THE SPRINGS FROM THE ”FĂGET” AREA OF CLUJ

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Abstract. – **The springs from the ”Făget” area of Cluj.** To the south of the city of Cluj, in the perimeter called “Făget”, there are numerous springs often frequented by locals. From a geological point of view, there is a great variety of rocks of different ages and characteristics. The waters cantoned in these geological structures appear on the surface along the valleys, on the slopes or even in the unevenness of the interfluves. Their existence was facilitated by vertical erosion processes and mass movements of the material. Through the inventory of the area, 28 sources were identified and located. They can be divided into several categories: with drain, wells, inactive, dried, captured. Spatial coordinates were determined for each source. Where possible, the flow rate, temperature and concentration of dissolved in water substances were measured. There is a large gap in flow variation, relatively constant temperatures and wide limits of TDS values. The expansion of the urban area involves potential risks of a quantitative and qualitative nature.

Key words: spring, geological formation, groundwater, linear erosion, mass movements, flow, temperature, TDS, risk.

1. INTRODUCTION

The hills in the south of Cluj represent one of the most loved and frequented leisure areas for the townspeople. On holidays, but not only, people do sports or go for a walk to admire the beauties of nature. On the occasion of going out, they drink the very tasty water that drips from the many springs of the area. This was the impetus for the inventory and study of these sources.

During November 2020, on the occasion of several field trips, 28 springs were identified, which are located in the perimeter of Mănăştur – Tăuţi – Sălicea – Casele Miceşti. For the most part, they are located in the river basin of the Gârbău brook, a tributary of the Someş Mic River. Some of them, in the south-eastern part of the area, line up along the streams that go to the Arieş River or on the slopes of the surrounding hills.

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2. GEOLOGICAL SUBSTRATE

The geological structure of the Făget Hill study area is exclusively made out of Paleogene and Neogene sediments (Fig. 1), from which the Late Eocene layer has formed over the Middle Miocene stratum. (Mészáros, Clichici, 1988; Cristea, Baciu, Gafta, 2002; Wanek, Poszet, 2010). Furthermore, these geological layers are covered by Quaternary deposits. The layer sequence represents a monoclinic structure in the East – Northeast direction, characterized by an 8–10º tilt. On top of these layers, Sarmatian sands can be found in near-horizontal position. This monotonic structure has been modified by displacements caused by faults and fractures (Krézsek, Filipescu, 2005). In the researched area, dip slip faults can be identified along the Gârbăului Valley and at the middle part of the area.

The Nadăș Valley Formation, which is the oldest lithostratigraphical unit from the Late Eocene (Priarbonian), can be found at the bottom of Gârbăului Valley's slopes. The formation is composed of tropical, fossil-bearing sediments (clay–rock flour–sand), which were deposited under terrestrial environments.

The Jebucu Formation lays above the before mentioned layer and they can be hardly separated from each other. The only difference between the two layers is the fact that the Jebucu Formation contains intercalations of oolithic limestone. (Mészáros, 1963, Wanek, Poszet 2010). These intercalations (about 3 levels), which can be seen on the surface due to slope inclination changes, represent indicators of gradual sea flooding.

The formation is made out of limestone which was deposited in a warm, normal salinity, nearshore, shallow water environment. It can be seen remarkably on both sides of the Pleșca and Gârbăului Valleys (due to sudden slope angle change), moreover, in the uppermost part of the Gârbăului Hill, it appears as a structural surface.

The uppermost level of the Priabonian is represented by the Brebi Marl Formation and contains epicontinental marl, marl-limestone formations. This is characterized by high miscofossil content, but it is poorer in fossils (Mészáros et al. 1982).

The Dej Tuff Formation represents a stratum from the Middle Miocen, which was deposited after the Badenian transgression, and can be found just in a few spots. In the southern part of the study area, the Feleacului Sandstone formation consists of a series of spherical sand – sandstone concretions, which has been deposited, with sediment hiatus, on the lithological layer sequence.

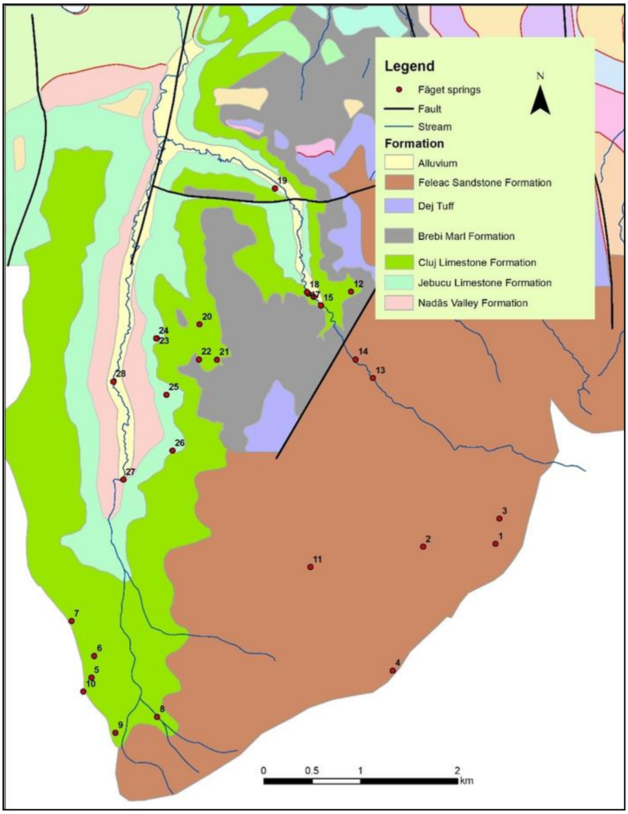

Fig. 1. Geological formations and the springs

River sediments, debris cones and debris slide were formed during the Quaternary. Most of the debris slide were created by the Pleistocene soligelifluction mass movements, however, formations caused by Holocene and present mass movements can also be observed (Tulogdi, 1930; Morariu, Mac, 1967; Kerekes et al. 2020).

Most of the aquifers from where the waters reach the surface are of the phreatic type, settled predominantly in sands, gravels and boulders (Cristea, Baciu, Gafta, 2002). The distribution of springs depends on the presence of geological layers that are able to store infiltrated water. In this sense, it is observed that most of them are located in the Cluj Limestone Formation area, which constitute vast areas in the Gârbău river basin (13 springs). A massive group is located in the Feleac Sandstone Formation area, which dominates the southeastern part (7 springs). The springs located near the riverbeds belong to the Quaternary alluvial formations.

3. GEOMORFOLOGICAL CHARACTERISTICS

The geomorphological characteristics of the study area are decisively determined by geological structure (lithology), climatic conditions of the Quaternary and of the following period, vegetation cover degree and the influences of the increasing anthropogenic activities.

From a lithological point of view, is noteworthy that the sediments with high clay mineral content (Nadăș Valley Clay Formation, Jebucu Formation, Brebi Marl Formation) are alternating with more compacted and cemented layers (limestone strips of the Jebucu Formation, Cluj Limestone Formation, Dej Tuff Formation). Mass movement processes form more favourably on the deeper slopes of the before mentioned clayey sediments. Furthermore, the sediments with stronger cementation characteristics, under specific structural and erosional conditions, can lead to the formations of cuestas (for example, in the case of the slopes of the Pleșca and Gârbău Valleys).

Is noteworthy that the uppermost limestone layer of the Jebucu Formation and the thick, compact limestone content of the Cluj Limestone Formation are predisposed to karstification processes. In the study area, along the Pleșca and Gârbău brooks, gorge-like, short valleys appear, also, on the structural surface of the Gârbăului Hill, sinkholes become visible. A series of dolinas can be seen on the southeaster slopes and karst springs also appear (Fig.1).

These geological and geomorphological factors determined the development of stepped landforms. They extend both on the slopes and in some areas of the interfluves. Swampy areas appear on the terraces of the steps, and at their base numerous springs. Nyárády describes them as being more in the low areas, called "Muddy Făget", and rarer in the "High Făget" area (Nyárády, 1941).

The climatic conditions of the Quaternary and of the following period had significantly changed the formation of the landscapes. The river erosion, which was greatly accelerated by the base-level decrease from the Quaternary, is responsible for the formation of deep valleys and terraces. Due to the accelerated deepening of the valleys, springs located near the reverbed appear. The most numerous along the main brooks Pleşca (7 springs) and Gârbău (3 springs). At the same time, this process was responsible for the formation of the steep slopes and slope retreat phenomena. The downcutting process of the Someșul Mic River's tributaries dissected the peneplain (dated from the end of the Pliocene), which remains (Feneș erosion surface) are visible on the plateaus. The Quaternary climatic conditions induced many mass movement processes.

Slope processes present an increased importance, moreover, two types of them can be associated with periglacial conditions. The first type represents derasion caused by freeze-thaw processes, which are influenced by the fact that the geological layers have almost the same inclination as the slope. Downstream springs with low flows have emerged in these areas (Pandi, 2009). Due to the alternation of impermeable and permeable layers, these springs drain more during rainy periods and are supply from surface deposits that store infiltrated water. Moreover, this type of process can be generally found on slopes covered by loose lithological structures.

The second type consists in large mass movements, with a depth of a gliding plane, which were formed by the thawing process of the freeze sediments form the end of the Pleistocene. (Morariu et al., 1964). The before mentioned formations can be seen on the upper third part of the slopes form the southern part of the study area (the lithological structures consist mostly of the Feleacului Sandstone Formation). Linear geomorphological processes and mass movements have disturbed some aquifers, as a result there are springs on the slopes: EKE, Major, Pasztor, Lepcsos, Binder, Dagonyas, etc. In the areas with wide interfluves, in the more accentuated unevenness of the relief, several springs appear: Gemes, Traian, Bivajos.

In other parts of the study area, the intercalated and more resistant strata served as an obstacle in front of the formation of large-scale mass movements. However, in some parts of the area (where vertical river erosion is dominant) the resistant layer sequence is dissected by faults, thus contributing to the formation of large mass movements and to deformations along the fault planes. Such longitudinal landslides have kilometric lengths in the central part of the area. The presented periglacial formations predominantly date back to the Würm-era, moreover, earlier traces had been covered up.

At the present, the anthropogenic influences are strongly and directly shaping the terrain surface (terraces, constructions, embankments, road construction, stream sewerage) moreover, the man-influenced natural processes are leading to land surface deformations. The need for water supply led to the complete or partial capture of some springs (Lepcsos and Bartha).

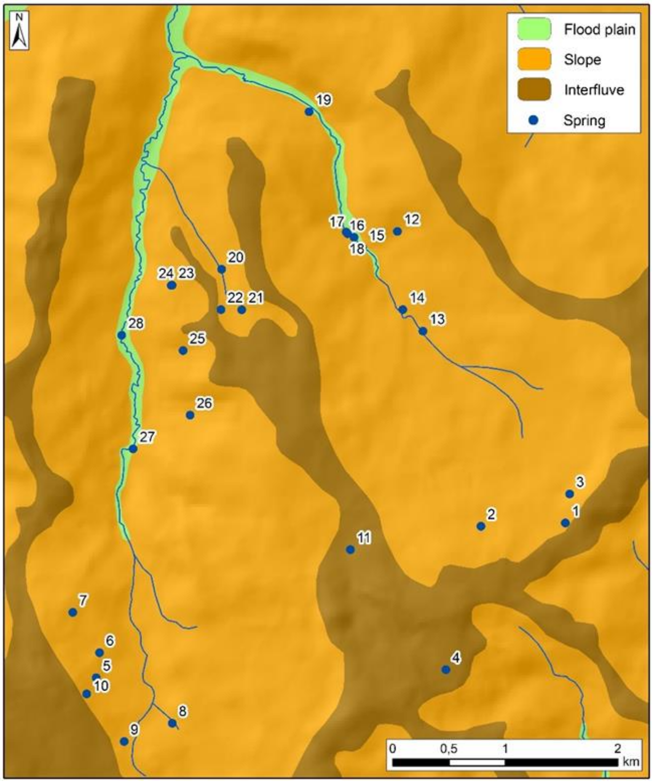

Fig. 2. Geomorfological units and the springs

4. EXPEDITIONARY MEASUREMENTS

The measurements took into account, first of all, the location of each source. In this sense, the coordinates and altitudes were established using GPS technology. A GIS methodology was used to make the maps. It consisted of downloading GPS points, related to the sources, and converting them to point-type shapefiles. Subsequently, the points and their number were displayed on the remote sensing image.

Determination of water flow was not possible at all sources. Some are in the form of small water holes (5 springs), without drainage at the time of measurement. Others have the drain arranged through tubes, there are small puddles, but no water has passed through the tube (5 springs). Two springs are captured to supply water to nearby houses and have no leaks. Another category was completely dried, having no water at all (3 springs). Under these conditions, the water flow could be measured at 13 sources. Of course, the water flow of some springs depends on the weather conditions in which they are inventoried. It can be seen that many of them have water drainage only after rainy periods. Water temperature measurement and TDS determination were not possible at springs that were fully captured or dried, a total of five springs.

Table nr.1. Measured parameters

	Name	North	East	H (m)	Q (l/s)	T (ºC)	TDS (mg/l)
1	Gemes	46 42 17.515	23 34 46.427	731	fountain	14	217
2	Majlat	46 42 16.108	23 34 11.213	715	0.133	9	209
3	Rajka	46 42 25.886	23 34 48.072	684	0.022	9	195
4	Traian	46 41 34.596	23 33 57.600	788	fountain	9	244
5	EKE	46 41 30.438	23 31 31.497	617	0.142	10	226
6	Major	46 41 37.664	23 31 32.715	579	0.086	9	226
7	Pasztor	46 41 49.146	23 31 21.233	599	fountain	10	197
8	Hideg	46 41 17.746	23 32 3.701	606	not flow	10	289
9	Ko alja	46 41 12.207	23 31 43.680	637	0.250	9	246
10	Lepcsos	46 41 25.729	23 31 27.673	666	captured	-	-
11	Bivajos	46 42 8.681	23 33 16.741	656	fountain	8	252
12	Rejtett	46 43 40.652	23 33 33.975	475	not flow	10	247
13	Istvan	46 43 12.029	23 33 45.429	502	0.008	7	240
14	Gombko	46 43 18.129	23 33 36.872	483	not flow	6	298
15	Szakadek	46 43 35.889	23 33 19.474	446	not flow	8	326
16	Szent Janos	46 43 38.711	23 33 15.901	442	0.200	8	296
17	Gyurus	46 43 39.717	23 33 13.233	432	fountain	8	307
18	Hovirag	46 43 40.189	23 33 12.588	462	dry	-	-
19	Erzsebet	46 44 14.642	23 32 56.137	404	not flow	8	278
20	Ordog	46 43 28.827	23 32 20.743	472	0.020	9	262
21	Cerna	46 43 17.201	23 32 29.532	507	0.015	9	283
22	Macko	46 43 17.172	23 32 20.787	529	0.004	10	289
23	Binder	46 43 23.927	23 32 0.137	461	dry	-	-
24	88	46 43 23.908	23 31 59.832	475	dry	-	-
25	Bartha	46 43 5.168	23 32 5.235	502	captured	-	-
26	Dagonyas	46 42 46.589	23 32 8.706	473	0.048	9	296
27	Patak	46 42 36.584	23 31 45.144	447	0.034	9	329
28	Rozsdas	46 43 9.238	23 31 39.457	412	0.056	9	364

The identification of the springs was made under the guidance of Mr. Kiss János, a prominent member of the Transylvanian Carpathian Society. Several springs have been found and named by this ardent guide of the Society, on the occasion of the numerous excursions organized in previous years.

5. DATA INTERPRETATION

The altitudes at which the springs are located vary between 788 - 404 m. From Fig.3 it is observed that three springs are at altitudes above 700 m, and 13 are below 500 m. Between these extremes, six springs are between 600-700 m, respectively between 500-600 m. The highest altitudes appear at springs that are located near the streams that flow towards Arieș River. At a maximum altitude of 788 m there is the Trajan spring. Then follows the group from the upper basin of the Gârbău brook. The rest is located in the lower basin of Gârbău brook, with a minimum altitude of 404 m for the Elisabeta spring. This distribution reflects the morphological characteristics of the valleys in the hilly area that stretches in the south of Cluj. The average altitude is 543 m.

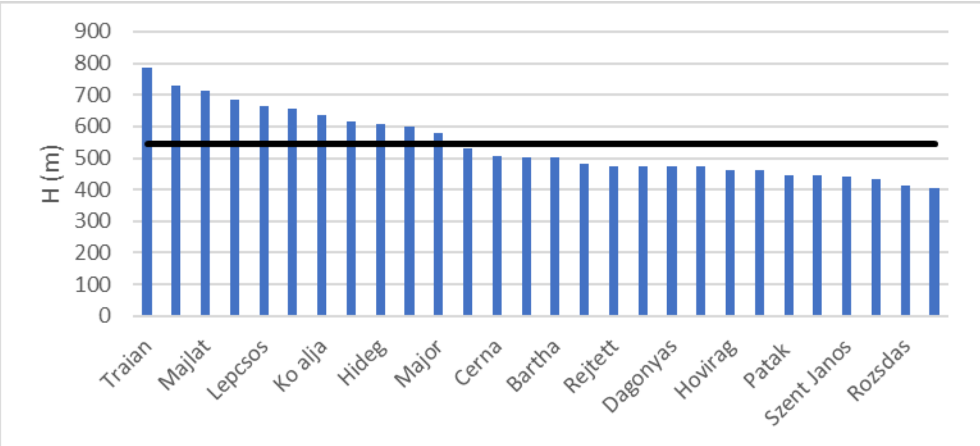

Fig. 3. The altitude of the springs

As shown above, the water discharges could be measured at 13 sources (Fig.4). Most are located in the basin of the Gârbău brook: eight springs at the bottom and three at the top. Also, two springs from the south-eastern area of the studied area presented water drainage. The maximum flow was measured at the Koalja spring (0.250 l/s, Fig.7.), and the lowest at Macko (0.004 l/s). Most springs have water flows below 0.100 l/s. The average flow at the measured sources is 0.078 l/s. Sf. Ion, the favourite source of the people of Cluj, where many bring drinking water, has a significant flow of 0.200 l/s.

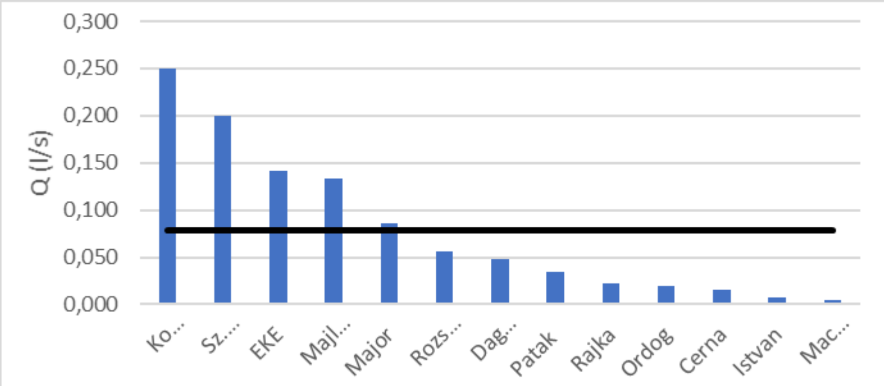

Fig. 4. Discharge variation

The temperature of the springs varies slightly, between 6 - 10°C (Fig.5). This indicates that the water comes from approximately the same depths, even if the bedrock is different. Six springs have the maximum temperature, but their spatial distribution does not present a regularity. The coldest springs (Gombko - 6°C and Istvan - 7°C) are close in the Pleşca river basin, a tributary of the Gârbău brook. Probably their water comes from the same geological deposits. The most common temperature is 9°C, which is found at ten springs. It also determines the average temperature, which is very close to this value (8.8°C).

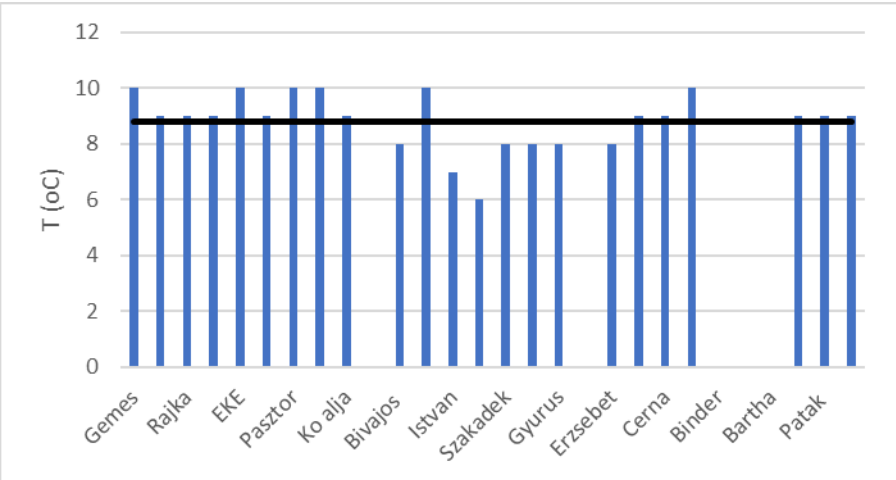

Fig. 5. The water temperature

The concentration of substances dissolved in water varies in relatively wide limits: 195 mg/l at Rajka spring and 364 mg/l at Rozsdas. The highest values are found at the springs in the Pleşca river basin, but the maximum (364 mg/l) was measured at the Rozsdas spring, located in the middle Gârbău basin. The minimum values (below 250 mg/l) are at the springs in the upper Gârbău basin and at those near the streams that flow towards Arieș River. The average TDS is 266 mg/l (Fig.6).

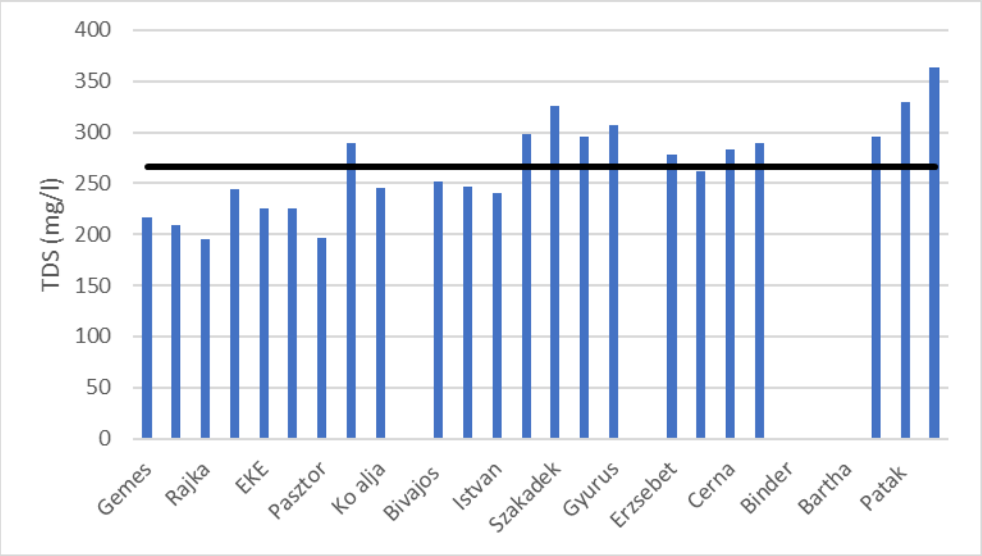

Fig. 6. Total dissolved solid variation

Fig. 7. Kőalja and Lépcsős springs

6. RISK

Does the existence and functioning of springs, as a natural phenomenon, involve a risk? Obviously, the answer is no. The appearance of groundwater on the land surface, in the form of springs, contributes to the discharge of water resources. This leads to the attenuation of internal stresses between the layers and reduces the onset of slope processes, especially landslides.

But increasing human presence and activity in the area certainly involves a potential risk. It can manifest itself in two ways: quantitative and qualitative. Quantitative aspects can already be seen at the Lépcsős (Fig.7.) and Bartha springs, which have been captured. In the future, due to the expansion of the built-up area, others will be captured, which will have negative effects on tourism. Regarding the qualitative side of spring water, the human presence is a potential polluter of surface and groundwater (Vigh, Pandi, 2013). These aspects must also be assessed in future expeditionary measurements.

CONCLUSIONS

In the "Făget" area, located south of the city of Cluj, there is a relatively large area rich in groundwater. Various geological structures, with different degrees of porosity, allow the storage of significant amounts of water. The penetration of water to the surface, in the form of springs, is facilitated by various linear hydro-geomorphological processes and mass movements. Expeditionary measurements have identified 28 springs located in different geological structures and landforms. Of these, 13 are active, some are dried, and two have been captured for water supply. The flow variation gap is large and depends on the climatic period of the investigation. The water temperature is relatively constant. The concentration of dissolved substances increases from single to double. The expansion of the urban area increases the human influence on these water units, which implies an increase in the potential risk in the area.

REFERENCES

1. Cristea, V,. Baciu, C., Gafta, D. (2002), *Municipiul Cluj-Napoca şi zona periurbană. Studii ambientale*. Ed. Accent. 25–36. Cluj-Napoca.
2. Cristea, V., Baciu, C., Gafta, D. (2002), *Municipiul Cluj-Napoca şi zona periurbană. Studii ambientale*. Ed. Accent. Cluj-Napoca.
3. Kerekes, Anna-Hajnalka, Poszet, Sz., Baciu, C. (2020), *Investigating land surface deformation using InSAR and GIS techniques in Cluj- Napoca city's most affected sector by urban sprawl (Romania)*, Revista de geomorfologie **22**: 43–59, DOI:10.21094/rg.2020.097

4. Krézsek, Cs., Filipescu, S. (2005), *Middle to late Miocene sequence stratigraphy of the Transylvanian Basin (Romania),* Elsevier, Tectonophysics 410, p. 437-463
5. Mészáros, N., (1963) *Paleogeografia depozitelor marine eocen-superioare de la vest şi sud-vest de Cluj,* Asoc. Geol. Carpato-Balcanică, Congr. V. Bucureşti 4–19 sept. 1961. III/1. Com. şt., Secţ. II. Stratigr. 307–312.
6. Mészáros, N., Clichici, O. (1988), *La géologie du municipe Cluj-Napoca,* Studia Univ. Babeş–Bolyai, geol.–geogr. XXXIII/1. 51–56.
7. Mészáros, N., Ianoliu, C., Bucur, I., Nicolescu, Şt. (1982), *Problema limitei eocen–oligocen în Valea Popii–Pădurea Mănăştur (sudul oraşului Cluj-Napoca,* Studia Univ. Babeş–Bolyai, geol.–geogr. XXVII/1. 13–18.
8. Morariu, T., Diaconeasa, B., Gârbacea, V. (1964), *Age of Land-Sliding in the Transylvanian Tabeland.* Rev. roum. géol. géophys. géogr., Géogr. 8. 149–157.
9. Morariu, T., Mac, I. (1967), *Regionarea geomorfologică a teritoriului oraşului Cluj şi împejurimilor,* Studia Univ. Babeş–Bolyai, geol.–geogr. XII/1. 75–88.
10. Nyárády, Gy. (1941), *Kolozsvár környékének mocsár világa,* Erdélyi Múzeum, 12, 1/2, Kolozsvár
11. Pandi, G. (2009), *Folyékony halmazállapotú kontinentális vizek,* Casa Cărții de Știință, Cluj
12. Tulogdy, J. (1930), *Kolozsvár környékének geomorfológiai kialakulása,* Erdélyi Muzeum. XXXV. Új folyam I/10–12. EME Term.tud. Szakoszt. közl. 35–52.
13. Vigh, M., Pandi, G. (2013), *Quality parameters for Somesul Mic river tributaries in Cluj Napoca,* Present Environment and Sustainable Development, Ed.Univ.Al.I.Cuza, Iași
14. Vlaicu-Tătărîm, N. (1963), *Stratigrafia eocenului din regiunea de la Sud-Vest de Cluj,* Ed. Acad. R.P.R. 204. Bucureşti.
15. Wanek, F., Poszet, Sz. (2010), *A Kis-Szamos jobb oldali lejtőinek földtani felépítéséből és morfológiájából adódó lejtőveszélyeztetettség Kolozsvár területén (a Bocsor-patak és a Papok-völgye között),* VI. Kárpát-medencei Környezettudományi Konferencia, Nyíregyháza, 355–360