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Chemical Quality of the Leading Bottled Water Brands Distributed in Gorgan, Iran



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ABSTRACT

Background: With the growing use of bottled water, the continuous research and monitoring of the quality of these products are crucial. The present study aimed to assess the chemical quality of the bottled water distributed in Gorgan, Iran.

Methods: This cross-sectional, descriptive-analytical study was conducted on the samples of bottled water distributed in Gorgan city. Sampling was performed during four months (one sample of each brand obtained every month; total: 36). The chemical quality of the samples was measured using standard methods.

Results: The mean concentrations of nitrate, fluoride, and iron and mean pH of the samples were 12.92 ± 11.05 , 0.33 ± 0.12 , and 0.64 ± 2.9 mg/l and 6.89 ± 0.39 , respectively. Only the physicochemical parameters of pH and iron were significantly higher than the standard values, and the mean levels of the chemical factors were significantly lower than the standard values ($P < 0.05$).

Conclusion: Consumers expect bottled water to have higher quality as they perceive the product to be a healthier choice than the water supplied by urban distribution networks. High levels of some chemical parameters could adversely affect the health of consumers, especially vulnerable populations, which should be taken into consideration by custodians and authorities.

1. Introduction

Consumption of bottled and mineral water has been on the rise worldwide, especially in developing countries [1]. In recent decades, the demand for bottled water has increased consistently due to better taste and lower impurity of the product from the perspective of the consumers [1, 2]. Currently, bottled water consumption has further increased as opposed to the consumption of the water supplied by urban water distribution networks despite the relatively high cost of bottled water [2].

Use of bottled water is a viable option in the areas where high-quality drinking water and water purification facilities are not available [3].

According to statistics, the average annual consumption of bottled water has increase by 7%. Although the main consumers of these products are currently European countries, the consumption rate has also risen in Asia and the Pacific more rapidly, with the rate estimated at approximately 15% [4].

In developed countries, the most important reason for the tendency toward the use of bottled water is that individuals

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mostly refrain from the consumption of the chlorinated or disinfected water supplied by urban distribution systems due to the risk of harmful compounds. In developing countries, the most important reason for the use of bottled water is to prevent the transmission of the diseases that are caused by contaminated water [5].

Today, many individuals in urban environments prefer bottled water to the tap water supplied by urban water distribution networks due to the natural quality, better taste, and higher quality of bottled water [6]. According to the literature, the development of technology and industry, population growth, wastewater and solid waste production, and growing use of pesticides have led to the entry of organic compounds and heavy metals into water and water pollution [7-13]. As such, the continuous monitoring of the quality of bottled water products is of utmost importance. Several studies have been focused on the chemical and microbiological quality of bottled water. For instance, Doria et al. (2006) reported that the main reasons for the increased use of bottled water are the dissatisfaction of Canadian and French consumers with the organoleptic status of water (especially the taste) and the associated health risks [1]. With this background in mind, continuous research and monitoring of the quality of bottled water is crucial. Since packaged water is supplied as a food product in food stores, the quality of bottled water may change due to the non-observance of the cold chain in its transit, as well as its unrefrigerated, outdoor storage (sunlight exposure).

The present study aimed to assess the chemical quality of the leading bottled water brands distributed in Gorgan, Iran and compare the values with the national and international standards in this regard.

2. Materials and Methods

2.1. Study Site and Sampling

This cross-sectional, descriptive-analytical study was conducted to investigate the chemical quality of nine bottled water brands. The sample population consisted of the bottled water products distributed in Gorgan city with nine commercial brands (total: 36 samples). Among the selected commercial brands, five cases are produced in Golestan province, and four brands are produced outside the province and distributed in Gorgan city.

Sampling was performed during four months when the consumption of bottled water has been reported to be highest (June-October), and one sample was obtained each month from all the brands (four samples per each brand; total: 36).

2.2. Determination of Chemical Parameters

The concentrations of calcium (standard: 3,500-Ca B), magnesium (standard: 3,500-Mg B), sodium (standard: 3,500-Na B), potassium (standard: 3,500-K B), fluoride (standard: 4,500-F-D), bicarbonate (standard: 2,320 B), and sulfate (standard: 4,500-SO₄-2 D) were measured using standard methods. In addition, we measured temperature (standard: 2,550 °C), hardness (standard: 2,340 °C), and alkalinity (standard: 2,320 B) for comparison with the water

and wastewater values published by the American Public Health Association (APHA) [14].

Calcium and magnesium ions, alkalinity, and chloride were measured using chemical titration. The concentrations of sodium, potassium, flame photometer, fluoride, nitrate, iron sulfate, and manganese were determined using a spectrophotometer (model: DR2500, HACH, Dusseldorf, Germany), and the concentrations of heavy metals (lead, cadmium, copper, and zinc) were measured using a polarography machine and voltammetric method (Metrohm Company, Herisau, Switzerland). Turbidity was also measured using the HACH turbidity sensor (model: 2100P, HACH, Dusseldorf, Germany). Measurement of electrical conductivity, soluble solids, and pH was performed using a multi-probe device (model: Sens Ion, HACH, Dusseldorf, Germany). All the experiments were carried out at the water and wastewater chemistry laboratory at the School of Health, Golestan University of Medical Sciences in Gorgan, Iran.

2.3. Statistical Analysis

Data analysis was performed in SPSS version 20 (IBM) at the significance level of $P < 0.05$. Independent t-test was used to compare the quality of the samples at the production and supply units with the normal data, and Mann-Whitney U test was applied in case of the non-normal data. The values of the physicochemical factors were compared with the standard values, and the distribution of the physicochemical factors was normal in these samples. However, non-normal distribution was observed in the variables of salinity, nitrate, chlorine, sodium, potassium, and manganese, and one-sample Wilcoxon signed rank test was used for the comparison of the mean values of these parameters with the standard values. Additionally, paired sample t-test was applied to compare the measured values with the stated levels on the labels of the bottled water samples. The criterion for entering the bottle was the type of bottled water and the expiration date was the expiry date.

3. Results and Discussion

The chemical quality of various brands of bottled water was evaluated and compared with the international and national standards. Table 1 shows the values of various parameters on the water bottle labels. Table 2 shows the mean values of various parameters in the bottled water samples produced inside and outside Golestan province, distributed in Gorgan city.

Kruskal-Wallis test was used to compare the mean chemical factors of various bottled water brands, which indicated significant differences in various parameters of the bottled water samples between various commercial brands ($P < 0.05$). On the other hand, the results of Wilcoxon test indicated no significant differences between the reported values on the labels of the bottled water samples and the measured concentrations ($P > 0.05$). Furthermore, one-sample Wilcoxon signed rank test was applied to compare the mean values of the chemical factors in each commercial brand with the values quoted on the packaging of the brand. Table 1 shows the values of each chemical

factor reported on the packaging of the products of each brand. Table 3 shows the results of the comparison of the chemical materials in the bottled water samples of each commercial brand.

According to the obtained results, the reported values of the chemical parameters in the studied commercial brands had no significant differences with the measured concentrations ($P > 0.05$) (Table 3). Table 4 shows the measured mean values of the chemical compounds in the samples of all the commercial brands, as well as the mean, standard deviation, minimum, maximum, K-S statistic, and the results of examining the normality of the data on each chemical factor. To compare data dispersion, the variation coefficient of each chemical agent has also been presented in Table 4. In the bottled water samples, the mean concentration of nitrate, fluoride, and iron and pH were estimated at 12.92 ± 11.05 , 0.33 ± 0.12 , and 0.64 ± 2.9 mg/l and 6.89 ± 0.39 , respectively.

According to the information in Table 5, the investigated bottled water commercial brands had significant differences in terms of the concentration of manganese, iron, chloride, and sulfate, while the least difference was observed in the pH, fluoride level, hardness, and magnesium concentration of the products.

In order to compare physicochemical factors with the standard values, the distribution of the physicochemical factors was observed to be normal in the samples. According to the information in Table 5, the evaluation of the normal distribution of the data indicated that only pH, fluorine level, water hardness, and magnesium concentration had normal distribution in the products. Considering the unpredictability of data distribution, it was assumed that the median magnesium content of all the studied commercial brands had no significant difference with the standard value ($P > 0.05$), with the exception of iron, the concentration of which was significantly higher compared to the standard value, while the concentrations of the other chemical agents were significantly lower than the standard values.

Table 5 shows the comparison of the physicochemical parameters with the data with normal and non-normal distribution, as well as the national and international standard values. Correspondingly, the T-1 test indicated a significant sample for all parameters. In other words, the bottled water samples had significantly higher pH values than the standard level, while their fluoride level, water hardness, and magnesium concentration were significantly lower than the standard values.

Table 6 shows the standard chemical values for bottled water in Iran, in addition to the values recommended by the World Health Organization (WHO) and the Environmental Protection Agency (EPA). In the studied bottled water samples in the present study, only the physicochemical parameters of pH and iron concentration were significantly higher than the standard values, and the mean values of the other physicochemical parameters were significantly lower than the standard values. On the other hand, the values of the chemical factors in the water package standard (6,694) were equal to the standards for drinking water (1,053) [15]. However, the standards for natural mineral water (2,441) [16] are slightly different with the standards for drinking water. For instance, the standard nitrate concentration for mineral water is 20 mg/l, while it is 50 mg/l for drinking water (Table 6).

In case of the other physicochemical factors in which the values of the studied samples had non-normal distribution, the mean values of the sample data were compared with the standard values, and it was observed that the mean values of all the physicochemical factors were significantly lower than the standard values.

In the current research, the measured data were compared with the standards of packaged water, and the obtained results were consistent with the findings of Lului et al. (2010) in Kerman (Iran). In the mentioned study, 7% of the samples had nitrate and chloride, while in 23% and 46% of the samples, the concentrations of potassium and sodium were higher than the standard values [17]. Furthermore, the results of the present study were compared with the findings of Miranzadeh et al. (2011) regarding the concentrations of heavy metals in 15 commercial brands of mineral water in Iran. According to the results of the mentioned study, the concentrations of metals and heavy metals in the bottled water products were standard [18].

The results of the present study are consistent with the findings of Derakhshani et al. (2018) in Birjand (Iran) in terms of compliance with standard values. According to the mentioned research, most of the chemical parameters in the bottled water samples in Birjand city had lower concentrations than the maximum contaminant levels in the Iranian mineral Water Quality Standards and WHO guidelines [3,19,20].

According to the results of the present study, the highest concentrations of heavy metals were observed in the bottled water produced outside of Golestan province. The standard values of cadmium, lead, copper, and zinc in bottled water are 0.003, 0.01, 2, and 3 mg/l, respectively.

Table 1: Values of various parameters on the water bottle brands distributed in Gorgan, Iran

Parameter	Unit	Brand NO								
		1	2	3	4	5	6	7	8	9
Calcium	mg/L	60	45	25	36	45	31.8	50	18.3	9.6
Magnesium	mg/L	20	15	9	28	11.5	6.5	120	-	2.2
Sodium	mg/L	26	4	1	20	19	1	7.8	17.2	4.6
Potassium	mg/L	-	0.6	0.8	2	0.6	0.4	0.6	0.1	-
Bicarbonate	mg/L	-	256	-	-	-	142.8	-	45	-
Chloride	mg/L	20	9	-	24	-	1.5	18	22.9	<1
Sulfate	mg/L	-	85	-	-	10	4	16	0.6	-
Nitrate	mg/L	6	2	0.4	8.2	3.5	3.5	1.8	1.36	2.5
TDS	mg/L	140	242	153	210	170	147	235	110	71.2
Fluoride	mg/L	0.06	0.2	0.1	0.55	0.1	-	-	0.003	0.11
Nitrite	mg/L	0.009	-	0	-	-	-	-	-	< 0.005
Total Hardness	mg/L	130	144	-	180	-	-	-	-	50.2
DO	%	-	-	50-60	-	-	-	-	-	-
pH	-	7.3	7.29	7.3	7.6	7.6	7.2	7.06	7.2	7.1

Table 2: The mean and standard deviation of various parameters in bottled water brands produced in and outside of Golestan province, distributed in Gorgan, Iran

Parameter	Unit	Brand NO (produced in Golestan province)				
		1	2	3	4	5
Calcium	mg/L	79 ± 1.4	94 ± 2.8	35 ± 1.8	91 ± 2.8	75.5 ± 6.4
Magnesium	mg/L	13.5 ± 4.9	29 ± 0.0	29 ± 1.9	26.5 ± 5	16.5 ± 7.7
Sodium	mg/L	32 ± 19.8	18 ± 0.0	46 ± 3.2	46 ± 0.0	18 ± 0.0
Potassium	mg/L	2.3 ± 0.0	2.3 ± 0.0	2.5 ± 0.0	2.4 ± 0.0	2.3 ± 0.0
Iron	mg/L	1.1 ± 0.0	0.19 ± 0.0	2.04 ± 0.1	0.0 ± 0.0	0.65 ± 0.09
Manganese	mg/L	0.03 ± 0.0	0.04 ± 0.0	0.028 ± 0.0	0.036 ± 0.0	0.071 ± 0.02
Chloride	mg/L	2.75 ± 0.0	5.5 ± 1.6	2.74 ± 0.5	5.75 ± 0.7	3 ± 0.35
Sulfate	mg/L					
Nitrate	mg/L	7.24 ± 0.06	7.24 ± 0.063	7.28 ± 0.8	19.37 ± 2.5	7.8 ± 0.7
Fluoride	mg/L	0.38 ± 0.06	0.43 ± 0.06	0.4 ± 0.11	0.32 ± 0.07	0.26 ± 0.06
Alkalinity	mg/L	174 ± 5	276 ± 2.2	123 ± 6.2	251 ± 0.7	201 ± 1.1
Hardness	mg/L	92.5 ± 6.3	129 ± 1.41	64 ± 2.8	110 ± 7.07	92 ± 1.4
DO	%					
pH	-	6.94 ± 0.05	7.17 ± 0.07	6.45 ± 0.02	7.24 ± 0.02	6.89 ± 0.03
TDS	mg/L	156 ± 3.3	234 ± 0.7	255 ± 3.2	214 ± 1.4	162 ± 0.03
Turbidity	NTU	0.45 ± 0.07	0.5 ± 0.0	0.55 ± 0.0	0.4 ± 0.14	0.5 ± 0.14
EC	µs/cm	325 ± 7.07	485 ± 0.7	255 ± 3.2	443 ± 28	336 ± 18.3
Salinity	%	0.1 ± 0.0	0.1 ± 0.0	0.1 ± 0.0	0.2 ± 0.0	0.1 ± 0.0
Temperature	°C	20.15 ± 0.9	21.4 ± 0.28	20.7 ± 0.6	21.35 ± 0.07	20.35 ± 0.21

Parameter	Unit	Brand NO (produced outside Golestan province)			
		6	7	8	9
Calcium	mg/L	51 ± 7.07	68.5 ± 2.8	20.5 ± 6.3	20.5 ± 0.87
Magnesium	mg/L	18.5 ± 7.7	26.5 ± 3.5	26.5 ± 4.9	12.5 ± 9.2
Sodium	mg/L	18 ± 0.0	46 ± 0.0	18 ± 0.0	18 ± 0.0
Potassium	mg/L	0 ± 0.0	2.3 ± 0.0	0 ± 0.0	2.5 ± 0.0
Iron	mg/L	0.65 ± 0.09	0.39 ± 0.93	0.39 ± 0.09	0.26 ± 0.093
Manganese	mg/L	0.03 ± 0.004	0.02 ± 0.0005	0.035 ± 0.003	0.02 ± 0.0009
Chloride	mg/L	2 ± 1.6	19.7 ± 0.00	2.7 ± 0.00	1.24 ± 0.00
Sulfate	mg/L				
Nitrate	mg/L	7.46 ± 0.12	34.5 ± 1.3	7.9 ± 1.01	7.28 ± 0.12
Fluoride	mg/L	0.11 ± 0.03	0.23 ± 0.11	0.34 ± 0.02	0.48 ± 0.29
Alkalinity	mg/L	146.5 ± 4.9	166 ± 0.0	26 ± 1.4	40 ± 0.0
Hardness	mg/L	69.5 ± 0.7	95 ± 2.8	47 ± 1.4	33 ± 8.4
DO	%				
pH	-	6.81 ± 0.05	6.76 ± 0.028	6.22 ± 0.03	7.57 ± 0.4
TDS	mg/L	120.7 ± 0.4	177 ± 0.84	129 ± 43	48 ± 0.63
Turbidity	NTU	0.45 ± 0.07	0.5 ± 0.00	0.3 ± 0.14	0.65 ± 0.07
EC	µs/cm	251.5 ± 0.7	367 ± 1.4	269 ± 90	101 ± 1.27
Salinity	%	0.1 ± 0.0	0.2 ± 0.00	0.1 ± 0.0	0.00 ± 0.00
Temperature	°C	20.55 ± 0.07	17.25 ± 2.61	21.25 ± 0.21	18.3 ± 1.97

Table 3: P-value of the Wilcoxon test for comparison of the quality parameters of different brands of bottled water with bottled concentrations

Parameter	Unit	Brand NO									
		1	2	3	4	5	6	7	8	9	
TDS	mg/L	0.125	0.125	0.125	0.18	0.125	0.125	0.125	0.125	0.25	0.125
pH	-	-	-	-	0.125	0.125	0.125	-	-	-	-
Fluoride	mg/L	0.125	0.125	0.097	0.125	0.125	0.125	-	-	0.125	0.125
Nitrate	mg/L	-	-	-	0.125	0.125	0.125	-	-	-	-
Chloride	mg/L	0.125	0.125	0.125	0.125	-	0.25	0.125	0.097	0.094	-
Sodium	mg/L	0.18	0.07	0.071	0.07	0.071	0.071	0.071	0.071	0.071	0.071
Potassium	mg/L	-	0.09	0.088	0.094	0.097	0.071	0.094	0.071	-	-
Iron	mg/L	-	-	-	-	0.068	-	-	-	-	-
Manganese	mg/L	-	0.097	-	-	0.068	-	-	-	-	-
Total Hardness	mg/L	0.125	0.097	-	0.125	-	-	-	-	-	0.125
Calcium	mg/L	0.097	0.097	0.097	0.125	0.125	0.125	0.125	0.19	0.097	-
Magnesium	mg/L	0.125	0.125	0.125	0.125	0.25	0.125	0.125	0.125	0.125	-
Sulfate	mg/L	-	-	-	-	0.125	0.125	0.125	0.125	0.125	-

Correspondingly, the concentrations of heavy metals in all the investigated bottled water brands were lower than the standard limits.

Table 5 shows the P-values for Wilcoxon test. Accordingly, the mean chemical values in the bottled water of all the commercial brands had no significant differences with the reported values on the package of the products. However, the most significant difference in this regard was observed in the brand labels. In the study by Samadi et al. (2006), the quality of 17 types of bottled water was investigated in Hamadan city (Iran). According to the in terms of the actual values in the water samples with the values reported on the bottle labels. In the mentioned study, potassium and sodium concentrations were reported to be

findings, the concentrations of the salts of nitrate, sulfate, chlorine, magnesium, and other elements differed from the reported contents on their labels. Accordingly, calcium concentration and pH were higher than the standard values in Iran, as well as the international standards [21]. In addition, the concentration of nitrate measured in some brands differed from the values labeled on the bottle.

The results of the present study are in congruence with the findings of Moazeni et al. (2013) in Isfahan (Iran) regarding the evaluation of the chemical and microbial quality of water in 21 commercial brands of bottled water higher than the values reported on the labels of the products in more than 43% and 52% of the samples, respectively. Moreover, calcium ions, chlorine, and pH were

approximately 71%, 48%, and 67% lower than the values reported on the labels of the products [22].

The findings of the current research are inconsistent with the study by El-Salam et al. (2008), which aimed to determine the physicochemical quality of bottled water in Egypt. In the mentioned study, 14 commercial brands of bottled water were examined during six months, and 84 samples were collected. The obtained results indicated that a large number of the bottled water samples contained elements such as some heavy metals and fluoride, the level of which were higher than the Egyptian standards [23]. In contrast, the levels of fluoride and heavy metals (copper,

zinc, lead, and cadmium) were observed to be lower than the standard limits in the present study.

Our findings were compared with the study by Bertoldi et al. (2011), which aimed to compare the chemical quality of 571 European bottled water samples. In total, the concentrations of 39 mineral components were measured in the samples, including anions, cations, and heavy metals. According to the obtained results, 8.2% of the samples did not meet the European standards, and 9% of the samples contained higher boron, nitrate, and nitrite levels than the European standards [24]. In the present study, the nitrate content was due to geological content, agricultural activities, and the discharge of human sewage [25].

Table 4: Mean (\pm SD) and coefficient of variation of each chemical parameters of all brands

Parameter	Mean	standard deviation	Coefficient of variation	Minimum	Maximum	K-S	Pvalue
Temperature	20.25	1.47	0.073	15.4	21.9	0.2	< 0.001
Turbidity	0.49	0.14	0.286	0.2	1	0.17	0.034
EC	320	113	0.352	100.4	500	0.12	0.037
TDS	175.5	149	0.849	45	1000	0.12	0.043
pH	6.89	0.39	0.057	6.2	7.86	0.12	0.336
Salinity	0.12	0.06	0.504	0.00	0.2	0.31	< 0.001
DO	6.67	0.69	0.103	5.99	8.56	0.29	< 0.001
Fluoride	0.34	0.12	0.354	0.009	0.69	0.1	0.252
Nitrate	13.0	11.0	0.855	7.2	50	0.41	< 0.001
Chloride	11.77	40.63	3.452	1.25	250	0.31	< 0.001
Sodium	34.2	31.2	0.911	18	200	0.38	< 0.001
Potassium	1.83	1.0	0.546	0.00	2.9	0.45	< 0.001
Iron	0.64	2.9	4.531	0.00	2.25	0.22	< 0.001
Manganese	0.077	0.38	4.935	0.02	0.4	0.4	< 0.001
Sulfate	28	48.7	1.738	3.2	250	0.24	< 0.001
Alkalinity	156	80.53	0.517	24	227	0.14	< 0.01
Hardness	84.2	35.2	0.418	27	200	0.093	0.42
Calcium	66.1	47.7	0.721	16	300	0.152	0.002
Magnesium	21.67	7.82	0.361	6	40	0.74	0.81

Table 5: Comparison of cochemical parameters with abnormal distribution and parameters with normal distribution with national and international standards

Parameter with abnormal dis	Median	Distance between the quartiles	Standard value	Pvalue
Turbidity	0.5	0.2	1	< 0.001
EC	330	115	500	< 0.001
TDS	158	58.4	1000	< 0.001
Nitrate	7.37	1.34	50	< 0.001
Chloride	2.8	2.75	250	< 0.001
Sodium	18	28	200	< 0.001
Iron	0.45	0.47	0.3	0.002
Manganese	0.03	0.01	0.1	0.002
Sulfate	15	26	250	< 0.001
Calcium	69	48	300	0.18
Parameter with normal dis	Mean	Standard deviation	Standard value	Pvalue
pH	6.89	0.39	6.5	< 0.001
Fluoride	0.33	0.12	0.5	< 0.001
Hardness	84.24	35.18	200	< 0.001
Magnesium	21.67	7.82	30	< 0.001

Table 6: Standard values of bottled water in Iran, the World Health Organization (WHO) and the Environmental Protection Agency (EPA)

Parameter	Iran standard			WHO Guideline	EPA standard	
	Allowable level	MCL1	MCL2		WQS ³	MCL ⁴
TDS	1000	1500	-	1000	500	500
pH	6.5-8.5	6.5-9	-	6.5-8.5	-	6.5-8.5
Turbidity	-	-	-	-	1-5	0.5-1
Fluoride	-	1.5	4	1.5	2.4	2
Nitrate (as NO3-)	-	50	20	50	50	50
Chloride	-	250	-	250	250	250
Sodium	-	200	-	200	-	20
Iron	0.3	-	-	0.3	-	0.3
Manganese	0.1	0.4	0.4	0.1	0.05	0.05
Sulfate	250	400	-	250	250	250
Hardness	200	500	-	200	-	-
Calcium	300	-	-	-	-	-
Magnesium	30	-	-	-	-	-
Copper	1	2	-	2	1	1.3
Zinc	3	-	-	-	5	5
Lead	-	0.01	0.01	0.01	0.005	0.015
Cadmium	-	0.003	0.003	0.003	0.005	0.005

1. Institute of Standards and Industrial Research of Iran, Standard 6694 [25]
2. Institute of Standards and Industrial Research of Iran, Standard 2441 [16]

3. Water Quality Standards
4. Maximum Contaminant Level

4. Conclusion

According to the results, the values of the chemical parameters in the samples of bottled water were consistent with drinking water standards in most of the cases. However, the levels of some parameters were higher than the standard values, such as iron and pH. In general, consumers expect the quality of bottled water to be higher than the water supplied by the urban distribution network. Although the levels of the chemical parameters were lower than the drinking water standards in some of the investigated bottled water brands, some parameters were in contrast to the expectations of the community regarding the higher quality of bottled water.

In some of the evaluated commercial brands, the measured values differed from the values reported on the labels of the products, especially nitrate, sulfate, water hardness, chloride, calcium, magnesium, pH, and total soluble solids; these values are often found at extremely low concentrations on the commercial label. High concentrations of some parameters could have health effects in the consumers, especially vulnerable populations, and this issue must be considered by custodians and authorities. Meanwhile, respected manufacturers must comply with the relevant standards of product labeling, and the actual values of the parameters should be mentioned in order to maintain the health of the consumers.

Authors' Contributions

M.S., and M.R., designed the study. M.G., performed sampling and laboratory analysis. N.R., and B.P., carried out data analysis. M.S., performed data analysis and manuscript preparation. All the authors read and approved the final manuscript.

Conflict of Interest

None declared.

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