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Original article

Chemical and Microbial Analysis of Commercial Bottled Drinking Water Available in Surman City Markets

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Abstract

This study aims to evaluate the levels of trace elements and microbial contamination in commercially bottled drinking water available in the markets of Surman city, to ensure the safety and quality of the water consumed. The study was conducted from March to May 2024. Samples from five local bottled water brands were subjected to extensive laboratory testing, including microbial and chemical analyses. Three samples were collected from each brand and compared against the Libyan standard specifications for bottled drinking water. The Microbial analysis revealed that none of the samples showed significant microbial activity, indicating the absence of microbial contamination. The chemical analyses showed compliance with Libyan standards, particularly in terms of pH levels and trace element concentrations, which were close to the acceptable limits. The study recommended to implement regular monitoring programs to ensure continuous compliance with standard specifications, enhance awareness among producers and consumers about the importance of adhering to health standards, encourage further studies to evaluate the quality of bottled water, and develop regulations related to quality monitoring.

Keywords: *Commercially Bottled Water, Libyan Standard Specifications for Water, Microbial Tests for Water, Chemical Analysis of Water*

Introduction

Water is a fundamental element of life, and access to clean and safe drinking water is essential for every individual. As bottled water becomes a popular choice for consumption, concerns about its quality and safety are increasing, particularly in light of reports of contamination from various chemical and microbial pollutants. The quality of bottled water depends on several factors, including the source of the water, purification processes, and packaging standards. This study aims to assess the quality of commercially bottled drinking water available in Surman city markets, evaluating its compliance with Libyan standards to ensure consumer safety and mitigate potential health risks.

Recent Research across various regions has painted a comprehensive picture of bottled water quality, highlighting both progress and ongoing concerns. In 2023, a study conducted in the United States focused on evaluating bottled water for chemical contaminants and microbial presence. The findings indicated that while most brands adhered to regulatory standards, some bottled waters contained trace levels of contaminants that could pose health risks over long-term consumption [1]. This underlines the importance of stringent quality control measures in ensuring the safety of bottled water.

Likewise, a 2022 survey in the European Union turned the spotlight on the presence of microplastics in bottled water. The study revealed a significant occurrence of microplastic contamination, sparking concerns about the potential health impacts and emphasizing the necessity for improved filtration and packaging practices to protect consumers [2].

In Australia, research conducted in 2021 explored the chemical composition of bottled water, particularly focusing on trace elements like lead and arsenic [3]. Although the majority of bottled waters complied with safety standards, occasional deviations were noted, prompting calls for enhanced regulatory scrutiny and increased consumer awareness regarding the potential risks [3].

Moving to Libya, a study in 2023 examined the bottled water available in Tripoli, uncovering issues related to microbial contamination and inconsistencies in chemical composition when compared to national standards. This study highlighted the need for more rigorous monitoring and enforcement of quality standards to safeguard public health [4].
In 2022, research in Benghazi delved into the influence of local water sources on bottled water quality. The findings revealed variations in the concentration of trace elements and microbial contaminants, suggesting that the quality of the final product is significantly affected by the source and treatment methods used [5].
Further back, in 2021, a comprehensive study across various regions in Libya evaluated the effectiveness of existing purification processes for bottled water. The research identified occasional non-compliance with national standards, stressing the importance of regular quality assessments and updates to regulatory practices to ensure that the water consumed by the public is safe [6].
In another study assessed the chemical quality of selected bottled water brands in Tripoli, Libya. Analyzing a range of water quality parameters such as pH, total hardness, and various ions, the study uncovered significant differences in the characteristics of bottled water [7]. While most brands met both national and international standards, five brands had pH levels below the acceptable threshold of 6.5.
In earlier research conducted in Misurata, Libya, found that the pH values of several bottled water samples were below the minimum required specifications. Additionally, one sample exceeded the maximum allowable levels for soluble salts, total hardness, and chlorides [8]. Despite these findings, other elements such as sodium, calcium, magnesium, and potassium remained within permissible limits, indicating areas where improvements could be made. Looking further back to 2013, another study was prompted by the lack of sufficient research on bottled water in Libya, focusing on its composition and health implications. This research echoed the concerns of later studies, finding that some samples had pH values below the minimum standards and that certain elements exceeded the allowable levels, underscoring the need for more comprehensive monitoring [9].
In 2021, a study in Alkoms City, Libya, analyzed the chemical and physical aspects of commercial bottled water. Most of the analyzed parameters were within acceptable limits continued according to Libyan and WHO standards, though calcium concentration exceeded recommended levels, indicating a need for vigilance in monitoring bottled water quality [10]**.** The aim of this study was to Evaluate the Quality of commercial bottled drinking water available in the Markets of Surman City.

Method

Sample collection

The study was conducted in May 2024 to evaluate some physical and chemical properties of five different brands of locally bottled drinking water. The tested brands were classified as companies from 1 to 5. For each brand, three samples were taken from each company from 0.5-liter bottles to ensure the accuracy of the results. All containers were tightly sealed and free of defects. The bottles were then transported to the laboratory for analysis. The analyses were conducted in the chemistry laboratories of the Environmental Sanitation Center in Sabratha. The parameters tested included pH, total dissolved solids, total alkalinity, electrical conductivity, total hardness, and concentrations of bicarbonate, chloride, sulfate, nitrate, and nitrite.

Methods of estimation

The physicochemical tests for water were conducted following the guidelines outlined in APHA (11). The concentration of hydrogen ions (pH) was measured using a pH meter, and the conductivity was determined with a Conductivity Meter, from which the total dissolved solids (TDS) were calculated during sampling. Sodium and potassium concentrations were measured using a Flame Photometer, while sulfate and nitrate ions were quantified using a Spectrophotometer. Calcium, magnesium, and total hardness were determined by titration with 0.01 M EDTA solution, using Murexide and Eriochrome Black T as indicators. Chloride ion concentration was estimated via titration with silver nitrate solution using potassium chromate as an indicator [12].

Detection of bacteria by membrane filtration method

A known volume of water sample (100 ml) was filtered through a sterile membrane filter with a pore size of 0.45 µm. The filter was placed on a selective nutrient medium, such as m-Endo Agar for total coliforms. The plates was inoculated at 35-37 °C for 24 hours (for total coliforms). Colonies were counted to determine the number of colonies forming units (CFU) per 100 ml of water.

Detection of fungi: Membrane filtration method
A water sample was filtered using a membrane filter with a pore size of 0.45 µm. The filter was placed on Sabbouraud dextrose agar (SDA) for selective fungal growth. It was incubated at 25-30°C for 3 to 5 days for yeast and mold growth. Fungal colonies were identified microscopically or by biochemical tests.

Identification of bacterial and fungal species
Gram stain or lactophenol cotton blue stain was performed for microscopic examination of bacteria and fungi. The number of colonies forming units and microbial species were compared to water quality standards (e.g., WHO guidelines) to determine the safety of drinking water.

Data analysis
Descriptive statistics such as frequency (%), mean and standard deviation were used to present the characteristics of the samples as appropriate. The results of the study and its characteristics

Results
The chemical composition of five locally bottled drinking water samples was evaluated and compared with the Libyan standard specifications for bottled drinking water. The pH values of the samples ranged from 6.8 to 7.2, which fall within the permissible limits of 6.5 to 8.5, as specified by the Libyan standards (Figure 1). This indicates that none of the water samples showed excessive acidity or alkalinity.

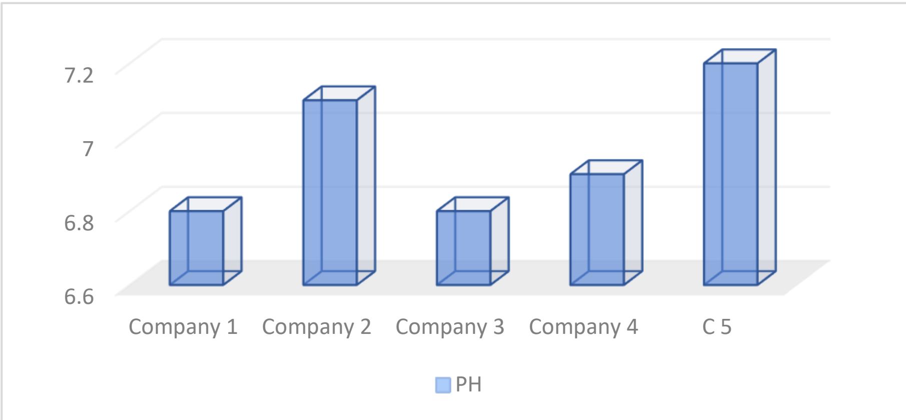

Figure 1. The pH values of the local water types studied

The conductivity values of the water samples varied significantly, with Company 1 showing a conductivity of 137 µS/cm and Company 5 having the highest value at 194 µS/cm. Total dissolved solids (TDS) were also measured, with results ranging from 70 mg/L in Company 2 to 122 mg/L in Company 5. These TDS levels fall within the acceptable range, indicating the water is safe for consumption according to the standard.

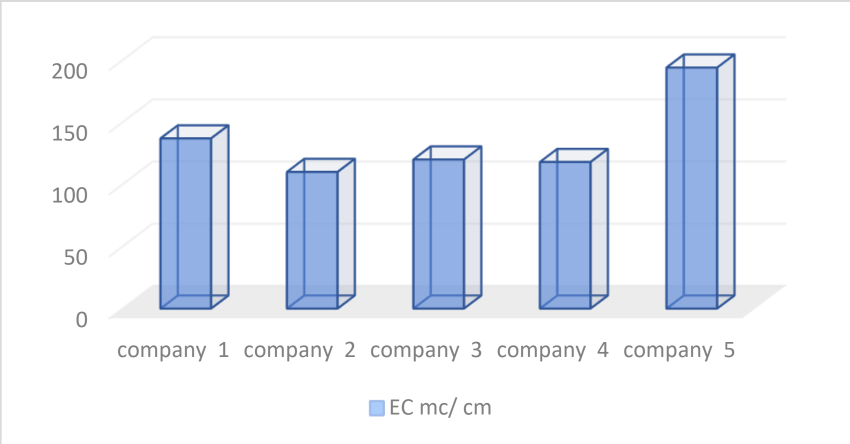

Figure 2. The electrical conductivity values of the studied local water types

The chloride concentration in the water samples varied, with Company 1 showing the highest value at 23 mg/L, while Company 5 had the lowest at 2 mg/L. The nitrate (NO3) levels were all within safe limits, with Company 5 showing no detectable nitrates, and the highest level of 6 mg/L detected in Company 3.

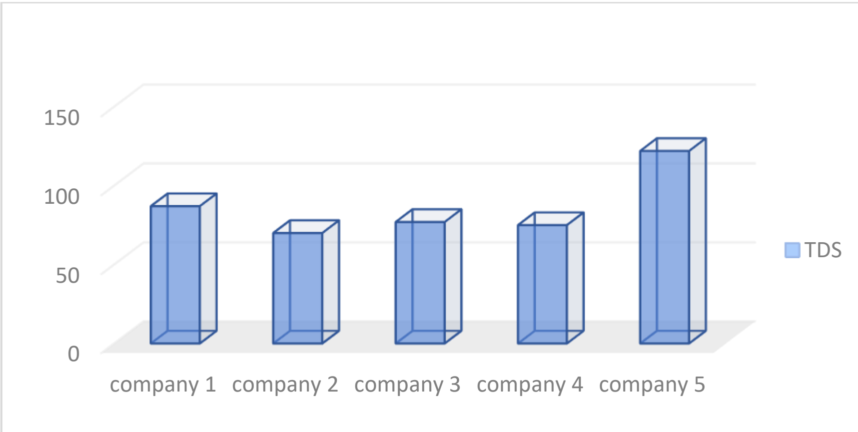

Figure 3. The values of total dissolved salts for the local water types studied

Calcium content ranged from 2 mg/L in Company 1 to 13 mg/L in Company 3, while magnesium levels varied from 1 mg/L in Company 2 to 18 mg/L in Company 5. Sodium concentrations showed considerable differences across the samples, with Company 1 having the highest value at 23 mg/L and Company 5 having the lowest at 0.8 mg/L. Potassium concentrations were generally low, ranging from 0.2 mg/L in Company 1 to 3.8 mg/L in Company 4.

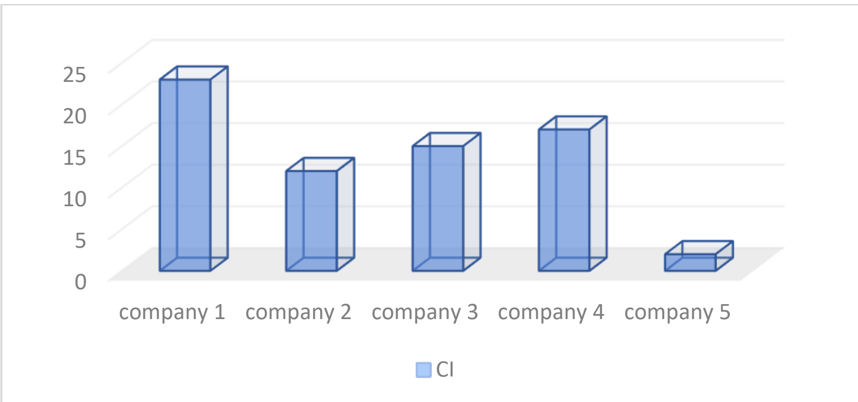

Figure 4. Shows chloride values for the local water types studied

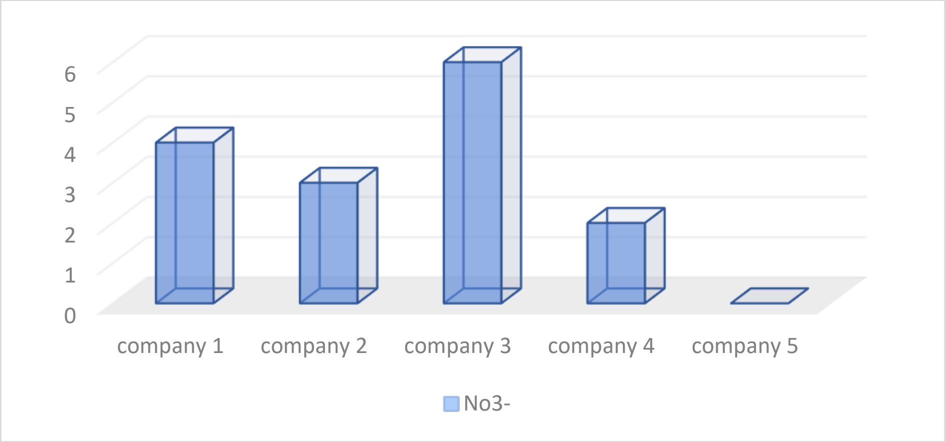

Figure 5. Values of nitrate and nitrite for the local water types studied

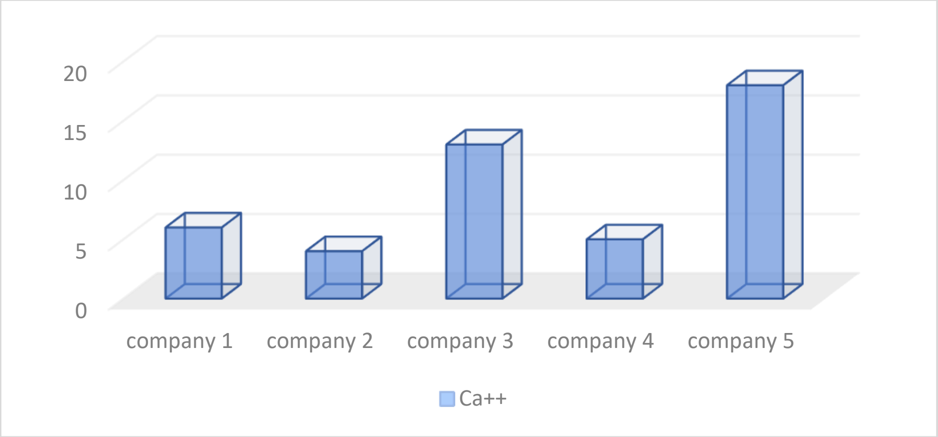

Figure 6. Values of Calcium for the local water types studied

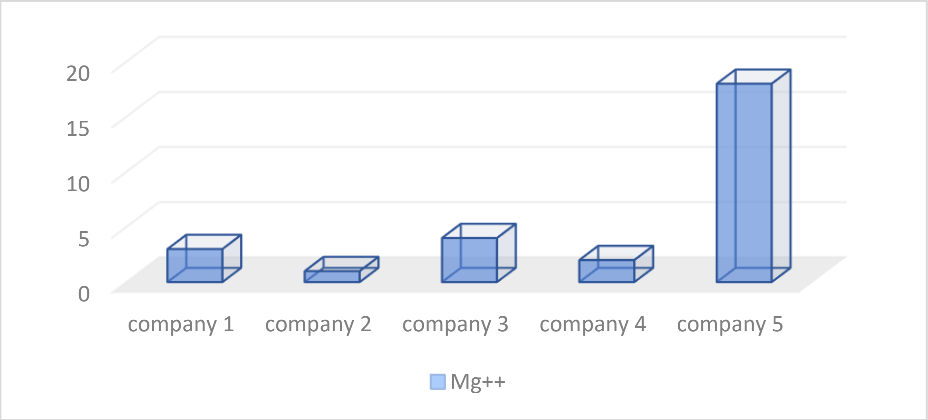

Figure 7. Values of magnesium for the local water types studied

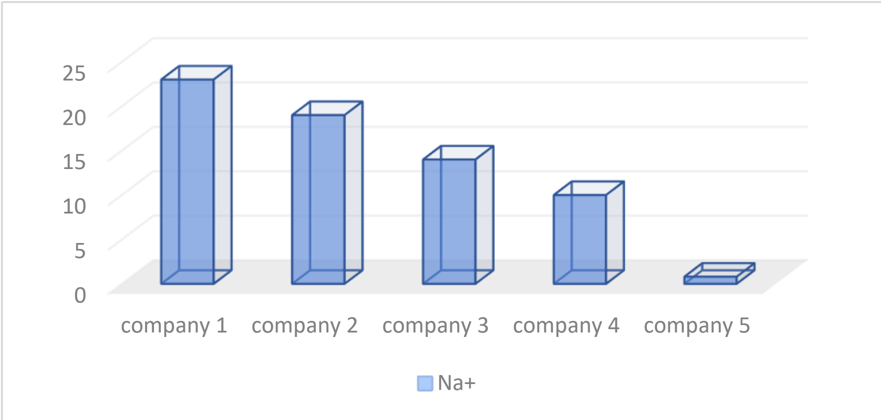

Figure 8. Values of sodium for the local water types studied

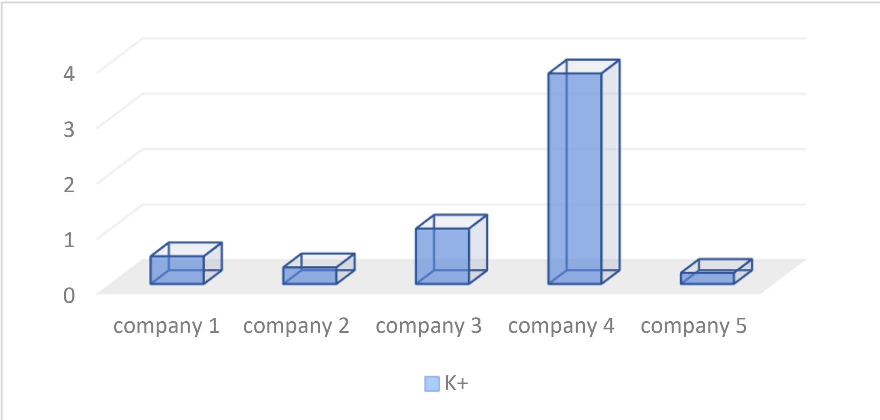

Figure 9. Values of potassium for the local water types studied

Analysis of Bacterial and Fungal Contamination in Water Samples from Various Companies. A recent study was conducted to assess the microbial quality of water samples from five different companies, aiming to determine if any contamination could compromise the water's suitability for either consumption or industrial purposes. This comprehensive analysis evaluated both the presence of bacteria and fungi, along with other physical properties such as dissolved salts. In the case of Company 1, all tests consistently demonstrated the absence of bacteria and fungi. The three rounds of testing conducted on the samples confirmed that the water was entirely free from microbial contamination, making it safe and suitable for use in various applications. Similarly, Company 2 also showed no signs of bacteria or fungi, but the samples revealed the presence of an undistinguished type of salt in a non-crystalline form. Although this indicates dissolved salts in the water, the lack of microbial contamination ensures that the water is still of good quality and safe for use. Company 3 followed the same pattern as Company 1, with all samples confirming the complete absence of bacteria and fungi This indicates that the water from this company is also clean and safe for consumption or industrial purposes. In contrast, the water samples from Company 4 contained large salt crystals, though no bacteria or fungi were detected. While the presence of these crystals highlights a higher concentration of mineral salts, there is no microbial threat to the water's safety, affirming its suitability for use. Lastly, the samples from Company 5 contained a percentage of impurities and salts, but like the other companies, there was no evidence of bacterial or fungal contamination. Although the impurities and salts may affect the water's physical properties, it remains free of microbial risks, ensuring it can be safely utilized.

Discussion

The results of the current study demonstrate that the pH values of the tested water samples ranged between 6.8 and 7.2, which is within the acceptable limits of the Libyan standard specifications for bottled drinking water (6.5–8.5). These results indicate that the water samples fall within the safe range, minimizing the risk of increased acidity or alkalinity that could affect water quality.

In terms of electrical conductivity (E.C.), the results revealed a range between 110 and 194 µS/cm, significantly lower than the maximum permissible limit of 1400 µS/cm set by the Libyan standards. This suggests that the tested water has a low concentration of dissolved ions, indicating good water quality, and is consistent with other studies in the region. For instance, the study by Najah et al. found similar results in commercial bottled water in Alkoms City, Libya, which confirms the reliability of purification processes [10].
Regarding total dissolved solids (TDS), the values ranged between 70 and 122 ppm, which is lower than the minimum acceptable limits. Such low levels of dissolved solids may indicate that the water is similar to distilled water, lacking essential minerals typically present in natural drinking water. While low TDS levels are not harmful, they might raise concerns about the potential lack of essential minerals for human health.
The chloride (Cl-) concentrations ranged from 2 to 23 ppm, well below the Libyan standard's maximum limit of 250 ppm. This indicates the absence of significant contamination from chloride sources, ensuring that the water is free from potential salt-related health risks. Similar findings were observed in other local studies, such as those by Shalouf et al. who also reported chloride levels well within acceptable ranges in Misurata's bottled water samples [8].
In terms of nitrate (NO3-) concentrations, the values were within the safe limits, ranging from 0.0 to 6 ppm, below the Libyan standard's maximum limit of 10 ppm. Nitrate is a common contaminant from agricultural runoff and improper waste disposal, but the low levels observed in this study indicate that the bottled water tested is safe from nitrate pollution. Previous studies, including the work of Brika and Alturki, also support the safety of bottled water with regard to nitrate contamination in the Tripoli region [7].
Finally, the study's microbiological analysis, while not detailed in the current results section, is supported by findings from another research. Studies in Tripoli and neighboring regions have consistently found that bottled water generally meets bacteriological safety standards, with bacterial counts remaining well below WHO recommendations. However, RO water samples have been found to occasionally harbor higher bacterial counts, as shown in recent studies conducted by Rbeida and Eteer [12]. This highlights the importance of proper maintenance of RO filtration systems to ensure water safety.
However, the overall chemical and physical characteristics of the bottled water samples tested in this study indicate that the water is of good quality and complies with Libyan standards for drinking water and the low TDS levels suggest that the water might be too purified, lacking beneficial minerals. Continued monitoring of bottled water quality and more frequent inspections of RO systems are recommended to maintain public health and ensure access to safe drinking water.

Conclusion

The results of this study indicate that the locally bottled drinking water samples analyzed are generally of good quality and comply with the Libyan standard specifications for drinking water. The pH, electrical conductivity (E.C.), total dissolved solids (TDS), chloride (Cl-), and nitrate (NO3-) levels in all samples were within the permissible limits, suggesting that the water is safe for consumption. The low levels of TDS observed in some samples may indicate that the water is highly purified, potentially lacking essential minerals, which could be a point of concern for long-term health effects. However, these low levels do not pose any immediate health risks. The absence of significant chloride contamination and the low nitrate levels further affirm the safety of the water. Although the study primarily focused on the chemical composition, it is recommended to continue monitoring both the chemical and microbiological quality of bottled water, particularly in regard to RO water systems, which can sometimes have elevated bacterial counts if not properly maintained. Overall, the findings of this study highlight the importance of ongoing water quality assessments to ensure that bottled drinking water remains safe, healthy, and in line with national and international standards.

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