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THE QUALITY OF SPRING WATERS OF FRUSKA GORA (VOJVODINA)

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Abstract

During the period from September 2011 to February 2012, the monitoring of spring, surface and groundwaters of Fruska Gora on 8 permanent and 15 temporary points for sampling was carried out. The water points on the three sources in the Old Ledinci and Sremski Karlovci were selected for sampling. The spring waters were established to have increased contents of: orthophosphates (0.27-0.5 mg/l), phenols (0003-0118 mg/l) and boron (0.5 mg/l). These parameters were above the MAC (regulated by law) for the use of water for drinking, bottling as well as in the production of consumable fish ponds. The samples were taken in Sremski Karlovci in the period from 2003 to 2012.

Keywords: orthophosphates, phenols, springs

Introduction

Fruska Gora is located easternmost within the chain of horst Slavonian mountains. It belongs to comparatively low mountains, because its highest peak Red Cot barely exceeds 500 m. Morphologically, the mountain stretches east-west being 80 km lengthwise and up to 15 km widthwise. It has an elongated lens-like shape and covers an area of 500 km^2. Its northern border is the River Danube, while the southern boundary is approximately the contour of 100.00 mnm above sea level, stretching along the line of Sid-Erdevik-Irig- Maradik-Krcedin-Old Slankamen.

This paper presents some preliminary results for spring water on the northern slopes of Fruska Gora. Water samples were collected from the Lazin water springs near the village Ljubi in the western part of Fruska Gora, then from the water springs in the Old Ledinci on the northern slopes as well as from those of Mutica and Varadinska fountain in Sremski Karlovci.

Materials and method

Throughout the annual survey, 12 observation points for field and laboratory tests were determined. The basic unit for the reinterpretation of existing documentation and setting up observation points network was the basin topography and hydrogeology. In terms of their type of porosity, sediment genesis and manner of occurrence in the basin, the water sources could be divided into the spring, surface and ground water (Stojiljković, 2003; 2004a; 2004b; 2005a; 2005b).

When interpreting the results, the longer time series of various parameters of the chemical composition of spring water were used, the better they enabled the use of the statistical method. Its program STATISTICA, verson 10, was used.

At the western, northern and eastern slopes, the points on the cadastral number 4, 6 and 8 (Fig. 1, 4), were set. The two complete and two shortened (only for some micro-components and organic matters) analyses were made (Table 1).

Laboratory testing of the water was performed by a verified laboratory of the Institute of Public Health of Vojvodina-Centre for Hygiene and Human Ecology in Novi Sad.
Water quality was defined in relation to the criteria for the quality of drinking water, bottling and fish production (Stojiljković, 2012; Zrnić, 2005).

Results and discussion

Figure 1. Geographical position of the point 4 in Kamenarski stream in Ledinci

The spring under the cadastral number 4 in the Old Ledinci, was tapped on the left side of the stream. Directly above the intake structure, a residential building with outbuildings and pigsties, was located. The results of physico-chemical testing of the spring waters, are given in Table 1.

P h y s i c a l p r o p e r t i e s: Coverage sources ranged from 0.38 l/s-0.33 l/s, the water was colourless, odourless. The water temperature was 11.2-12.8°C, pH index of the test water 7.2-7.4 showing a neutral to alkaline medium. The values of the hardness were found to range from 24 to 24.8°dH. According to Klute- this classification of water includes "hard" waters. Mineralization was determined through the values of dry residue obtained analytically and being quite variable in the samples. Thus, the values of dry residue ranged from 683.5- 699.4 mg/l. Conductivity was considerably high, ranging from 1061-1108 µS/cm, exceeding the MAC for drinking water.

C h e m i c a l c o m p o s i t i o n: Based on the investigation results, the chemical composition of the ground water from the spring denoted to the water being analysed to fall under the hydrocarbon class, calcium-magnesium-sodium group (according to the classification Alekin-a). Thus, within the cation content, the cation composition of calcium ions were reported to prevail with 37.8% eq. on average. The content of magnesium ions was found to amount to 36.8% eq. and that of sodium ions to 25.3% eq. on average (Fig. 2, 3). The anion content was absolutely dominated by hydro-carbonate ions, amounting to 82% eq. on average. The total content of sulfate ions was 7.8% eq. and that of chloride ones 10.1% eq.

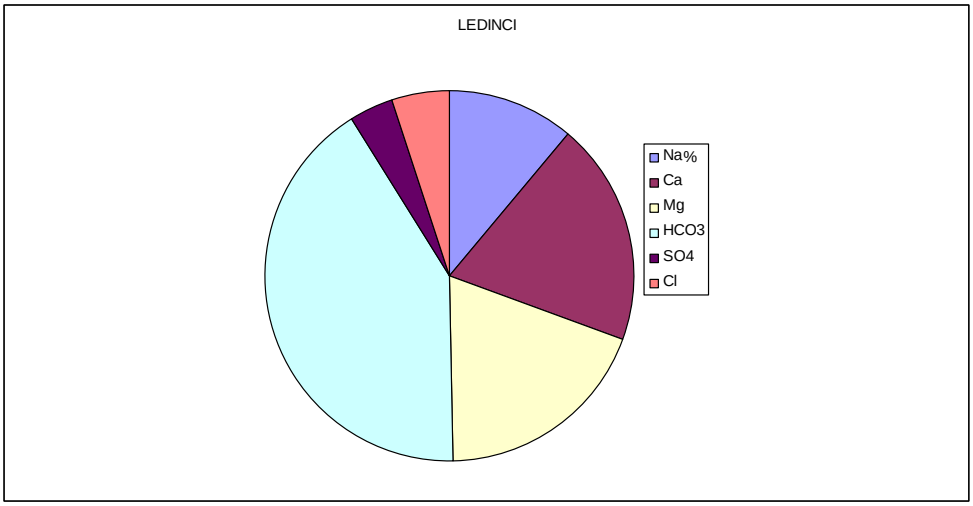

Figure 2. Pie chart of the chemical composition of the water content from the spring in the Old Ledinci

Overall, the physico-chemical parameters were not stable, which was expected from the aquifers having a free level and being fully open toward the surface field. Namely, in the last analysis made, the content of sulfate and chloride increased.

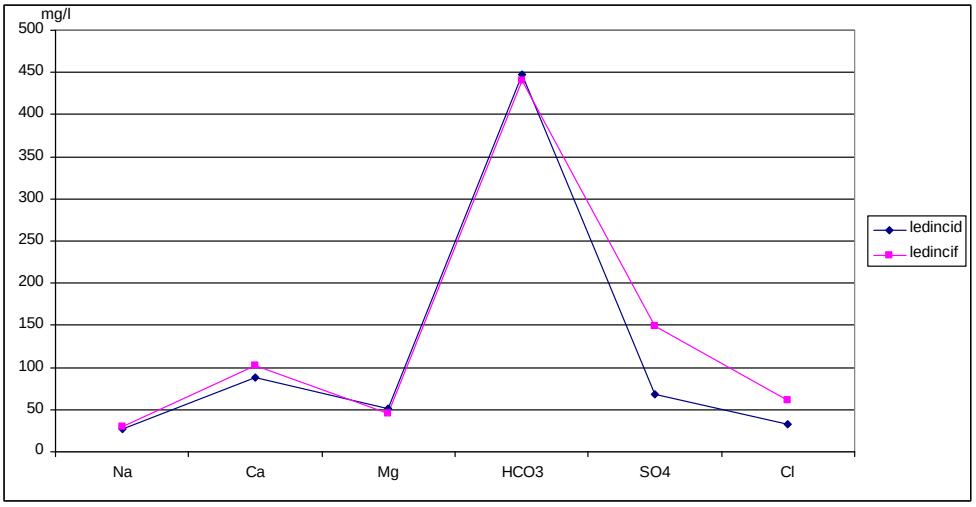

Figure 3. Sheler’s permanence diagram of the major ions content in the spring water in the Old Ledinci

Of the micro components contained in the water, none was found to have increased its content. The manganese content was not recorded while the total iron content was below the maximum allowable limit. The content of organic matter in the water was expressed through the consumption of potassium permanganate ($KMnO_4$), not exceeding the MAC drinking water, being higher over the dry season in December 2011 but lower in the wet February of 2012.

The content of ammonium ions did not exceed the MAC drinking water. The water contained more orthophosphates, boron, phenols than allowed by the regulations for hygienic quality of drinking water ("Off. Gazette of FRY", no. 42/98). Microbiological testing of the water was not done. It was not recommended for use till the entire procedure of the water facility sanitation was used and microbiological quality of water checked.

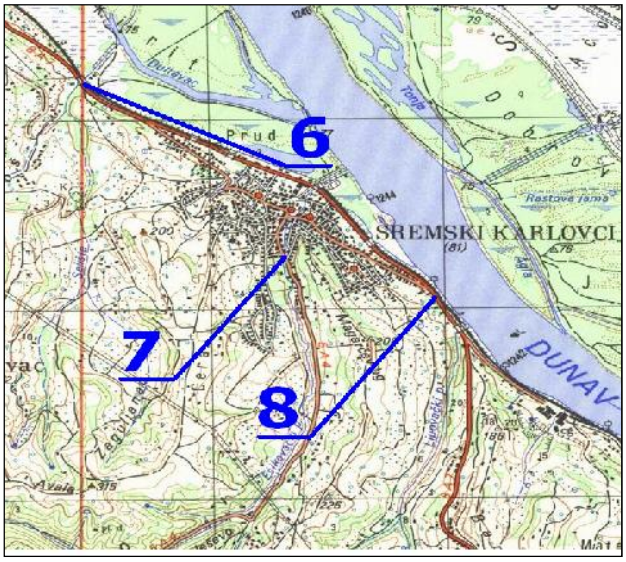

Figure 4. Geographical position of the spring : 6 -”Varadinska fountain”, 7 – Stražilovski stream, 8 – the spring ”Mutica”

The spring of cadastral number 6 in Sremski Karlovci "Varadinska fountain": is located on the right side of the road Novi Sad-Belgrade. The spring drains the paleo-landslide and is known from the Turkish period. This fountain had an icon of St. Elias and Archdeacon Stevan in the wall. Directly above the intake structure there is also a residential building with outbuildings. The trap is completely open and therefore easy to be polluted by surface water.

P h y s i ca l p r o p e r t i e s: Abundance of the spring was constant 0.476 l/s, the water was clear, or almost clear. Water was odourless, water temperature 12.6-13.4°C. The pH of the test water index was 6.92-7.43, showing a neutral to alkaline medium. The values of the hardness ranged from 19-24.37°dH. According to Klute- this classification of water indicated that it belonged to the "hard" water, with mineralization being determined through the dry residue value obtained analytically and showing noticeable variations in the samples studied. The values of dry residues ranged from 345-1148 mg/l, averaging 530 mg/l. Conductivity was high, being within the range of 557-1851 S/cm, the average being of about 800 S/cm, visibly exceeding the MAC for drinking water.

C h e m i c a l c o m p o s i t i o n: The investigation of the chemical composition of groundwater in the site denoted to the water analyzed to fall under hydrocarbon-class calcium - magnesium-sodium groups (according to the classification Alekin-a). The cation composition of calcium ions ranged from 70.7-102.4 mg/l, accounting for 44% eq. on average. The content of magnesium ions was found to range from 42-44 mg/l being 34.6% eq. The content of sodium varied from 21.3-28.1 mg/l, accounting for 21.1% eq. on average (Fig. 5, 6). The anion content was absolutely dominated by carbonate ions content ranging from 524.9-536.8 mg/l or 85.8% eq. on average. The total content of sulfate ions was found to vary from 13.3- 74.5% of 9.2 eq. while chlorides were reported to range from 7.4-27 mg/l, or 4.9% eq. on average. During the monitoring from 2003–2011, the variations of chlorides and sulfate were found to be high.

Except for boron, of all other micro-components contained in water, none had an increase in content. Manganese and total iron content were reported to range below the maximally allowable amount.

Content of organic matter in the water expressed through consumption of potassium permanganate ($KMnO_4$) did not exceed the MAC potable water, but it did in the dry season in December 2011, but also it was lower in the wet in February 2012. Water contained

orthophosphates and phenols over allowable standards based on the regulations for hygienic drinking water ("Off. Gazette of FRY", no. 42/98).

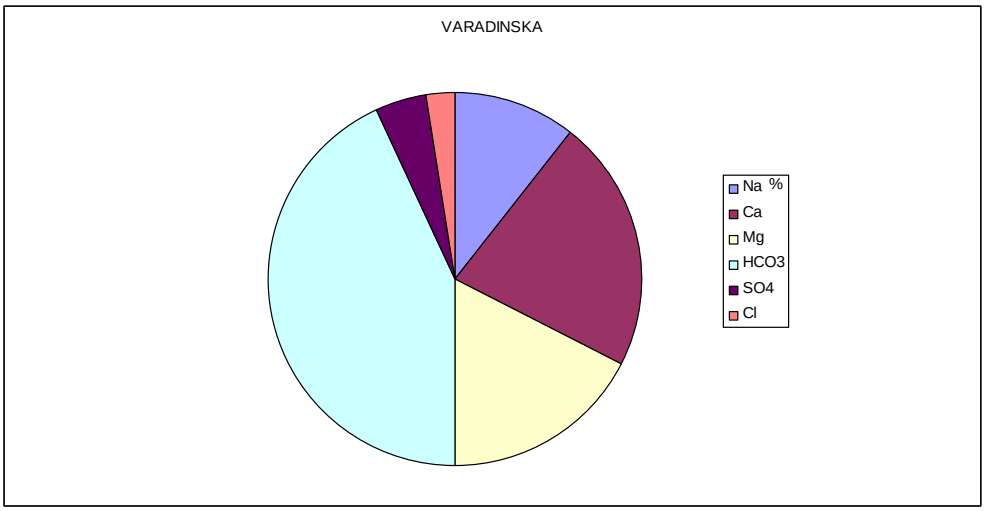

Figure 5. Pie diagram of the chemical composition of the spring water „Varadinska fountain“in Sremski Karlovci

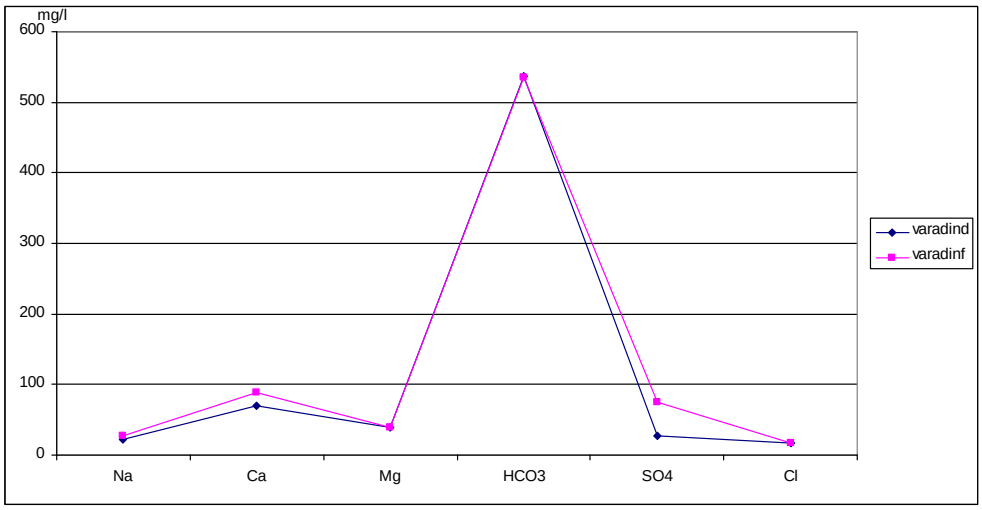

Figure 6. Sheler’s diagram of the spring water major ions contained in the „Varadinska fountain“u Sremski Karlovci

Microbiological testing of water – the most frequent causes of microbiological incorrectness of water were established in 41 (61.19%) control samples of drinking water from public wells "Varadinska Fountain" for the period 2005-2011, with the findings of thermo-tolerant microorganisms in 38 (56.72%) controlled samples, followed by the increase in the total coliform microorganisms in 23 (34.33%) and controlled samples as well as in those of streptococci of fecal origin in 18 (26.87%) control samples.

The most commonly cultured microorganisms in drinking water from public well "Varadinska Fountain" in the period 2005-2011, appeared to be *Escherichia coli* (in 22 controlled patients, being 32.84% of the total number of microbiological analysis) and *Bacillus spp*. (in 20 samples of controlled, or 29.85% of the total number of microbiological analysis). It was not

recommended for use until the complete process of the facility water sanitation was applied and microbiological quality of water controlled.

The spring of cadastral number 8 in Sremski Karlovci "Mutica" located on the right side of the road Novi Sad-Belgrade, outside Sremski Karlovci. It drains moderate paleo-landslide. Directly above the intake structure there was a residential facility with the outbuildings. The cover of intake structure was in the level of the flat terrain and quite easy to go into the capping of surface water from higher elevation.

Physical properties: Abundance of sources varied from 0.32 to 0.27 l/s, the water was clear, or at the border, no smell. The water temperature was 11.4-13.6°C. The pH value of the index of the test water was 7.18 to 7.50, showing neutral to alkaline medium. The values of total hardness ranged from 23.9- 26.89°dH. According to Klute - this classification of water belongs to the "hard" water. Mineralization was found through the values of dry the residue obtained analytically appearing to be quite variable with the samples examined. The values of dry residues ranged from 494-657 mg/l, averaging 601 mg/l. Conductivity was high, ranging from 782-1081 µS/cm, averaging about 900 µS/cm. In the period of monitoring of the project it exceeded the MAC for drinking water.

Chemical composition: The investigation of the chemical composition of groundwater at the source denoted to the water analyzed to belong to hydrocarbon classes, magnesium-calcium-sodium group (according to the classification Alekin-a). The cation composition of calcium ions ranged from 79-102.1 mg/l prevailing by 39.3% eq. on average. The content of magnesium ions was found to range from 53-58.5 mg/l or 39.7% eq., whereas the content of sodium varied from 22.5-28.1 mg/l or 20.8% eq. on average (Fig. 7, 8). As for the anion content, carbonate ions were absolutely dominant, with their content ranging from 523.4-553.9 mg/l or 85.6% eq. on average. The total content of sulfate ions varies from 40.8-93.8% amounting to 6.5 eq. while chlorides were found to range from 1.8-28.7 mg/l or 8% eq. average. During the monitoring from 2003–2011, the variations in chlorides and sulfates were noticeably high.

Throughout the final analysis made, sulfate and chloride content were revealed to be higher. Of the micro components in water, no increase in content of any element other than boron was revealed. Occasionally, as a result of pollution, cadmium, nitrogen triad, potassium and arsenic appeared in unallowable concentrations. The content of organic matter in the water expressed through the consumption of potassium permanganate ($KMnO_4$) did not exceed the MAC in drinking water, except for water sampled in February 2012. The water of each sample contained orthophosphates and phenols over allowable limit confirmed by regulations for hygienic standards of drinking water ("Off. Gazette of FRY", no. 42/98).

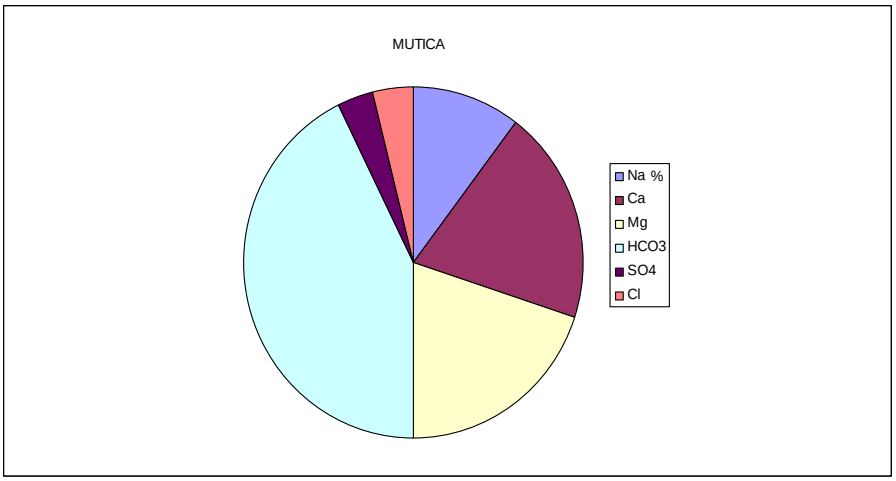

Figure 7. Pie diagram of the chemical composition of the spring water „Varadinska fountain“in Sremski Karlovci

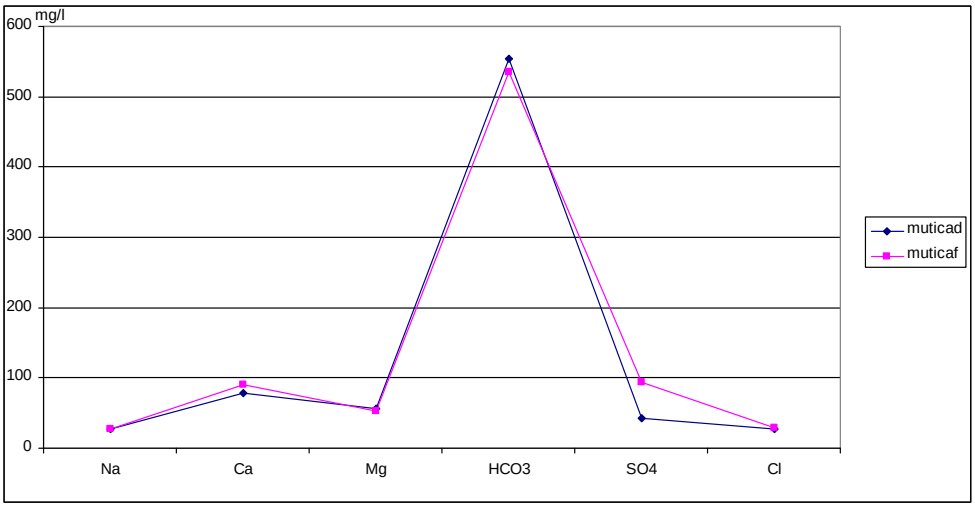

Figure 8. Sheler’s diagram of the spring water major ions content of the „Varadinska fountain“u Sremski Karlovci

Tabela 1. Results of physico-chemical analyses made on the spring waters in Old Ledinci i Sremski Karlovci

Parameters (mg/l)	**Ledinci (5)**	**Sample (5)**	**Petro.Česma (6)**	**Sample (6)**	**Mutica (8)**	**Sample (8)**	**MAC drinking water**
Date	22.12.2011.	23.02.2012.	22.12.2011.	23.02.2012.	22.12.2011.	23.02.2012.	
EC(µS/cm)	**1061**	**1108**	936	917	**1081**	**1077**	**1000**
NH_4	0	0.07	0	0.06	0	0.07	**0.1**
Nitrates	8.07	12.8	10.39	13.25	25.04	21.83	**50**
Nitrites	0	0	0	0	0	0	**0.03**
$KMnO_4$	4.9	2.3	2.6	0.73	2.6	**15.2**	**8**
HPK	2.75	0.58	2.75	0.18	2.75	3.8	**-**
SO	683.5	699.4	533.3	510.7	657.5	628.8	**-**
Chlorides	32.3	60.9	17.4	16.7	27.7	28.7	**200**
Bicarbonates	447.7	441	536.8	534.9	553.9	534.9	**-**
Sulfates	68.1	149.7	27	74.5	43.2	93.8	**250**
Total iron	0.08	0.04	0.04	0.03	0.03	0.05	**0.3**
Calcium	87.5	102.9	70.7	88.5	79	90	**200**
Magnesium	51.5	45.5	40	40	**56**	**53**	**50**
Sodium	27	29.4	22.2	28.1	28.1	27	**150**
Potassium	4.4	3.6	4.3	3.5	**12.7**	12	**12**
pH	7.4	7.2	7.1	7.1	7.3	7.2	**6.8-8.5**
Ortophosphates	**0.39**	**0.5**	**0.27**	**0.38**	**0.36**	**0.4**	**0.15**
Phenols	**0.003**	**0.079**	**0.004**	**0.118**	**0.008**		**0.001**
Ba	0.47	0.32	0.6	0.32	0.6	0.33	**0.7**
Total Cr	0.03	0.02	0.03	0.02	0.03	0.03	**0.05**
Pb		0.01		0.01		0.01	**0.01**
Boron	**0.05**	**<0,5**	**0.01**	**<0,5**	**0.01**	**<0,5**	**0.3**

* the values marked with red colour are above the MAC for drinking water.

Conclusion

Spring waters are of low mineralization. According to hardness, they belong to the category of "hard" waters. By classification of Alekin – the waters belong to hydro-carbonate class of water, of calcium-magnesium-sodium type. Overall, physical-chemical parameters were not stable as being expected from aquifers having a free level, as being entities open toward the soil surface, also with the trap in these wells being lower than the ground level, so that the surface water along with seasonally scattered pollutants from the surface flow into the catchment area.

Based on the analysed chemical parameters, the water did not meet the requirements of the drinking water because of physical-chemical improperness: due to increases in concentrations of orthophosphates, phenols and boron in all the samples analysed, further, due to occasional organoleptic changes in the water examined and due to its constant bacteriological improperness.

Therefore, it is not recommended to use as drinking water without water treatment being completely performed.

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