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STUDY ON THE QUALITY OF BOTTLED DRINKING WATER

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KEYWORDS

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Potable water
TSD

ABSTRACT

This study presents a comparative analysis of twelve commercial brands of still bottled water from Romania. To this end, we compared the placement of chemical parameters below the maximum permissible limit of each compound. It was also verified whether the information is inscribed on the label according to the legislation in force. To evaluate population awareness of the importance of drinking water's quality, a questionnaire was created to which 117 people from several different counties of Romania answered. So it was found that the most popular aspect on wich the respondents based on their preferences in purchasing the water they drink, is represented by the organoleptic properties, most of them (33.33%), preferring the brand *Aqua carpatica*. The study found that all the analysed still water assortments fall within the accepted standards for the chemical parameters of drinking water.

INTRODUCTION

Water is the primordial element of life, representing a major compound of the human body, essential for maintaining the health at cellular level and facilitating most of the physiological processes. About 97% of the planet's water consists of salt water, while the rest of 3% is fresh water from which we have accessed to aproximmately 30% of it, the rest being retained in glaciers (Katsanou, 2017). According to WHO: „*Drinking water is that which does not pose any danger to human health when consumed throughout life*" (Cherres-Seminario, 2020). It presents variable particularities depending on the method of obtaining it and the source of its origin, variations due to the incorporation of some soluble elements through their contact with water sources.
The main sources of raw water from which drinking water is processed are groundwater and surface water. This type of untreated water comes from sources that can provide sufficient quantities of water, and its quality must be good enough when treated, meeting accepted standards. Surface water consists in any source of water exposed to the atmosphere. Typically, a substantial amount of water is filtered through the banks, where it carries a diverse load of pathogens and chemicals, thus making water purification imperative. Groundwater is located beneath the layers of soils and sediments, being less exposed than surface water. However, groundwater extraction requires drilling and pumping equipment that can be quite expensive (Katsanou, 2017).
Water quality is determined according to a series of physical, chemical and biological parameters, determining the presence and concentration of chemicals present in the water, which can disrupt public health. Most often, to establish the quality of drinking water in terms of physical properties, the following are determined: organoleptic properties (taste, smell), turbidity and electrical conductivity (Conejeros-Molina, 2021). Among the chemical compounds that can represent a risk factor for the health of the population, we mention nitrates (coming from compost, landfills and fertilizers), nitrites (formed from nitrates following incomplete bacterial oxidation) and heavy metals with a degree of high toxicity due to their biotransformation, bioaccumulation and bioconcentration properties along the food chains (Cherres-Seminario, 2020).
At the same time, the microbial properties of water also refer to the population of microorganisms present in water, which affect its quality and can even spread certain water diseases. Water potability standards have established that water intended for human consumption must not contain any pathogenic germs (*Escherichia coli, Streptococcus sp., Clostridium sp.*). Therefore, before drinking water is distributed to the population, it must undergo specific disinfection and purification processes, from which chlorination is the most used. Chlorination

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destroys microorganisms, but it is also important in the oxidation of some inorganic chemical compounds (Fe, Mn, sulfides, etc.). However, chlorination can also generate some toxic by-products with carcinogenic potential (trihalomethanes, haloacetic acids, dissolved organic halogens, etc.). That is why, nowadays, the disinfection of water with the help of UV rays is a process that is becoming more and more significant, as it reduces the use of dangerous chemical reagents, its effect on water doesn't take long to manifest (a few seconds/minutes), and costs are lower (Rossel-Bernedo, 2020).

Current regulations around the world on drinking water quality mainly refer to the allowed limits for toxic elements and the highest accepted levels of microorganisms in water, so that it is safe for human consumption. Nevertheless, the drinking water may contain compounds that do not affect human health in any harmful way, but in beneficial ways, which can be organic or inorganic, for example, some mineral substances and microorganisms that can improve human health.

It is essential to note that as long as the concentrations of these elements fall within the consumption parameters mentioned in the legislation, they do not negatively affect the human organism. Otherwise, these chemical compounds become toxic and the water becomes unfit for consumption. (Rosborg, 2020).

Recently, the global consumption of bottled drinking water has increased, due to consumers' perception, considering that bottled water has higher qualities and superior organoleptic properties compared to drinking water from other sources. Bottled still water consumption preferences vary according to demographic and socio-economic characteristics (Arellano. A., 2019). For bottling drinking water, polyethylene terephthalate (PET) containers are most commonly used, because this material has advantageous physical proprieties and is easy to recycle. Even though their use is advantageous, recent studies have identified the risk that, by repeatedly using the same PET container and by subjecting it to high temperatures and direct solar radiation, some of the chemical compounds in the structure of this material will migrate into the water contained (Jayaweera, 2020). Among them, a health risk factor is represented by phthalates, which are a group of water pollutants that tend to bioaccumulate in the adipose tissue of consumers.

Given the increased consumption rate of bottled water globally, this study aims to conduct a comparative research concerning the bottled drinking water's quality from various trademarks in the country, highlighting the importance of marketing bottled water according to the existing legislation on bottling and proper labelling.

MATERIALS AND METHODS

In this study was carried out an inventorying of the chemical composition written on the label of 12 varieties of still bottled water, present in two shopping centers in Bacău County, Romania. The varieties included in the study are known under the trade names: *Aqua carpatica, Aquatique, Aquavia, Borsec, Bucovina, Carpatina, Dorna, Izvorul minunilor, Perla Harghitei, San Benedetto, Smartwater* and *Zizin.* In addition to the 12 assortments of bottled water mentioned previously, we have also identified an assortment that could not be included (*Codrii Vlăsiei*), due to the lack of information on its chemical composition on the label.

The data regarding the chemical composition written on the label were noted in a table, and then compared according to the drinking water quality standards, provided by law no. 458 of July 8, 2002 (from Romanian legislation) and by Directive (EU) 2020/2184 on the quality of water intended for human consumption. Among the compounds written on the label, we chose to compare cations (Na^+, K^+, Mg^{2+}, Ca^{2+}), anions (F^-, Cl^-, NO^{3-}, SO_4^{2-}, HCO^{3-}), the amount of dry residue at 180ºC (TSD) and pH (Table 1).

In addition to the comparative analysis of the bottled still water assortments marketed in the two shopping centres, we have conducted a questionnaire in Google Forms, to evaluate the awareness of the population regarding the quality of drinking water and the criteria they consider when purchasing a certain assortment of bottled still water. The questionnaire was completed by 117 respondents from 17 different counties (Bacău, Neamț, Botoșani, Suceava, Iași, Brașov, Vrancea, Calarași, Bucharest, Vâlcea, Ilfov, Argeș, Prahova, Ialomița, Galați, Brăila and Constanța).

Table 1. The chemical composition of the 12 varieties of bottled still water

Brand name	Cations (mg/L)				Anions (mg/L)					TDS <200-400	*p*H 6,5-9,5
	Na^+ <200	K^+ <10	Mg^{2+} <50	Ca^{2+} <100	F^- <1,5	Cl^- <250	NO_3^- <50	SO_4^{2-} <250	HCO_3^- 25-400		
Aqua carpatica	1,34	-	13,1	40,5	-	-	-	-	181	132	7,89
Aquatique	<1	-	1,81	30,3	<0,2	-	-	6,11	102	105	7,6
Aquavia	65,7	0,32	-	2.8	-	-	<1	-	158	160	9,4
Borsec	2,13	-	27,9	54,6	-	-	-	-	292	304	7,48
Bucovina	9,23	0,53	10,5	79,6	0,05	-	-	-	253	164	7,8
Carpatina	0,66	0,37	3,2	55,56	-	3,24	-	16,87	195,2	166	7,74
Dorna	0,9	0,4	1,7	65,3	-	<1	7,1	-	187	178	7,99

Brand name	Cations (mg/L)					Anions (mg/L)				TDS <200-400	*p*H 6,5-9,5
	Na^+ <200	K^+ <10	Mg^{2+} <50	Ca^{2+} <100	F^- <1,5	Cl^- <250	NO_3^- <50	SO_4^{2-} <250	HCO_3^- 25-400		
Izvorul minunilor	1,14	0,91	3,62	17,8	-	-	2,99	-	79,3	70	-
Perla Harghitei	6,95	1,36	10	102	-	17,3	-	11	327	338	7,3
San Benedetto	6,3	0,99	29.9	51,1	<0,1	2,8	9	4,5	283	271	7,55
Smartwater	-	4,6	4,5	61	-	-	-	-	-	-	7,5
Zizin	8,65	1,07	3,1	73,65	-	16,3	-	<40	250,1	233	7,2

RESULTS AND DISCUSSION

Among the data found through the comparative study of the labels of the 13 varieties of bottled still water analyzed, the most complete label in terms of chemical composition was identified from *San Benedetto*, and the most incomplete from the *Codrii Vlăsiei* still water, where it didn't have any information regarding the chemical composition. Also, the most complete label from a legislative point of view (trade name, source, chemical composition, net quantity, product storage conditions, etc.) was identified from *Borsec* still water.
We have highlighted the maximum and minimum values for each individual compound. Thus, the maximum Na^+ concentration allowed is 200 mg/L; the biggest value was recorded for *Aquavia* still water (65.7 mg/L), and the minimum value was recorded for *Dorna* still water (< 1 mg/L). The highest K^+ concentration (CMA = 10 mg/L) identified is 4.6 mg/L, at *Smartwater*. The concentration of Mg^{2+} closest to the CMA (100 mg/l) was recorded in the *San Benedetto* assortment (29.9 mg/L). Regarding Ca^{2+}, the maximum recommended concentration is 100 mg/L, the highest value, identified in the *Perla Harghitei* still water, slightly exceeding this value (102 mg/L), and the lowest value was identified in the *Izvorul minunilor* still water (17.8 mg/L) (Figure 1).

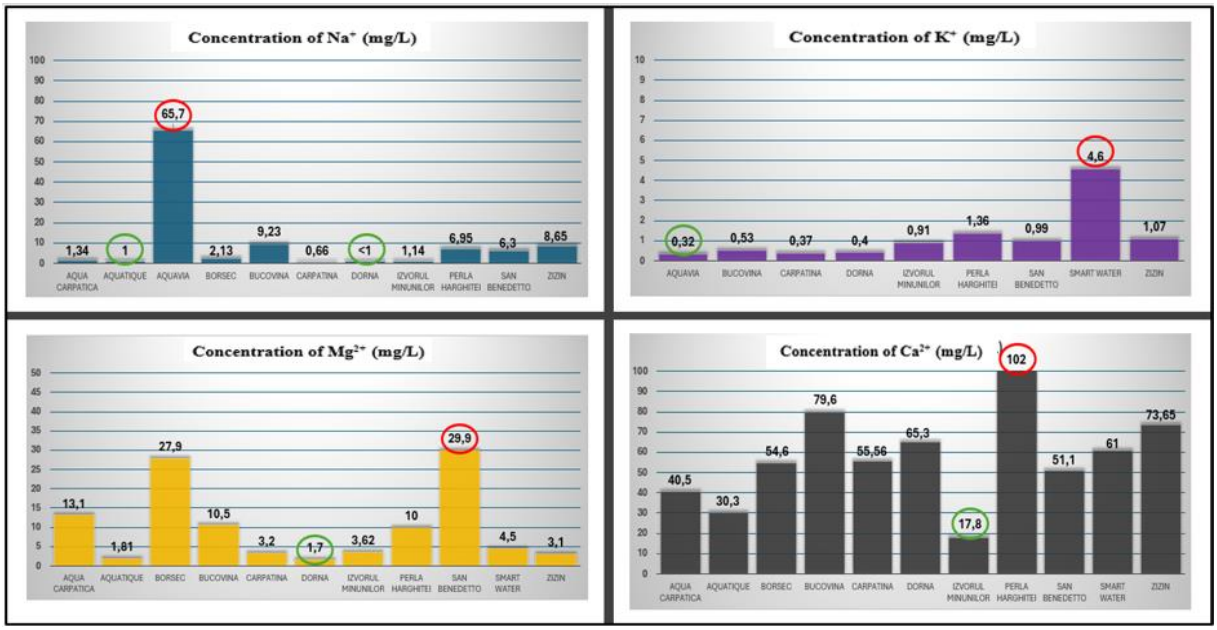

Figure 1. Concentration of various cations (Na^+, K^+, Mg^{2+}, Ca^{2+}) present in drinking water

The highest value of fluorides identified is < 0.2 mg/L at *Aquatique*, wich falls below the CMA value (1.5 mg/L). Also, the highest concentration of chlorides in drinking water has been identified in the *Perla Harghitei* assortment (17.3 mg/L), which is well below the CMA (250 mg/L). A chemical parameter that has been taken into account in determining the quality of drinking water is the nitrate concentration, the maximum permissible concentration being 50 mg/L. Thus, compared to other assortments, the highest nitrate concentration value was found in the San Benedetto variety of 9 mg/L. On the other hand, the lowest value was recorded for the Aquavia variety, of less than 1 mg/L. Sulfates are another category of chemical compounds present in water, but for safe human consumption the sulfates` concentration should be below the limit of 250 mg/L. All assortments included in the study fall below this limit, the highest value being much lower than the CMA (40 mg/L) at the *Zizin* still water. The maximum permissible concentration for HCO^{3-} is about 250-400 mg/L, and in the case of bottled still water *Perla Harghitei*, the concentration of HCO^{3-} reaches its maximum limit, having a value of 327 mg/L; the minimum value was identified for the *Izvorul minunilor* assortment, of 79.3 mg/ L (Figure 2).

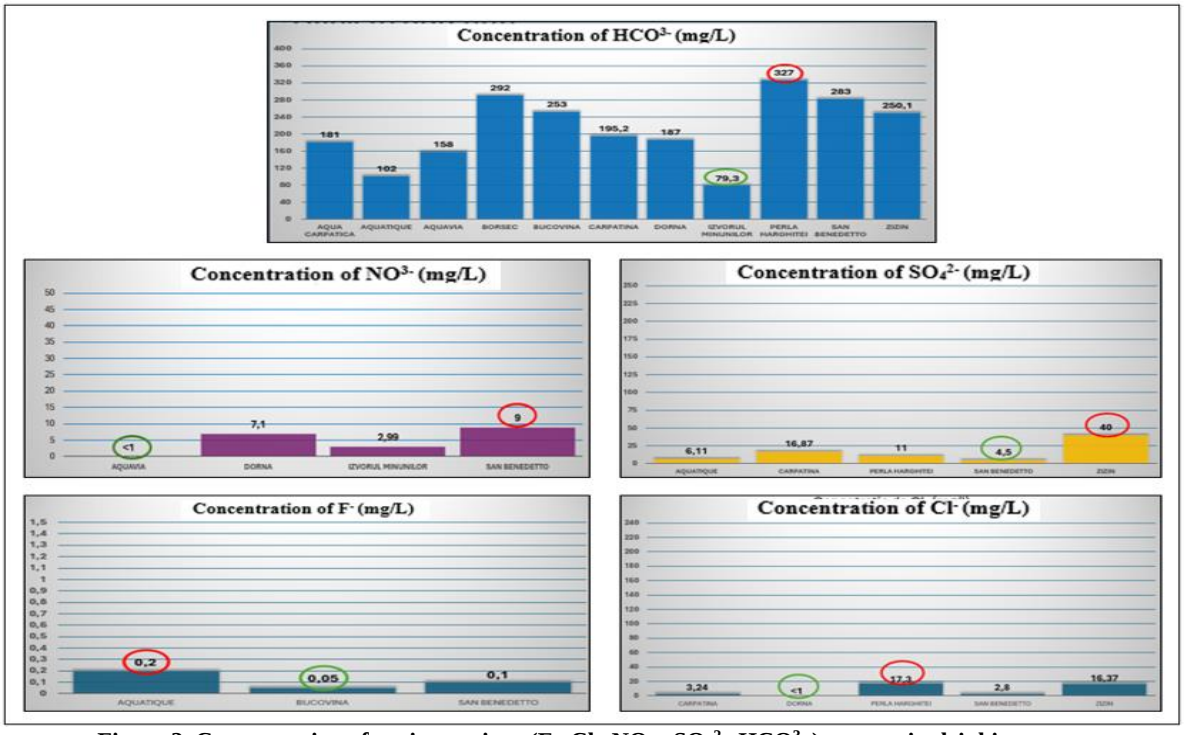

Figure 2. Concentration of various anions (F^-, Cl^-, NO_3^-, SO_4^{2-}, HCO^{3-}) present in drinking water

In addition to the cations and anions as chemical proprieties, TDS (total dissolved solids) and pH were analyzed as well. Thus, considering the CMA for TDS (200-400 mg/L), the highest value recorded was in the case of the *Perla Harghitei* assortment, its concentration being included in the mentioned limit range (338 mg/L). The pH value for the varieties of still bottled water is on average 7, the drinking water analyzed being neutral according to this parameter, except for the alkaline variety *Aquavia*, with a *p*H value of 9.4, barely falling within the maximum accepted limits; the optimum pH value of drinking water is between 6.5 and 9.5 (Figure 3).

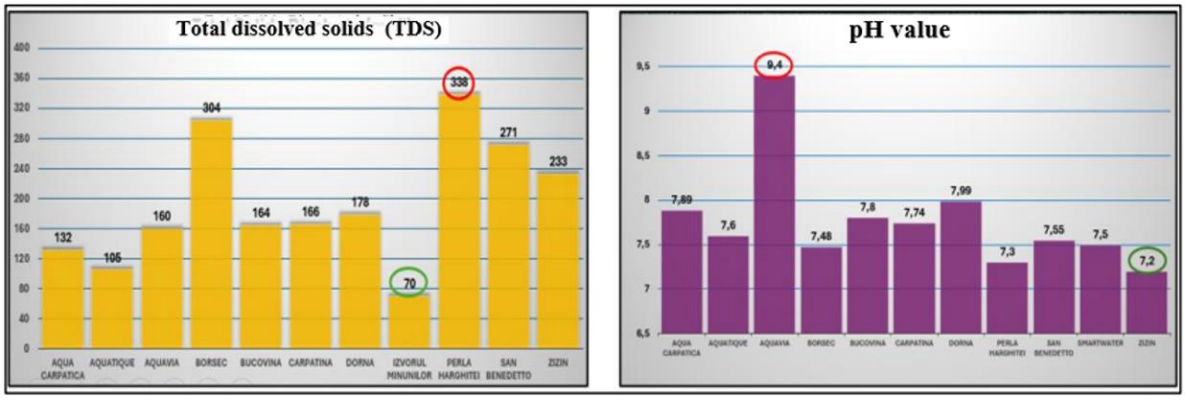

Figure 3. Concentration of TDS and pH of drinking water

After analysing the questionnaire replies, it was found that nearly half of the respondents (46.15%) consume less than the average amount of water recommended for the daily consumption of an adult (2 l). Only 8.54% consume more than 2 L of water daily, and 38.46% approximately 2 L. For the majority of respondents (52.99%), the most important criterion on the basis of which they select the water they consume is represented by its organoleptic properties, 23.07% consider the price of bottled water, 13.67% buy their water according to the brand name, and 10.25% according to the volume of the container.

Of the 117 respondents, only 37.60% have their own source of drinking water, while the rest consume still bottled water from the market. So, among the 12 varieties analyzed, most people prefer the *Aqua carpatica* still bottled water (33.33%).

The second variety preferred by respondents is *Borsec*, with a percentage of 22.22%, followed by *Bucovina* (13.67%), *Dorna* (7.69%) and *Zizin* (5.69%). *Perla Harghitei*, *Aquatique* and *Izvorul miunilor* are consumed by an equal percentage of respondents (2.56%), and *Aquavia* is preferred by 1.70%. The lowest percentage was recorded in the case of people consuming *San Benedetto* still bottled water, of only 0.85%.

CONCLUSION

According to the completed questionnaire, almost half of the respondents (46.15%) consume less than 2 L of water per day.
Aqua Carpatica is the variety of still bottled water preferred by most of the respondents to the questionnaire (33.33%).
The still bottled water with the most complete label in terms of chemical composition is *San Benedetto*, and the most incomplete is *Smart Water* (with the exception of the *Codrii Vlăsiei* assortment, which does not mention the concentration of any chemical compound).
The range of still water with the highest values for chemical parameters is *Perla Harghitei* (Ca^{2+}, Cl^{-}, HCO^{3-}, TDS).
The still water variety with the lowest values of chemical parameters is *Izvorul Mununilor.*
Bottled drinking water must fall within the parameters specified in the legislation in force. Therefore, following the study, all 12 types of plain water mentioned did not exceed the maximum concentrations allowed for the chemical parameters.

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