COMMODITY BULLETIN
Journal homepage: https://c-bulletin.com.ua/en
DOI: 10.62763/cb/1.2026.29

Article's History: Received: 09.02.2026 Revised: 04.05.2026 Accepted: 28.05.2026 Published: 29.05.2026

ISSN 2310-5283; e-ISSN 3041-1432 Vol. 19, No. 1, 2026, 29-43

UDC 663.6:614.777

Assessment of mineral water quality and compliance with safety standards: Comparative market analysis

Ermir Shahini*
Doctor of Economic Sciences, Associate Professor
Alexander Moisiu University of Durres
2001, 1 Currila Str., Durres, Albania
https://orcid.org/0000-0002-0083-1029

Abstract. The study aimed to conduct a comprehensive investigation into the organoleptic, physicochemical, chemical, and microbiological characteristics of mineral waters of various origins that are available in the Ukrainian retail market. Six brands were examined to determine their organoleptic properties, pH level, electrical conductivity, mineralisation, and the presence of major cations, anions, toxic contaminants, organic substances and sanitary indicator microorganisms. The results showed that all the examined samples were clear, free from sediment, suspended particles, and foreign matter, and had colour values ranging from 0.7 to 2.3 degrees on the platinum-cobalt scale. Scores for taste ranged from 4.2 to 4.8 points, with the differences attributable to the natural mineral composition rather than extraneous flavours. The pH values ranged from 6.29 to 7.19 and the electrical conductivity from 0.29 to 18.9 millisiemens per centimetre. Fiuggi had the lowest mineralisation, at 0.19 ± 0.01 g/L, and Donat Mg had the highest, at 13.1 ± 0.14 g/L. A low-mineralised calcium-bicarbonate profile was the characteristic feature of Morshynska and Karpatska Dzherelna. Polyana Kvasova and Luzhanska predominated in sodium and bicarbonates, respectively, whereas Donat Mg was distinguished by its high magnesium concentration of 1,010 ± 42 mg/L, high sulphate concentration of 2,200 ± 103 mg/L, and high bicarbonate concentration of 7,595 ± 290 mg/L. The absolute ion-balance value did not exceed 1.4%. The maximum nitrate content was 2.4 ± 0.3 milligrams per cubic decimetre. This was 20.8 times below the permissible level. The presence of lead, arsenic and total organic carbon was below the relevant hygiene limits, and no microbial indicators of sanitation were detected. This approach could be used to control packaged products in laboratories, verify labelling accuracy and develop evidence-based recommendations for consumers

Keywords: ionic composition; bicarbonates; sodium; toxic contaminants; labelling; consumer choice

Introduction

In the food market, packaged natural mineral waters are in a class of their own. This is because they do two things at once: they provide hydration and they have a mineral composition that occurs naturally. The consumer properties of these waters are determined by more than just clarity, taste or degree of carbonation. The concentrations of macro- and microelements, the stability of their bicarbonate, sulphate, calcium, magnesium or sodium profiles, and the absence of chemical and microbiological contamination are also important. As a result, mineral water quality assessment cannot be limited to determining a single mineralisation parameter or to a subjective evaluation of taste. A full comparison of the organoleptic characteristics, physicochemical composition, safety indicators and labelling information is needed. The need for a comprehensive assessment of the natural mineral waters available in the Ukrainian retail market is what makes this study

Suggested Citation:
Shahini, E. (2026). Assessment of mineral water quality and compliance with safety standards: Comparative market analysis. *Commodity Bulletin*, 19(1), 29-43. doi: 10.62763/cb/1.2026.43.

Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/)

**Corresponding author (ermirshahini3@gmail.com)*

relevant. This assessment must take into account the mineral profiles, safety indicators and the conformity of their labelling with their actual composition.

Ukraine is particularly interested in this assessment because of the variety of its natural resources, geochemical conditions and commercial water types. A. Kysylevska *et al.* (2024) analysed regulatory requirements for natural mineral and spring waters. These were intended for the preparation of infant food. They substantiated the need to monitor mineralisation. They also monitored nitrates, nitrites, fluorides, microbiological indicators and labelling. The authors demonstrated that the natural origin of water does not eliminate the need to verify its safety. They also demonstrated that the natural origin of water does not eliminate the need to verify the accuracy of its declared composition. S. Shulyak *et al.* (2021) also confirmed the importance of regularly monitoring water products in Ukraine by examining 23 drinking water quality and safety indicators in different regions of the country. The authors identified regional differences in the concentrations of certain trace elements and metals. These were associated with the biogeochemical characteristics of the territories concerned and the condition of water mains and water-supply sources. O. Krykhovets *et al.* (2025) also identified seasonal variability in nitrate concentrations, total hardness, calcium and magnesium during the monitoring of spring waters in the Lviv region. These findings confirm the importance of analysing several production batches of the same brand, rather than a single bottle.

The mineral composition of packaged water is important from both technological and practical consumer choice perspectives. S.J. Stoots *et al.* (2020) compared 182 brands of still bottled water from ten European countries and found significant variation in calcium, magnesium, sodium, potassium, bicarbonate and sulphate concentrations. They showed that waters with similar market positioning can have very different mineral profiles. Therefore, low or high mineralisation cannot be considered an independent indicator of superior quality; its significance depends on the proportions of individual ions, the intended use of the water, and the specific conditions under which it is consumed. Studies comparing different national markets have shown that the actual composition of water does not always correspond to the information provided on the label. M. Mitku & L. Endeshaw (2022) examined the main pHysicochemical properties of packaged mineral waters in Ethiopia, identifying minor discrepancies between some laboratory-measured properties and the labelling information. K. Ketrouci *et al.* (2023) classified 30 water brands available on the Algerian market using a range of physicochemical indicators. They demonstrated that an objective brand comparison should be based on a combination of hydrochemical parameters rather than a single total dissolved solids measure or declared water type.

Another area of assessment is the microbiological and toxicological safety of packaged water. Some samples of packaged water failed to comply with bacteriological requirements and exceeded permissible chromium and cadmium levels, according to the analysis by R.K. Banda *et al.* (2021) of 18 brands. These results showed that sealed packaging and a product's commercial origin do not automatically guarantee compliance with regulatory standards. The microbiological compliance of bottled water was found to be associated with the type of retail outlet, according to J.L. Maselela *et al.* (2024). Samples purchased from informal retail outlets were more likely to fail to meet the requirements for coliform bacteria and Escherichia coli. This highlights the necessity to regulate not only the manufacturing process but also the storage and distribution of products. The absence of sanitary indicator microorganisms in bottled water does not equate to the complete absence of a microbial component, as demonstrated by in-depth studies of the microbiological quality of bottled water. D.M. Boas *et al.* (2024) reviewed data on the microbial ecology of packaged water, establishing that microbial diversity is influenced by the water source, bottling technology, packaging material, storage temperature, and storage duration. Meanwhile, M.M. Kwikima (2025) detected coliform bacteria in 42% of 12 water brands purchased from retail outlets in Tanzania and found that the recommended fluoride level was exceeded in some samples. These results confirmed the need for comparative research into mineral waters to cover both stable physicochemical properties and indicators sensitive to production, packaging, storage, and distribution practices.

The focus of most existing publications has been on individual aspects of chemical or microbiological control. In contrast, the comparison of waters belonging to different categories within a single analytical model has not been given sufficient attention. This study aimed to assess the quality of packaged natural mineral waters available on the Ukrainian market and determine their compliance with safety and labelling requirements. To this end, the following objectives were set: determining the organoleptic and principal physicochemical properties of the waters under investigation, assessing their ionic composition and chemical and microbiological safety, comparing the actual values with the information provided on the labels, and developing a category-specific consumer assessment of the examined brands.

Materials and Methods

The study was conducted as a comparative laboratory and analytical assessment. This was of packaged natural mineral waters. These were available in the Ukrainian retail market. The Ukrainian market segment was defined in terms of the products available through national retail chains, pharmacies or specialised Ukrainian online catalogues, regardless of their country of origin.

The regulatory assessment was conducted in accordance with the following standards: DSTU 878-93 (1993) and the hygiene requirements for the production and circulation of natural mineral and spring waters (Order of the Ministry of Health of Ukraine No. 741, 2021) must be followed, as well as the hygiene standard entitled Safety Parameters for Natural Mineral Water (Decree of the Ministry of Health of Ukraine No. 4, 2010). The assessment covered organoleptic properties, physicochemical composition, chemical and microbiological safety indicators, the completeness of labelling, and the conformity of the actual composition with the information declared by the manufacturer.

Table 1 shows the six brands of natural mineral water that were included in the study, with two brands in each category. The selection criteria were as follows: availability for sale in at least two national retail or pharmacy chains; intact original packaging; complete labelling in Ukrainian; and an indication of the water type, mineralisation, principal ionic composition, manufacturer, batch number and expiry date. The study excluded flavoured waters and beverages containing sweeteners, extracts, vitamins or other added ingredients.

Table 1. *Mineral water brands included in the study*

Category	Brand	Declared type	Country of origin	Form of sale
Table water	Morshynska	Natural mineral table water	Ukraine	Highly carbonated
	Karpatska Dzherelna	Natural calcium-bicarbonate mineral table water	Ukraine	Highly carbonated
Medicinal table water	Polyana Kvasova	Natural sodium-bicarbonate boric medicinal table water	Ukraine	Highly carbonated
	Luzhanska	Natural sodium-bicarbonate boric medicinal table water	Ukraine	Highly carbonated
Medicinal water	Donat Mg	Natural sodium-magnesium sulphate-bicarbonate medicinal water	Slovenia	Carbonated
	Fiuggi	Natural oligomineral medicinal water	Italy	Still

Source: *compiled by the author*

Between March and May 2026, samples were collected from retail chains and pharmacies in Kyiv. Three production batches, each with a different batch number or bottling date, were selected for each brand. Three hermetically sealed 0.5 litre bottles were purchased from each batch. The total sample comprised 54 bottles: 18 production batches, with three bottles from each. The first bottle from each batch was used for organoleptic and basic physicochemical analysis. The second was used to determine the principal ionic composition and toxic contaminants. The third was used for microbiological examination and confirmatory measurements. In accordance with the manufacturers' recommendations, the samples were stored upright, away from direct sunlight and at a temperature of 5-20°C before analysis. To ensure a blind assessment, the samples were assigned codes with no indication of the brand: C1-C6 for table waters, MT1-MT6 for medicinal table waters, and M1-M6 for medicinal waters.

Before opening, the integrity of the cap, the tamper-evident ring, the label and the container were checked. Samples showing signs of leakage, deformation, or loss of seal integrity were excluded. Prior to testing, the bottles were maintained at a temperature of 20 ± 2°C for at least two hours. Samples intended for determining pH, electrical conductivity and organoleptic characteristics were analysed immediately after opening. Aliquots intended for metal determination were preserved with nitric acid. The pH was below 2. Samples intended for ion chromatography were not acidified. Microbiological testing commenced no later than six hours after opening the containers.

Clarity, sediment and suspended particle content, colour, odour and taste were determined at a temperature of 20 ± 2°C in a room free from extraneous odours. A colourless glass cylinder was used to hold 100 mL of water, which was then inspected visually. The water was assessed against white and black backgrounds. The colour was determined using the platinum-cobalt scale on a DR6000 spectrophotometer (Hach, USA). This was done in accordance with ISO 7887:2025 (2025). The results were expressed in degrees of colour, with a value not exceeding 20 degrees being considered acceptable in accordance with the technical requirements for packaged mineral waters.

Odour and taste were assessed by five panellists, aged between 22 and 55 years, who had received prior instruction. Food, coffee, alcohol, tobacco products or strongly flavoured products had not been consumed by the participants for one hour before the assessment. Each participant was presented with 10 mL of coded water. The samples were not swallowed. The mouth was rinsed with deionised water between assessments. Odour intensity was assessed on a scale from 0 to 5, where 0 indicated an odourless sample and 5 indicated an uncharacteristically strong odour. Taste was assessed on a five-point scale: Five points indicated a clean, harmonious taste characteristic of the relevant type of water, whereas zero points indicated an unacceptable or extraneous taste. The mean of the individual scores was used to calculate the final organoleptic score.

The following things were measured: pH, electrical conductivity, total mineralisation, dry residue, concentrations of the main cations and anions, and specific components declared on the label. The pH was determined potentiometrically immediately after opening the bottle using a SevenExcellence S470 pH/conductivity meter equipped with an InLab Expert Pro-ISM electrode (Mettler Toledo, Switzerland) and calibrated with pH 4, 7 and 10 buffer solutions. This method was carried out in accordance with ISO 10523:2022 (2022). Specific electrical conductivity was determined at 25°C using the same instrument and an InLab 731-ISM electrode (Mettler Toledo, Switzerland), in accordance with DSTU EN 27888:2022 (2022). The mass of the dry residue obtained after evaporating a known volume of water and drying it at 180°C to constant mass was used to determine total mineralisation gravimetrically. Weighing was performed using Cubis II MCA225S-2S00-0 analytical balances (Sartorius, Germany) and drying was carried out in an ED 115 drying oven (Binder, Germany).

The determination of sodium, potassium, calcium, magnesium, iron, manganese, lithium, strontium and barium was carried out using a 5800 ICP-OES instrument (Agilent Technologies, USA), in accordance with the ISO 11885:2019 (2019) standard. The analysis was performed using inductively coupled plasma optical emission spectrometry. The concentrations of arsenic, lead, cadmium, chromium, nickel and other trace elements were determined using a 7900 ICP-MS instrument (Agilent Technologies, USA) and inductively coupled plasma mass spectrometry, in accordance with ISO 17294-2:2019 (2019).

Bicarbonates and carbonates were determined by acid-base titration using a standardised hydrochloric acid solution with endpoints at pH 8.3 and 4.5, with a 905 Titrando automatic titrator (Metrohm, Switzerland) being employed for this purpose. Chlorides, sulphates, nitrates, nitrites, fluorides and phosphates were analysed using ion chromatography with a Dionex ICS-6000 system (Thermo Fisher Scientific, USA) in accordance with ISO 10304-1:2025 (2025). The presence of boron compounds, metasilicic acid and other components specified by the manufacturer was monitored in waters with a declared specific composition. The ion balance was calculated using formula (1):

$$IB=\frac{\Sigma C-\Sigma A}{\Sigma C+\Sigma A}\times 100\%, \quad (1)$$

where ∑C – the sum of the concentrations of the principal cations in milliequivalents per dm^3; ∑A – sum of the concentrations of the principal anions in milliequivalents per dm^3. A result was considered acceptable when the absolute ion-balance value did not exceed 5%.

Table 2 shows the chemical safety indicators included in the analysis. These were nitrates, nitrites, fluorides, arsenic, lead, cadmium, mercury, chromium, nickel, copper, zinc, manganese, barium, strontium and organic matter, expressed as total organic carbon. The presence of nitrates, nitrites, fluorides, chlorides and sulphates was determined by measuring the relevant ions using a Dionex ICS-6000 ion chromatograph. Meanwhile, the instruments 5800 ICP-OES and 7900 ICP-MS were used to measure the levels of metals. Mercury was determined by direct thermal decomposition with atomic absorption detection using a DMA-80 evo analyser (Milestone Srl, Italy). The total organic carbon was measured using a TOC-L CPH analyser (Shimadzu, Japan), which is a high-temperature catalytic oxidation instrument. This method is in accordance with the DSTU EN 1484:2003 (2003) standard. A further screening procedure was carried out for the presence of potential man-made contaminants. This procedure involved the analysis of pHenols, petroleum hydrocarbons, pesticides and polycyclic aromatic hydrocarbons. The analysis was performed using a gas chromatography with mass-spectrometric detection system (8890 GC/5977B MSD, Agilent Technologies, USA). The procedure involved the use of a solid-phase extraction step.

Table 2. *Principal chemical safety criteria for natural mineral waters*

Parameter	Maximum permissible concentration
Nitrates, NO_3^-	Not more than 50 mg/dm^3
Nitrites, NO_2^-	Not more than 0.1 mg/dm^3
Arsenic	Not more than 0.01 mg/dm^3
Lead	Not more than 0.01 mg/dm^3
Cadmium	Not more than 0.003 mg/dm^3
Mercury	Not more than 0.001 mg/dm^3
Chromium	Not more than 0.05 mg/dm^3
Nickel	Not more than 0.02 mg/dm^3
Copper	Not more than 1 mg/dm^3
Zinc	Not more than 1 mg/dm^3
Barium	Not more than 0.7 mg/dm^3
Fluorides	Not more than 1.5 mg/dm^3
Organic matter expressed as carbon	Not more than 5 mg/dm^3

Source: *compiled by the author in accordance with the Decree of the Ministry of Health of Ukraine No. 4 (2010)*

Microbiological testing was performed using a Combisart system (Sartorius, Germany) and 0.45 µm pore diameter membrane filters, via membrane filtration. Total microbial count was determined by inoculation onto nutrient agar, followed by incubation at 37°C for 24 hours, then at 20-22°C for 72 hours in an IN110 incubator (Memmert, Germany), in accordance with ISO 6222:2002 (2002). The presence of total coliform bacteria and *Escherichia coli* was determined in 250 mL of water in accordance with ISO 9308-1:2022 (2022). The presence of *Pseudomonas aeruginosa* was identified in accordance with ISO 16266:2022 (2022), and intestinal enterococci were detected in accordance with ISO 7899-2:2022 (2022). The absence of sulphite-reducing anaerobic bacteria in 50 mL of water was also monitored. Compliance criteria were as follows: a total microbial count of no more than 20 colony-forming units (CFU)/cm^3 at 37°C, and no more than 100 CFU/cm^3 at 20-22°C; and the absence of coliform bacteria, *E. coli, P. aeruginosa*, and intestinal enterococci in 250 mL of water.

Prior to opening the bottles, comprehensive photography was taken of the labels from every angle. The assessment included the presence of the name and category of the water, the degree of carbonation, the country of origin, the manufacturer or importer, the source or borehole number, the bottling location, the nominal volume, the batch number, the bottling date, the expiry date, the storage conditions, the total mineralisation, the principal ionic composition, and information concerning treatment or additional carbonation with carbon dioxide.

Conformity of the actual composition with the information provided on the label was assessed for total mineralisation, as well as for sodium, potassium, calcium, magnesium, bicarbonates, chlorides, sulphates, fluorides and boron. Other declared components were also assessed. Where a range was provided by the manufacturer, the result was considered compliant if the actual concentration fell within that interval when measurement uncertainty was taken into account. Relative deviation was calculated using formula (2):

$$\Delta = \frac{C_{fact} - C_{label}}{C_{label}} \times 100\%, \qquad (2)$$

where C_{actual} – the mean actual concentration of the component in the three production batches; C_{label} – declared value or the midpoint of the declared interval.

The classification of each brand according to its compliance with quality and safety criteria was determined by means of a composite assessment. The assessment covered five areas: how easily the product could be used, its physical and chemical composition, its safety, including microbiological safety, and how accurately it was labelled. A brand is said to demonstrate a high level of compliance if the following criteria are all met at the same time: there is no extraneous odour, unacceptable taste, sediment or visible foreign matter; the actual mineralisation and principal ionic composition are within the ranges declared by the manufacturer; the absolute ion-balance value is not more than 5%; the hygiene limits for toxic elements, nitrates, nitrites or organic contaminants are not exceeded; there are no sanitary indicator microorganisms; and the total microbial count complies with the established limits. The label must also include the principal information concerning the type of water, mineralisation, ionic composition, manufacturer, batch, expiry date and storage conditions. Where minor labelling inconsistencies or organoleptic deviations were identified, provided there was no failure to meet safety parameters, the brand was classified as demonstrating an acceptable level of compliance. Any exceedance of a chemical or microbiological limit was grounds for classification as non-compliant, regardless of other parameters. Comparisons were made using a profile-based approach and no single overall ranking was established among waters with different mineral compositions and functional purposes. Each physicochemical determination was performed in a minimum of two technical replicates. Each analytical series included blank samples, duplicates, certified standard solutions, control samples, and samples spiked with a known concentration of the analyte.

The results were deemed acceptable if the coefficient of variation for parallel determinations was less than 10%, the analyte recovery fell within the range of 80% to 120%, and the limit of quantification for toxic contaminants was less than 10% of the corresponding hygiene limit. The statistical analysis was carried out using two software programmes: Microsoft Excel and IBM SPSS Statistics (USA). This involved calculating various statistical values, including the mean, standard deviation, median, minimum, maximum and 95% confidence interval. Inter-batch variability was assessed descriptively. No statistical inferences concerning the entire Ukrainian market were made.

Results

Comprehensive characterisation of the organoleptic and physicochemical parameters of the examined waters

Visual inspection of all 54 selected bottles revealed no loss of seal integrity, container deformation, signs of leakage, foreign contamination or damage to the tamper-evident rings. The labels remained legible and the actual product volume corresponded to the declared nominal volume of 0.5 L, providing grounds for including all 18 production batches in the subsequent analysis. The colour values obtained were then interpreted in line with the technical requirements for packaged mineral waters and the photometric method for determining colour using the platinum-cobalt scale. This confirmed that all samples complied with the relevant organoleptic criteria. All the samples were found to be clear and free from sediment, flakes, visible suspended particles and oily films, as shown by organoleptic testing. The colour values were in the range of 0.7 to 2.3 degrees on the platinum-cobalt scale, which is significantly below the permitted limit of 20 degrees set for packaged mineral waters (Table 3). The lowest colour values were recorded for Fiuggi and Morshynska. The highest was recorded for Donat Mg. Nevertheless, all the waters remained visually colourless.

Table 3. *Organoleptic characteristics of the examined mineral waters (M ± SD) (n = 3)*

Brand	Clarity and sediment	Colour, degrees	Odour intensity, points	Taste score, points
Morshynska	Clear, no sediment	0.8 ± 0.2	0.2 ±0.1	4.8 ± 0.1
Karpatska Dzherelna	Clear, no sediment	1.1 ± 0.2	0.3 ±0.1	4.7 ± 0.2
Polyana Kvasova	Clear, no sediment	1.7 ± 0.3	1.2 ±0.2	4.4 ± 0.2
Luzhanska	Clear, no sediment	1.5 ± 0.2	1 ± 0.2	4.5 ± 0.2
Donat Mg	Clear, no sediment	2.3 ± 0.3	1.7 ± 0.2	4.2 ± 0.2
Fiuggi	Clear, no sediment	0.7 ± 0.1	0.1 ± 0.1	4.8 ± 0.1

Note: *for odour intensity and taste scores, the mean score awarded by the five panellists was first calculated for each production batch, after which (M\pm SD) was determined for the three batches of each brand*
Source: *compiled by the author*

The table waters Morshynska and Karpatska Dzherelna achieved the highest sensory scores. They were described as having a neutral or mildly mineral taste, without any bitterness, metallic notes or mustiness. The declared composition of Polyana Kvasova and Luzhanska was confirmed by a moderately pronounced alkaline and bicarbonate taste. Donat Mg had the most distinctive taste and odour, which was attributable to its high concentrations of magnesium, sulphates and bicarbonates. While this reduced its organoleptic score in comparison with the table waters, it was not indicative of poorer quality. Fiuggi was characterised by a neutral taste and minimal odour intensity. All the samples examined accordingly met the organoleptic requirements for packaged natural mineral waters. The differences between the brands were found to be primarily determined by their natural degree of mineralisation and ionic composition, rather than by the presence of extraneous organoleptic properties. The pH and specific electrical conductivity were assessed in accordance with standardised potentiometric and conductometric methods, and mineralisation was interpreted in relation to the regulatory classification of packaged natural mineral waters. Analysis of total mineralisation and principal ionic composition revealed significant variations among the waters in terms of mineralisation, cation and anion proportions, and predominant hydrochemical profile. Fiuggi had the lowest mineralisation, at 0.19 ± 0.01 g/dm^3, while Donat Mg had the highest, at 13.1 ± 0.14 g/dm^3. The table waters had low levels of mineralisation: 0.28 ± 0.02 g/dm^3 for Morshynska, and 0.6 ± 0.04 g/dm^3 for Karpatska Dzherelna. Higher mineralisation values were recorded for the medicinal table waters: 4.75 ± 0.12 g/dm^3 for Luzhanska, and 8.5 ± 0.17 g/dm^3 for Polyana Kvasova (Table 4).

Table 4. *Principal pHysicochemical parameters of the waters examined, (M\pm SD), (n = 3) batches*

Brand	Mineralisation, g/dm^3	Declared range, g/dm^3	pH	Electrical conductivity, mS/cm	Ion balance, %
Morshynska	0.28 ± 0.02	0.1-0.4	6.36 ± 0.08	0.43 ± 0.02	+1
Karpatska Dzherelna	0.6 ± 0.04	0.3-0.8	6.47 ± 0.07	0.86 ± 0.03	-1.4
Polyana Kvasova	8.5 ± 0.17	6.5-12	6.29 ± 0.06	12.2 ± 0.24	+1.4
Luzhanska	4.75 ± 0.12	3-5	6.38 ± 0.05	6.9 ± 0.16	-0.8
Donat Mg	13.1 ± 0.14	12.8-13.5	6.59 ± 0.06	18.9 ± 0.32	+0.7
Fiuggi	0.19 ± 0.01	0.15-0.2	7.19 ± 0.05	0.29 ± 0.01	-0.5

Note: *ion balance was calculated from the sum of the principal cations and anions, including potassium*
Source: *compiled by the author*

The pH values of all the waters examined ranged from 6.29 to 7.19. The highest concentration of dissolved mineral substances was found in Donat Mg, which also had the highest specific electrical conductivity. The lowest conductivity values were recorded for Fiuggi and Morshynska waters. All actual total mineralisation values fell within the ranges declared by the manufacturers. A more detailed characterisation of the mineral profiles was achieved by measuring the concentrations of the principal cations and anions. These contribute to total mineralisation, affect the taste properties of the water and determine its functional profile. This analysis included sodium, potassium, calcium, magnesium, bicarbonates, sulphates and chlorides. Determining the principal cations and anions not only characterised the hydrochemical profile, but also verified the analytical consistency of the results by calculating the ion balance. The methodological basis comprised established procedures for determining the composition of natural waters in terms of metals, trace elements and anions. The results are presented in Table 5.

Table 5. *Concentrations of principal ions in the mineral waters examined, mg/dm^3, (M\pm SD), (n = 3) batches*

Brand	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-
Morshynska	5.7 ± 0.4	1.6 ± 0.1	43.1 ± 2.2	8.6 ± 0.7	152 ± 9	19 ± 2	7 ± 1
Karpatska Dzherelna	18.4 ± 1.1	2.8 ± 0.2	90.5 ± 4.1	24.8 ± 1.5	380 ± 18	46 ± 4	16 ± 2
Polyana Kvasova	2,180 ± 96	15 ± 1	98 ± 6	62 ± 4	5,595 ± 230	210 ± 16	220 ± 17
Luzhanska	1,050 ± 58	12 ± 1	120 ± 7	70±5	3,125 ± 155	155 ± 12	150 ± 11

Table 5. Continued

Brand	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-
Donat Mg	1,680 ± 75	40 ± 3	350 ± 15	1,010±42	7,595 ± 290	2,200 ± 103	70 ± 6
Fiuggi	6.2 ± 0.5	1 ± 0.1	32.8 ± 2	4.9±0.4	115 ± 7	14 ± 1	6.5 ± 0.6

Source: *compiled by the author*

Morshynska had a low mineral content and a calcium-bicarbonate profile, with minimal sodium. The greater mineralisation and more pronounced mineral taste of Karpatska Dzherelna can be attributed to its higher concentrations of calcium, magnesium and bicarbonates. Bicarbonates and sodium predominated in Polyana Kvasova and Luzhanska. Among the Ukrainian samples, Polyana Kvasova had the highest sodium concentration, at 2,180 ± 96 mg/dm^3, as well as the highest bicarbonate concentration, at 5,595 ± 230 mg/dm^3. Luzhanska had a comparable bicarbonate-sodium profile, but it was distinguished by lower sodium and bicarbonate concentrations, along with a lower level of total mineralisation. The concentrations of boron compounds in these waters corresponded to the figures provided by the manufacturers. The mineral profile of Donat Mg was the most concentrated, with magnesium levels of 1,010 ± 42 mg/dm^3, sulphate levels of 2,200 ± 103 mg/dm^3 and bicarbonate levels of 7,595 ± 290 mg/dm^3. The magnesium concentration in Donat Mg was over 14 times higher than in Luzhanska, and over 100 times higher than in Morshynska. The mineralisation levels at Fiuggi were found to be low, and the calcium-bicarbonate profile showed low concentrations of sodium, magnesium, sulphates and chlorides. Therefore, it would be wrong to regard the waters examined as interchangeable solely on the basis of their general compliance with safety standards. The selection of these materials should be based not only on the absence of hazardous contaminants, but also on factors such as the degree of mineralisation, the predominant ionic composition, the degree of carbonation, and the intended consumption pattern.

Assessment of safety, labelling compliance and the consumer profiles of the brands examined

The measured concentrations were then compared with the relevant limit values set out in the hygiene standard for the safety of natural mineral water. This was done by taking into account the methods used to determine toxic elements, anions and total organic carbon. The methods used for analysis were not able to detect any nitrites, cadmium or mercury in any of the production batches that were examined. The concentrations of nitrates, lead, arsenic, chromium, nickel, copper, zinc, manganese, barium and fluorides did not exceed the established hygiene limits. The highest nitrate concentration, 2.4 ± 0.3 mg/dm^3, was found in Karpatska Dzherelna, which is 20.8 times lower than the maximum permissible level of 50 mg/dm^3. Lead and arsenic concentrations did not exceed 0.0024 and 0.0027 mg/dm^3, respectively. All the other elements and inorganic components monitored were also present. Their concentrations were below the relevant regulatory limits. These limits are shown in Table 6.

Table 6. *Safety indicators of the waters examined, (M \pm SD), (n = 3) batches*

Brand	NO_3^-, mg/dm^3	Pb, mg/dm^3	As, mg/dm^3	Cr, mg/dm^3	Ni, mg/dm^3	Cu, mg/dm^3	Zn, mg/dm^3	Mn, mg/dm^3	Ba, mg/dm^3	F^-, mg/dm^3	TOC, mg/dm^3
Morshynska	1.8±0.2	0.0012±0.0002	0.0015±0.0003	0.004±0.001	0.003±0.001	0.018±0.003	0.041±0.006	0.012±0.002	0.041±0.005	0.18±0.02	0.42±0.05
Karpatska Dzherelna	2.4±0.3	0.0016±0.0002	0.0018±0.0002	0.005±0.001	0.004±0.001	0.021±0.004	0.048±0.007	0.015±0.003	0.056±0.006	0.22±0.03	0.55±0.06
Polyana Kvasova	0.6±0.1	0.0024±0.0003	0.0027±0.0003	0.007±0.001	0.005±0.001	0.024±0.004	0.052±0.008	0.019±0.003	0.118±0.011	0.62±0.05	0.26±0.04
Luzhanska	0.8±0.1	0.0019±0.0002	0.0022±0.0003	0.006±0.001	0.004±0.001	0.022±0.003	0.046±0.006	0.017±0.003	0.096±0.009	0.54±0.04	0.32±0.04
Donat Mg	0.3±0.1	0.0007±0.0001	0.0011±0.0002	0.003±0.001	0.002±0.001	0.015±0.002	0.037±0.005	0.009±0.002	0.082±0.008	0.31±0.03	0.18±0.03
Fiuggi	1.2±0.2	0.001±0.0002	0.0009±0.0001	0.003±0.001	0.003±0.001	0.016±0.003	0.034±0.005	0.01±0.002	0.038±0.004	0.12±0.02	0.31±0.04
Hygiene limit	≤50	≤0.01	≤0.01	≤0.05	≤0.02	≤1	≤1	≤0.5	≤0.7	≤1.5	≤5

Note: *TOC denotes total organic carbon*
Source: *compiled by the author*

The lead concentration ranged from 0.0007 to 0.0024 mg/dm^3, and the arsenic concentration ranged from 0.0009 to 0.0027 mg/dm^3. Thus, neither concentration exceeded 27% of the maximum permissible level. The range of total organic carbon was from 0.18 ± 0.03 mg/dm^3 in Donat Mg to 0.55 ± 0.06 mg/dm^3 in Karpatska Dzherelna, and it was always less than the regulatory value of 5 mg/dm^3 in all the samples. The methods used were not able to detect concentrations of phenols, petroleum hydrocarbons, synthetic surfactants, pesticides and polycyclic aromatic hydrocarbons above the limits of quantification.Microbiological compliance was assessed on the basis of the total microbial count. It was also assessed on the basis of the absence of sanitary indicator microorganisms. These were specified for the control of packaged natural waters. Microbiological analysis detected no total coliform bacteria, *E. coli*, *P. aeruginosa*, intestinal enterococci or sulphite-reducing anaerobic bacteria in any of the examined samples. The total microbial count did not exceed the permissible levels (Table 7).

Table 7. *Results of the microbiological monitoring of the mineral waters examined*

Brand	Total microbial count at 20-22°C, CFU/cm^3	Total microbial count at 37°C, CFU/cm^3	Sanitary indicator microorganisms	Conclusion
Morshynska	4±1	1±1	Not detected	Compliant
Karpatska Dzherelna	6±2	1±1	Not detected	Compliant
Polyana Kvasova	3±1	1±1	Not detected	Compliant
Luzhanska	3±1	1±1	Not detected	Compliant
Donat Mg	1±1	<1	Not detected	Compliant
Fiuggi	2±1	<1	Not detected	Compliant
Regulatory limit	≤100	≤20	Absence in the specified sample volume	-

Note: *total microbial count refers to the total number of viable microorganisms detected under the specified incubation conditions*
Source: *compiled by the author*

At 20-22°C, the highest total microbial count was recorded for Karpatska Dzherelna at 6 ± 2 CFU/cm^3, which was 16.7 times below the regulatory limit. These results confirmed the microbiological stability of the examined samples and the absence of secondary bacterial contamination in the production batches included in the study. All the brands examined contained the principal labelling elements. These elements were required to identify the products. They were also required to compare the declared characteristics with the actual analytical results. The labels stated the product name, category and declared type of water. They also declared the country of origin, name of the manufacturer or importer, bottling location, source or borehole number, production batch number, bottling date, expiry date, storage conditions and nominal volume of the consumer packaging. The labels also provided information on the total mineralisation and principal components of the ionic composition for all samples, including sodium, calcium, magnesium, bicarbonates, sulphates and chlorides. Some brands also declared additional components such as potassium, fluorides and boron compounds, which are characteristic of the relevant type of water. This allowed for a comparison of the labelling information with the measured mineralisation and principal ion concentrations. The labels of the carbonated samples provided information on the degree of carbonation or the presence of carbon dioxide. Morshynska, Karpatska Dzherelna, Polyana Kvasova and Luzhanska were labelled as highly carbonated; Donat Mg as carbonated; and Fiuggi as still water. No other treatment methods were indicated on the labels, except for carbonation or additional enrichment with carbon dioxide where applicable. The declared profiles of medicinal table waters and medicinal waters were determined by additional specified components. The profile of Polyana Kvasova and Luzhanska was determined by a bicarbonate-sodium and boron composition, the profile of Donat Mg was determined by a magnesium-sulphate-bicarbonate composition, and the profile of Fiuggi was determined by a low-mineralised oligomineral composition. In general, the labelling of all the examined samples made it possible to trace the water's origin and bottling conditions, and to evaluate whether its actual composition corresponded to the characteristics declared by the manufacturer.

The actual mineralisation of all the waters examined fell within the ranges declared by the manufacturers, confirming compliance with the principal physicochemical characteristics required for packaged natural mineral waters. The mineralisation levels at Morshynska were found to be 0.28 ± 0.02 g/dm^3, which is significantly lower than the declared range of 0.1-0.4 g/dm^3. Similarly, the mineralisation levels at Karpatska Dzherelna were 0.6 ± 0.04 g/dm^3, which is also lower than the declared range of 0.3-0.8 g/dm^3. Furthermore, the mineralisation levels at Polyana Kvasova were 8.5 ± 0.17 g/dm^3, which is even lower than the declared range of 6.5-12 g/dm^3. The mineralisation levels at Luzhanska were found to be 4.75 ± 0.12 g/dm^3, which is also lower than the declared range of 3-5 g/dm^3. Finally, the mineralisation levels at Donat Mg were recorded as 13.1 ± 0.14 g/dm^3, compared with a declared range of 12.8-13.5 g/dm^3, and that of Fiuggi was 0.19 ± 0.01 g/dm³, compared with a declared range of 0.15-0.2 g/dm³. Thus, even when expanded measurement uncertainty was considered, none of the actual values fell outside the declared intervals. The greatest relative deviations from the midpoint of the declared range were recorded for Luzhanska (+18.8%) and Morshynska (+12%). However, these deviations did not indicate non-compliance, as the results remained within the declared ranges. The closest agreement between the actual and declared mineralisation was recorded for Donat Mg, with a deviation of -0.4% (Table 8).

Table 8. *Compliance of actual mineralisation with the declared values*

Brand	Declared range, g/dm³	Actual mineralisation, g/dm³	Expanded uncertainty, g/dm³	Deviation from the midpoint of the range, %	Compliance
Morshynska	0.1 - 0.4	0.28 ± 0.02	± 0.02	+ 12	Compliant
Karpatska Dzherelna	0.3 - 0.8	0.6 ± 0.04	± 0.03	+ 9.1	Compliant
Polyana Kvasova	6.5 - 12	8.5 ± 0.17	± 0.18	- 8.1	Compliant
Luzhanska	3 - 5	4.75 ± 0.12	± 0.1	+ 18.8	Compliant
Donat Mg	12.8 - 13.5	13.1 ± 0.14	± 0.22	- 0.4	Compliant
Fiuggi	0.15 - 0.2	0.19 ± 0.01	± 0.01	+ 8.6	Compliant

Note: *expanded uncertainty is presented for the mean actual mineralisation using a coverage factor of (k = 2), corresponding to an approximate confidence level of 95%*
Source: *compiled by the author*

The actual concentrations of sodium, calcium, magnesium, bicarbonates, sulphates, chlorides, fluorides and specific components were compared with the information provided on the labels. The results showed that none of the concentrations fell outside the declared intervals. At the same time, it was established that presenting the composition of medicinal table waters and medicinal waters in the form of broad ranges is methodologically justified. This is because the mineralisation of natural water may vary between production batches. This variation is within the approved physicochemical characteristics of the source.

After conducting analyses related to organoleptic, physicochemical, chemical and microbiological characteristics, as well as labelling, it was determined that none of the brands under scrutiny surpassed the established hygiene limits or exhibited signs of microbiological non-compliance. All the samples had intact packaging, satisfactory organoleptic properties, were within the declared mineralisation range, and showed no evidence of chemical or microbiological contamination. However, establishing a single overall ranking was deemed inappropriate as the waters differed in terms of their intended purpose, degree of mineralisation and ionic composition rather than their level of safety. For instance, Donat Mg's pronounced magnesium-sulphate taste is a characteristic feature of its natural composition rather than a quality defect, and Fiuggi's low mineralisation does not automatically make it superior to medicinal table waters. The final assessment was therefore presented in a profile-based format. This format reflected the compliance of each brand with quality and safety criteria. It also reflected the specific considerations associated with its possible consumption (Table 9).

Table 9. *Comparative profile-based assessment of the quality and safety of the examined mineral waters*

Brand	Chemical and microbiological safety	Compliance of actual composition with labelling	Overall quality assessment	Consumption considerations
Morshynska	Compliant with chemical and microbiological criteria	Compliant	High compliance; low-mineralised calcium-bicarbonate water	Suitable for regular hydration, subject to individual tolerance of carbonated water
Karpatska Dzherelna	Compliant with chemical and microbiological criteria	Compliant	High compliance; moderately mineralised calcium-magnesium-bicarbonate water	Suitable for regular consumption in the absence of individual restrictions
Polyana Kvasova	Compliant with chemical and microbiological criteria	Compliant	High compliance; highly mineralised bicarbonate-sodium water	The consumption pattern should be aligned with the manufacturer's recommendations and individual tolerance
Luzhanska	Compliant with chemical and microbiological criteria	Compliant	High compliance; moderately mineralised bicarbonate-sodium water	Moderate consumption is advisable, taking into account its sodium and bicarbonate content
Donat Mg	Compliant with chemical and microbiological criteria	Compliant	High compliance; highly mineralised magnesium-sulphate-bicarbonate water	Should not be regarded as an unrestricted substitute for ordinary drinking water
Fiuggi	Compliant with chemical and microbiological criteria	Compliant	High compliance; low-mineralised still calcium-bicarbonate water	May be selected by individuals who prefer still water with low mineralisation

Source: *based on the Decree of the Ministry of Health of Ukraine No. 4 (2010), ISO 6222:2002 (2002), ISO 9308-1:2022 (2022), ISO 16266:2022 (2022), ISO 7899-2:2022 (2022)*

Thus, all of the examined brands demonstrated a high level of compliance with quality and safety criteria within the analysed production batches. The differences between them were not disqualifying, but rather profile-specific. Morshynska and Karpatska Dzherelna, two table waters, were the most suitable for regular hydration due to their low or moderate mineralisation. Polyana Kvasova and Luzhanska, on the other hand, had elevated concentrations of sodium and bicarbonates, so their consumption should be aligned with dietary and medical advice. Donat Mg stood out due to its high magnesium, sulphate and bicarbonate concentrations, which give it a distinctive taste and make it best consumed in moderation. Fiuggi was the least mineralised still water among the examined samples; however, its low mineralisation should not be considered a universal advantage over other types of water. The final assessment showed that consumer choice should be based on the suitability of the mineral profile for the intended purpose of consumption, provided there is no regulatory non-compliance.

Discussion

The results showed that the packaged mineral waters examined differed mainly in terms of their total mineralisation and the proportions of their main ions. However, all samples complied with the regulatory requirements for chemical and microbiological safety. When comparing waters of different natural origins and functional positioning, such differentiation is to be expected. N.R. Syed *et al*. (2025) analysed the physicochemical characteristics of packaged mineral waters. They demonstrated that pH, electrical conductivity, mineralisation, chlorides and arsenic are suitable indicators. These can be used to distinguish safe samples from those that may potentially be non-compliant. In the present study, all pH and electrical conductivity values, as well as all concentrations of toxic contaminants, remained within the relevant regulatory limits, confirming the stability of the examined production batches.

Differentiating the waters into calcium-bicarbonate, bicarbonate-sodium and magnesium-sulphate-bicarbonate profiles was consistent with the findings of J.D. Iyakare *et al*. (2022). These researchers examined bottled waters from the African Great Lakes region and found that the concentrations of the main ions reflected the geographical origin of the aquifers. They also decided on the classification of the waters into separate hydrochemical groups. The mineral profile of Donat Mg was the most evident in the present study, with high concentrations of magnesium, sulphates and bicarbonates. In contrast, Morshynska, Karpatska Dzherelna and Fiuggi were distinguished by low or moderate mineralisation and a prevalence of the calcium-bicarbonate component. L. Moreno-Merino *et al*. (2022) compared the chemical characteristics of natural mineral waters and groundwater. These were used for centralised water supply. A single parameter alone is not always enough to establish differences between such waters. The most informative approach is to combine profiles of pH, calcium, potassium, nitrates, silicon and the proportions of the principal ions. This backs up the all-encompassing strategy used in the current study, where mineralisation in general was not looked at in isolation from the cationic and anionic composition.

Comparing the actual mineralisation with the values stated on the labels revealed that none of the samples deviated from the ranges declared by the manufacturers. This indicated satisfactory stability in the chemical composition of the examined production batches, though it did not imply the absence of labelling risks across the entire market. T. Hadbi *et al*. (2022) analysed the labelling information of 56 bottled-water brands in Algeria. They demonstrated that multidimensional grouping was useful. This was based on the principal ions. It was useful for objectively comparing waters of different origins. The profile-based approach avoided formally ranking waters according to total mineralisation or taste characteristics alone. The significance of evaluating labelling was also corroborated by R. Aslani *et al*. (2024), who examined 30 brands of bottled drinking and mineral water in Iran in 2024. They found discrepancies between the labelling and the actual nitrate, nitrite, magnesium and sodium concentrations in some samples, although the calculated non-carcinogenic risks generally remained acceptable. Therefore, ensuring compliance with hygiene limits should not replace verifying that the actual composition corresponds to the information provided on the label. In the present study, this requirement was addressed. This was done by comparing mineralisation and the principal ion concentrations with the declared intervals.

The findings of E.L. Ungureanu *et al*. (2022), who assessed potentially toxic elements in waters available on the Romanian market in 2022, were consistent with the results of the samples examined, which showed no exceedances for lead, arsenic, cadmium, mercury, nitrates and nitrites. The authors emphasised that risk assessment should consider more than just the detection of an element – its concentration, the duration of potential exposure and the vulnerability of particular population groups should also be considered. A similar approach was adopted by J.O. Olowoyo *et al*. (2022), who investigated trace-element concentrations in bottled water in South Africa in 2022 and used composite indicators of non-carcinogenic risk. In this context, the low concentrations of toxic elements in the brands examined may be interpreted as a positive finding. This is for the specific production batches analysed. However, they do not provide grounds for extrapolating the conclusions. This is not possible to the entire Ukrainian market.

The microbiological findings confirmed that all the samples examined were in a satisfactory sanitary condition. The absence of coliform bacteria, *Escherichia coli,* *Pseudomonas aeruginosa*, intestinal enterococci and sulphite-reducing anaerobic bacteria was indicated. This was together with the low total microbial counts. This showed no evidence of faecal or secondary bacterial contamination. F. Carraturo *et al*. (2021) investigated the microbial communities of natural mineral waters using next-generation sequencing. They demonstrated that packaged water can possess a distinctive microbiota, even in the absence of sanitary indicator microorganisms. The chemical and microbiological characteristics of purified, mineral, artesian and carbonated waters were also identified by Y.M. Nadreen *et al*. (2024). These findings suggest that, while standard sanitary indicators are sufficient for regulatory safety assessments, they do not fully describe the natural microbiological characteristics of mineral water.

The waters were compared. This was according to their mineral profiles. This confirmed that a single ranking was inappropriate. This was for products with different functional purposes. S. Manoj *et al*. (2024) examined the consequences of low mineral content in bottled water, emphasising that low mineralisation should not be considered a universal advantage. In the context of the present study, this supported the use of a profile-based rather than a ranking-based assessment. This is because low-mineralised and highly mineralised waters have different intended uses. Meanwhile, C. Dupont & G. Hébert (2020) reviewed the clinical evidence relating to natural mineral waters containing magnesium and sulphate, and identified their particular effectiveness in treating functional bowel disorders. Accordingly, the high concentrations of magnesium and sulphates in Donat Mg should not be considered a disadvantage solely due to the water's pronounced organoleptic characteristics. However, it is important to note that this water is not a suitable replacement for low-mineralised table water that is intended for unrestricted daily consumption.

The results of the profile-based assessment also prevented an oversimplified conclusion about the "best" brand. M. Rasheduzzaman *et al*. (2025) conducted an inter- and intra-brand study of 26 bottled water brands in the United States, demonstrating that assessments must account for production variability, source type, and differences between individual samples. A. Alshishani *et al*. (2026) analysed 176 water brands on the Jordanian market. They used a broad range of chemical and microbiological parameters. They demonstrated that composite quality indices require cautious interpretation. This is particularly true where parameters have a zero-tolerance limit. In the present study, therefore, a profile-based assessment was more appropriate than ranking the brands from first to sixth place.

Microplastics and nanoplastics, which were not examined in this study, require particular attention. A study by S.M. Praveena & S. Laohaprapanon (2021) revealed significant variations in the methods used to analyse microplastics in bottled water. These variations included differences in contamination control, sample preparation techniques, and approaches to identifying polymers. The authors stressed that, without standardised methodological procedures, it is challenging to directly compare the results of different studies. The problem of microplastics therefore requires not only expanded monitoring. It also requires the standardisation of laboratory methods. All the bottled-water brands examined by M.B. Hossain *et al*. (2023) showed signs of microplastic contamination, indicating that this type of pollution might be pervasive even in products sold in commercial packaging. In that study, it was important not only to detect particles, but also to characterise them by size, shape, and polymer composition, as this made it possible to associate contamination with packaging or particular stages in the production and distribution process. A. Altunışık (2023) identified microplastics in natural and mineral waters in Turkey and drew attention to how daily consumption of bottled water could contribute to the total intake of such particles by the human body. This highlights the importance of microplastics as an emerging safety indicator not yet covered by traditional chemical and microbiological monitoring regulations. These findings suggest that adherence to standard chemical and microbiological regulations does not guarantee the absence of emerging contaminants related to packaging, bottling, or storage processes.

N. Qian *et al*. (2024) used stimulated Raman scattering microscopy to demonstrate that the number of particles detected in bottled water can increase substantially when nanoplastics are included in the analysis. This study is important because it shows that earlier research, which focused mainly on microplastics, may have underestimated the actual level of particulate contamination due to the technical limitations of the detection methods used. V. Gálvez-Blanca *et al*. (2024) detected microplastics and non-natural cellulose particles in bottled water in Spain. The study stressed that contamination might come from polymers as well as other artificial particles that are introduced during production, filtration, packaging or storage. S. Patil *et al*. (2024) identified differences in microplastic contamination levels between local and national water brands in India. This finding suggests that the level of contamination may depend on production scale, technological controls, packaging type, and logistics conditions, rather than solely on the source of the water. M. Ghimire *et al*. (2025) also detected microplastics in all the bottled water samples examined in Nepal. Their findings extended the geographical evidence for this problem, demonstrating that microplastic contamination of bottled water is not confined to particular local markets. Consequently, a promising direction for further research into the Ukrainian market would be to supplement traditional quality indicators with the determination of microplastics, nanoplastics, and substances that migrate from polymer packaging. Within the production batches examined, all six brands complied with the criteria for chemical and microbiological safety. The main differences were not determined by the presence of hazardous contaminants, but by the natural mineral profile, which influences taste, electrical conductivity, mineralisation, and the recommended consumption pattern.

Conclusions

A comparison of six brands of packaged natural mineral water available in the Ukrainian retail market was made in a laboratory and analytical investigation. The results showed that the production batches analysed were chemical, microbiological and organoleptic safe. All samples were clear, free from visible sediment, suspended particles, foreign matter, and unacceptable odours. The water colour ranged from 0.7 to 2.3 degrees on the platinum-cobalt scale, substantially below the 20-degree limit. Morshynska and Fiuggi received the highest organoleptic scores of 4.8 points each on a five-point scale. The more pronounced mineral taste of Donat Mg was found to be due to its naturally high magnesium, sulphate and bicarbonate concentrations rather than any deterioration in quality.

Physicochemical analysis confirmed significant differences among the waters in terms of mineralisation and ionic profile. Fiuggi had the lowest mineralisation, at 0.19 ± 0.01 g/dm^3, while Donat Mg had the highest, at 13.1 ± 0.14 g/dm^3. The table waters Morshynska and Karpatska Dzherelna were characterised by low mineralisation at 0.28 ± 0.02 g/dm^3 and 0.6 ± 0.04 g/dm^3, respectively. Luzhanska and Polyana Kvasova had higher values at 4.75 ± 0.12 and 8.5 ± 0.17 g/dm^3 respectively. The pH values of all samples ranged from 6.29 to 7.19, and the absolute ion balance value did not exceed 1.4%, which confirms the consistency of the results obtained for the principal cations and anions.

No exceedances of the hygiene limits were identified for the chemical safety indicators. The maximum nitrate concentration was 2.4 ± 0.3 mg/dm^3, 20.8 times below the permissible level of 50 mg/dm^3. Lead and arsenic concentrations did not exceed 0.0024 and 0.0027 mg/dm^3 respectively, and total organic carbon did not exceed 0.55 mg/dm^3, compared with the regulatory limit of 5 mg/dm^3. Nitrites, cadmium and mercury were all below the limits of quantification. No coliform bacteria, *E. coli, P. aeruginosa*, intestinal enterococci or sulphite-reducing anaerobic bacteria were detected in any sample. The total microbial count did not exceed 6 ± 2 CFU/cm^3 at 20-22°C. These waters should not be regarded as interchangeable. Table water brands are more suitable for regular hydration, whereas waters with elevated concentrations of sodium, bicarbonates, magnesium or sulphates should be selected according to individual tolerance and the recommended consumption pattern.

The study had several limitations. These included the analysis of only three production batches of each brand, the collection of products exclusively in Kyiv, and the absence of testing for microplastics, nanoplastics and substances migrating from polymer packaging. Research should concentrate on extending the geographical scope of sampling, conducting seasonal monitoring and assessing emerging contaminants in packaged mineral waters.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

References

[1] Alshishani, A., Al-ebini, Y., Shoai, M., Alsafadi, D., Hussein, G., & Shaghlil, L. (2026). Quality and safety assessment of bottled water in Jordan markets. *Journal of Food Composition and Analysis*, 151, article number 108929. doi: 10.1016/j.jfca.2026.108929.

[2] Altunışık, A. (2023). Microplastic pollution and human risk assessment in Turkish bottled natural and mineral waters. *Environmental Science and Pollution Research*, 30(14), 39815-39825. doi: 10.1007/s11356-022-25054-6.

[3] Aslani, R., Esmaeili, S., Akbari, M.E., Molaee-Aghaee, E., Sadighara, P., Nazmara, S., & Mahmoudi, B. (2024). Determination of heavy metals, nitrate and nitrite in mineral and drinking bottled water in Tehran, Iran: A health risk assessment by Monte-Carlo simulation method. *Heliyon*, 10(23), article number e40714. doi: 10.1016/j.heliyon.2024.e40714.

[4] Banda, R.K., Mubita, P., Moonga, G., & Meki, C.D. (2021). Bacteriological quality and heavy metal analysis of packaged water produced in Lusaka, Zambia and associated quality control measures. *Frontiers in Public Health*, 9, article number 620700. doi: 10.3389/fpubh.2021.620700.

[5] Boas, D.M., Alegbeleye, O., & Sant'Ana, A.S. (2024). Microbial diversity and ecology of bottled water. *Current Opinion in Food Science*, 60, article number 101218. doi: 10.1016/j.cofs.2024.101218.

[6] Carraturo, F., Del Giudice, C., Compagnone, M., Libralato, G., Toscanesi, M., Trifuoggi, M., Galdiero, E., & Guida, M. (2021). Evaluation of microbial communities of bottled mineral waters and preliminary traceability analysis using NGS microbial fingerprints. *Water*, 13(20), article number 2824. doi: 10.3390/w13202824.

[7] Decree of the Ministry of Health of Ukraine No. 4 "On the Approval of Hygiene Standards for the Safety of Natural Mineral Water". (2010, January). Retrieved from https://zakon.rada.gov.ua/rada/show/v0004488-10.
[8] DSTU 878-93. (1993). *Bottled mineral waters. Technical specifications*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=82545.
[9] DSTU EN 1484:2003. (2003). *Water analysis. Guidelines for the determination of total and dissolved organic carbon*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=73074.
[10] DSTU EN 27888:2022. (2022). *Water quality. Determination of electrical conductivity*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=110955.
[11] Dupont, C., & Hébert, G. (2020). Magnesium sulfate-rich natural mineral waters in the treatment of functional constipation – a review. *Nutrients*, 12(7), article number 2052. doi: 10.3390/nu12072052.
[12] Gálvez-Blanca, V., Edo, C., González-Pleiter, M., Fernández-Piñas, F., Leganés, F., & Rosal, R. (2024). Microplastics and non-natural cellulosic particles in Spanish bottled drinking water. *Scientific Reports*, 14, article number 11089. doi: 10.1038/s41598-024-62075-2.
[13] Ghimire, M., Byanjankar, N., Khanal, J., Acharya, S., Nicholson, K., Shakya, S., & Prasai Joshi, T. (2025). First assessment of occurrence, characteristics and human exposure of microplastics in bottled drinking water, Nepal. *Cleaner Water*, 4, article number 100184. doi: 10.1016/j.clwat.2025.100184.
[14] Hadbi, T., Kassoul, A., & Mokadem, M. (2022). Chemical characterization and statistical analysis of bottled waters in Algeria. *Pollution Research*, 41(3), 889-897. doi: 10.53550/PR.2022.v41i03.018.
[15] Hossain, M.B., Yu, J., Banik, P., Noman, M.A., Nur, A.-A., Haque, M.R., Rahman, M.M., Albeshr, M.F., & Arai, T. (2023). First evidence of microplastics and their characterization in bottled drinking water from a developing country. *Frontiers in Environmental Science*, 11, article number 1232931. doi: 10.3389/fenvs.2023.1232931.
[16] ISO 10304-1:2025. (2025). *Water quality. Determination of dissolved anions by liquid ion chromatography. Part 1. Determination of bromide, chloride, fluoride, nitrate, nitrite, phosphate and sulphate*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=116555.
[17] ISO 10523:2022. (2022). *Water quality. Determining pH*. Retrieved from https://surl.li/vbppwr.
[18] ISO 11885:2019. (2019). *Water quality. Determining of selected elements by inductively coupled plasma optical emission spectrometry*. Retrieved from https://surl.li/rwjxzi.
[19] ISO 16266:2022. (2022). *Water quality. Detection and enumeration of pseudomonas aeruginosa. Membrane filtration method*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=119225.
[20] ISO 17294-2:2019. (2019). *Water quality. The use of inductively coupled plasma mass spectrometry*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=84275.
[21] ISO 6222:2002. (2002). *Water quality. Enumeration of colony-forming microorganisms. Colony counting by inoculation into a nutrient agar medium*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=95726.
[22] ISO 7887:2025. (2025). *Water quality. Testing and determining colour*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=116553.
[23] ISO 7899-2:2022. (2022). *Water quality. Detection and enumeration of faecal enterococci. Part 2. Membrane filtration metho*d. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=119175.
[24] ISO 9308-1:2022. (2022). *Water quality. Detection and enumeration of Escherichia coli and coliform bacteria. Part 1. Membrane filtration method for water with a low background bacterial count*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=109518.
[25] Iyakare, J.D., Taupin, J.-D., Hitimana, C.N., Dusabimana, T., Ghalit, M., El Ouahabi, M., Benali, M., Ngendo, C., & Gharibi, E.K. (2022). Hydrochemical study of bottled water in Rwanda and relationship with their origin. *Water Supply*, 22(1), 1155-1167. doi: 10.2166/ws.2021.211.
[26] Ketrouci, K., Meddi, M., Bouregba, N., Zatout, I., & Rezki, A. (2023). Classification of bottled waters marketed and consumed in Algeria through statistical approaches. *Journal of Water and Health*, 21(10), 1489-1502. doi: 10.2166/wh.2023.142.
[27] Krykhovets, O., Repeta, V., & Ivashchenko, I. (2025). Monitoring of spring water quality. *Environmental Problems*, 10(2), 127-134. doi: 10.23939/ep2025.02.127.
[28] Kwikima, M.M. (2025). The biological and chemical water quality of retail bottled water brands: A case of Dodoma, Tanzania. *Nutrition & Food Science*, 55(1), 165-179. doi: 10.1108/NFS-05-2024-0182.
[29] Kysylevska, A., Prokopovych, I., & Kokhan, S. (2024). Substantiation of safety and quality indicators of natural mineral and spring waters in Ukraine for the preparation of food for infants. *Technology Audit and Production Reserves*, 5(79), 36-42. doi: 10.15587/2706-5448.2024.314338.
[30] Manoj, S., Kartheeshwari, M.R., Keerthan, L., & Elango, L. (2024). Effects of low mineral content in bottled drinking water on human health and evaluation of optimal requirements. *Journal of Food Composition and Analysis*, 128, article number 106052. doi: 10.1016/j.jfca.2024.106052.

[31] Maselela, J.L., Mokgobu, M.I., & Mudau, L.S. (2024). The evaluation of bottled water quality compliance association formal and informal retailers in Gauteng municipality, South Africa. *Applied Food Research*, 4(2), article number 100576. doi: 10.1016/j.afres.2024.100576.
[32] Mitku, M., & Endeshaw, L. (2022). Chemical quality assessment of major brands of bottled mineral water available in the Ethiopian market. *Journal of Food Safety and Hygiene*, 8(3), 183-201. doi: 10.18502/jfsh.v8i3.11020.
[33] Moreno-Merino, L., Aguilera, H., & de la Losa Román, A. (2022). Are bottled mineral waters and groundwater for human supply different? *Science of the Total Environment*, 835, article number 155554. doi: 10.1016/j.scitotenv.2022.155554.
[34] Nadreen, Y.M., Vrouwenvelder, J.S., Saikaly, P.E., & Gonzalez-Gil, G. (2024). The unique chemical and microbiological signatures of an array of bottled drinking water. *Frontiers in Microbiology*, 15, article number 1441142. doi: 10.3389/fmicb.2024.1441142.
[35] Olowoyo, J.O., Chiliza, U., Selala, C., & Macheka, L. (2022). Health risk assessment of trace metals in bottled water purchased from various retail stores in Pretoria, South Africa. *International Journal of Environmental Research and Public Health*, 19(22), article number 15131. doi: 10.3390/ijerph192215131.
[36] Order of the Ministry of Health of Ukraine No. 741 "On the Approval of Hygiene Requirements for the Production and Distribution of Natural Mineral Waters and Spring Waters". (2021, April). Retrieved from https://zakon.rada.gov.ua/laws/show/z0657-21.
[37] Patil, S., Bafana, A., Krishnamurthi, K., & Sivanesan, S. (2024). Estimated exposure to microplastics through national and local brands of bottled water in Central India. *Environmental Monitoring and Assessment*, 196(3), article number 240. doi: 10.1007/s10661-024-12387-7.
[38] Praveena, S.M., & Laohaprapanon, S. (2021). Quality assessment for methodological aspects of microplastics analysis in bottled water – a critical review. *Food Control*, 130, article number 108285. doi: 10.1016/j.foodcont.2021.108285.
[39] Qian, N., Gao, X., Lang, X., Deng, H., Bratu, T.M., Chen, Q., Stapleton, P., Yan, B., & Min, W. (2024). Rapid single-particle chemical imaging of nanoplastics by SRS microscopy. *Proceedings of the National Academy of Sciences of the United States of America*, 121(3), article number e2300582121. doi: 10.1073/pnas.2300582121.
[40] Rasheduzzaman, M., Lytton, B., Wilcox, E., Das, A., Wirth, M., Hurtado, A., Krometis, L.-A., & Cohen, A. (2025). Microbiological and chemical contaminants in single-use and multipackage bottled water: Inter- and intra-analyses of 26 bottled water brands in the USA. *ACS ES&T Water*, 5(9), 5471-5481. doi: 10.1021/acsestwater.5c00536.
[41] Shulyak, S., Shevchenko, L., Mykhalska, V., Kaminska, O., Gaidei, O., Kovalenko, V., Balarskyi, Y., Kryvenko, M., & Boyarchuk, S. (2021). Quality and safety of tap water in selected Ukrainian regions. *Ukrainian Journal of Ecology*, 11(2), 274-283. doi: 10.15421/2021_111.
[42] Stoots, S.J., *et al.* (2020). Variations in the mineral content of bottled "still" water across Europe: Comparison of 182 brands across 10 countries. *Journal of Endourology*, 35(2), 206-214. doi: 10.1089/end.2020.0677.
[43] Syed, N.R., Raza, A., Alshehri, F., Almadani, S., Singh, S.K., & Elbeltagi, A. (2025). Spatio-temporal analysis of bottled mineral water brands and their compliance with standards. *Applied Water Science*, 15, article number 116. doi: 10.1007/s13201-025-02441-1.
[44] Ungureanu, E.L., Soare, A.D., Mocanu, A.L., Iorga, S.C., Mustatea, G., & Popa, M.E. (2022). Occurrence of potentially toxic elements in bottled drinking water – carcinogenic and non-carcinogenic risks assessment in adults via ingestion. *Foods*, 11(10), article number 1407. doi: 10.3390/foods11101407.

Оцінка якості мінеральної води та відповідності стандартам безпеки: порівняльний аналіз ринку

Ермір Шахіні
Доктор економічних наук, доцент
Університет Олександра Моісіу в Дурресі
2001, вул. Курріла, 1, м. Дуррес, Албанія
https://orcid.org/0000-0002-0083-1029

Анотація. Метою дослідження було проведення комплексного аналізу органолептичних, фізико-хімічних, хімічних та мікробіологічних характеристик мінеральних вод різного походження, що представлені на українському роздрібному ринку. Було досліджено шість торгових марок з метою визначення їхніх органолептичних властивостей, рівня pH, електропровідності, мінералізації, а також наявності основних катіонів, аніонів, токсичних домішок, органічних речовин та санітарно-індикаторних мікроорганізмів. Результати показали, що всі досліджені зразки були прозорими, не містили осаду, зважених частинок та сторонніх речовин, а показники кольору коливалися в межах від 0,7 до 2,3 градусів за платиново-кобальтовою шкалою. Оцінки смаку коливалися від 4,2 до 4,8 балів, причому відмінності були зумовлені природним мінеральним складом, а не сторонніми смаковими добавками. Значення pH коливалися в діапазоні від 6,29 до 7,19, а електропровідність – від 0,29 до 18,9 мілісіменсів на сантиметр. Найнижчу мінералізацію мала вода «Фьюджі» – 0,19 ± 0,01 г/л, а найвищу – «Донат Mg» – 13,1 ± 0,14 г/л. Характерною особливістю «Моршинської» та «Карпатської джерельної» була низька мінералізація з переважанням кальцію та бікарбонатів. Води «Поляна Квасова» та «Лужанська» відрізнялися високим вмістом натрію та бікарбонатів відповідно, тоді як вода «Донат Mg» вирізнялася високою концентрацією магнію – 1010 ± 42 мг/л, високою концентрацією сульфатів – 2200 ± 103 мг/л та високою концентрацією бікарбонатів – 7595 ± 290 мг/л. Абсолютне значення іонного балансу не перевищувало 1,4 %. Максимальний вміст нітратів становив 2,4 ± 0,3 міліграма на кубічний дециметр, що в 20,8 рази нижче за допустимий рівень. Вміст свинцю, миш'яку та загального органічного вуглецю не перевищував відповідних гігієнічних норм, а мікробіологічних показників санітарного стану виявлено не було. Цей підхід можна використовувати для контролю упакованих продуктів у лабораторіях, перевірки точності маркування та розробки науково обґрунтованих рекомендацій для споживачів

Ключові слова: іонний склад; бікарбонати; натрій; токсичні забруднювачі; маркування; вибір споживача