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Physicochemical Quality and Label Accuracy of Locally Bottled Water in Al-Samawah City, Iraq

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Abstract The growing consumption of bottled drinking water in Iraq has increased the need to evaluate the quality of products available in local markets. This study assessed physicochemical characteristics of ten locally marketed bottled-water brands purchased in Al-Samawah in April 2026 and compared laboratory findings with the limits reproduced from Iraqi and international sources and with values declared on product labels. The measured indicators included pH, total dissolved solids (TDS), turbidity, total hardness, calcium, magnesium, sodium, potassium, nitrate, sulfate, and chloride. According to the principal analytical table, pH ranged from 6.3 to 7.5, TDS from 22 to 269 mg/L, turbidity from 0 to 1.55 NTU, and total hardness from 64 to 240 mg/L as calcium carbonate. Calcium concentrations ranged from 9 to 51 mg/L, magnesium from 9.8 to 35 mg/L, sodium from 2 to 50 mg/L, and potassium from 0 to 1 mg/L. The reported nitrate, sulfate, and chloride ranges were 0–0.9, 8–30, and 8.9–76 mg/L, respectively. Sample W2 had a pH of 6.3, below the study's stated Iraqi comparison range of 6.5–8.5, while sample W1 had the highest recorded turbidity, 1.55 NTU. Product-label comparisons indicated substantial discrepancies in several declared mineral concentrations. However, some analytical values differ between the two original data tables and require verification against laboratory records before definitive brand-level conclusions are drawn. Because microbiological contaminants and toxic trace substances were not assessed, the results characterize selected physicochemical indicators and cannot establish comprehensive drinking-water safety. The study highlights the need for standardized quality assurance, accurate labeling, replicated sampling, and complementary microbiological surveillance.

Index Terms bottled drinking water; Al-Samawah; physicochemical quality; total dissolved solids; mineral composition; drinking-water standards; label accuracy

I. Introduction

Bottled drinking water is water intended for human consumption and distributed in sealed containers under applicable requirements for identity, quality, processing, and labeling. International product definitions distinguish packaged drinking water from other beverages and regulate the addition of minerals and certain treatments rather than assuming that all bottled products have identical composition [1], [2]. Reliable access to safe drinking water is a fundamental public-health requirement, and the increasing sale of packaged products in Iraqi markets makes independent evaluation important. Prior Iraqi investigations documented differences in mineral characteristics between commercial brands and demonstrated that conformity with selected physicochemical criteria does not necessarily establish freedom from microbial contamination [3]–[5]. Similar work examining locally manufactured and imported bottled waters illustrates the value of evaluating pH, salts, ions, and microorganisms separately rather than assuming uniform quality on the basis of product identity alone [6]. Consumers may also encounter differences between laboratory determinations and concentrations printed on product labels; an Iraqi assessment in Baghdad has previously reported such discrepancies [7]. The present investigation focuses on the physicochemical characteristics of ten bottled-water products sold in Al-Samawah and compares those measurements with the numerical comparator values reproduced in the source manuscript and with product-label statements. The main questions are whether the measured indicators lie within the selected comparison ranges and whether the declared mineral composition accurately reflects the tested samples. Importantly, this is a market-based, single-period assessment, not a comprehensive certification of potability. Assessment of microbial pathogens, potentially toxic contaminants, production controls, and variability across batches would be necessary before stronger conclusions about product safety could be justified [8], [9].

II. Materials and Methods

Sampling took place during April 2026. Ten commercially available bottled-water products were purchased from local markets in Al-Samawah. Selection was limited to commonly sold brands with comparatively recent production dates and intact, securely closed packaging. The bottles were transported for laboratory analysis within 24 hours of collection

to reduce the possibility of post-purchase deterioration. Each product was assigned a code from W1 to W10. Table 1 records the brand names, nominal package volumes, labeled treatment methods, and stated geographic origins. The labels describe ultraviolet irradiation, ozone treatment, or a combination, but those treatment claims were not independently verified at the bottling facilities. The source record reports one sampled product per brand and does not provide independent batches, analytical replicates, storage histories, or laboratory quality-control records; consequently, the measurements should be interpreted as a limited cross-sectional screening of the sampled products.

Table 1: Bottled-Water Products Included in the Study

No	Code	Company Name	Capacity	Sterilization Method	Origin
1	W1	Al-Lu'lu'a	1 L	UV & Ozone	Baghdad
2	W2	Yanabea Al-Lujain	200 ml	Ozone	Al-Muthanna
3	W3	Al-Furqan	200 ml	UV & Ozone	Babil
4	W4	Venezia	180 ml	Ozone	Baghdad
5	W5	Aquafina	750 ml	Ozone	Baghdad
6	W6	Alam	500 ml	Ozone	Basra
7	W7	Uyoun Al-Basra	500 ml	Ozone	Basra
8	W8	Durrat Al-Khaleej	500 ml	UV & Ozone	Basra
9	W9	Uyoun Baghdad	500 ml	UV & Ozone	Baghdad
10	W10	Ser Al-Hayat	500 ml	Ozone	Baghdad

Source: Prepared by the researcher based on information on the packaging.

The physicochemical assessment included pH, turbidity, electrical conductivity, TDS, total hardness, calcium, magnesium, sodium, potassium, chloride, sulfate, and nitrate. The source protocol identifies an electronic meter for pH measurement and an electrical-conductivity-based estimate for TDS; the broader analytical procedures were described in relation to established laboratory-method compilations [10], [11]. The original account does not specify instrument models, calibration standards, the conversion factor used to estimate TDS from conductivity, detection limits, analytical uncertainty, or replicate measurements for individual ions. These details are needed to assess analytical precision and independently reproduce the measurements. The recorded values were compared with the Iraqi and international numerical limits reproduced in the original results table and with labeled product concentrations. The term "international" in that table is retained as the original study's comparison category; the values should not automatically be treated as legally binding or health-based WHO limits. WHO guidance distinguishes health-based chemical guideline values from recommendations concerning taste, appearance, and the operational effectiveness of treatment [8].

III. Results and Discussion

Physicochemical indicators provide essential, but partial, information about drinking-water quality. pH influences chemical equilibrium and treatment conditions; dissolved solids reflect the aggregate ionic composition; turbidity indicates the presence of suspended particles; and specific ions inform interpretation of mineral content and possible source-water influences. Their significance depends on the parameter, the intended use of the water, and whether a health-based guideline, an aesthetic benchmark, or a product standard is involved [3], [8]. Table 2 reproduces the study's primary laboratory measurements and the two sets of comparison values. Because the referenced Iraqi and industry documents are not supplied as original standards, the comparator rows are reported as source-stated thresholds pending direct confirmation. The parameters are examined below, followed by a separate discussion of the product-label data and inconsistencies across the source tables.

The source manuscript identifies Iraqi Standard No. 1937/1995 for bottled drinking water and Iraqi Standard No. 417/2009 for drinking water as relevant national frameworks [12]. These are distinct references and should not be conflated without inspecting the complete official texts. Published Iraqi surveillance research also refers to the packaged-water specification No. 1937/1995 [5]. The numeric Iraqi comparison row in Table 2 has been preserved as reported; its current validity and applicability to each parameter require confirmation from the regulatory authority.

The International Bottled Water Association's 2025 Code of Practice addresses product quality, operational requirements, monitoring, and labeling [9]. For international context, Codex Alimentarius also provides a general standard for packaged drinking water other than natural mineral waters [2]. These frameworks should not be interpreted as making every numeric value in the source's "international specifications" row a universal legal or WHO health-based limit.

The following comparisons use the recorded values in Table 2 and the study's stated comparator rows. Where a result falls below a listed numerical ceiling, this is described as conformity with that particular reported criterion, not proof of overall product safety. Interpretations are restricted to the collected samples and are subject to the laboratory-data discrepancies documented in the product-label table.

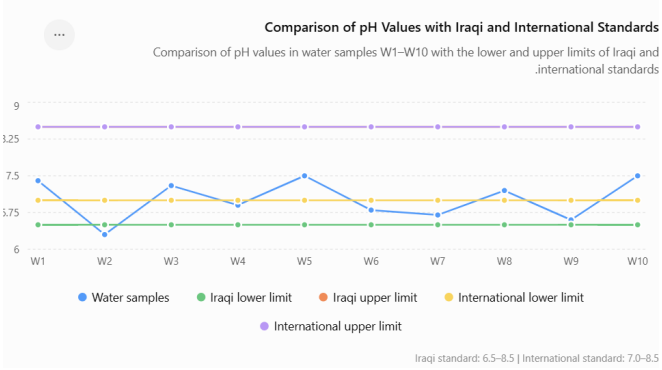


Figure 1: Measured pH in the ten bottled-water samples and source-stated comparator intervals

A. pH Level

Table 2 and Figure 1 show that measured pH values ranged from 6.3 to 7.5. Sample W2 had the lowest pH (6.3), while W5 and W10 both reached 7.5. On the basis of the study's stated Iraqi comparison interval of 6.5–8.5, W2 falls below the lower bound and the remaining nine products fall within that

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Table 2: Reported Laboratory Results and Source-Stated Drinking-Water Comparison Values

Chloride	Sulfate	Nitrate	Potassium	Sodium	Magnesium	Ca	Hardness	Turbidity	Dissolved Salts	pH	Symbol	No
8.9	12	0.9	0.5	2	31	30	201	1.55	167	7.4	W1	1
47	8	0	0.3	21	22	9	121	0	82	6.3	W2	2
63	12	0.1	0.7	30	33	19	198	0.1	177	7.3	W3	3
8.9	25	0	0.4	3	26	25	169	0.2	189	6.9	W4	4
25	9	0	0	3.9	21.9	29	163	0.1	213	7.5	W5	5
17	8.9	0	0	9	9.8	10	64	0	22	6.8	W6	6
31	30	0	0.4	29	35	15	191	0.1	200	6.7	W7	7
71	27	0	0.5	20	29	51	240	0	269	7.2	W8	8
76	28	0	0	20	26	27	172	0	199	6.6	W9	9
66	8	0	1	50	20	13	132	0.2	101	7.5	W10	10
250	500	45	-	-	50	75	300	5	300	6.5–8.5	Iraqi Specifications	Iraqi Specifications
250	250	50	10	200	30	100	500	0.5	500	7.0–8.5	International Specifications	International Specifications

interval. A value of 6.3 indicates slightly acidic water; it does not, by itself, establish a health hazard. The difference may relate to the source water, dissolved carbon dioxide, mineral composition, or treatment conditions. Filtration and reverse-osmosis processes can alter acidity and ionic content, but no direct evidence identifies the treatment responsible for W2's value [13]. The source's separate international pH interval of 7.0–8.5 is not equivalent to WHO's universal health-based limit, and treating it as such would overstate the evidence [8]. Repeat sampling and pH measurement with documented calibration would clarify whether the result represents a stable brand characteristic or a single-batch observation.

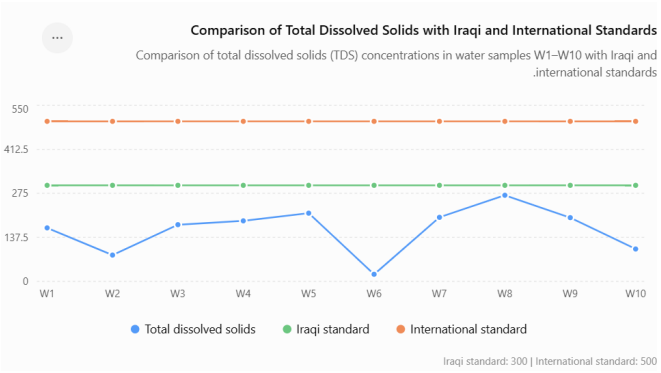


Figure 2: Measured total dissolved solids in bottled-water samples and source-stated comparator values

B. Total Dissolved Solids (TDS)

Table 2 and Figure 2 present TDS concentrations of 22–269 mg/L in the primary analytical table. The minimum was reported for W6 (22 mg/L), and the maximum for W8 (269 mg/L). All ten reported values lie below the source's Iraqi ceiling of 300 mg/L and its international comparator of 500 mg/L. These comparisons are useful for describing the mineral content and acceptability of the sampled products, but TDS is not a stand-alone measure of toxicological safety. WHO characterizes relatively low TDS principally in terms of palatability and does not establish a general health-based guideline value for TDS [8]. Likewise, an extremely low TDS concentration does not demonstrate that drinking the water causes kidney disease, and claims of a universal "ideal" drinking-water range of 500–1500 mg/L are not supported by the cited international guidance. Water can contribute to dietary mineral intake, but nutritional sufficiency depends on diet and wider physiological factors [14]. The 22 mg/L value for W6 also conflicts with the 119 mg/L laboratory result assigned to W6 in Table 3. This contradiction must be resolved through the original measurement sheet before interpreting the magnitude of that brand's TDS discrepancy.

C. Turbidity (NTU)

As shown in Table 2 and Figure 3, turbidity was reported as 0–1.55 NTU. W1 had the largest value (1.55 NTU), whereas the other samples ranged from 0 to 0.2 NTU. All measurements are below the study's stated Iraqi comparison level of 5 NTU. However, W1 exceeds the 0.5-NTU operational benchmark included in the source's international row. This is an operational and acceptability comparison, not proof that W1 is microbiologically contaminated. WHO identifies turbidity as a useful indicator of treatment performance because suspended particles can interfere with disinfection; the interpretation depends on the stage of treatment and water-supply system [8]. Since the bottles were not tested for microbial indicators, the possible connection between turbidity and microbial safety remains unmeasured in this investigation. W1 should be prioritized for repeat measurements, inspection of handling conditions, and targeted microbiological testing rather than classified as unsafe on turbidity data alone.

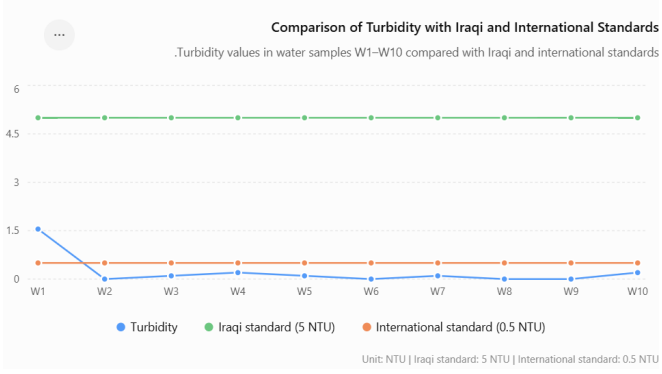


Figure 3: Measured turbidity of bottled-water samples and source-stated comparison levels

D. Total Hardness

Table 2 and Figure 4 indicate total hardness values of 64–240 mg/L as $CaCO_3$. W6 showed the lowest hardness, and W8 the

highest. The other recorded values fell between 121 and 201 mg/L. Hardness is associated mainly with dissolved calcium and magnesium salts, although the relationship between ion concentrations, reported hardness, and other dissolved species needs to be considered using consistent units. All ten samples fall below the study's stated numerical hardness comparisons. Nevertheless, the World Health Organization does not regard hardness alone as a sufficiently established basis for declaring water safe or unsafe or for requiring a universal health-based maximum [8]. The presence of harder water must not be interpreted as direct evidence of kidney-stone causation, and observational reports on cardiovascular outcomes do not establish causality. These values instead characterize differences in mineral composition, possible scaling, and taste-related properties that can influence consumer preference. Replicate testing would be particularly valuable for W8 because the product-label comparison reports a very different declared hardness value.

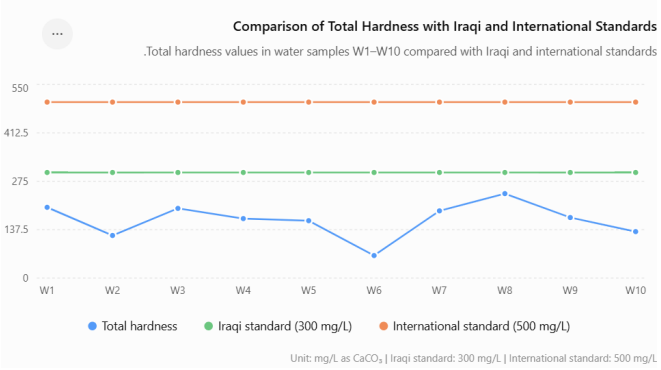


Figure 4: Total hardness of sampled bottled waters and source-stated comparison levels

E. Calcium

Calcium is an essential nutrient involved in bone and tooth mineralization, neuromuscular function, intracellular signaling, and blood coagulation. Drinking water may contribute to dietary calcium intake, depending on its concentration and the volume consumed; calcium-rich mineral waters have been reviewed as potentially useful dietary sources [14]. Table 2 and Figure 5 show calcium concentrations of 9–51 mg/L, with W2 providing the lowest reported concentration and W8 the highest. Other values fall within this range and demonstrate material differences across brands. None exceeds the two calcium comparator values reproduced in the main table (75 and 100 mg/L). However, meeting those selected comparators does not establish comprehensive safety or nutritional adequacy. Importantly, W1 is assigned 30 mg/L in Table 2 but 16 mg/L in the laboratory-results row of Table 3. This discrepancy affects the calculated label deviation and cannot be resolved editorially without confirming the laboratory record. The association between the larger calcium concentration of W8 and its relatively high hardness is compatible with the role of calcium in water hardness, but it does not isolate the contributions of magnesium and other constituents. A water-specific mineral analysis could be interpreted more fully if the measurement procedure, uncertainty, and replication were reported.

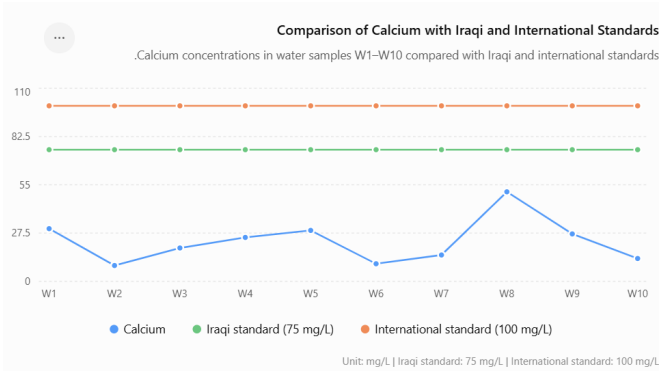


Figure 5: Calcium concentrations measured in the ten bottled-water samples

F. Magnesium

Magnesium (Mg) is an essential element and is one of the divalent cations contributing to total water hardness. Figure 6 and Table 2 show a concentration range of 9.8–35 mg/L across the analyzed products. W6 had the lowest concentration (9.8 mg/L), and W7 had the highest (35 mg/L); most remaining samples were reported between 20 and 33 mg/L. These concentrations may reflect water-source geology and treatment differences, although the specific processes employed by the manufacturers were not independently evaluated.

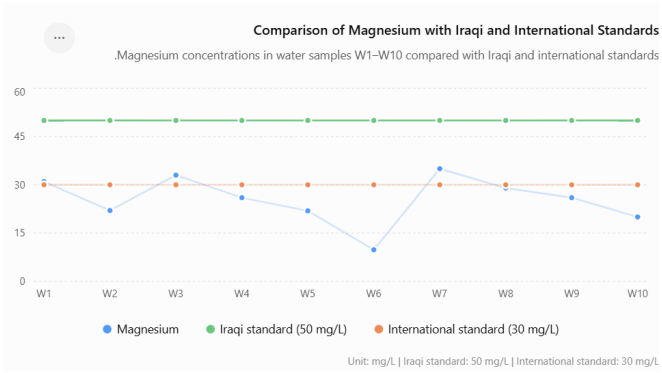


Figure 6: Magnesium concentrations measured in the ten bottled-water samples

The study's Iraqi comparator row lists 50 mg/L, below which all samples fall. Its international comparator row lists 30 mg/L, which W1 (31 mg/L), W3 (33 mg/L), and W7 (35 mg/L) exceed. This comparison should be reported accurately without equating the 30 mg/L figure to a universal WHO health-based guideline. Recent WHO guidance does not set a general health-based concentration limit for magnesium in drinking water, and mineral-related health effects depend on

broader conditions [8]. Further work should distinguish regulatory product requirements from dietary considerations and the effects of unusually mineralized drinking-water sources.

G. Sodium

Sodium occurs naturally in drinking water as a dissolved ion and may also be influenced by treatment procedures. Table 2 and Figure 7 show sodium concentrations of 2–50 mg/L, with the minimum in W1 and the maximum in W10. The remaining samples were reported between 3 and 30 mg/L, except for intermediate values of 3.9 and 9 mg/L also documented in the table. All values are below the source's 200 mg/L international comparison concentration. Sodium is relevant to taste and to total dietary intake, particularly for consumers following medically prescribed sodium restrictions. However, the observed concentrations alone are insufficient to determine an individual's intake or overall health status. Claims that water within this range directly causes vomiting, dehydration, or other acute effects are unsupported. A more careful assessment would use the bottled-water measurements alongside drinking-water consumption, dietary intake, and any applicable product labeling requirements [8].

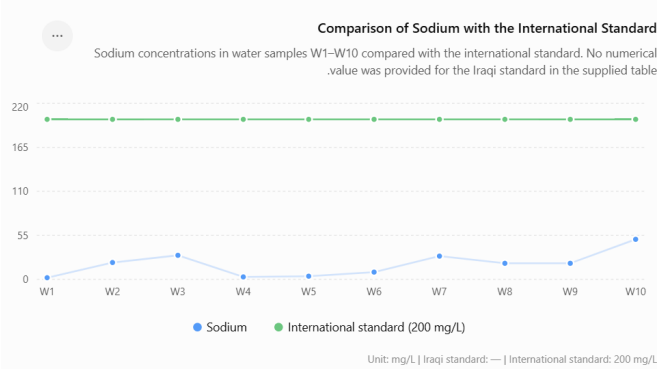


Figure 7: Sodium concentrations measured in the ten bottled-water samples

In comparing these findings with the findings as stated in the standards utilized in this study, the sodium concentrations in all samples analyzed were far below the level specified by that standard. Not only did the standards show that sodium levels in water samples are small, but they also revealed that the level of sodium is far lower than the threshold regarded internationally (200 mg/L). Even for W10 which, demonstrated the highest concentration of sodium (50 mg/L), the level is still considered to be low. In conclusion, although sodium levels in the bottled water samples varied from each other with some of them determined, this does not present a health hazard and does not indicate that sodium contribution varies significantly from one sample to the other.

H. Potassium

Potassium is present at relatively low concentrations in the analyzed products. Table 2 and Figure 8 report values from 0 to 1 mg/L; W5, W6, and W9 were recorded as zero, while W10 had the maximum of 1 mg/L. The other brands contained between 0.3 and 0.7 mg/L. All results fall below the study's international comparison concentration of 10 mg/L, while the Iraqi comparator row does not provide a potassium value. It would therefore be incorrect to attribute the 10 mg/L figure to both national and international standards without supporting documentation. These small values make bottled water a limited source of potassium in relation to typical dietary requirements, but the analysis does not establish the nutritional status of consumers. Label comparisons also indicate large proportional differences where the declared concentration was much higher than the measured value; interpretation depends on instrument detection limits and how zero measurements were handled.

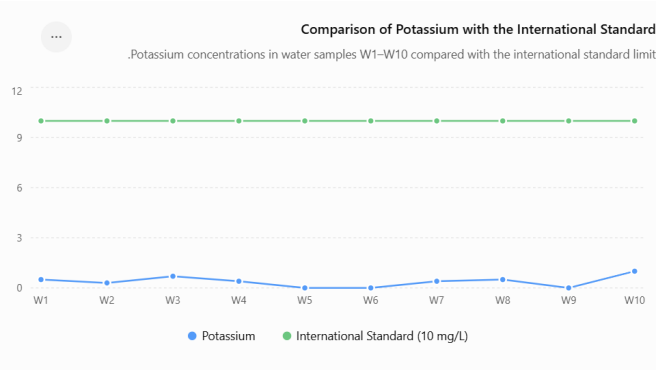


Figure 8: Potassium concentrations measured in the ten bottled-water samples

I. Nitrate (NO_3)

Table 2 and Figure 9 show that nitrate (NO_3^-) ranged from 0 to 0.9 mg/L in the primary analytical table. The largest value was observed in W1, and most other samples were reported as zero or 0.1 mg/L. The concentrations fall below the source's Iraqi comparison value of 45 mg/L and the WHO health-based guideline of 50 mg/L expressed as nitrate ion [8].

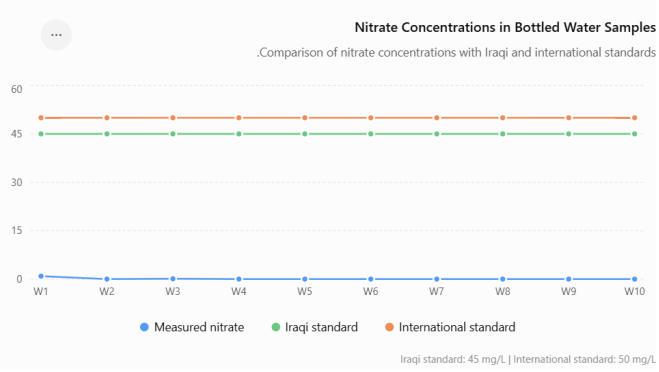


Figure 9: Nitrate concentrations measured in the ten bottled-water samples

Nitrate is important in drinking-water surveillance because its reduction to nitrite can contribute to methemoglobinemia

in susceptible infants. Nevertheless, low nitrate values do not rule out other forms of chemical or microbial contamination, nor do they identify the sources of nitrogen in the tested waters. The nitrate entries in Table 3 differ from the primary analytical table for several brands, including nonzero values where the primary table lists zero. The original laboratory sheets and reporting or detection limits are needed to distinguish a transcription error from separate measurements. In the absence of those records, the study supports only a limited finding of low nitrate concentration in the primary results table.

J. Sulfate

The sulfate concentration in the primary analytical results ranged from 8 to 30 mg/L, as presented in Table 2 and Figure 10. W7 had the highest reported value (30 mg/L), while W2 and W10 each recorded 8 mg/L and W6 recorded 8.9 mg/L. Sulfate concentrations in the remaining bottles varied between the reported extremes. All measurements are below the study's listed comparison values of 500 mg/L for the Iraqi row and 250 mg/L for the international row. Sulfate may influence taste or cause gastrointestinal effects at substantially higher concentrations, but no such effects were measured here and the results do not establish clinical outcomes. Variation may be associated with minerals present in the source water or with production and treatment processes; the current research did not identify a specific mechanism. Interpretation should therefore remain descriptive and linked to the reported laboratory values [8].

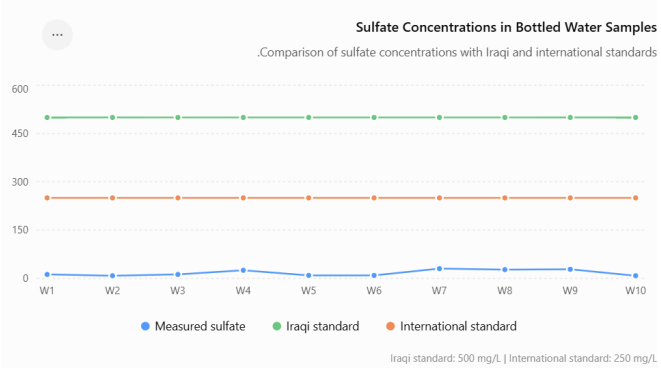


Figure 10: Sulfate concentrations measured in the ten bottled-water samples

Analyzing the results in comparison with the standards used during the research reveals that all sulfate concentrations were at very low levels taking into account the Iraqi standard level of 500 mg/L and internationally accepted level of 250 mg/L. Although sample W7 showed the highest sulfate concentration of 30 mg/L, it is only around 6% of the Iraqi standard level that indicates that sulfate concentration is well within the limits. The highest sulfate concentration (30 mg/L in sample W7) cannot be related to the problems with digestion and taste. That is why the values of sulfate do not represent risks to health.

K. Chloride

Chloride (Cl^-) contributes to the ionic composition and sensory characteristics of water, particularly at elevated concentrations. Table 2 and Figure 11 report chloride values ranging from 8.9 to 76 mg/L. W1 and W4 had the lowest values (8.9 mg/L), whereas W9 had the highest (76 mg/L); the other results ranged from 17 to 71 mg/L, except for W10 at 66 mg/L. Every sample is below the 250 mg/L comparison concentration reproduced in both rows of the source table. This finding does not, however, demonstrate the absence of other hazards or support claims of a direct causal effect on blood pressure. Chloride is one of several ions contributing to dissolved solids, and its concentration depends on both source-water chemistry and processing. A comparison of W9's measured chloride (76 mg/L) with its reported TDS (199 mg/L) illustrates the presence of mineral ions but should not be taken as a complete ionic mass balance. The label table refers to this indicator as "chlorine"; because its values correspond to the chloride analysis, the descriptive label has been standardized to chloride without altering the measurements.

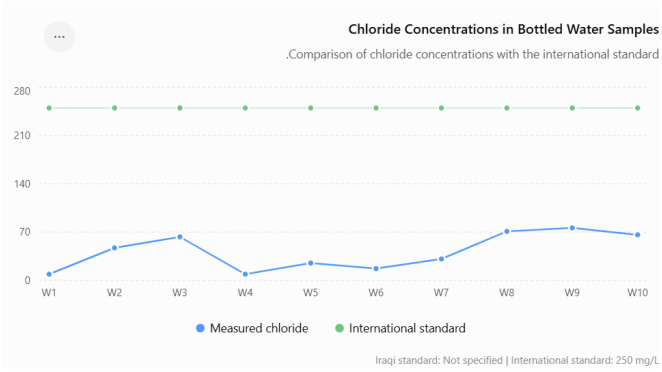


Figure 11: Chloride concentrations measured in the ten bottled-water samples

L. Comparison of Analysis Results for Local Bottled Water With the Concentrations Stated on the Bottles

Table 3 compares the values reported as laboratory measurements with the mineral information declared on the packaging of the ten products. The objective of the comparison is to assess the consistency of labeling for pH, TDS, turbidity, hardness, calcium, magnesium, sodium, potassium, nitrate, sulfate, and chloride. Some parameters are absent from many product labels, and a missing entry does not necessarily constitute regulatory noncompliance unless the applicable labeling rule requires it. The table reports missing hardness information for W1, W2, W5, W6, W7, W9, and W10, and nitrate information for only a small subset of products. Several mineral measurements also differ substantially from the available declarations. These findings support a recommendation for more complete and accurate product information, although a definitive label-accuracy analysis requires reconciliation of the laboratory values in Tables 2 and 3.

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Table 3: Laboratory Results and Concentrations Declared on Product Labels

Test	Comparison of results	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Average
pH	Analysis result	7.4	6.3	7.3	6.9	7.5	6.8	6.7	7.2	6.6	7.5	7.0
pH	Analysis result on the package	6.8-7.5	7.1	7.2	7.3	-	7	7.8	7.5	8.5-6.5	7	7.2
	Percentage difference (%)	0%	11%	1%	5%	-	2%	14%	4%	0%	7%	5%
Salts	Analysis result	167	82	177	189	213	119	200	269	199	101	171
Salts	Analysis result on the package	30	-	120	80	-	110	110	50	30	35	71
Salts	Percentage difference (%)	82%	-	32%	57%	-	7%	45%	81%	84%	65%	57%
Turbidity	Analysis result	1.55	0	0.1	0.2	0.1	0	0.1	0	0	0.2	0.2
Turbidity	Analysis result on the package	0.1	-	-	-	-	-	-	-	0	-	0.0
Turbidity	Percentage difference (%)	93%	-	-	-	-	-	-	-	0%	-	46%
Hardness	Analysis result	201	121	198	169	163	64	191	240	172	132	165
Hardness	Analysis result on the package	-	-	40	43	-	-	-	6.8	-	-	29
Hardness	Percentage difference (%)	-	-	79%	74%	-	-	-	97%	-	-	83%
Ca	Analysis result	16	9	19	25	29	10	15	51	27	13	21
Ca	Analysis result on the package	15	22	14.4	12	10	5	26	5.8	-	1	12
Ca	Percentage difference (%)	6%	59%	24%	52%	65%	50%	42%	88%	-	92%	53%
Magnesium	Analysis result	31	22	33	26	21.9	9.8	35	29	26	20	25
Magnesium	Analysis result on the package	-	16	3	-	20	13	1.9	2.6	-	20.7	11
Magnesium	Percentage difference (%)	-	27%	90%	-	8%	24%	94%	91%	-	3%	49%
Sodium	Analysis result	2	21	30	3	3.9	9	29	20	20	50	19
Sodium	Analysis result on the package	10	-	12.3	11	3	14	1	3.7	10	1.4	7
Sodium	Percentage difference (%)	80%	-	59%	72%	23%	35%	96%	81%	50%	97%	66%
Potassium	Analysis result	0.5	0.3	0.7	0.4	0	0	0.4	0.5	0	1	0.3
Potassium	Analysis result on the package	5	-	1.5	0.6	10	1	0.2	0.5	5	9	4
Potassium	Percentage difference (%)	90%	-	53%	33%	100%	100%	50%	0%	100%	88%	68%
Nitrates	Analysis result	0.9	0.01	0.1	0.1	0.9	0.1	0.03	0.25	0.1	0.1	0.2
Nitrates	Analysis result on the package	-	-	2.5	-	-	-	-	-	-	-	2.5
Nitrates	Percentage difference (%)	-	-	96%	-	-	-	-	-	-	-	96%
Sulfates	Analysis result	12	8	12	25	9	8.9	30	27	28	8	16
Sulfates	Analysis result on the package	-	-	28	18.2	-	-	-	-	-	-	23
Sulfates	Percentage difference (%)	-	-	57%	27%	-	-	-	-	-	-	42%
Chloride	Analysis result	10	47	63	8.9	25	17	31	71	76	66	41
Chloride	Analysis result on the package	10	-	17.5	-	13	-	-	28	10	1	13
Chloride	Percentage difference (%)	0%	-	72%	-	48%	-	-	60%	86%	98%	61%

The label comparisons in Table 3 show that the recorded pH percentage differences ranged from 0% to 14%, with a source-reported average of 5% among entries with labeled values. This relative agreement contrasts with larger source-reported differences for several mineral indicators. Nevertheless, the percentages must be interpreted cautiously because the table mixes exact numbers, ranges, blank declarations, and values recorded as zero. A percentage difference is meaningful only when the chosen denominator, measurement precision, and handling of missing values are stated explicitly. For pH, a ratio-based percentage also has limited scientific meaning because pH is logarithmic rather than a linear concentration scale. The data therefore demonstrate the importance of clear reporting conventions and laboratory confirmation more directly than they demonstrate a particular manufacturing process as the cause of the differences.

For TDS, Table 3 presents percentage differences from 7% to 84%, with a reported average of 57%. The largest deviations were assigned to W9 (84%), W1 (82%), and W8 (81%), whereas W6 was assigned 7%. These values are reproduced from the original source table and have not been recalculated because that table assigns W6 a laboratory result of 119 mg/L, in contrast to 22 mg/L in Table 2. The contradiction affects the estimated difference for W6 and potentially summary measures. Similar discrepancies in other analytes make it inappropriate to present the source's averages as independently verified. The general pattern nevertheless calls for repeat measurement and comparison of the results against the actual dated labels for each product.

For turbidity, sample W1 was reported at 1.55 NTU in laboratory testing, compared with 0.1 NTU on its label, corresponding to a tabulated difference of 93%. The second available turbidity declaration concerned W9, for which both laboratory and label values were zero. Other products lacked declared turbidity values, preventing comparable percentage calculations. In the original table, the mean of the available percentages was reported as 46%, but this summary is strongly influenced by a very small number of labeled observations. For total hardness, the source reports deviations of 74–97% among the products with labeled values: W3, W4, and W8. The respective laboratory and label pairs are 198 versus 40 mg/L, 169 versus 43 mg/L, and 240 versus 6.8 mg/L. The reported average deviation is 83%. These substantial differences may reflect labels, analytical procedures, source-water variation, or transcription problems. Without repeat samples and verified measurement units, no particular cause can be established. A quality-control audit should examine raw reports, package photographs, and the methods used for both the declared and measured values.

For calcium, the source reports percentage differences from

6% to 92%, averaging approximately 53% among products with a declared value. The highest percentage difference was assigned to W10 (92%), followed by W8 (88%); W1 showed the lowest (6%) within the label-comparison table. However, the recorded laboratory calcium concentration for W1 is 16 mg/L in that table, compared with 30 mg/L in the primary analytical table. Accordingly, the source-reported percentages should not be presented as an independently validated statistical summary. Magnesium shows another wide range of tabulated differences, 3–94%, with a reported mean of 49%. W7 was assigned the greatest deviation (94%), followed by W8 (91%) and W3 (90%), while W10 showed the smallest (3%). Such discrepancies indicate that further analytical and documentation checks are needed. The importance of these indicators lies in both label accuracy and their contribution to the nutritional and physicochemical characterization of drinking water. The study does not measure adverse effects arising from these differences.

For sodium, percentage differences between laboratory measurements and declared values were reported as 23–97%, with a source-reported mean of 66%. W10 had the largest difference (97%), followed by W7 (96%), whereas W5 had the smallest among products with declared sodium content (23%). Since some of the labels state very low concentrations, substantial relative discrepancies can arise even from relatively modest absolute changes. Sodium labeling may matter for consumers monitoring sodium intake, but the measured concentrations should be assessed alongside actual consumption and overall diet. The analysis supports more rigorous control of label accuracy and consistency, not an inference that the recorded concentrations were clinically harmful.

Potassium exhibited source-reported label deviations of 0–100%, with a stated mean of 68%. W5, W6, and W9 were recorded as having zero measurable potassium while their packaging declared nonzero concentrations. W8 showed the same laboratory and declared value (0.5 mg/L) and therefore no tabulated difference. Other comparisons ranged from moderate to high relative differences. Since some measured concentrations are zero or very small, uncertainty and limits of quantification become particularly important in interpreting percentage changes. For nitrate, the label-comparison table reports a 96% deviation for W3, for which the laboratory value is 0.1 mg/L and the declared value is 2.5 mg/L. The same row includes measured nonzero nitrate values for products recorded as zero in the primary table. Thus, a reliable calculation of average nitrate mismatch cannot be obtained until the conflicting entries are reconciled.

For sulfate, Table 3 lists values for only W3 and W4, giving source-reported differences of 57% and 27% and an average of 42%. The measurements remain low compared with the comparator concentrations reproduced in the study, but the sparse label information limits generalization across all brands. A reasonable interpretation is that some labels may not adequately represent the measured composition and that complete documented values would improve consumer information. Label differences do not, by themselves, demonstrate treatment failure or a public-health hazard.

For chloride, the source table reports percentage differences from 0% to 98%, with a stated average of 61%. W10 was assigned the maximum deviation, with measured chloride of 66 mg/L against 1 mg/L declared, whereas W1 showed agreement at 10 mg/L in the label-comparison table. That measured value for W1 differs from the 8.9 mg/L recorded in the primary analytical table, offering another example of internal inconsistency. The original table also lists substantial differences for W9 and W3. Before the results can be interpreted as validated labeling errors, the laboratory records should establish which sample and analytical run generated each entry, and the bottle labels should be documented using dated photographs or equivalent source records.

Overall, Table 3 suggests greater consistency for some pH declarations than for several mineral concentrations, but it contains inconsistencies that prevent precise ranking of brands by labeling accuracy. The original percentage averages are retained as reported descriptive values, not independently reproduced estimates. Further investigations should standardize how differences are computed, distinguish absent labels from mismatched labels, report laboratory uncertainty, and repeat analyses across production lots.

M. Data Consistency, Standards, and Study Limitations

The two principal data tables should be regarded as separate source-reported records until they are reconciled. For example, W6 has TDS of 22 mg/L in Table 2 but 119 mg/L in Table 3. Likewise, W1 has calcium of 30 mg/L in the primary analytical table but 16 mg/L in the label-comparison table, and nitrate entries differ between tables. Such inconsistencies may reflect transcription mistakes, reporting of different analytical runs, or unrecorded changes in sample identity. These are possibilities rather than established explanations. The source does not provide the raw worksheets required to determine the reason for the differences. Consequently, the averages and percentage deviations reproduced from the source should not be treated as independently validated analytical outcomes. Recalculation should take place only after the original observations, measurement units, labels, and definition of percentage difference have been verified.

The comparator rows also require careful interpretation. The table identifies values as Iraqi and international specifications, but a benchmark for appearance or palatability does not necessarily represent a health-based chemical limit. WHO's 2026 drinking-water guidance emphasizes risk management and distinguishes parameters such as TDS and hardness, for which no universal health-based concentration limit is specified, from substances such as nitrate for which a health-based guideline is available [8]. The IBWA Code of Practice provides additional requirements concerning bottled-water manufacture, monitoring, and labeling [9], while Codex gives a separate internationally recognized product framework [2]. These are not interchangeable documents, and they may apply differently to a specific bottled product. Accordingly, this investigation compares samples with the values reported in its

original table but cannot certify formal regulatory compliance in the absence of direct verification of the applicable national legal instruments and laboratory methods.

The study was limited to ten products purchased during one month in a single city. Brand selection was not probabilistic, and only one reported unit per brand was assessed. The absence of repeat measurements prevents estimation of within-brand variability and confidence intervals for the chemistry results. Unrecorded batch numbers, production dates, storage temperature, instrument calibration, and measurement uncertainty constrain reproducibility. The sampling design does not support generalizing the findings to every bottle sold under the same name or to the entire local bottled-water market. Moreover, the chemical analysis did not include all potentially relevant substances, such as toxic trace elements and organic contaminants. No microbiological cultures or molecular pathogen tests were reported, so even a product meeting every physicochemical comparison value would require additional evidence before comprehensive safety could be asserted. Future research should integrate product-specific regulatory checks, detailed analytical quality control, microbiological testing, replicated sampling, and time-resolved assessment across production batches and seasons [3], [8], [15].

The investigation also illustrates why transparent reporting is essential when market-surveillance findings may affect commercial products and consumer decisions. Each bottle should be linked to a unique laboratory identifier, purchase location, collection date, manufacturing batch, and dated label record. Laboratory tables should identify whether results refer to a single determination, the mean of repeated measurements, or values imported from different testing sessions. Where the study uses an electrical conductivity conversion to report TDS, that factor should be stated and its appropriateness for the ionic composition should be assessed. Reports should include meaningful units, limits of quantification, and a description of how nondetects were encoded, since a displayed zero does not necessarily imply the complete absence of the analyte. When measurements are compared with product declarations, the analysis should distinguish absolute deviation from relative percentage differences, state the denominator used, and avoid averaging values calculated from incomparable label ranges. These measures would allow independent reviewers to distinguish genuine variation in bottled-water composition from limitations of sampling, analytical chemistry, and transcription.

Taken together, the available results are best understood as a preliminary appraisal of selected water-quality characteristics in a geographically and temporally bounded market. They provide a basis for selecting products for further testing and identifying gaps in information available to consumers. They do not determine how frequently any nonconformity occurs across manufacturing batches, nor whether an observed difference originates during production, distribution, storage, or laboratory analysis. The distinction matters because appropriate interventions depend on the source of variation: a genuine treatment problem calls for different corrective action from a transcription error or an outdated product label. A multidisciplinary follow-up involving water chemists, microbiologists, public-health specialists, and the responsible standards authority would therefore be a more robust basis for regulatory or clinical recommendations.

IV. Conclusion

The study demonstrates substantial variability in the physicochemical composition of ten bottled-water products sampled from the Al-Samawah market. Most results in the primary analytical table fall below the numerical comparator concentrations reproduced by the original authors, but the study does not establish complete product safety. A single sample per brand, absent microbiological analysis, and unverified comparator definitions limit conclusions about population exposure and regulatory compliance. The pH of W2 (6.3) falls below the study's stated Iraqi comparison interval, and W1 has the highest turbidity (1.55 NTU), exceeding the source's international operational benchmark of 0.5 NTU but remaining below the reported Iraqi comparator of 5 NTU. These findings should motivate targeted retesting and quality assurance rather than categorical declarations that the products are safe or unsafe. The concentrations of hardness, calcium, and magnesium were below the numerical Iraqi comparator values; W1, W3, and W7 exceeded the source's separate 30 mg/L magnesium comparator. Sodium, potassium, sulfate, chloride, and nitrate were comparatively low across the primary results table. However, the source's product-label comparison indicates substantial differences in some declared concentrations, as well as internal inconsistencies between the two laboratory tables. The original observations therefore support a preliminary physicochemical characterization and reveal a need for improved data integrity, transparent product labeling, and repeated independent testing.

1) Almost all the samples showed low turbidity, with the highest turbidity being registered by sample W1 (1.55 NTU), which is higher than what is stipulated in the Iraqi regulations so its filtration system, bottling, and storage need to be improved.
2) The results on total hardness, calcium, and magnesium were within Iraqi regulations, but some samples demonstrated a little excess in magnesium according to international standards adopted in this paper.
3) The concentrations of sodium, potassium, sulfate, chloride, and nitrate were low and within acceptable limits as there were no concentrations providing the health risk from the presence of these materials in the water.
4) laboratoratory results were compared with the data provided in packaging with the majority of parameters confirming their results, with pH showing the lowest discrepancy.6. The average discrepancies recorded in laboratory results are quite astounding for the total hardness, nitrates, potassium, and sodium content with values of 83%, 96%, 68%, and 66%, respectively. This indicates that there are contradictions between the stated water contents and actual water compositions. 7. There

is a significant lack of information and consistency in terms of information on the water labels and the most significant characteristics, such as turbidity, hardness, nitrates, and sulfates among a huge number of brands.

V. Recommendations

Bottled-water producers and relevant authorities should establish scheduled quality monitoring that covers physicochemical, microbiological, and relevant contaminant indicators. Monitoring should be based on standards demonstrably applicable to the product category, with calibration, sampling procedures, batch identifiers, and analytical uncertainty documented. Follow-up testing is especially important for the unusual pH and turbidity results reported here. Product labels should be checked against current laboratory measurements and revised whenever the declared composition no longer reflects the product. Information on pH, dissolved solids, hardness, major mineral ions, chloride, sulfate, and nitrate should be presented consistently where required by applicable labeling rules. Routine examination of source water, treatment efficiency, packaging, storage, and transport should also be incorporated into quality-assurance programs. Future studies should include multiple units and production lots of each brand, sampling across seasons, photographic documentation of labels, validated laboratory protocols, and statistical treatment of repeated observations. Replicated microbiological testing would be particularly important before making a comprehensive public-health safety claim. A final audit should reconcile differences between the two original analytical tables, especially for W6 TDS, W1 calcium, and nitrate entries. These steps would allow reliable evaluation of labeling accuracy and improve the evidence available to consumers, producers, and regulators.

1) There is a need to ensure continuous updating of the numbers regarding the chemical and physical properties of water contained on the labels.
2) It is highly recommended that all the significant properties of water be indicated on the labels including the following: pH, dissolved solids, hardness, calcium, magnesium, sodium, potassium, chlorides, sulfates, and nitrates.
3) Ensure that laboratory results match the declared values strictly in cases where there are significant differences in the water source and bottling process.
4) Increase the level of health and ecological monitoring of the bottled water production facilities in order to ensure the safety of water sources and effectiveness of treatment and bottling processes.
5) Use regular bacterial testing in order to check the water safety and suitability for drinking. 7. It is very important to improve the conditions for storing and transportation of bottled water and to protect it from high humidity and sunlight since inappropriate conditions may affect the properties of bottled water.
6) Further studies should be conducted with more brands of bottled water for longer periods of time in order to compare laboratory data with values declared on the packaging and reference to Iraqi and international standards.

Conflict of Interest

The author declares no known financial or non-financial conflicts of interest related to this investigation.

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Data Availability

The study reports original laboratory observations and information transcribed from bottled-water labels. The tabulated measurements are included in this manuscript; the underlying laboratory worksheets, analytical records, and dated label documentation can be requested from the corresponding author.

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