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Analysis of the Chemical Composition of Five Brands of Bottled Drinking Water Available in Libya Concerning WHO and Libyan Standards

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تحليل التركيب الكيميائي لخمس علامات تجارية من مياه الشرب المعبأة المتوفرة في ليبيا مقارنة بمعايير منظمة الصحة العالمية والمعايير الليبية

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Abstract:
Assessing the safety of bottled drinking water in Libya holds significant importance. Hence, the current research sought to contrast the chemical makeup (as indicated by manufacturers) of 5 locally available bottled drinking water brands and measure them against WHO and Libyan standards. Containers of bottled drinking water were purchased from local stores. The chemical makeup of these brands was documented from the labels and then contrasted with both WHO and Libyan standards. The pH, EC, (µs/cm), TDS (p.m), TH hardness, Ca++, Mg++, Na+, NO3-, Cl–, and Alkalinity measurements were measured. It was observed from the results that the pH levels of all bottled water brands fell within the acceptable range as per both WHO and Libyan standards. The total dissolved solids, hardness, sodium, chloride, and nitrate levels were found to be lower than the maximum limits specified by WHO and Libyan standards for either primary or secondary (aesthetic) criteria.
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Keywords: Bottled Water, Chemical Components, Standards.

الملخص
يحظى تقييم سلامة مياه الشرب المعبأة في ليبيا بأهمية كبيرة. ومن ثم، سعى البحث الحالي إلى مقارنة التركيب الكيميائي (كما أشارت الشركات المصنعة) لخمس علامات تجارية لمياه الشرب المعبأة المتوفرة محليًا وقياسها وفقًا لمعايير منظمة الصحة العالمية والمعايير الليبية. وتم شراء عبوات مياه الشرب المعبأة من المتاجر المحلية. تم توثيق التركيب الكيميائي لهذه العلامات التجارية من الملصقات ثم مقارنته مع معايير منظمة الصحة العالمية والمعايير الليبية. تم قياس قياسات الأس الهيدروجيني pH، EC (µs/cm)، TDS (pm)، TH، Ca ++، Mg ++، Na +، NO3-، Cl- ، والقلوية. وقد لوحظ من النتائج أن مستويات الرقم الهيدروجيني لجميع ماركات المياه المعبأة تقع ضمن النطاق المقبول وفقا لمعايير منظمة الصحة العالمية والمعايير الليبية. وتبين أن إجمالي مستويات المواد الصلبة الذائبة والصلابة والصوديوم والكلوريد والنترات أقل من الحدود القصوى المحددة من قبل منظمة الصحة العالمية والمعايير الليبية سواء للمعايير الأولية أو الثانوية.

الكلمات المفتاحية: مياه معبأة، تركيب كيميائي، معايير قياسية.

Introduction

Humans need water to survive, but the growing population and increasing human activities that can cause contamination are raising the need to ensure an adequate supply of safe drinking water. [1,2]. Therefore, bottled drinking water industries were established to bridge that gap between supply and demand [3]. Bottled water is sourced from a variety of locations, including springs, aquifers, reservoirs, mineral-rich springs, and in some cases, directly from municipal water supplies, as is the practice of numerous manufacturers [4].

The chemical composition of bottled drinking water varies among different brands, and this may increase the concern about its possible effects on health [5]. Bottled drinking water can include minerals such as sodium (Na), magnesium (Mg), calcium (Ca), and fluoride (F). However, it is crucial to ensure that certain harmful elements, including lead (Pb) and cadmium (Cd), are absent from bottled drinking water due to their detrimental effects on human health (Mahajan *et al*., 2006) [3]. A study by Chiarenzelli and Pominville (2008) [4] showed that Ca, chloride (Cl-), potassium (K), Mg, Na, sulphur (S), and silicon (Si) were the dominant inorganic elements found in their samples [6].

Due to the persistent water scarcity, inhabitants of Tripoli and various other cities in Libya have turned to alternative methods for securing safe drinking water, notably through the purchase of bottled water. The preference for bottled water over tap water stems from the belief that it is safer and of superior quality. In Tripoli, bottled water is available in a range of sizes and packaging, from 200 mL to 20 L. The smaller containers, specifically those ranging from 200 mL to 500 mL, are the most popular among consumers due to their convenience in handling and transport. Consequently, bottled water has gained widespread acceptance for use in households, workplaces, and numerous service establishments, including hospitals, schools, universities, and other venues [7].

The inception of bottled water production in Libya can be traced back to 1959 with the founding of the Bin Gheshir water facility. By 2004, approximately 43 local factories were operational, collectively producing 109,586 liters of water. In recent years, numerous water treatment and bottling facilities have been established across Libya, particularly in Tripoli. The products from these facilities are now increasingly accessible in shops and markets throughout Libya. The primary source of bottled water available in Tripoli is derived from drilled wells, utilizing a reverse osmosis desalination process [8].

Groundwater represents a crucial natural resource, essential for human health and well-being, socio-economic progress, and the functioning of ecosystems. Additionally, it is extensively utilized for a range of domestic, industrial, and agricultural purposes [9].

This study seeks to examine and contrast the components present on water bottle labels, encompassing both physical and chemical characteristics, of various types of bottled drinking water available in the city of Al-Jmail, and to compare these with the actual measurements acquired during the research.

Material and methods

A total of five bottles of drinking water, each containing 500 mL, were purchased from local retailers. The chemical composition data, as indicated by the manufacturers, included parameters such as pH, dissolved solids, hardness, and concentrations of Ca, Mg, Na, K, F, nitrate (NO3-), Cl, bicarbonate (HCO3-), and sulphate (SO42-). This information was collected and documented. The chemical compositions were then analyzed through straightforward comparisons and evaluated against the standards set by the World Health Organization (WHO) and those established in Libya.

Study Limitations:

Spatial Boundaries: A group of water packaging factories and companies in Al-Jmail city.

Temporal Boundaries: This study was conducted within the time frame from May 2023 to July 2023.

Results

Comparison with international and local Libyan standard specifications for packaged drinking water is reported.

Table 1 Samples components of bottled drinking water compared with international and local Libyan standards for bottled drinking water.

Package name	PH	EC (µs/cm)	TDS (p.m)	TH. Hard	Ca++	Mg^{++}	Na^{+}	NO_3^-	Cl^-	Alk.
Alnabaa	7.1	-	114.5	38.35	20.5	7	7	-	35.35	27.4
Dajla	7.0	-	88.25	31.8	15.5	9	6.5	-	28.4	20.5
Sultan	7.1	-	80	7.25	3.7	1.45	2.05	-	39.5	21
Aquafina	7.25	-	113.5	80.95	35	19	19.5	-	18.2	15.35
Aquasila	6.95	-	78	36.6	14.3	8.5	6.5	-	22	32.3
Standard Specifications for Bottled Drinking Water										
Libyan Standards	6.5-8.5	1400	100-500	200	-	-	100	10	150	200
WHO Standards	6.5-8.5	450-1500	500-1500	500	30-200	1-50	200-400	50	150-250	150-200

PH values: As described in table (1) the pH levels of the water samples are in accordance with the Libyan standard specifications and the international standard specifications for drinking water, which specify a pH value in water ranging (6.5 to 7.8). figure (1) illustrates a comparison of the pH concentration of the water samples under study with the Libyan standard specifications and international specifications.

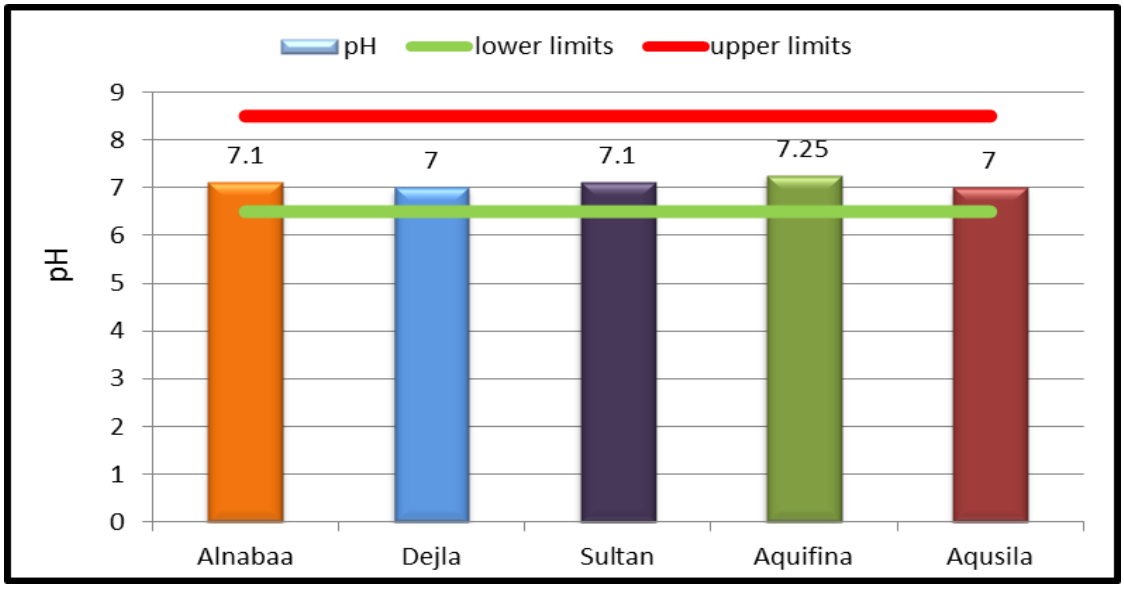

Figure 1 pH concentration of the water samples under study with the Libyan standard specifications and international specifications.

TDS: as shown in table (1). The concentration total solids in samples of bottled water for both (Al-Nabaa, Aquafina) was in accordance with the Libyan standard specifications. However, samples of (Dajla, Sultan, Aquasila) were not in compliance with these specifications, which defined the acceptable TDS concentration in these waters to be within the range of mg/l (100-500). On the other hand, The TDS concentration for all samples of water under study is lower than the minimum allowed limit according to international standard specifications, thus making them non-compliant with these specifications. Figures (3) and (4) illustrate the comparison of TDS for samples of water under study with the Libyan and international standard specifications, respectively.

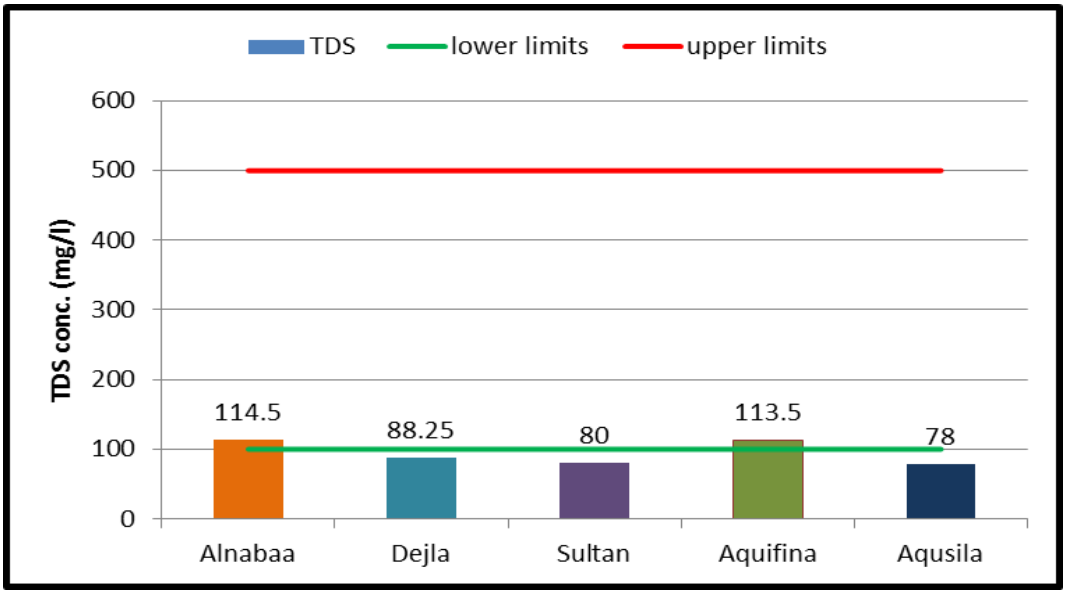

Figure 2 The average TDS (Total Dissolved Solids) in the water samples under study with the Libyan Standard Specifications.

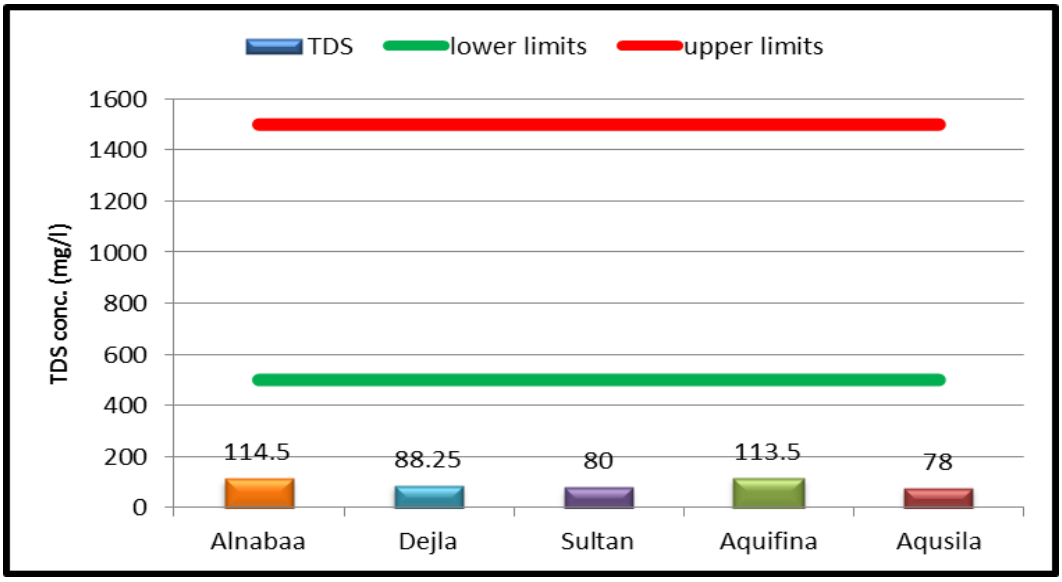

Figure 3 The average TDS in the water samples under study with the international standard specifications.

Total hardness (TH): as presented in fig (5) and table (1) The concentration of Total Hardness (TH) salts in these water samples is in accordance with the Libyan standard specifications and the international standard specifications for drinking water, which specify a TH concentration in water not exceeding 500.

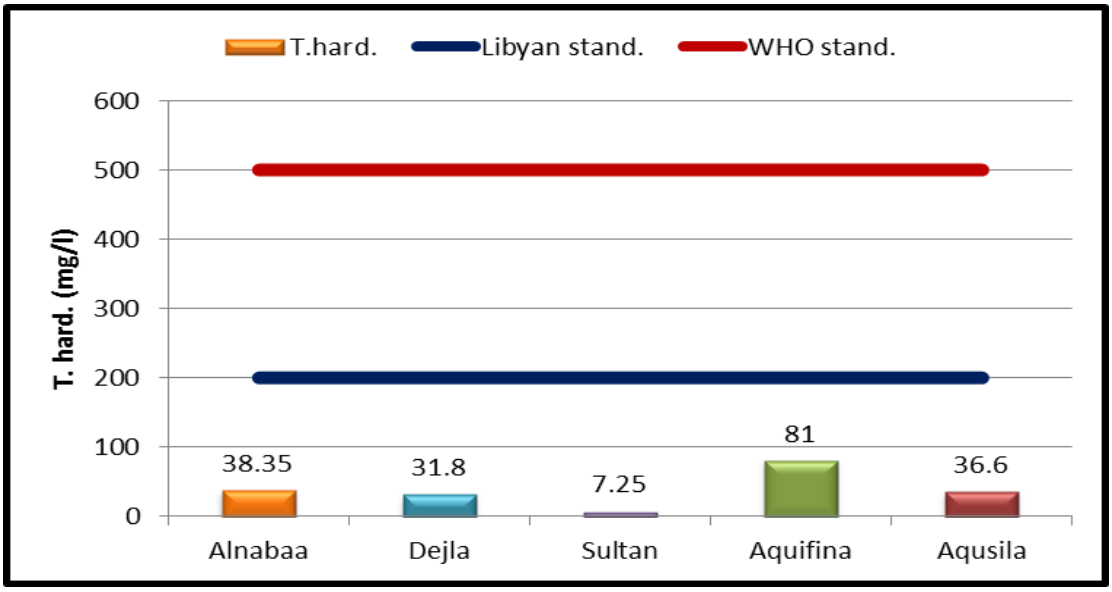

Figure 4 Comparison of total hardness concentration in the water samples under study with the Libyan and international standard specifications.

Calcium (Ca^{+2}): as described in fi (6) and table (1) the concentration of calcium ions in all samples of water under study is lower than the minimum allowed limit according to international standard specifications, thus making them non-compliant with these specifications. As for the Libyan standard specifications, they do not include any specifications for the concentration of calcium ions.

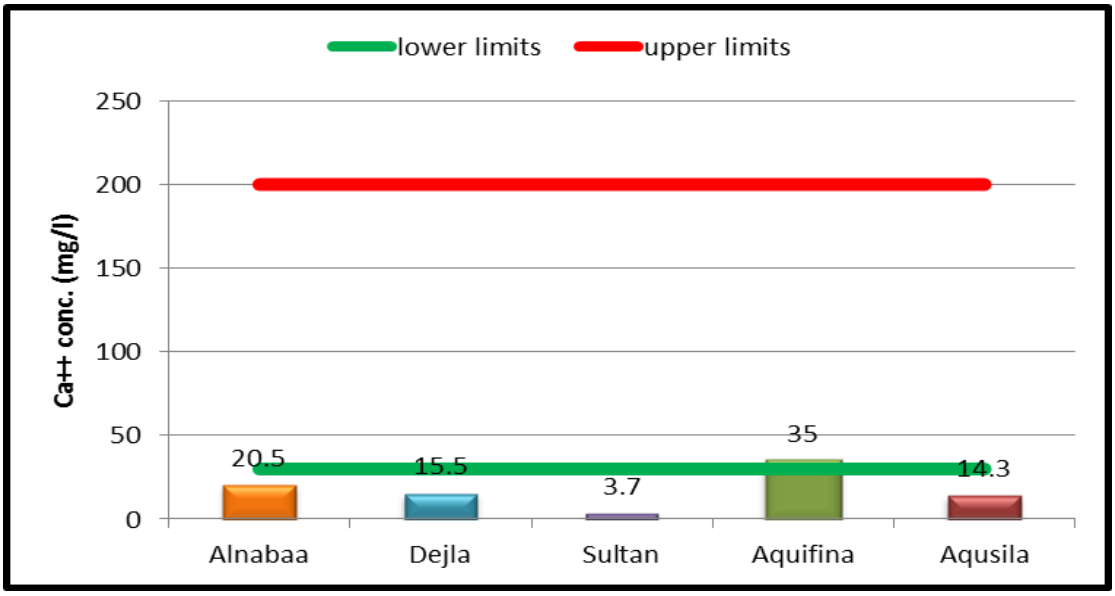

Figure 5 comparison of the average concentration of Ca^{+2} in the water samples under study with the international standard specifications.

Magnesium (Mg^{+2}): data presented in table (1) and fig (6) shows that, The concentration of magnesium ions in all samples of water under study is within the limits allowed by international standard specifications, thus making them compliant with these specifications. As for the Libyan standard specifications, they do not include any specifications for the concentration of magnesium ions.

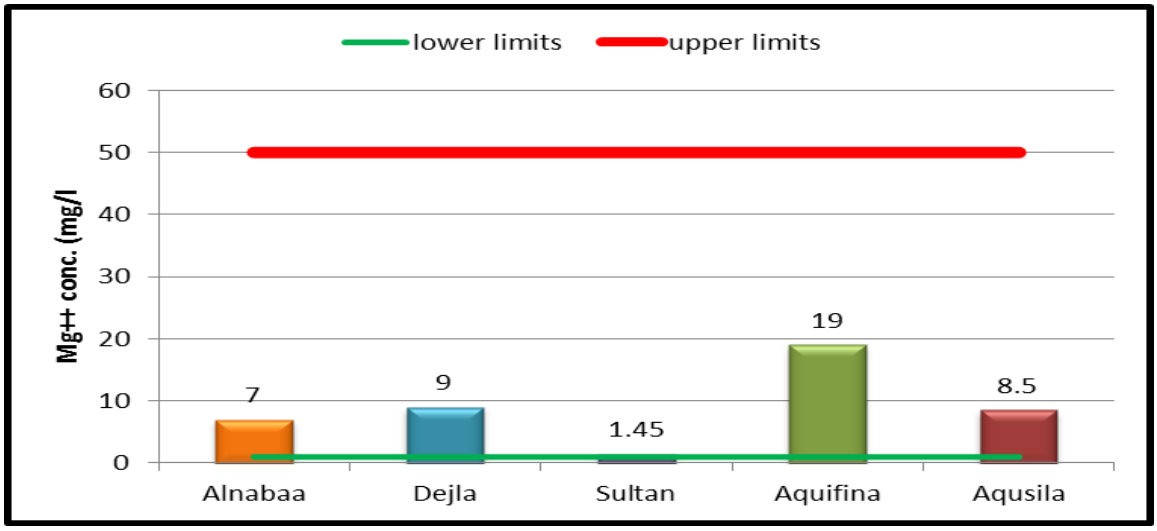

Figure 6 Comparison of the concentration of the average Mg^{+2} in the water samples under study with the international standard specifications.

Sodium Na +: as shown in figs (7 and 8) and table (1) the concentration of sodium ions in all samples under study is compliant with the Libyan specifications and is lower than the maximum allowed limit defined by these specifications. The concentration of sodium ions in all samples of water under study is lower than the minimum allowed limit according to international standard specifications, thus making them non-compliant with these specifications.

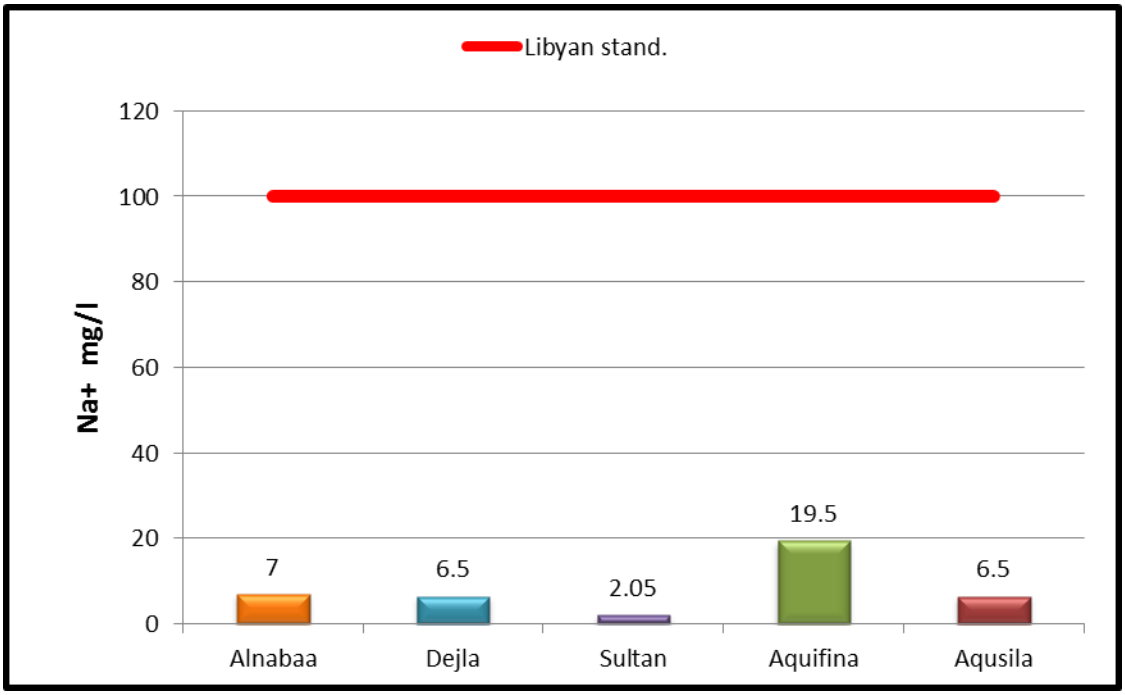

Figure 7 The average Na^{+1} concentration for samples of water under study with the Libyan standard specifications.

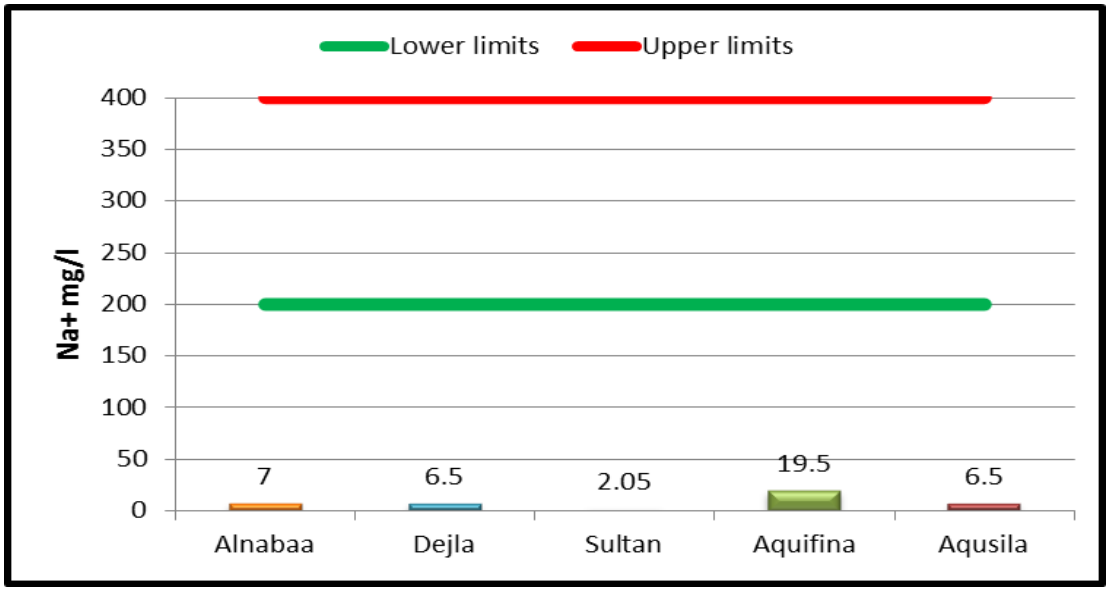

Figure 8 Comparison of the average Na^{+1} concentration for samples of water under study with the international standard specifications.

Cl^- (Chloride): data presented in figs (9 and 10) and table (1) clearing that, the concentration of chloride ions in all samples under study is compliant with the Libyan specifications and is lower than the maximum allowed limit defined by these specifications. The concentration of chloride ions in all samples of water under study is

lower than the minimum allowed limit according to international standard specifications, thus making them non-compliant with these specifications.

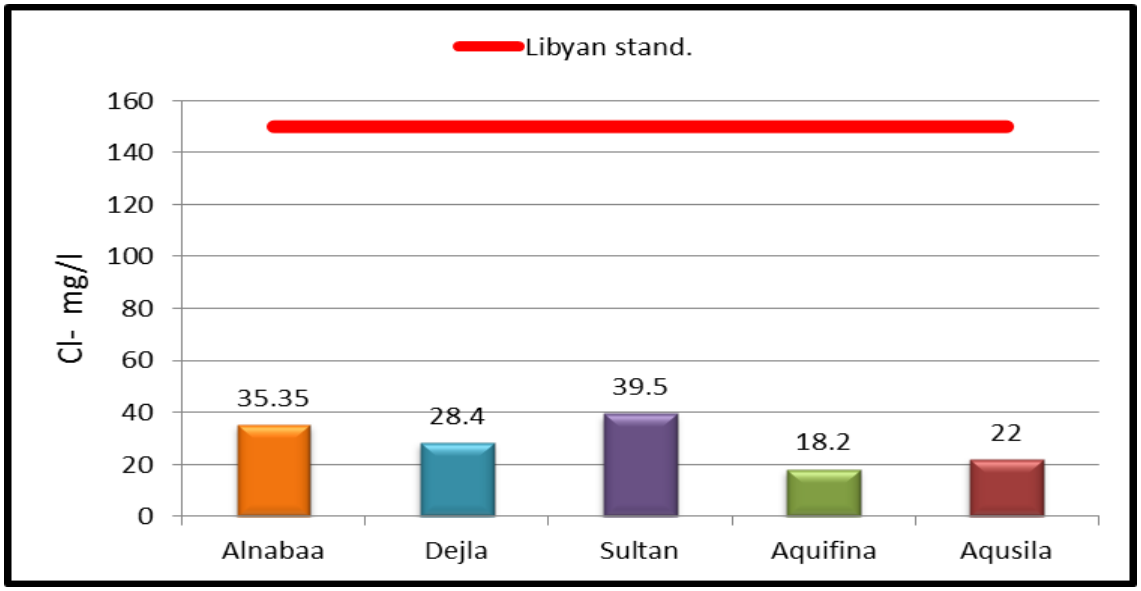

Figure 9 Comparison of the average Cl^{-1} concentration for samples of water under study with the Libyan standard specifications.

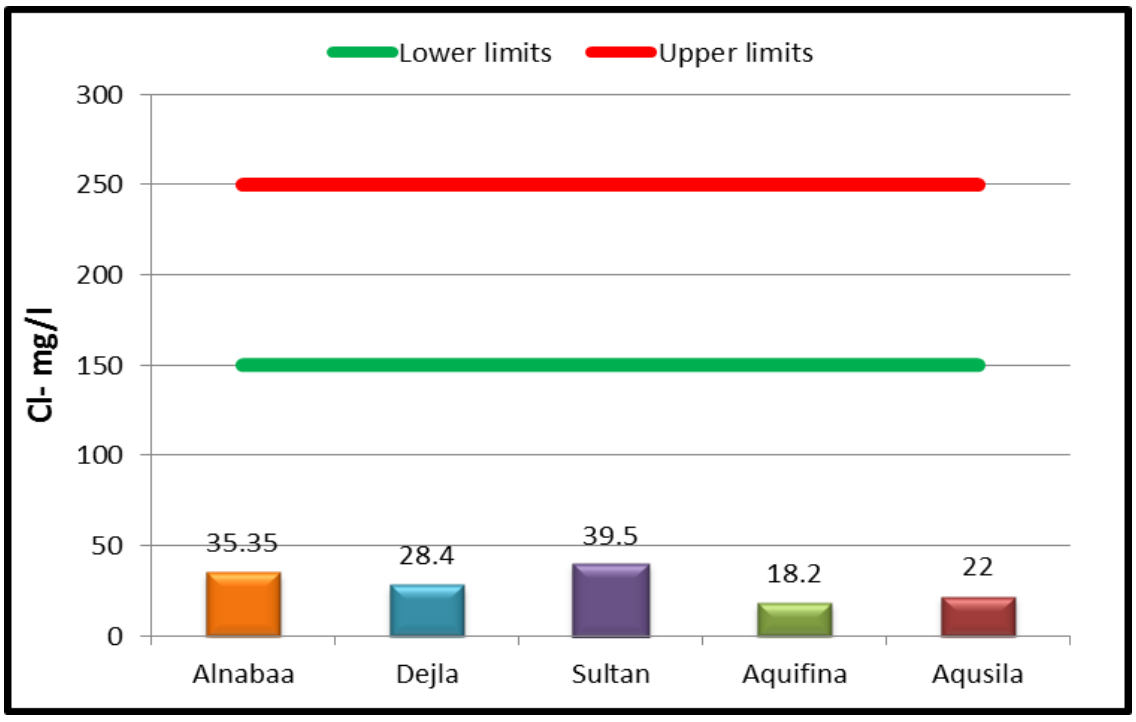

Figure 10 Comparison of the average Cl^{-} concentration for samples of water under study with the international standard specifications.

Discussion

Based on the provided information, the results can be summarized as follows: According to the Libyan standard specifications, the Alnabaa water and Aquafina are considered the best types of drinking water samples selected in this study because all the analyses conducted on these samples were in accordance with the Libyan standard specifications. The comparison of the studied water samples with the international standard specifications for bottled drinking water yielded the following results: pH: All samples were in accordance with the specifications. TDS: None of the samples met these specifications. Total hardness: All samples were in accordance with the specifications. Calcium (Ca^{+2}): All samples were in accordance with the specifications. Magnesium (Mg^{+2}): All

samples were in accordance with the specifications. Sodium (Na^+): None of the samples met the specifications. Chloride (Cl^-): None of the samples met the specifications. Therefore, all the studied water samples do not meet the international standard specifications. these results are in agreement with those of Al Aamri and Badreldin (2017) [10] who concluded that, the analysis of the labels of 17 brands of bottled drinking water sold in Oman revealed that pH of all brands was within normal limits prescribed by both WHO and USEPA. Concentrations of TDS, hardness, nitrate, chloride and sodium were lower than primary or secondary maximum contaminant levels prescribed by USEPA and/or WHO maximum limits. Fluoride was not reported by about 53% of the brands and it was very low in all brands that reported it.

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