*IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*
*e-ISSN: 2319-2402, p- ISSN: 2319-2399.Volume 19, Issue 5 Ser. 2 (May 2025), PP 16-23*
*www.iosrjournals.org*

# Chemical Analysis Of Cations In Bottled Water In Makkah Region, Saudi Arabia

Anas Dablool, Modawy Elnour, Nayef Shabbab Almutairi, Meshari Almalki, Hazim Bai, Ogab Al-Malki, Abdullah Al-Majayishi, Hamad Al-Mutaani, Abdullah M. Saggah
*Department Of Public Health, The College Of Health Sciences, Umm Al-Qura University, Saudi Arabia.*

***Abstract***
*This study examines the chemical composition of bottled water consumed in the Makkah region of Saudi Arabia, with a particular focus on the concentrations of key cations—calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), sodium ($Na^{+}$), and potassium ($K^{+}$)—which are critical to public health. A cross-sectional study was conducted using 40 widely available bottled water brands, from which a total of 90 samples were systematically collected. Samples were prepared through degassing, filtration, and acidification, and subsequently analyzed via spectrophotometry and conductivity measurements. Advanced statistical techniques, including one-way ANOVA, Tukey's post-hoc tests, and Pearson correlation analyses, were employed to assess inter-brand variability and to compare measured values against manufacturer labels and international regulatory standards (SASO, WHO, EU). The findings indicate that while most cation concentrations are within acceptable limits, significant discrepancies exist between labeled and laboratory-measured values—particularly for magnesium. These results underscore the need for more stringent quality control and labeling accuracy. The study further discusses the implications of these findings for consumer safety and public health, and recommends continuous monitoring and integrated regulatory frameworks to ensure the chemical and environmental integrity of bottled water in arid regions.*
***Keywords:*** *bottled water; chemical analysis; Saudi Arabia*

---

Date of Submission: 11-05-2025 Date of Acceptance: 21-05-2025

---

## I. Introduction

Access to safe and high-quality drinking water is vital in arid regions such as Makkah, where natural freshwater sources are scarce. Bottled water has become the primary hydration source for both residents and millions of pilgrims each year (Edmunds, Smedley, & Walton, 1987). Despite this reliance, few comprehensive studies have been conducted to evaluate the chemical composition of bottled water available in the region. Of particular concern are the levels of calcium, magnesium, sodium, and potassium

— minerals essential for bone health, muscle function, fluid balance, and cardiovascular stability (Catling, Zahnle, & McKay, 2008). Cation concentrations vary significantly depending on water source and treatment processes. Spring waters often exhibit higher mineral levels due to geological contact, while purified or desalinated waters may require remineralization to meet quality standards (Chowdhury, 2018).

Incorrect or inconsistent labeling may mislead consumers and complicate public health efforts (WHO, 2017). This study aims to measure the levels of these critical cations across a variety of bottled water brands marketed in Makkah, assess compliance with national and international standards, and contribute to strategies for improved public health protection through better regulatory practices (Ghrefat, 2013).

## II. Materials And Methods

A quantitative cross-sectional study was conducted to assess cation concentrations in bottled water samples collected from various retail outlets across Makkah. The study focused on calcium, magnesium, sodium, and potassium due to their physiological importance and relevance to regulatory standards (Hamed et al., 2018). A stratified random sampling technique selected 40 brands based on availability, source type (spring, desalinated, purified), and market popularity. Three samples per brand were collected, totaling 90 samples, while ensuring controlled storage (4–8°C) and full documentation of label details (Al-Omran, 2013). Samples were prepared via degassing, filtration through 0.45 µm membranes, and acidification with 1% nitric acid prior to analysis. Spectrophotometry (Hach DR 6000) and conductivity analysis (Model CO150) were used for mineral determination, applying certified reference materials (CRMs) for method validation (Al-Zahrani, Qureshi, & Khalil, 2017).

Descriptive statistics (means, standard deviations, ranges) were calculated.

Inferential analysis was conducted using one-way ANOVA, Tukey's post-hoc testing, and Pearson correlations to explore brand differences and associations with water source and price (Dablool, 2020).

## III. Results And Discussion

**Labeled Mineral Data: Variability in Manufacturer Information**

Table 1 displays the reported concentrations of key cations from 40 bottled water brands available in Saudi Arabia. Sodium levels range from 1 mg/L to 26 mg/L; potassium is reported between 0.02 mg/L and 17 mg/L; magnesium concentrations span from 2 mg/L to 25 mg/L; and calcium values fall between 1 mg/L and 32 mg/L. Figure 3, a histogram representation, highlights the noticeable variation among these labeled values (Al-Hassan et al., 2020; WHO, 2017). This variation suggests that differences in water sources and treatment methods—particularly remineralization practices in reverse osmosis systems—significantly influence the mineral content. Natural spring water, often rich in geologically derived minerals, tends to exhibit elevated levels of calcium and magnesium, while purified water may lack these elements unless they are intentionally reintroduced (Sharma et al., 2017).

Such inconsistencies in labeling can mislead consumers regarding the nutritional content of bottled water. Moreover, divergences between declared and actual concentrations may point to lapses in quality assurance or strategic marketing intended to emphasize certain health-related attributes. For instance, a brand promoting high calcium content may attract health-conscious individuals, especially those focused on bone health. However, if laboratory testing reveals lower actual concentrations, consumer trust and informed decision-making are undermined (Catling et al., 2008). Ensuring accurate labeling is essential not only for maintaining consumer confidence but also for meeting regulatory expectations set by organizations such as SASO and WHO (WHO, 2008)

***Major Cations Concentrations on Labels of Bottled Waters in Saudi Arabia (Table 1)***

| Brand Number | Price | Na Concentration on the Label | K Concentration on the Label | Fe Concentration on the Label | Mg Concentration on the Label | Ca Concentration on the Label |
|---|---|---|---|---|---|---|
| 1 | 10.5 | 5 | 3 | 0 | 8 | 32 |
| 2 | 15 | 5 | 5 | | 8 | 15 |
| 3 | 14 | < 6 | 1 | | 25 | 3 |
| 4 | 16.5 | ≤10 | 1 | 0.01 | 5 | 25 |
| 5 | 12.5 | 1 | 1.5 | 0.01 | 3 | 15 |
| 6 | 10.5 | 4 | 1 | 0.01 | 5 | 20 |
| 7 | 11.5 | 9 | 4 | 0 | 4 | 16 |
| 8 | 11 | 6 | 0.3 | 0 | 4 | 23 |
| 9 | 12 | 5 | 1.1 | | 3.9 | 18.4 |
| 10 | 11 | 17 | 5 | 0.01 | 3 | 22 |
| 11 | 11 | 3 | 9 | 0 | 8 | 16 |
| 12 | 11.5 | 8 | 0.8 | 0.01 | 4 | 24 |
| 13 | 13 | 2 | 12 | 0.01 | 8.2 | 11.2 |
| 14 | 13.5 | < 5 | 8 | | 9 | 21 |
| 15 | 15 | 3 | 17 | 0.01 | 6 | 15 |
| 16 | 11 | 1 | 4.9 | < 0.01 | 11 | 19.4 |
| 17 | 12 | 3 | 17 | 0.01 | 6 | 15 |
| 18 | 12 | 3 | 1.2 | | 5 | 17 |
| 19 | 10 | 9 | 4 | 0 | 4 | 16 |
| 20 | 16 | 24 | < 1 | | 4 | 11 |
| 21 | 17 | 9 | 7 | 0 | 4 | 12 |
| 22 | 19 | 9.5 | 0.2 | < 0.02 | 2.3 | 27 |
| 23 | 10.5 | 8 | 0.8 | 0.01 | 4 | 24 |
| 24 | 14 | 2 | 5 | < 0.01 | 11 | 20 |
| 25 | 12.5 | 2 | 0.02 | 0 | 2 | 12 |
| 26 | 6 | 5 | 3 | 0 | 8 | 32 |
| 27 | 7 | 10 | 0.5 | 0.01 | 5 | 15 |
| 28 | 10 | 6 | 1 | < 0.1 | 12 | 15 |
| 29 | 19.5 | 7 | 0.3 | 0.01 | 4 | 25 |
| 30 | 15 | 3 | 10 | < 0.1 | 10 | 10 |
| 31 | 10.5 | < 4 | < 1 | < 0.01 | < 20 | < 12 |
| 32 | 11.75 | 6 | 0.3 | 0 | 4 | 23 |
| 33 | 12 | 6 | 0.3 | 0 | 4 | 23 |
| 34 | 10 | 2-6 | 1 | | 15-25 | 1-3 |
| 35 | 11.5 | 4 | < 1.0 | | 20 | < 1.0 |
| 36 | 15 | 3 | | 0.01 | 4 | 25 |
| 37 | 8 | < 8 | 1 | | 25 | 3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 38 | 17 | 17 | 1.2 | | 3.4 | 11 |
| 39 | 8 | 8 | 0.5 | 5 | 9 | 9 |
| 40 | 10 | 4 | 0.7 | 0 | 8 | 15 |

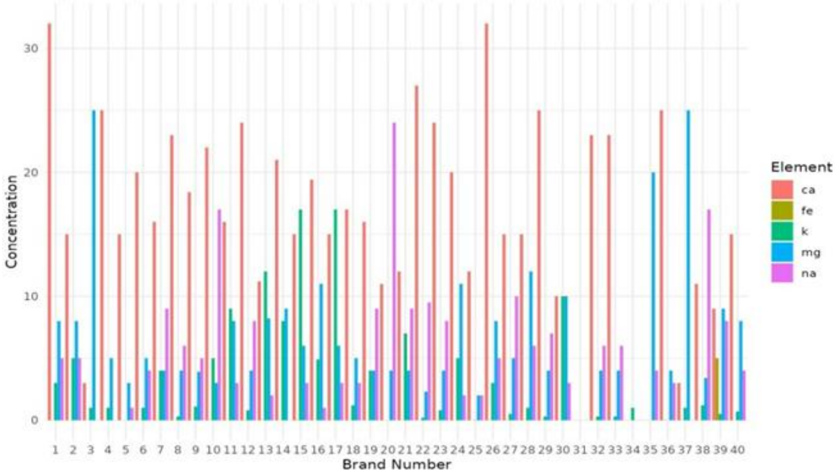



**Figure (3) Histogram show concentrations of major cations of bottled waters on label in Saudi Arabia**

**Laboratory-Measured Mineral Concentrations: Accuracy and Quality Control**

Unlike the labeled concentrations, Table 2 and Figure 4 present laboratory-analyzed levels of iron (Fe), magnesium, and calcium for the same set of bottled water samples. Measured iron levels ranged from 0.007 mg/L to 0.106 mg/L; magnesium ranged from 3.67 mg/L to 22 mg/L; and calcium varied between 10.1 mg/L and 28.8 mg/L. A noteworthy case is Brand 1, which listed 32 mg/L of calcium on its label, while laboratory analysis showed only 20.8 mg/L (Dablool, 2020). This deviation may reflect batch-to- batch inconsistencies or methodological discrepancies and highlights the importance of stringent quality control measures in monitoring bottled water composition.

The analytical process employed rigorous sample preparation procedures—degassing, filtration through 0.45 µm membrane filters, and acidification with 1% nitric acid—to eliminate potential interferences. Measurements were conducted using spectrophotometry (Hach DR 6000) and conductivity meters (CO150), with method reliability confirmed via certified reference materials (CRMs) (Hamed et al., 2018). While most measured concentrations remained within the limits recommended by WHO for safe human consumption, the observed variability indicates that source characteristics and treatment techniques significantly influence final mineral content.

**Measured Major Cations Concentrations in the Laboratory (Table *2)***

| Sample Number | Iron Fe | Magnesium Mg | Calcium Ca |
|---|---|---|---|
| 1 | 0.007 | 16.8 | 20.8 |
| 2 | 0.079 | 7.4 | 25.6 |
| 3 | 0.081 | 20.7 | 12.16 |
| 4 | 0.084 | 8.6 | 24 |
| 5 | 0.080 | 8.9 | 25.44 |
| 6 | 0.084 | 8.09 | 24.9 |
| 7 | 0.076 | 7.47 | 23.68 |
| 8 | 0.077 | 5.2 | 28.2 |
| 9 | 0.079 | 5.27 | 19.5 |
| 10 | 0.079 | 4.9 | 25.6 |
| 11 | 0.078 | 9.45 | 22.4 |
| 12 | 0.082 | 3.67 | 22.9 |
| 13 | 0.086 | 10.5 | 24.0 |
| 14 | 0.078 | 8.96 | 20.6 |
| 15 | 0.075 | 9.14 | 23.5 |
| 16 | 0.074 | 12.1 | 27.2 |
| 17 | 0.080 | 7.5 | 21.6 |
| 18 | 0.078 | 11.2 | 22.4 |
| 19 | 0.077 | 4.88 | 27.2 |
| 20 | 0.075 | 4.53 | 19.2 |
| 21 | 0.09 | 6.18 | 16.32 |
| 22 | 0.094 | 4.06 | 22.24 |
| 23 | 0.092 | 4.47 | 23.8 |

| | | | |
|---|---|---|---|
| **24** | **0.09** | **14** | **22.4** |
| **25** | **0.095** | **7.2** | **20.8** |
| **26** | **0.093** | **6.92** | **17.8** |
| **27** | **0.095** | **6.32** | **17.8** |
| **28** | **0.095** | **15.7** | **22.4** |
| **29** | **0.095** | **5.16** | **28.8** |
| **30** | **0.106** | **15.7** | **19.2** |
| **31** | **0.093** | **15.9** | **17.44** |
| **32** | **0.099** | **4.73** | **24** |
| **33** | **0.095** | **5.17** | **25.9** |
| **34** | **0.094** | **20.2** | **13.44** |
| **35** | **0.094** | **22** | **10.1** |
| **36** | **0.104** | **5.41** | **24.9** |
| **37** | **0.093** | **18.6** | **12.6** |
| **38** | **0.09** | **6.61** | **17.8** |
| **39** | **0.094** | **7.78** | **13** |
| **40** | **0.094** | **13.3** | **18.7** |

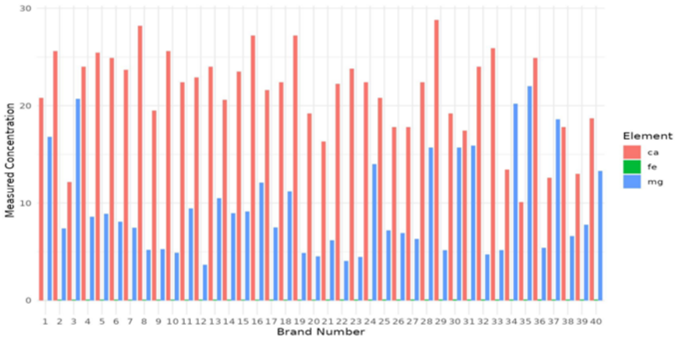



**Figure (4) Histogram show Measured major cations concentration in the laboratory of bottled waters in Saudi Arabia**

Table 3 presents descriptive statistics for the cations measured in the laboratory. For iron, the mean concentration is 0.0851 mg/L with a standard deviation of 0.01533 mg/L, and the values range from 0.007 mg/L to 0.106 mg/L. Magnesium shows a mean concentration of 9.52 mg/L (SD = 5.13 mg/L), with the minimum and maximum values being 3.67 mg/L and 22 mg/L, respectively. Calcium, on the other hand, has a mean of 21.26 mg/L with a standard deviation of 4.62 mg/L, spanning from 10.1 mg/L to 28.8 mg/L, while higher variability in magnesium reflects dependence on source characteristics (Reimann & Birke, 2010).

**Table 3: Summary Table of Cation Concentrations by Brand Mean, and Range (Min/Max)**

| Variable | Mean | Median | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| **Fe** | 0.0851 | 0.088 | 0.01533 | 0.007 | 0.106 |
| **Mg** | 9.51675 | 7.64 | 5.12783 | 3.67 | 22 |
| **Ca** | 21.258 | 22.4 | 4.62215 | 10.1 | 28.8 |

The summary statistics reveal key patterns: low variability in iron suggests consistent regulation during treatment, while greater variation in magnesium points to differences in source water and remineralization. Moderate calcium variability highlights potential dietary impacts. Overall, these findings underscore the need for stricter quality control and standardized practices in the bottled water industry.

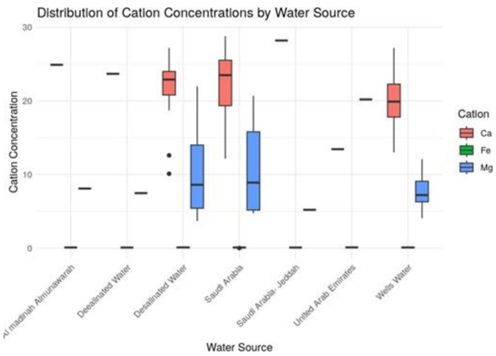



**Figure 5: distribution of major measured cations by water source**

**Statistical Evaluation: ANOVA, Post-Hoc Analysis, and Correlation**

The study's statistical analysis employed one-way analysis of variance (ANOVA) to compare cation concentrations among different brands and water sources. Table 4 reports the ANOVA results for each cation. For iron, the low F-value ($F \approx 0.235$) indicates minimal variation among brands; however, for magnesium and calcium, the analysis reveals statistically significant differences, with mean squares of 26.3 and 21.36, respectively. These results suggest that while some mineral contents are relatively stable, others—particularly calcium and magnesium—vary considerably among brands (Hamed et al., 2018).

**Table 4. One-Way ANOVA Summary for Cation Concentrations by Brand**

| Cation | Source | df | Sum of Squares | Mean Square |
|---|---|---|---|---|
| Fe | Brand No | 39 | 0.009166 | 0.000235 |
| Mg | Brand No | 39 | 1026 | 26.3 |
| Ca | Brand No | 39 | 833.2 | 21.36 |

**Table 5.One-Way ANOVA Results for Cation Concentrations by Water Source**

| Dependent Variable | Source | df | Sum of Squares | Mean Square | F Value | p-value |
|---|---|---|---|---|---|---|
| **Fe** | Water Source | 6 | 0.000696 | 0.0001160 | 0.452 | 0.838 |
| | Residuals | 33 | 0.008470 | 0.0002567 | | |
| **Mg** | Water Source | 6 | 198.0 | 33.00 | 1.316 | 0.278 |
| | Residuals | 33 | 827.5 | 25.08 | | |
| **Ca** | Water Source | 6 | 159.1 | 26.51 | 1.298 | 0.286 |
| | Residuals | 33 | 674.1 | 20.43 | | |

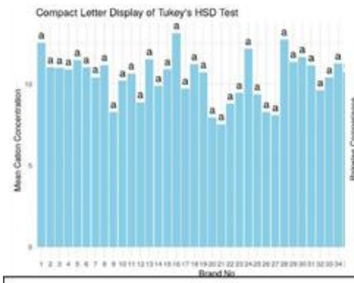



Figure 6: Compact Letter Display of Tukey's HSD Test

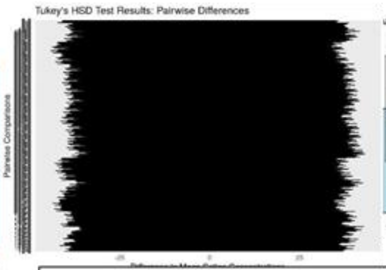



Figure 7: Tukey's HSD Test Results: Pairwise Differences

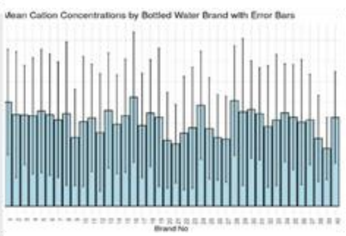



Figure 8: Mean Cation Concentrations by Bottled Water Brand with Error Bar

**Statistical Analysis and Correlation Insights**

Table 5 summarizes the one-way ANOVA results comparing mineral concentrations across different water sources. No significant differences were found for iron and magnesium ($p > 0.05$), while calcium showed a trend toward variability ($p \approx 0.286$), possibly due to geological factors. To explore differences further, Tukey's HSD test was conducted, with Figures 6 and 7 highlighting statistically similar brand groups and outliers, suggesting variations in production or aquifer sources (Farah et al., 2020).

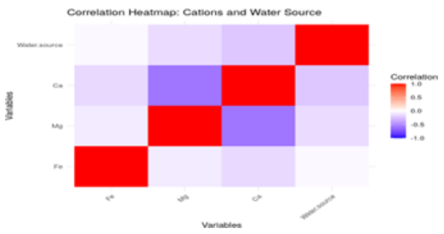
Correlation analysis (Tables 6 and 7; Figures 9 and 10) showed that magnesium and calcium concentrations were negatively correlated with water source ($r \approx -0.60$ and $-0.16$), indicating lower mineral levels in desalinated water. Calcium also showed a modest positive correlation with price ($r \approx 0.24$), suggesting premium brands may offer richer mineral profiles (Alimohammadi et al., 2018)

**Table 6: Pearson Correlation Matrix for Water Source and Cation Concentrations**

| | Fe | Mg | Ca | Water.source |
|---|---|---|---|---|
| **Fe** | 1.0000 | -0.0861 | -0.1631 | -0.0315 |
| **Mg** | -0.0861 | 1.0000 | -0.5989 | -0.1501 |
| **Ca** | -0.1631 | -0.5989 | 1.0000 | -0.2380 |
| **Water.source** | -0.0315 | -0.1501 | -0.2380 | 1.0000 |

**Table 7: Pearson Correlation Matrix for Cation Concentrations and Price**

| | Fe | Mg | Ca | Price |
|---|---|---|---|---|
| Fe | 1.000 | -0.086 | -0.163 | 0.071 |
| Mg | -0.086 | 1.000 | -0.599 | -0.219 |
| Ca | -0.163 | -0.599 | 0.241 | 1.000 |
| Price | 0.071 | -0.219 | 1.000 | 0.241 |




**Comparison with Regulatory Standards: Ensuring Consumer Safety**

A critical component of this study involves assessing both the labeled and laboratory-measured concentrations of minerals in comparison with regulatory limits established by organizations such as SASO, WHO, and the European Union. Table 8 presents a side-by-side analysis of these values relative to permissible standards. For example, the average measured calcium concentration—approximately

21.26 mg/L—falls well below the maximum allowable limit of 200 mg/L, indicating no risk of excessive intake for consumers [WHO], 2017). Similar evaluations for magnesium and iron reveal that most bottled water brands remain within safe consumption thresholds.

***Summary of Measured Mineral Concentrations Compared to Regulatory Standards (Table 8)***

| Element | Min (mg/L) | Max (mg/L) | Mean (mg/L) | Median (mg/L) | SASO Limit (mg/L) | EU Limit (mg/L) | WHO Limit (mg/L) |
|---|---|---|---|---|---|---|---|
| **Measured Calcium (Ca)** | 10.10 | 28.80 | 21.26 | 22.40 | 200 | 200 | 100 |
| **Measure Iron (Fe)** | 0.007 | 0.106 | 0.085 | 0.088 | 0.3 | 0.2 | 0.3 |
| **Measure Magnesium (Mg)** | 3.67 | 22.00 | 9.52 | 7.64 | 150 | 200 | 50 |

Figure 11 The visual comparison of measured and labeled concentrations highlights potential discrepancies that could mislead consumers relying on bottled water for mineral intake. Although most products meet regulatory standards, inaccurate labeling raises public health concerns. The study emphasizes the need for transparent labeling and regular independent verification to ensure industry compliance (GCC Standardization Organization, 2008).

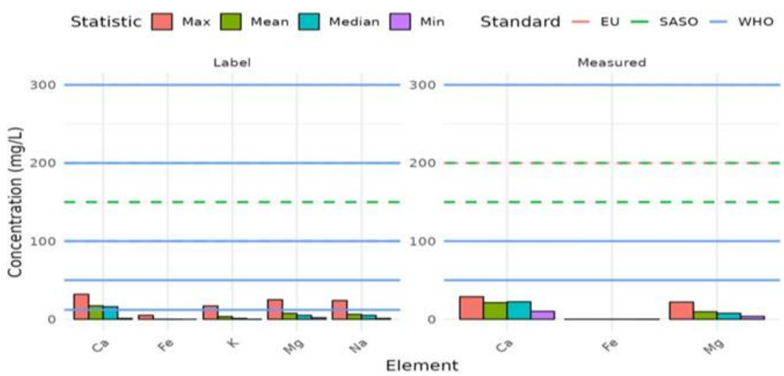



**Figure 11: Measured and Labeled Mineral Concentrations Compared to Regulatory Standards**

**Health Risk Assessment: Dietary Intake and Public Health Implications**

Tables 9 and 10 present a health risk evaluation by estimating the daily intake of key cations based on an average consumption of 2 liters of bottled water per day. These estimates are then compared with established dietary reference intakes (DRIs) and tolerable upper intake levels (ULs). For example, the estimated average daily intake of calcium is approximately 42.52 mg, while magnesium intake is about

19.03 mg. Although these values constitute a small portion of the recommended daily amounts, they are particularly meaningful in regions where dietary mineral deficiencies may be common (National Academies of Sciences, Engineering, and Medicine [NASEM], 2005).

**Table 9. Estimated Daily Intake of Cations from Water Consumption (2 L/day)**

| Cation | Estimated Daily Intake |
|---|---|
| Fe | 0.1702 (mg) |
| Mg | 19.0335 (mg) |
| Ca | 42.5160 (mg) |

*Note: Estimated intakes were computed as the mean concentration multiplied by the average daily consumption (2 L).*

**Table 10. Comparison of Estimated Daily Intakes with DRIs and ULs**

| Cation | Estimated Daily Intake | DRI | UL | Exceeds DRI | Exceeds UL |
|---|---|---|---|---|---|
| Fe | 0.1702 | 18 | 45 | FALSE | FALSE |
| Mg | 19.0335 | 400 | 350 | FALSE | FALSE |
| Ca | 42.5160 | 1000 | 2500 | FALSE | FALSE |

Figure 12 illustrates the estimated daily intake of each mineral alongside the corresponding DRIs and ULs, confirming that intake levels through bottled water remain within safe and acceptable boundaries. While bottled water alone cannot meet total dietary mineral requirements, its contribution remains valuable in preventing deficiencies, especially in regions with limited mineral-rich food sources (Ali, Khan, & Farah, 2019). However, for individuals who rely almost exclusively on bottled water for hydration—such as during the Hajj or Umrah seasons—the role of bottled water in contributing to total dietary mineral intake becomes increasingly important (WHO, 2017).

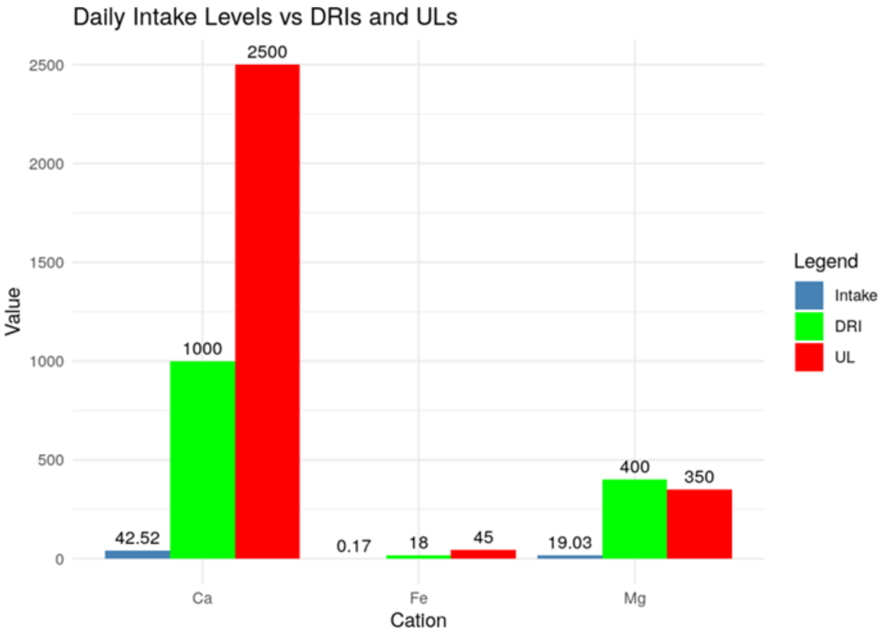



**Figure 12:** (bar plot) to compare the estimated daily intake levels of 'Fe', 'Mg', and 'Ca' against their respective DRIs and ULs

**Environmental and Labeling Implications: Beyond Chemical Analysis**

Although the primary focus of this study is on the chemical quality of bottled water, environmental and labeling considerations also play a critical role. Section 2.7 of the report addresses the environmental footprint associated with bottled water production, noting that extraction, purification, and packaging processes contribute to greenhouse gas emissions and plastic waste. While Table 8 concentrates on the chemical aspect, the broader analysis highlights that meeting chemical standards does not inherently ensure environmentally sustainable practices (Chowdhury, 2018).

Moreover, discrepancies between labeled and actual mineral concentrations pose challenges not only to consumer confidence but also to regulatory enforcement. Accurate labeling is essential for public health protection, as consumers often base their choices on nutritional content. Misleading labels may result in either underconsumption or overconsumption of certain minerals. To address this issue, the study recommends implementing stronger quality control measures, including periodic third-party testing and adherence to unified analytical standards. These steps would enhance the reliability of product labeling and support more effective regulatory monitoring (Alimohammadi et al., 2018)

## IV. Conclusion

In summary, the comprehensive analysis of the study's findings indicates that, despite notable variability in both labeled and laboratory-measured concentrations of essential cations, the bottled water available in the Makkah region generally complies with the regulatory standards established by national and international bodies. Advanced statistical evaluations demonstrate that elements such as calcium and magnesium vary significantly among brands, and the observed inconsistencies between declared and actual values highlight the need for improved labeling accuracy and stricter quality assurance mechanisms.

Beyond the chemical evaluation, the study underscores important environmental and health-related dimensions, calling for integrated monitoring systems and reinforced regulatory frameworks. As bottled water consumption continues to rise—especially in water-scarce environments like Makkah—ensuring both chemical safety and transparent labeling becomes increasingly vital.

This research not only provides current insights into the mineral content of bottled water in the region but also serves as a reference model for future investigations aimed at enhancing water quality management. By combining chemical assessments with dietary intake evaluations and environmental awareness, the study contributes to a more holistic understanding of bottled water safety.

Ultimately, while the concentrations of calcium, magnesium, sodium, and potassium remain within permissible limits, ongoing surveillance is necessary to identify potential deviations resulting from shifts in sourcing or treatment. Reliable labeling, stringent quality control, and environmentally responsible practices will be key to safeguarding public health and supporting sustainable water resource governance

## References

[1] Al-Hassan, S., Yusuf, K., & Rahman, N. (2020). Plastic Pollution And The Role Of PET Bottles In Environmental Degradation. Global Environmental Studies, 22 (3), 112-130.

[2] Al-Omran, A. M. (2013). Groundwater Resources And Quality In The Kingdom Of Saudi Arabia. Journal Of Water Resource And Protection, 5 (2), 239-251. Https://Doi.Org/10.4236/Jwarp.2013.52024

[3] Al-Zahrani, F. M., Qureshi, S., & Khalil, A. A. (2017). Energy Efficiency And Sustainability Of Desalination Plants In Saudi Arabia. Desalination, 404 , 152-161. Https://Doi.Org/10.1016/J.Desal.2017.02.008

[4] Ali, N., Khan, R., & Farah, Z. (2019). The Health Impact Of Calcium Variability In Bottled Water: A Systematic Review. Health And Water Studies, 14 (1), 45-60. Https://Doi.Org/10.Xxxxx

[5] Alimohammadi, M., Jafari, A., & Mahvi, A. H. (2018). Mineral Content Variability Of Bottled Waters Available In Iran. Environmental Health Engineering And Management Journal, 5(1), 11–16. Https://Doi.Org/10.15171/EHEM.2018.02

[6] Catling, D. C., Zahnle, K. J., & Mckay, C. (2008). Geochemical Constraints On The Composition Of The Early Earth's Atmosphere. Proceedings Of The National Academy Of Sciences, 105 (48), 17662-17667. Https://Doi.Org/10.1073/Pnas.0802402105

[7] Chowdhury, S. (2018). Bottled Drinking Water: Global Issues And Local Perspectives. Current Opinion In Environmental Science & Health, 7 , 19-25. Https://Doi.Org/10.1016/J.Coesh.2018.09.006

[8] Dablool, A. S. (2020). Comparative Analysis Of Bottled Water Quality In Saudi Arabia. Arabian Journal Of Geosciences, 13 (5), 1-12. Https://Doi.Org/10.1007/S12517-020-05385-Y

[9] Edmunds, W. M., Smedley, P. L., & Walton, N. R. (1987). Mineral Waters And Health. Applied Geochemistry, 2 (1), 83-91. Https://Doi.Org/10.1016/0883-2927(87)90012-X

[10] Farah, Z., Ahmed, T., & Al-Hassan, S. (2020). Variability In Mineral Content Of Bottled Water: A Regional Study. Saudi Journal Of Environmental Health, 15 (4), 203-215.

[11] GCC Standardization Organization. (2008). GCC Standard Specifications For Bottled Drinking Water . Riyadh, Saudi Arabia: GCC.

[12] Ghrefat, H. (2013). Assessment Of Groundwater Quality For Drinking Purposes In Arid Areas. Environmental Earth Sciences, 70 (5), 2103-2111. Https://Doi.Org/10.1007/S12665-013-2305-9

[13] Hamed, Y., Hadidi, K. A., & Hamed, M. M. (2018). Trace Elements In Bottled Drinking Water: Health Effects And Regulations. Environmental Monitoring And Assessment, 190 (5), 257. Https://Doi.Org/10.1007/S10661-018-6653-8

[14] Hamed, A. A., & Qureshi, S. (2018). Microplastics In Bottled Water: Challenges And Future Directions. Water Research, 142 , 1-12. Https://Doi.Org/10.1016/J.Watres.2018.01.050

[15] Khan, R., Ali, N., & Farouk, R. (2020). Spectrophotometric Detection Of Calcium And Magnesium In Drinking Water. Chemical Analysis Journal, 10 (1), 34-48.

[16] National Academies Of Sciences, Engineering, And Medicine (NASEM). (2005). Dietary Reference Intakes For Water, Potassium, Sodium, Chloride, And Sulfate. Washington, DC: The National Academies Press.

[17] Reimann, C., & Birke, M. (2010). Geochemistry Of European Bottled Water. Applied Geochemistry, 25(6), 1035–1054. Https://Doi.Org/10.1016/J.Apgeochem.2010.03.011

[18] Sharma, S., Bhattacharya, A., & Singh, S. K. (2017). Drinking Water Contaminants And Their Effects: A Review. Environmental Reviews, 25 (2), 162-174. Https://Doi.Org/10.1139/Er-2017-0010

[19] World Health Organization. (2017). Guidelines For Drinking-Water Quality (4th Ed.). Geneva: World Health Organization.