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WATER QUALITY OF SOME DRINKING WATER SOURCES IN RURAL AREA OF BOTOSANI COUNTY

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Key words: drinking water, water source, water hardness.

Abstract. A significant risk for human health can result from exposure to natural or toxic non-pathogenic contaminants which are ubiquitously present in the water sources for population. The purpose of this study was to analyze the mineral content of drinking water from surface and subterranean sources in 10 rural localities (Răchiţi, Corni, Vârfu Câmpului, Dersca, Drăguşeni, Rădăuţi Prut, Dobîrceni, Albeşti, Prăjeni, Frumuşica) of Botoşani County. According to the standardized methods, the concentration of important ions, temperature, total pH, dissolved salts, alkalinity, chlorides, hardness and some toxic metals (lead and cadmium) were determined. The ratio of Ca/Mg, Na/total cations, SO_4/Cl was recalculated. The study showed variations of the ratio Ca/Mg and the presence of lead in stagnant drinking water. A raised concentration of minerals and corrosivity can restrict the use of water and can influence population health.

Introduction

Water is the environmental factor at which the whole population is exposed. An important request for a good health is providing human communities with water, according to the hygienic- sanitary rules.

Many affections with higher incidence in certain geographical areas are determined or favored by the chemical composition of drinking water. Water consumption with a low or high content of mineral salts, fluorine, iodine, other chemicals determines, in time, metabolic disorders of mineral salts in the body, endemic goiter, cardiovascular diseases, chronic intoxications, cancer, etc.

Drinking water can also contain microelements, some of them with toxic properties, lead (Pb), cadmium (Cd), copper (Cu) whose presence can be put in

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relation with the distribution systems degradation, with water aggressiveness and/or corrosivity, and less because of natural background.

1. Material and methods

Samples collection and analysis was performed together with the specialists of A.P.M. Botosani and D.S.P. Botosani within the above mentioned laboratories.

Samples collection. Water samples were drawn (double samples of ground):

- in the rural area from individual sources (fountains) and springs in 10 villages of Botosani County;
- in the rural localities at the level of the water supply collective systems from phreatic subterranean and surface sources (10 villages of Botosani County, fig.1).

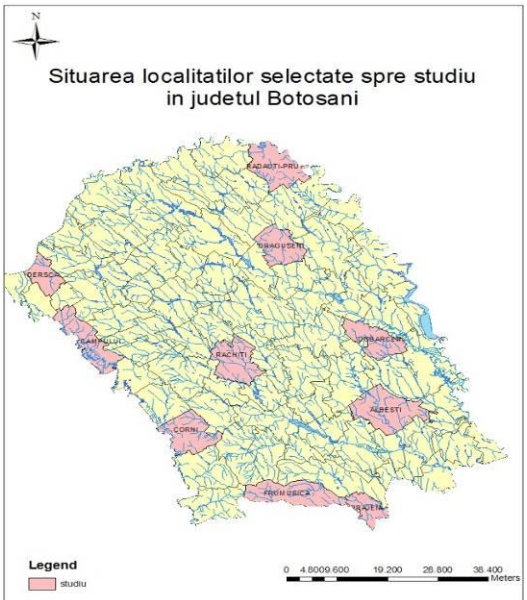

Fig. 1

When choosing the localities, we intended to cover a large area of Botosani County, but also the membership at watersheds of the Prut and Siret springs.

For metals analysis, water samples were collected in polyethylene vessels conditioned with nitric acid for 24 h, washed and rinsed with doubly distilled water. The samples kept at +5^{o}C were acidified with 05 milliliters concentrated nitric acid.

Physical-chemical analysis. Temperature and pH were determined at harvest, and the conductivity was measured with *Conductive-meter CD-2002 SELECTA*, calibrated with potassium chloride solution 0,01 mol/l, at 25°C. All chemical analyses were performed according to the standard methods stipulated in the Law 458/2002: calcium (Ca) and total hardness (D_T) by complexometric methods, magnesium (Mg) by spectrophotometrical method with titanium yellow. Mohr method by titration with silver nitrate was applied for determining the chlorides (Cl^-) and by titration with normal hydrochloric acid/10, we dosed the carbohydrates ($HC0^-_3$). Sodium (Na^+) and potassium (K^+) were dosed by the flam-photometric method and heavy metals by atomic absorption spectrometry in acetylene flame. For routine analytic control we used standard control samples (2,5 μg/l Cd and 20,0 μg/l Pb), which were reviewed after each 10 water samples. Measurements for water samples were the average of three determinations and they were accepted if the calculated standard deviation was less than 5%. The analyzed data were processed in Excel.

2.Results

It is known that in Romania only 63% of the population is connected at public (collective) systems of water supply, the rest of the population, mostly rural, being dependent of the water quality in public and particular fountains or springs. In Botosani County, too, in the rural area, the fountains are the only water sources for 85% of the localities.

Tab. 1 - The calcium and magnesium level (mg/l) in fountain water

Localities		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mg^{2+}	mm	93,23	97,30	24,32	20,42	60,31	92,55	105,05	37,97	51,56	79,40
	max	242,70	315,90	287,95	156,62	197,31	195,51	240,28	249,04	147,86	352,15
Ca^{2+}	mm	31,47	62,44	76,14	57,89	41,0	95,77	53,80	64,96	81,75	131,42
	max	131,42	141,10	428,0	187,55	439,55	270,92	100,0	187,71	180,15	304,08

1.Răchiţi, 2.Corni, 3.Vârfu Câmpului, 4.Dersca, 5.Drăguşeni, 6.Rădăuţi Prut, 7.Dobîrceni, 8.Albeşti, 9.Prăjeni, 10. Frumuşica

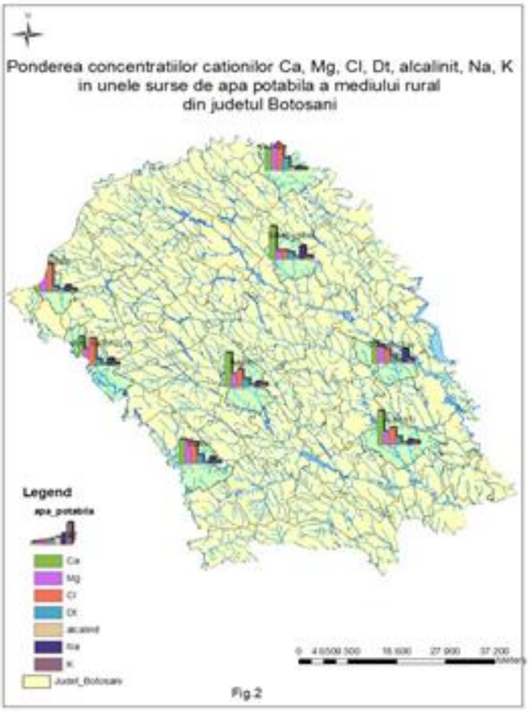

Fig.2

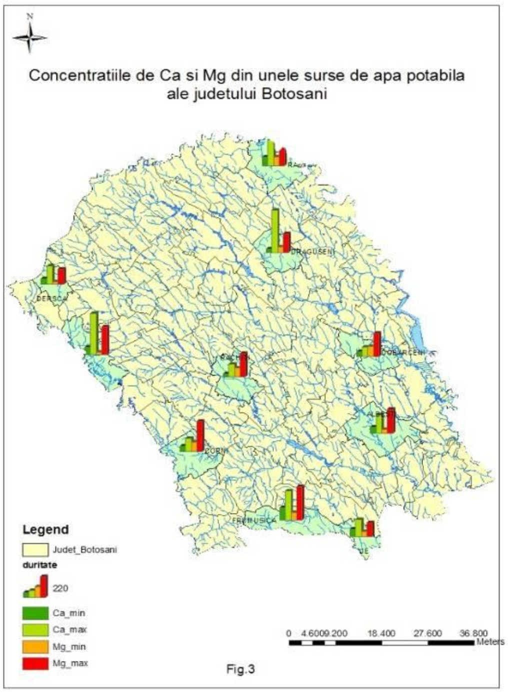

Fig.3

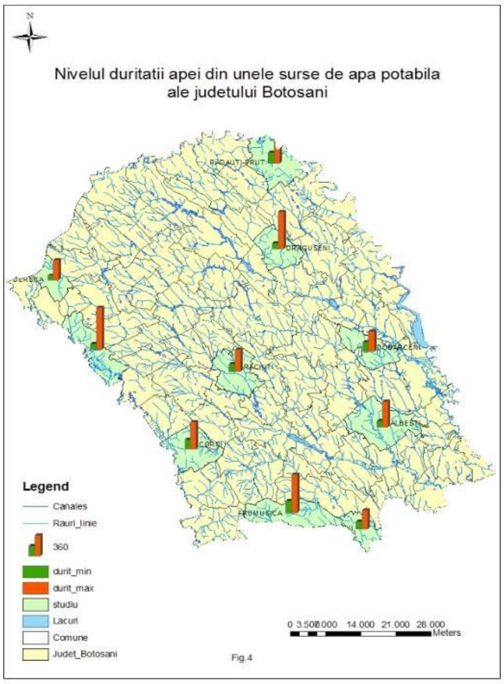

Fig.4

Because of the drought of the last years, sources flow decreased, magnesium ions (40,37-221,40 mg/l) and calcium (43,28-151,68 mg/l), chlorides (11-80 mg/l), HCO_3^- (396,8 – 762,5 mg/l) becoming predominant (in the samples analyzed)

Drinking water from surface sources processed by classic technology (coagulation, filtration, disinfection) was appropriate in terms of chemical parameters, with a reduced level of mineral compounds (Table 2).

Tab. 2 - Values of some chemical parameters of drinking water (surface sources)

Station	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Cl^- (mg/l)	D_T (^oG)	Alkalinity (ml HCl n/10)	Na^+ (mg/l)	K^+ (mg/l)
1 (A)	65,72	24,32	33	14,67	3,80	8,34	5,63
2 (A)	46,49	44,75	40	16,81	2,85	11,41	3,48
3 (C)	53,51	30,90	52	11,28	2,92	12,53	3,91
4 (A)	83,85	30,32	53	9,63	3,63	10,75	5,14
5 (C)	62,53	16,53	16	12,64	3,33	25,02	6,23
6 (C)	58,51	62,74	50	22,62	5,46	7,24	3,26
7 (B)	40,07	33,07	25	13,22	3,78	27,11	8,06
8 (B)	40,01	39,88	53	14,78	5,04	52,68	10,94

(A) Accumulation on a river; (B) Natural lake; (C) River;
1. Răchiţi, 2. Corni, 3.Vârfu Câmpului, 4. Dersca, 5. Drăguşeni, 6. Rădăuţi Prut, 7. Dobîrceni, 8. Albeşti

Water chemical analysis of six springs which, because of the constant flow are used by the population in the rural area (Rachiti, Corni, Dersca, Draguseni, Prajeni, Frumusica), showed variations of the investigated chemical parameters: 15-33 mg Cl^-, 56,11-159,69 mg Ca^{2+}/l, 65,2-160,17 mg Mg^{2+}/l, 83-160,12 mg SO_4^{2+}/l, 36,11-50,97 mg Na^+/l, 4,73-39,2 mg K^+/l.

Corrosive water is “aggressive” water that can dissolve materials which it comes in contact with. Water distribution systems to consumers (pipes, branchings and taps) are made of copper, lead or alloys of other metals. Soft water, with low hardness with pH < 7,5 or > 9,5 with a certain content of sulphates, chlorides, alkalinity, can drag along these metals producing modifications of the water physical properties (taste, colour) and affecting health in case of severe corrosion.

In order to evaluate the corrosive properties of water circulated through the supply system in a centralized way, the following coefficient was calculated:

in milli-equivalents/l (the Ratio Larson-Skold). We also calculated the ratio Ca/Mg, Na/total cations, SO_4/Cl, the values being presented in Table 3.

Table 3.The ratio between different mineral compounds of drinking water from different sources

Drinking water	Ca/Mg	K_1	Na/total cations	SO_4/Cl
Fountains water	0,68 - 2,41	0,46 - 0,8	0,094 - 0,25	0,16 - 0,52
Subterranean sources	0,58 - 2,74	0,41 - 0,9	0,096 - 0,72	1,23 - 2,21
Surface sources	0,93 - 2,76	0,21 - 0,55	0,091 - 0,58	0,11 - 0,75
Springs	0,54 - 2,06	0,31-1,05	0,06 - 0,43	1,56 - 4,72

Heavy metals (Pb and Cd) were determined in drinking water collected in the morning (stagnant water A_1) and in the evening (A_2) from consumers which live in houses and apartments (Rachiti, Radauti Prut, Albesti). The data analyzed obtained when determining the Pb in the drinking water of Rachiti (houses) are presented in fig.5

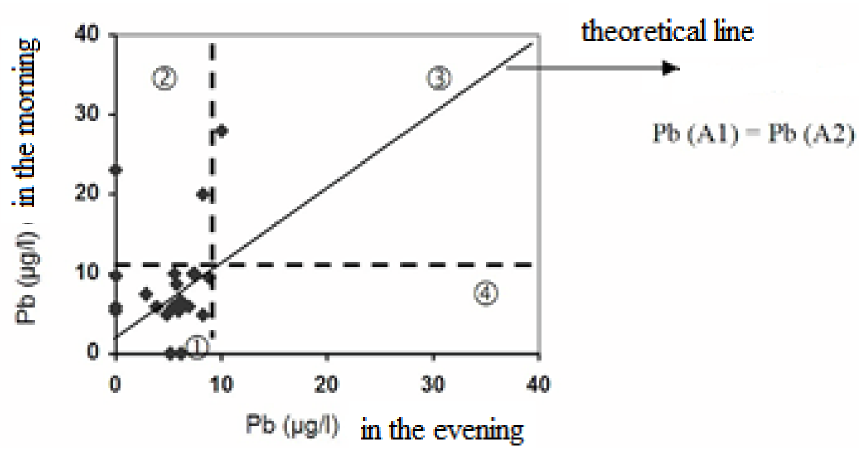

Fig.5 - Pb concentration in drinking water samples collected in the morning and in the evening

The dotted lines which represent the value of maximum permissible concentration (CMA=MPC) (10 μg/l) divide the graphic in four sectors. Most of the dots are represented in sector 1, where the lead concentration both in the evening and in the morning situated in the limits 0-10 μg/l. In sector 2 the dots represent water samples in which Pb concentration in the morning exceeded MPC, but it is in the MPC limits in the case of the samples collected in the evening.

Only in 10% of the samples, Cd was detected in concentrations under MPC (0,001-0,0037 mg/l).

3.Discussions

The importance of water consumption with a high degree of mineralization was proved by many studies which revealed a lower incidence of cardiovascular diseases in areas where water is hard **(**Kousa , Havulinna, 2006).

Law 458/2002 doesn't provide MPC for Ca and Mg, but in some European countries there are recommended minimum and maximum limits for these macro elements 40-80 mg/l Ca and 20-30 mg/l Mg .

In the present study, we found out that water in the fountains and subterranean phreatic sources contain Ca and Mg in higher concentrations than water from surface sources, where it exceeded MPC in the morning, but it is within the MPC limits in the case of the samples collected in the evening.

Only in 10% of the samples, Cd was detected in concentrations under MPC (0,001-0,0037 mg/l).

The ratio Ca/Mg is less than the optimum recommended value (2:1). Obviously, the presence of HCO_3^-, SO_4^{2+}, Cl^- anions in the water of these sources in Botosani County contributes to increasing their mineralization degree.

An increased ingestion of Na and more recently an increased ratio of Na/K were associated with hypertension, that's why the concentration Na at 200 mg/l is normalized in the water.

The maximum value for sodium was registered in the drinking water supplied from subterranean sources – 84,53 mg/l. Positive correlations were observed between the concentration of Na – HCO_3^-, K – Ca, D_T – Cl and negative correlations between the concentration of Ca – HCO_3^-, Mg – HCO_3^- (table 4).

Concentration increases of the sulfate ion were not registered in the drinking water of the surface sources, being known that the aluminum sulfate is used in treating drinking waters.

In water distribution systems, metals corrosion (Fe, Pb, Cu) is frequently produced, the water chemical characteristics circulated pH, alkalinity, TDS, SO_4^{2+}, Cl^-, Ca^{2+}, Mg^{2+}, having a very important role in the process of involving elements with toxic properties. The study showed slight increases of lead concentration in stagnant water (water samples collected in the morning) (0,028 mg/l). Only 10% of the analyzed samples contained Cd in concentrations that did not exceed MPC (maximum value 0,0037 mg/l).

Table 4. The correlation matrix for 8 quality parameters of drinking water (subterranean sources)

	Temperature (^{0}C)	Cl (mg/l)	HCO_3^- (mg/l)	D_T (^{o}G)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)
T(C)	1							
Cl(mg/l)	-0.02287	1						
HCO_3^- (mg/l)	-0.44119	-0.14465	1					
D_T(^{o}G)	-0.37262	0.823515	0.308747	1				
Ca(mg/l)	0.026473	0.586009	-0.79071	0.258758	1			
Mg(mg/l)	0.889166	-0.02462	-0.51986	-0.31431	0.229661	1		
Na(mg/l)	-0.11897	-0.45659	0.750925	-0.27925	-0.86098	-0.29188	1	
K(mg/l)	-0.42296	0.319135	-0.25243	0.286016	0.665168	-0.02693	-0.38715	1

Taking into account the values of the K_1 coefficient, we appreciate that drinking water is slightly corrosive (subterranean sources) (K_1 = 0,2-0,65) and very corrosive in case of springs and some fountains (K_1 -0,65).

Conclusions

1. In the chemistry of the phreatic subterranean waters investigated, used for non-centralized (fountains, springs) and centralized supply, we found out that

cations predominate, the concentration average (in mg/l) being in the order Mg^{2+} $>Ca^{2+} > Na^{+}> K^{+}$, and for the main anions it was $HCO^{3-} > Cl> SO_4^{2+}$.

2. The calculation of the ratio between the main ions showed that Na is not the main cation, being in inferior concentrations MPC, and the ratio Ca/Mg does not have the optimum value recommended in most of the water samples.

3. Slight increases of the Pb concentration in stagnant water were discovered in the drinking water of the locality, and the calculation of the Kl coefficient (Larson-Skold) allowed evaluations of the corrosivity of water from different sources.

The analytic control of drinking water quality allows reconsideration of environmental problems, which can appear in some geographical areas, including those in which the drinking water quality is involved, to establish correlations with the health of the exposed population, and where it is the case, establishing long-term health programs.

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****Legea 458/2002 privind calitatea apei potabile*.