

ANALYSIS OF PHYSICAL AND CHEMICAL PARAMETERS OF ROMANIAN BOTTLED DRINKING WATER

C. ROȘU¹, I.M. VARGA¹



ABSTRACT. – Analysis of physical and chemical parameters of Romanian bottled drinking water. Twenty-one different brands (31 samples) of bottled drinking water collected from different retail shops in Cluj-Napoca, Romania, were analyzed for different physical and chemical parameters to ascertain their compliance with the prescribed/ recommended limits of Romanian drinking water laws, L458/2002 and L311/2004. The bottled drinking waters were analyzed for pH, Electrical Conductivity (EC), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^+), Bicarbonate (HCO_3^-), Sulfate (SO_4^{2-}) and Chloride (Cl^-) using standard techniques in laboratory. Electric conductivity (EC) vary between 92 $\mu\text{S}/\text{cm}$ and 3910 $\mu\text{S}/\text{cm}$ and pH vary between 5.35 and 7.93. The Calcium content ranges from 10 to 326 mg/L, 29% exceed the MCL. The Magnesium content ranges from 2 to 335 mg/L, 19% exceed the MCL. The Sodium content ranges from 1 to 428 mg/L, 16% exceed the MCL. The bicarbonate content ranges from 52 to 3111 mg/L. The Sulfate content ranges from 2 to 62 mg/L. The Chloride content ranges from 2 to 308 mg/L, 3% exceed the MCL. Romanian bottled drinking water bicarbonate correlates positively with Ca^{2+} ($r^2=0.7857$), with Mg^{2+} ($r^2=0.6874$) and with Na^+ ($r^2=0.6848$). Electric conductivity (EC) correlates positively with Ca^{2+} ($r^2=0.7148$), with Mg^{2+} ($r^2=0.6369$), with Na^+ ($r^2=0.6625$) and with HCO_3^- ($r^2=0.9252$).

Keywords: bottled water, mineral water, cations, water quality, anions.

1. INTRODUCTION

Because of growing concern that constituents of drinking water may have adverse health effects, consumption of tap water in Romania has decreased and consumption of bottled water (plate or mineral) has increase [1–2].

One of 6 Romanian households now uses bottled drinking water and in Romania annual per capita consumption of bottled water increased from less than 42 l in 2006 to almost 75 l in 2009. Because drinking water may be an important source of mineral intake, the shift in consumption from tap water to bottled water may have important implications for health and disease.[3–5]. Thus, the objectives of this study were 1) to determine whether differences in the mineral content of plate and commercially available mineral bottled waters are important and 2) to determine whether are strong correlations.

¹ “Babeș-Bolyai” University, Faculty of Environmental Science, 400006 Cluj-Napoca, Roumanie,

E-mail: crisrosu@yahoo.com



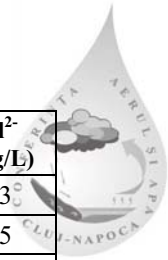
2. METHODS

Various physical parameters like pH and EC were determined with the help of digital multi parameter (WTW Inolab 720). Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Chloride (Cl^-), Bicarbonate (HCO_3^-) and Sulfate (SO_4^{2-}) by volumetric titration methods; while Sodium (Na^+) by Flame photometry.

These respective values for all these parameters are reported in Table 1; all results are compared with standard limit recommended by the Romanian drinking water laws.

Table 1. Physical and chemical parameters of Romanian bottled drinking water

No.	pH	EC ($\mu\text{S}/\text{cm}$)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^+ (mg/L)	HCO_3^- (mg/L)	SO_4^{2-} (mg/L)	Cl^- (mg/L)
1.	5.45	546	88	21	45	539	17	14
2.	6.39	1 631	265	98	231	1711	28	97
3.	5.35	1 646	270	95	235	1714	31	99
4.	7.93	507	58	40	3	305	0	1
5.	5.45	2 470	326	108	71	1634	29	25
6.	7.07	92	10	3	3	73	3	10
7.	6.36	1023	134	42	17	732	9	8
8.	6.88	2560	148	22	428	1647	28	21
9.	5.96	1944	156	45	255	946	12	308
10.	7.25	578	36	12	11	168	9	12
11.	6.69	863	107	47	17	537	32	8
12.	5.95	898	108	48	17	560	33	8
13.	6.78	419	96	15	13	366	40	14
14.	7.70	324	62	2	1	187	8	2
15.	5.66	1402	313	13	21	1045	17	5
16.	7.18	567	55	3	1	171	20	3
17.	7.15	123	15	5	3	52	10	8
18.	5.75	134	17	6	4	62	12	9
19.	6.07	904	106	39	109	746	16	29
20.	6.41	996	107	44	71	732	4	17
21.	5.45	1775	249	30	263	1556	7	51
22.	5.41	1881	262	41	255	1599	5	47
23.	6.43	320	37	18	25	262	16	16
24.	7.12	648	73	29	91	461	59	43
25.	6.02	672	71	28	95	455	62	44
26.	6.81	383	27	3	2	86	2	8
27.	7.27	333	33	8	14	108	25	22



No.	pH	EC ($\mu\text{S/cm}$)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^+ (mg/L)	HCO_3^- (mg/L)	SO_4^{2-} (mg/L)	Cl^- (mg/L)
28.	5.40	2550	265	103	196	1 783	24	23
29.	5.37	2660	268	105	190	1 789	19	25
30.	6.27	746	121	7	16	387	23	18
31.	6.55	3921	287	335	317	3111	5	66
MCL	6.5–8.5	2 500	180	80	200	–	250	250
TW	6.84	98	17	3	5	54	10	5

MCL – Maximum contaminant level; TW – Tap water (Cluj-Napoca)

3. RESULTS AND DISCUSSION

Important variations exist in the mineral content of Romanian bottled water. Precise definitions of mineralization levels vary from country to country [6]. For the purpose of this study, *low* mineralization indicates less than 200 $\mu\text{S/cm}$, *moderate* mineralization indicates between 200 to 700 $\mu\text{S/cm}$, *high* mineralization indicates between 700 to 2500 $\mu\text{S/cm}$ and *super high* mineralization (*medicinal* water) indicates more than 2500 $\mu\text{S/cm}$.

Calcium levels varied from 10 to 326 mg/L, 9 samples (29%) exceed the MCL. Magnesium levels varied from 2 to 335 mg/L, 6 samples (19%) exceed the MCL. Sodium levels varied from 1 to 428 mg/L, 5 samples (16%) exceed the MCL. The strong correlation found were between electric conductivity (EC) and Ca^{2+} ($r^2=0.7148$), Mg^{2+} ($r^2=0.6369$) and Na^+ ($r^2=0.6625$) – figure 1.

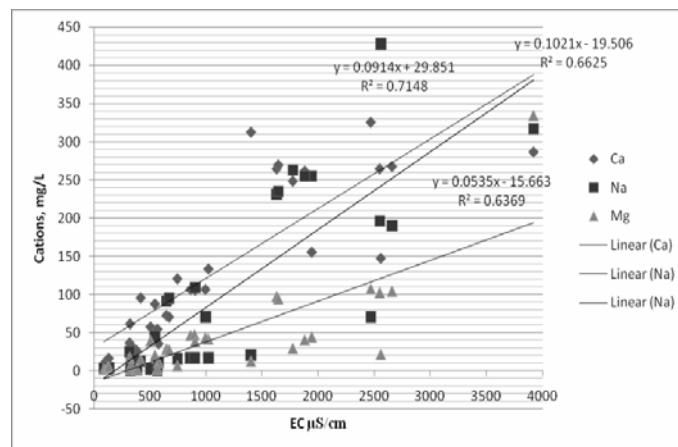


Fig. 1. Plot of EC versus Ca^{2+} , Mg^{2+} and Na^+ for all 31 bottled water samples

Bicarbonate levels varied from 52 to 3111 mg/L, and correlated very good with EC ($r^2=0.9241$). Sulfate levels varied from 2 to 62 mg/L and chloride levels varied from 2 to 308 mg/L (one sample exceed the MCL). No correlation between EC and sulfate or chloride.

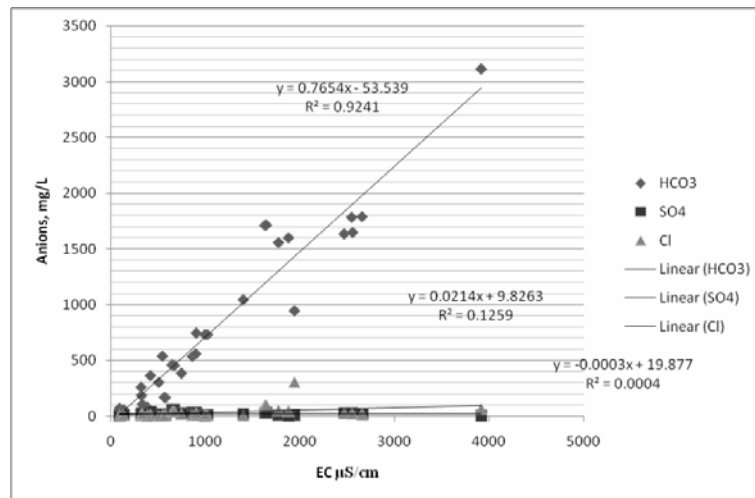


Fig. 2. Plot of EC versus HCO_3^- , SO_4^{2-} and Cl^- for all 31 bottled water samples

The strong correlation found were between bicarbonate anion levels and Calcium ($r^2=0.7857$), Magnesium ($r^2=0.6874$) and Sodium ($r^2=0.6848$) – figure 3.

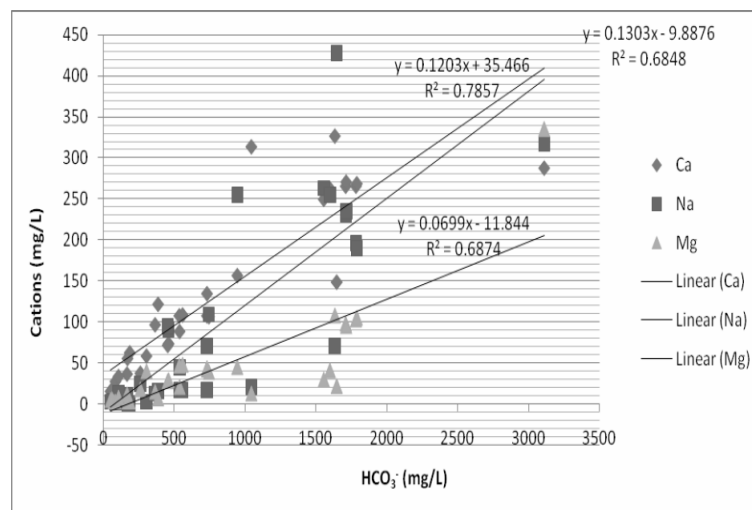


Fig. 3. Plot of HCO_3^- versus Ca^{2+} , Mg^{2+} and Na^+ for all 31 bottled water samples

4. CONCLUSIONS

Variation in mineral levels exist among commercially available bottled water. Mineral intake from low mineralization bottled water is minimal. If Romanian people prefer to drink commercially bottled waters, they should be selective when deciding which water to drink. Individuals should choose to drink bottled water with an optimal mineral profile, i.e., high levels of Calcium (40–80 mg/L) and Magnesium (20–40 mg/L) and little Sodium (< 50 mg/L).

REFERENCES

1. Rosu C., Vlaicu A., Boita S., (2008), *Apa minerala, apa plata sau apa de izvor*, Environment&Progress, 12, pp. 421–426
2. Rosu, C., Costin, D (2009), *Noi parametrii de evaluare a calitatii apelor imbuteliate rominesti*, Environment&Progress, 13, pp. 211–416
3. Garzon, P., Eisenberg, M., J. (1998), Variation in the mineral content of commercially available bottled waters: implications for health and disease, *American Journal of Medicine*, 105(125), pp. 30–43
4. Whelton, P.A, Dietrich, A.M., Burlingame, G.A., Schehs, M., Duncan, S.E. (2007), *Minerals in drinking water: Impacts on taste and importance to consumer health*, *Water Science and Technology*, 55(5), pp. 283–291
5. Feru, A. (2004), *Bottled natural mineral waters in Romania*, *Environmental Geology*, 46(5), pp. 670–674
6. Green, T., Green, M (1994), *The Good Water Guide*, London, England, Rosendale Press

