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PHYSICOCHEMICAL QUALITY EVALUATION OF SOME BRANDS OF BOTTLED WATER IN KURDISTAN REGION, IRAQ: COMPARISON OF ANALYTICAL RESULTS WITH LABELS AND STANDARDS

HAJAR AMEEN AMEEN
Dept. of Soil and Water Science, College of Agriculture, University of Duhok, Kurdistan region – Iraq

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ABSTRACT

The production and consumption of bottled water have increased dramatically over the last decades. Kurdistan region of Iraq is one of the areas that have a large number of brands of bottled water. However, periodic quality assessment of the quality of bottled waters is very necessary to guarantee their suitability for human consumption. Accordingly, 136 samples of bottled water were collected randomly from different markets and supermarkets in Duhok city, Kurdistan region, Iraq, and were analyzed for their major physicochemical characteristics including: calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), sulfate (SO_4^{2-}), nitrate (NO_3^{-}), pH, total dissolved solids (TDS), turbidity and total hardness (TH). The data were analyzed statistically and compared to the labels and Iraqi's standards (IQS: 417, 2001) and other international standards. The obtained results indicated that, except Ca^{2+} at brands (Evain, Kara and Kani) and K^{+} at brand (Kani), almost all the values obtained in the laboratory were lower than the maximum permissible limits set by Iraqi's standards and other international standards for drinking water. In regard to the comparison between the laboratory and reported labels values, there was a huge variation in most of the studied parameters values. It was observed that the majority of parameters values (about 86.7% on average) tested in the laboratory were higher than the label values and some (about 12.2%) were lower than label values, while only 1.1% has the same values as labels. In the light of these finding, it can be suggested that the monitoring agencies and authorities should plan effective monitoring programs for companies producing bottled drinking water.

KEYWORDS: Bottled water, Water standards, Iraqi's standards, Physicochemical parameters.

1. INTRODUCTION

Over the past century, there has been a dramatic increase in the production and consumption of bottled water worldwide and has been regarded as the fastest growing and most dynamic sector of all the food and beverage industries (Semerjian, 2011; Carstea *et al.,* 2016; Mohsen *et al.*, 2016). Bottled water can be defined as any potable water that is manufactured, distributed or offered for sale, sealed in food-grade bottles or other sanitary container, and intended for human consumption (FDA, 2017). According to the latest statistical report, the global consumption of bottled water amounted to 288 billion liters in 2012 and was forecasted to reach 391 billion liters by 2017 (Statista, 2018). In spite of the existence of some safe sources of drinking water in Kurdistan region, the demand for bottled water is increasing particularly after the recent severe drought faced the region. According to *Kassir et al.,* (2015) bottled drinking water industry in Iraq represents 54% over other food industries, more than 100 factories are registered (excluding Kurdistan region) these factories produce about 160 Million m³/yr. The same author reported that the factories authorized in Iraqi were 10 factories until the end of 2006; currently 234 factories are under construction and distributed on the different Iraqi governorates.

There are numerous explanations behind this constant increase in the consumption of bottled water includes it is associated with naturalness (Saad *et al.,* 1998), humans have inadequate access to drinking water and use sources contaminated with disease vectors, pathogens, or unacceptable levels of toxins or suspended solids (William and Frank 2000; Al-Omran *et al.,* 2013), the consumers regarded it as taster than tap water (no chlorine taste), they may also perceive it as being safer, healthier and of better quality (Ferrier, 2001). Bottled water is also utilized in emergency

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or water shortage situations caused by natural disasters (e.g. drought, earthquake, flood and hurricane) or human-made disasters (e.g. sabotage, siege, terrorism, and war), which can severely damage public and private water supplies for extended periods of time (Güler, 2007).

Generally, the sources of water that are utilized for the production of bottled water are mainly from free-flowing spring and drilled wells. These water sources sometimes are passed through treatment processes such as filtration, deionization, reverse osmosis, and ozonation to ensure its quality (Kassir *et al.,* 2015), but poor quality control during production and handling can contaminate these widely consumed resources (Ikem *et al.,* 2002). At elevated concentrations, some elements can be harmful to health (Al Fraij *et al.,* 1999) and can cause morphological abnormalities, mutagenic effects, reduced growth and increased mortality in humans (Nkono and Asubiojo, 1997). Therefore, standards have been developed by national and international organizations to define a quality of water that is safe and acceptable to consumers (Güler and Alpaslan, 2009). Most of these standards set upper limits for physical parameters, chemical constituents, and microorganisms that are dangerous, potentially hazardous, or obnoxious to consumers (Güler and Alpaslan, 2009).

Label, on the other hand, is one of the most important brand’s features that should be considered when assessing the product suitability for health and also judging its legal compliance. The label is a piece of paper that is attached to a product to demonstrate some information regarding the address, source of water, quality and safety of products, public health aspect of constituents, chemical components, the legal and technical data, promotional information and brand’s name, warnings and recycling recommendations (FAO and WHO, 2007; FDA, 2017). However, in some courtiers, there is no stringent regulation on the labeling of bottled water contents and the concentration shown on the labels may not be accurate (Khan and Chohan, 2010). In some cases, due to the benefits of the producers, it is possible that the measured quality of the water is differed from the quality mentioned on the label and is hidden from the consumers which are in conflict with the rights of consumers (Miranzadeh and Marzaleh, 2015). Accordingly, various studies conducted at different place and times revealed uncertainty between the labels and real content of bottled water product (Cemek *et al.,* 2007; Khanand Chohan, 2010; Mesa *et al.,* 2003; Cidu *et al.,* 2011). For example, in a study conducted by Moazeni *et al.,* (2013) found that K^+ and SO_4^{2-} ions about 43% and 52% of studied sample contents had values higher than label amounts, respectively. Similarly, an investigation has been conducted in Saudi Arabia, reported that the mean level of F^-, Ca^{2+}, and pH in bottled water was significantly higher than the values reported on the labels for 21 brands that are being consumed in Riyadh (Khan and Chohan, 2010). These findings indicate that inaccurate labeling practices are more pronounced in the industry and may pose serious public health problems, especially to high risk and Immunocompromised individuals (Amogne, 2016). Nevertheless, regular monitoring the accuracy of the concentration of different essential elements mentioned on the labels of the bottled drinking water is quite necessary for safe drinking water supply and healthy living.

Despite significant increases in the number of brands and bottled water consumption in Iraq in general and Kurdistan region in particular, the consumer and Governmental Authorities might not be fully aware of the quality of this water. Additionally, to the best of researcher's knowledge, few studies were conducted to assess bottled water quality in the area and only one of these studies (Radha, 2014) considered the accuracy of bottled water labels and their comparison with real contents. This necessitated intensive studies to be conducted on monitoring the quality of bottled water in the area. Therefore, this study will be conducted to assess the quality of bottled water of some most widely distributed brands in the Kurdistan region, Iraq and check the accuracy of their labels with national and international standards. Accordingly, this paper will analyze the concentrations of some elements of bottled water and compare them with the levels reported on product’s label and with Iraqi drinking water standard (IQS:417, 2001) and several other standards around the world including European Economic Community Council Directive 98/83/EC (EEC, 1998), International Bottled Water Association (IBWA, 2009), United States Food and Drug Administration (FDA, 2017), United States Environmental Protection Agency (EPA, 2018), World Health Organization (WHO, 2017) and Turkish Legislation no. 23144 (Gazete, 1997).

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2. MATERIAL AND METHODS

2.1. Sample collection

In this study, 136 bottled water samples from 17 different Brands (8 samples per brand) were purchased randomly from different supermarket stores in Duhok city, Kurdistan region, Iraq from March to July 2018. The Capacity of purchased bottled water was range from 0.25L to 0.5L. The bottled water were consisting of natural spring and natural mineral water, imported as non-carbonated water in polyethylene plastic containers with plastic screw caps. The information such as brands name, bottled water types, location and sample container types were noted from the labels of bottled water and presented in Table 1. In addition, the physicochemical parameters given on bottled labels of each brand were used as a dataset for this study (Table 2). The samples were brought to the laboratory and kept sealed and refrigerated at 4 °C until the physicochemical analysis to be conducted.

Table (1):- Information on bottled water.

Brand code	Brands name	Location	Bottled water types	Sample container types
1	Sirma	Mersin - Turkey	NMW	Glass
2	Evian	Évian-les-Bains - France	NMN	Plastic
3	Volvic	Auvergne France-	NMW	Plastic
4	Pinar	Bozdogan Aydin -Turkey	NMW	Glass
5	Masafi	Erbil –Iraq	NMW	Plastic
6	Slemani	Al sulaymaniyah -Iraq	BDW	Plastic
7	Alwaha	Erbil –Iraq	NMW	Plastic
8	Mazi	Duhok –Iraq	NSW	Plastic
9	Shreen	Duhok –Iraq	NSW	Plastic
10	Aljod	Duhok –Iraq	NMW	Plastic
11	Tyan	Zakho-Duhok -Iraq	NSW	Plastic
12	Life	Zakho-Duhok -Iraq	NSW	Plastic
13	Zeren	Duhok –Iraq	NSW	Plastic
14	Kara	Duhok –Iraq	NSW	Plastic
15	Kani	Erbil –Iraq	NSW	Plastic
16	Rovian	Duhok –Iraq	NSW	Plastic
17	Zalal	Duhok –Iraq	NSW	Plastic

NMW = natural mineral water; NSW = natural spring water; BDW = bottled drinking water.

2.2. Laboratory analysis

Bottled water samples were taken to the Central Laboratory of College of Agriculture, University of Duhok, Kurdistan region, Iraq. Since bottled water samples did not contain particles, the samples were not filtered prior to analyses for various parameters. The samples were analyzed for pH, TDS, turbidity, total hardness, Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, Cl^{-}, NO_3^{-} and SO_4^{-2} in accordance with the procedures delineated in the standard methods described by Motsara and Roy (2008) and APHA (1995). Table 2 shows the technical and methods used for the analysis of different parameters, alongside the instruments and units used in this study.

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Table (2):- Water quality parameters, analytical methods and instruments used for the current study.

Parameters	Unit	Instruments/analytical methods used
Ph		Digital pH meter (EcoScan pH 5 Palmtop pH Meter)
Total dissolved solids (TDS)	mg/L	Conductivity meter (Waterproof Conductivity Meter HI 9835)
Turbidity	NTU	Digital Turbidity Meter (HF Scientific 20016, Micro 1000 IR Laboratory Turbidimeter)
Total hardness as $CaCO_3$	mg/L	EDTA Titrimetric method
Calcium (Ca^{2+})	mg/L	EDTA Titrimetric method
Magnesium (Mg^{2+})	mg/L	EDTA Titrimetric method
Chloride (Cl^-)	mg/L	$AgNO_3$ Titrimetric method
Sodium (Na^+)	mg/L	Flame-photometric method (Jenway PFP7 clinical flame photometer
Potassium (K^+)	mg/L	Flame-photometric method (Jenway PFP7 clinical flame photometer
Sulfate (SO_4^{2-})	mg/L	Barium sulfate turbidity (Spectrophotometer)
Nitrate (NO_3^-)	mg/L	Steam distillation method (Kjeldahl)

2.3. Labels Evaluation

The values of each parameter given on labels of bottled water of all brands were evaluated and compared with measured values in the laboratory and then compared to national and international standards to assess their suitability for health and also to judge their legal compliance (Table 3). It has been found that Iraqi's standards were mostly similar to the international standards, thus, in most cases, Iraqi's standards, Maximum permissible limits (IQS:417, 2001) were used to study the compliance of the collected bottled water with respect to different quality parameters. However, in the case the parameters did set in the Iraqi's standards, the other national and international standards were used (See Table 3).

2.4. Statistical Analysis

One sample T-test was used to determine if there were significant variations (at 95% confidence level) in parameter values shown on labels and measured (actual) values. Accordingly, two-tailed T-test was used to test whether the measured samples values are greater than or less than the values reported on labels, while right (upper) tailed T-test was used to examine if the measured values are greater than the recommended standard's values, except pH value, which has been examined by two-tailed T-test. Prior analysis, data were evaluated for normal distribution using the Anderson-Darling normality test (if P-value < 0.05 data considered non-normal). Long Root square transformation was used where data were not normally distributed. All Statistical analysis was performed using the Minitab software package 17.

Table (3):- National and international standards related to assessing the quality of bottled water.

	Unit	WHO (2017)	EPA (2018)	EEC (1998)	IBWA (2009)	FDA (2017)	Iraqi standards (IQS:417, 2001)	Turkish Legislation R.G. no. 23144a (Gazete, 1997)
Parameter		Drinking water (Gv)[a]	Drinking water (MCL)[b]	Drinking water (MAC)[c]	Bottled water (SOQ)[d]	Bottled water (MAL)[e]	(MPL)[f]	Bottled drinking water (MAC)[c]

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pH			6.5 - 8.5	6.5-9.5	6.5 - 8.5		6.5–8.5[g]	5.5–8.5
TDS	mg/L		500[g]		500	500	1000	
Ca^{2+}	mg/L						50[g]	100
Mg^{2+}	mg/L						50[g]	50
Cl^-	mg/L		250	250	250	250	250[g]	250
Na^+	mg/L			200			200[g]	175
K^+	mg/L							12[g]
SO_4^{2-}	mg/L		250	250	250	250	250[g]	250
NO_3^-	mg/L	50	44	50	44	44	50[g]	45
Total Hardness	mg/L						500[g]	
Turbidity	NTU		1		0.5	5	5[g]	5

WHO= World Health Organization; EPA = US Environmental Protection Agency; EEC = European Economic Community; IBWA = International Bottled Water Association; FDA = US Food and Drug Administration. [a]Guideline value; [b]Maximum contaminant level; [c]Maximum admissible concentration; [d]Standard of quality; [e]Maximum allowable level; [f]Maximum permissible limits; [g]depended values for comparison and water quality assessment.

3. RESULT AND DISCUSSION

The relative abundance of major chemical constituents in bottled water is determined by the types of geological rocks, weathering processes and the composition of rocks from which the water is abstracted (Birke *et al.*, 2010). The physicochemical analysis is frequently used as one of the effective techniques for detecting the possible source of these dissolved constituents in water (Barakat *et al.*, 2018). Accordingly, in the current study, the collected samples from different brands of bottled water were analyzed for 11 physicochemical parameters. The frequencies of the parameters reported on the labels of brands studied are shown in Figure 1. The measured values of physicochemical analysis of bottled water and their comparison with the standards and with the values inscribed on labels are given in Table 4, together with one sample T-test analysis results. In addition, the number and percent of samples with a concentration value equal, greater, less than label values and equal or greater than maximum permissible limits set by Iraqi's standards are illustrated in Table 5.

a. Parameters specification on the labels

There was a considerable variation among the studied bottled water with respect to the number and type of parameters inscribed on the labels (Fig 1 and Table 4). The most parameters, which have been reported on the labels of examined bottled waters, were basic parameters (major ions), only two to three brands reported trace elements such Al^{3+} and Fe^{3+}, thus the current study focused on the study of major ions for evaluating the quality of bottled water samples. However, the parameters that are reported most frequently on labels were pH, Ca^{2+} and Mg^{2+} which were indicated on the labels of all brands. The other frequency is for Na^+ and NO_3^-, which were reported on the labels of 128 and 112 samples out of 136 samples for both Na and NO_3^- respectively. SO_4^{2-} and Cl^- had a similar frequency of 104 times reported on labels followed by TDS and potassium which have been indicated on 96 labels out of 136. The least parameters reported on the labels were TH (56 labels) and Turbidity (24 labels).

As regard to the total number of parameters inscribed on the label of each brands, it has been observed that brands Slemani, Al-waha and Kani had the higher number of parameters (10 out of 11), followed by Sirma, Pinar, Shireen, Life and Zeren which had 9 parameters on their labels. The rest of brands had the number of parameters between 7 to 8 on their labels, with the exception of Tyan which had only 6 parameters on its label. Based on these findings, it seems that the number and type of parameters reported on the labels of studied bottled water showed a lack of homogeneity. Therefore, it is very necessary that

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the local authorities such as quality control and quality assurance to produced unified specifications and continuously monitoring these brands to follow their specification.

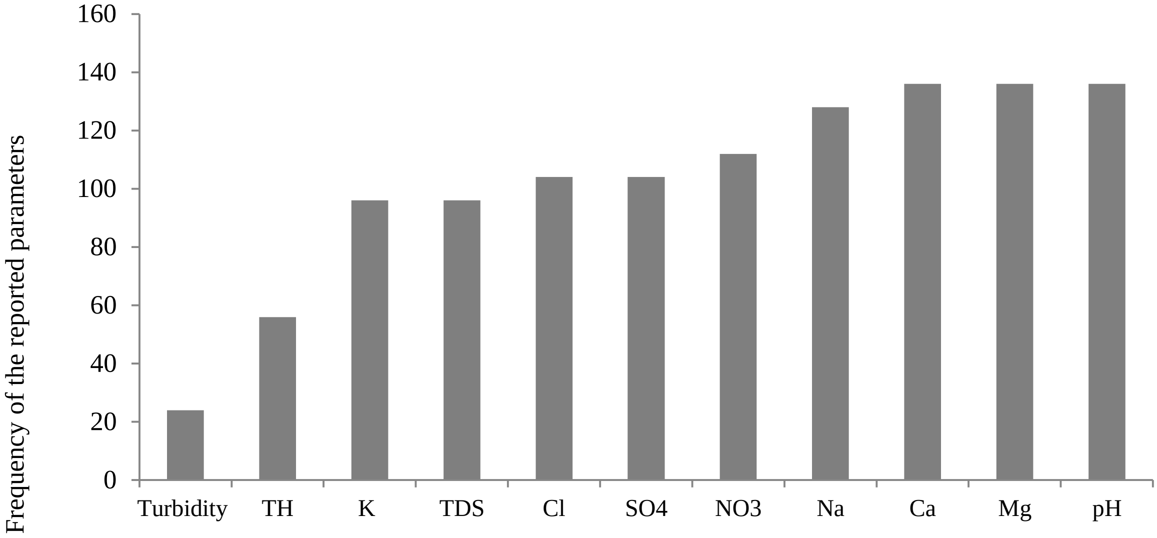

Figure (1):- Frequency of the parameters reported on the labels of studied brands.

b. Comparison of measured values with standards

The results of pH values in all bottled water samples were in a range of 7.0 for Life to 8.1 for Kara. Depending on these results it can be reported that all of the collected water samples were almost neutral to slightly alkaline, this could be due to the geological composition of the region from which the plants have been established as almost all of the studied brands use natural springs water, which are largely composed of calcium carbonate $CaCO_3$ (Al-Jiburi and Al-Basrawi, 2015). It was also noticed that the pH values in all the study brands were within the acceptable range (6.5-8.5) as per Iraqi's standards.

It was observed that the mean content of TDS ranged from 84.8mg/L at Pinar brand to 393.6mg/L at Evian brands. According to one sample T-test analysis, none of the studied brands had a significantly higher TDS value than the Maximum contaminant level (500mg/L) based on (EPA, 2018) standards. Therefore, it can be claimed that these brands of bottled water are suitable for drinking depending on this parameter. TDS, which measure the salinity behaviors of water, may result in offensive odors, tastes, colors, and health problems when its concentration is high and this depends on the specific contaminants present (Abd *et al.*, 2008). Water with extremely low concentrations of TDS may also be unacceptable because of its flat, insipid taste, although no health-based guideline value is proposed by (WHO, 2017).

The analyzed results have shown that the values of calcium (Ca^{2+}) and magnesium (Mg^{2+}) were ranged from 9.60 to 88.8 mg/L and from 7.1 to 35.1mg/L respectively. Among the samples analyzed, it was observed that the brands Evian, Kani and Kara had higher contents of Ca^{2+} with means concentrations of 88.8, 75.1 and 64.9mg/L for each of Evian, Kani, and Kara respectively, and these values were significantly ($p < 0.05$) higher than the permissible limit (50mg/L) per Iraqi's standards. This higher trends of Ca^{2+} could be related to the types of rocks present in the area of these brands. Comparing the Mg^{2+} contents to standards, the values of all the studied brands were not exceeded the permissible limit of 50mg/L as per Iraqi's standards (IQS:417, 2001). The data obtained from this study can be utilized to estimate ingestion amounts of certain elements by consumers. It has been reported that adult humans between ages 19 and 50 years require daily 1000mg Ca^{2+}, 310-420mg Mg^{2+} (Azoulay *et al.*, 2001). For the bottled waters examined in this study, adult humans may fulfill only ~ 7% of their Ca^{2+} dietary reference intake (DRI), between 6 and 4.5% of their Mg^{2+} DRI by drinking 2L of bottled water per day (calculations were made using mean values). Although, no health-based guideline values for these parameters have been proposed by (WHO, 2017), it was suggested that, consumers should choose to drink bottled water containing optimal levels of Ca^{2+} and Mg^{2+} to prevent adverse health effects (Quattrini *et al.*, 2016).

The mean concentrations of Na^{+} ranged from 2.6 to 22.5 mg/L and K^{+} concentration ranged from 1.1 to 13.7 mg/L. Observations revealed that none of the analyzed samples had significantly higher values of Na^{+} and K^{+} than maximum permissible limit (200mg/L and 12mg/L respectively) according to Iraqi's standards (IQS:417, 2001) and Turkish Legislation. Even though, the mean concentration of K^{+} of Kani brand was 13.7mg/L, which is slightly higher than the permissible limit (12mg/L) suggested by Turkish Legislation (Gazete, 1997), statistically this value was not significant ($p > 0.05$). According to Azoulay *et al.*, (2001), adult humans between ages 19 and 50 years require daily 2400-3000mg Na^{+}. Depending to the waters examined in this study, it can be said that a consumption of 2L of these water a day would contribute to the fulfillment between only 0.3 and 0.2% of Na^{+} dietary reference intake to the adults (calculations were made using mean values).

The total hardness (TH) values obtained were ranged from 53.7 (Pinar brand) to 346.7mg/L (Evian brand). Different government has different regulations for the TH level for drinking water. According to the Iraqi's standards (IQS:417, 2001), the maximum permissible limit of TH for natural drinking water is 500mg/L. Based on this, it was found that the levels of TH of all the brands' samples were lower than the permissible limit (500mg/L) per Iraqi's standards. The higher value of TH at Evain brand could be due to the geological rock surrounding the water source of this brands, although the value was lower the prescribed limits. According to Barakat *et al.*, (2018) the development of hardness in water is primarily derived by dissolved alkaline earth metals such as calcium and magnesium, with all other divalent cations also contributing to the concentration. Even though, no health-based guideline value is proposed for hardness in drinking water, it could affect the taste of water (WHO, 2017).

In the present investigation, it was observed that the values of chloride (Cl^{-}) were ranged from 15.6 (at Shireen brand) to 53.9mg/L (at Al-waha brand). These ranges of Cl^{-} show that the mean concentrations of the analyzed samples were far below the prescribed limits (250mg/L) according to all the recommended standards in present study, except WHO (2017). According to WHO (2017) chloride concentrations in excess of about 250mg/L can give rise to detectable taste in water, but the threshold depends on the associated cations. However, No health-based guideline value is proposed by WHO (2017) for chloride in drinking water. Concerning the nitrate concentrations (NO_3^{-}) in the analyzed samples, it was observed that the NO_3^{-} values varied from 1.39 to 10.6mg/L. The maximum value of NO_3^{-} was recorded with Kani and the minimum value was recorded with Mazi. It was also observed that the NO_3^{-} values of the studied bottled waters were significantly lower than the prescribed limits (50mg/L and 45mg/L) according to all standards reported in current study.

Sulfate (SO_4^{2-}) concentration in the bottled water samples were ranged from 6.4 (at Kara brand) to 78.5mg/L (at Shireen brand). The analyzed results revealed that the concentrations of (SO_4^{2-}) of the studied brands were lower than allowable limit (250mg/L) according to all the reported standards, with exception of WHO (2017) standards. Although no health-based guideline value has been derived for sulfate, it was reported that water containing higher levels of SO_4^{2-} could have a noticeable taste and might cause a laxative effect in unaccustomed consumers (WHO, 2017).

The last physical indicators, which has been analyzed in this study, was turbidity. In the present study, the mean turbidity readings of the tested samples were in the range of 0.022 to 0.136NTU. Only two brands (Pinar and Kara) had a bit high levels of turbidity, while the values of the rest brands were very low. It has been claimed that the level of turbidity should be very low (lower than 0.5NTU) because if consumers lose confidence in a drinking-water supply, they may drink less water or use lower turbidity alternatives that may not be safe (WHO, 2017). However, it was noticed these ranges were far below the permissible level (5NTU) suggested by Iraqi's (IQS:417, 2001) and other international standards for drinking water, indicating that all the bottled water samples were free from turbidity.

According to the above-mentioned results, it can be reported that except Ca^{2+} in two cases and K^{+} in one case, almost all the values of physicochemical parameters were significantly lower than the recommended values. These results could be due to the fact that usually the brands of bottled waters subject the water to several treatment processes such as filtration, purification by reverse osmosis, deionization, ozonation...etc, to ensure its quality and consequently this could lead the values of the studied parameters to be lower than their normal values. However, it was observed that 26 out of 136 (19.1%) samples of bottled waters had a higher Ca^{2+} content and 6 out of 136 (4.4%) had a higher K^{+} content compared to the prescribed standards. The higher contents of Ca^{2+} were recorded with brands names Evian, Kara and Kani and K^{+} were recorded with Kani. Based on these results it can be suggested that all these bottled water studied are safe for drinking according to the applied standards, although in a few cases there are slightly higher values than recommended standards.

a. Comparison of analytical results with the reported label values

As it is shown in Table 4 and 5, the comparisons were only made on parameters that were reported on the labels. Analyzed results of one sample T-test showed that there was a huge variation between the findings obtained in the laboratory and those inscribed on the labels. Overall, it was observed that the measured mean concentrations of studied parameters are significantly ($p < 0.05$) higher than values mentioned on the labels, although the measured values of some samples were significantly lower than or similar the labels. It was observed that the percentages of samples (No. of brands), whose measured values are more than the values reported on the labels, were as follow: pH 77.2% (12 brands), TDS 100% (12 brands), Ca^{2+} 91.9% (15 brands), Mg^{2+} 100% (17 brands), Na^{+} 62.5% (9 brands), K^{+} 85.4% (9 brands), TH 100% (7 brands), Cl 100% (13 brands), NO_3^{-} 66.9% (10 brands), SO_4^{2-} 86.5% (11 brands) and Turbidity 100% (3 brands). For the rest of the results, few percentages of samples and No. of brands had their measured values to be less than/equal the values mentioned on the labels. Güler and Alpaslan (2009) claimed that observed changes that can be found between measured values and labels may be due to the fact that information reported on the bottle labels is simply based on analysis results obtained several decades ago, during which significant changes may have occurred in the source water chemical composition. The same authors stated that additional changes to water chemistry can occur during the storage of the bottles such as co-precipitation of constituents or leaching of some constituents from the bottle, as well as from production line of the bottling plant itself. Another reason may be due to accuracy, precision or detection limits of the employed analytical methods/instruments used. Whatever the reasons are, the results have shown that there can be significant differences between labeled and measured values. Therefore, it is recommended that the bottled water producers and production supervisor should be more careful about the quality control of the bottled water. Although, almost all of the examined bottled water had significantly lower values than the recommended limits of drinking water, the measured physicochemical contents of brands were far more than the inscribed labels, and this may be due to the differences in water supply resources and water treatment processes (Miranzadeh and Marzaleh, 2015).

Table (4):- Comparison of label values and measured values of studied bottles water samples.

	pH		TDS (mg/L)		Ca^{2+} (mg/L)		Mg^{2+} (mg/L)		Na^{+} (mg/L)		K^{+} (mg/L)		TH (mg/L) $CaCO_3$		Cl^{-} (mg/L)		NO_3^{-} (mg/L)		SO_4^{2-} (mg/L)		Turbidity NTU	
Samples	L	M	L	M	L	M	L	M	L	M	L	M	L	M	L	M	L	M	L	M	L	M
Sirma	7.36	7.64	63.0*	123.8	16.2*	25.7	1.6*	7.10	1.0*	2.60	0.3*	1.62		93.9	1.4*	22.8	1.1*	2.37	6.2*	43.5		0.057
Evian	7.20*	7.61	345*	393.6	80.0*	88.8*	26*	30.3	6.5*	5.30	1.0*	1.67		346.7		25.3	3.8*	3.57	14.0*	63.2		0.046
Volvic	7.00*	7.20		165.5	12.0*	13.8	8.0*	13.3	12*	8.10	6.0*	6.60		89.4	15*	30.3	7.3*	7.70	9.0*	6.9		0.089
Pinar	6.80*	7.10	61.6*	84.8	3.14*	9.60	1.1*	7.20	4.9	5.00	1.53*	3.00	20.3*	53.7	3.6*	22.98		2.53	7.9*	20.5		0.136
Massafi	7.60*	7.40	100*	139.0	12.0*	22.8	7.0*	11.8	10*	3.20		1.10		105.4	1.0*	21.6	6.3*	1.56	7.0*	30.7		0.024
Slemani	7.24*	7.70	118*	156.1	23.3*	26.9	7.0*	35.1	1.75*	5.90	0.19*	2.20	87.3*	211.9	5.0*	18.0	3.1*	2.90	5.0*	77.9		0.03
Al waha	7.10	7.10	129*	201.1	<1.0*	10.4	18.1*	29.7	7.0*	22.5	<1.0*	3.70	<10.0*	148.3	2.5*	53.9	6.8*	9.68	67.4	59.2		0.023
Mazi	7.38*	7.78		205.9	28.0*	49.4	3.4*	17.9	2.91	2.98		1.97		197.1	1.4*	17.9	1.1*	1.39	4.2*	71.6		0.022
Shireen	7.30	7.26	118*	234.9	27.0*	37.6	4.0*	18.3	8.0*	4.29	3.0*	1.97	90.0*	169.4	6.0*	15.6		3.00	10.0*	78.5		0.022
Al-joud	7.30*	7.73	190*	139.7	20.0*	29.1	2.4*	12.3	5.0*	9.13	0.4*	2.31		123.3		17.7	0*	2.47		44.5		0.034
Tiyan	7.30	7.32		169.2	26.0*	27.2	7.5*	16.0		4.84		2.15	10.0*	134.1		41.1	0.2*	1.70		16.8	0.0*	0.023
Life	7.20*	7.00		156.8	24.2	24.1	4.4*	16.8	2.0*	6.31		3.54	40.0*	129.2	11.5*	37.5	0.5*	1.49	16.8*	25.1	0.2*	0.028
Zereen	7.30*	7.73	118*	186.7	27.0*	29.5	4.0*	29.3	8.0*	4.84	3.0	2.86	90.0*	194.5	6.0*	46.8		2.00	10.0*	40.7		0.022
Kara	7.40*	8.10	115*	239.0	45.0*	64.9*	2.4*	23.9	1.5*	3.10	0.5*	2.80		239.0	10*	38.2	0*	1.99		6.41		0.11
Kani	7.40*	7.89	280*	315.1	70.0*	75.1*	10*	24.6	3.1*	11.5	1.5*	13.7		288.9	2.5*	45.5	10.5	10.6	13.6*	25.1	0.0*	0.044
Rovian	7.30*	7.74	121*	143.8	28.0	29.1	2.3*	8.90	2.2*	9.29	1.3	2.52		109.3		18.2	0*	2.95		41.5		0.022
Zalal	7.36*	7.51		178.0	29.0*	42.4	3.4*	16.6	2.9*	3.91		3.75		174.4	1.4*	44.1	1.1*	3.23	4.2*	21.0		0.052
Standards	6.5–8.5		500[c]		50		50		200		12[d]		500		250		50		250		5	

All the parameters are in mg/L except pH and Turbidity (NTU).

L = Label values; M = Measured values; * on Label values in each column = Label value significantly different from Measured value; * on Measured values in each column = measured value significantly greater than recommended standard value.

[c](EPA, 2018): Drinking water, (Maximum contaminant level).

[d]Turkish Legislation R.G. no. 23144a (Gazete, 1997): Bottled drinking water (Maximum admissible concentration).

Table (5):- the number and percentage of samples having concentrations equal/higher than recommended standards and equal, higher and less than label values.

	equal or greater than standards			greater than label values			less than the label values		equal to label values	
Parameters	Total No. of samples (n)	No.	%	Total No. of sample (n)	No.	%	No.	%	No.	%
pH	136	0	0.0	136	105	77.20	28	20.59	3	2.21
TDS	136	0	0.0	96	96	100	0	0.0	0	0.0
Ca^{2+}	136	26	19.1	136	125	91.91	6	4.41	5	3.68
Mg^{2+}	136	0	0.0	136	136	100	0	0.0	0	0.0
Na^{+}	136	0	0.0	128	80	62.5	45	35.2	3	2.3
K^{+}	136	6	4.4	96	82	85.42	14	14.58	0	0.0
TH	136	0	0.0	56	56	100	0	0.0	0	0.0
Cl^{-}	136	0	0.0	104	104	100	0	0.0	0	0.0
NO_3^{-}	136	0	0.0	112	75	66.96	33	29.46	4	3.57
SO_4^{2-}	136	0	0.0	104	90	86.54	14	13.46	0	0.0
Turbidity	136	0	0.0	24	20	83.3	4	16.7	0	0.0

c. CONCLUSION

The present study was conducted to evaluate the quality of bottled water of different brands based on several physiochemical parameters and making a comparison of the analyzed results with the standards limits and with values reported on the labels. However, it was observed that there was a huge inconsistency among the studied brands of bottled water regarding the number, types, and frequency of reporting parameters on labels. Characteristics such as pH, Ca^{2+} and Mg^{2+} were the only parameters that have been reported more on the labels of all brands. As regards to the comparison between laboratory results and recommended standards for drinking water, nearly most of the bottled water samples were suitable for drinking purposes as they were within permissible limits according to the chosen standards, with the exception of few cases such as the Ca^{2+} in brands (Evain, Kara and Kani) and K^{+} in brand (Kani). Additionally, there was a large variation between the measured values and those inscribed on the labels. It was found that on average 86.7% of the samples their measured values were higher than the label values, 12.2% of the samples their measured values were lower than the label values and only 1.1% of the samples have the same values as labels. Thus, according to these results, it can be concluded that the laboratory results of studied bottled water were far different from the values mentioned on the labels.

d. Recommendation

In the light of the findings reported in this study, it can be recommended that the monitoring agencies and authorities such as ministry of health, governmental quality control, quality assurance, and research institute should plan effective monitoring programs for companies producing bottled drinking water. Moreover, local standards agencies should introduce and apply unified, new, and important specifications, and periodically monitor the quality of bottled water to ensure spotless and secure water supply to the consumers.

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REFERENCES

– Abd M. E. S., El-Ghitany E. M. and Kassem M. M.,Quality of bottled water brands in egypt part I: physico-chemical analyses. *The Journal of the Egyptian Public Health Association*, *83*(5-6), (2008), 369-388.

– Al-Jiburi H. K. and Al-Basrawi N. H., HYDROGEOLOGICAL MAP OF IRAQ, SCALE 1: 1000 000, 2013. *Iraqi Bulletin of Geology and Mining*, *11*(1) (2015), 17-26.

– Al Fraij Khalefa M., Mohammed K., Abd El Aleem and Hamad Al Ajmy, Comparative study of potable and mineral waters available in the State of Kuwait, *Desalination* 123, no. 2-3 (1999), 253-264.

– Al-Omran A.M., El-Maghraby S.E., Aly A.A., Al-Wabel M.I., Al-Asmari Z.A. and Nadeem M.E., Quality assessment of various bottled waters marketed in Saudi Arabia. *Environmental monitoring and assessment*, *185*(8) (2013), 6397-6406. DOI:10.1007/s10661-012-3032-z

– Amogne W.T., Labeling practices of water bottling firms and its public health perspective in Ethiopia. *Ethiopian Journal of Health Development*, *30*(2) (2016), 79-87.

– APHA (American Public Health Association), WPCF, Standard methods for the examination of water and wastewater. *American Public Health Association, Washington, DC,* (1995).

– Azoulay A., Garzon P. and Eisenberg M.J. Comparison of the mineral content of tap water and bottled waters. *Journal of General Internal Medicine*, *16*(3) (2001), 168-175. DOI: 10.1111/j.1525-1497.2001.04189.x

– Barakat A., Meddah R., Afdali M. and Touhami F., Physicochemical and microbial assessment of spring water quality for drinking supply in Piedmont of Béni-Mellal Atlas (Morocco). *Physics and Chemistry of the Earth, Parts A/B/C*, *104* (2018), 39-46.

– Bertoldi D., Bontempo L., Larcher R., Nicolini G., Voerkelius S., Lorenz, G.D., Ueckermann H., Froeschl H., Baxter M.J., Hoogewerff J. and Brereton P., Survey of the chemical composition of 571 European bottled mineral waters. *Journal of food composition and analysis*, *24*(3) (2011), 376-385. DOI: 10.1016/j.jfca.2010.07.005

– Birke M., Rauch U., Harazim B., Lorenz H. and Glatte W., Major and trace elements in German bottled water, their regional distribution, and accordance with national and international standards. *Journal of Geochemical Exploration*, *107*(3) (2010), 245-271. DOI: 10.1016/j.gexplo.2010.06.002

– Carstea E.M., Levei E.A., Hoaghia M.A. and Savastru R. Quality assessment of Romanian bottled mineral water and tap water. *Environmental monitoring and assessment*, *188*(9) (2016), 521. DOI:10.1007/s10661-016-5531-9

– Cemek M., Akkaya L., Birdane Y.O., Seyrek K., Bulut S. and Konuk M., Nitrate and nitrite levels in fruity and natural mineral waters marketed in western Turkey. *Journal of Food Composition and Analysis*, *20*(3-4) (2007), 236-240. DOI: 10.1016/j.jfca.2006.12.003

– Cidu R., Frau F. and Tore P., Drinking water quality: Comparing inorganic components in bottled water and Italian tap water. *Journal of Food Composition and Analysis*, *24*(2) (2011), 184-193. DOI: 10.1016/j.jfca.2010.08.005

– Diduch M., Polkowska Ż. and Namieśnik J., Chemical quality of bottled waters: a review. *Journal of food science*, *76*(9) (2011), R178-R196. DOI:10.1111/j.1750-3841.2011.02386.x

– EEC (European Economic Community, Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption. Official Journal L 330/32, 05.12.1998, (1998).

– EPA (Environmental Protection Agency), 2018 Edition of the Drinking Water Standards and Health Advisories Washington, DC, USA, (2018). [ONLINE] Available at: https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf. [Accessed 20 Jul. 2018].

– FAO and WHO., Food labeling. Fourth edition. *Rome, Italy*, (2007). [ONLINE] Available at: http://www.fao.org/tempref/codex/Publications/Booklets/Labelling/Labelling_2007_EN.pdf. [Accessed 20 Jul. 2018].

– Ferrier C., Bottled water: understanding a social phenomenon. *Ambio*, *30*(2) (2001), 118-119.

– FDA (Food and Drug Administration), Guidance for industry: a food labeling guide. *Food and Drug Administration, Washington, DC, USA*, 2008. [online] Available at: https://www.fda.gov/downloads/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/UCM265446.pdf. [Accessed 20 Jul. 2018].

– Gazete R., Ic-ilebilir nitelikteki suların istihsali, ambalajlanması, satıs-ı ve denetlenmesi hakkında yonetmelik. Resmi Gazete, 23144. In Turkey, (1997).

– Güler C. and Alpaslan M., Mineral content of 70 bottled water brands sold on the Turkish market: assessment of their compliance with current regulations. *Journal of Food composition and Analysis*, *22*(7-8) (2009), 728-737. DOI: 10.1016/j.jfca.2009.03.004

– Güler C., Evaluation of maximum contaminant levels in Turkish bottled drinking waters utilizing parameters reported on manufacturer's labeling and government-issued production licenses. *Journal of Food Composition and Analysis*, *20*(3-4) (2007), 262-272. DOI: 10.1016/j.jfca.2006.10.005

– IBWA (International Bottled Water Association). (2009). Model bottled water regulation. *Alexandria, Va., USA*. [ONLINE] Available at: https://www.bottledwater.org/files/IBWA%20Code%20of%20Practice%20Updated%202009%20Final_0.pdf . [Accessed 20 Jul. 2018].

– Ikem A., Odueyungbo S., Egiebor N.O. and Nyavor K., Chemical quality of bottled waters from three cities in eastern Alabama. *Science of the total* *environment*, *285*(1-3) (2002), 165-175. DOI: 10.1016/S0048-9697(01)00915-9

– IQS, (Iraqi drinking water standard:417), Central Organization for Quality Control and Standardization, Council of Ministers, Republic of Iraq, (2001).

– Kassir M.G., Dawood L.M. and Fuad F., Quality Assurance for Iraqi Bottled Water Specifications. *Journal of Engineering*, *21*(10) (2015), 114-132. DOI:10.5376/ijms.2016.06.0017

– Khan N.B. and Chohan A.N., Accuracy of bottled drinking water label content. *Environmental monitoring and assessment*, *166*(1-4) (2010), 169-176.

– Mesa J.C., Armendáriz C.R. and de la Torre A.H., Nitrate intake from drinking water on Tenerife Island (Spain). *Science of the total environment*, *302*(1-3) (2003), 85-92. DOI: 10.1016/S0048-9697(02)00341-8

– Miranzadeh M.B. and Marzaleh M.A., Assessing the Chemical Components of some Iranian Brands of Bottled Water. *International Archives of Health Sciences*, *2*(3) (2015), 125-128.

– Moazeni M., Atefi M., Ebrahimi A., Razmjoo P. and Vahid Dastjerdi M., Evaluation of chemical and microbiological quality in 21 brands of Iranian bottled drinking waters in 2012: a comparison study on label and real contents. *Journal of environmental and public health*, *2013*, (2013). DOI: 10.1155/2013/469590

– Mohsen D.E.H.G.H.A.N.I., Saeid N.A.Z.E.M.I., Hajer S.H.A.H.S.A.V.A.R. and Pyrasteh N., Quality assessment of 30 various brands of bottled drinking waters in Iran. *Environment Protection Engineering*, *42*(4) (2016), 65-73. DOI: 10.5277/epe160405

– Motsara M.R. and Roy R.N., *Guide to laboratory establishment for plant nutrient analysis* (Vol. 19). Rome: Food and Agriculture Organization of the United Nations, (2008).

– Nkono N.A. and Asubiojo O.I., Trace elements in bottled and soft drinks in Nigeria—a preliminary study. *Science of the total environment*, *208*(3) (1997), 161-163. DOI: 10.1016/S0048-9697(97)00289-1

– Quattrini S., Pampaloni B. and Brandi M.L., Natural mineral waters: chemical characteristics and health effects. *Clinical Cases in Mineral and Bone Metabolism*, *13*(3) (2016), 173-180. DOI:10.11138/ccmbm/2016.13.3.173

– Radha M., Quality Assessment of Various Bottled-Water Andtap-Water in Kirkuk-Iraq. *International Journal of Engineering Research and Applications*, *4*(6) (2014), 08-15.

– Ragusa A.T. and Crampton A., To buy or not to buy? Perceptions of bottled drinking water in Australia and New Zealand. *Human ecology*, *44*(5) (2016), 565-576. DOI: 10.1007/s10745-016-9845-6

– Saad B., Pok F.W., Sujari A.N.A. and Saleh M.I., Analysis of anions and cations in drinking water samples by capillary ion analysis. *Food chemistry*, *61*(1-2) (1998), 249-254. DOI:10.1016/S0308-8146(97)00024-1

– Semerjian L.A., Quality assessment of various bottled waters marketed in Lebanon. *Environmental monitoring and assessment*, *172*(1-4) (2011), 275-285. DOI:10.1007/s10661-010-1333-7

– Statista, *Bottled water consumption worldwide, 2017 Statistic*, (2018). [ONLINE] Available at: https://www.statista.com/statistics/387255/global-bottled-water-consumption/. [Accessed 12 July 2018].

– William J.C. and Frank R.R., *World Water Vision: making water everybody's business.* World Water Council, Tanet Press, UK, (2000).

– WHO (World Health Organization), *Guidelines for drinking-water quality: first addendum to the fourth edition*, (2017). [ONLINE] Available at: apps.who.int/iris/bitstream/10665/254637/1/9789241549950-eng.pdf. [Accessed 20 Jul. 2018].

هەلسەنگاندنا جوریا فزیکوکیمیائی بو بتلێن ئاڤا ڤەخارنێ ل جەند کومپانیەکا ل هەرێما کوردستانا عراقێ: بەراوردی دنافبەرا ئەنچامێن تاقیگەهێ دگەل ئەنچامێن ل سەر بتلان وبیڤەران

پوختە

چێکرن ئو بکارئینانا ئاڤا بتلان ل ڤان سالێن جویێ ب شێوەکێ بەرچاف زێدەبوویە. کوردستانا عراقێ ئێگ ژ وان دەڤەرایە گو ئەڤ جورێن ئاڤا بتلا لێ زیدەبویە. فێجا سەرەرای ڤێ چەندێ،بەردەوام هەلسەنگاندنا ئافێ بو ڤان چورێن ئافا بتلان گەلەك یا گرنگە بو گەرەنتیکرا پاقشیا ڤان ئاڤا بو ڤەخارنێ. ژ بەر ڤێ جەندێ، ١٣٦ نمونێن ئاڤا ڤان بتلان هتتە کومکرن ب شێوەیەکێ رەندوم ژ چەند بازارەکا ل پارێزگەها دهوکێ ل کوردستانا عراقێ، ئو ئەڤ نمونە هاتتە شلوفەکرن ل تاقیگەهێ بو چەند پێکهاتییەکێت فزیکوکیمیائی وەکو: کالسیوم، مەکنیسیوم، سودیوم، بوتاسیوم، کلوراید، سەلفاد، نایترێت، ترشاتیا ئاڤێ، سەرجەم خوێیا حەلیای دناف ئاڤێدا، شێلیاتیا ئاڤێ ئو سەنکا ئاڤێ یا سەرچەم بوڤەخارنێ. هەروەسا ئەنچام هاتتە شلوڤەکرن ب شوێ ئاماری ئو هاتتە بەراورد کرن دکەل بیڤەرێن عراقی **((IQS:417, 2001** ئو یێن جیهانی. ئەنچامان دیارکر کو رێژا بارا پتر یان بێکهاتیێن ئاڤان کێمتربوو ژ پیڤەرێن هاتینە بکارئینان، ژ بلی توخمێ کالسیومی ل کومپانیا (ایڤیان، کارە و کانی) هەروەسا توخمێ

بوتاسیومی ل کومپانیا (کانی). هەروەسا بەراوردکرنا ئەنچامین تاقیگەهێ دگەل ئەنچامێن سەر بتلان دیارکر کو چێوازیەکا بەرچاڤ یاهەی دناڤ بەرا واندا. هاتە دیارکرن کو بارا پتر (نێزیکی ٨٦,٧%) ژ بیڤەرێن هاتینە دەست فە ئینان ل تاقیگەهێ ریژا وان بتر بوو ژ ریژا بیڤەرێن سەر بتلان، ئو نێزیکی (١٢,٢%) رێژا پیڤەران کێمتربوو ژ رێژا بیڤەرێن سەر بتلان، بەلێ ب تنێ ١,١% وەك هەڤی هەبو دناڤ بەرا واندا. بشت بەستن ب ڤان ئەنچاما، گەلەك یاگرنگە دەسهەلات و بریکارێن چاڤدێریێ پلانەکا ئەکتیڤ یا چاڤدیریێ دانن بو کارگەهێن ئاڤا بتلا یێن ڤان کومپانیا.

التقييم النوعي الفيزيوكيميائي لبعض شركات المياه المعبأة بالقناني في اقليم كردستان العراق: مقارنة النتائج التحليلية مع بيانات الملصق ومع المعايير القياسية العالمية المتوفرة

الخلاصة

ازداد انتاج و استهلاك المياه المعبأة بالقناني بشكل كبير في العقود الاخيرة.إن اقليم كردستان- العراق هي احدى المناطق التي تتواجد فيها عدد كبير من الشركات المنتجة للمياه المعبأة بالقناني، مع ذالك، فان التقيم الدوري و النوعي للمياه المعبأة ضروري لضمان ملائمتها للاستهلاك البشري.طبقا للذلك تم جمع (١٣٦) عينة عشوائية من المياه المعبأة من المحلات التجارية و الاسواق المركزية للمحافظة دهوك في اقليم كردستان- العراق، و تم تحلليلها مختبريا لدراسة بعض الصفات الفيزيوكيميائي حيث شملت أيونات الكالسيوم (Ca^{2+}) و المغنيسيوم (Mg^{2+}) و الصوديوم (Na^{+}) و البوتاسيوم (K^{+}) و الكلوريدات (Cl^{-}) و الكبريتات (SO_4^{2-}) و النترات (NO_3^{-}) و درجة الحموضة (pH) و الاملاح الذائبة الكلية (TDS) و العكارة و العسرة الكلية (TH). البيانات حللت احصائيا و تم مقارنة نتائج التحليلات مع البيانات المسجلة على العبوة وطبقا للمواصفات العراقية القياسية (IQS:417, 2001) وبعض المواصفات العالمية. أشارت النتائج المتحللة بأن جميع نتائج التحليلات المختبرية كانت اقل من القيم القياسية وفقا للمعايير العراقية و العالمية ماعدا أيون الكالسيوم لأصناف المياه الخاصة بالشركات (ايفيان وكارة وكاني) وأيون البوتاسيوم لصنف المياه التابع لشركة (كاني). عند مقارنة نتائج التحليل المختبري مع البيانات الموجودة على عبوات المياه، اضهرت النتائج وجود فروقات كبيرة لأغلب الصفات المقاسة. لوحظ ان اكثرية الصفات المقاسة مختبريا (مايقارب ٨٦,٧% كمعدل) كانت ذات قيم اعلى من القيم الموجودة على عبوات المياه و حوالي (١٢,٢%) من الصفات المقاسة كانت ذات قيم اقل من تلك القيم المجودة على عبوات المياه بينما (١,١%) فقط من النتائج التحليلات كانت مطابقة مع تلك الموجودة على العبوات. على ضوء هذه النتائج نقترح ان تعمل الجهات الرقابية و السلطات الحكومية على وضع برنامج رقابي فعال على الشركات المنتجة لمياه الشرب المعبأة.