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SOME KARST SPRING ANALYSIS AT THE PEIDMONT OF BÜKK MOUNTAINS

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Összefoglalás – Sok karsztforrás található a Bükk-hegységben, amelyek közül néhány, mint a Kács-Sályi vízrendszer jelentős szerepet játszik a Borsodi-régió vízellátásában. Előfordul itt langyos vizű, kevert vizű és hideg vizű forrás is. A rendszer működésének tanulmányozása céljából mintát gyűjtöttünk ezekből a forrásokból és néhány vízfolyásból. Elemeztük a víz teljes keménységét, Ca^{2+} és Mg^{2+} tartalmát, valamint a klorid, nátrium, kálium, foszfát, nitrát, szulfát és nehézfémtartalmát. Különbség mutatkozott a források között. A tanulmány bemutatja a vizsgált területet és a kutatást.

Summary – There are several karst springs in the Bükk Mountains. Some of these, like the system of Kács and Sály, have in important role in the drinking water supply system in the region of Borsod. Here we can find springs with lukewarm water, springs with mixed water and cold water springs. We have sampled these springs and some streams in order to learn how the system works. We analysed the total hardness, the Ca^{2+} and Mg^{2+} contents, and also the content of chloride, sodium, potassium, phosphate, nitrate, sulphate and heavy metals. There are some differences between these springs. In this article we give some general information about the research and the study area.

Key words: karst springs, hydrochemistry, pollution, discharge

INTRODUCTION

Karst water has an important role in the drinking water supply system all over the world. The Bükk Mountain, which is situated on the north part of the country, is one of the most important karst areas in Hungary. Several villages and towns get their drinking water from there. But nowadays there is an increasing human impact on natural systems, so I have to be aware of their effects on the karst, which is very sensitive not only to the quantity of the water, but also to the quality.

The study area is situated in the SE part of the Bükk piedmont (*Fig. 1*) near Kács, Sály and Lillafüred. The aim of my research is to learn the function of these springs during the year and also to observe the behaviour of the pollution from the springs along the streams. I find the karst springs by the side of a little fault line especially at Kács and Sály. There are three types of springs: springs with cold, with lukewarm and mixed water.

About this system several articles were published, but the most of them are specialised on the protection area. In 1970 the spring Vízfő- (Sály) and Alap-spring (Kács) were occupied to provide water for the drinking water supply system. However the research was not established enough so it is necessary to analyse the quality changes during the years.

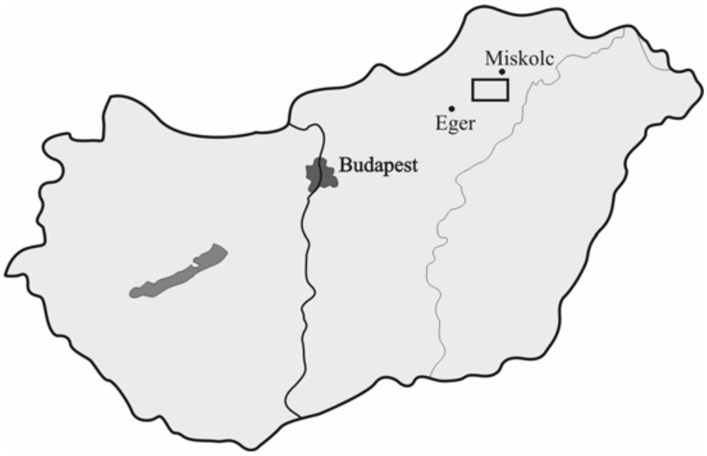

Fig.1 The situation of the study area in Hungary

METHODS

After the data collection we realised I had not data about the water quality, which is very important, because it can help us recognise changes in the aquifer. So we decided also to analyse the chemical components of the different springs. I gather samples every two weeks at 11 points, 4 of which are points on the streams of Kács and Sály. Regular data acquisition is necessary for gaining knowledge of the function of the whole system. The other 7 points are the karst springs.

In the field I measure conductivity, pH and temperature with a RADELKIS 104 Type II instrument. After, according to the method of *Hoffmann and Pellegrin* (1996), I measure the Total Hardness, Ca, Mg, HCO_3 ions with titration.

In the laboratory I analyse the water within 24 hours, because I do not add any acid to the samples. Heavy metal content (Cd, Zn, Ni, Pb and Cu), sodium, and potassium are determined by AAS (PERKIN ELMER 3110). The SO_4 and PO_4 are measured by spectrophotometer HELIOS, according to *Krawczyk* (1996). The Cl is determined with titration with 0,01 mol $AgNO_3$.

PRECEDING RESEARCH

The Bükk Mountain is in the moderately humid continental climate region. The yearly sunshine duration is between 1850 and 1900 hours. The mean annual temperature is 8, 5-9, 6 ^{o}C, during the growth season it changes between 15, 5-16, 7, and it depends on the altitude and the exposition. Generally the last frost comes before 20. April, and the first freeze in autumn is after 15 October.

Annual precipitation is approximately 650mm (*Fig 2.)* and half of it falls during the growth season. In winter snow is frequent, generally there are 40-55 snow-covered days and the mean maximal thickness of the snow is 18 cm. This climate is good for growing crops and horticultural activity.

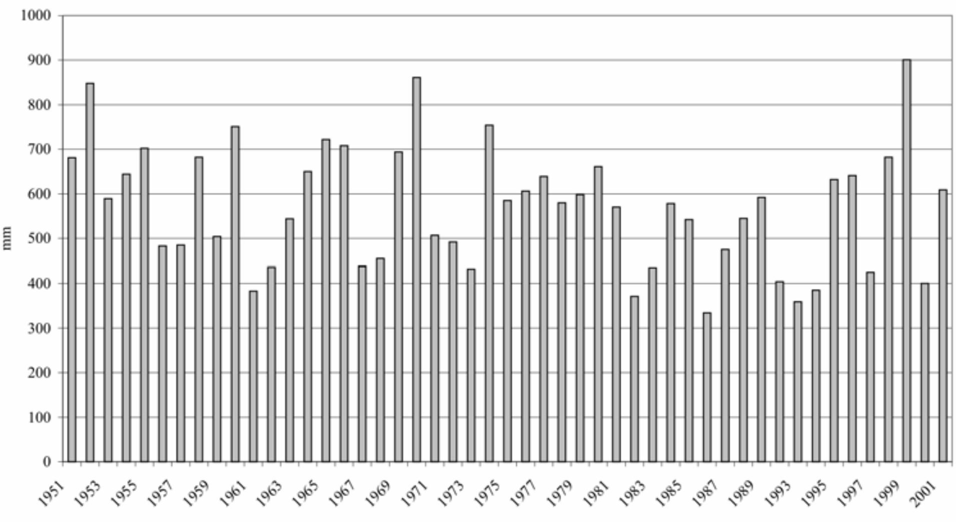

Fig. 2 The annual precipitation at Miskolc 1950-2001

The latest geological analyses have shown that in the Bükk Mountain there is not a homogeneous karst water system, but several independent systems exist. In consequence, we cannot speak about a homogeneous karst water level (*Sásdi et al.,* 2002). The system of Kács and Sály get the water from the south part of the Bükk and this water is banked up by the rhyolite tuffs, which lies on the Eocene limestone at the Bükk piedmont. In the catchment area there is dolomitic limestone, limestone with silex. According to *Rádai* (1988) this little water system has no relation with the other karst water systems around. But the latest research of *Jambik and Lénárt* (1995) has shown a relationship between the system of Miskolctapolca and Kács-Sály. Thus the former system grows at the expense of the latter. *Jambik and Lénárt* (1995) has modified some data in his work, in which he has treated the articles published so far critically. For example he has modified the superficial extent of the catchments area, because the discharge data did not verify an extent of 51.4 km^2. He presents two values for the catchment area, one before the occupations of the springs and one after: 23.8 km^2 and 16.2 km^2.

The springs rise to surface on a low altitude (f.e. 194.9 mBf) on the mountain front (*Fig. 3)*. This altitude shows the lowest karst water level in the Bükk. According to *Jambik and Lénárt* (1995) the spring Tükör, which is a spring with warm water, has no more overflow water.

Here we know three types of the karst water. Springs with cold water belong to the descending precipitation water in the karst and their regime depends on the precipitation and the texture of the limestone. Their temperature is about 10-12 ^oC.

The second type is the mixed water springs. Their water has two sources: the precipitation and the stagnant zone. Their temperature is 14-16 ^oC.

Third type is springs with warm water, of which the temperature is 20-21^oC. *Shcréter* (1954) has also taken measurements in these springs, and he got different values, 15-23^oC. According to *Jambik and Lénárt* (1995) there is a tendency for the decrease of the temperature over time. During my field work I measure the temperature regularly, and I saw the change to be seasonal. During the winter there is really little decrease, but after the temperature increases till a certain value *(Table 1)*.

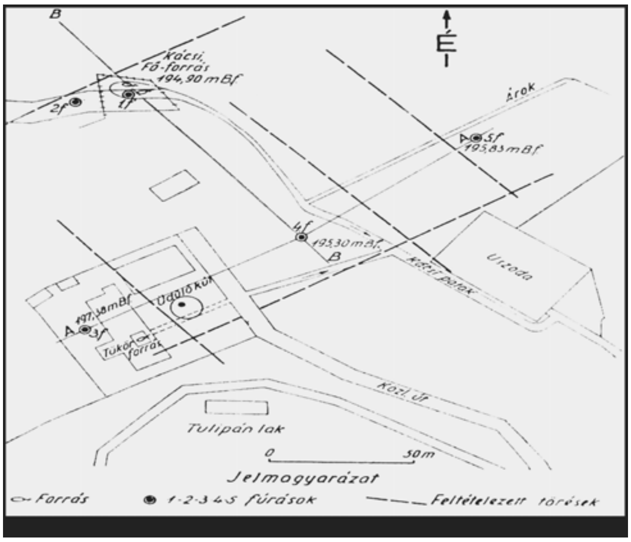

Fig. 3 Scheme of the Kács spring and the hydro-geological boreholes (after *Almássy and Scheuer,* 1967)

Table 1 The temperature of the different point of samples

Point of sample	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
S1	16	16	15	15	15,5	15,5
S2	9,5	2	2,5	0	1,5	8,5
K1	12	11	10,5	11	11,5	12
K2	16,7	14	12,75	12,5	14	15
K3	15,5	11	7,25	7	9,5	10
K4	13,5	9	7	5,5	7	12,5
K5	15	14,5	14	14	14,5	14,5
K6	20,5	20	20	18,5	20	20
K7	18	19	20	19,5	20	21
K8	21	20	20	20	20	21
B	7,5	6,5	6	6	6,5	8

For the discharge the VITUKI (Water Resources Research Center) took measurements, 1950-2000:

- discharge of warm water: 3203 l/min
- discharge of cold water: 7851 l/min

In the case of the mixed spring at Kács I have not found data for the discharge, because the warm and cold springs all break out in the bed of Kács stream, along a little fault line. Still *Aujeszky and Scheuer* (1979) mentioned values of 10000 l/min for Kács and

2500 l/min for Sály. According to *Aujeszky and Scheuer* (1979), the occupation of the karst water affected only 40% of the springs at Kács.

Hertelendi et al. (1994) analysed the age of several springs in the Bükk Mountains, including the spring Kács and Sály. He pointed out that the oldest water breaks up in the Vízfő spring at Sály, which is very interesting, because there is no such difference between the concentration of Ca and Mg ions in the spring of Kács and Sály. Furthermore at Kács there are 3-4 springs with warm water and according to other authors they are older than the other springs (*Table 2).*

Table 2 The results of the radiocarbon and tritium date calculation (*Hertelendi et al.,* 1994)

Springs	$\delta^{13}C$ [‰]	$D^{14}C$ [‰]	pMC [%]	^{3}H [TU]	T [^{o}C]
Kács Alap-spring	-7.43	-403	59.4	6.6	14.8
Sály Vízfő-spring	-10.1	-563	43.5	2.9	15.9
Kács LKM-well	-9.07	-522	47.6	3.1	20.5

As we saw there are several works about the discharge and the general presentation of these springs. But there is lack of quality information about these springs. Are they really in the same system? Is there difference among the different parameters? Is there any pollution in the catchment area? Still in the reports of VITUKI (*Rádai,* 1988) there are no data for the hydrochemistry of the different springs.

RESULTS AND DISCUSSION

As a result of the analysis I have found differences not only in the temperature of the springs, but also in the proportions of different ions. There is a difference for example in the concentration of the Na, K, PO_4, and Ca, Mg ions.

There are two samples in which the conductivity is very high, and I found these samples highly polluted with PO_4 (*Fig. 4*). In the stream of Sály and in the spring Máriás at Kács the PO_4 concentration is always very high, more than 1 mg/l, while the threshold limit value is 0.5 mg/l. It is clearly a human impact. At Kács there is no sewer system, while at Sály there is an illegal waste deposit. In the sample taken from the Kács stream there is a tendency of increasing PO_4 contamination. Besides the stream Kács and Sály there are arable land, which are treated with artificial fertilizer (rich in NO_3 and PO_4), but the main source of the PO_4 is the households.

As to the carbonate system, the values are very similar in the whole system. Generally the whole system moves together the same way. However, there is an exception: the spring Máriás at Kács has a content of Ca and Mg higher than the other springs. Total Hardness changes between 6-7.2 meq/l, while in the former spring its value is between 8.9-10.4 meq/l. The proportions of the Ca and Mg ions are relatively high, but here I find three types of karts springs. The spring Bársonyos at Lillafüred behaves like a "normal" karst spring with descending waters, namely the Mg ion concentration is low, 0.2-04 meq/l. The second type is the spring Vízfő at Sály, here the proportion of Mg ion is 3-2 meq/l, which is a characteristic of the springs from dolomite areas. It might also mean that this water is older than the others, and it probably comes from the ascending waters. In the third group there are four springs, which have a Mg ion concentration of 1-1.5 meq/l (*Fig. 5*).

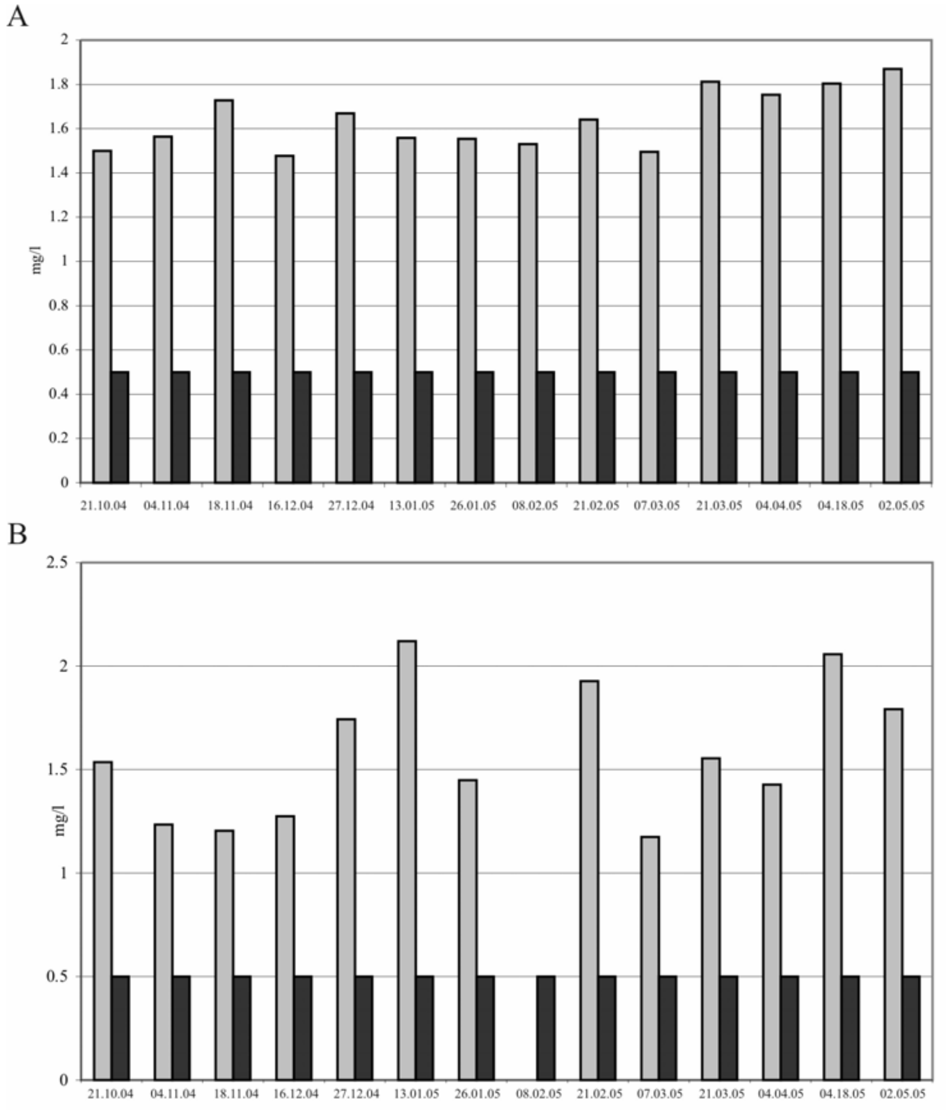

Fig. 4 The contents (grey) and the limit values (black) of PO_4 in the spring Máriás (A) at Kács and in the stream of Sály (B*)*

At the University of Miskolc there was a project to analyse the radon concentration of the different springs of Bükk (*Lénárt,* 1992*) (Table 4).*

Table 4 The results of the radon measurements of *Lénárt* (1992*)*

Springs	**Date**	**Number of measurements**	**Rn mean kBq/m3**	**Rn max.kBq/m3**	**Rn min. kBq/m^3**	**T mean ^oC**
Kács Alap-spring	05.05.1991	10	2,18	2,89	0,69	14,7
Kács Tükör-spring	05.05.1991	10	2,76	3,78	1,39	20,9
Sály Vízfő-spring	05.05.1991	8	4,09	7,59	3,34	15,7

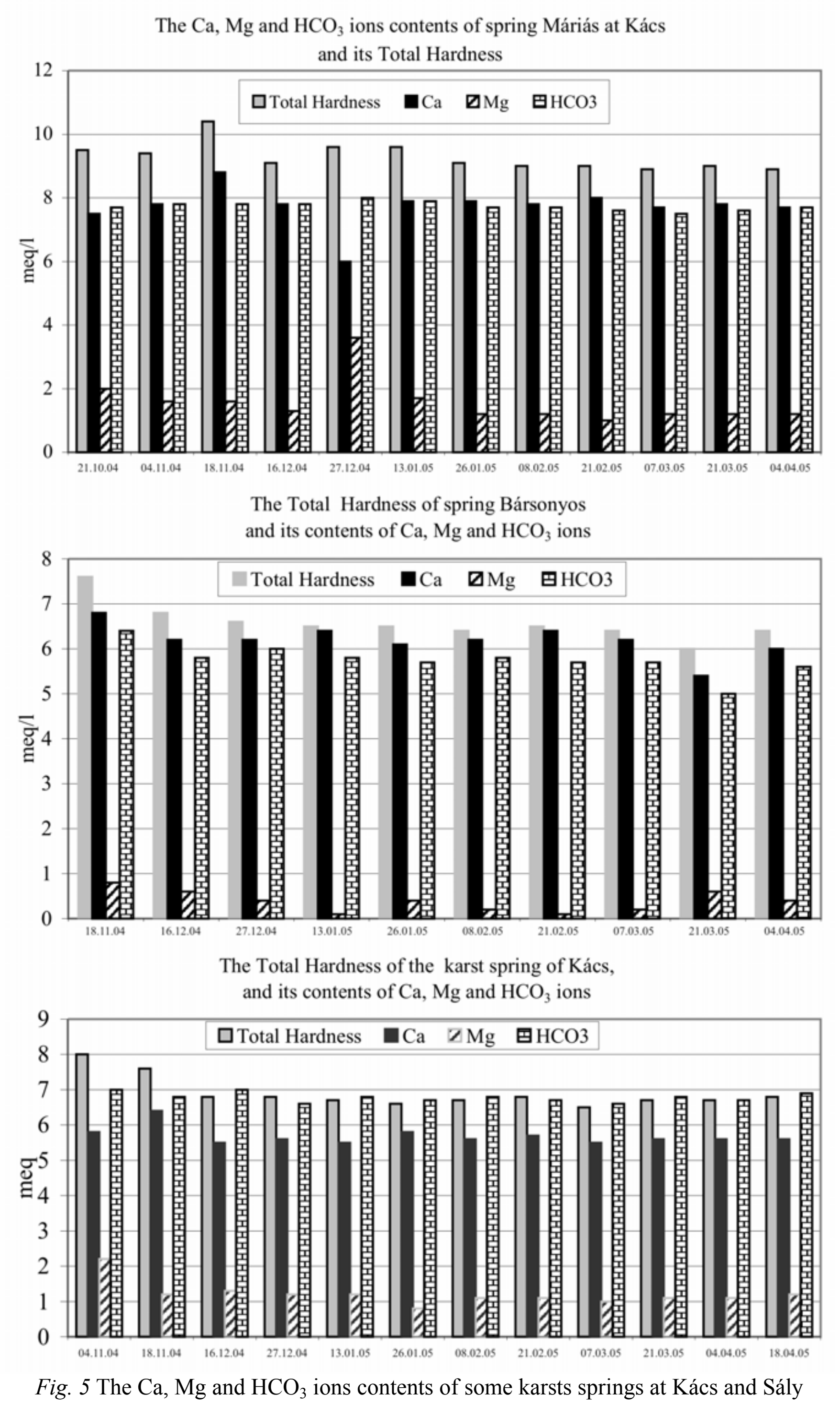

Fig. 5 The Ca, Mg and HCO_3 ions contents of some karsts springs at Kács and Sály

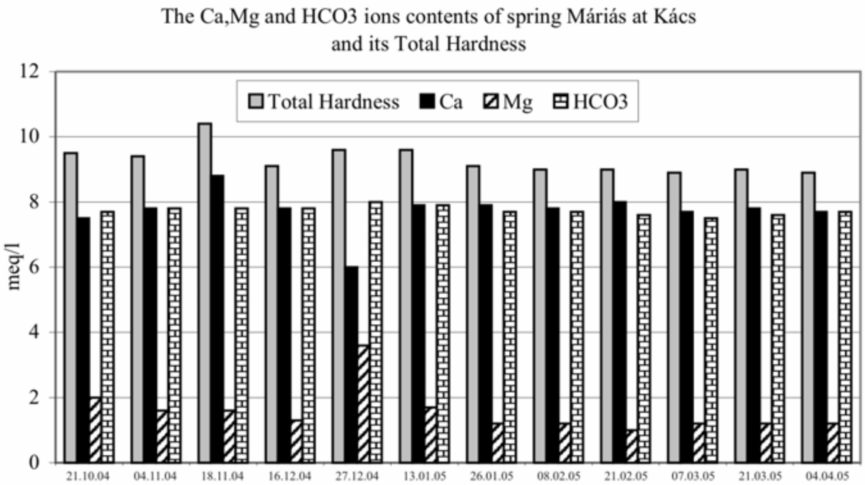

Fig. 5 (continued)

Table 5 The heavy metal concentration of some spring and stream at Kács and Sály

spring Máriás	**21.10.2004**	**04.11.2004**	**18.11.2004**	**16.12.2004**	**27.12.2004**	**13.01.2005**	**26.01.2005**
Cd µg/l	58.61	0.8	20.57	5.673	1.714	0	1.914
Ni µg/l	0	0	0	0	0	0	0
Zn µg/l	108.9	153.9	11.85	151.5	221.5	29.32	57.63
Cu µg/l	20.69	21.03	6.546	44.01	36.02	43.1	40.88
Pb µg/l		605.9	43.19	38.62	69.14	78.46	96.23
stream Sály	**21.10.2004**	**04.11.2004**	**18.11.2004**	**16.12.2004**	**27.12.2004**	**13.01.2005**	**26.01.2005**
Cd µg/l	0	64.57	0	2.616	7.429	1.837	0
Ni µg/l	0	0	0	0	0	0	0
Zn µg/l	27.41	193.1	77	114.7	163	83.17	103.3
Cu µg/l	9.776	24.39	11.52	42.07	62.97	32.61	41.56
Pb µg/l		1401	0	39.99	59.94	85.83	95.25
spring Kács	**04.11.2004**	**18.11.2004**	**16.12.2004**	**27.12.2004**	**13.01.2005**	**26.01.2005**	**08.02.2005**
Cd µg/l	70.25	14.93	3.141	0	0	0.367	2.208
Ni µg/l	0	0	0	0	0		84.18
Zn µg/l	166.5	27.54	204.9	23.28	38.93	82.9	22.34
Cu µg/l	16.21	12.6	55.79	14.04	19.1	18.9	0
Pb µg/l		32.67	50.29	42.82	67.11	97.92	15.65
spring Vízfő Sály	**21.10.2004**	**04.11.2004**	**16.12.2004**	**27.12.2004**	**13.01.2005**	**26.01.2005**	**08.02.2005**
Cd µg/l	52.1	33.37	9.32	3.388	0.634	0	7.629
Ni µg/l	0	0	0	0	0	0	82.73
Zn µg/l	34.75	121.1	122.7	223.5	91.01	111.3	17.02
Cu µg/l	19.38	0.984	35.03	52.97	29.37	35.6	0
Pb µg/l			22.62	62.89	67.23	68.9	11.99

The radon content of the water depends on the U-238 and Ra-226 content of the stone, the time of storage in the deep karst or in the aquifer, and the content of Ra-226 dissolved in the water.

I also measured the heavy metal content. According to *Merian* (1984) the heavy metal content in the limestone is: Cu: 4, Cd: 0.165, Ni: 15, Pb: 5, Zn: 23 ppm. According to *Brümmer et al.* (1991) the mobility of heavy metal changes with the pH: Cd pH<6-6.5; Ni, Zn pH<5.5; Cu pH<4,5; Pb pH<4 will be movable. In our samples the pH varies between 6.9 and 8.2, at which heavy metal are not soluble. We determined the following heavy metals in our samples: Ni, Zn, Cd, Cu and Pb. During the period of snow the heavy metal content diminished, some components, like Ni, have disappeared. But with the melting of the snow there is a great increase in these values. This is also true for the other components measured. Lead concentration is relatively high in the whole system, which can be result of the human impact on the catchment area, but I do not know the exact source (*Table 5*). The coloured cells are the values higher than the threshold limit according to the law *10/2000 (VI/2)*.

CONCLUSION

As I have written before, there are two mixed-water springs and according to *Jambik and Lénárt* (1995) the spring Kács gets its water mostly from descending waters. But according to our observations the precipitation and the melting of the snow arrive with a difference of approximately two months. This period can be detected in the changes of each parameter.

The data shown in this essay form part of a complex research, which I have just begun. The results bring up other questions, for example: What is the source of pollution? Thus I have to extend my research to more fields.

I have to pay attention to the pollutants, their movements in time and space, because these springs are connected to the drinking water supply system of the region Borsod. The lead and nickel concentrations are distressing and it is urgent to clear up the source of the pollution.

This research is a part of a more general analysis of which the aim is to explore the relation between pollution possible in the soil, in the vegetation.

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