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Exploring the Quality of Bottled Drinking Water in Dhaka, Bangladesh: A Focus on Physicochemical Parameters, Heavy Metals, and Microbial Contamination

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ABSTRACT

This research endeavors to assess the quality of bottled drinking water (n=30) available in Dhaka, Bangladesh, aiming to provide crucial insights into its safety and suitability for consumption. The investigated parameters were pH (6.34-8.71), EC (3.11-546.00 μScm^{-1}), DO (5.73-11.20 mgL^{-1}), TDS (9.90-317.00 mgL^{-1}), TH (2.24-172.48 mgL^{-1}), Cl^- (0.56-43.84 mgL^{-1}), Na^+ (1.57-40.46 mgL^{-1}), K^+ (0.00-3.43 mgL^{-1}) and Ca^{2+} (0.37-64.81 mgL^{-1}). According to microbial analysis, imported and domestic brands of water were free of total coliform, *E. coli*, *Fecal coliform*, and *Salmonella spp.* Atomic absorption spectrophotometer (AAS) analysis indicates Pb, Cd, and Cr were 0.01-0.06, bdl-0.0009 and bdl-0.0009 mgL^{-1}, respectively. The Water Quality Index indicates that 70% of the samples were good in quality. The comprehensive analysis reveals that aside from minor fluctuations in pH and DO, the majority of tested parameters align with national and international standards, suggesting overall safety and suitability for consumption, supported by microbiological and elemental analyses, as well as the Water Quality Index assessment.

Keywords: Bottled Drinking Water, Heavy Metals, Microbial Analysis, Physicochemical Parameters, Water Quality Index

INTRODUCTION

Water is the most valuable resource for domestic, industries, and agriculture and an essential liquid for metabolism and cell function (Mancosu et al., 2015). Pollutants, harmful chemicals, pathogens, and dangerous radio nuclides should not be present in drinking water and the water quality is determined by its quality indexes such as physical, chemical, and microbial parameters (Akter et al., 2016; Nawaz et al., 2013; Li et al., 2022; WHO, 2012). Consumption of polluted water is thought to be responsible for roughly 80% of all infections and one-third of all deaths in impoverished countries (Some et al., 2021). As reported by WHO, 89% of the population in the world drinks water from improved drinking water sources like harmless dug wells, public standpipes, household connections, boreholes, etc. But this water can be still contaminated by heavy metals and microorganisms (Gibson et al., 2011; Edokpavi et al., 2018; Walter et al., 1961). Water pollution and fresh water shortage are Asia's two most critical environmental challenges (Musie et al., 2023). In the South Asian region, notably in Bangladesh, contamination of surface water in urban areas, especially in Dhaka has become a concern (Hasan et al., 2014). The perception of bottled water as superior to conventional sources of drinking water is based on the expectation that it will be of greater quality, more appealing, and free of health risks (Ismail et al., 2017; Uddin et al., 2021). Due to the widespread use of bottled water, the concern of the long-term effects of varied chemical compositions on public health naturally arises (Rahman et al., 2012).

If the pH of the water is 6.5-8.5, it is deemed safe to consume (WHO, 2011). Tuberculosis is caused by acidic water while incrustation is caused by alkaline water (Gouzy et al., 2021). Because of the lack of direct health effects, high conductivity is not necessarily a cause for concern. However, dissolved ionizable solids can create undesirable water hardness or alkalinity diminishing consumers' satisfaction (Xianhong et al., 2021). Despite the fact that higher DO levels improve the quality of drinking water, there are certain drawbacks. Higher DO levels in water can harm industrial components such as corrosion in water pipes, costing water suppliers more money in maintenance and repairs (Kumar et al., 2012, Kannel et al., 2007). High TDS levels indicate that it is harmful to drinking and may cause nausea, lung irritation, rashes, vomiting, headache, and other symptoms (Islam et al., 2016). Consuming hard water is thought to be a key etiological factor in many diseases such as cardiovascular disease, diabetes, reproductive failure, neurological disorders, and renal dysfunction (Sengupta et al., 2013, Anderson et al., 1975). The presence of coliform bacteria, specifically *E.coli* in drinking water causes vomiting, diarrhea, cramps, nausea, fever, fatigue, and even sometimes cause death (Joseph et al., 2018). The negative consequences of specific ions (Ca^{2+}, Na^+, $K^{+,}$ and Cl^-) in water samples on human health have also been examined. Excessive Ca^{2+} consumption causes hypercalciuria, hypercalcemia, urinary tract calculi, and calcification in a large assortment of tissues, including the kidney, arterial walls, and bone remodeling suppression (Heaney et al., 1982). WHO encouraged consumers to choose brands with high calcium content and low salt content. However consuming bottled water with high calcium content is not recommended for people who have stones in their upper bladder (Razaee et al., 2012). K^+ works in tandem with Na^+ to maintain the body's water balance, physiological neuron function, and muscle control. Diets high in K^+ and low in Na^+ may help to prevent hypertension (Rosborg et al., 2016). Heavy metals are widely recognized malignancies that can lead to skin, lung, liver, and bladder cancer (Martin et al., 2009). For cadmium toxicity, which causes chronic kidney failure in humans, the renal cortex appears to be the most vulnerable target tissue. There have also been reports of osteomalacia (softening of the bones) (Honda et al., 2010). Pb in drinking water has been shown to lower children's intelligence quotient, and promote hyperactivity and depression (Navas et al., 2007). Drinking water may indeed contain toxic Cr (VI) due to industrial discharges (Rosborg et al., 2016). Some persons may get allergic eczema and skin responses if they drink water that contains Cr (III) in violation of the water quality standards over a long period. When Cr (IV) enters the human body through dermal and inhalation routes causes nasal irritation, nasal ulcers, lung cancer, and hypersensitivity reactions (Shrivastava et al., 2002).

In the last 30 years, the global consumption of bottled water has expanded at an annual pace of 7% due to its benefits, which include easy to transport, availability to public areas, acceptable water quality, pathogen-free, more pleasant, clear and easy to distribute (Aslani et al.,2021, Asgari et al.,2021). Although it is mandatory in Bangladesh to register bottled water companies to assure quality, there have been influxes of duplicate brands into the market causing health concerns for the people. The current study has tried to investigate the physicochemical parameters, cations, anions, heavy metals, and microbial analysis of different branded bottled drinking water that are commonly consumed by individuals.

MATERIALS AND METHODS

Sample collection and study area: Bottled water (n=30) comprising one imported brand and 29 commercially accessible indigenous branded water collected from different commercial markets of Dhaka city, Bangladesh (Figure 1). The sampling areas in Dhaka city are Azimpur (Shwapno outlet), Moghbazar (Kazi Store), Kamlapur Railway Station, Malibagh (Rajib Store), Shantinagar (Meena Bazar), New Market (New Grocery Market), Katabon (Ayon General Store), Arambagh (Moubon Confectionary), Segunbagicha (Madina Confectionary), New Elephant Road (Meena Bazar), Purana Paltan (Islamia Store), Lalbagh (Shwapno outlet), Hatirpool (S.M Enterprise), Polashi Bazar (Sabiha Store), Dhanmondi (Shimanto Shambhar), and Mohammadpur (Meena Bazar). The samples had a one-year shelf-life, according to the indication on their body labels. The water samples were coded as D1-D30 to keep the brand's name anonymous. After buying, the samples were stored at -4º C until the analysis was done.

Figure 1: Geographical positions of the sampling sites in Dhaka City, Bangladesh

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Physicochemical parameters and heavy metals analysis: While assessing the parameters, the samples were well stirred and then tested using established standard procedures. To determine the pH, EC, and TDS of the water samples, a pH meter (HI 2211, Hanna instruments; USA), EC meter (Milwaukee Mi170, bench top conductivity meter), TDS meter (HI 98302, Hanna instruments, USA) was used and a stable reading was recorded. Chloride content was determined by mercurimetric method using a mixed indicator (diphenyl carbazone and bromophenol blue), 0.2 M HNO_3, and standard 0.01M mercuric nitrate. The Cl^- content was determined using the equation, 1.0 mL of 0.1M Hg^{2+} = 0.2 mmol Cl^- = 7.10 mg Cl^-. To measure DO, the Winkler method was followed using $MnSO_4$, H_2SO_4, and alkali-iodide-azide reagent, and the I_2 released was titrated against 0.025M $Na_2S_2O_3$ using starch as an indicator. The DO was calculated using the equation, 1.0 mL 0.0125M $Na_2S_2O_3$ = 0.1 mg D.O.

$$\text{D.O. in mgL}^{-1} = (\text{mL of titrant}*1000*0.1)/\ (\text{Volume of D.O. bottle, mL})$$

To assess TH of water, a complexometric method was used where Eriochrome black-T indicator was added and the mixture was titrated against standard 0.01M Na_2-EDTA. TH was calculated in parts of $CaCO_3$ per million of water using the equation,

$$1\text{mL of } 0.01 \text{ M EDTA} = 1.000 \text{ mg } CaCO_3.$$

Na^+, K^+, and Ca^{2+} in water samples were determined by a flame photometer (JENWAY 500731 PEP7). Calibration curves were constructed by plotting the peak area versus the concentration of the standard solution of both Na^+, K^+, and Ca^{2+} (Figure 2). The coefficient of determination (R^2) from the calibration curves was found to be 0.9935 for Na^+, 0.9953 for K^+, and 0.9382 for Ca^{2+}, respectively which represents that absorbance correlated perfectly with concentration. An Atomic Absorption Spectrophotometer (Varian AA240, Australia) was used to measure the concentration of Pb, Cr, and Cd in water samples. For each element, a standard solution of various concentrations was initially prepared and the absorbance was measured with a blank as reference and the readings were noted.

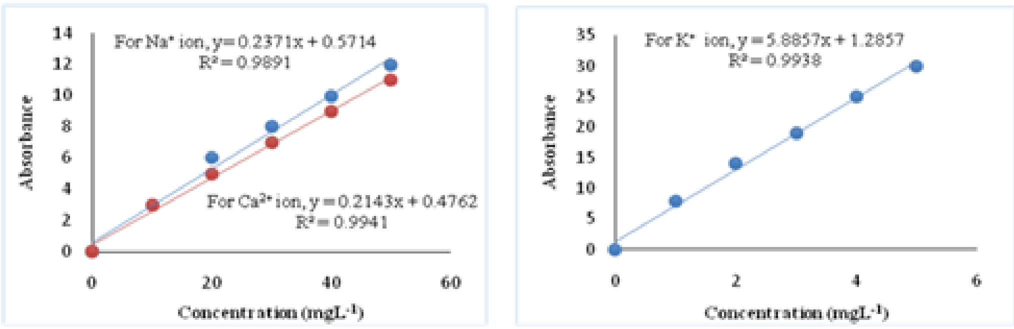

Figure 2: Calibration curves of Na^+, Ca^{2+} and K^+ standard solutions

Microbiological analysis: To determine total bacterial growth, water was diluted to 10^{-2} and cultured using the pour plate method. 1.0 mL of each sample was taken to a sterile vial having 9.0 mL of distilled water resulting in a dilution of 1:10. Then, 1.0 mL of each dilution was plated by a pipette. The sterile melted media was poured into the plates rotating uniformly to distribute the media and incubated overnight at 37°C using an incubator (Memmert UN55). Bacterial colonies on EMB (Eosin Methylene Blue Agar) media from confirmed tests were inoculated in LB (NaCl 1%, tryptone 1%, yeast extract 0.5%,) broth and using a Laminar flow hood (SHL 422, India) and sub-cultured on MacConkey agar plate. A colony counter was used to count the number of colonies. The total plate count was obtained by multiplying the number of colonies on the plate by the dilution factor.

Weighted arithmetic Water Quality Index (WQI): The weighted arithmetic index method developed by Brown was used to calculate the water quality index (WQI) using MS Excel (Brown et al.,1972). According to this method, WQI = $\Sigma QiWi$; Where, Wi (Unit weight) = K/Sn; K (constant) =1/ $(1/Vs_1+1/Vs_2+1/Vs_3+\ldots\ldots\ldots+1/V_{Sn})$ and Sn= 'n' number of standard values, Qi (water quality rating) = 100 × (Va-Vi)/ (Vs-Vi); Va= actual value present in the water sample; Vi= ideal value (0 for all parameters except

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pH and DO, which are 7.0 and 14.6 mgL^{-1} respectively). Pollutants are completely absent if the quality rating Qi=0, while 0<Qi<100 suggests that the contaminants are within acceptable limits. When Q>100, it indicates that the contaminants are above the limits.

RESULTS AND DISCUSSION

Physicochemical parameters such as pH, EC, DO, TDS, TH, Cl^-, Na^+, K^+, and Ca^{2+} were determined quantitatively in the laboratory and reported in Table 1 and Figure 3. Table 1 provides a comprehensive overview of the statistical parameters of water quality attributes found in various bottled drinking water samples, juxtaposed with established guideline values set forth by the World Health Organization (WHO) and the Bangladesh Standards and Testing Institution (BSTI). The table includes essential parameters such as pH, EC, DO, TDS, TH, Cl^-, Na^+, K^+, and Ca^{2+}. For each parameter, the table presents the minimum, maximum, median, mean, and standard deviation (SD) values derived from the analysis of the sampled bottled water. These statistical metrics offer insights into the range and variability of water quality characteristics observed across the samples. Moreover, the table juxtaposes these statistical findings with the WHO limit recommendations established in 2011 and the BSTI standards updated in 2020. By comparing the measured values against these regulatory thresholds, stakeholders can assess the conformity of bottled drinking water with established quality standards and identify areas where improvements may be necessary to ensure compliance and consumer safety. The desirable limit of pH is 6.5-8.5 according to WHO (2011). From Table 1, it may be seen that the pH values were 6.34-8.71 with a median of 7.25. The samples were categorized into three groups depending on the pH such as slightly acidic (6.34-6.67), neutral (6.94-7.10), and slightly basic (7.14-8.71). The pH of 28 samples was in the desirable limit and only 2 samples (D14 and D23) slightly exceeded the permissible limit (Figure 3). But another study showed that the pH was between 6.11-6.80, where all the samples were acidic (Rosborg et al.,2016). According to WHO, the maximum allowable EC of water is 1000 μScm^{-1}. EC values of the bottled water samples were 3.11-546.00 μScm^{-1} with a median of 77.15μScm^{-1}. It can be speculated from the data that D23 contains a low ionic concentration whereas D6 contains a high ionic concentration. The gap in between the lowest and the highest EC values is wide enough. Such a variation of ionic concentration may depend on the availability of mineralizing agents such as CO_2, metal redox conditions of adsorbed complexes, etc (Tchobanoglous et al., 1985, Matloob et al., 2011). In a comparative study of bottled drinking water values for D12 and D15 are found to be 269.50 and 247.00 μScm^{-1} respectively which were almost matched to our measured values (Uddin et al.,2021). The requirement for DO is prescribed as 5.0 mgL^{-1} for drinking purposes, 4.0-6.0 mgL^{-1} for livestock animals, and 5.0 mgL^{-1} for industrial activities (WHO,2011). From Table 1, it was found that sample coded D8 contained the highest level (11.20 mgL^{-1}) and sample coded D24 contained the lowest (5.73 mgL^{-1}). There were no significant differences in DO values among the brands. A different study for DO was found between 6.88-8.76 mgL^{-1} (Rosborg et al.,2016). All studies show higher concentrations of DO in water samples. From the comparative description of samples, except D6 and D8, all contain DO less than 10.00 mgL^{-1}. The permitted quantity of TDS for both bottled water and drinking water is between 500-2000 mgL^{-1}, according to various authorities. Low TDS and TH water comprise 1-100 mgL^{-1} of dissolved minerals in water (Sasikaran et al.,2012). The TDS values appeared in the range of 9.90-317.00 mgL^{-1} with an average of 79.74 mgL^{-1}. The lowest EC valued D23 has the lowest TDS value and the highest EC valued D6 has the highest TDS value. In a comparative study of bottled drinking water, D2 and D6 contain TDS values of 209.00 and 345.00 mgL^{-1}, whereas, in this study, D2 and D6 contained TDS values of 218.00 and 317.00 mgL^{-1} which are approximately the same (Uddin et al.,2021). The standard limit for hardness is 200-500 mgL^{-1} which is recommended by WHO (2011). TH values of the bottled water were 2.24 –172.48 mgL^{-1}.

Table 1: Statistical parameters of bottled drinking water and guideline values

Sample ID	**pH**	**EC (μScm^{-1})**	**DO (mgL^{-1})**	**TDS (mgL^{-1})**	**TH (mgL^{-1})**	**Cl^- (mgL^{-1})**	**Na^+ (mgL^{-1})**	**K^+ (mgL^{-1})**	**Ca^{2+} (mgL^{-1})**
Min.	6.34	3.11	5.73	9.9	2.24	0.56	1.57	0	0.37
Max.	8.71	546	11.2	317	172.48	43.84	40.46	3.43	64.81

Median	7.25	77.15	9.03	46.2	10.58	3.05	11.59	0.155	2.53
Mean	7.34	127.71	8.73	79.74	30.29	8.83	12.74	0.53	10.22
SD	0.50	125.04	1.22	72.31	39.11	12.22	8.91	0.75	16.69
WHO limit (2011)	6.5-8.5	1000.0	5.0	1000.0	500.0	250.0	200.0	12.0	75.0
BSTI Standards (2020)	6.5-7.5	700.0	4.0-6.0	500.0	300.0	250.0	200.0	-	75.0

Other studies found TH in between 1.50-228.00 mgL^{-1} (Rosborg et al.,2016). Water with a hardness < 300 mgL^{-1} is regarded as portable and hardness levels above these can irritate the gastrointestinal tract (Denny et al.,2005). Water samples D1, D3, D4, D7-D11, D13-D15, D17-D26, D28-D30 contained hardness <60 mgL^{-1} and considered as very low mineral water, whereas D2, D5, D12, D16, D27 contained hardness <120 mgL^{-1} as low mineral water and D6 containing 172.48 mgL^{-1} considered as rich in mineral. Figure 3 illustrates the variations in water quality parameters across different branded bottled drinking water samples. The graph showcases a comparative analysis of key physicochemical attributes, including pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), total hardness (TH), chloride ion (Cl^-), calcium ion (Ca^{2+}), sodium ion (Na^+), and potassium ion (K^+), as measured in each sample. Each parameter is plotted against the respective bottled water brand, allowing for a clear visual representation of the variability in water quality among the different products.

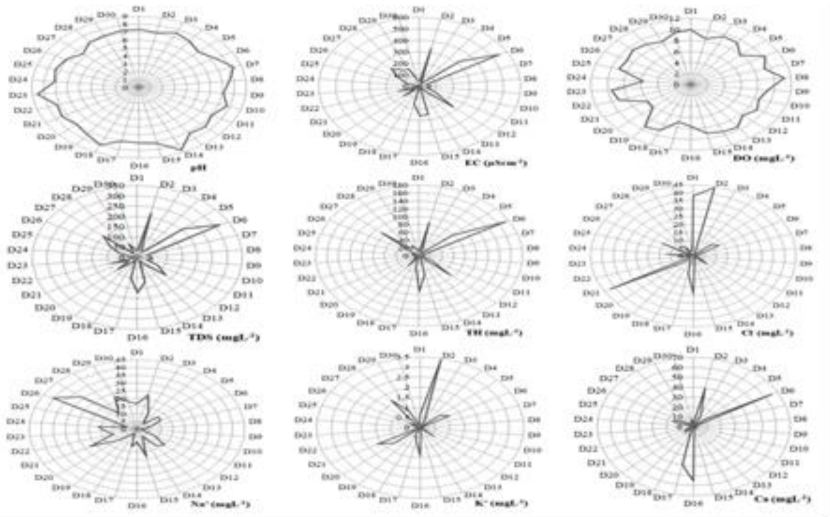

Figure 3: Variations of water quality parameters in different branded bottled drinking water samples

IBWA (2008), WHO (2011), BIS (2012), and US EPA (2018) suggest Cl^- in drinking water must be < 250 mgL^{-1} (Van der Aa et al.,2003). The obtained result of Cl^- concentration in imported brands was 12.89 mgL^{-1}. The highest and lowest Cl^- were in D2 (43.84 mgL^{-1}) and D13 (0.56 mgL^{-1}) (Table 1). Other two different studies show their samples contain Cl^- in between 0.24-2.69 mgL^{-1} and 0.0-43.75 mgL^{-1} which indicates a very lower Cl^- present in bottled water (Uddin et al.,2021, Rosborg et al.,2016). WHO recommended the level of metal ions in drinking water as 200 mgL^{-1} for Na^+, and 50-200 mgL^{-1} for Ca^{2+} and there was no limit for K^+ (WHO,2011). Na^+ contents in bottled water were 1.57-40.46 mgL^{-1}, K^+ contents were 0.0-3.43 mgL^{-1} and Ca^{2+}contents were 0.37-64.81 mgL^{-1}. All the metal ion concentrations were below the prescribed values. Na^+ in imported brand (D6) was 11.44 mgL^{-1}. D7, D9, D10, D19 and D22 contain the least K^+. Ca^{2+} in the imported brand (D6) was 64.81 mgL^{-1}. The local samples contain a lower amount of Ca^{2+} than the imported brand. D7, D11, D13, D14, D15, D22 and D24 contain the least Ca^{2+} as <1.0 mgL^{-1}. The variations of major ions in D1-D30 (Fig. 3). The experimental data of other studies also show the level of minerals in bottled drinking water is very low (Uddin et al.,2021).

For each sample (designated as D1 to D30), the analysis was done for the mean bacteria counts, expressed as colony-forming units per milliliter (CFU/mL), and metal contents (in mgL^{-1}). IBWA (2008), WHO (2011), and

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SASO (1994) recommended total coliforms should be zero in 100 mL for safe water (Denny et al.,2005). The presence of *E. coli*, and *fecal coliform* in imported brand and local brands were 0.00 MPN per 100 mL and <1.0 MPN per 100 mL, respectively, suggesting the targeted samples are free of microbial contamination and suitable for drinking. According to WHO and USEPA, the maximum allowable concentration of Pb in drinking water are 0.01 and 0.015 mgL^{-1}, respectively (Van Der Aa et al.,2003). D5, D9, D14, D16, D24 and D29 had maximum concentration of Pb (0.06 mgL^{-1}) which exceeded the standard limits whereas D2, D19 contained the least concentration of Pb (0.01 mgL^{-1}). In a comparative study, Pb was found below the detection limit in most Bangladeshi branded samples (Fardous et al.,2015). In the current study, Cr and Cd were identified in Bangladeshi branded drinking water samples, and their mean±SD concentrations were 0.000303±0.000307 mgL^{-1} and 0.00034±0.000301 mgL^{-1}, respectively which were compared with another study, whereas their mean concentrations were 0.0004±0.000473 mgL^{-1} and 0.00046±0.000341 mgL^{-1}, respectively (Fardous et al.,2015). They were all below the WHO recommended levels of 0.050, 0.003, and 0.040 mgL^{-1} as the safe limit for Cr and Cd metals in drinking water (WHO, 2011). As a result, the range of Cr and Cd in all samples was within the accepted limits, indicating no adverse impacts on public health. The overall variations of the targeted heavy metals are shown in Figure 4.

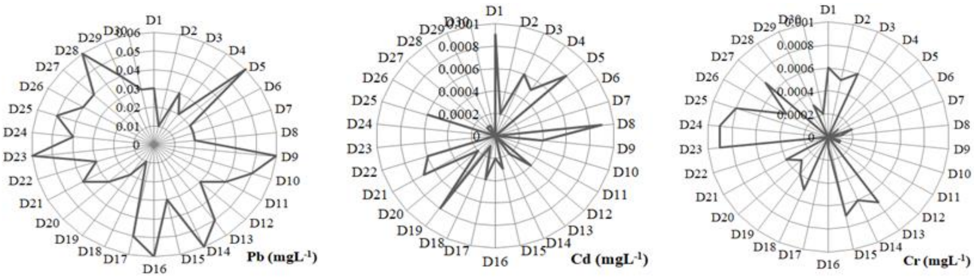

Figure 4: Variations of heavy metals in different branded bottled drinking water samples

Pearson's Correlation between Various Constituents

Pearson correlation indicates the existence and strength of inter-correlation between two measurable parameters (Gilchrist et al.,2018). The correlation coefficient is denoted by r which ranges between -1 and +1. The correlations among the different physicochemical parameters are shown in Table 2.

Table 2: Correlation matrix (r) for water quality parameters in the samples

	pH	**EC**	**DO**	**TDS**	**TH**	**Cl^-**	**Na^+**	**K^+**	**Ca^{2+}**
pH	1								
EC	-0.476	1							
DO	0.271	-0.029	1						
TDS	-0.467	**0.963**	-0.037	1					
TH	-0.367	**0.922**	0.047	**0.917**	1				
Cl^-	-0.188	0.274	-0.366	0.310	0.269	1			
Na^+	-0.417	0.296	-0.213	0.275	0.189	0.397	1		
K^+	-0.271	**0.529**	-0.327	0.498	0.454	**0.758**	0.306	1	
Ca^{2+}	-0.226	**0.693**	-0.112	**0.750**	**0.734**	0.417	0.065	**0.557**	1
Correlation is significant at the 0.01 level (2-tailed)									
Correlation coefficients that are larger than 0.50 are indicated in bold.									

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pH value with EC, TDS, and Na^+ ion shows moderate negative linear correlation and DO, TH, K^+, and Ca^{2+} show weak positive linear correlation. EC value with TDS, TH shows a very strong positive linear correlation whereas Ca^{2+} and K^+ ions show strong and moderate positive linear correlation respectively. DO value shows a weak negative linear correlation with Cl^-, Na^+, and K^+ ions which indicates that these parameters are inversely proportional to DO. TDS value with TH, Ca^{2+}, and K^+ shows very strong, strong, and moderate positive linear correlation respectively. TH value with Ca^{2+} ion shows strong and with K^+ ion shows moderate positive linear correlation. Cl^- value with Ca^{2+}, and K^+ ions show strong and moderate positive linear correlation respectively. K^+ value with Ca^{2+} ion shows a moderate positive linear correlation which indicates that K^+ ionis directly proportional to Ca^{2+} ion. This result suggested that the reduction of conductance through enhancement of DO level stimulated to lower the TDS value. Other parameters indicate both positive and negative linear correlations, which are statistically insignificant.

Water quality classification is based on computed WQI values in different branded bottled water samples, whereas WQI values 0-25 (excellent water quality); 26-50 (good water quality); 51–75 (poor water quality); 76-100 (very poor water quality), and >100 (water unsuitable for drinking purposes). Table 3 presents the computed Water Quality Index (WQI) values for different branded bottled water samples, along with their corresponding quality status classifications. The WQI serves as a comprehensive indicator of overall water quality, integrating multiple parameters to provide a single numerical value for easy interpretation. Upon analysis, it is evident that the WQI values vary significantly across the sampled bottled water brands. The quality status classifications range from "Good" to "Very Poor" and even "Unfit" for consumption.

Table 3: Computed water quality index for different branded bottled water samples

Sample ID	**WQI value**	**Quality Status**	**Sample ID**	**WQI value**	**Quality Status**
D1	43.989	Good	D16	41.2278	Good
D2	38.1278	Good	D17	35.2809	Good
D3	58.7024	Poor	D18	87.7155	Very Poor
D4	39.1006	Good	D19	45.3233	Good
D5	43.9896	Good	D20	43.7161	Good
D6	44.8953	Good	D21	68.5706	Poor
D7	103.4867	Unfit	D22	39.0826	Good
D8	50.4428	Good	D23	117.0920	Unfit
D9	30.6808	Good	D24	47.7699	Good
D10	72.0249	Poor	D25	47.4803	Good
D11	26.6804	Good	D26	31.8708	Good
D12	58.4160	Poor	D27	65.2496	Poor
D13	34.8465	Good	D28	31.6866	Good
D14	127.5521	Unfit	D29	39.2236	Good
D15	42.6264	Good	D30	42.2704	Good

Several samples, such as D1, D2, D4, D5, D6, D9, D13, D24, D25, D26, D28, D29, and D30, exhibit WQI values indicating "Good" water quality, suggesting that they meet acceptable standards for drinking water consumption. These samples likely have favorable levels of physicochemical parameters and microbial content, reflecting their suitability for consumption. However, there are notable exceptions. Samples D3, D10, D12, D21, and D27 are classified as having "Poor" water quality based on their respective WQI values. These samples may have elevated levels of contaminants or other factors affecting their suitability for drinking. The most concerning findings are observed in samples D7, D14, and D23, which are categorized as "Unfit" for consumption due to exceptionally high WQI values. These samples likely contain significant levels of contaminants or other factors posing potential health risks to consumers. Overall, the computed WQI values highlight the considerable variability in water quality among different bottled water brands. These findings underscore the importance of regular monitoring and stringent quality control measures to ensure the safety and suitability of bottled drinking water for consumers. Additionally, they emphasize the need for transparent labeling and regulatory oversight to guide consumers in making informed choices about the treated water.

CONCLUSION

The present study aimed to expose different brands of bottled drinking water to determine physicochemical parameters, metal ions, heavy metals, and microbial contamination. It was assessed that the level of water quality parameters varies significantly in different bottled water. Microbial analysis showed satisfactory results for all the tested samples. About 70% of drinking water samples were deemed "good" because all the parameters followed the acceptable limit. On the other hand, 10% of water that was deemed "unfit for drinking" typically had lower pH and DO levels. Few brands of bottled water contain a higher concentration of Lead than the prescribed value by WHO. Most drinking water products do not specify the water source, derivatives added, and tested quality values on the bottle. The results show that local drinking water distributors may not fully comply with regulatory standards and quality guidelines properly.

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