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Content of the Label Paper and the Variation of Physico-Chemical Parameters in Bottled Water in Kosovo

Hazir Çadraku[1]

[1] Faculty of Civil Engineering and Infrastructure, University for Business and Technology, Magjistralja Prishtine – Ferizaj, Kosovo

E-mail: hazir.cadraku@ubt-uni.net

ABSTRACT

Water is a vital resource for the existence of mankind and all ecosystems on Earth. Before using it, it must be ensured that water is of good quality, within the hygienic-sanitary norms for human consumption. In recent decades, the supply of drinking water has been supplemented with the water bottled in glass and plastic bottles, which is found everywhere in the market of the Republic of Kosovo. This paper deals with the content of the label paper and the variation of physico-chemical parameters of bottled water which is extracted, analyzed, processed, filled, packaged and distributed on the market of the Republic of Kosovo and beyond as a product for consumption. i.e. In this paper 20 brands of groundwater (types of water) produced and packaged in the territory of Kosovo.

Keywords: water quality, bottled waters, physico-chemical parameters, Kosovo.

INTRODUCTION

In many debates, seminars, conferences, reports and scientific papers, various institutional leaders, researchers and professionals emphasize the need to preserve and protect water quality and its rational use, because in the coming years it is very likely that good quality water will be in deficit and at high prices for humanity on Earth. Kosovo emerged from the war for the liberation of the country in June 1999. Independence was declared in 2008. Kosovo has an area of 10905.25 km^2 (KAS, 2022) and extends in northern latitude from 41°50'58'' to 43°15'42'' and eastern longitude from 20°01'02'' to 21°48'02'' (MESP, 2011), is characterized by a central position in the Balkan Peninsula (Southeast Europe). It has 1.798.506 inhabitants with a population density of 164 inhabitants per square kilometer. There are 38 municipal administrative units, seven regions and 1500 settlements (KAS, 2011). The highest point is Gjeravica (2656 m), while the lowest is 270 m in Vërmica (AKMM, 2022). It consists of two main lowlands Dukagjini and Fushë e Kosovës. The catchment area has an area of 11645 km^2 (KEPA, 2022), is relatively rich in surface and groundwater. The provision of public services with drinking water is done by seven regional companies. Monitoring of drinking water quality is performed by the National Institute of Public Health and by the water service providers themselves. The protection of the quality of drinking water is done through the legal act QRK No.10/2021 (Official Gazette of the Republic of Kosovo, dated 30.03.2021). The developments that have taken place since 1999 have brought about changes and transformations in all sectors; administrative, social and economic. As a result of these developments, the drinking water sector was supplemented by the provision of drinking water service through bottled water, which in the past was very underdeveloped. Opening the opportunities for investment by the private sector, creates the conditions for the construction of factories for processing, packaging of bottled water and its distribution in the domestic market and beyond, thus becoming an alternative way of drinking water supply. This water supply alternative creates a convenience for all consumers, as bottled water is easily found in the market and is easy to use and exploit. The bottled water that is offered in the

market is obtained from groundwater, from captured springs and drilling wells. Water treatment and packaging plants are located mainly on the eastern, southeastern and western side of Kosovo. Their quality control is performed by the National Institute of Public Health (NIPH). The data regarding their quality are presented on the label paper which is placed on the packaging of each glass or plastic shield. In principle, any water that is in nature can be used for drinking as long as it does not pose side effects or danger to human health and life. Drinking water is mainly obtained from surface and groundwater. The service can be provided on its own from natural resources, wells dug or drilled, by water service providers-public water utilities, as well as from water treatment plants and bottling plants. The common element that connects at one point these three types of water service providers is water quality. The quality and physicochemical composition of water depend on natural and anthropogenic factors. The natural factors involve, the geological environment where water is located, circulates and stays important, while the anthropogenic factor is related to the person in charge, knowledge, laboratory equipment, methods and interpretation and drawing conclusions about the quality of a water that can be used for wide consumption public.

STUDY AREA

The Republic of Kosovo is located in the central part of the Balkan Peninsula (Fig. 1), between the geographical coordinates (northern latitude from 41°50’58’’ to 43° 15’42’’ and eastern longitude from 20°01’02’’ to 21°48’02’’). It has an area of 10905.25 km^2. It is relatively rich in surface and groundwater. From the hydrogeological point of view, intergranular, karstic and fissured aquifers are of importance (ICMM, 2006).

MATERIALS AND METHOD

In this study, 20 brands of water which are found in the market of the Republic of Kosovo and are offered for public consumption as drinking

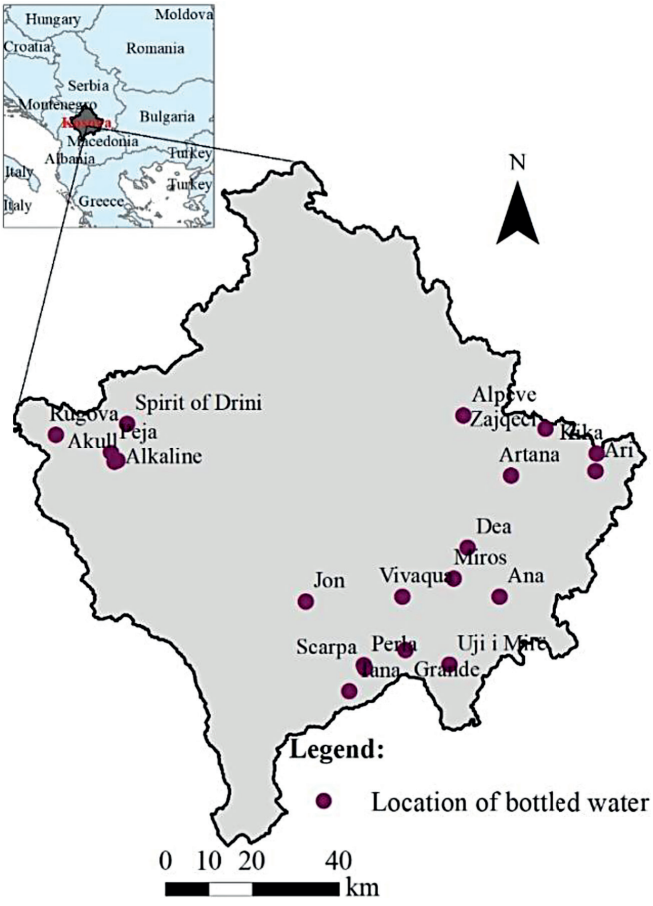

Figure 1. Position of the Republic of Kosovo

water are included. These waters are extracted, analysed in relation to their quality, processed, filled, packaged and distributed in the market of the Republic of Kosovo. Data collection, systematization, processing, analysis, interpretation and drawing of conclusions has included a time period from October 2021 to May 2022. The materials used for this study were glass and plastic bottles filled with water with different volumes from 0.5 litres (Fig. 2) and 10 litres. They were bought in the Kosovo market in various locations and markets (shops). The data regarding physico-chemical parameters were obtained from the label paper found on the water bottle. Then, these data were further developed for the purpose of this paper which are elaborated in the results section with this paper.

DISCUSSION OF RESULTS

The quality of water for human consumption is important for maintaining overall health and well-being. Water quality control and monitoring in the Republic of Kosovo is performed by the National Institute of Public Health (NIPH), while from the legal aspect it is regulated by Administrative Instruction (NRC) No. 10/2021 On Water Quality for Human Consumption, which determines the value of parameters for the water used for human consumption. Bottled water has now become an important alternative in the drinking water sector. It contains the physico-chemical parameters which are presented on the label paper (Table 1).

Temperature is a key property of water. It affects the development of many chemical processes in water, the amount of gas and salts dissolved in it. Groundwater temperature depends on many factors. Shallow groundwater is affected by fluctuations in air temperature, while at depth they are affected by the thermal conductivity of rocks, tectonics, localization of volcanic eruptions, etc. The temperature parameter in 8 or 44.44% of bottled water is indicated on the label paper, while in 10 or 55.56% of them it is not presented. In the bottled waters which are used for public consumption, the temperature varies from 6.60°C to 12.00°C with an average temperature of 8.66°C (Fig. 3). The highest value of temperature shows water Dea (T = 12.00°C) in the locality Zhegovc-Gjilan (southeast of Kosovo), while the lowest value shows water Rugova (T = 6.60°C), Rugova-Peja (west of Kosovo). On the basis of the temperature values, it results that the bottled water belongs to the group of cold groundwater (T = 4–16°C).

Electrical conductivity – in the 20 waters (water brands) considered in the paper, this parameter was presented on the label of bottled water only in 14 or 77.77% of them, while 4 or 22.23% of them was not presented. From these data it results that the value of EC in bottled waters fluctuates in the range from 92.50 µS/cm to 571.00 µS/cm with an average value of 26.80 µS/cm (Fig. 4). Zajqeci water (eastern part of Kosovo) shows lower value (EC = 92.50 µS/cm), while Alpeve water-Koliq (central part of Kosovo) shows higher value (PE = 571.00 µS/cm). Dry residue expresses the mass of sediment remaining after evaporation at T = 180 °C. Dry residue is presented only in 14 or 70% on the paper label of packaged water, while in 6 or 30% of them it is not presented. The values of this parameter range from 41 mg/l (Zajqeci water-Kamenica, eastern part of Kosovo) to 590 mg/l (Jon water-Suhareka, southwestern part of Kosovo) (Fig. 1), with an average value of 213.21 mg/l (Fig. 5).

The groundwater pH includes acidic, neutral and alkaline. Water pH is one of the main indicators of water quality. According to pH, waters are divided into pH < 5 acidic, pH = 5–7 weakly acidic, pH = 7 neutral, pH = 7–9 weakly alkaline and pH > 9 alkaline (Dakoli, 2007). The pH value

Figure 2. Bottled water

Table 1. Content of the label paper present in bottled water

No.	The name of the water	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO^{-}_{3}	SO_4^{2-}	Cl^{-}	NO_3^{-}	NO_2^{-}	SiO_2	F^{-}	NH_3N	NO_3^{-}-N	Ammonia	pH	T°C	EC (µS/cm) in 20°C	Dry residue (mg/l)	TH (d°H)
1	Dea	19.20	5.34	33.15	0.46	146.40	15.00	9.12	0.20							7.54	12.00	188.40	200.00	
2	Akull	64.00	16.30	12.10			16.70	10.60	1											
3	Rugova	58.80	2.00	4.38	0.25	178.12	10.90	5.67	0.122	0.001						7.54	6.60	242.00	149.00	
4	Peja	34.00	18.20	18.65	1.00	219.60	28.10	7.09	0.4		12.8					7.80	9.00	284.00	207.00	
5	Miros	34.00	14.00	18.65	1.00	201.00	27.80	7.09	0.4		12.8					7.80	9.00	280.00	204.00	7.50
6	Alkaline	5.00	3.60	0.18	<0.1		14.70	14.70	0.42			<0.02				9.33		110.00	207.00	7.50
7	Alpeve	76.80	25.04	5.40	1.40	305.00	38.40	7.10	0.3			0.05						571.00	328.00	
8	Kika	3.28	0.67	4.74	0.95	23.18	10.12	1.13				0.016								0.95
9	Zajqeci	6.30	2.50	3.80	1.30		10.00	8.50	0.4	0.002						7.10	7.10	92.50	41.00	
10	Ari	15.90	3.02	7.43	1.23	122.00	20.04	10.53					0.01						280.00	
11	Jon	586.00	7.84	16.60	1.02	280.00	28.20	12.05						0.3		7.50	9.60	390.00	590.00	
12	Uji i Mirë	35.12	11.68	12.19		23.11	27.55	7.55	0.10									390.00	180.00	
13	Vivaqua	34.00	18.20	18.65	1.00	219.60	28.10	7.09	0.40		12.8					7.80	9.00	284.00	207.00	7.50
14	Ana	22.04	0.79	7.50	0.50	153.00		14.16										223.00	121.00	
15	Spirit of Drini	52.00	2.40	0.70	0.10	238.00	2.00	1.10	0.40		2.14					7.50			131.00	
16	Artana	22.12	3.68		0.51		2.60	4.00	2.10	0.009					0.0013	7.88		193.30		6.83
17	Tana	6.65		1.03	0.57	61.00		1.30	0.50							7.95		206.00		
18	Grande	34.48	5.83	0.09	0.20	122.00	3.00	1.05	6.10							7.35	7.00	197.00		6.16
19	Scarpa	34.5	5.83	0.09	0.23	122.00	3.00	1.05								7.35		211.00		6.16
20	Perla	10.7	2.13	1.89	0.77	4.48	20.50	11.34				0.075				7.69			140.0	

DO (mg/l)	TDS (mg/l)	Irom	Manganese	Zinc	Copper	Cobalt	Nickel	Aluminum	Chromium	Arsenic	Selenium	Mercury	Silver
		0.02	0.06	2.34	0.20								
		0.00008	0.00006		0.0001	0.00001	0.00004	0.00005	0.0003	0.00006	0.0009	0.00006	0.0000004
8.93	98.00												
8.93	140												
		0.01	0.17						0.75				

Note: unit in miligrams per liter.

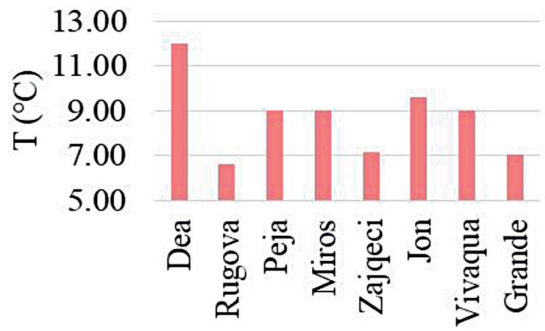

Figure 3. Variation of temperature

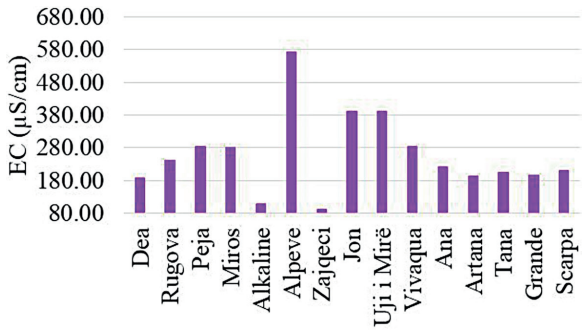

Figure 4. Variation of EC

ranges from 7.1 to 9.33 with an average value of 7.72 (Fig. 6). The highest value is shown by the alkaline water (Peja-Vitormirica) on the western side of Kosovo, while the lowest pH value is shown on the water Zajqeci-Kamenica on the eastern side of Kosovo.

Hardness has great practical importance. Hard water is unsuitable for use in the food industry. Groundwater, depending on the time of contact with the rock, acquires increasing strength. The TH parameter on the paper of the packaged water label considered in this paper is presented only in 7 or 35%, while 13 or 65% of them do not have this parameter presented. The values of TH in packaged waters range from 0.95 German degrees (Kika-Kamenica water, eastern part of

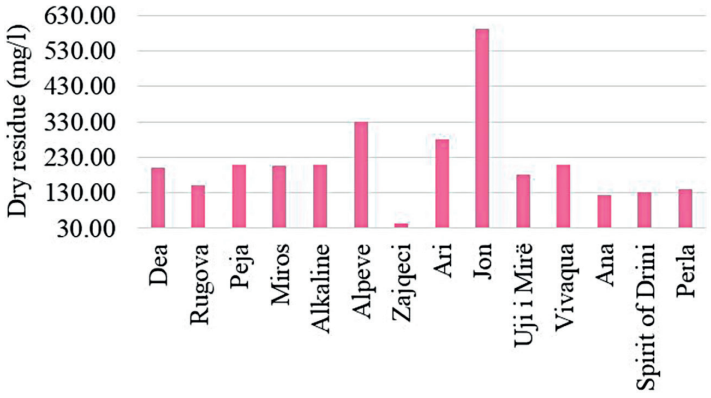

Figure 5. Variation of dry residue

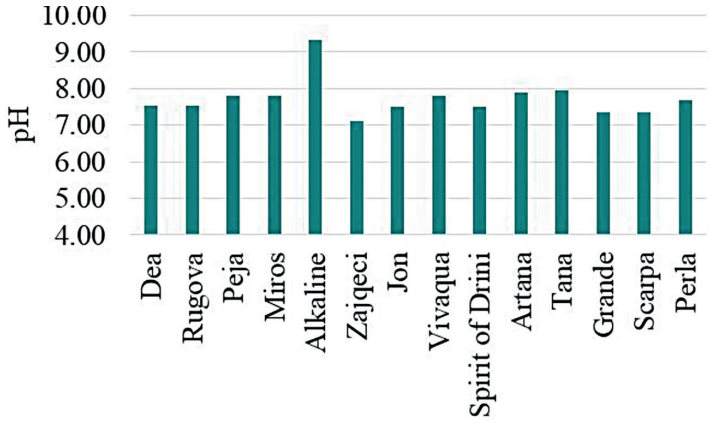

Figure 6. Variation of pH

Kosovo) to German 7.50 degrees (Miros water, Vivaqua-Ferizaj southern part of Kosovo and Alkaline water-Peja, western part of Kosovo) and average value 6.09 German degrees (Fig. 7). On the basis of the values of TH it turns out that the Miros, Alkaline, Vivaqua, Artana and Grande water belong to the groundwater with soft hardness 4–8 degrees German. Only the Kika water belongs to the group of waters with very soft hardness below German 4 degrees.

Calcium (Ca^{2+}) is the main element that causes water hardness. The high content of Ca^{2+} in water does not pose a health risk, however it does affect the taste of the water. According to (Leurs et al., 2010) Ca^{2+} is essential for the development of the bone and tooth system, for blood clotting and nerve impulse to the muscles. Ca^{2+} in bottled water ranges from 3.28 mg/l (Kika water) to 586 mg/l (Jon water) with a mean value of Ca^{2+} of 57.74 mg/l (Fig. 8).

Magnesium (Mg^{2+}) according to WHO (2010) Mg^{2+} is present in natural groundwater usually at lower concentrations from negligible to about 50

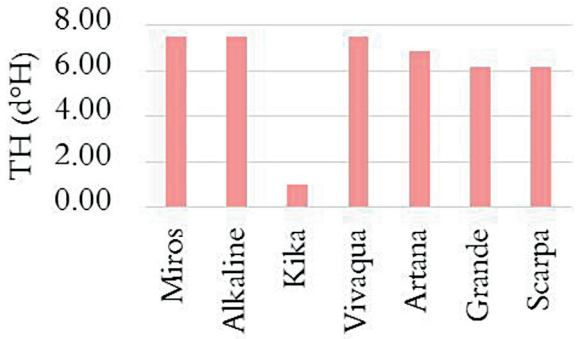

Figure 7. Variation of TH

mg/l and rarely above 100 mg/l. Mg^{2+} in packaged waters ranges from 0.67 mg/l (Kika water) to 25.04 mg/l (Alpeve water) with a mean value of Mg^{2+} of 7.84 mg/l (Fig. 9).

Sodium (Na^{+}) according to EPA (2003), Na^{+} is important for regulating tissue tension, body water balance and muscle sensitivity. The use of groundwater with high concentrations of Na^{+} ion is not recommended for drinking. Above 200 mg/l is considered harmful to the body. Na^{2+} in bottled water ranges from 0.087 mg/l (Grande

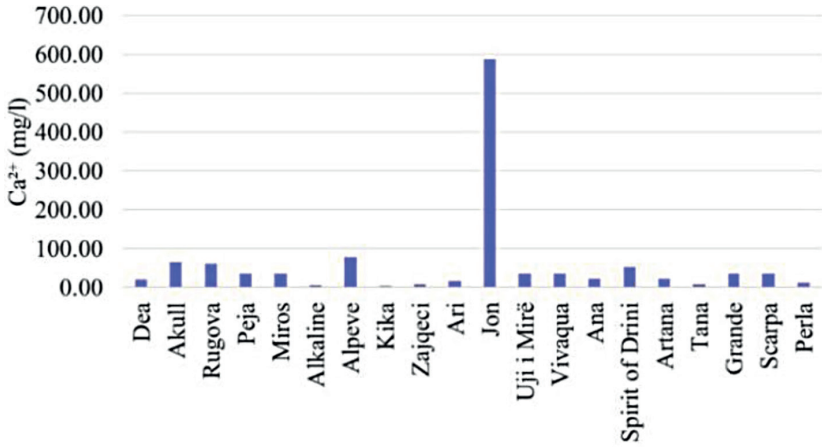

Figure 8. Variation of Ca^{2+}

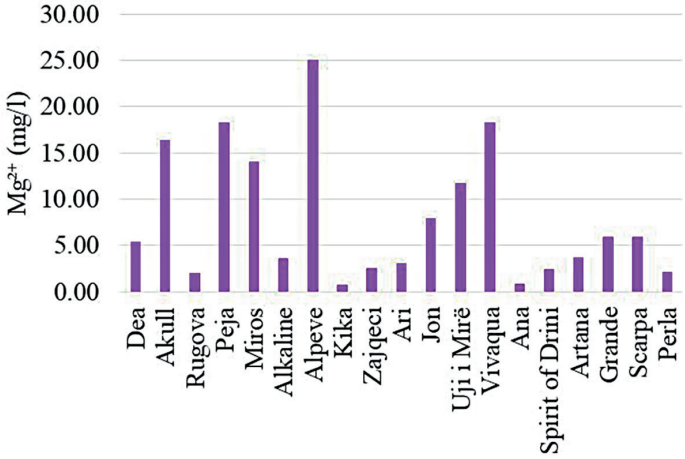

Figure 9. Variation of Mg^{2+}

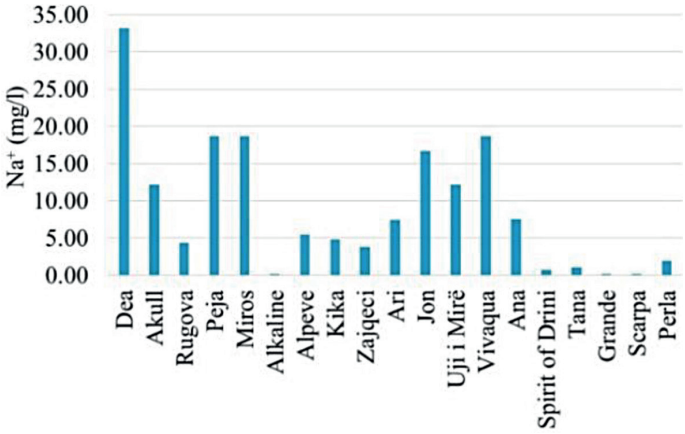

Figure 10. Variation of Na^{+}

and Scarpa water) to 33.15mg/l (Dea water) with a mean value of Na^{2+} of 8.80 mg/l (Fig. 10).

Potassium (K^{+}) in packaged waters ranges from 0.10 mg/l (Spirit of Drini water) to 1.4 mg/l (Alpine water) with a mean K^{+} value of 0.76 mg/l (Fig. 11). Bikarbonatet (HCO_3^{-}) bicarbonates in packaged waters range from 4.48 mg/l (Perla water) to 305 mg/l (Jon water) with a mean value of HCO_3^{-} of 73.13 mg/l (Fig. 12). A statistical summary of the physico-chemical parameters presented on the paper label of the bottled water is shown in Table 2. Table 2 shows that Ca^{2+} and Cl^{-} are presented on

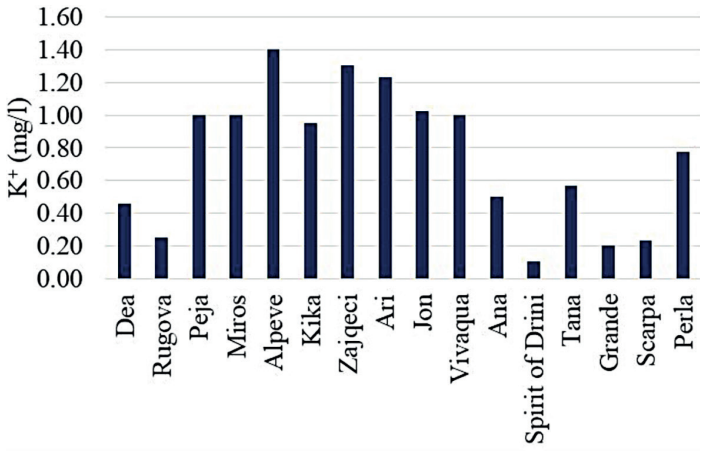

Figure 11. Variation of K^+

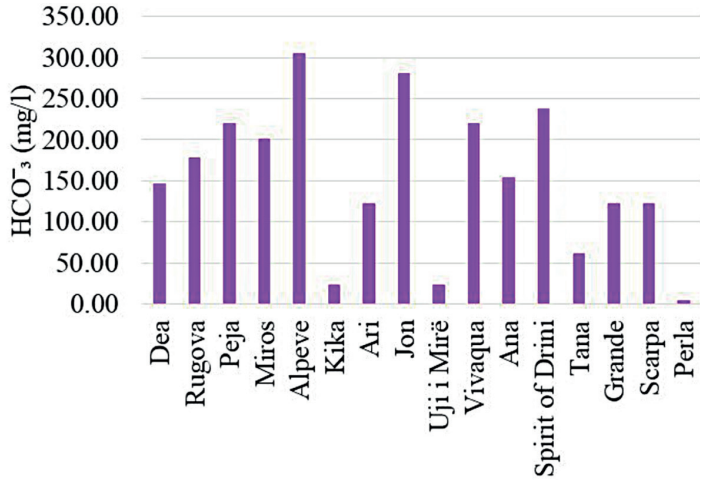

Figure 12. Variation of HCO_3^-

Table 2. Summary statistics of present and non-present parameters on paper label of bottled water

Physico-chemical parameters	Presented and not presented on the label letter		In %	
	Presented	Not presented	Presented	Not presented
T	8	12	40.00	60.00
pH	14	6	70.00	30.00
EC	15	5	75.00	25.00
Dry residue	14	6	70.00	30.00
TH	7	13	35.00	65.00
Ca^{2+}	20	0	100.00	0.00
Mg^{2+}	19	1	95.00	5.00
Na^+	19	1	95.00	5.00
K^+	19	2	95.00	10.00
HCO^-_3	16	4	80.00	20.00
SO_4^{2-}	18	2	90.00	10.00
Cl^-	20	0	100.00	0.00
NO_3^-	14	6	70.00	30.00
NO_2^-	3	17	15.00	85.00
SiO_2	4	16	20.00	80.00
F^-	4	16	20.00	80.00

the paper label of all the bottled water that were treated in this paper. Moreover, a statistic regarding the highest values of the physico-chemical parameters in the bottled water is shown in Table 3. Sulphate (SO_4^{2-}) in bottled water ranges from 2.00 mg/l (Spirit Drini water) to 38.4 mg/l (Alpeve water) with a mean value of SO_4^{2-} of 17.03 mg/l (Fig. 13). Chlorine (Cl^-) in packaged waters ranges from 1.05 mg/l (Kika water) to 14.70 mg/l (Jon water) with a mean value of Cl^- of 7.11 mg/l (Fig. 14). Nitratet (NO_3^-) in bottled water ranges from 0.10 mg/l (Uji i Mirë water) to 6.10 mg/l (Grande water) with a mean value of NO_3^- of 6.10 mg/l (Fig. 15).

Hydrochemical types of bottled water – the chemical composition of groundwater is primaly dependent on the geology as well as on the geochemical processes and antrophogenic activities which take place within the aquifer system (Dakoli, 2007, Kamtchueng et al., 2016, Eftimi and Sara, 2021). The processing of the analyses was done with the AquaChem software, which enables the construction of the praph (Fig.15). In Figure 16 the spatial distributon of the hydrochemical types of bottled water is shown, while in Figure 17 a statistic is shown regarding the

Table 3. Higher values of physico-chemical parameters in bottled water

Parameter	Higher values	Name of bottled water
T	12.00	Dea
EC	571.00	Alpeve
Dry residue	590.00	Jon
TH	7.50	Miros, alkaline, vivaqua
pH	9.33	Alkaline
Ca^{2+}	586.00	Jon
Mg^{2+}	25.04	Alpeve
Na^+	33.15	Dea
K^+	1.40	Alpeve
HCO^-_3	305.00	Alpeve
SO_4^{2-}	38.40	Alpeve
Cl^-	14.70	Alpeve
NO_3^-	6.10	Grande

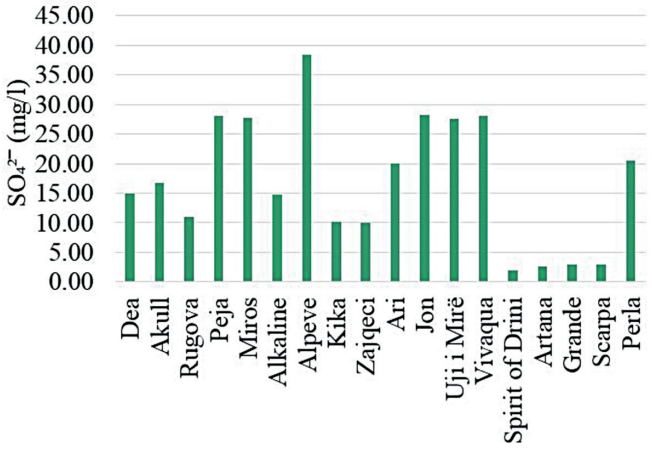

Figure 13. Variation of SO_4^{2-}

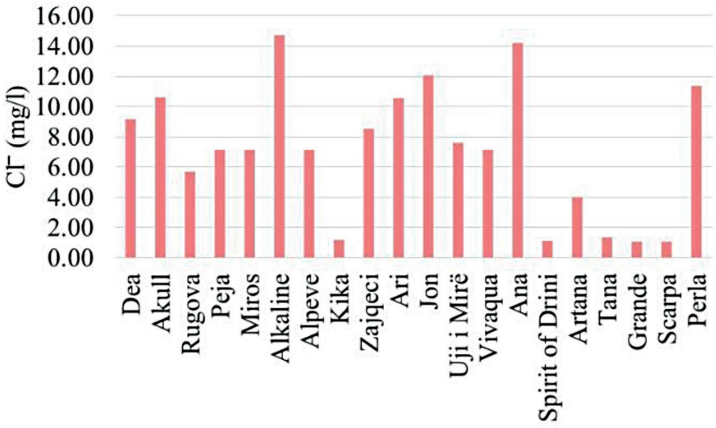

Figure 14. Variation of Cl^-

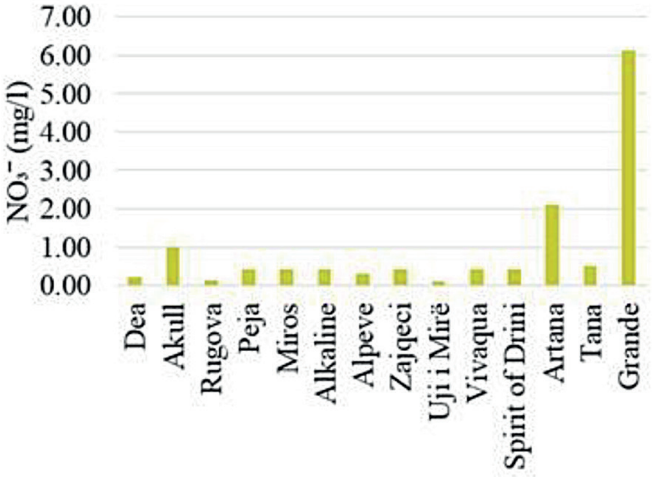

Figure 15. Variation of NO_3^-

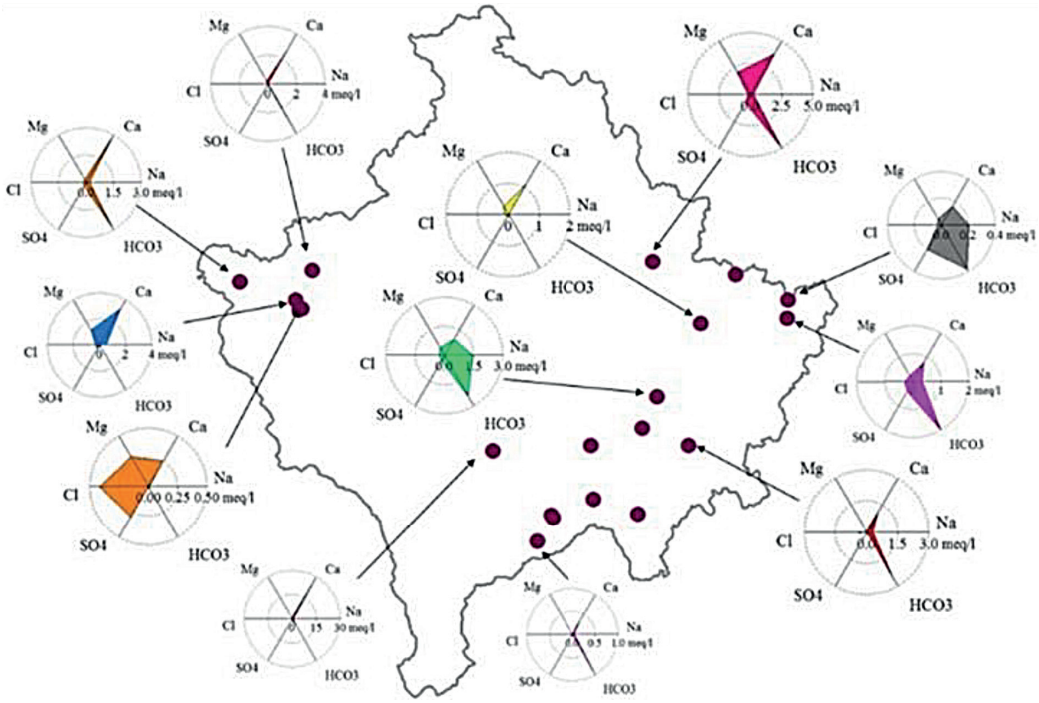

Figure 16. Spatial distribution of hydrochemical types of bottled water in Kosovo

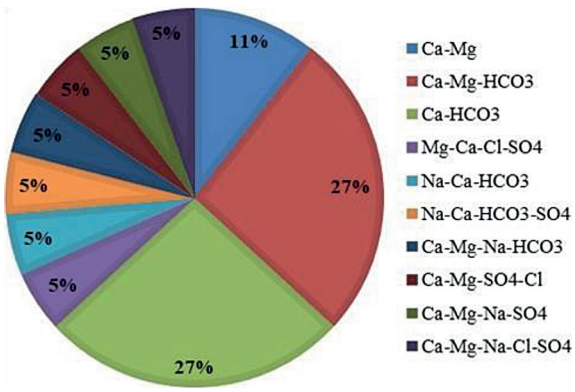

Figure 17. Participation in % of hydrochemical water types

hydrochemical type of water most present in the groundwater of our country, analysed by the data of presented on paper the label of bottled water. The most present hydrochemical types are Ca-HCO_3 (Calcium-bicarbonate) and Ca-Mg-HCO_3 (Mixed-bicarbonate) (Fig. 17).

CONCLUSIONS

On paper the label of all 20 water brands considere in this study the following results were obtained: in 19 water brands or 95% of them the

analyses for the water villa were performed by NIPH and only one or 5% of them the analysis was performed by an institute outside Kosovo. Moreover, 5 or 25% of the brands of water bottled contain the following parameters on paper label: temperature, EC, dry residue, pH, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, SO_4^{2-}, Cl^{-}, NO_3^{-}. Besides, 8 or 40% of them contain the parameters Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, SO_4^{2-}, Cl^{-}, NO_3^{-}. The heavy metals in the bottled water label paper treated in this paper are partially presented in only two water brands. Water packaging factories are wide spread in the territory of Kosovo. All factories use groundwater for packaging. In addition, 16 or 80% of them receive water from springs at altitudes from 1000 m to 2474 m, while 4 or 20% of them use water from drilling wells. In only one case or in 5% of the packaged names is the water permit number set. The highest value of Ca^{2+} is shown in the bottled water named Jon (Suhareka).

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