh recommended the acceptable range of TH that is 100-300 mg/L (Towhid, 2018). On the other hand, according to BDS 1240:2001, the optimum value of TH in manufactured potable water in a Polyethylene Terephthalate (PET) bottle should not exceed 300 mg/L (Table 2). All samples are found within the BDS

https://doi.org/10.26656/fr.2017.8(6).496

Table 1. Physical-chemical properties of jar drinking water samples.

Sample No.	pH	TH (mg/L)	Ca (mg/L)	TDS (mg/L)	Total Alkalinity (mg/L)	Cl (mg/L)	Fe (mg/L)	EC (µS/cm)	Nitrate (mg/L)	Mg (mg/L)
1	6.68	108.74	65.93	191.27	19.53	35.33	0.14	335.84	0.20	42.80
2	6.42	106.17	64.67	188.30	20.17	31.87	0.20	331.49	0.27	41.50
3	6.87	48.20	29.43	105.17	12.10	15.30	0.03	185.02	0.38	18.77
4	6.73	96.60	59.90	172.20	20.17	9.43	0.33	302.46	3.33	36.70
5	6.93	89.77	58.43	165.30	18.13	14.33	0.33	291.13	3.32	31.33
6	6.70	107.87	59.40	189.30	16.23	30.23	0.10	332.40	0.31	48.47
7	6.88	47.90	25.13	74.33	10.20	10.43	0.03	131.23	0.28	22.77
8	6.77	47.07	21.20	103.50	10.00	14.33	0.01	183.54	0.46	25.87
9	6.98	95.40	54.20	169.40	19.83	8.27	0.32	299.82	3.51	41.20
10	6.68	94.73	56.30	166.37	18.30	11.47	0.36	293.58	3.46	38.43
11	6.70	108.40	70.07	192.43	20.13	34.17	0.13	339.38	0.36	38.33
12	6.77	72.47	60.20	105.33	12.20	10.17	0.02	182.40	0.54	12.27
13	6.93	95.30	57.33	169.33	17.30	17.37	0.34	298.19	3.70	37.97
14	6.98	95.00	55.63	171.53	18.23	21.30	0.40	299.85	3.47	39.37
15	6.66	47.53	19.40	103.33	10.33	12.30	0.03	184.03	0.53	28.13
16	6.96	46.33	23.57	99.33	9.13	7.31	0.02	174.35	0.38	22.77
17	6.98	72.27	56.23	135.30	15.30	15.30	0.29	237.48	3.83	16.03
18	6.95	112.03	62.30	201.27	22.17	38.20	0.17	353.26	0.33	49.73
19	6.86	54.30	24.23	115.50	14.20	16.33	0.03	205.73	0.47	30.07
20	6.98	63.23	55.33	180.53	22.27	12.33	0.47	316.87	4.02	7.90
21	7.00	108.97	69.67	191.90	19.87	33.30	0.20	336.82	0.25	39.30
22	6.67	44.07	21.40	92.43	11.30	13.27	0.03	162.24	0.63	22.67
23	6.67	50.30	19.63	105.87	12.20	8.97	0.03	183.40	0.84	30.67
24	7.00	88.10	56.20	160.33	18.13	11.43	0.53	281.42	2.83	31.90
25	6.86	89.77	55.30	137.12	17.39	28.64	0.25	297.23	1.56	37.89
26	6.82	107.97	71.80	190.23	20.33	34.23	0.17	333.90	0.18	36.17
27	7.02	47.57	19.33	103.37	11.70	5.60	0.03	181.43	0.65	28.23
28	7.03	42.87	25.33	98.43	9.60	12.37	0.05	173.74	0.34	17.53
29	7.02	76.47	54.17	149.33	16.23	10.30	0.61	262.11	3.62	22.30
30	6.57	75.60	49.43	147.33	15.23	9.50	0.84	258.60	3.27	26.17
31	6.45	107.90	64.20	190.30	20.10	34.63	0.19	334.02	0.22	43.70
32	6.65	41.03	28.33	90.23	9.53	10.83	0.08	158.38	0.36	12.70
33	6.26	71.10	55.33	130.47	13.20	6.33	0.77	229.00	5.17	15.77
34	6.46	68.03	51.60	125.67	13.50	5.47	0.98	224.70	2.80	16.43
35	7.03	110.57	67.40	135.27	15.20	29.37	0.18	237.42	0.14	43.17
36	6.88	105.57	73.60	187.30	18.20	32.27	0.13	328.75	0.36	31.97
37	6.53	50.50	24.37	109.33	12.27	8.50	0.03	191.90	0.54	26.13
38	6.59	65.37	56.30	119.37	15.47	11.37	1.01	209.51	3.40	9.07
39	6.64	67.67	49.67	123.80	16.47	10.33	0.66	218.08	5.00	18.00
40	6.42	106.73	61.37	189.40	20.23	24.30	0.25	332.44	0.21	45.37
41	6.40	45.50	25.27	99.97	11.30	14.23	0.02	175.46	0.28	20.23
42	6.43	48.47	21.80	105.10	12.33	7.40	0.03	184.47	0.48	26.67
43	6.50	95.60	51.37	170.37	18.40	12.27	0.34	299.03	3.13	44.23
44	6.39	96.30	49.47	172.47	19.55	13.27	0.03	302.71	3.43	46.83
45	6.83	103.23	62.33	184.40	20.27	28.20	0.19	323.66	0.23	40.90
46	6.53	45.73	24.40	105.40	12.07	17.37	0.03	182.53	0.35	21.33
47	6.60	87.53	55.43	156.33	17.57	15.53	0.08	274.40	3.57	32.10
48	6.68	42.70	19.50	95.33	10.67	6.30	0.03	167.33	0.53	23.20
49	6.36	45.77	25.30	100.17	11.53	2.27	0.06	179.99	0.64	20.47
50	6.86	94.37	38.93	169.07	19.50	14.33	0.87	296.75	4.23	55.43

https://doi.org/10.26656/fr.2017.8(6).496

1224:2001 standard, respectively.

3.3 Calcium and magnesium

The presence of calcium and magnesium may affect the acceptability of drinking water, however, no health-based guideline value for these two minerals has been proposed by the WHO. The taste point for calcium ions varies from 100 to 300 mg/L and the taste threshold for magnesium is probably lower than for calcium (Cotruvo, 2017). In the present study, the score of Magnesium ions detected in the jar drinking water samples ranges from 30.44 to 55.43 mg/L. Among 50 samples, 20 samples (40%) were found above the maximum range, 24 samples (48%) were below the normal range and the rest of the 6 samples (12%) were within the acceptable limit (Table 1). From Table 2, according to BDS 1240:2001 and DPHE, Bangladesh, an acceptable limit for calcium ions is ≤ 75mg/L. The current results show the maximum and minimum values of calcium ions are 73.60 mg/L and 19.37 mg/L. Magnesium is present in groundwater usually at a lower extent than calcium. According to the DPHE, Bangladesh, an acceptable range for magnesium ions in drinking water is 30-35 mg/L. Rahman *et al.* (2013) reported that Minerals like magnesium, potassium and calcium were present in some cases in such a low concentration in bottled water collected from retail shops and food shops beside the University of Dhaka.

3.4 Electrical conductivity and total dissolved solids

The EC of collected jar drinking water samples ranges from 131.23-353.26 µS/cm. Variation in the EC value may be due to variations in the geographical location, type of water, and finally mineral content in the water samples. According to the US-EPA, the EC of potable water should be 2500 µS/cm at 20°C. In the current study, all samples are within the recommended value.

Different inorganic salts notably calcium, magnesium, sodium, sulfates, and organic matter which are dissolved in the water are called TDS. No health-based guideline values regarding the TDS of drinking water have been found (Cotruvo, 2017). Although, TDS content in drinking water affects its acceptability of drinking water (Choure *et al.,* 2021). Experts classify the drinking water based on dissolved ions present in the water into the following categories: unacceptable (1200 mg/L), poor (900-1200 mg/L), fair (600-900 mg/L), and good (300-600 mg/L) and excellent (< 300 mg/L). From Table 1, all 50 samples fall under the excellent category. Moreover, all the jar drinking water samples were within the acceptable range determined by the BDS 1240:2001 and DPHE, Bangladesh.

3.5 Total alkalinity

Water alkalinity is the measurement of the buffering capacity of water. The alkalinity of all collected samples ranged from 9.13 to 22.27 mg/L (Table 1). No health-based guideline value has been demonstrated by the WHO regarding the alkalinity of drinking water. Alkalinity is the dissolved minerals, especially carbonate, bicarbonate, and sulfate and they are beneficial for our health when consumed within the limit of 20–200 mg/L (Segun and Raimi, 2021).

3.6 Chloride

Excess chloride in drinking water brings a salty taste. Additionally, high chloride in the water results in corrosion of the distribution system (Cotruvo, 2017). The minimum concentration of chloride ion in the collected sample was 2.27 mg/L, while the maximum value was 38.20 mg/L (Table 1). BDS 1240:2001 and US-EPA recommended acceptable range of chloride in potable water is ≤ 200 mg/L (Table 2). All the samples are within the normal range of chloride ions.

3.7 Iron

Iron is an abandoned metal in the earth and may be found in drinking water ranging from 0.5 to 50.0 mg/L. It is an essential nutrient for humans and the requirements for iron vary from 10 to 50.0 mg/L

Table 2. Physicochemical parameters of drinking water according to the BDS 1240:2001, DPHE and WHO.

Parameters	Units	BDS 1224:2001	DPHE	WHO	EPA
pH	-	6.4 - 7.4	-	6.5 - 8.5	≥ 6.5 and ≤ 9.5
Total Hardness (TH)	mg/L	≤ 300	200 - 500	-	-
Calcium Hardness	mg/L	≤ 75	75	-	-
Magnesium Hardness	mg/L	-	30 - 35	-	-
Total Dissolved Solids (TDS)	mg/L	≤ 500	1000	-	-
Total Alkalinity (As $CaCO_3$)	mg/L	-	-	-	-
Chloride	mg/L	≤ 250	150 - 600	-	250
Total Iron	mg/L	≤ 0.3	0.3 - 1.0	-	0.2
Electrical Conductivity (EC)	µS/cm	-	-	-	2500 at 20°C
Nitrate	mg/L	≤ 4.5	10	≤ 50	≤ 50
Turbidity	NTU	≤ 5	10	-	-

*According to Towhid (2018)

depending on age, sex, physiological status, and bioavailability of iron (Gassmann, 1991). Like chloride, the WHO has not provided direct health-based guidelines for the optimum range of Iron in drinking water. The BDS 1240:2001 recommends the iron level is 0.3 mg/L in drinking water (Table 2). Again, according to DPHE, the acceptable iron limit in potable water is 0.3 to 1.0 mg/L. In the current study, 34 samples (68%) are within the drinking water standard of Bangladesh. On the other hand, all but one sample is within the approved limit of DPHE, Bangladesh.

3.8 Nitrate

The typical sources of nitrate in drinking water include wastewater treatment, agricultural activities (manure and inorganic fertilizers), discharges from motor vehicles and industrial processes, and nitrogenous wastes from humans (Keeney and Hatfield, 2008). Excess doses (67 to 833 mg/kg BW) of nitrate in potable water sometimes may cause methemoglobinemia ("blue baby" syndrome). The nitrite is converted from nitrate, which reacts with hemoglobin in the blood resulting in a reduced availability of the blood to bind oxygen (Boink *et al.,* 1999). The Environmental Protection Agency (EPA) of the United States and the WHO suggested the safe limit of nitrate in drinking water must be less than 50 mg/L. As mentioned in BDS 1240:2001, the approved mark of nitrate in drinking water manufactured and marketed inside the local market of Bangladesh should be below 4.5 mg/L. Among the collected jar drinking water samples, 2 samples have been found above the approved value of BDS 1240:2001.

3.9 Correlation between different parameters of drinking water

Table 3 shows the Pearson correlation between different physicochemical properties of drinking water samples. The correlation coefficient denotes the interrelationship between water quality indices. Strong positive correlations were observed between TH and calcium (0.906), TDS (0.935), alkalinity (0.881), chloride (0.720), EC (0.935), and Mg (0.766). A previous study in South Gujrat, India reported more or less the same correlation among the water quality parameters that support our current study (Shroff *et al.,* 2015). On the other hand, calcium and total iron (0.375), magnesium (0.422); alkalinity and total iron (0.371), and nitrate (0.422) are moderately correlated. All the parameters show a weak correlation with pH.

3.10 Microbial test parameters

The microbial test result of collected jar drinking water samples is illustrated in Table 4. Total coliform is one of the crucial water quality and safety indicators. Additionally, HPC is also used to evaluate the common microbial quality of drinking water (Sharmin *et al.,* 2013). In the current study, a total of 18 (36%) samples are found contaminated with coliform bacteria. Among them, sample no. 24 contains the highest coliform count (29 CFU/100 mL) and for other samples, the coliform count was within 3 to 29 CFU/100 mL (Table 4). According to WHO as well as all the local and international standards for drinking water quality, coliform bacteria must be absent per 100 mL of drinking water (Cotruvo, 2017). HPC is present in 47 (86%) drinking water samples (ranges from 0.01×10^4 to 5.8×10^4 CFU/mL). According to the Bangladesh Standard for drinking water, the HPC should be less than 1000 CFU/mL (Akond *et al.,* 2009), but this study found (68%, n = 34) was beyond the safety limit of HPC according to BDS-1240 (Table 4). A previous study also revealed that most of the tested water samples were loaded with microorganisms beyond the recommended limit (Sharmin *et al.,* 2013).

3.11 Enumeration of Escherichia coli and Salmonella

Based on the biochemical test a total of seven (14%) and three (6%) drinking water samples were found contaminated with *Salmonella* spp. and *E. coli*. This may be due to poor hygienic practices during processing,

Table 3. Correlation between different parameters of drinking water.

	pH	TH	Ca	TDS	Alkalinity	Cl	Iron	EC	Nitrate	Mg
pH	1									
TH	0.121	1								
Calcium	0.119	0.906	1							
TDS	0.110	0.935	0.853	1						
Alkalinity	0.125	0.881	0.824	0.950	1					
Chlorine	0.130	0.720	0.632	0.692	0.585	1				
Total Iron	-0.048	0.227	0.375	0.244	0.317	-0.184	1			
EC	0.108	0.934	0.852	0.999	0.950	0.690	0.246	1		
Nitrate	0.033	0.157	0.265	0.207	0.324	-0.405	0.731	0.208	1	
Mg	0.079	0.766	0.422	0.707	0.636	0.582	-0.084	0.707	-0.065	1

https://doi.org/10.26656/fr.2017.8(6).496

filling, storage and/or distribution. A study concluded with street vended food including jar drinking water predicted that street vendor food and drinking jar water may be contaminated with microorganisms due to inappropriate processing, lack of accurate hygiene, and sanitation practices. They also revealed that most of the street-vended foods including drinking water were contaminated with aerobic bacteria as well as coliform bacteria (Tabashsum *et al.,* 2013). Coliforms such as *E. coli*, and *Salmonella* spp. are responsible for causing severe illnesses including diarrhea, enteritis, and even death (Momba *et al.,* 2006). If these coliform bacteria frequently contaminate jar water in the street vended food stalls may significantly create a potential health hazard situation for the general people.

4. Conclusion

This work studied both chemical and microbial quality and safety of jar drinking water marketed in Dhaka City, the capital of Bangladesh. In terms of chemical parameters, pH and TH of most analyzed samples were within local and international standards. Only six samples were within the acceptable limit of calcium and magnesium hardness. On the other hand, EC, TDS, and chloride were within the permitted value, however, around one-third of the total samples were found to contain iron above the guideline. More than one -third of drinking water samples were not potable based on coliform bacterial contamination and 68% of samples exceeded the recommended safety limit of HPC. *Escherichia coli* present in seven samples and *Salmonella* spp. in three samples were highly alarming along with other microbial parameters. To our knowledge, people prefer and consider jar water due to being safer than tap water, and on the other hand, jar water is more affordable than commercially marketed PET mineral bottled water. Bacteriological parameters pose a considerable threat to the public health of Dhaka City dwellers especially consumers WHO prefer to drink water from street vended jars. This chemical and microbial contamination may be caused by to lack of practices such as good manufacturing practices (GMPs), hazard analysis, and a critical control point (HACCP) during processing, storage, and/or distribution. Furthermore, proper chlorine treatment which ensures microbial safety as well as strict regulatory guidelines should be implemented and monitored to ensure both the

Table 4. Microbial test result of collected jar drinking water samples.

Sample No.	HPC (CFU/mL)	TCC (CFU/100 mL)	Sample No.	HPC (CFU/mL)	TCC (CFU/100 mL)
1	0.07×10^4	7	26	3.9×10^4	Absent
2	5.0×10^4	5	27	0.03×10^4	Absent
3	0	Absent	28	0	Absent
4	2.3×10^4	Absent	29	4.6×10^4	Absent
5	3.0×10^4	3	30	4.0×10^4	Absent
6	10^4	Absent	31	5.5×10^4	22
7	5.8×10^4	14	32	5.6×10^4	19
8	3.6×10^4	Absent	33	2.0×10^4	17
9	2.2×10^4	Absent	34	0	Absent
10	2.8×10^4	Absent	35	0	Absent
11	3.0×10^4	10	36	0.06×10^4	Absent
12	1.5×10^4	4	37	0.01×10^4	Absent
13	2.1×10^4	Absent	38	4.1×10^4	17
14	0.05×10^4	Absent	39	6.1×10^4	10
15	0	Absent	40	2.1×10^4	19
16	2.7×10^4	Absent	41	2.5×10^4	16
17	2.5×10^4	Absent	42	0.06×10^4	Absent
18	0.01×10^4	Absent	43	2.8×10^4	9
19	2.8×10^4	Absent	44	0.01×10^4	Absent
20	0	Absent	45	4.0×10^4	Absent
21	0.09×10^4	Absent	46	1.1×10^4	5
22	1.4×10^4	Absent	47	3.6×10^4	11
23	3.5×10^4	Absent	48	0	Absent
24	4.1×10^4	29	49	3.1×10^4	Absent
25	2.80×10^4	14	50	1.3×10^4	Absent

https://doi.org/10.26656/fr.2017.8(6).496

safety and quality of jar drinking water.

Conflict of interest

The author declares there is no conflict of interest.

Acknowledgments

The authors are very much thankful to the Lab Technician of the Food Safety Laboratory of the Department of Food Technology and Nutritional Science, Mawlana Bhashani Science and Technology University, Tangail, Bangladesh, for providing technical support to analyze the water sample.

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