Open Journal of Applied Sciences, 2025, 15(6), 1871-1884
https://www.scirp.org/journal/ojapps
ISSN Online: 2165-3925
ISSN Print: 2165-3917

Study of Physicochemical Properties of Locally Packaged and Imported Bottled Water Brands

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How to cite this paper: Simbo, R.T., Oladejo, T.A., Bello, T.O., Nyuma, F.F. and Olajide, T.E. (2025) Study of Physicochemical Properties of Locally Packaged and Imported Bottled Water Brands. *Open Journal of Applied Sciences*, **15**, 1871-1884.
https://doi.org/10.4236/ojapps.2025.156125

Received: February 26, 2025
Accepted: June 27, 2025
Published: June 30, 2025

Abstract

The research study determined the levels of physicochemical water quality properties in branded locally packaged waters and branded imported bottled waters, consistent with *WHO* permissible threshold standards, consumed most frequently in both Harper and Pleebo cities. The following hypothesis was proposed: H_0: Levels of physicochemical quality parameters of the branded locally packaged waters were not different from the branded imported bottled water H_1: Levels of physicochemical quality parameters of the branded locally packaged waters were different from the branded imported bottled waters. The hypothesis was tested in MS Excel 2010 and 2016 via the T-Test function. There was significant difference in temperature between each local brand and all imported brands of water, $p < 0.05$; in terms of EC, pH and TDS water quality properties, there was no significant difference between each local brand and all imported brands of water, $p > 0.05$. A calibrated temperature compensated multifunction pen type water quality meter (meter model: JHL 202, backlight model: EZ-9909) was used to measure all parameters of six (6) samples of each brand of locally packaged and imported bottled waters. Results indicated temperature, EC and TDS of all samples were within *WHO* permissible limits. The pH values of all samples were not within the range of *WHO* standard; hence, all samples were acidic. The study recommended that routine testing be carried out on samples of both local and imported brands of water by the Liberia Standards Authority (LiSA).

Keywords

Harper, Pleebo, Physicochemical, Temperature, Total Dissolved Solids, Electrical Conductivity

1. Introduction

The importance of water cannot be overstated. It is a universal solvent and it is used for domestic, industrial and agricultural purposes. According to Helmenstine [1], water is a chemical compound consisting of two hydrogen atoms and one oxygen atom (H_2O). Water is the third most abundant molecule in the universe, after hydrogen gas and carbon dioxide [1]. Only about 2.5% of the Earth's water is fresh water. Nearly all of that water (98.8%) occurs as ice and groundwater. The name water typically refers to the liquid state of the compound. In accordance with [2] safe drinking water is a basic human right, but also a requirement for good health. Freshwater is a limited resource in the world. In the next century, it will become even more limited due to the effects of increasing population, urbanization and climate change. It was reported by [3] that water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Improving access to safe drinking-water can result in tangible benefits to health. Every effort should be made to access potable water which meets water safety standards. Safe drinking-water, as defined by the guidelines, does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages. Those at greatest risk of waterborne disease are infants and young children, people who are debilitated and the elderly, especially when living under unsanitary conditions. Those who are generally at risk of waterborne illness may need to take additional steps to protect themselves against exposure to waterborne pathogens, such as boiling their drinking-water. Safe drinking-water is required for all usual domestic purposes, including drinking, food preparation and personal hygiene. The World Health Organization estimated that up to 80% of all sicknesses and diseases in the world are caused by inadequate sanitation, polluted water or unavailability of water [4]. Sustainable development goal six (SDG 6) is to ensure sustainable water management and sanitation for all by 2030 [5]. In spite of this, some 2.2 billion people lack access to safe drinking water [6]. Nearly half of this number is in Sub-Saharan Africa and South Asia [6]. Furthermore, about 297,000 children under age 5 die yearly from use water-borne diseases like diarrhea [6]. While some 2 billion people live in high water stress regions [7], another 2 billion use healthcare-centers without basic facilities like water [8].

Increase in human population, expansion in industrialization, urban drift, and socioeconomic development result in acute stress on both the quantity and quality of available water resources [9] [10]. Some 80% of global wastewater flows back into the ecosystem untreated [11]. Natural resources of water are contaminated via various physical, chemical and biological agents. As such, its quality control is vital for both environment preservation and public health protection [12]. This signals the need for more investment in water consequently attracting growth of different companies for potable water packaged in pouches or bottles (plastics). According to [13] the incessant pollution in fresh natural water resources has led to the exponential demand for bottled water. Additionally, in a research carried out by [14] it was reported that the consumption of bottled water has increased to a significant proportion in the last three decades most especially in food and beverage industries with an annual average of 12% in spite of its high cost.

Palatability, viscosity, solubility, odors, and chemical reactions are influenced by temperature [15]. Thereby, the sedimentation and chlorination processes and biological oxygen demand (BOD) are temperature dependent [16]. It also affects the biosorption process of the dissolved heavy metals in water [17]. Most people find water at temperatures of 10˚C - 15˚C most palatable [15]. Warm groundwater averaging of 26.5˚C (79.8˚F) measured in water from springs and porous aquifers can result in resident pathogen populations [18].

Excessively high and low pH can be detrimental for the use of water. A change of 1 unit on a pH scale represents a 10-fold change in the pH, so that water with pH of 7 is 10 times more acidic than water with a pH of 8, and water with a pH of 5 is 100 times more acidic than water with a pH of 7. The amount of oxygen in water increases as pH rises. Low-pH water will corrode or dissolve metals and other substances [15]. A high pH makes the taste bitter and decreases the effectiveness of the chlorine disinfection, thereby causing the need for additional chlorine. Heavy metals such as cadmium, lead, and chromium dissolve more easily in highly acidic water (lower pH). This is important because many heavy metals become much more toxic when dissolved in water [19].

Pure water is not a good conductor of electricity. Typical conductivity of water is as follows: Ultra-pure water = 5.5×10^{-6} S/m; and drinking water = 0.005 - 0.05 S/m [20]. Due to the self-ionization of water into H^+ and OH^-, the electrical conductivity of pure water is non-zero, EC = 0.055 µS/cm at 25˚C [21].

Total dissolved solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates) and small amounts of organic matter that are dissolved in water. TDS in drinking-water originate from natural sources, sewage, urban runoff and industrial wastewater. Salts used for road de-icing in some countries may also contribute to the TDS content of drinking-water. Concentrations of TDS in water vary considerably in different geological regions owing to differences in the solubility of minerals. The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l. The presence of high levels of TDS may also be objectionable to consumers, owing to excessive scaling in water pipes, heaters, boilers and household appliances [22].

Solids occur in water either in solution or in suspension. These two types of solids can be identified by using a glass fiber filter that the water sample passes through [23].

The thrust of this research was to explore the levels of physicochemical water quality parameters in different branded locally packaged waters and different branded imported bottled waters, mostly consumed by the human population of Maryland County in Liberia. In this research study the hypothesis put forward was; H_0: Levels of physicochemical quality parameters of the branded locally packaged waters are not different from the branded imported bottled water H_1: Levels of physicochemical quality parameters of the branded locally packaged waters are different from the branded imported bottled waters. Additionally the under mentioned are indicative of the research objectives;

- To determine the levels of temperature, hydrogen ion index (pH), electrical conductivity (EC) and total dissolved solids (TDS) in different brands of locally packaged waters
- To determine the levels of temperature, hydrogen ion index (pH), electrical conductivity (EC) and total dissolved solids (TDS) in different brands of imported bottled waters.

2. Materials and Methods

2.1. Sample Site and Sample Collection

Four sachets of locally packaged water brands (**Figure 1**) namely: cheway, natural rock, dajab, and maimie pure mineral drinking water; also four packs of imported bottled water brands (**Figure 2**) which include: success, eau crystal, belvie, and perlaa, all indicative of potable water samples for analysis, were bought from recognized grocery stores in two cities, Harper and Pleebo, of Maryland County in Liberia within the period April and May, 2024. These brands of local and imported waters are the only set of water brands available and mostly consumed, during the period as indicated above, in the study locations.

Figure 1. Locally packaged water brands.

Figure 2. Imported bottled water brands.

2.2. Sample Treatment

In the laboratory the samples, both locally packaged branded waters and imported bottled branded waters, were placed on two separate sterile tables, protected from light, tearing or further damage and preserved at 25˚C.

Six (6) samples of each brand of locally packaged and imported bottled waters were cross-examined in the laboratory. These samples were assigned codes for easy identification and recognition of water samples during and after analysis according to brand name; for locally packaged branded waters it was indicated as follows: cheway (CW1 to CW6), natural rock (NR1 to NR6), dajab (DJ1 to DJ6), and maimie pure mineral drinking water (MP1 to MP6); the imported bottled branded waters as follows: success (SUC1 to SUC6), eau crystal (CRY1 to CRY6), belvie (BEL1 to BEL6) and perlaa (PER1 to PER6).

2.3. Laboratory Equipment

The water quality of locally packaged water brands and imported bottled water brands was determined from the degree of occurrence of selected water properties, including temperature, hydrogen ion index (pH), electrical conductivity (EC) and total dissolved solids (TDS) Temperature of samples of each locally packaged water brands and imported bottled water brands was measured in degrees Celsius (˚C), using two mercury thermometers for comparative purposes. A calibrated temperature compensated multifunction pen type water quality meter (meter model: JHL 202, backlight model: EZ-9909) was used to analyze pH, EC, and TDS respectively. Additionally, sterilized gloves, distilled water, and 500 ml, 3000 ml beakers were used.

For the pH calibration, the multifunction pen type water quality meter was turned on reading 6.86 and then the calibration mode was pressed for six (6) seconds; this reading flashed intermittently three (3) times to completion. The electrode of the meter was now dipped into a 4.00 standard solution which indicated a reading of 4.00; the calibration mode was then pressed for six (6) seconds and the 4.00 reading flashed sporadically three (3) times stabilizing to completion. This process was lastly completed by putting the electrode of the meter in a 9.18 standard solution and the 9.18 reading was indicated; the calibration mode was pressed again for six (6) seconds, the reading, 9.18, then flashed on and off three (3) times and the meter was stabilized to completion.

In order to calibrate for EC/TDS, the multifunction pen type water quality meter was turned on reading 1413m/S this was followed by pressing the calibration mode for six (6) seconds; the reading flashed intermittently three (3) times to completion. The electrode of the meter was now placed into a 12.88 m/S standard solution which indicated a reading of 12.88 m/S; the calibration mode was then pressed for six (6) seconds and the 12.88 reading flashed on and off three (3) times and the equipment was stabilized to completion. This process was completed by immersing the electrode of the meter into a 111.8m/S standard solution and the 111.8 reading was indicated; the calibration mode was pressed again for six (6) seconds, the reading, 111.8, then flashed on and off three (3) times and then the multifunction pen type water quality meter was stabilized to completion.

2.4. Method

Physicochemical parameter measurement results of samples of locally packaged water brands and imported bottled water brands were taken in triplicates procedurally and recorded accordingly; temperature, pH, EC and TDS, in accordance with [24].

The temperature was measured by immersing the thermometer in 500 ml water sample of each of six (6) locally packaged water brands and imported bottled water brands in an approximate 500 ml beaker, and the temperature was recorded after equilibration [24].

The electrode of the calibrated temperature compensated multifunction pen type water quality meter was dipped into the container of distilled water for sterilization until a stable reading of zero was obtained. The pH, EC, and TDS of the locally packaged water brands and imported bottled water brands water samples were now measured by immersing the electrode in an approximate 500 ml beaker of each sample of six (6) locally packaged water brands and imported bottled water brands. The reading was taken and recorded after stabilization of the instrument in few minutes; the electrode of the calibrated temperature compensated multifunction pen type water quality meter was re-rinsed with distilled water before subsequent reading of each sample of six (6) locally packaged water brands and six (6) imported bottled water brands was taken, three readings were taken for each of six (6) locally packaged water brands and six (6) imported bottled water brands sample at a time following same procedure for each sample before any reading was taken and recorded. The electrical conductivity (EC) or specific conductance was recorded preferably at 25˚C in μS/cm [24].

2.5. Data Analysis

Laboratory analyses data were statistically analyzed in MS Excel 2010 and 2016. Q-test was used to accept or reject Outliers from each data set [25], the coefficient of variation (CV) was used to assess the data variability, and T-test function was used to guide whether to accept or reject a hypothesis at $p < 0.05$.

3. Results and Discussion

Samples of both locally packaged branded waters and imported bottled branded waters were analyzed in accordance with defined procedures of USGS NFM and were compared with WHO standards.

Tables 1-8 are physicochemical water quality analysis results of both locally packaged branded waters and imported bottled branded waters used in this study; the mean (average) values of the physicochemical parameters (properties) determined in water samples which include temperature, pH, EC and TDS, are indicated in **Tables 1-4** and **Tables 5-8** for locally packaged branded waters and imported bottled branded waters respectively.

Table 1. Levels of physicochemical properties of locally packaged Cheway waters.

Local Sample	Properties/Variables			
	Temp (˚C)	pH	EC (μSm/cm)	TDS (ppm)
CW1	29.67	5.15	56.33	39.43
CW2	29.50	5.27	50.67	35.47
CW3	39.83	5.21	50.00	35.00
CW4	29.67	5.22	50.67	35.47
CW5	29.83	5.22	50.67	35.47
CW6	29.87	5.30	49.33	34.53
Mean	**29.73**	**5.23**	**51.28**	**35.89**

The coefficients of variation (CV) for temperature, pH, EC, and TDS in Table 1 above are 0.4779%, 4.9407%, 1.0215% and 4.9407% progressively of the water samples during the period of the study. As such the analysis of temperature, pH, EC, and TDS is indicative of insignificant fluctuations in each of the data set of the physicochemical properties.

Table 2. Levels of physicochemical properties of locally packaged Natural Rock waters.

Local Sample	Properties/Variables			
	Temp (˚C)	pH	EC (μSm/cm)	TDS (ppm)
NR1	29.83	6.23	167.99	74.90
NR2	29.72	6.12	100.00	70.00
NR3	29.67	6.20	90.67	63.47
NR4	29.50	6.27	97.00	67.90
NR5	29.67	6.06	98.00	68.60
NR6	29.83	6.07	97.33	63.13
mean	**29.70**	**6.16**	**98.33**	**68.83**

The coefficients of variation (CV) for temperature, pH, EC, and TDS in Table 2 above are 0.4205%, 5.37267%, 1.4288% and 5.348% in succession of the water samples during the period of the study. This implies the analysis results of temperature, pH, EC, and TDS is of low fluctuations in each of the data set.

The coefficients of variation (CV) for temperature, pH, EC, and TDS in Table 3 above are 0.48%, 4.2593%, 0.8965% and 3.6703% respectively, of the water samples during the period of the study. This therefore demonstrates insignificant fluctuations in each of the data set of the physicochemical properties.

The coefficients of variation (CV) for temperature, pH, EC, and TDS in Table 4 above are 0%, 1.0196%, 2.3169% and 2.3169% consecutively of the water samples during the period of the study. This is suggestive of very minimal fluctuations in each of the data set of the physicochemical properties.

Table 3. Levels of physicochemical properties of locally packaged Natural Dajab waters.

Local Sample	Properties/Variables			
	Temp (˚C)	pH	EC (µSm/cm)	TDS (ppm)
DJ1	29.67	5.16	33.33	29.00
DJ2	29.83	5.03	31.00	21.70
DJ3	29.92	5.07	30.33	21.23
DJ4	30.00	5.10	30.00	21.00
DJ5	29.92	5.09	30.00	21.00
DJ6	30.08	5.06	30.00	21.00
mean	**29.90**	**5.08**	**30.18**	**21.49**

Table 4. Levels of physicochemical properties of locally packaged Maimie pure mineral waters.

Local Sample	Properties/Variables			
	Temp (˚C)	pH	EC (µSm/cm)	TDS (ppm)
MP1	27.00	6.43	30.67	21.47
MP2	27.00	6.32	29.00	20.30
MP3	27.00	6.28	29.00	20.30
MP4	27.00	6.29	30.33	21.23
MP5	27.00	6.25	30.00	21.00
MP6	27.00	6.29	30.00	21.00
mean	**27.00**	**6.31**	**6.31**	**20.88**

Table 5. Levels of physicochemical properties of imported bottled Success waters.

Local Sample	Properties/Variables			
	Temp (˚C)	pH	EC (µSm/cm)	TDS (ppm)
SUC1	28.67	4.64	30.33	21.23
SUC2	28.25	4.59	29.00	20.30
SUC3	28.67	4.67	29.67	20.77
SUC4	28.67	4.70	29.00	20.30
SUC5	28.42	4.68	27.00	18.90
SUC6	28.50	4.71	28.00	19.60
mean	**28.53**	**4.67**	**28.83**	**16.33**

In the data set as indicated in **Table 5** above, the coefficients of variation (CV) for temperature, pH, EC, and TDS are 0.6034%, 0.9692% 4.1199%, and 2.2137% respectively of the water samples within the period of the research study; these values suggest very low fluctuations in each data set of the physicochemical properties.

Table 6. Levels of physicochemical properties of imported bottled Perlaa waters.

Local Sample	Properties/Variables			
	Temp (˚C)	pH	EC (μSm/cm)	TDS (ppm)
PER1	28.33	6.24	26.67	18.67
PER2	29.00	6.31	24.00	23.80
PER3	28.33	6.33	28.67	20.07
PER4	28.17	6.38	30.33	21.22
PER5	27.83	6.40	28.00	19.60
PER5	27.83	6.40	29.00	20.30
mean	**28.25**	**6.35**	**29.44**	**20.61**

The coefficients of variation (CV) for temperature, pH, EC, and TDS determined from the data, as shown in **Table 6** above, are 1.5271%, 0.9906%, 8.6117% and 8.6117%, respectively, of the water samples during the period of the study. This is indicative of very low fluctuations in each of the data set of the physicochemical properties.

Table 7. Levels of physicochemical properties of imported bottled Eau Crystal waters.

Local Sample	Properties/Variables			
	Temp (˚C)	pH	EC (μSm/cm)	TDS (ppm)
CRY1	28.83	5.00	10.67	7.47
CRY2	28.67	5.00	4.67	3.27
CRY3	28.67	5.00	5.00	3.50
CRY4	28.83	5.00	2.67	1.87
CRY5	28.17	5.00	2.00	1.40
CRY6	29.00	5.00	3.67	2.57
Mean	**28.86**	**5.00**	**4.78**	**3.34**

The coefficients of variation (CV) for temperature, pH, EC, and TDS as was determined from the data as results in **Table 6** above are 0.6751%, 0%, 35.4845% and 34.776% in succession of the water samples during the period of the study. This demonstrates very low fluctuations in each of the data set of temperature and pH but some level of variation in the data set of EC and TDS.

The coefficients of variation (CV) determined from the data set as stipulated in **Table 8** for temperature, pH, EC, and TDS are 0.8641%, 2.1902%, 0.405% and 0.405% accordingly of the water samples during the period of the study. This therefore implies very low variations in each of the data set of the physicochemical properties.

Table 8. Levels of physicochemical properties of imported bottled Belvie waters.

Local Sample	Properties/Variables			
	Temp (˚C)	pH	EC (µSm/cm)	TDS (ppm)
BEL1	29.33	6.51	180.67	126.47
BEL2	29.17	6.46	180.67	126.47
BEL3	29.00	6.45	181.33	126.93
BEL4	29.33	6.17	179.33	125.53
BEL5	29.00	6.56	179.67	125.77
BEL6	29.07	6.52	180.33	126.23
mean	**29.25**	**6.44**	**180.33**	**126.23**

The mean values of temperature of the water samples ranged from 28.92˚C - 29.90˚C (**Tables 1-4**) and 28.53˚C - 29.25˚C (**Tables 5-8**) for locally packaged branded waters and imported bottled branded waters respectively. The temperature values were within WHO optimum limits of 30˚C; however, palatability, viscosity, solubility, odors, and chemical reactions are influenced by temperature [15]. Additionally, most people find water at temperatures of 10˚C - 15˚C most palatable [15]. As such the temperature levels for both locally packaged branded waters and imported bottled branded waters are far above 10˚C - 15˚C which implies most people will not experience or find these waters pleasant in taste during consumption. Importantly, high water temperature enhances the growth of microorganisms and may increase taste, odor, color and corrosion problems [3]. Much as both local and imported water temperatures were observed to be within the threshold limits of WHO standard, but far above the consumable ideal value of 10˚C - 15˚C; it is further indicative that such values will influence other water quality properties which suggests it must have affected the sedimentation, chlorination processes, biological oxygen demand (BOD) [16]. It also affects the biosorption process of the dissolved heavy metals in water [17]. The significance of the difference in temperature property values between each of locally packaged branded waters and all imported bottled branded waters was determined by considering the p-value. The significance level α (alpha) is allowed up to 0.05 (95% confidence level). If the p-value is higher than the significance level α, H_0 is accepted ($p > 0.05$). Accepting H_0 ensures that there is no trend in terms of difference, while if the p-value is less than the significance level α, H_0 is rejected. In this case the p-values are 0.009301, 0.009977, 0.006001, 0.002052 for CW, NR, DJ and MP respectively and all imported bottled branded waters. Being far lower than 5%, the p-value does provide strong evidence against the null hypothesis; the alternative hypothesis (H_1) was accepted indicative of significant difference in the temperature property values between each of the four locally packaged branded waters and all imported bottled branded waters in the study location and therefore the null hypothesis (H_0) which stated that there is no significant difference in the temperature between locally packaged branded waters and all imported bottled branded waters was rejected.

Data analysis expressed the range of mean values of pH from 5.08 to 6.46 (**Tables 1-4**) for locally packaged branded waters and 4.67 to 6.44 (**Tables 5-8**) for imported bottled branded waters. The pH levels were not within WHO permissible limits of between 6.5 and 8.5. Consequently all water samples of both locally packaged branded waters and all imported bottled branded waters are acidic. Excessively high and low pH can be detrimental for the use of water. According to [15] a change of 1 unit on a pH scale represents a 10-fold change in the pH, so that water with pH of 7 is 10 times more acidic than water with a pH of 8, and water with a pH of 5 is 100 times more acidic than water with a pH of 7. Therefore, hydrogen ion index (pH) values lower than 6.5 are considered too acidic for human consumption. The observed samples of both local and imported water brands are of low pH values indicative of acidity which further suggests the presence of metal particulates in the water samples of this research study. In accordance with [19] it was reported that Heavy metals such as cadmium, lead, and chromium dissolve more easily in highly acidic water (lower pH). This is important because many heavy metals become much more toxic when dissolved in water. The significance of the difference in pH levels between each of locally packaged branded waters and all imported bottled branded waters was determined by considering the p-value. For this property, the p-values are 0.2301275, 0.158816, 0.1625586, 0.1123246 for CW, NR, DJ and MP respectively and all imported bottled branded waters. This therefore suggests that there is no significant difference in pH levels between each of the locally packaged branded waters and all imported bottled branded waters, and therefore, the null hypothesis (H_0) in this case was not rejected.

Consistent with world health organization standards, the permissible limit for electrical conductivity (EC) of water is 400 μS/cm. Specific conductance (EC) values of the locally packaged branded water samples ranged from 30.18 to 164.94 μS/cm (**Tables 1-4**) and EC values of imported bottled branded water samples ranged from 4.78 to180.33 μS/cm (**Tables 5-8**). The EC values of both locally, packaged branded waters and imported bottled branded waters are below the WHO permissible limit. Although the EC values for all samples as indicated are far below the WHO threshold standards, yet according to [20] reported that pure water is not a good conductor of electricity. Typical conductivity of water is as follows: Ultra-pure water = 5.5×10^{-6} S/m; and drinking water = 0.005 - 0.05 S/m. Consequently this implies all samples contain to some extent ions that enhance electrical conductivity including the ions of auto-ionization in each of the water samples in question that was observed. In accordance with [21], it was indicated, due to the self-ionization of water into H^+ and OH^-, the electrical conductivity of pure water is non-zero, EC = 0.055 μS/cm at 25˚C. In order to ascertain whether there is disparity in the EC property of the water samples; the significance of the difference in EC levels between each of locally packaged branded waters and all imported bottled branded waters was determined by considering the p-value. For this property, the *p*-values are 0.413674, 0.210143, 0.25477, 0.248506 for CW, NR, DJ and MP respectively and all imported bottled branded waters. This therefore demonstrates that there is no significant difference in EC levels between each of the locally packaged branded waters and all imported bottled branded waters; therefore, the null hypothesis (H_0) in this case was accepted.

Total dissolved solids ranged from 21.49 to 115.46 ppm (**Tables 1-4**) for locally packaged branded water samples, whereas for imported bottled branded water samples TDS ranged from 3.34 to 128.23 ppm (**Tables 5-8**). All the samples had a total dissolved solid concentration below the WHO permissible limit in drinking water of 1000 ppm. However, the TDS concentration levels indicated above will not have significant effect on the taste of all water samples in question. In conformity with [22]... the palatability of water with a TDS level of less than 600 mg/l is generally considered to be good. However, the low TDS values in both the local and imported brands of water in this study are not in agreement with some heath issues and may have some implications on the aesthetic property of the water samples explored; it was indicated by [26], that distilled and low mineral content water (TDS < 50 mg/L) can lead to negative taste characteristics to which the consumer may adapt with time and can be less thirst quenching. In accordance with [27], severe acute damage, such as hyponatremic shock or delirium, may occur following intense physical efforts and ingestion of several liters of low-mineral water. In an effort to detect inconsistency in the TDS property of the water samples; the significance of the difference in TDS concentration levels between each of locally packaged branded waters and all imported bottled branded waters was determined by considering the *p*-value. In this case also for TDS property, the *p*-values are 0.426527, 0.204684, 0.264932, 0.259237 for CW, NR, DJ and MP successively and all imported bottled branded waters. This therefore reveals that there is no significant difference in TDS concentration levels between each of the locally packaged branded waters and all imported bottled branded waters, consequently the null hypothesis (H_0) in this case was accepted.

4. Conclusion

It was indicated by [4] up to 80% of all sicknesses and diseases in the world are caused by inadequate sanitation, polluted water or unavailability of water. Additionally, Sustainable Development Goal six (SDG 6) is to ensure sustainable water management and sanitation for all by 2030 [5]. Based on the results of the physicochemical water properties explored in this study; it was revealed that there was no significant difference in pH, EC and TDS variables between the branded locally packaged water and the imported bottled branded waters; while these properties indicated no significant difference, there was significant difference in temperature between the branded locally packaged water and the imported bottled branded waters, However, all results of temperature variable recorded for both types of water observed were within WHO permissible standards of consumption but far above the range of 10˚C - 15˚C that favors palatability and other properties of water. Therefore, both types of water will not be pleasant in taste during consumption. Generally, samples of both locally packaged branded waters and all imported bottled branded waters were acidic, below the 6.5 - 8.5 threshold permissible limit as required by WHO, which have serious health implications on consumers. The EC and TDS properties of both types of water samples explored were in accordance with the WHO permissible limits for consumption, as such will not pose any significant effect on consumption. It was therefore recommended by this study that routine testing be carried out consistent regularly by the Liberian bureau of standards on samples of both imported bottled branded waters and branded locally packaged waters before human consumption in the study and other areas for especially health issues as indicated supra.

Acknowledgements

The Authors of this work are quite grateful to GOD Almighty in going through this piece of work together in like minds and good health.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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