

The Quality of Drinking Water Bottled Domestic and Imported in Iraq

^{1,2}Amjad Hussein and ^{2,3}Ruqayah Mohammed

¹Department of Civil Engineering, College of Engineering,
Al-Muthanna University, Al-Muthanna, Samawah, Iraq

²Civil Engineering Research Group, School of Computing, Science and Engineering,
University of Salford, Newton Building, Peel Park Campus, Salford,
Greater Manchester M5 4WT, United Kingdom

³Department of Civil Engineering, Faculty of Engineering, University of Babylon, Hilla, Iraq

Abstract: Assess the quality of 10 kinds of imported water and 5 domestic varieties of bottled drinking water during the first half of 2017 in the city of Samawah, Iraq and the results compared with the attributes of bottled drinking water issued by the Saudi Arabian Standards Organization standards for the lack of standard special Iraqi drinking bottled water. Evaluation criteria included the physical and chemical the following: pH, turbidity, total dissolved solids, total hardness, calcium, magnesium, sodium, fluoride, nitrates, sulfates, chlorides, iron, manganese. Results showing that the levels of water quality standards of domestic and imported brands were identical to different specifications with the exception of dissolved solids in the category of one domestic and one imported brand and fluoride in all varieties and types of domestic importers. Measurements also revealing explosives that have been selected for each item of different types of variation in the values of water standards explosives with rates ranging from 0-35% for domestic brand and 0-100% for imported brand and the values of most of the criteria listed on the packaging does not reflect the actual content of the water bombs.

Key words: Water bottled, environment, packaging, domestic, brands, nitrates

INTRODUCTION

The most important characteristic of bottled drinking water when compared it with tap water is the quality of bottled water, particularly in terms of taste and the regularity of water quality over time (Huerta-Saenz *et al.*, 2012; Johnstone and Serret, 2012) and the tap water of the networks may change as a result of the materials they are exposed from the surrounding environment from reservoirs and pipes that pass in before they reach the consumer while the probability of contamination of bottled water is very low because it is placed in sealed packaging.

A 4 year study in the United States, reported by US Natural Resources Defense Council in which more than 1,000 packages covering 104 items of bottled drinking water were screened in some states, revealed that bottled water is not necessarily more pure or safe than tap water with about 33% of the bottled water at least one of them has different contaminants including some organic chemicals and bacteria at levels higher than permitted in the specifications of bottled drinking water and the results showed that about 25% of bottled water is actually a tap water that has been bottled after further treatment or

without treatment, according to the survey, the main reason for the growing consumption of bottled drinking water in the US States is the marketing and promotional means used by some manufacturers to persuade the costumer of the purity and safety of bottled water, exploiting the anxiety and suspicions of people about the quality and safety of the water networks.

In Iraq, the drinking water industry, packed over the past 20 years has grown significantly and has a high production capacity and bottled water is available in different sizes, most of which are used for one time and items imported from different countries are available on the local market. This research aims to assess the water quality of five domestic produced bottled drinking water and ten imported bottled drinking. The assessment included the following comparison of results with international standards for bottled drinking water Comparing the quality of domestic varieties with the quality of imported items comparing the results with the water content on the packaging and assessment of the difference in water quality between packaging of each item.

Abbreviations:

- I : Imported
- KSA : The Kingdom Saudi Arabia
- NBOS : Number of Bottled Out of Standard
- Mn : Manganese
- Fe : Iron
- Cl : Chloride
- NO₃ : Nitrate
- F : Fluoride
- Na : Sodium
- So₄ : Sulphates
- Mg : Magnesium
- CaCO₃: Calcium Carbonate
- Ca : Calcium
- TDS : Total Dissolved Solids
- TU : Turbidity

MATERIALS AND METHODS

Samples collection method: The process of obtaining bottled drinking water packages from some of the city’s shops randomly during the first half of 2018, taking into account the fact that the factory production date for packaging taken from the same packaging to avoid the possibility of a change in the characteristics of the water with the expiry of the packaging. The water quality analysis was performed according to APHA., (1995) Hussein (2017) and Hussein and Scholz (2017), unless stated otherwise. Two packages of each item were purchased and the physical and chemical characteristics were measured twice per item to confirm the accuracy of the measurement. The spectrophotometer DR 2800 Hach Lange (www.hach.com) was applied for the water quality analysis for variables NO₃-N, Fe, Cl, F, Na, SO₄, Mg, CaCO₃, Ca and Mn. Turbidity was determined with a Turbichack Turbidity Meter (Lovibond Water Testing, Tintometer Group, Division Street, Chicago, IL, USA) (Al-Isawi *et al.*, 2015 a, b; Al-Isawi *et al.*, 2017). The pH for all samples was measured using a VARIO pH meter (Wissenschaftlich-Technische Werkstätten, Weilheim, Germany) (Al-Isawi *et al.*, 2015a, b). This meter was calibrated with standard buffer solutions of pH 4, 7 and 9 each two weeks or whenever required. The Total Dissolved Solids (TDS) were measured using a Mettler Toledo Education Line Conductivity Meter (Boston Road, Leicester, UK). The packaging’s included 10 imported items and 5 domestic items, Table 1, showing the names of the domestic and imported items studied as well as water quality, raw water sources and packing city.

In order to investigate statistically significant differences, the Shapiro-Wilk’s test (Shapiro and Wilk, 1965; Razali and Wah, 2011) was used to assess the normality of data all data were non-normal distribution. A Mann-Whitney test was used to analyse non-normal data

Table 1: Locally produced and imported bottled water

Type of bottled water/		
Name of bottled water	Source of water	Country of origin
Imported		
Muen	(n/a) ^a	KSA ^b
Alwadi	Fatima valley	KSA ^b
Zalal	(n/a) ^a	KSA ^b
Aquafina	(n/a) ^a	Kuwait
Abraj	(n/a) ^a	Kuwait
Faihaa	(n/a) ^a	KSA ^b
Raudhtain	Raudhtain field	Kuwait
Hania	(n/a) ^a	KSA ^b
Delta	(n/a) ^a	KSA ^b
Algdeer	(n/a) ^a	KSA ^b
Locally		
Sawa	(n/a) ^a	Iraq/Samawah
Alraya	(n/a) ^a	Iraq/Samawah
Razan	(n/a) ^a	Iraq/Karbala
Alkhazer	(n/a) ^a	Iraq/Karbala
Salsabeel	(n/a) ^a	Iraq/Karbala

^aNot applicable; ^bThe kingdom Saudi Arabia

(Stoline, 1981; Kasuya, 2001). The Mann-Whitney tests were used to compare means between different treatments. Significant findings have been outlined and discussed. Somehow surprising and/or important insignificant findings have occasionally been highlighted as well.

RESULTS AND DISCUSSION

Domestic and imported water quality: Table 2 and 3 show the values of arithmetic average of the measurements of quality standards (intended as a statistical term) of two packaging water for each domestic and imported item, respectively indicating the values of the standards contained in the specifications of the bottled drinking water issued by the Saudi Arabian authority. The two tables also included the number of items that did not meet the required specifications. A code of one character and a number for each of the tested items was given to avoid mentioning the trade names, representing the character (L) of the domestic items and the character (I) of the imported items, Fig. 1 and 2 show the value of the arithmetic mean for elements reading of the domestic and imported items in case of high and low readings. A Mann-Whitney test (Nonparametric statistics) was used to determine whether the mean values of water standards for domestic varieties were statistically different from those in imported water.

pH: The pH values of the domestic varieties water varied from 7.1-7.8 (mean value was 7.34) and for the imported items from 7.2-7.8 (mean value was 7.48) and by comparing the results with Saudi Arabian Standard Specifications which determine the value of pH between 6.5 and 8.5, the researchers found that both the domestic and imported items conform to the specifications with a significant (p>0.05) differences between them.

Table 2: The quality measurements results of drinking water for the local items

Symbols	Element						
	Mn ¹	Fe ²	Cl ³	NO ₃ ⁴	F ⁵	Na ⁶	SO ₄ ⁷
	mg L ⁻¹						
L ₁ ^a	0.00	0.010	20	4.10	0.600	20	31
L ₂	0.00	0.000	36	9	0.095	49.4	47
L ₃	0.00	0.015	187	4.30	1.100	50	210
L ₄	0.00	0.000	16	0.115	0.300	13	48
L ₅	0.01	0.010	197	1.100	1.150	22.5	48
KSA ^b standard	0.05	0.300	250	10	0.6-1	-	250
NBOS ^c	0.00	0.000	0	0.00	5.00		0
Symbols	Element				TU ¹²	pH ¹³	
	Mg ⁸	CaCO ₃ ⁹	Ca ¹⁰	TDS ¹¹			
	mg L ⁻¹						
L ₁	5.05	46	10	118	0.28	7.20	
L ₂	3.60	184	68	123	0.22	7.50	
L ₃	6.10	145	48	162	0.24	7.65	
L ₄	2.35	20	4.1	19.8	0.10	7.30	
L ₅	3.60	130	46	204	0.21	7.10	
KSA standard	30.0	300	75	100-700	5.00	6.5-8.5	
NBOS ^c	0.00	0	0	1.00	0.00	0.00	

^aLocal; ^bThe Kingdom Saudi Arabia; ^cNumber of bottled out of standard; ¹Manganese; ²Iron; ³Chloride; ⁴Nitrate; ⁵Fluoride; ⁶Sodium; ⁷Sulphates; ⁸Magnesium; ⁹Calcium carbonate; ¹⁰Calcium; ¹¹Total dissolved solids; ¹²Turbidity

Table 3: The quality measurements results of drinking water for imported items

Symbols	Element						
	Mn ¹	Fe ²	Cl ³	NO ₃ ⁴	F ⁵	Na ⁶	SO ₄ ⁷
	mg L ⁻¹						
I ₁ ^a	0.0005	0.010	20	4.1	0.6	20	31
I ₂	0.0000	0.000	22	5	0.9	22	25.6
I ₃	0.0	0.005	18	0.2	0.2	17	54
I ₄	0.001	0.000	56	1.3	0.7	11	19
I ₅	0.0	0.015	21	0.6	0.7	19	33
I ₆	0.0	0.010	21	7.1	0.6	9	34
I ₇	0.0	0.010	15	4.51	0.8	12	51.5
I ₈	0.0	0.010	4.5	0.1	0.2	1	2.2
I ₉	0.0	0.000	43	6	0.67	19	5.95
I ₁₀	0.0	0.010	22.15	6.9	0.85	21	14
KSA ^b standard	0.05	0.300	250	10	0.6-1	-	250
NBOS ^c	0.00	0.000	0	0	2		0
Symbols	Element				TU ¹²	pH ¹³	
	Mg ⁸	CaCO ₃ ⁹	Ca ¹⁰	TDS ¹¹			
	mg L ⁻¹						
I ₁ ^a	5.05	46	10	118	0.28	7.2	
I ₂ ^b	7.7	45.5	5.5	105	0.23	7.2	
I ₃ ^c	19.5	105	10	120	0.18	7.8	
I ₄ ^d	10.55	101	23	111	0.1	7.65	
I ₅ ^e	1.8	50	22.5	112	0.22	7.4	
I ₆ ^f	6.45	121.5	38	159	0.26	7.7	
I ₇ ^g	13.4	95	16.5	114	0.115	7.2	
I ₈ ^h	5.55	50	10.7	50	0.23	7.65	
I ₉ ⁱ	17.6	110	15	139	0.4	7.3	
I ₁₀ ^j	8.5	75	16	120	0.16	7.7	
KSA standard	30	300	75	100-700	5	6.5-8.5	
NBOS	0	0	0	1	0	0	

^aImported; ^bThe Kingdom Saudi Arabia; ^cNumber of bottled out of standard; ¹Manganese; ²Iron; ³Chloride; ⁴Nitrate; ⁵Fluoride; ⁶Sodium; ⁷Sulphates; ⁸Magnesium; ⁹Calcium carbonate; ¹⁰Calcium; ¹¹Total dissolved solids; ¹²Turbidity

Turbidity (TU): The range of turbidity for the domestic items was (0.1-0.24; 0.195 as a mean value) and for the imported items was (0.1-0.4; 0.217 as a mean value). Both of them were characterized by low levels of turbidity

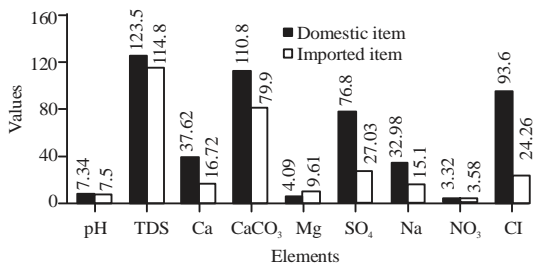


Fig. 1: Values of the arithmetic mean for elements reading of the domestic and imported items for high reading

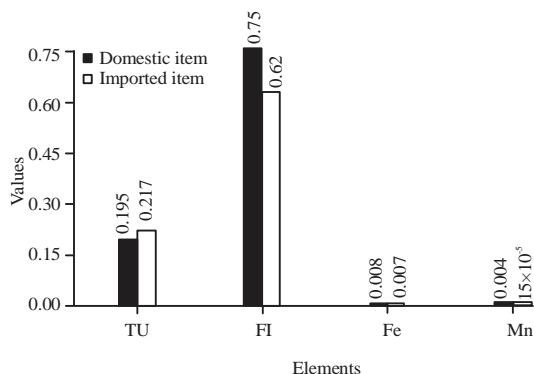


Fig. 2: Values of the arithmetic mean for elements reading of the domestic and imported items for low readings

when compared to the upper limit allowed in the specifications of the World Assembly for bottled drinking water and the United States Food and Drug Administration as shown in Table 2 and 3, respectively. There was no significant ($p < 0.05$) differences between them as shown in Fig. 2.

Total Dissolved Solids (TDS): Concentration of total dissolved solids for domestic items ranged from (19.8-204, 123.5 mg L⁻¹ as a mean value) and for imported items from (50-159, 114.8 mg L⁻¹ as a mean value). This means that all measured concentrations are below the upper limit allowed in Saudi Arabian specifications, noting that there is a domestic item and an imported item below the minimum limit In Saudi Arabian specifications as shown in Table 2 and 3 and Fig. 1. There was no significant ($p < 0.05$) differences between them.

Calcium (Ca): The concentration of the Calcium in domestic varieties ranged from (4.1-68 37.62 mg L⁻¹) as a mean value) and in items imported from 5.5-38, 16.72 mg L⁻¹ as a mean value). These values did not exceed the upper limit allowed in Saudi Arabian specifications as shown in Table 2 and 3 and Fig. 1. There was no significant ($p < 0.05$) differences between them.

Total hardness (CaCO₃): The concentration of total hardness in domestic varieties ranged between (20-184 , 110.8 mg L⁻¹ as a mean value) as a calcium carbonate while the concentration of total hardness in imported varieties ranged between (45.5-121.5, 79.9 mg L⁻¹) as a mean value) as calcium carbonate as shown in Fig. 1 and by comparing the median values, the researchers found that the median value of the items Domestic (110.8 mg L⁻¹) higher than the median value of imported items (79.9 mg L⁻¹) by 38% with note that all domestic and imported items did not exceed the upper limit allowed in Saudi Arabian specifications as shown in Table 2 and 3. There was no significant ($p < 0.05$) difference between them.

Magnesium (Mg): The concentration of magnesium in domestic varieties ranged between (2.35-6.1, 4.09 mg L⁻¹ as a mean value) while the concentration in the imported varieties ranged from (1.8-17.6 9.61 mg L⁻¹) as a mean value) as shown in Fig. 1 with a significant ($p > 0.05$) difference between them. All domestic and imported items are identical to Saudi Standard Specifications as they do not exceed the maximum allowable limit as shown in Table 2 and 3.

Sulphate (SO₄): Domestic varieties contained sulfate with concentrations of 31-210, 67.8 mg L⁻¹ as a mean value) and imported items between (2.2-54, 27.03 mg L⁻¹ as a mean value) as shown in Fig. 1 and the median value of the domestic items (67.8 mg L⁻¹) is approximately three times the median value of the imported items (27.03 mg L⁻¹) with no significant ($p < 0.05$) difference between them. All domestic and imported items are identical to Saudi Standard Specifications as they do not exceed the maximum allowable limit as shown in Table 2 and 3.

Sodium (Na): Domestic sodium varieties contained a higher concentration of imported items with concentrations in domestic varieties ranging from (13-50, 32.98 mg L⁻¹ as a mean value) while in imported items between (1-22 15.1 mg L⁻¹ as a mean value) as shown in Fig. 1 with no significant ($p < 0.05$) difference between them. Saudi standard specifications did not specify a value for the allowable level of sodium in bottled drinking water but Iraqi Standard Specifications for bottled drinking water stipulate that sodium concentration shall not exceed (200 mg L⁻¹).

Fluoride (F): Fluoride concentration in domestic varieties ranged between (0.095-1.15, 0.75 mg L⁻¹) as a mean value) and in imported items (0.2-0.9, 0.62 mg L⁻¹ as a mean value) as shown in Fig. 2 with no significant ($p < 0.05$) difference between them. It is clear that two imported items do not conform to Saudi Standard

Specifications while all domestic items are not matched Saudi Standard Specifications as shown in Table 3. Lewis, 1996 and Spellman, 2014 demonstrated that drinking water containing fluoride with a concentration of 1.0 mg L^{-1} helps in reducing the incidence of tooth decay by 65% for children between 12-15 years while increasing fluoride concentration more than 2 mg L^{-1} the grey or black spots appear on the children's permanent fingers are accompanied by a necrosis of the tooth and this is known as fluorosis. Furthermore, if fluoride concentration in drinking water is more than (8.0 mg L^{-1}) this leads to hardening of cartilage and bones because of its accumulation, leading to hardening of the spine and difficulty bending.

Nitrate (NO_3): Nitrate concentrations in domestic varieties ranged from $(0.115\text{-}9, 3.32 \text{ mg L}^{-1}$ as a mean value), higher than nitrate concentration in imported items $(0.1\text{-}9, 3.58 \text{ mg L}^{-1}$ as a mean value) as shown in Fig. 2 with no significant ($p < 0.05$) difference between them. The nitrate concentration in the domestic and imported varieties did not exceed the upper limit allowed in Saudi Arabian specifications as described in Table 2 and 3, respectively.

Chlorides (Cl): Concentrations of chlorides in domestic varieties are higher than in imported items where the concentration in domestic varieties ranged between $(16\text{-}197, 93.6 \text{ mg L}^{-1}$ as a mean value) and imported items between $(4.5\text{-}56, 24.26 \text{ mg L}^{-1}$ as a mean value) as shown in Fig. 1 with no significant ($p < 0.05$) difference between them. The concentration of chlorides in both of domestic and imported items did not exceed the upper limit allowed in Saudi Standard specifications as shown in Table 2 and 3, respectively.

Iron (Fe): The concentration of iron in the domestic varieties ranged between $(0.0\text{-}0.015, 0.004 \text{ mg L}^{-1}$ as a mean value) and in the imported items between $(0.0\text{-}0.015, 0.0002 \text{ mg L}^{-1}$ as a mean value) as shown in Fig. 2 with a significant ($p < 0.05$) difference between them. All domestic and imported items did not exceed the upper limit allowed in Saudi specifications as shown in Table 2 and 3, respectively.

Manganese (Mn): Domestic varieties, the manganese concentration ranged between $(0.0\text{-}0.01, 0.004 \text{ mg L}^{-1}$ as a mean value) and in the imported items between $(0.0\text{-}0.001, 0.00015 \text{ mg L}^{-1}$ as a mean value) as shown in Fig. 2, noting that the median value of the domestic items $(0.004 \text{ mg L}^{-1})$ is equivalent to about two and a half times the median value of the imported items $(0.00015 \text{ mg L}^{-1})$ with a significant ($p < 0.05$) difference between them. All domestic and imported items did not exceed the maximum allowable limit in Saudi Arabian specifications as shown in Tables 2 and 3, respectively.

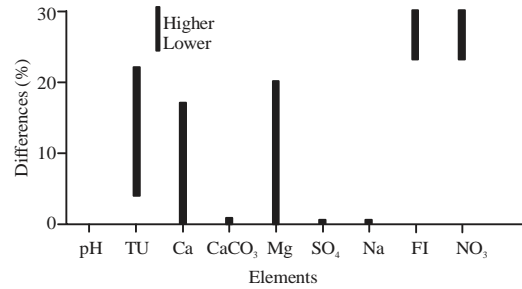


Fig. 3: Percentages difference for each element in case of domestic packaging

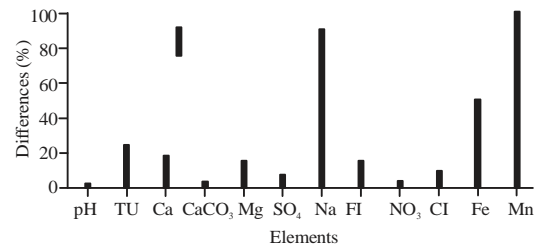


Fig. 4: Percentages difference for each elements in case of imported packaging

Comparison of the quality of the packaging water for one element: Laboratory tests of the two items tested for each of the different domestic and imported bottled water showed that the test results for some of the elements (from 5-10 variables) were equal in the two packages while the other elements differed in varying proportions ranging from (0-35%) in case of domestic items and (0-100%) in case of imported items as shown in Fig. 3 and 4, respectively. In the domestic varieties, the percentages difference between the two packaging for the pH, TU, Ca, Hardness, Mg, SO₄, Na, FI and NO₃ were 0-2, 4-22, 0-17, 0-1, 0-20, 0-0.5, 0-0.5, 10-35 and 23-30, respectively. While laboratory tests for TDS, Cl, F and MN did not record any percentages of difference. In case of imported items, the percentages difference between The two packaging of pH, TU, TDS, Ca, Hardness, Mg, SO₄, Na, FI, NO₃, Cl, F and Mg were 0-3, 0-25, 0-3, 0-18, 0-4, 0-15, 0-8, 0-90, 0-16, 0-4, 0-10, 0-50 and 0-100, respectively.

Comparison of the quality of water packaged with the content on the packaging: Of the 13 quality standards carried out, two of them did not mention any concentration in the domestic and imported varieties, namely, TU and Mn. All domestic and two of imported varieties did not mention FI concentration. Total hardness was not mentioned in Four domestic and six imported items. the nitrate concentration was not mentioned in four domestic varieties and two items of imported. TDS was

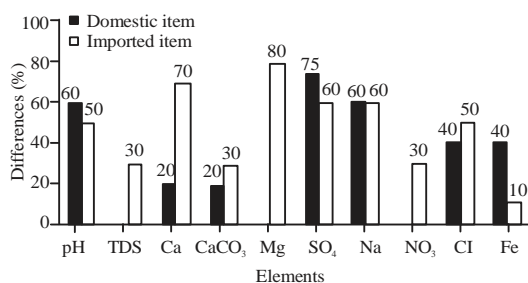


Fig. 5: Comparison of the percentage of domestic and imported varieties that exceeded the mentioned concentrations in their packaging for each element

not mentioned in three domestic varieties and two imported items. Iron concentration was not mentioned in three domestic varieties and four imported items. Figure 5 compare the proportion of domestic and imported bottled water that have exceeded their packaging for element.

CONCLUSION

Domestic and imported items have achieved good quality in all physical and chemical standards except for two criteria, namely, total dissolved solids and fluoride where one domestic item and one imported item did not achieve the level of concentration of dissolved solids and all domestic items were not specifications are achieved in fluoride concentration while two imported items did not achieve the specifications in fluoride concentration.

Statistical analysis using the Mann-Whitney test at the significance level 0.05, the quality of the domestic varieties is no different from the quality of the imported items in the following criteria: turbidity, dissolved solids, total hardness, calcium, sodium, fluoride, nitrate, sulphate and chlorides, the quality varies in the following criteria: pH, magnesium, iron and manganese.

There is a variation in the water quality of the same item as the measurement of the two packaging's tested for each item revealed a difference in the values of the standards in varying proportions ranging (0-35%) for domestic items and (0-100%) for imported items which indicates the irregularity of the efficiency of the water purification processes in the factory, the difference in the quality of the raw water over time and the multiplicity of water sources of one factory.

There is a significant discrepancy between the values of the measured standards and their stated values on the packaging's except for dissolved solids, magnesium and nitrates in domestic varieties and iron in imported items.

RECOMMENDATIONS

Some domestic items need to be added fluoride and others need to be reduced in fluoride either for imported items, some of which need to be increased fluoride.

Relevant agencies must take their oversight role from monitoring all stages of packaged water factories and their water sources and carrying out periodic checks on the water produced from these factories for domestic items. Imported items must be subject to laboratory tests from time to time to ensure that they conform to standard specifications.

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