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Short communication

CHANGING OF THE ABIOTIC PARAMETERS OF KARST CAVE BELOJAČA IN PANNONIAN SUBURB (SLOVENIA)

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A b s t r a c t: Knowing abiotic parameters of cave on the edge of the Pannonian basin, where the Eastern Karavanke ends and marl hills begin is important from three rare geological phenomenoma. We followed characteristics of air on four different points (point 1 – outside the cave, point 2 – 20 m before the entrance, point 3 – right behind the entrance and point 4 – 20 m deep in the cave). Next to air data collection (humidity, temperature, ozone, light) we also followed water characteristics in the stream Šega as well as soil characteristics, which we analyzed once, because it does not change so rapidly. Important outcome of the analysis is that caves have important influence on the microclimate and wider ecosystemic characteristics of the landscape.

Key words: karst cave; abiotic parameters; microclimate; water; soil

1. INTRODUCTION

Slovenia´s territory is mostly carbonate (2/3 of the territory is carbonate (Ančić and Juriša, 1984 and 1985). For such floor is common often specific curdling and with these phenomena connected karst forms (Bedjanič, 2009). In this area of Slovenia are karst phenomena and forms connected only to the specific small areas of limestone. Because of that are those phenomena rare in the north-eastern Slovenia and therefore very important from the ecosystemic point of view. (Kamenšek, 2005).

On the eastern part of Boč, we find the area of lonely karst Leneš, which is geomorphological continuation of the eastern Karavanke. Geologically are these Eastern Alps (Žibret, 2015, p. 20, and Gospodarič, 1960). This is limestone massive, surrounded by the Miocene sandstones and marls and is therefore interesting example of the rare lonely karst (Hamra, 1962). In the small area of specific karst phenomena like sinkholes, karst springs, rocky and limestone crackly area we find specially interesting underground cave system Belojača, formed by three karst swallow-holes. In this area of Slovenia is that a rare example of lonely karst, rich with surface and underground geomorphological forms (Gregorač, 1995) and so certified as geomorphological reservation as well. Karst on the edge of the Pannonian basin is very interesting, since it is a limestone ridge that has all characteristics of karst phenomena (sinkholes, swallow-holes). Lonely rocky massive, to which water chiselled out smaller cave at the end of the Ice Age, ended here because of the tectonic movements. Cave Belojača lies 330 m above the sea. This is 550 m long spring, water cave in Haloze. It was chiselled out by the Šega stream. Cave is divided into two tunnels, left ends after 30 m, the right one after 50 m takes us into bigger hall, where two streams flow together. For lonely karst, as we call it, specific springs and sinkholes are specific, but not larger karst areas such as karst fields and karst valley, as well we can find many other karst specific forms like sinkholes, sallow-ends and cracks (Gregorač, 1995 in http://www. katasterjam.si/index.php ?c=dok.preview&id=5139,21.2.2017).

Entrance is close to the deserted mine Šega, which was abandoned because of the water threat. (https://www.geocaching.com/geocache/GC4640J_jama-belojaca-belojaca-cave?guid=d6cf7fabeb6c-404a-95db-3d0d83be734e, 21.2. 2017).

Belojača as a lonely karst has over 700 m of explored tunnels. It lies NE of Boč in the direction of Donačka Gora. It was discovered by the miners of nearby mine Šega, where they were excavating black coal anthracite. Cave was formed at the end of the Ice Age, when there was more precipitation.

Limestone massive, in which cave is, was formed in early Perm era, that is when Karavanke were formed and major tectonic movements happened. Cave was created by enormous quantities of water, which flowed through cracks. This was proven by bigger gravel stones found at the bottom of the cave as well as big rock formations in the first floor of cave.

Entrance into the cave is 324 m above the sea level on the southern side in rock crack from limestone. When we enter the caves, we come into Vhodni Rov, where is stream that gets water from the sink-holes and swallow-ends above. Left from the entrance is the calcareous sinter system, formed by water. Vhodni Rov is over 50 m long. In the cave there are more tunnels with karst phenomena. (Kelenc M., Kelenc D., 2004).

1.1. *Characteristics of the Belojača cave*

With the formation at the end of the Ice Age, the cave belongs between younger caves. It was created in the Perm limestone for which numerous joints and tectonic fragmentation are specific. For usual visitors only the Vhodni Rov is accessible. Entrance into Belojača is in 20 m high crack in the rock that leads into Vhodni Rov.

Photo 1. Entrance into cave Belojača
(Source: private photo, February 2017)

Tunnel is immediately after the entrance widened into bigger hall, to which we access easily, except after heavy rains. Then is the entrance inaccessible, since it becomes a swift. Vhodni Rov is around 50 m long and is divided into Slepi Rov and siphon that leads towards the Križišče. Right tunnel is 90 m long and there we find a stream. Left tunnel has three elevations. It leads into Krtov Rov above the Križišče and Obelisk into Blatni Rov. Until now more than 600 m of tunnels have been discovered. In the tunnels we find interesting systems of stalactites. In the cave we find bats, spiders, cave keels, bugs and moths. Especially important is as the shelter for the endangered species of bats, such as common bent-winged bat and greater horseshoe bat (Senegačnik, 2010).

In the hills of Boč we find many karst phenomena like karst springs, caves, sink-holes and swallow-ends (Novak, 1980). On the limestone and dolomite karst evolved. Where there is limestone in majority, we do not find many surface waters, since on karst they quickly end underground, but they again emerge at the foothills as karst springs (Senegačnik, 2010).

Wider area of Boč is because of the diversity and quantity of natural values protected as a landscape park, but it hides cultural values and human history that created the image of the mountain as well.

Purpose of the research was to follow the abiotic characteristics of the cave for six months (October 2016 – March 2017). Points were in front of the cave (two points) and in the cave (two points). We were analyzing air temperature, humidity, light, ozone, as well as soils where we analyzed physical and chemical parameters. We also monitored water, where we followed temperature and conductivity, opaqueness, colour, pH, nitrogen compounds, phosphates, and oxygen levels.

Photo 2. Stream Šega in the past created cave Belojača
(Source: private photo, February 2017)

2. METHODS

2.1. *Field data collection*

Field work took place in front of the entrance, at the entrance and in the cave with the purpose to follow abiotic parameters and their winter changing. In front of the cave we monitored the stream Šega that flows through the cave. We chose four spots (marked as spots 1, 2, 3, 4). Field work was performed once a month (from the end of October 2016 to the end of March 2017). The first and last month we analyzed soil as well, where we also determined four sample places:

- sample place of climate before the cave 1– 100 m before the entrance,
- sample place of climate before the cave 2 – 5 m before the entrance,
- sample place of climate in the cave 3 – 5 m deep in the cave,
- sample place of climate in the cave 4 – 20 m deep in the cave.

Sample place of climate before the cave 1 is approximately 100 m before the cave entrance. Place is enough away from cave, so that cave climate cannot influence into it. Nearby is deciduous forest and 10 m lower the stream Šega flows.

Sample place of climate before the cave 2 is 5 m before the cave entrance. The place is very close to the entrance, so that we can say that the cave has the influence into it. Air temperature and humidity come close to the cave climate. Sample place is in the shelter of the cave rock on unevenly rocky terrain.

Sample place of climate in the cave 3 is 5 m deep in the cave. Spot is in the beginning of the rounded hall, which is why we still notice small influence of the outside climate. Influence is especially seen by the amount of light, since the only light that gets here is the one from the outside.

Sample place of climate in the cave 4 is 20 m deep in the cave. Sample place is without the influence of the outside climate.

Sample place of the stream Šega is next to the point where the stream comes out from the cave Belojača. The purpose of sampling here is to learn what the quality of water is as an important part of cave and its natural values.

Sample place for soil analysis is located on the slope in front of the entrance into the cave.

Measurements: we measured climate characteristics in front of and in the cave (temperature, air movement, air humidity, ozone in the air, amount of light); characteristics of waters in the stream Šega that flows through the cave (temperature, conductivity, pH, oxygen in the water, opaqueness, colour, smell, common water hardness, carbonate hardness, ammonium, nitrates, nitrites, sulphates, phosphates, iron and zinc). We also analyzed soils according to the ISO standards (physical and chemical), like the colour, moisture, texture, structure, consistency, pH, skeleton and carbonates as it is seen in chapter 3 Results.

3. RESULTS AND DISCUSSION

Results of the measurements we collected in charts and wrote down those that are important for the specific abiotic parameters of the cave (Chart 1).

In the October 2016 was warm like it should be in the autumn after shorter period of rain, so was the humidity outside the cave higher than inside the cave. Cave was quite cold and since the cooler air accepts less moisture, we felt big differrence between all four samples places.

Temperature falls from point 1 (climate in front of the cave) towards point 2, in front of the cave, to the points 3 and 4, which are already in the cave. Therefore it also stays direct connection between dropping of the temperature and the lightness, so we can conclude that there is positive correlation between the lowering of the temperature with the lightness (Graphs 1 and 2), as well the moisture is in decline from before cave and cave climate (Graph 3).

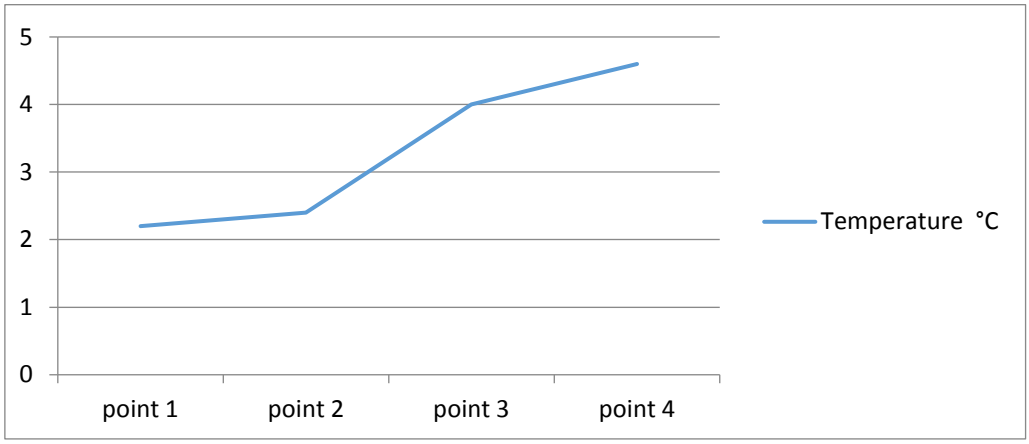
Graph 2 shows how the lightness diminishes from the outside towards the inner part of the cave.

From the measured data for cave climate we clearly see the correlation between the falling of the temperature, diminishing of light and growing of the humidity, which can confirm facts that cave climate has so called retinence, means that is cooler in the summer and less moisten than the outside climate.

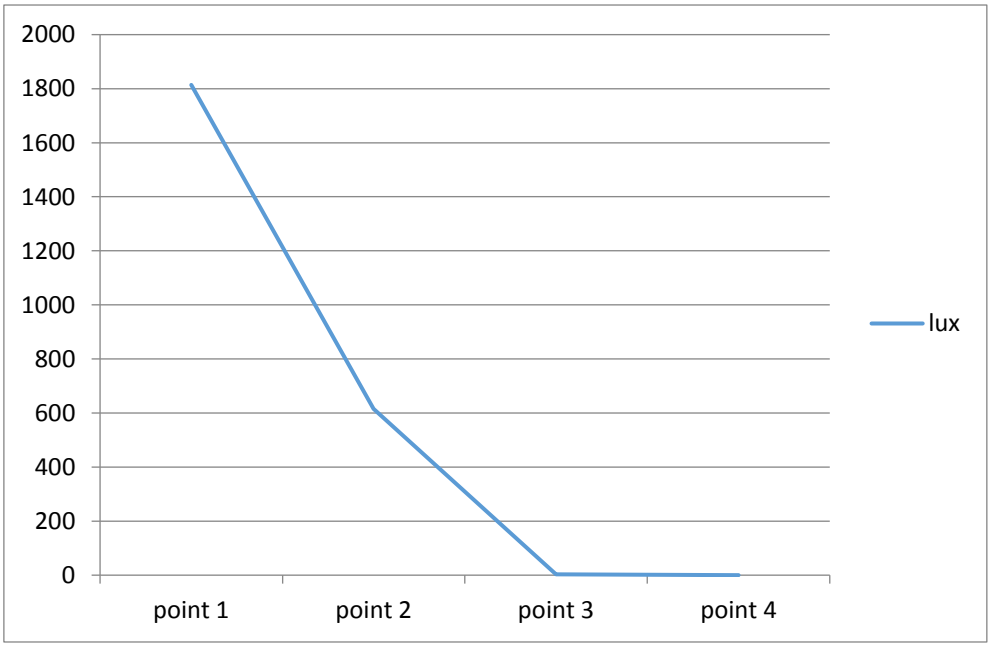
Chart 1

Before the cave and cave climate (October 2016)

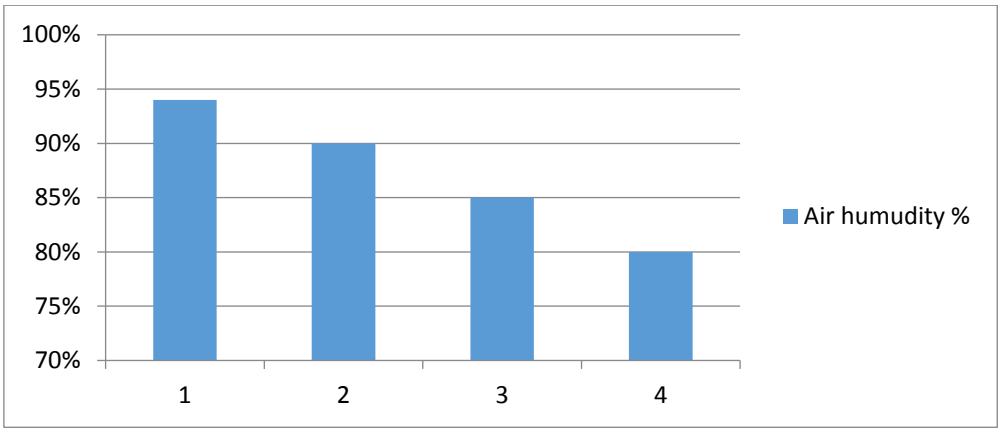
Climate parameters	Sample 1	Sample 2	Sample3	Sample 4
Temperature (°C)	13.9	13.2	12.8	11.7
Air movement (km/h)	0	0	0	0
Air humidity (%)	94	90	85	80
Amount of the ozone in the air	0	0	0	0
Amount of the light (lux)	1814	615	2,5	0



Graph 1. Falling of the temperature in front of the entrance (1), close to the entrance (2), entrance to the cave (3) and inside of the cave (4)



Graph 2. Diminishing of the light from the outside towards inside



Graph 3. In October 2016 the humidity of air was diminishing with the depth, since it was warmer outside (13.9 ° outside and inside 11.7°).

Water in the stream Šega that flows from the cave Belojača has lower temperature than the air, which is the consequence of the fact that water flows from the cave where the temperature is lower than outside. Colour of the water was yellow, since it rained a few days ago. Conductivity indicates clear, clean water with no nutrients added.

Soil by the stream is flooded, so the humidity was very high, dark coloured, texture sandy and structure also sandy with high amount of the sand in the soil (65%), which is typical for such soils. Some other parts in the soils are consequence of the rock base melting.

Chart 2

Characteristics of the stream Šega in October 2016

Physical and chemical parameters of the stream Šega	Point 1
Temperature (°C)	10.3 °C
Conductivity (µS/cm)	315 µS/cm
pH	8.4
Oxygen in the water (mg/l)	11.7 mg/l
Opaqueness	medium opaqueness
Colour	yellow
Smell of the water	no smell
Joint hardness	10 °d
Carbonate hardness	10 °d
Ammonium (NH_4)	0 mg/l
Nitrites (NO_2)	0 mg/l
Nitrates (NO_3)	10 mg/l
Sulphates (SO_4)	25 mg/l
Phosphates	0,07 mg/l
Iron (Fe)	0,15 mg/l
Zink (Zn)	0 mg/l

Chart 3

Characteristics of the soils near Belojača cave in October 2016

Soil analysis by the stream Šega	Point 1
Colour	10 YR 2/2 very dark brown
Moisture	Wet
Texture:	
Sand	sand 65 %
Silt	silt 25 %
Clay	clay 10 %
Structure	non structured, transferred
Consistency	sandy
pH of the soil	7,2
Skeleton	1 %
Percentage and size	size up to 3 mm
Percentage of the carbonates	5 %
Footnote	In the sample there were no visible roots and animal species

High pH of soil is the consequence of carbonate base, limestone end dolomite; this is also why the skeleton is very low. Soil has only 1% of it, since carbonate rocks does not rerun physically but melt chemically.

We repeated measurements in November 2016 and figure it out that the air temperature in front of the cave was 2.2 °C, points 2 and 3 closer to the cave had higher temperature. Outside the cave in point 1 has the temperature between October and November changed (fell) for more than 10 °C, while in the cave, the temperature fell only for 5 °C. This is important data and confirms the fact that the cave climate does not change rapidly.

Growing of the temperature from point 1 (outside the cave) and point 4 (cave climate) is obvious and shows how the cave stays warmer for longer period of time and that the air in front of the cave becomes quickly cooler as in the cave. Growing percentage of moisture shows that because of the warmer air (2.2 higher) also humidity in the cave was higher against outside where the air was cooler.

More moisture in the cave is also a consequence of the water in the cave. Light has fallen from the point 1 outside the cave to the cave and it was 0 (darkness) in the cave.

Temperature of the water in the stream Šega has fallen for approximately 3 °C and was still higher for 5 °C from the temperature of an outside air, which is the consequence of the fact that stream Šega flows from the karst cave, where the temperature changes less. Water was clearer, since the conductivity fell under 300 μS/cm. Chemical data did not change crucially (medium hard water, oxygen level 10 mg/l and no other additives).

At the end of the December 2016 the weather became very cool which was seen with the measurements as well. Temperature on point 1 was negative –5 °C, as well it was negative in the point 2, where it was –3 °C, in the cave, at the entrance was –1 °C, but it has risen on 2 °C inside the cave, which shows the meaning of the cave ecosystem with stabile temperatures. Difference between outside and inside moisture has increased, outside air was dry and moist inside the cave (relation 1 : 2.5). There is the correlation between the temperatures and moisture in December; therefore with the increase of the temperatures moisture rises as well, so there is positive correlation between the temperature and percentage of moist and vice versa cooler as it gets, less moisture is in the air.

January 2017 was the coolest in the six month time, since the temperatures were negative on three points, only in the cave the temperature was 0°C. That was the time of extremely cold winter, so it does not surprise that the temperatures stayed below zero during the day. At the same time, the humidity was also very low, only 20% in the first point and in the second 24% . The humidity in the cave was 68%.

There was more light in the area outside the cave, that is 2150 lux and even 1.2 lux in the cave. There are seen positive correlations between low temperature and higher moisture, which means that humidity completely diminishes with the negative temperatures. Temperatures in the cave Belojača did not exceed 15 °C in January 2017. Inside the cave Belojača the humidity was the highest all the time which is important for the cave ecosystem.

At the end of February 2017 came the warmth after long and sharp winter, which was seen at the movement of the temperatures as well as at the humidity (we still keep the positive correlation).

Characteristics of the stream Šega were all the time similar and the effect of the warmth was seen on a bit higher temperature of water. Water was medium hard all the time, with low conductivity and basic pH around 8.

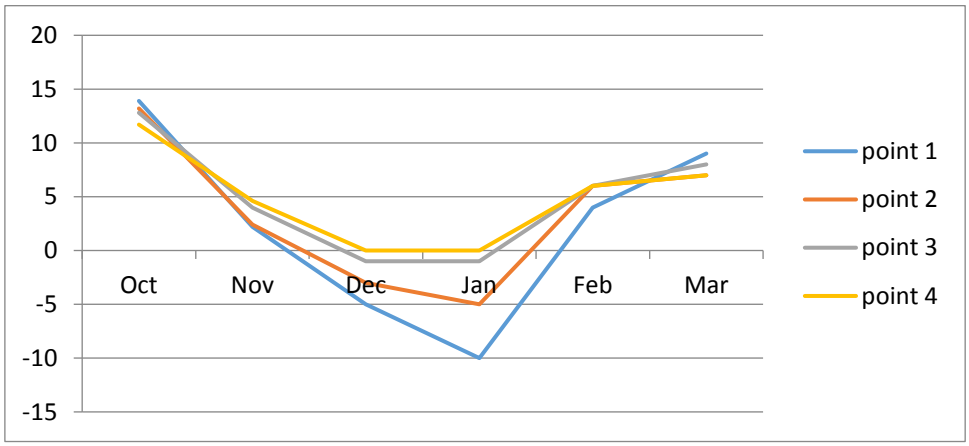
Movement of the temperatures and air humidity in March 2017 was similar, very active and not similar to the autumn, since the cave become very cold in the winter. Therefore the climate outside the cave was warmer than the cave one; it means the effect of collecting the warmth after winter months disappeared.

In point 3, that is right before the entrance into the cave in March was the moistest that is 96%, which can be explained by equal temperatures in the outside the cave system with the cave system, since point 3 lies exactly on the border between both.

Water in the creek Šega has heated for 2 degrees according to the temperature in February (to 9.1 °C), carbonate hardness of water stays around 15 °C.

Movement of the temperatures and percentage of the oxygen in the stream Šega show us the rule, that higher than the temperature is, less oxygen we find in the stream, so the cooler water has more oxygen than the warmer (great examples December and January).

Data from field work about the quality of climate outside the cave and in cave climate show about the diminishing of the light, so closer as we get darker is and vice versa (over 2000 lux, measured in the point 1 – outside cave climate, half less in point 2, while points 3 and 4 in cave tell us about cave ecosystem, 3 with a little bit of light and 4 without light except in January 1.2 lux).



Graph 4. Movement of the temperatures during the measurement period shows how the temperatures fall point 4 stands out, (purple line) with the lowest movement of the temperatures (cave climate)

Visible legality of the cave climate is constant temperature, while the outside cave climate has big movements.

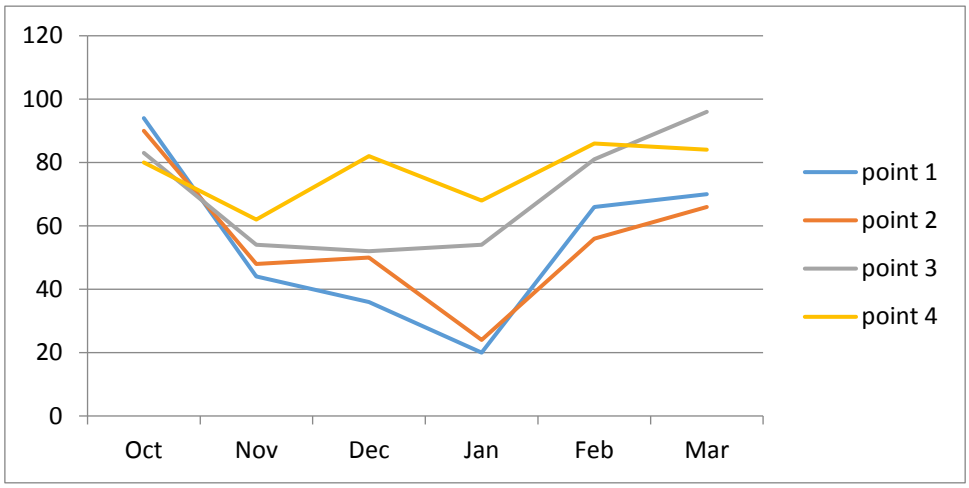
Movement of humidity (Graph 5) in all four sample points monthly shows that humidity in the cave stayed the same during the winter, between 60 and 90%, while in other points has fallen, even to 20%.

Comparison of the cave climate (point 4) shows evenly changing of the temperature and humidity monthly (Graph 6).

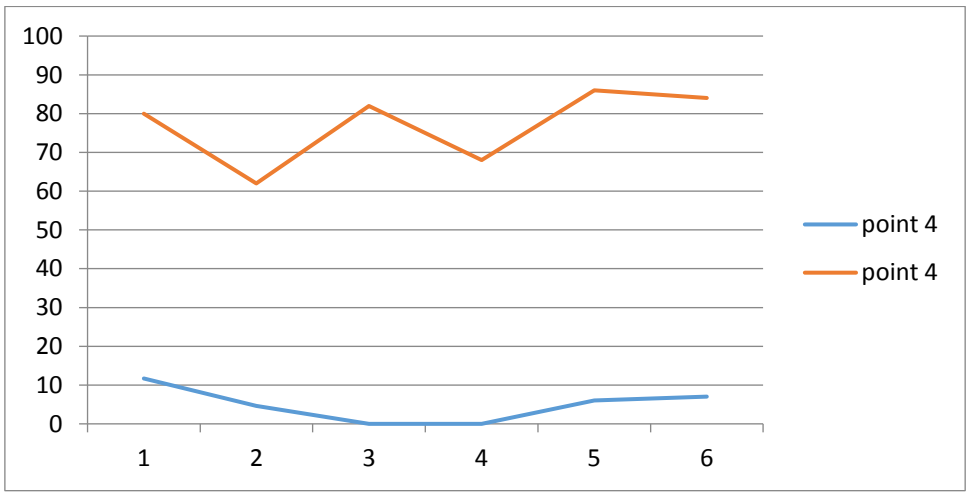
On the other hand the difference between movement of the temperatures and humidity differs quite a lot during the seasons. We get the biggest difference during the warmer months, while in cooler the difference stays smaller.

Point 1 (Graph 7) shows all the characteristics of outside the cave climate since it received the atmosphere influence of low temperatures but from February on warmer weather began.

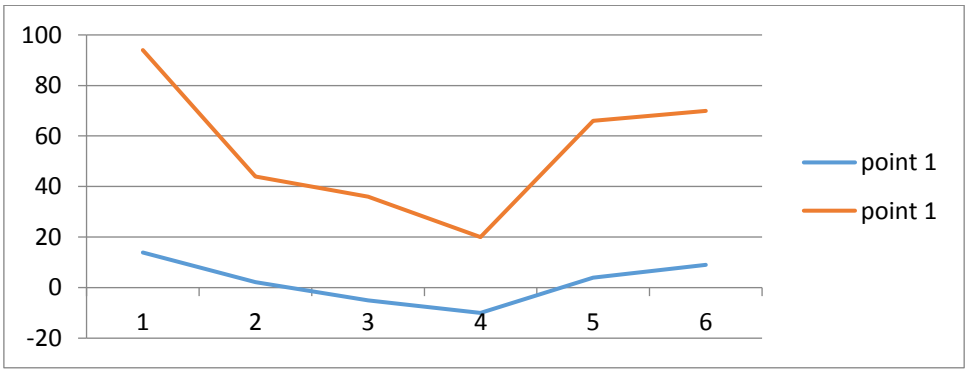
Green and pink lines (point 4 in the cave), graph 8 show smaller temperature changes and moisture than the red and blue lines (point 1 outside the cave).



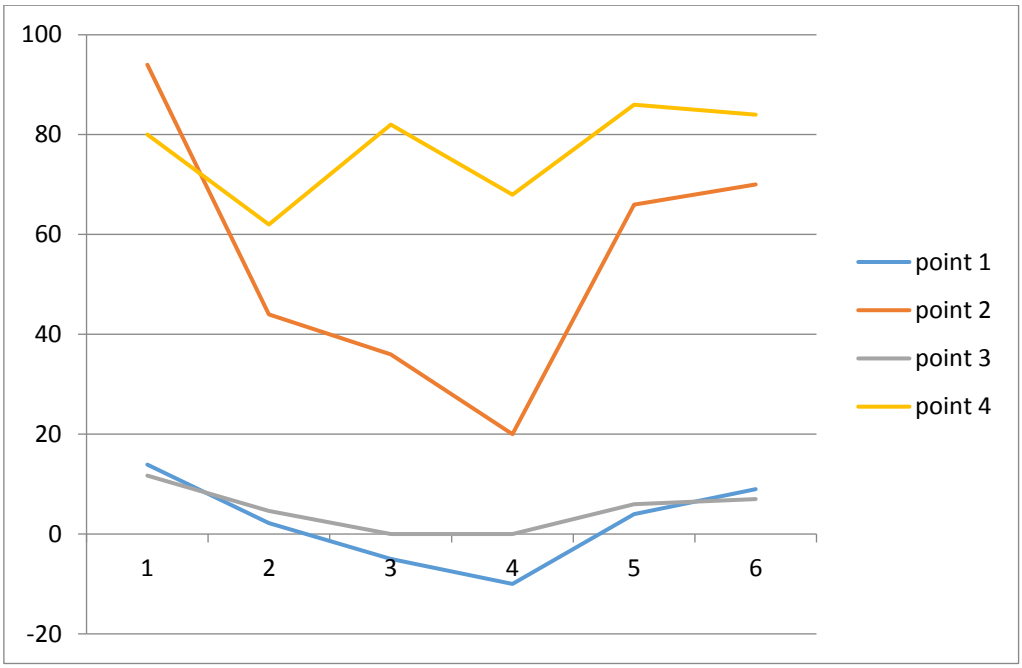
Graph 5, Comparison of the humidity movement



Graph 6. Cave climate of point 4



Graph 7. Comparison of the moisture (red line) and temperatures in point 1



Graph 8. Comparison of "in front of the cave" and "cave climate"

CONCLUSION

We can conclude that we proved big differences between cave and outside the cave climate; cave climate is more stable and has smaller movements as the outside cave climate, which shows the stability of this abiotic parameter. Data about humidity and temperatures have positive correlation, so that with the fall of the temperature we get lower humidity. If we measured deeper in the cave we would have received even higher temperature as well as humidity, which is important speciality of that abiotic factor.

Data measured about air (movement of air, lightness) appear on all spots in logical anticipated sequence, only when we increase distance from the outside surface we get changes in humidity and temperature, other changes does not change.

Soils around cave Belojača show typical characteristics for karst, since they have high percentage of carbonates, clay and are humid. Similar karst characteristics appear about the water of stream Šega that comes from Belojača. Characteristics of water show influence of the delayed movement of the temperature in the cave that can be seen in the stream temperature. Abiotic parameters of the cave Belojača are very connected in-between and correlations that appear show how the caves are important ecosystem in Pannonian basin area.

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Р е з и м е

МЕНУВАЊЕ НА АБИОТСКИТЕ ПАРАМЕТРИ НА КАРСНАТА ПЕШТЕРА БЕЛОЈАЧА ВО ПАНОНСКАТА ОБЛАСТ (СЛОВЕНИЈА)

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Клучни зборови: карсна пештера; абиотски параметри; микроклима; вода; почва

Познавањето на абиотските параметри на пештерата на работ од Паноскиот басен, каде што завршуваат изворните Караванки и започнуваат мермерните ридови е важно поради три ретки геолошки феномени. Ние ги проследивме карактеристиките на воздухот во четири различни точки (точка 1 – надвор од пештерата, точка 2 – 20 m пред влезот во пештерата, точка 3 – веднаш по влезот во пештерата и точка 4 – 20 m длабоко во пештерата). Покрај собраните податоци за воздухот (влажност, температура, озон, светлина), ги проследивме и карактеристиките на водата во потокот Шега, како и карактеристиките на почвата, кои ги анализиравме еднаш, бидејќи тие не се менуваат толку бргу. Важен исход од анализата е дека пештерата има значајно влијание врз микроклимата и пошироките екосистемски карактеристики на пределот.