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Study of the Quality of Bottled Drinking Water Available in the Local Market of Benghazi City Libya

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Abstract

Water is the first biological liquid. It facilitates the reactions of turning food into energy. It is also the means of transporting pollutants due to the large number of pollutants that reach it in different ways and cause many serious diseases that affect the health of living organisms, especially humans. This research was conducted due to the lack of sufficient studies on bottled drinking water that entered different new brands on the local market of the city of Benghazi, and this research aims to evaluate its quality. 10 samples of bottled drinking water in the market were collected randomly, sealed and sterile from the source of treatment and each sample carries a different brand and is (Enor, Safwa, Pure, Aquafina, Arwa, Reem, Aseel, Sultan, Al Ain, Arin). The sample collection period was January 2023 and the physiological, chemical and biology properties were revealed in the Precision Laboratory for Analysis. The results showed that the physical properties such as the total of dissolved salts and electrical conductivity are less than the upper limit of the Libyan standard specifications (126) mg/l (209) micromoses/ cm .the chemical properties of sodium (26.4) mg/l are less than the upper limit of the Libyan standard specifications and the international specifications WHO, as for the biology properties were two commercial samples (Al-Safwa, Arwa), it was found that they had a microbial growth for each colony unit formed in 1 ml, where the elite sample was 2 colonies and the Arwa sample was 8 colonized in 1 ml, while the rest of the study samples were within the limits of the Libyan standard specifications and the international specifications WHO.

Keywords: Bottle Drinking Water, Physical, Chemical and Biological Analysis, Trademarks

1. Introduction

Water is an essential element for all living organisms, and it is the lifeblood, but we deal with it badly, misuse it and contribute to its pollution with our own hands, and we know very well that this pollution will reach us directly or indirectly [1-2]. Many of the diseases and problems that people suffer from, whether children or adults, are due to water, either because of its pollution or because of its lack of salts and essential elements necessary for the body [3-4]. Some areas in Libya still have residents who drink water extracted directly from wells (groundwater) without any treatment, and sometimes without conducting any evaluation of its biological, physical and chemical properties that suit it for drinking, and they are satisfied with only noticing its taste, whether it is palatable or not. The problem of water shortage in coastal areas in Libya is highlighted due to the prevailing climate factors in addition to the problem of seawater mixing with groundwater, causing an increase in its salinity and making it unfit for human consumption [5-6].

Providing potable water has become a difficult task due to the large number of pollutants that reach it in different ways and cause many serious health problems that affect living organisms, especially humans. It has been observed in our current era that most water sources, starting from oceans, seas and rivers, and ending with groundwater and rainwater, have become a real threat to the human body from pollutants present in water daily, whether these pollutants are biological or chemical [7-8]. In (WHO, 2022) studied (drinking water standards and legislation) and studied them and reached the benefit of the standards and legislation of the World Health Organization and the Ministry of Health [9]. In 1999 Ibrahim, Fatima studied (estimation of dissolved solids in some samples of bottled drinking water) and reached that all bottled water samples had concentrations less than 500 mg/L for the water samples of Kufra, Safari, Al-Naba, Al-Mazn and Safina, respectively [10].

Also 2009 Amjad Fadel conducted a study in which (10 types of imported bottled water were analyzed) and the results showed that they conformed to international specifications except for the total dissolved solids in one local type and one imported type [11]. In 2019 Balq studied (the physical and chemical properties of bottled drinking water from the western region of Libya) to evaluate the quality of the most commonly used bottled drinking water in the western region, and then compare the results with the Libyan standard specification and the World Health Organization (WHO) specifications. The results of the study showed that bottled drinking water in the western region conforms to the Libyan standard specification and the World Health Organization (WHO) specifications, but the percentage of salts in the samples is much lower than the permissible limit, which causes many health problems [12]. In the same year 2019, Al-Mabrouk studied some (physical and chemical properties of some types of local drinking water) for five samples of bottled drinking water circulating in the Libyan market, these types were Al-Naba, Al-Saqi, Al-Dhifa, Shaima and Rahaf water. It was concluded that the properties measured for the five types of bottled water were within the permissible limits of the Libyan specifications for bottled drinking water in most analyses, except for the total dissolved solids (T.D.S), which were less than the minimum permissible limit in spring, saqi and hospitality water. In 2020, Qabasa conducted a study (Analysis of chemical and biological properties to assess the quality of bottled drinking water in the city of Tripoli - Libya). The study showed that all analysis results were sound and acceptable despite the lack of dissolved salts and the low acidic medium. The results of the eight chemical analyses were different from the optimal limit allowed in local and international standard specifications. This study aims to evaluate the quality of bottled drinking water available in the local market of the city of Benghazi. The evaluation included studying the physical, chemical and biological properties of the studied samples, and comparing the results with the specifications mentioned on the plastic packaging by the producing company, as well as the results with the Libyan standard specifications and the international specifications WHO [13].

2. Sample Collection Methods

10 samples of bottled drinking water ready for human consumption available in the local market of Benghazi city were collected. The samples were collected randomly from different commercial factories that were recently packaged and manufactured. The sample collection period was in January 2023. They were kept at room temperature until the required laboratory tests were conducted on them as shown in Figure (1) and Table (1) The most important shapes, data and sizes of these studied samples. Then, laboratory tests were conducted in (Al-Daqah Laboratory).

Figure 1: Random Samples Collected and Tested

NO	Water type	Water source	Capacity ML	Origin
1	Al Reem	Underground well	500	Benghazi
2	Aseel	Underground well	500	Benghazi
3	Sultan	Underground well	500	Tripoli
4	Al Ain	Underground well	500	Benghazi
5	Erin	Underground well	500	Benghazi
6	Eno	Underground well	500	Benghazi
7	Al Safwa	Underground well	500	Benghazi
8	Pure	Underground well	500	Benghazi
9	Aquafina	Underground well	500	Tripoli
10	Arwa	Underground well	500	Benghazi

Table 1: Data on Types of Random Bottled Drinking Water Samples (Ozone Sterilization Method)

2.1. Physical, Chemical and Biological Tests

2.1.1. First: Physical properties tests: The physical analysis elements are important to describe the quality of bottled drinking water samples, which are the pH analysis, electrical conductivity and total dissolved salts of the samples.

• The method of measuring the pH, where the pH is measured by a pH meter at room temperature, which depends on the electrical potential difference between two solutions with different hydrogen concentration rates, where it was calibrated before the measurement process using buffer solutions [4,7,9].

Figure 2: PH Testing Device

• Electrical conductivity measurement (EC): Electrical conductivity is defined as a measure of the ability of a solution to carry an electrical current (the inverse of resistance) and is measured using a conductivity meter.

• Estimation of total dissolved salts (TDS): The purpose of measuring electrical conductivity in water samples is to evaluate the total dissolved solids (TDS). Accordingly, the degree of electrical conductivity is proportional to the degree of concentration of solids and is measured using a conductivity meter.

2.1.2. Second: Chemical Properties Tests

The most important elements of chemical analysis are the analysis of heavy elements in bottled drinking water samples, where the chemical properties of all samples are measured by several sample measuring devices, as shown in Table (2).

No	Tests	Device used
1	Calcium	Titrate with 0.1 EDTA Solution
2	Magnesium	Hatch Lange / DR6000 - Spectrophotometer
3	Chloride	Titrate with 0.1 Silver Nitrate
4	Fluoride	Hach Lange / DR6000 - Spectrophotometer
5	Sulfate	Hach Lange / DR6000 - Spectrophotometer
6	Nitrate	Hach Lange / DR6000 - Spectrophotometer
7	Iron	Hach Lange / DR6000 - Spectrophotometer

Table 2: Devices Used in Chemical Properties Tests

2.1.3. Third: Biological Tests

Biological water tests and measurements are conducted to determine the best standards for water safety and suitability. Accordingly, the type and quantity of microbes in the water must be determined in order to remove and eliminate them. The group of bacteria known as coliform bacteria is an indicator of the degree of water pollution and thus the suitability of water for various uses. Biological analyses are conducted on samples immediately after they arrive at the laboratory and the number of coliform bacteria is estimated using the most probable number (MPN) method.

2.2. Method of Work and Discussion of Results Tests:

2.2.1. Method of work: 10 samples of bottled drinking water produced locally in groundwater wells in Benghazi were tested. These samples were randomly sliced from grocery stores in the local market in Benghazi. Physical, chemical and biological analyses were conducted in the Accuracy Laboratory for analysis in January 2023.

3. Results and Discussion

3.1. From the results shown in Figure (3) for the pH, we find that the pH values of the samples range between values (6.82/7.36) and the lowest value in the Al-Ain factory sample and the highest value in the Al-Rayem factory sample 7.36. The samples were within the limits of the Libyan and international standard specifications WHO, which makes the water of all sample sources suitable for human consumption.

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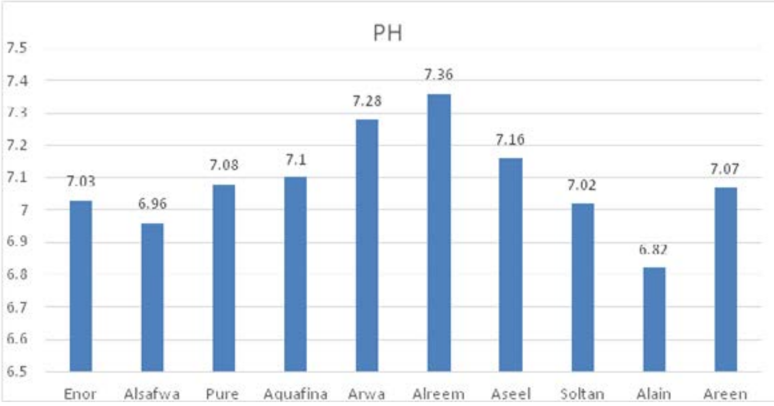

Figure 3: Results of Ph Concentration Values for the Trampled Samples

3.2. From the results shown in Figure (4) for electrical conductivity EC, we find that the electrical conductivity values in the bottled drinking water samples range between (112/209) and that the lowest electrical conductivity is 112 in the Arwa factory sample and the highest electrical conductivity in the Aquafina factory sample (209). The electrical conductivity test results for the samples were much lower than the maximum limit allowed in the Libyan standard specifications and lower than the minimum limit in the WHO international specifications. Conductivity gives an idea about the geology of the groundwater well, which is high in untreated water and small in treated water as a result of ozone sterilization. This is what the obtained results showed, as all values were less than 450 micromohs/cm2, which leads to a decrease in the conductivity rate during the oxidation of negative and positive ions of salts [14].

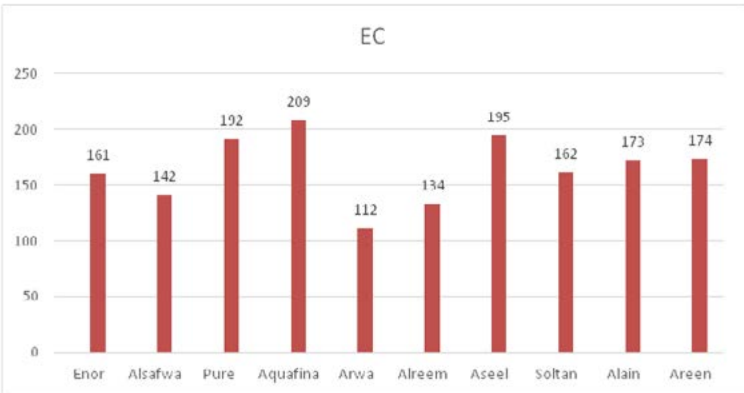

Figure 4: Results of Electrical Conductivity Test Values

3.3. Total dissolved salts (TDS) shown in Figure (5) We find that the concentration of dissolved salts in bottled drinking water ranges between values (126-64) mg/L in the sample (Arwi factory, Aquafina factory) and was less than the maximum limit allowed in the Libyan specifications, and less than the minimum limit of the international specifications WHO as reached by (Mohammed and others). Therefore, this water is similar to distilled water that does not contain salts, and the use of this water does not benefit the human body except for quenching and refreshing apparently as reached by Najla and others when comparing their results with the Iraqi standard specifications and also agrees with (Ramadan Al-Haloub). Therefore, with the abundance of drinking this water, it will harm the human being and cause him heart disease, stroke and premature aging [15].

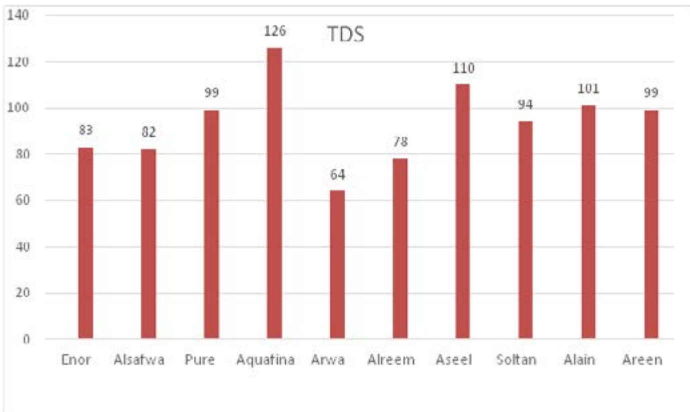

Figure 5: Results of The Values of the Concentration of Total Dissolved Salts

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3.4. Total hardness The total hardness results shown in Figure (6) for the total hardness concentration T.H in bottled drinking water, and it was found that the sample values ranged between (90-13) mg/L in the (Al-Safwa) factory sample and the highest concentration of total hardness is 90 mg/L in the Aquafina factory sample and the results of the total hardness concentration test for the samples are less than the maximum limit allowed in the Libyan and international standard specifications WHO and they are in accordance with the specifications [16].

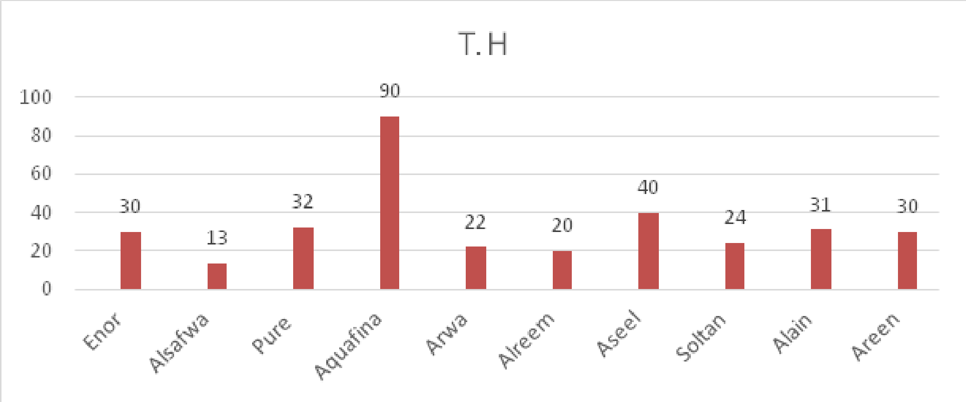

Figure 6: Results of Total Hardness Concentration Values

3.5. The results of the chloride concentration shown in Figure (7) for the concentration of chlorides Cl in bottled drinking water, and it was found that the chloride values in the samples ranged between (42.6-12.4) mg/L in the (Aquafina, Sultan) factory, and the results of the chloride concentration test for the samples were less than the maximum limit allowed in the Libyan standard specifications, the minimum limit for the international specifications WHO [17].

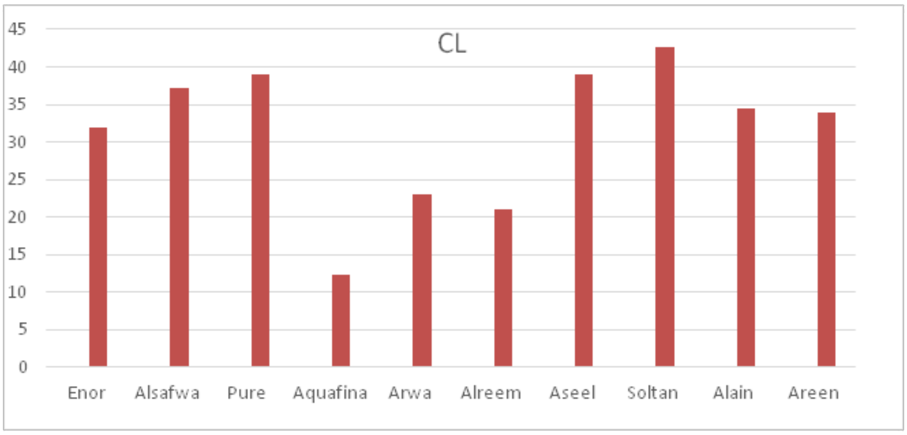

Figure 7: Results of Chloride Concentration Values

3.6. The results of sodium concentration shown in Figure (8) for sodium concentration Na were found to range between values (6.4/26.5) mg/L in the sample of two factories (Aquafina, Al-Safwa). The results of the sodium concentration test for the samples were less than the maximum limit allowed in the Libyan standard specifications and the minimum limit of the international specifications WHO, as reached by both Al-Zawali and Shalouf as the sodium values for all samples were low, the lowest value was 18.80 and the highest value was 76.06 mg/L in their study [18].

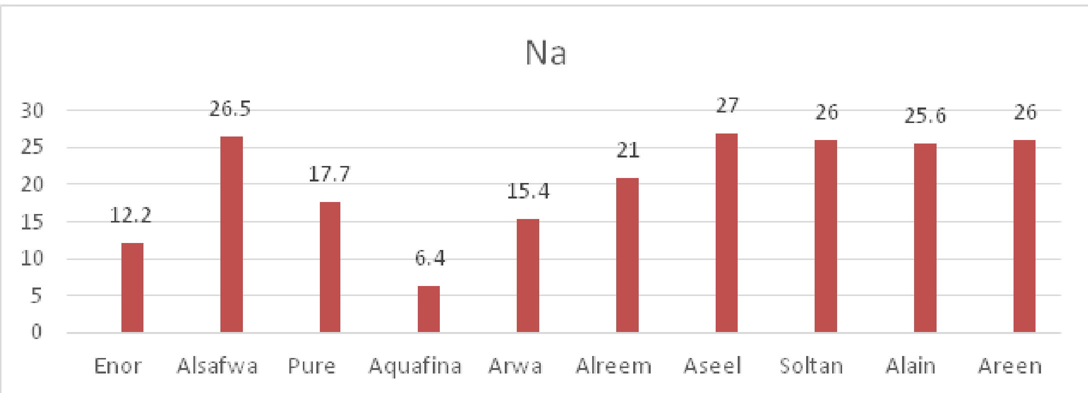

Figure 8: Results of Sodium Concentration Values

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3.7. Magnesium concentration shown in Figure (9) for magnesium concentration values in bottled drinking water, and it was found that the sample values ranged between values (1.9/14.8) mg/L, and we find that the lowest concentration of magnesium is 1.9 mg/L in the Al-Safwa factory sample, and the highest concentration of magnesium is 14.8 mg/L in Aquafina. The results of the magnesium concentration test for the samples were less than the maximum permissible limit in the Libyan standard specifications and less than the minimum limit in all samples except for the Aquafina sample, which was higher than the minimum limit and less than the maximum limit in the WHO international specifications. Shalouf reached the highest concentration of magnesium, which was 3.9 mg/L, and that all samples did not exceed the permissible value, so they are suitable for human consumption. [19].

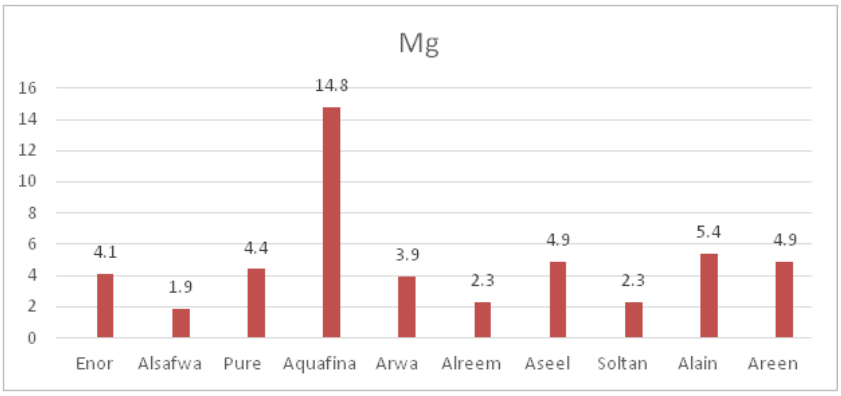

Figure 9: Results of Magnesium Concentration Values

3.8. The potassium concentration shown in Figure (10) for the potassium concentration in bottled drinking water, and it was found that its value was (0.4) mg/liter for all samples, and all of them are less than the maximum limit permitted in the Libyan and international specifications WHO [20].

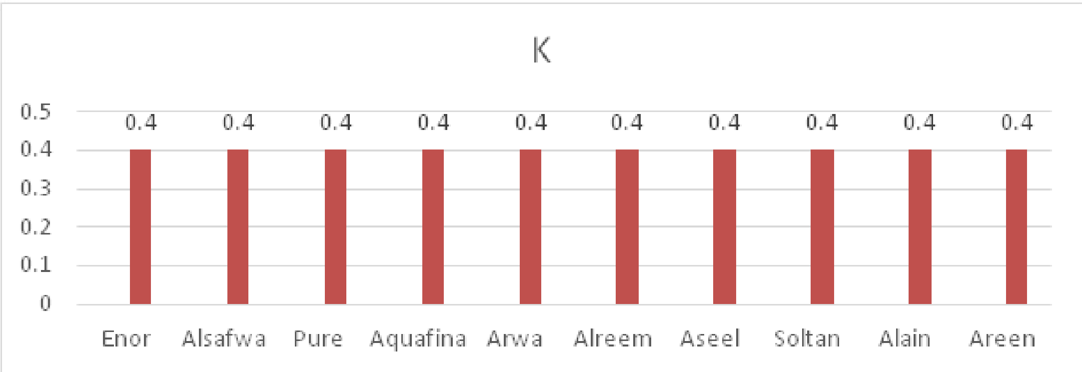

Figure 10: Results of Potassium Concentration Values

3.9. Calcium concentration shown in Figure (11) for calcium concentration in bottled drinking water. It was found that the sample values ranged between (2.0/11.6) mg/L. We find that the lowest calcium concentration is 2.0 in the Al-Safwa factory sample and the highest concentration is in the 11.6 Aquafina factory sample. The results of the calcium concentration test for the samples were less than the upper limit permitted in the Libyan specifications and less than the minimum limit of the international specifications WHO [21].

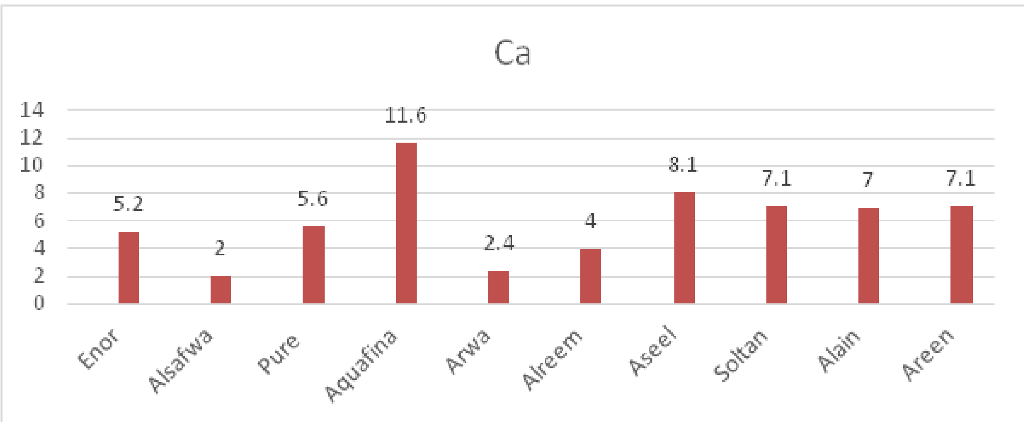

Figure 11 Results of calcium concentration values

3.10. The concentration of sulfates shown in Figure (12) for the concentration of sulfates in bottled drinking water. It was found that the concentration of sulfates for the samples ranged between values of (7.7/75.8) mg/L, and the lowest concentration in the Al-Safwa factory was 7.7, and the highest concentration in the Aquafina factory sample was 75.8. The results of the sulfate concentration test for the samples were less than the maximum limit permitted in the Libyan specifications and less than the minimum limit of the international specifications WHO [22].

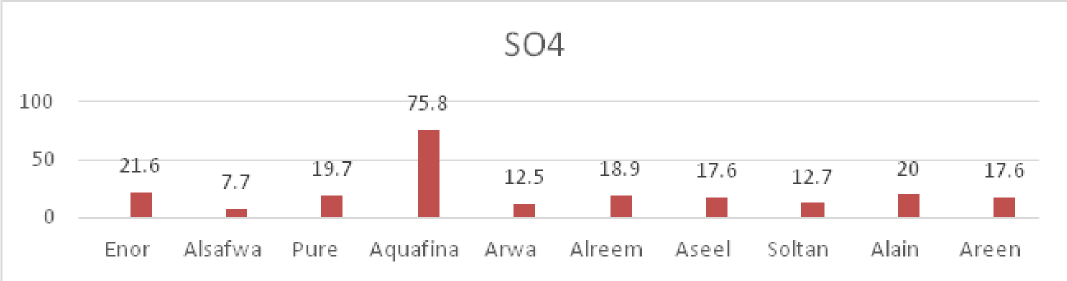

Figure 12: Shows the Results of Sulfate Concentration Values

3.11. Bicarbonate shown in Figure (13) for the concentration of bicarbonate in bottled drinking water. It was found that the bicarbonate values for the samples ranged between values (9.2/30.5) and the lowest concentration in a sample of two factories, which are (Sultan/Aquafina) and the highest concentration in the Asil factory. The results of the bicarbonate concentration test for the samples were less than the maximum limit permitted in the Libyan and international standard specifications [23].

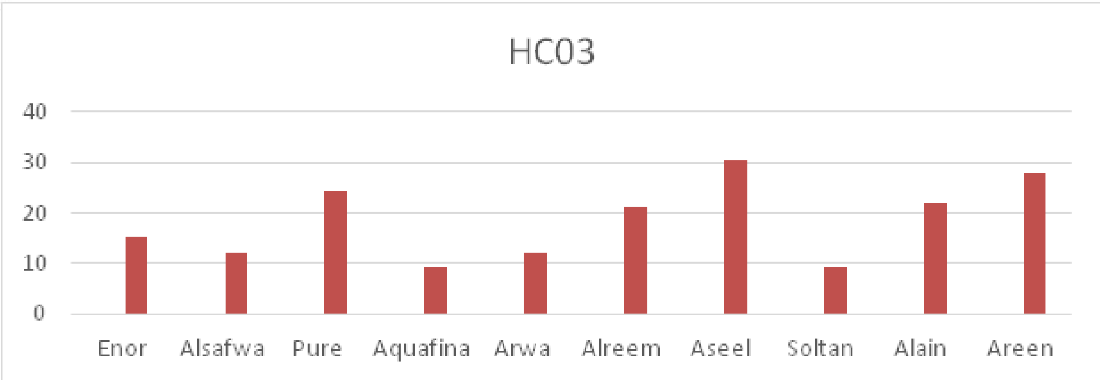

Figure 13: Results of Bicarbonate Concentration Values

3.12. The carbonates shown in Table (4) for the concentration of carbonates in bottled drinking water. It was found that the bottled water containers do not contain any carbonates at all, and the results of the carbonate concentration test for the samples were much lower than the upper limit (150) in the Libyan and international standard specifications (WHO) [24].

Results of Biological Tests: From the results shown in Table (3) to estimate the group of coliform bacteria and fecal coliform bacteria in bottled drinking water, it was found that its value was the same for all samples >0.05, and the results of the coliform bacteria concentration test for the samples were within the limits of the Libyan and international standard specifications WHO and that there were no bacteria in them [25].

No	samples	CO3	E.coli bacteria group	fecal coliform bacteria
1	Erin	0	> 0.05	> 0.05
2	Al Ain	0	> 0.05	> 0.05
3	Sultan	0	> 0.05	> 0.05
4	Aseel	0	> 0.05	> 0.05
5	Al Reem	0	> 0.05	> 0.05
6	Arwa	0	> 0.05	> 0.05
7	Aquafina	0	> 0.05	> 0.05
8	Pure	0	> 0.05	> 0.05
9	Al Safwa	0	> 0.05	> 0.05
10	Eno	0	> 0.05	> 0.05

Table 3: Shows the Results of the Carbonate and Bacteria Group Tests

From the results shown in Figure (14), the microbial count in bottled water bottles did not show any growth in the samples of the factories (Al Reem - Sultan - Al-Ain - Enor - Al-Safwa - Aquafina - Pure - Al-Rawi) and was within the limits of the Libyan and international standard specifications, but the two samples, Al-Safwa and Arwa factories, showed that they had microbial growth for every 1 ml [26].

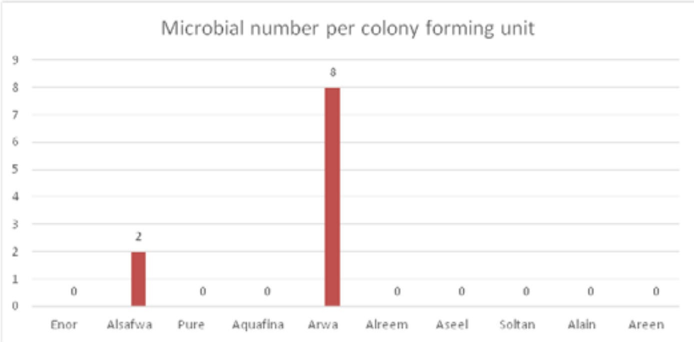

Figure 14: Results of Microbial Number Concentration Values for Each Composition Unit

4. Conclusion

The physical, chemical and biological properties of bottled drinking water available in the local market of Benghazi city were studied for ten local water treatment plants in Libya and were tested in the Accuracy Laboratory for Analysis. The results were as follows:

• The physical and chemical properties of the studied samples for the pH within the specifications. As for the electrical conductivity, it was much lower than the maximum permissible limit in both Libyan and international specifications, as the highest value was in the Aquafina factory water sample (209) micromohs / cm / 25. As for the total dissolved salts (TDS), they were all lower than the maximum permissible limit in the Libyan standard specifications and lower than the minimum limit in the international specifications (WHO). (126-64) mg / liter in two factories (Arwi, Aquafina). As for the magnesium concentration values, they ranged between values (1.9/14.8) mg / liter and the lowest concentration of magnesium in the Al-Safwa factory sample, and the highest concentration in the Aquafina factory sample, and the results were lower than the maximum permissible limit In the Libyan standard specifications and less than the minimum limit in all samples except for the Aquafina sample, which was higher than the minimum limit and less than the maximum limit in the international specifications WHO, and the concentration of potassium was constant in all samples (0.4) mg/L and conformed to the specifications, and the concentration of sulfates was not according to the international specifications and less than the maximum limit of the Libyan specifications.

• The biological characteristics of the studied samples were within the specifications written on the package and the Libyan and international standard specifications WHO, except for the sample of the (Al-Safwa) factory and the sample of the (Arwa) factory, which did not conform to the specifications, as there is a microbial number for each colony-forming unit, so it is recommended to monitor the production line and conduct tests continuously inside the factory and obligate water-producing companies to establish laboratories to examine products continuously to ensure their compliance with the Libyan standard specifications and regulatory follow-up by the competent regulatory authorities (health, environmental, commercial and industrial).

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