Quality evaluation of some bottled water that available in Hawler city, Iraq

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ABSTRACT

The healthy status of twelve bottles water brands that available in Hawler city was evaluated, each sample was collected on four replication during September-2014 to December-2014 from different shops of the city, physical, chemical and bacteriological variables were examined, the major goals are evaluating the suitability of bottled water states for drinking purposes through water quality index)WQI(investigation. For calculating the WQI, 12 parameters have been considered turbidity, pH, electrical conductivity, total dissolved solid, alkalinity, hardness, calcium, magnesium, sodium, potassium, Nitrate and chloride. The WQI for these samples ranges from 43.55 to 85.42. According to the WQI all the bottled samples were classified as excellent to good water they are suitable for drinking purpose. A comparison between the maximum permissible levels depended on the world health organization (WHO) guidelines was reported and discussed and water quality. They were changed in composition among the form and brands. Key Words: Bottled water, Water Quality Index, WHO.

تقييم النوعي لبعض مياه الشرب المعبأة المتوفرة في مدينة هولير، العراق

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الخلاصة

فقد فحصت المتغيرات الفيزيائيه والكيميائيه والبكتيريولوجيه لأثنا عشر نوعا منمياه القنائى من السوق المحليه و لأربعه مكررات و لفترةمن سبتمبر – ديسمبر ٢٠١٤ وكانت معايير الدراسة التعكر,قيمه الأس الهيدروجينى , التوصيل الكهربائى, مجموع الماد الصلبه المذابه و القلويه, الكالسيوم, العسرة, المغنسيوم,الصوديوم ,البوتاسيوم, النترات, الكلوريد, وكانت قيمه WQI لتقييم مياه قنائى الشرب المتوفره فى مدينه هولير من خلال مؤشر للعينات ٥٥,٤٣ – ٤٢,٨٥ وأظهرت النتائج أن جميع العينات ممتازة وصالحة للشرب أعتمادا على WQI فى تقيم نوعية المياه .كذلك لم يطرأ أى تغير فىالتركيب بين الانواع (WHO) الذى تعتمده منظمه الصحة العالميه WQI الحد المسموح من للعلامات التجارية.

Introduction

After oxygen water being essential for all life forms people can survive for days. Climate change and desertion, drinking water became a vital and crucial component to our day-to-day life. The quality of the drinking water is of greater importance to human health and depends on the quantity of harmful element present in it (Skipton et al., 2005). Drinking water must be free from pathogens. Actually that clean water is absolutely essential for a healthy living [Mandalm et al., 2009). Investigates have shown that consumers are turning to bottled water as a healthy substitute to soft drinks or because they are related about the taste or safety of their drinking water [Dorothy .and Nicholas, 2005). Sources of bottled water, like mineral water, drawn from underground and spring; they differ in their mineral content and composition (Warburton and Aziz, 2000). Causing organisms and free from mineral and organic substance may that may produce patho-physiological effect and generally the drinking water should be acceptable with regard to turbidity, color and taste (AWWA, 1990). In recent years, there has been a growing concern for chemical contamination present in drinking water that might be danger to human health and through to lead to human health problems ranging from minor effect such as fatigue to more serious effect such as cancer (Wilkes et al., 1992) according to the World Health Organization. Estimated about 80 % diseases worldwide are associated with contaminated drinking water, besides about a billion case of diarhea and 7 million death annually are caused by consumption of unsafe water and lack of sanitation, most gradual deterioration of water quality was regulated by the increase in human population and urbanization (WHO, 1992). Bottle water must be with no added agent also must be calori-free and free sugar, extract, but this addition must comprise less than 1% by weigh as the final product [Mehta et al., 1999(. Water Quality Index (WQI) is a very efficient and helpful method for evaluating the suitability of water quality; it is also a very helpful an arithmetical method used to change large quantities of water quality data into communicating the information on overall quality of water and a single cumulatively derived number, to the concerned people and policy makers. It, thus, becomes an important parameter for the evaluation and management of water quality (both ground and surface water). WQI reflects the composite impacted of different parameters of water quality and is calculated from the point of view of the suitability of (both ground and surface water) for human usage (Akoteyon et al., 2011). When the amounts of some ions exceed in water cause some health problems such as, according to, (Fatoki et al., 2001) 500 mgCaCO3/L, Alkalinity itself has little public health significance, although highly alkaline waters are unpalatable and cause gastrointestinal discomfort (Cole, 1983). Short -term revelation to nitrate drinking water over the admissible standard could conduct to health problems in child under six months causing to a disease known as blue- baby or (methemoglobinemia syndrome) (Basahi, 2000), high nitrate level in drinking water cause Congenitial malformations,also possible relationships between nitrate intake and effects on the thyroid as it is known that nitrate competitively inhibits iodine uptake. The high levels of sodium in drinking water cause hypertensions, muscular twitching and pulmonary oedema (WHO, 1996). Potassium deficiency causes irregular and rapid heartbeat, hypertension, muscle weakness, bladder weakness, kidney diseases, bladder infection, ovarian cysts, and weakened immune system (Marijic and Toro, 2000). The aim of the study is estimating the quality of some bottles water that found in Hawler city market Kurdistan of Iraq for drinking purposes by using quality index.

Material and method

Glassware:

The glass wares used for the analyses were washed with detergent, rinsed with tap water and dried in an oven at 150 0C 2h.

Reagents and chemicals

All reagents and chemicals were in high quality and grades, and the standards were prepared under the instruction of the (APHA, 1989).

Sample collection

The present study was carried out during four months period from September to December – 2014 on a total of 48 bottled water samples belong to 12 commercial brands produced in Iraq, Turkey, Iran and were collected in various shopes in Erbil city. The studied area (Hawler city)covers about 70 Km2 between longitude 43° 58¯ to 44° 03¯ E and between latitude 36° 09¯ to 36° 14¯ N, the water source and type of each one is represented in table [1].

Table [1]: The bottled water type and source of each brand

Bottled water brand	Water type	Source of water
Sky water	Natural mineral water	Erbil-Iraq
Mazi	Natural spring water	Duhok-Iraq
Rovian	Natural spring water	Duhok-Iraq
Lava	Natural spring water	Zakho-Iraq
Tiyan	Natural spring water	Zakho-Iraq
Mira	Natural mineral water	Erbil-Iraq
Kani	Natural spring water	Erbil-Iraq
Reni	Natural spring water	Erbil-Iraq
Shekhy balak	Natural spring water	Hagiomaran-Iraq
Life	Natural spring water	Zakho-Iraq
Hayat	Natural spring water	Turkey
Oxab	Natural spring water	Iran

٢،٤ The analyses:All the analyses were preceded according to the methods described by Standard method, (APHA, 1989).

١- Electrical conductivity and TDS: Was measured in the laboratory directly using a portable EC-meter with two different models (HANNA instruments, HI98303and Thermo electron corporation USA (Orion reorder 080515). The instruments were calibrated before each sampling with prepared standard solutions given by the same instrument company. The results expressed in µS.cm-1, TDS calculated mathematically by (EC * 0. 64).

٢- Turbidity: Was measured in the laboratory by Nephalometric method using HACH turbidity-meter model (2100 A, U.S.A.).The instrument calibrated before each sampling by using standard solutions of (0.61, 1, 10, 100 and 1000 N.T.U.) prepared by manufactured company. The result expressed as N.T.U. (APHA, 1989).

٣- pH: Was measured using portable pH-meter with three different models (HANNA instruments, HI98107, HANA 9025 and Thermo electron corporation USA (Orion reorder 080515). The instruments were calibrated before each sampling by standard buffer solutions of pH 4, 7 and 10.

٤- Total Alkalinity:Alkalinities of samples were determined using the (titration method) as described by APHA (1989). Samples were titrated against 0.02N H_2SO_4 till the end point then the volume of titrant was recorded.Results were represented as mg $CaCO_3.l^{-1}$ using the following formula:

Alkalinity as mg $CaCO_3.l^{-1}$ = A × B × 50٠٠٠ / ml of sample used

Where: A= ml of H_2SO_4 titrant

B= Normality of H_2SO_4

50000= 50: eq.wt of $CaCO_3$× 1000: to obtained in 1L

٥- Total hardness: The EDTA titrimetric method used for the determination of total hardness as described by (APHA, 1989).The titration was carried out against 0.01M (EDTA – 2Na salt) using Erichrome Black T as indicator and buffer solution of pH 10. Results expressed as mg $CaCO_3.l^{-1}$ using the following formula:Total Hardness (mg$CaCO_3.l^{-1}$) = A×B ×1000/ml of sample

Where: A = volume of titrated EDTA for total hardness.

B = mg $CaCO_3$ equivalent to 1.00 ml EDTA titrant.

٦- Calcium hardness: Calcium hardness was determined using EDTA- titrimetric method as described by, (APHA, 1989). using buffer solution pH 12 and Murexide as indicator. The results will be expressed in mg $CaCO_3.l^{-1}$, using the following equation:

Calcium (mg $CaCO_3.l^{-1}$) = A×B × 1000/ ml of sample

Where: A = volume of EDTA titrant.

B = mg $CaCO_3$ equivalent to 1.00 ml EDTA titrant at the calcium indicator end point.

* For Calcium ion concentrations (mg Ca l^{-1}) the following equation was used (APHA, 1989).

Mg Ca^{+2} l^{-1} =A × B×400.8/ml of sample

٧- Magnesium hardness: As described by (APHA, 1989), magnesium hardness in mg $CaCO_3.l^{-1}$ was calculated according to the following equation:

Mg^{+2} hardness (mg $CaCO_3.l^{-1}$) = {(Total hardness, which measured previously, as (mg $CaCO_3.l^{-1}$) – Calcium hardness as (mg $CaCO_3.l^{-1}$)}.

* To convert Magnesium hardness values to Magnesium ion concentrations (mg Mg. l^{-1}) the above equation multiplied by 0.243 (APHA, 1989).

٨- Sodium (Na^+): Sodium cations were determined by Flame Emission Photometric Method as described by (APHA, 1989). Standard solutions (0.5, 1, 2, 4, 6, and 20 mg.$l^{-1}$of Na^+) from sodium chloride were prepared for the calibration of the instrument, and creation of a standard curve. Results were expressed in mg.l^{-1}.

٩- Potassium (K^+): Photometric Method (Flame photometric method) was used for determination of K^+ cat ions as described in (APHA, 1989), in a precisely similar manner to that described for Na^+, except that standard potassium chloride solutions of (0.2, 0.5, 0.75, 1, and 1.5 mg.l^{-1} K^+) were used for the calibration of the instrument and for obtaining the standard curve. Results were expressed in mg.l^{-1}.

١٠- Sulfate ($SO_4^=$): Sulfate was determined in the present work using the standard turbidimetric procedure as described by (APHA, 1989).Sulfate ions were precipitated in anccb acetic acid medium, with barium chloride ($BaCl_2$) to form barium sulfate ($BaSO_4$) crystals in a constant reaction time (1min ± 2sec.). The precipitation then measured spectrophotometrically at 420nm in 1cm cuvette cell. Finally mg $SO_4^=$.l^{-1} was calculated by the following equation: mg $SO_4^=$.l^{-1} = mg $SO_4^=$ × 1000/ ml sample.

١١- Chloride (Cl^-): It was determined by argentometric method according to a procedure of (APHA, 1989).In which $K_2Cr_2O_4$ was added to water sample as indicator, and titrate against 0.0141N $AgNO_3$ to a pinkish yellow end point. Similar steps were carried out for the blank by using distilled water instead of water samples. As in the formula explained bellow:

mg $C\bar{l}$ / L =(A – B) × N ×35450 / ml of sample

Where: A=volume of titrant used for sample

B= volume of titrant used for blank

N=Normality of titrant.

١٢- Nitrate (NO_3^-): The UV sepctrophotometere method was used in present study which described by (APHA, 1989), and the absorbency of the solution was measured at 220nm(measure organic matter and

NO_3) while in 275 nm measure only (organic matter) in 1cm cuvette and then determined NO_3 at this equation NO_3= result of 220 nm - result of 275 nm The results of above equation compared with standard curve prepared for this purpose. The blank was prepared using distilled water instead of water sample, and above steep was applied as of water sample. The result then expressed as mg.l-1.

١٣-Most probable number (MPN) of total coliform bacteria:
Standard MPN technique used for quantitative enumeration of coliform group of bacteria as described in (APHA, 1989), using MacConkey broth as a cultivating medium, and incubation at 35±0.5ºC for 24±2 h. Results were expressed as MPN of total coliforms (cell / 100ml) of sample Calculation of WQI :For computing WQI there are three steps were followed. In the first step, each of the 12 parameters has been appointed a weight (wi) according to its related relevance in the overall quality of water for drinking purposes. The maximum weight of 4 and 5 has been assigned to the parameters pH and nitrates due to its major importance in water quality evaluation, while the minimum weight is 1 was given to alkalinity because it plays an insignificant role in the water quality evaluation. (Srinivasamoorthy et al., 2008).Then, the relative weight (RW) was calculated by the following equation (Horton, 1965):

$$RW = W_i / \sum^{n} W_i \text{ .... } 1$$

Where:

RW = relative weight

wi = weight of each parameter

n = number of parameters

Computed relative weight (RW) values of each parameter are also given in (Table 2).Then, a quality classification scale (qi) for all parameter other than pH was appointed by dividing its concentration in each water sample by its respective standard according to the guidelines recommended by (WHO, 2004). and the result multiplied by 100:

$$Q_i = [C_i/S_i] \times 100 \text{ ---------------- } 2$$

$$Q_i\ pH = [C_i \times V_i / S_i \times V_i] \times 100 \text{ -------- } 3$$

Where:

Qi = quality classification

Ci = concentration of each chemical parameter in each water sample in mg/L . Si = drinking water standard for each chemical parameter in mg/L according to the guidelines (WHO) standard of analogous parameter.Vi = the perfection value considered as 7.0 for pH. Equations 2 and 3 make sure that (Qi = zero) when a pollutant in the water sample is totally absent and (Qi = 100) when the value of this parameter is just equal to its acceptable value. Thus the higher value of Qi , when the water is more polluted (Mohanty, 2004). For computing the WQI, SI is first determined for each chemical parameter, and then it was used for calculation of WQI as follows

$$SI_i = RW \times Q_i \text{ ----------------- } 4$$

$$WQI = \sum SI_i \text{ --------------------- } 5$$

In the foundation of WQI, water quality can be sorted to the following orders: Excellent WQI < 50; Good 50.1-100; Poor 100.1-200; Very poor 200.1-300 and unsuitable > 300 (Ramakrishnaiah et al., 2009).Table [2]: WHO standards weight (wi) and calculated relative weight (Wi) for each parameter.

Parameters	**Unit**	**WHO**	**Weight (wi)**	**Relative Weight (RW)**
Turbidity	NTU	5	3	0.0909
pH		6.5 – 8.5	4	0.1212
EC	µs/ cm	1000	3	0.0909
TDs	mg/ L	500	3	0.0909
Alkalinity	$mgCaCO_3$/ L	200	1	0.0303
T. Hardness	$mgCaCO_3$/L	200	2	0.0606
Calcium	mg/L	100	2	0.0606
Sodium	mg/L	200	3	0.0909
Potassium	mg/L	10	3	0.0909
Nitrate	mg/L	50	5	0.1515
Chloride	mg/ L	250	2	0.0606
Magnesium	mg/L	30	2	0.0606

٣. Results and Discussion

Characterization for all water quality parameters investigated [(pH, Electrical conductivity (EC), Total dissolved solids (TDS), Turbidity, Alkalinity, Total hardness, Calcium, Magnesium, Nitrate(NO3), Sodium(Na), Potassium(K) and Chloride(Cl)] are shown in (table3).Table [3]: Show all parameter values in different bottled water during the study period.

	Type of bottled water											
Parameters	Sky water	Mazi	Rovian	Lava	Tiyan	Mira	Kani	Reni	Shekhy balak	Life	Hayat	Oxab
Turbidity(NTU)	0.52	0.36	0.66	0.93	0.54	0.59	0.53	0.33	0.34	0.37	0.34	0.57
pH	7.50	7.75	8.10	7.25	7.50	7.90	7.50	7.30	7.80	7.90	8.12	7.70
EC(µs/cm)	408.00	303.00	367.00	246.00	293.00	487.00	198.00	281.00	247.00	317.00	226.00	288.00
TDS(mg/l)	204.00	151.00	183.00	123.00	146.00	243.00	99.00	140.00	123.00	151.00	113.00	177.00
Alkalinity(mgCaCO3/l)	90.00	109.00	176.00	98.00	134.00	182.00	241.00	263.00	144.00	145.00	128.00	157.00
T. Hardness(mgCaCO3/l)	229.00	209.00	256.00	236.00	241.00	321.00	278.00	300.00	315.00	272.00	267.00	241.00
NO3 (mg/l)	17.87	3.80	8.21	4.66	3.40	27.43	25.72	2.46	2.49	2.04	2.52	3.23
Cl (mg/l)	51.70	64.62	62.60	44.80	49.00	59.60	66.62	62.20	51.75	45.80	57.75	47.60
Na (mg/l)	7.30	9.15	9.20	10.00	12.90	27.07	22.30	9.70	14.80	6.60	17.90	14.65
K (mg/l)	1.02	0.87	1.87	1.40	0.95	0.75	1.62	1.67	0.95	0.87	1.05	1.00
Ca (mg/l)	43.83	55.71	48.43	47.43	54.60	55.11	53.70	53.42	58.11	48.69	59.59	44.83
Mg (mg/l)	24.12	25.60	32.89	34.70	25.45	41.11	35.10	32.90	41.48	34.80	24.42	31.41
Total coliform bacteria (MPN) Cell/100ml	nill	nill	nill	nill	nill	nill	nill	nill	nill	nill	nill	nill

Turbidity is observed as an important parameter for drinking water. However, the concerned values were hush within the admissible level advised by the WHO for drinking water. The results of pH between 7.25 to 8.12, indicating that the bottled water samples are close to neutral to sub-alkaline in nature. pH is an important consideration that detects the opportuneness of water for different purposes [Ahipathy and Puttaiah 2006). The noticed values show corresponding agreement with pH values of drinking water which lie between 6.5 to 8.5. Electrical conductivity [EC] considered the measure of salt content in water thus has significant impact on the user acceptance of the water as potable and abundantly affects the taste. High conductivity may arise through natural weathering of certain sedimentary rocks or may have an anthropogenic source, e.g. industrial and sewage effluent (WHO, 2004). The results showed that EC values were within the permissible level recommended by the WHO for drinking water.Results show that TDS of the bottled water samples were inside the standard range of. High TDS could impact taste in drinking water while water of very low TDS may be unacceptable because of flat inspirable taste (Bruvold and Ongerth, 1969). Total alkalinity of water is known as its capacity to neutralize acid, the amount of a strong acid needed to neutralize the alkalinity called the total alkalinity [Bartram and Balance, 1996), The results of total alkalinity through the present study fluctuated from minimum of 90 mg CaCO3/L recorded in sky water and the maximum of 263 mg CaCO3/L recorded in Reni water. The results showed that alkalinity values were within the permissible level recommended by the WHO for drinking water except the value of alkalinity in Reni and Kani bottled water was 263 mg CaCO3/L and 241 mg CaCO3/L.The results of total hardness in the present study fluctuated from minimum of 209 mgCaCO3/L recorded in Mazi bottled water and the maximum of 321 mgCaCO3/L recorded in Mira bottled water, this result show the hardness in studied bottled water samples different from hard to very hard water, this may reflect to soil properties, geographical and source of the collected area, various human activities as well as climate condition have had influence on the hardness value in any water sources (Cole ,1983). The maximum agreeable level of total hardness in drinking and bottled water on the report of (WHO, 2004). guideline is 500 mg CaCO3/L, thus all studied water samples were considered harmless for drinking purpose. Water afford with hardness greater than 200 mg.l-1 are considered poor, but have been abide through consumers; those in excess of 500 mg.l-1 are unsatisfactory for most domestic aims. When the amount of hardness very high in water may cause an unfortunate health effect on humans (WHO ,1993). Studies have shown weak correlations between cardiovascular health and water hardness (Marque et al.,2003). Some data advise that extremely soft or pliable waters with a hardness of less than 75 mg.l-1 may have an unfortunate impact on mineral balance (WHO, 1996).Nitrate concentrations of all bottled water samples were recorded variable values throughout the studied brands. The values varied from the lowest concentration of 2.04 mg.l-1 recorded in Life brand to the highest concentration of 27.43 mg.l-1 recorded in Mira, the wide range of variation was recorded in nitrate results throughout this investigation in different brands and in regard to several authors may be result from the seepage of water through soil containing nitrate-bearing minerals or as the result of using certain fertilizers in the soil which runoff or leaching from agricultural land, or septic effluents, however, nitrates are one of the products of decomposition of animal and human wastes. The data exist in this study showed that all bottled water brands were within the admissible limits of 50 mg.l-1 in drinking water (WHO, 2004). Short -term revelation to nitrate drinking water over the admissible standard could conduct to health problems in child under six months causing to a disease known as blue- baby or (methemoglobinemia syndrome) (Basahi, 2000)., high nitrate level in drinking water cause Congenitial malformations,also possible relationships between nitrate intake and effects on the thyroid as it is known that nitrate competitively inhibits iodine uptake. (WHO, 1996).Chloride is widely distributed in nature, generally in the form of (NaCl), (KCl) and (CaCl2) salts. It constitutes approximately 0.05% of the lithosphere (WHO, 1996).The results showed variable range values [44.8-68.62 mg.l-1] that were not exceeded the permissible limits of 250 mg/l in drinking water (WHO, 2004).Accordingly; all bottled water brands were in the safe side for drinking purposes. Chloride toxicity observed in the special case of impaired sodium chloride metabolism, e.g.in congestive heart failure. (WHO, 1996).Sodium is the principal cation in hydrosphere. It is extracted geologically from the filtrating of underground and surface precipitates of salts [e.g. NaCl] and from the dissolution of sodium- aluminum silicates and similar minerals. The sodium ion is a major constituent of natural waters (Shelton et al., (2007). Sodium values in these analyzed brands of bottled water were low and fell below the permissible sodium limits less than 200 mg/L for drinking water were fluctuations between the studied bottled water brands. The results showed that the measured values of Na+ revealed high, they ranged from the lower value [6.6] mg.l-1 recorded in Life brand to the highest value [27.07] mg.l-1 recorded for Mira brand. Potassium ranks 7th among the elements in order of abundance on the earth crust. Potassium values in this analyzed brand of bottled water were also low. Results in the present study regarding the bottled water brands showed concentration of potassium ranged from [0.75 to 1.87 mg.l-1]. The results showed that Potassium values were within the permissible level recommended by the WHO for drinking water. In fresh water, the principle hardness–causing ions are Ca+2 and Mg+2, originated from the deposited rocks, the most usual being chalk and limestone (WHO, 2004).Moreover, the calcium ion level dominates on magnesium ion level in Iraqi Kurdistan region (Nabi, 2005). Calcium and Magnesium concentration in studied bottled water changed from 43.83-59.59 mg.l-1 in Sky water and Hayat and 24.12 - 41.48 mg.l-1 in Sky water and Shekhy balak respectively, generally calcium ion level passes the level of magnesium ions in this investigations, this condition associated to the chemical properties of the geological and soil basis of water source (Hassan,1998). The concentration of Magnesium and Calcium ions in all studied bottled water situated within the agreeable level of WHO and considered safe for drinking purposes. Bacteria in the water are, in general, not present individually, but as clumps or in association with particulate matter. The presence of the indicator bacteria in water is an evidence of fecal contamination, and therefore of a risk that pathogens are present (Nabi, 2005). Coliform bacteria are a commonly used bacterial indicator of sanitary quality of foods and water.(Shekha, 2006). As is shown in the present study in table 3 and 4), total coliform bacteria in all studied sample was undetectable, WHO guidelines for drinking-water quality recommend that indicators of faecal contamination (coliform bacteria) should not be detectable in any 100-ml sample of any water intended for drinking (Mader,2001).The physic-chemical and bacteriological parameters analyzed were all located within the WHO standards (WHO, 2004).for bottled samples. The smaller values of WQI denote that the water is very clear free of any uncleanness. WQI values individual bottled water samples represented in table (4) varies from 43.55 to 85.42. On the bases of the WQI classifications, all bottled water samples under study were classified within excellent and good categories hence they are acceptable for human consumption .Table 4: Computed water quality index in bottled water samples during the studied period

Bottled water	Water Quality Index	Water Quality status
Sky water	85.42	Good water
Mazi	43.55	Excellent water
Rovian	49.198	Excellent water
Lava	65.96	Good water
Tiyan	44.216	Excellent water
Mira	61.66	Good water
Kani	52.36	Good water
Reni	82.12	Good water
Shekhy balak	56.23	Good water
Life	59.78	Good water
Hayat	43.75	Excellent water
Oxab	51.35	Good water

٤. Conclusion:

The WQI for the studied bottled water samples that found in Hawler city ranges from 43.55 to 85.42, the bottled water samples were classified as either excellent or good. Mazi brand were better than other bottled water brands because the value of WQI was less than other bottled water brands, therefore, the bottled water quality needs further investigations such as the chemical compounds that leaching from the bottle to water and continuous monitoring.

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