International Journal of Scientific Research in Chemical Sciences **Research Paper**
Vol.8, Issue.3, pp.01-05, June (2021) **E-ISSN:** 2455-3174

Determination of major minerals in natural bottled fruit-flavored mineral water samples consumed in Turkey

Ş. Turhan

Department of Physics, Faculty of Science and Letters, Kastamonu University, Kastamonu, Turkey

Author's Mail Id: serefturhan63@gmail.com, Tel.: +90-366-2801940

Available online at: www.isroset.org

Received: 09/Jun/2021, Accepted: 20/Jun/2021, Online: 30/Jun/2021

***Abstract*—** Recently bottled mineral water has become very popular as a nutritional (mineral) supplement. In this study, the concentrations of major minerals (K, Na, Mg, and Ca) in twenty-nine natural bottled fruit-flavored mineral water (BFMW) samples of ten brands marketed in Turkey were analyzed by an inductively coupled plasma optical emission spectrometry (ICP-OES). The concentrations of K, Na, Mg and Ca analyzed in BFMW samples varied from 28 to 189, 11 to 282, 17 to 104 and 36 to 380 mg/L, respectively. The concentration results obtained were compared with those analyzed for natural bottled waters in the literature. Also, BFMW samples were categorized according to their K, Na, Mg and Ca content. Consequently, 38%, 31%, 24%, and 24% of the studied water samples are calcium waters, magnesium waters, sodium waters, and waters suitable for the sodium diet respectively.

***Keywords*—** Bottled mineral water; Sodium, Magnesium, Calcium; Potassium; Macro mineral

I. INTRODUCTION

Natural mineral water containing different dissolved minerals has been used for treatment in spas and baths for thousands of years in Anatolia as well as in many parts of the world. Since water-borne minerals such as potassium (K^+), sodium (Na^+), magnesium (Mg^{2+}), and calcium (Ca^{2+}) are easily absorbed by the gastrointestinal system, mineral water (MW) is widely consumed as a healthy beverage [1]. MW represents underground water that is naturally formed in suitable geological conditions at various depths of the Earth's crust and is extracted to the Earth by one or more sources spontaneously or by technical methods [2]. MW is defined with mineral content, residual elements and other components and bottled directly at the source and protected against any contamination risks [2]. Any bacteriological treatment for natural mineral waters is prohibited and no substance can be added, except for carbon dioxide [2].

A great increase in the consumption of bottled mineral water (BMW) has been observed in the last decades. Average annual BMW consumption per capita in the European Union (EU) countries has reached 105 L [3]. However, BMW consumption in Turkey is very low compared to EU countries. In recent years, some companies have produced mineral waters with various fruit flavors to increase the consumption of BMW in Turkey. After natural bottled fruit-flavored mineral waters (BFMWs) were introduced on Turkish markets per capita mineral water consumption reached 7.6 L [4].

About twenty mineral elements such as chloride (Cl^-), fluoride (F^-), manganese (Mn^{2+}), copper (Cu^{2+}), iron (Fe^{2+}), zinc (Zn^{2+}), Mg^{2+}, K^+, Na^+, Ca^{2+}, etc. are required for humans. The mineral abundance in the human body is about 5% of body mass [5]. The mineral elements required at a level higher than 100 mg per day are considered macro elements (K, Na, Mg, Ca, etc.). Mg and Ca are needed for the bones and the health of the cardiovascular system. Na and K are in solution and important for the electrolyte balance [5]. The mineral contents of bottled natural mineral waters vary significantly from one source to another depending upon the nature of the geological formations through the groundwater passed. BMWs have been categorized differently according to their mineral content. Each mineral water was named considering firstly, the common anion and secondly, the cation [6]. According to the European Commission (EC) directive, BMWs were categorized as follows [6]: magnesium water (Mg content > 50 mg/L), calcium water (Ca content > 150 mg/L), sodium water (Na content > 200 mg/L), water suitable for sodium diet (Na content < 20 mg/L), etc. Therefore, bottled mineral waters should be supported by accurate information about their chemical composition.

II. RELATED WORK

So far, many studies were performed to monitor the chemical quality of bottled waters marketed in some countries [7-21]. However, few studies were done to determine the chemical quality of BMW samples marketed in Turkey [22-26]. According to the author's literature research, no study was on the determination of major minerals in bottled fruit-flavored mineral waters sold

commercially in Turkey. Having all these in mind, the objective of the study is to analyze the concentration of K, Na, Mg, and Ca in BFMW samples consumed in Turkey by using an ICP-OES, categorize BFMW samples according to their Ca, Mg, and Na contents and compare the results obtained with those from similar studies in the literature.

III. METHODOLOGY

Collection and preparation of water samples

For this study, ten brands of commercially existing BFMW samples were chosen as the preferred popular brands throughout the country. A large part of the BFMWs in Turkey is marketed in a glass bottle with volumes of 0.2 and 0.25 L. Twenty-nine carbonated BFMW samples were collected from supermarkets in Turkey (Table 1).

Table 1. Information on the bottled fruit-flavored mineral water samples

Brand code	Samples code	Fruit flavored
B1		
	BFMW1	Mango and pineapple
	BFMW2	Lemon
	BFMW3	Lemon and tangerine
	BFMW4	Kiwi
	BFMW5	Apple
	BFMW6	Watermelon and strawberry
	BFMW7	Black mulberry
B2		
	BFMW8	Pomegranate
	BFMW9	Lemon
	BFMW10	lemon C plus
	BFMW11	Lemon
	BFMW12	Lemon extra
	BFMW13	Apple
B3		
	BFMW14	Apple
	BFMW15	Lemon
B4		
	BFMW16	Watermelon and strawberry
B5		
	BFMW17	Lemon and tangerine
B6		
	BFMW18	Strawberry
	BFMW19	Lemon
	BFMW20	Sour cherry
B7		
	BFMW21	Tangerine
	BFMW22	Lemon
B8		
	BFMW23	Lemon
	BFMW24	Watermelon and strawberry
	BFMW25	Apple
	BFMW26	Lemon, kiwi, and orange
	BFMW27	Pear, mandarin, lime, and melon
B9		
	BFMW28	Lemon
B10		
	BFMW29	Lemon

All reagents used for analyses were of analytical grade and dilutions were made by using ultrapure water (18.2 MΩ cm^{-1}). Each BFMW sample was opened in the laboratory and degassed by using an ultrasonic bath for 15 minutes at room temperature. The water samples were prepared using the following procedure: Analytical fractions were digested using a microwave digestion system (CEM MARS 6, USA) equipped with pressure and temperature control up to 45 bar and 200 °C. 1 mL of aliquot each sample was transferred into the digestion vessel and 10 mL of nitric acid (67% v/v) was added to the aliquot. Before closing the vessel, the mixture was swirled slightly and the lid was tightly closed. The vessel placed in a microwave oven was heated according to the digestion program. After the digestion, the sample solution was cooled to room temperature. The aliquot was transferred to a volumetric flask of 25 mL, 50 mL, and 100 mL and completed with ultrapure water. It is filtered through a microfilter so that no particles are left in it.

Calibration and instrumental analysis

The concentrations of major elements were analyzed by the ICP–OES (Spectroblue). The ICP-OES is equipped with software (ICP Analyzer Pro) that facilitates the simplified operation of the instrument and full use of its analytical capabilities. The system offers a resolution of 8 pm for wavelengths of 165 to 285 nm and 16 pm for higher wavelengths. The operating parameters of the ICP–OES system were as follows: RF power is 1.2 kW. Plasma flow rate, auxiliary gas flow rate, nebulizer flow rate, and coolant flow are 13, 0.8, 0.8 and 13 L/min. The sample pump speed is 30 rpm. Each analysis was performed in triplicate (n = 3). Calibration solutions of the linear range of 0.01– 0.1 mg L^{-1} were prepared by diluting the certified standard ICP TraceCert mix solutions (10 mg L^{-1}) containing 33 elements purchased from Sigma–Aldrich. Calibration of the ICP–OES system was performed at the beginning of the measurements and the correlation coefficients for all analytes were equal to 0.999.

IV. RESULTS AND DISCUSSION

The concentration values and some descriptive statistical data of major minerals analyzed in BFMW samples are presented in Table 2. Frequency distributions of the concentrations of major minerals in BFMW samples are given in Fig. 1. The comparison of the average concentration of these major cations in the studied BFMW samples with those in bottled waters marketed in various countries is presented in Table 3. As can be seen from Table 2, the order of major minerals analyzed in the studied BFMW samples is Na > Ca > K > Mg according to their average concentration values. The concentration of Ca ranged from 36 to 380 mg/L (average= 135 mg/L). The highest Ca concentration was analyzed in the B4 (BFMW16) coded brand, the lowest Ca concentration was analyzed in the B1 (BFMW5) coded brand. As can be seen from Fig. 1, the frequency distribution of the concentration of Ca exhibits a log-normal distribution. 38%, 24%, and 38% of the concentrations of Ca in the BFMW samples are

in the range of 36-100, 100-150, and 150-400 mg/L, respectively.

Table 2. Concentrations of major minerals analyzed in bottled fruit-flavored mineral water samples

Sample Code	Concentration (mg/L)			
	Ca	*K*	*Mg*	*Na*
BFMW1	43.8	68.6	24.3	276.0
BFMW2	43.4	65.5	23.1	271.2
BFMW3	39.3	65.1	20.0	218.2
BFMW4	55.4	129.4	24.2	229.5
BFMW5	36.4	63.5	18.0	188.6
BFMW6	45.3	157.2	23.8	279.0
BFMW7	48.6	63.6	26.4	281.6
BFMW8	141.3	143.1	21.7	147.5
BFMW9	95.0	181.7	31.4	93.8
BFMW10	136.4	93.1	17.4	189.7
BFMW11	68.0	68.6	24.4	43.2
BFMW12	181.9	118.2	20.1	19.5
BFMW13	76.5	73.3	27.6	65.3
BFMW14	203.1	86.0	43.5	26.9
BFMW15	208.3	84.7	45.8	12.5
BFMW16	380.1	118.2	30.4	11.4
BFMW17	84.9	189.0	30.5	151.0
BFMW18	167.0	83.5	94.6	90.8
BFMW19	197.9	89.1	104.4	156.7
BFMW20	170.7	84.2	76.7	191.0
BFMW21	160.6	116.8	96.1	115.5
BFMW22	117.0	78.5	38.9	124.8
BFMW23	124.3	84.2	56.4	98.4
BFMW24	144.1	90.0	66.3	129.0
BFMW25	154.7	100.8	67.2	250.7
BFMW26	147.4	116.1	66.9	166.2
BFMW27	130.8	160.6	58.5	127.2
BFMW28	189.8	27.9	34.3	22.9
BFMW29	330.9	51.0	21.7	38.3
Average	135.3	98.3	42.6	138.5
Standard error	15.3	7.2	4.8	16.3
Standard deviation	82.6	39.0	25.8	87.9
Median	136.4	86.0	30.5	129.0
Kurtosis	2.0	0.2	0.2	-1.1
Skewness	1.2	0.8	1.1	0.1
Min	36.4	27.9	17.4	11.4
Max	380.1	189.0	104.4	281.6

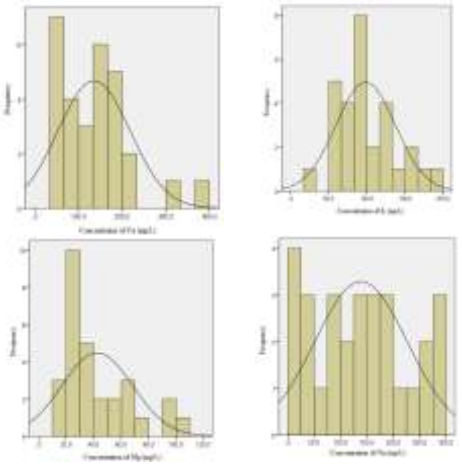

Figure 1. Frequency distributions of the major minerals in bottled fruit-flavored mineral water samples

Table 3. Comparison of the average concentration of major minerals with the literature values

Water type	N	Country	Concentration (mg/L)				Reference
			Ca	*K*	*Mg*	*Na*	
BDW	10	Chile	36	1	8	25	[27]
BDW	908	Germany	91	3	22	20	[7]
BDW	10	Croatia	57	0.4	17	3	[9]
BDW	13	Spain	42	2	14	45	[28]
BDW	20	Iran	33	1	12	17	[29]
BDW	17	Oman	13	2	10	12	[30]
BDW	17	India	17	3	8	23	[31]
BMW	186	Italy	69	4	13	20	[32]
BMW	9	Malaysia	41	2	10	11	[33]
BMW	14	Egypt	20	7	8	31	[34]
BMW	9	Serbia	46	2	22	33	[35]
BMW	86	British Isles	46	2	8	18	[10]
BMW	47	Poland	82	6	26	44	[36]
BMW	5	Estonia	69	13	23	212	[3]
BMW	21	Romania	107	6	27	47	[37]
BMW	571	EU	67	2	16	15	[11]
BMW	9	Ethiopia	13	5	6	38	[12]
BMW	22	Nordic	6	1	11	12	[8]
BMW	53	Iran	50	1	12	8	[29]
BMW	35	Slovenia	120	15	104	218	[38]
BFMW	29	Turkey	135	98	43	139	This study

Eleven samples belonging to eight brands can be classified as natural mineral water with calcium. The average Ca

content is greater than those analyzed in bottled drinking water (BDW) and bottled mineral water (BMW) samples marketed in all countries given in Table 3.

The concentration of K ranged from 28 to 189 mg/L (average= 98 mg/L). The highest K concentration was analyzed in the B5 (BFMW17) coded brand, the lowest K concentration was analyzed in the B9 (BFMW28) coded brand. The frequency distribution of K concentrations exhibits a near-normal distribution. 58%, 24% and 14% of the K concentrations in the BFMW samples are in the range of 50 to 100, 100 to 150 and 150 to 200 mg/L, respectively. The average K content is greater than those analyzed in BDW and BMW samples marketed in all countries given in Table 3.

The concentration of Mg ranged from 17 to 104 mg/L (average of 43 mg/L). The highest Mg concentration was analyzed in the B6 (BFMW19) coded brand, the lowest Mg concentration was analyzed in the B2 (BFMW10) coded brand. The frequency distribution of Mg concentrations exhibits a log-normal distribution. While 69% of concentrations of Mg in the BFMW samples are in the range of 15-50 mg/L, 31% of them are greater than 50 mg/L. Nine samples belonging to three brands can be classified as natural mineral water with magnesium. The average Mg content is higher than those analyzed in BDW and BMW samples marketed in all countries, except for Slovenia, given in Table 3.

The concentration of Na ranged from 11 to 282 mg/L with an average of 139 mg/L. The highest Na concentration was analyzed in the B1 (BFMW7) coded brand, the lowest Na concentration was analyzed in the B4 (BFMW16) coded brand. The frequency distribution of Na concentrations exhibits a non-normal distribution. While 24% of concentrations of Na in the BFMW samples are lower than 50 mg/L, 24% of them are greater than 200 mg/L. Seven samples belonging to two brands can be classified as natural mineral water with sodium. Seven samples belonging to five brands can be classified as suitable mineral water sodium diet. The average Na content is higher than those analyzed in BDW and BMW samples consumed in all countries, except for Estonia and Slovenia, given in Table 3.

V. CONCLUSION AND FUTURE SCOPE

Differences in major mineral concentrations were observed in the BFMW water samples obtained from different parts of Turkey because natural MWs are mostly obtained from regions close to geothermal regions with deep underground water circulation patterns and tectonic/volcanic activity. A comparison of the average values of the major minerals in the studied BFMWs revealed that the concentrations of K, Na, Mg, and Ca are higher than those consumed in many countries.

The BFMW samples belonging to the B2 brand are calcium, magnesium, and sodium waters. The BFMW samples belonging to the B6 and B7 brands are both calcium and magnesium waters. The BFMW samples belonging to the B2, B3, B4, B9, and B10 brands are water with calcium and suitable for a sodium diet. The BFMW samples belonging to the B1 brand are sodium water.

ACKNOWLEDGMENT

The author sincerely thanks Merve Zurnacı for helping with major mineral analysis.

REFERENCES

[1] A. Azoulay, P. Garzon, M.J. Eisenberg, "Comparison of the mineral content of tap water and bottled waters,". *Journal of General Internal Medicine*, Vol.**16**, Issue.**3**, pp. **168–175**, **2001**.

[2] E. Dinelli, A. Lima, S. Albanese, M. Birke, D. Cicchella, L. Giaccio, P. Valera, B. De Vivo, "Comparative study between bottled mineral and tap water in Italy," J*ournal of Geochemical Exploration*, Vol.**112**, Issue.**1,** pp. **368–389**, **2012**.

[3] L. Bityukova, V. Petersell, "Chemical composition of bottled mineral waters in Estonia," J*ournal of Geochemical Exploration*, Vol.**107**, Issue.**3**, pp.**238–244**, **2010**.

[4] M. Cemek, L. Akkaya, Y.O. Birdan, K. Seyrek, S. Bulut, M. Konuk, "Nitrate and nitrite levels in fruity and natural mineral waters marketed in western Turkey," *Journal of Food Composition and Analysis*, Vol.**20**, Issue.**3-4**, pp. **236–240**, **2007**.

[5] K.O. Soetan, C.O. Olaiya, O.E. Oyewole, "The importance of mineral elements for humans, domestic animals and plants: A review," *African Journal of Food Science*, Vol. **4**, Issue.**5**, pp. 200-222, **2010**.

[6] S. Quattrini, B. Pampaloni, M.L. Brandi, "Natural mineral waters: chemical characteristics and health effects," *Clinical Cases in Mineral and Bone Metabolism,* Vol.**13**, Issue.**3**, pp.**173–180**, **2016**.

[7] M. Birke, U. Rauch, B. Harazim, H. Lorenz, W. Glatte, "Major and trace elements in German bottled water, their regional distribution, and accordance with national and international standards," J*ournal of Geochemical Exploration,* Vol.**107**, pp.**245–271**, **2010**.

[8] B.S. Frengstad, K. Lax, T. Tarvainen, Ø. Jæger, B.J. Wigum, "The chemistry of bottled mineral and spring waters from Norway, Sweden, Finland and Iceland," J*ournal of Geochemical Exploration,* Vol.**107**, Issue.**3**, pp.**350–361**, **2010**.

[9] Z. Peh, A. Šorša, J. Halamić, "Composition and variation of major and trace elements in Croatian bottled waters," J*ournal of Geochemical Exploration,* Vol.**107**, Issue.**3**, pp.**227–237**, **2010**.

[10] P.L. Smedley, "A survey of the inorganic chemistry of bottled mineral waters from the British Isles," *Applied Geochemistry*, Vol.**25**, Issue.**12**, pp.**1872–1888**, **2010**.

[11] D. Bertoldi, L. Bontempo, R. Larcher, G. Nicolini, S. Voerkelius, G.D. Lorenz, H. Ueckermann, H. Froeschl, M.J. Baxter, J. Hoogewerff, P. Brereton, "Survey of the chemical composition of 571 European bottled mineral waters," *Journal of Food Composition and Analysis*, Vol.**24**, Issue.**3**, pp.**376–385**, **2011**.

[12] T. Seda, M. Assefa, B.S. Chandravanshi, M. Redi, "Levels of common ions in bottled mineral waters consumed in Addis Ababa, Ethiopia," *Ethiopian Journal* of *Science*, Vol.**36**, Issue.**1**, pp.**27–40**, **2013**.

[13] M.R. Hadiani, S. Dezfooli-Manesh, S. Shoeibi, P. Ziarati, A.M. Khaneghah, "Trace elements and heavy metals in mineral and bottled drinking waters on the Iranian market," *Food Additives and Contaminants B*, Vol.**8**, Issue.**1**, pp.**18–24**, **2015**.

[14] E.M. Carstea, E.A. Levei, M.A., Hoaghia, R. Savastru, "Quality assessment of Romanian bottled mineral water and tap water,"

Environmental Monitoring and Assessment, Vol.**188**, Issue.**52**, pp.**1–14**, **2016**.

[15] É.J. Dos Santos, J.D.R. Oliveira, A.B. Hermann, R.E. Sturgeon, Chemical quality of bottled mineral waters from markets of Curitiba-PR-Brazil," *Brazilian Archive of Biology and Technology*, Vol.**59**, Issue.**1-12**, pp.**1–24**, **2016**.

[16] A. Szmagara, A. Krzyszczak, Monitoring of fluoride content in bottled mineral and spring waters by ion chromatography," *Journal of Geochemical Exploration*, Vol.**202**, Issue.**6**, pp.**27–34**, **2019**.

[17] J. Kończyk, E. Muntean, J. Gega, A. Frymus, R.Michalski, "Major inorganic anions and cations in selected European bottled waters," J*ournal of Geochemical Exploration*, Vol.**197**, Issue.**7**, pp.**27–36**, **2019**.

[18] T. Todorović, M.Ć. Đurović, J. Štrbački, P. Papić, "Rare earth elements in mineral waters in Serbia," *Environmental Earth Sciences*, Vol.**79**, Issue.**290**, pp.**1–12**, **2020**.

[19] V. Lyubomirova, V. Mihaylova, R. Djingova, "Chemical characterization of Bulgarian bottled mineral waters," *Journal of Food Composition and Analysis*, Vol.**93**, Issue.**9**, pp.**1–12**, **2020**.

[20] M.A. Ali, A.M. Elgerbi, E.J. Emhemmad, W.K. Amhimmid, "Assessment of Some Physico-chemical and Bacteriological Properties of Bottled Drinking Water in the Wadi Al-Shati Area Southern of Libya," *International Journal of Scientific Research in Chemical Sciences*, Vol.**7**, Issue.**6** , pp. 6-11, **2020**.

[21] K. Bodor, Z. Bodor, A. Szép, R. Szép, "Classification and hierarchical cluster analysis of principal Romanian bottled mineral waters," *Journal of Food Composition and Analysis*, Vol.**100**, Issue.**6** , pp.**1–9**, **2021**.

[22] A. Baba, F.S. Ereeş, Ü. Hiçsönmez, S. Çam, H.G. Özdilek, "An assessment of the quality of various bottled mineral water marketed in Turkey," *Environmental Monitoring and Assessment*, Vol.**139**, Issue.**1-3,** pp.**277–285**, **2008**.

[23] C. Güler, M. Alpaslan, "Mineral content of 70 bottled water brands sold on the Turkish market: Assessment of their compliance with current regulations," *Journal of Food Composition and Analysis*, Vol.**22**, Issue.**7-8,** pp.**728–737, 2009**.

[24] M.F. Cengiz, M.Z. Durak, S. Nilufer, A.K. Bilgin, "Ion chromatographic setermination of free cyanide in different classes of bottled natural mineral water consumed in Turkey," *International Journal of Food Properties*, Vol.**18**, Issue.**4,** pp.**746–756**, **2015**.

[25] S. Kilic, "Survey of trace elements in bottled natural mineral waters using ICP-MS," *Environmental Monitoring and Assessment*, Vol.**191**, Issue.**452**, pp.**1–7**, **2019**.

[26] Y. Oruç, B. İzgi, "Determination of anion and cation amounts in various mineral waters," *The Journal of Food*, Vol.**45**, Issue.**2**, pp.**242-252, 2019**.

[27] L. Daniele, C. Cannatelli, J.T. Buscher, G. Bonatici, "Chemical composition of Chilean bottled waters: Anomalous values and possible effects on human health," *Science of the Total Environment*, Vol.**689**, Issue.**11**, pp.**526–533**, **2019**.

[28] S. Platikanov, A. Hernández, S. González, J.S. Cortina, R. Taulera, R. Devesa, "Predicting consumer preferences for mineral composition of bottled and tap water," *Talanta*, Vol.**162**, Issue.**1**, pp.**1–9**, **2017**.

[29] K.Y.Kermanshahi, R. Tabaraki, H. Karimi, M. Nikorazm, S. Abbasi, "Classification of Iranian bottled waters as indicated by manufacturer's labellings," *Food Chemistry*, Vol.**120**, Issue.**4**, pp.**218–223, 2010**.

[30] Z.M. Al Aamri,B.H. Ali, "Chemical composition of different brands of bottled drinking water sold in Oman as labelled by manufacturers,"*Asian Journal of Water, Environment and Pollution*, Vol.**14**, Issue.**3**, pp.**1–7**, **2017**.

[31] R.K. Mahajan, T.P.S. Walia, B.S. Lark, Sumanjit, "Analysis of physical and chemical parameters of bottled drinking water," *International Journal of Environmental Health Research*, Vol.**16**, Issue.**2**, pp.**89–98**, **2006**.

[32] D. Cicchella, S. Albanese, B. De Vivo, E. Dinelli, L. Giaccio, A. Lima, P. Valera, "Trace elements and ions in Italian bottled mineral waters: Identification of anomalous values and human health related effects," J*ournal of Geochemical Exploration*, Vol.**107**, Issue.**3**, pp.**336–349, 2010**.

[33] M.U. Khandaker, N.L.M. Nasir, N.S Zakirin, H. Abu Kassim, K. Asaduzzaman, D. Bradley, M.Y. Zulkifli, A. Hayyan, "Radiation dose to the Malaysian populace via the consumption of bottled mineral water," *Radiation Physics and Chemistry*, Vol.**140**, Issue.**3**, pp.**173–179**, **2017**.

[34] H.A. Yousef, "Assessment of the annual effective dose of bottled mineral waters using closed can technique," *Journal of Advanced Physics*, Vol.**14**, Issue.**3**, pp.**5696–5707**, **2018**.

[35] M.M. Janković, D.J. Todorović, N.A. Todorović, J. Nikolov, "Natural radionuclides in drinking waters in Serbia," *Applied Radiation and Isotopes*, Vol.**70**, Issue.**12**, pp.**2703–2710**, **2012**.

[36] A. Astel, R. Michalski, A. Łyko, M. Jabłońska-Czapla, K. Bigus, S. Szopa, A. Kwiecińsk, "Characterization of bottled mineral waters marketed in Poland using hierarchical cluster analysis," *Journal of Geochemical Exploration*, Vol.**143**, Issue.**8**, pp.**136–145**, **2014**.

[37] E.A. Levei, M.A., Hoaghia, M. Senila, M. Miclean, C. Tanaselia, E.M. Carstea, "Chemical composition of some Romanian bottled natural mineral waters," *Studia UBB Chemia*, Vol.**3**, Issue.**2**, pp.**391–400**, **2016**.

[38] M. Brenčič, T. Ferjan, M. Gosar, "Geochemical survey of Slovenian bottled waters," *Journal of Geochemical Exploration*, Vol.**107**, Issue.**3**, pp. **400–409**, **2010**.

AUTHORS PROFILE

Mr. Ş. Turhan is Professor in Department of Physics, Faculty of Science and Letters, Kastamonu University. He has 10 years of teaching experience and 35 years of research experience.

