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The Physical and Chemical Properties Study to Evaluate the Quality of Bottled Drinking Water Offered in Misurata Markets

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تحليل بعض الخواص الفيزيائية والكيميائية لتقييم جودة مياه الشرب المعبأة المعروضة في أسواق مصراتة

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Abstract:
This paper addresses the first biological liquid water, which facilitates the conversion of food into energy and acts as a conduit for the transfer of pollutants to and from the human body. The most significant distinction between bottled drinking water and water sourced from public networks is the quality of the former. This study aimed to analyses and evaluate the quality of bottled drinking water consumed in Misurata markets. A total of 12 samples of local and imported bottled water products were selected for analysis, with the chemical and physical properties of each sample evaluated. These properties included turbidity, The samples were analyzed for a range of chemical and physical properties, including colour, total dissolved salts, pH, electrical conductivity, ammonia, nitrate, nitrite, magnesium, bicarbonate, sulfate, sodium, calcium, total hardness, potassium, residual ozone. The results were then compared with the Libyan and international standard specifications for bottled drinking water, as well as the data provided on the packaging, in order to evaluate the quality of the samples. The results of the chemical analysis of total dissolved solids indicated that 50% of the samples were below the permissible limit set forth in the Libyan specifications. Conversely, the results of the other analyses demonstrated that they conformed to the aforementioned specifications. With regard to the data

presented on the packaging, there were numerous discrepancies between the observed results and the information stated on the packaging.

Keywords: Drinking water; Total dissolved salts; Total dissolved solids; Suspended solids; Total hardness.

الملخص

يتناول هذا البحث أولاً المياه السائلة البيولوجية التي تسهل تحويل الغذاء إلى طاقة وتعمل كموصل لنقل الملوثات من وإلى جسم الإنسان. إن أهم ما يميز مياه الشرب المعبأة والمياه المأخوذة من الشبكات العامة هو جودة الأولى. هدفت هذه الدراسة إلى تحليل وتقييم جودة مياه الشرب المعبأة المستهلكة في أسواق مصراتة. تم اختيار إجمالي 12 عينة من منتجات المياه المعبأة المحلية والمستوردة للتحليل، مع تقييم الخصائص الكيميائية والفيزيائية لكل عينة. تضمنت هذه الخصائص العكارة، والقلويات. وقد أشارت نتائج التحليل الكيميائي للمواد الصلبة الذائبة الكلية إلى أن 50% من العينات كانت أقل من الحد المسموح به في المواصفات الليبية، وعلى العكس من ذلك، فقد أثبتت نتائج التحليلات الأخرى أنها مطابقة للمواصفات المذكورة أعلاه. وفيما يتعلق بالبيانات المقدمة على العبوة، فقد كانت هناك العديد من التناقضات بين النتائج المرصودة والمعلومات المذكورة على العبوة.

الكلمات المفتاحية: مياه الشرب، الاملاح الكلية الذائبة، المواد الصلبة الذائبة، المواد الصلبة العالقة، العسر الكلي.

Introduction

Water is a vital component of human life, constituting approximately two-thirds of the body's weight. The absence of water results in a significantly shorter lifespan. It is possible to survive for several weeks without food, but only a few days without water. The loss of water from the body is a more rapid cause of death than hunger. (Al-Shaer and Qatash, 2004) Water is an essential element for all living organisms and constitutes 71% of the Earth's surface. Despite water's indispensable role in sustaining life, we often treat it irresponsibly, causing significant environmental degradation. This pollution, whether direct or indirect, will inevitably impact us (Aoun and Kamoka, 2019).

The provision of clean drinking water has become a challenging endeavour due to the prevalence of pollutants that reach it in various ways and cause significant health issues, particularly in humans. In the contemporary era, the majority of water sources have been contaminated, spanning from oceans, seas, and rivers to groundwater and rainwater. The pollutants that enter the human body on a daily basis through the consumption of water represent a significant health risk, irrespective of whether these pollutants are biological or chemical in nature. Consequently, the monitoring of drinking water quality represents a crucial aspect in the enhancement of public health. This is achieved through the continuous investigation of the quality of water and its suitability for human consumption.

The implementation of modern purification technologies inevitably entails significant material costs. A significant proportion of the diseases and health issues that affect people, whether children or adults, are attributable to water. This is due to either its pollution or its lack of salts and essential elements that are necessary for the human body. In some areas of Libya, the inhabitants continue to consume water extracted directly from wells (groundwater) without any form of treatment. In some cases, no evaluation of the water's biological, physical, or chemical properties is conducted to determine its suitability for drinking. The satisfaction with the water's taste, regardless of whether it is palatable or not, is a common observation. The issue of water scarcity in coastal regions of Libya is further compounded by the prevailing climatic conditions, in addition to the phenomenon of seawater intrusion into groundwater systems, which results in elevated salinity levels and renders the water unfit for human consumption. As a potential solution to this problem, the government permitted the establishment of numerous desalination factories, which produce and bottle water in plastic containers of varying sizes for sale to consumers for drinking purposes. The demand from citizens to purchase bottled water has contributed to the growth of the bottled water sector (Aoun and Kamoka, 2019). The aforementioned water has become a pervasive presence in a multitude of settings, including residential, occupational, and service facilities such as hospitals and schools. The physical and chemical properties of water are of great consequence in academic and other settings, exerting a profound influence on water quality.

The water molecule is constituted by the union of one oxygen atom with two hydrogen atoms, forming a strong bond that is resistant to rupture. The atoms are linked to each other in a way that exhibits a clear electrical polarity, due to the fact that each of the hydrogen atoms carries a relative positive charge, and the oxygen atom carries a relative negative charge. This results in the water molecule not being completely electrically neutral. This electrical polarity is the reason for the distinctive properties of water, including its superior ability to dissolve, surface tension, and the intensity of the adhesion of its molecules, which allows it to climb (capillary property) and to curl into droplets, as well as the incomplete mixing of its solutions (Al-Zawawi, 2004).

The industrial process of preparing water for human consumption can be broadly classified into two categories: natural and unnatural. The former encompasses spring water, groundwater, and rainwater, while the latter includes desalinated water. Regardless of its origin, the purification and filtration of water involves the removal of impurities and the addition of chemical elements to enhance its quality in accordance with the standards set by the World Health Organization (Nizam and Hassan, 2005).

The broke down solids present in packaged normal mineral water have been viewed as under 250 sections for every million. Moreover, normal mineral water can be grouped into two subcategories: premium regular mineral drinking water and normal mineral water. Packaged drinking water will be water extricated from any wellspring of drinking water (indeed, groundwater, and so forth) and may go through different treatment processes, including filtration, air circulation, and opposite assimilation. The previously mentioned processes bring about the decontamination of water over a drawn-out period (Belal, 2015).

Turbidity is brought about by the presence of suspended materials in the water, including dust, natural particles and other tiny organic entities. Thus, turbidity may in a roundabout way influence water quality and its related wellbeing chances. It is along these lines ideal for turbidity to be under 1 nephelometric turbidity unit (NTU). (Al-Tarifi et al., Conductivity values in sea-going conditions act as dependable pointers for assessing the disintegrated solids content and the general immaculateness of water. This is because of the way that the more noteworthy the centralization of disintegrated solids in water, the more prominent its capacity to communicate electric momentum. (Mohamed and Shawq, 2019)
Furthermore, the pH esteem measures the degree to which different mixtures broke up in water accomplish a balance among acidic and basic properties. Regardless of its backhanded effect on general wellbeing, the connection among pH and water quality includes a large number of interrelated factors (Shalouf et al., 2018).

With regard to water hardness as a compound or a single component, it encompasses a group of natural dissolved salts, to which the phenomenon of hardness is attributed. These include calcium carbonate, magnesium carbonate, and magnesium sulfate, in addition to other components present in lesser quantities, such as carbonates, bicarbonates, and sulfates of barium, silica, iron salts, manganese, and aluminum. The consumption of water with a high degree of hardness may result in an increased risk of developing urinary stones. The objective of this study is threefold: firstly, to compare the results of laboratory testing of bottled drinking water with the specifications set out by the Libyan Authority and the requirements outlined by the World Health Organization; secondly, to compare the results of laboratory testing of bottled drinking water with the standards mentioned on the preamble of the packages; and finally, to measure the quality of bottled drinking water.

A substantial body of local research has been undertaken to examine the chemical and physical characteristics of bottled drinking water. A study was conducted (Shalouf et al., 2018) in which 12 samples of bottled drinking water in plastic containers were randomly collected from factories in different areas of Misurata city. The findings of the study demonstrated that the pH values of eight samples were below the minimum permitted levels as outlined in the specifications. The results of the analysis of dissolved salts and total hardness indicated that one sample exceeded the maximum permitted level set forth in the Libyan specifications but did not exceed the global health specifications.

Additionally, a study was conducted on the physical and chemical properties of drinking water in private desalination plants within the borders of Sabha city. Water samples were taken from some private desalination plants and examined in cooperation with the Chemistry Department at Sabha University. The results demonstrated that the pH values exhibited a tendency towards neutrality, with a range of

7.03 to 8.08. This falls inside as far as possible set out by both Libyan and worldwide details for drinking water and human use. (Al-Haqqar et al., 2020). A further report (Qabasa et al., 2020) focused on the examination and assessment of the nature of packaged drinking water from a determination of tests drank in Libyan business sectors. The outcomes acquired in the research center for every one of the concentrated-on examples were thought about, and it was found that none of the water tests met the determinations set out in the Libyan norm for human utilization. Furthermore, a review was conducted (Al-Huwaidi and Al-Sadiq, 2020) on various types of bottled drinking water available on the local market in the city of Sabha. The study encompassed a total of 12 samples, comprising both locally produced and imported varieties. A progression of actual properties was assessed, including thickness, surface pressure, consistency, electrical conductivity, refractive file, turbidity, and pH. The aftereffects of the actual boundaries of the filtered water tests were contrasted and the qualities demonstrated on the bundling. A few boundaries, like electrical conductivity and turbidity, were either not characterized by any stretch of the imagination or were grouped exclusively in a predetermined number of brands of filtered water.

The aftereffects of the turbidity tests showed that 55% of the examples were without microscopic fish, and the pH values fell inside as far as possible set by the World Wellbeing Association (WHO). In contrast with the standard incentive for surface strain in water, the surface pressure values were viewed as essentially raised. The consequences of the measurable examination exhibited an ideal positive relationship between's electrical conductivity and complete broke up solids, notwithstanding a huge positive connection between's surface strain and thickness. As indicated by the math water quality list, 46% of the examples showed phenomenal water quality. In contrast with the norms set out by the Public Place for Principles and Metrology, the World Wellbeing Association, and the Global Filtered water Affiliation (IBWA) for packaged drinking water, the brands of packaged drinking water created locally in Libya and the imported brands remembered for this study exhibited an excellent degree of value across every single actual boundary. Additionally, a study was conducted (Balq et al., 2019) to assess the quality of the most frequently consumed bottled drinking water in the western region.

In May 2018, a study was conducted to evaluate the physical and chemical properties of five samples of local bottled drinking water that were available on the Libyan market. These types were represented by Al-Nabaa, Al-Saqi, Al-Dhifayya, Shaimaa and Rahaf, all of which are local varieties. The analyses included the determination of pH, electrical conductivity, total hardness, and the estimation of total alkalinity, nitrates, nitrites, chloride, and bicarbonates. The results demonstrated that the evaluated properties for the five types of bottled water were within the permissible limits of the Libyan specifications for bottled drinking water in the majority of analyses. However, the total dissolved solids (TDS) exhibited values below the minimum permissible limit for Al-Nabaa, Al-Saqi and Al-Dhifayya water. Therefore, this water is similar to distilled water. Furthermore, when the concentrations mentioned on the packages were compared to the results, the former were found to be lower. However, a comparison of the remaining analyses with those stated on the packaging revealed that the values were largely identical (Aoun and Kamoka, 2019).

Material and Methods

It is of the utmost importance that the sample to be analysed is taken in the correct manner, as this will have a significant impact on the subsequent analysis. In this study, 12 samples of the most widely consumed packaged drinking water were selected to ensure that any changes in properties were minimal as illustrated in Table 1. Newly packaged and manufactured samples were randomly collected from various locations within Misurata city and from different brands, including 10 locally produced brands and 2 imported samples. A total of 17 analyses were conducted on the samples in order to evaluate their quality and to facilitate a comparison of the results with the specifications and standards set out by the Libyan authorities and the World Health Organization for the quality and suitability of bottled drinking water.

Table (1): shows the studied samples.

NO	Sample code	Sample volume in liters	Country of origin
1	S1	0.5	Misurata - Libya
2	S2	0.5	Tripoli - Libya
3	S3	0.5	Zliten - Libya
4	S4	0.5	Tripoli - Libya
5	S5	0.5	Misurata - Libya
6	S6	0.5	Misurata - Libya
7	S7	0.5	Benghazi - Libya
8	S8	0.5	Tripoli - Libya
9	S9	0.5	Misurata - Libya
10	S10	0.5	Tripoli - Libya
11	S11	0.5	Italy
12	S12	0.5	Italy

A series of physical and chemical tests were conducted on a range of bottled waters, including both local and imported samples. The tests were carried out on a number of parameters, including pH, total dissolved solids, electrical conductivity, turbidity, colour, ammonia, nitrates and nitrites, magnesium, bicarbonates, sulfates, potassium, total hardness, ozone, sodium, and calcium.

Results and discussion

Specifications adopted in the study: (M.Q.L, 2020). Table (2) shows the specifications adopted in the study.

Table (2): The specifications adopted in the study.

NO	Chemical symbol	Standard unit	Local Standard Specifications	International Standard Specifications
1	PH	–	8-6.5	8.5-6.5
2	TDS	mg/l	500-100	1000-500
3	EC	cm/ µS	-	1500-450
4	Turbidity	NTU	1	5
5	Colors	TCU	5	15
6	NH_3	mg/l	0.5	1.5
7	NO_3	mg/l	10	50
8	NO_2	mg/l	3	3
9	T.H	mg/l	200	500
10	O_3	mg/l	0.4	-
11	SO_4	mg/l	150	400-200
12	K	mg/l	12	12
13	Mg	mg/l	30	50-10
14	Na	mg/l	100	200
15	Ca	mg/l	75	200-30
16	HCO_3	mg/l	150	200

A change in pH value will consequently impact the chemical activities of the human body. The pH value of the fluids within the human body typically ranges between 7.2 and 7.0. A pH value below 6.4 impairs the absorption of vitamins and disrupts the function of enzymes. Additionally, a pH value exceeding 8.5 results in the water acquiring a pungent taste (ALHORY, 2013). As illustrated in Figure 1, the pH values exhibited a range between 6.9 and 7.5, with the highest value observed in sample S12 and the lowest in sample S8. The pH values of samples S1, S3, S6, S7, S8 and S9 were identical to the values recorded on the packaging. With regard to the remaining samples, the pH values were found to be in close alignment with the values indicated on the packaging. The discrepancy in pH values can be attributed to the prevailing types of salts in the soil, which exert an influence on the pH values. As illustrated in the figure, all study samples comply with the Libyan standard specifications and the World Health Organization specifications.

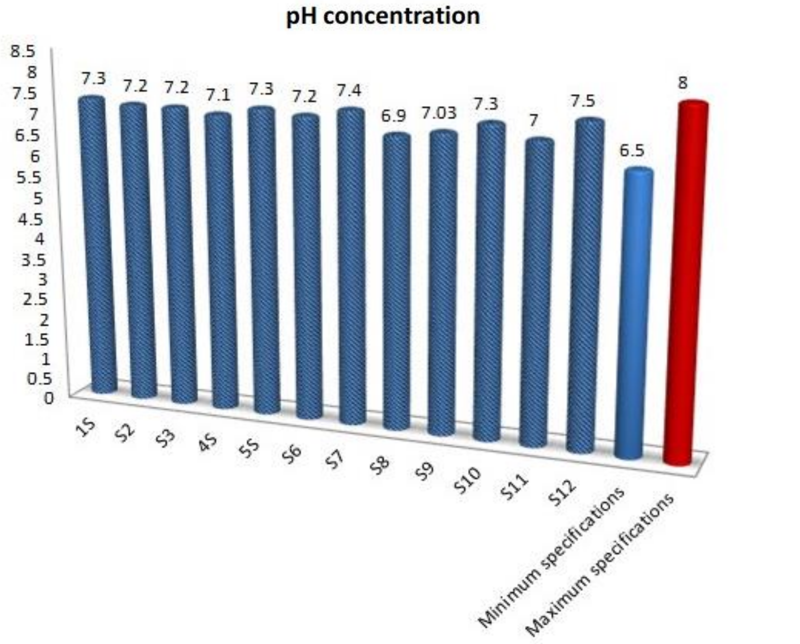


Figure (1): pH values of the studied samples.

The following inorganic salts and select organic materials are soluble in water: calcium, magnesium, sodium, potassium, carbonates, chlorides, sulfates, and nitrates. The quantity and quality of dissolved and undissolved materials in water are highly variable, and may contain substances that consume oxygen and pathogenic agents. An elevated concentration of dissolved solids in potable water results in an unfavorable taste, necessitating the implementation of costly and sophisticated treatment methods (ALHORY, 2013). The concentration of total dissolved solids was determined for all samples and the results were compared with the local and international specifications for drinking water, as illustrated in Figure 2. The total dissolved solids (TDS) concentration was found to range between 174 and 20 mg/L across the 12 samples.

The highest TDS value was observed in sample S2, while the lowest was observed in sample S11. It would appear that 50% of the samples are below the minimum recommended level set out in the Libyan specifications. Of the remaining samples, four were local and two were imported. The remainder were in accordance with the Libyan specifications. It is notable that all the results were relatively low. This is a cause for concern, as high levels of dissolved solids in drinking water have been linked to a range of health issues, including low blood pressure, high blood cholesterol, osteoporosis, tooth decay and poor memory. Despite its suitability for drinking, the water in question remains inconsistent with the standard specifications set out locally and internationally. (Insaniya, 2021), and the data recorded on the packaging of the samples (S1, S3, S6, S9, S10) were in accordance with the results obtained. However, the remaining samples did not align with these findings. The low concentrations of dissolved salts in the samples may be attributed to the difference in the water source and the efficiency of the treatment system. During the process of production, the water loses a large amount of its salts, which are not compensated for in the production stages.

The measurement of electrical conductivity is a crucial parameter in the assessment of water quality. It is a numerical representation of the solution's capacity to facilitate the flow of electrical current. The value of this number is contingent upon the total concentration and equivalence of ionised materials present in the water sample, as well as the temperature at which the measurements are taken. Electrical conductivity serves as an indicator for measuring total dissolved solids (Ahwidy et al., 2020). Figure 3 illustrates that the electrical conductivity values range between 260 and 30 µS/cm, with the highest value observed in sample S2 and the lowest in sample S11. The discrepancies in the outcomes can be attributed to the adaptability of the treatment units in controlling the proportion of salts that are removed.

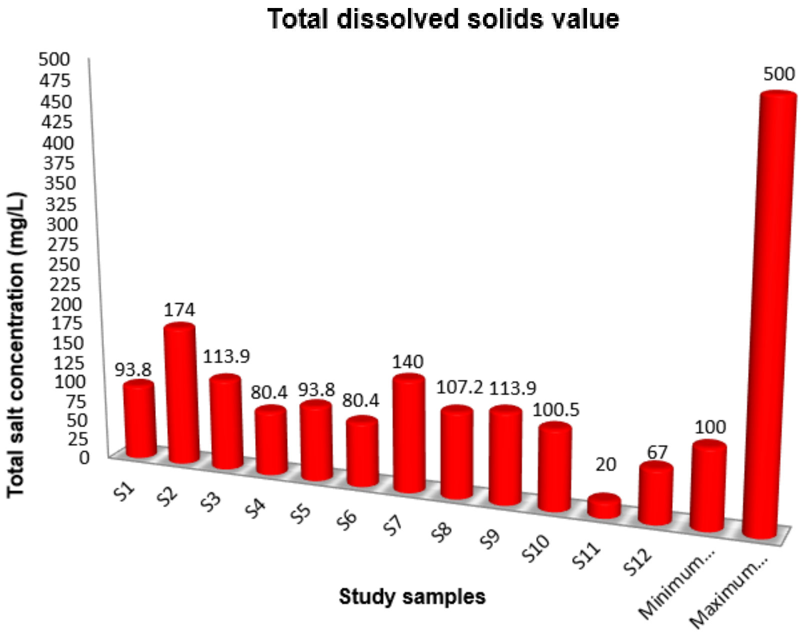


Figure (2): Total dissolved salts values for the studied samples.

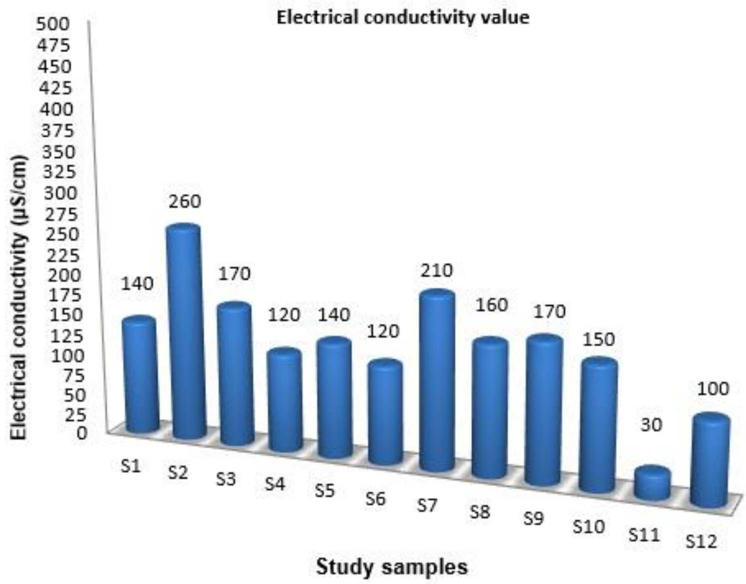


Figure (3): Electrical conductivity values of the studied samples.

Turbidity analysis is regarded as a crucial variable in the evaluation of water intended for human consumption, given the potential presence of mineral elements among suspended particles that may pose a health risk to consumers. Furthermore, it demonstrates the efficacy of the treatment units. The discrepancy in turbidity values can be attributed to the distinct sources of water utilized in the treatment system, including spring, river, and well water, as well as the varying efficacy of the treatment processes employed. Figure 4 illustrates the turbidity values observed in all study samples, which were devoid of suspended particles and met the Libyan specification.

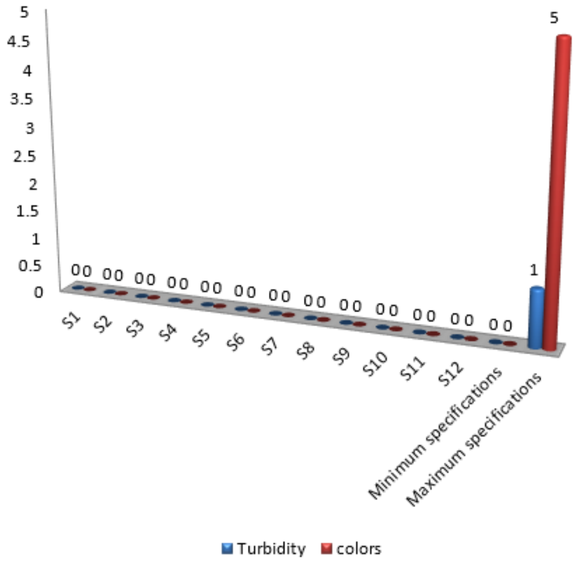


Figure (4): Turbidity and color values of the studied samples.

It is evident that the concentration of ammonia in all samples was minimal and fell below the minimum limits set forth by the Libyan standard specifications for drinking water and the specifications of the World Health Organization. The lowest recorded value was zero in samples S2, S3, S5, and S9, while the highest value was 0.05 mg/L in sample S6. These findings are illustrated in Figure 5. It is important to highlight that the presence of ammonia in drinking water is indicative of the impact of black wells on groundwater and the contamination of this water source with sewage from the surface tank. An elevated concentration of ammonium has been linked to certain neurological disorders, including Alzheimer's disease, which predominantly affects the elderly. However, it remains uncertain whether this is a primary cause or merely a contributory factor in the development of other underlying conditions.

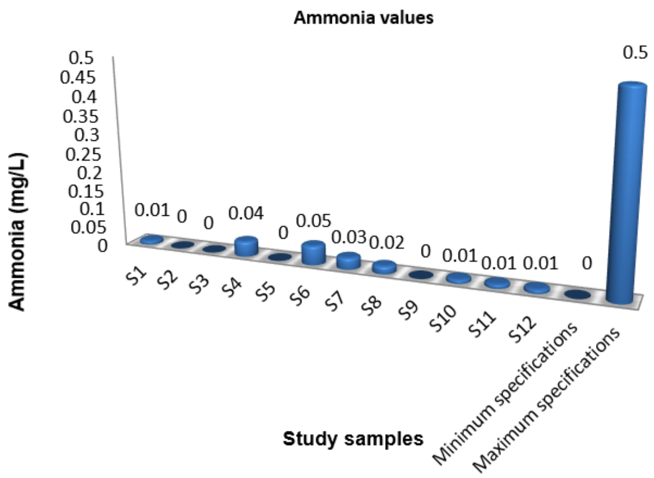
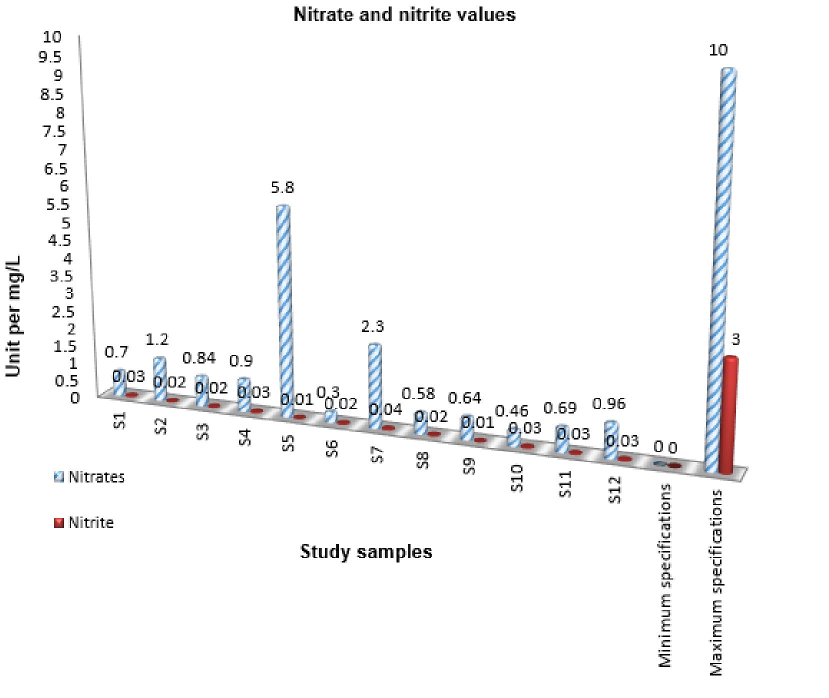


Figure (5): Ammonia values for the studied samples.

The concentration of nitrate in drinking water has been linked to adverse effects on human health, with instances of severe brain dysfunction reported. Furthermore, the danger of nitrates in the human body also lies in their conversion into nitrogenous compounds, which are highly deleterious and can lead to kidney failure as well as anaemia in children (Al-Insaniya, 2021). Figure 6 illustrates the range of nitrate concentration values, which were observed to fall between 5.8 and 0.30. The lowest recorded value was observed in sample A6, while the highest value was noted in sample S5. Therefore, the nitrate concentration in all samples is in accordance with both the Libyan standard specifications and the World

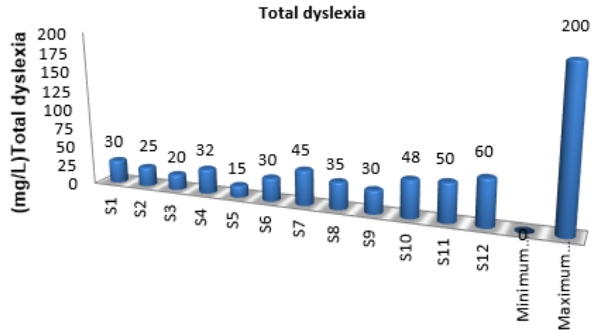
Health Organization specifications. The recorded nitrate concentration values on the packages of all samples were found to be inaccurate in comparison to the analysis results, with the exception of samples S1, S5 and S7. The nitrate concentration values were not included on the packaging. It seems probable that the nitrate values in the samples are low as a result of the absence of fertilizers and industrial discharges from water sources, their distance from landfills, and their lack of interference with sewage, as well as the quality of water purification in factories. Figure 6 illustrates the concentration of nitrite values for the study samples. It is noteworthy that the highest value was 0.04 in sample S7, while the lowest value was 0.01 in samples S5 and S9. All results were within the permissible limit as defined by the Libyan standard specifications and the World Health Organization specifications. The classification of water hardness is based on the concentration of calcium carbonate ($CaCO_3$). The term "soft" is used to describe water with a concentration of $CaCO_3$ below 100 mg/L. A concentration exceeding 200 mg/L is indicative of hard water. Water is considered to be of an extremely high degree of hardness if the concentration of $CaCO_3$ exceeds 500 mg/L (ALHORY, 2013). The disparity in recorded hardness values can be attributed to the provenance of the water source and the geomorphological characteristics of the region through which it flows. The soil composition is characterized by a high concentration of calcium, which is a primary factor influencing the agricultural landscape.

Figure 7 illustrates the concentration of total hardness, which was found to range between 15 and 60 mg/L across the samples. The lowest value was observed in sample S5, while the highest value was observed in sample S11. All results were found to be within the permissible limits set forth in the Libyan standard specifications. It should be noted that the total hardness values displayed in the containers for samples (S2, S4, S6, S7, S10) do not accurately represent the total hardness results obtained from the analyses. Furthermore, the remaining samples did not exhibit total hardness values within their containers.



	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	Minimum specifications	Maximum specifications
Nitrates	0.7	1.2	0.84	0.9	5.8	0.3	2.3	0.58	0.64	0.46	0.69	0.96	0	10
Nitrite	0.03	0.02	0.02	0.03	0.01	0.02	0.04	0.02	0.01	0.03	0.03	0.03	0	3

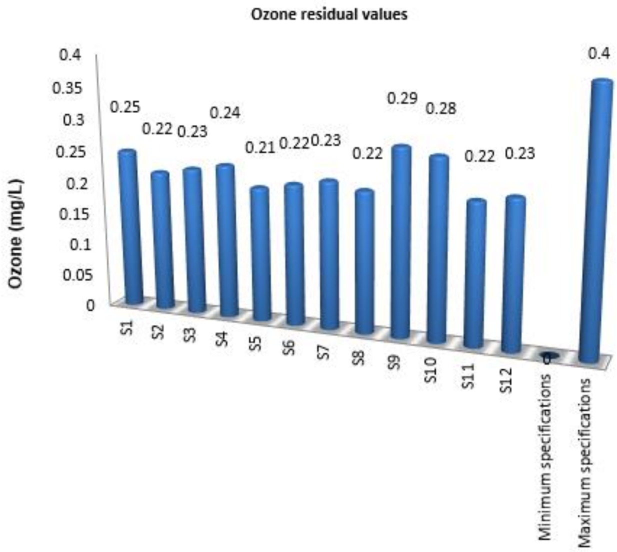
Figure (6): Nitrate and nitrite values for the studied samples



	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	Minimum specifications	Maximum specifications
Total dyslexia	30	25	20	32	15	30	45	35	30	48	50	60	0	200

Figure (7): Total hardness values for the studied samples.

The ozone results demonstrated that all study samples were in compliance with the Libyan standard specifications. The lowest value (0.21) was observed in sample S5, while the highest value (0.29) was observed in sample S9 (Figure 8). The sulfate concentration values in all study samples were relatively low, but within the permissible range of both Libyan standard specifications and World Health Organization specifications. The lowest value (0 mg/L) was observed in samples S6, S7, S9, and S10, while the highest value (2 mg/L) was observed in samples S4, S8, and S12. These findings are illustrated in Figure 9. It should be noted that sulfate values were not included in the data recorded on the packages for samples S1 and S11. Additionally, the recorded values for the remaining samples differed from the test values. The absence of sulfate in potable water below the requisite threshold has been linked to an increased susceptibility to respiratory infections, including pneumonia (Al-Insaniya, 2021).



	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	Minimum specifications	Maximum specifications
Ozone residual	0.25	0.22	0.23	0.24	0.21	0.22	0.23	0.22	0.29	0.28	0.22	0.23	0	0.4

Figure (8): Ozone values for the studied samples.

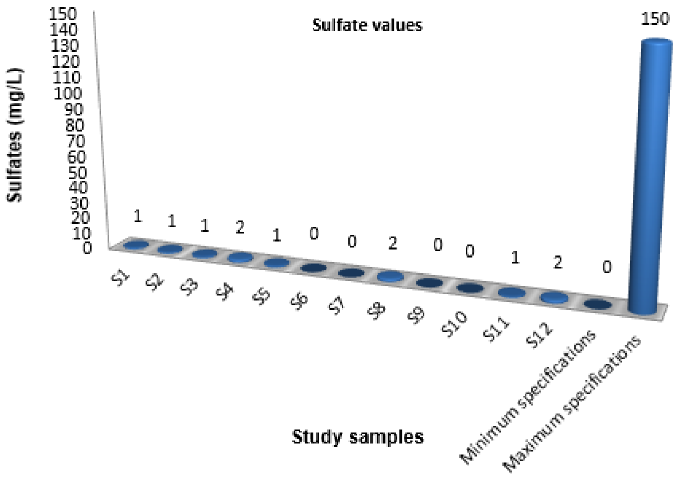


Figure (9): Sulfate values for the studied samples

The potassium concentration values demonstrated that all the study samples were in compliance with the Libyan standard specifications. The lowest value (1.3 mg/L) was observed in sample S9, while the highest value (9 mg/L) was observed in samples S3, S10, and S11. Additionally, the potassium values in the samples were higher than the data recorded on the packages, with the exception of samples S1 and S11, for which the concentration was not mentioned on the package. This is illustrated in Figure 10. The disparity in potassium concentrations can be attributed to the type of soil surrounding the water source and the efficacy of the treatment unit.

Figure 10 illustrates the concentration of magnesium, which exhibited a range of values between 31 and 1 mg/L. The lowest value was observed in sample S5, while the highest was noted in sample S12. All results fell within the permissible limits set forth in the Libyan standard specifications for drinking water, with the exception of sample S12, which exhibited a slightly elevated concentration. Furthermore, samples S1, S6, S9 and S11 did not include the magnesium concentration in the recorded data. However, the recorded concentration of magnesium on sample N3 matched the analysis result. Conversely, the remaining samples exhibited discrepancies. It is noteworthy that magnesium plays a crucial role in metabolic processes within the human body, yet it does not exert any adverse effects on human health.

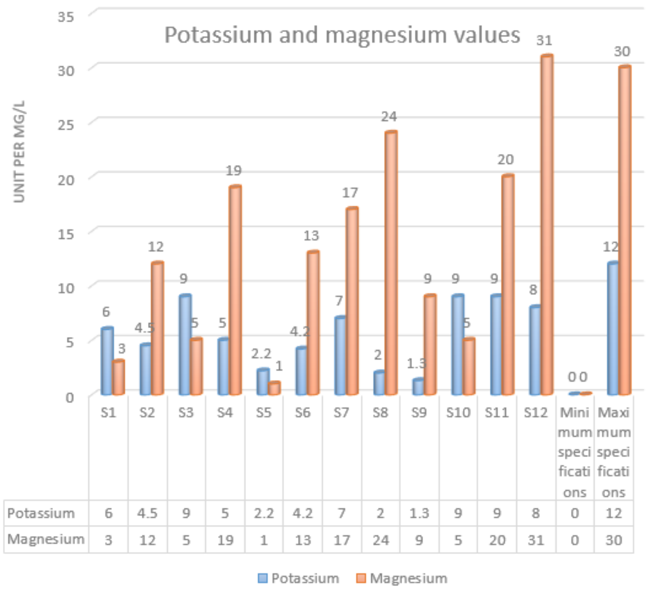


Figure (10): Potassium and magnesium values for the studied samples

The concentration of the substance in question varies in accordance with the concentration of water, and the substance's concentration increases in hard water. An increase in concentration in water causes acute poisoning, vomiting, convulsions and dehydration in children (ALHORY, 2013). The sodium results demonstrated that all study samples were within the permissible range as defined by the Libyan standard specifications and the World Health Organization specifications. The lowest value (8) was observed in sample S12, while the highest value (32) was observed in samples S2, as illustrated in Figure 11. The sodium values in samples S3, S5 and S8 were found to be consistent with the data recorded on the packaging, while the remaining samples exhibited inconsistencies. Calcium is the most prevalent mineral element in the human body (ALHORY, 2013). Figure 11 illustrates the concentration of calcium in the samples, which fall within the permissible limit set by the Libyan standard specifications for drinking water (9-4 mg/L). The lowest value is observed in sample S12, while the highest value is seen in samples S2 and S7. It is evident that the concentration of calcium in drinking water is markedly low, falling below the optimal level of 75 mg/L. This is crucial for the development of bones and teeth, particularly in children. The discrepancy in calcium concentration between the water sources used for production and the surrounding geological composition and soil type is a significant contributing factor.

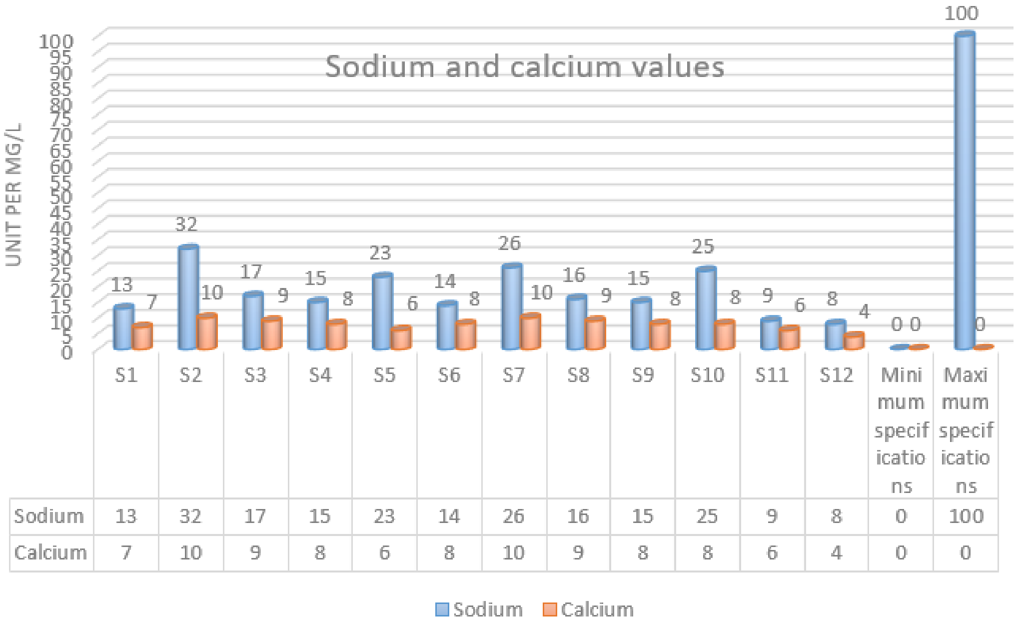


Figure (11): Sodium and calcium values for the studied samples.

Figure 12 illustrates the concentration of bicarbonate, which was found to range between 128 and 4 mg/L. It can be observed that the lowest value is present in sample S5 and the highest value is present in sample S12. All samples comply with the specifications set forth by the Libyan authorities and the World Health Organization, and are therefore deemed suitable for human consumption.

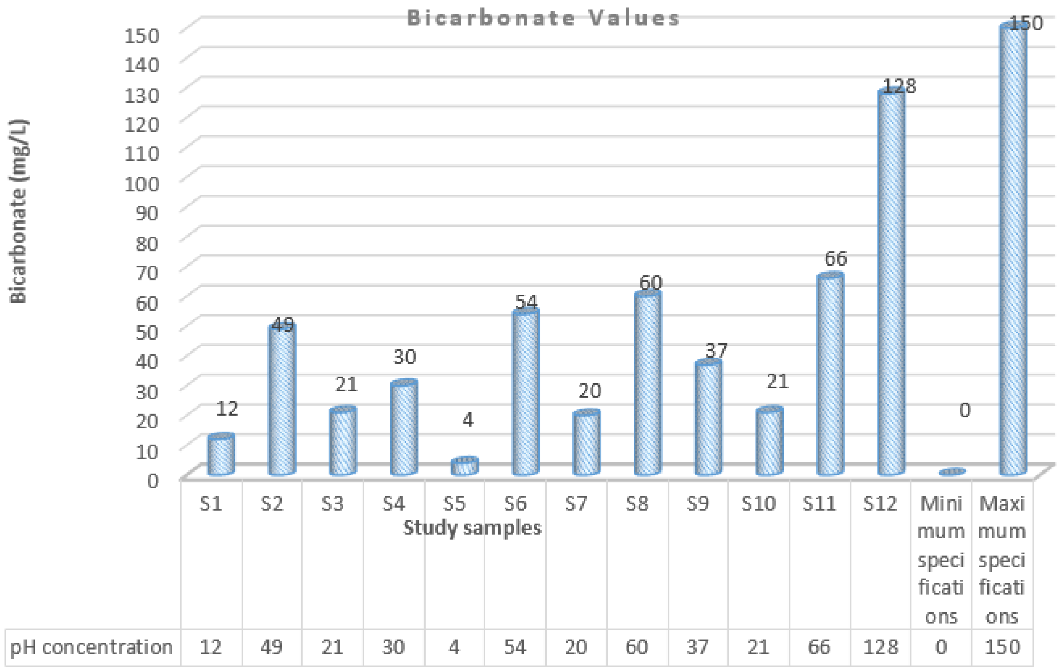


Figure (12): Bicarbonate values for the studied samples

Table (3): Comparing the results with the data written on the packages.

(a) Comparing the analysis results.

Sample	Analysis results							
	PH	TDS	EC	Turbidity	Colors	NH3	NO3	NO2
S1	7.3	93.8	140	0	0	0.01	0.70	0.03
S2	7.2	174	260	0	0	0	1.20	0.02
S3	7.2	113.9	170	0	0	0	0.84	0.02
S4	7.1	80.4	120	0	0	0.04	0.90	0.03
S5	7.3	93.8	140	0	0	0	5.80	0.01
S6	7.2	80.4	120	0	0	0.05	0.30	0.02
S7	7.4	140	210	0	0	0.03	2.30	0.04
S8	6.9	107.2	160	0	0	0.02	0.58	0.02
S9	7.3	113.9	170	0	0	0	0.64	0.01
S10	7.3	100.5	150	0	0	0.01	0.46	0.03
S11	7	20	30	0	0	0.01	0.69	0.03
S12	7.5	67	100	0	0	0.01	0..96	0.03

(b) The data written on the packages.

Sample	Data written on the bottle							
	PH	TDS	EC	Turbidity	Colors	NH3	NO3	NO2
S1	7.2-7.8	150<	-	-	-	-	-	-
S2	6.7	105	-	-	-	-	0.5	-
S3	6.5-7.5	100 -120	-	-	-	-	3	-
S4	7	>100<	-	-	-	-	0.1	-
S5	6.9	100-130	-	-	-	-	-	-
S6	6.5-8	70-200	-	-	-	-	0.34	-
S7	6.5-7.5	80-130	-	-	-	-	-	-
S8	6.5-7.5	>120<	-	-	-	-	3	-

S9	6.5-8.5	100-130	-	-	-	-	0.05	-
S10	6.5-7	100-120	-	-	-	-	2	-
S11	6.9	22	-	-	-	-	0.81	-
S12	7.7	48	-	-	-	-	2.6	-

Table (4): Comparison of results with data recorded on the packages.

(a) Analysis results.

Sample	Analysis results							
	Caco3	O3	So4	K	Mg	Na	CA	HCO3
S1	30	0.25	1	6	3	133	7	12
S2	25	0.22	1	4.55	122	32	100	49
S3	20	0.23	1	9	5	17	9	21
S4	32	0.24	2	5	19	15	8	30
S5	15	0.21	1	2.2	1	23	6	4
S6	30	0.22	0	4.2	13	14	8	54
S7	45	0.23	0	7	17	26	10	20
S8	35	0.22	2	2	24	16	9	60
S9	30	0.29	0	1.3	9	15	8	37
S10	48	0.28	0	9	5	25	8	21
S11	50	0.22	1	9	20	9	6	66
S12	60	0.23	2	8	31	8	4	128

(b) Data written on the bottle.

Sample	Data written on the bottle							
	Caco3	O3	So4	K	MG	Na	Ca	HCO3
S1	-	-	-	-	-	-	-	-
S2	84	-	86	1	20	3	1	1.3
S3	-	-	17	1	5	17	8	25
S4	40	-	7	0.9	2	25	8	7
S5	-	-	41	2	7	23	8	23
S6	14.4	-	7.04	0.60	-	17.09	-	5.59
S7	>200<	-	65	0.8	13.2	14.5	5.2	6
S8	-	-	15	1	5	16	8	25
S9	-	-	2	0.9	-	10	9	25
S10	22	-	10.7	0.8	2.2	19	4.2	22.6
S11	-	-	-	-	-	1.5	2.9	10
S12	-	-	1.8	0.25	4.2	0.30	10	51.4

Conclusion

The findings of this study are based on a comparison of the laboratory results of the twelve samples under investigation with the Libyan standard specifications and international standards. The study's most significant findings are as follows:

- The results of the chemical analyses demonstrated that 50% of the study samples exhibited concentrations of total dissolved salts below the minimum limits specified by the Libyan standard (500-100 mg/L), and all samples were below the World Health Organization limit (500 mg/L). Consequently, the reduction in salt concentration has adverse implications for public health and safety.
- The results of the chemical and physical analyses demonstrated that the concentrations of sodium, potassium, nitrates, nitrites, sulfates, ammonia, total hardness, pH, ozone residual, turbidity, and colors were in accordance with the Libyan specifications. Conversely, the concentrations of magnesium, calcium, bicarbonates, and electrical conductivity did not have corresponding Libyan specifications.

- The data presented on the packaging do not accurately reflect the actual values, as there were numerous discrepancies between the results obtained and the data recorded on the packaging.

Recommendations

- The obligation of bottled water factories to conduct laboratory tests within their own facilities, with the results subject to supervision and conforming to the specifications set out in the Libyan standard for bottled water.
- The role of supervision should be activated on a periodic and continuous basis, and appropriate penalties should be imposed on factories producing bottled drinking water. This is to ensure that the consumer receives a safe product.
- Identifying suitable solutions to address the deficiency of salts in drinking water.
- It is imperative that companies engaged in the production of bottled water are compelled to alter the specifications recorded on the packaging on an ongoing basis, in order to ensure that the quality of the water produced is accurately represented.
- It is recommended that the general public be made aware of the necessity to refrain from purchasing products that do not comply with the established standards, utilizing a combination of visual, audio and print media.

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