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CHARACTERIZATION AND CHANGES IN THE STATE OF THE LAKES IN THE FIELD OF AGGTELEK AND SLOVAK KARST

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Summary – Karstic lakes belong to the natural values of karst. Some of these are very significant land elements, important as habitat as well as aesthetic attraction. Currently most of the lakes are strongly eutrophicated. That is mainly the result of traditional karstic land use shifting to intensive farm production and also increased sewage inflow. We monitored the quality of four lakes on the Aggtelek and Slovak karst: the Papgödör-lake (Farárova jama), the Vörös-lake, the Aggteleki-lake and the Kender-lake. We measured some chemical and physical parameters to check the state of these lakes. In the analysis we determined the changes in the parameters and according to the operative Hungarian standard we carried out a complex water quality assessment for the year 2008.

Key words: karst, water quality, monitoring

1. INTRODUCTION

Karstic lakes are important land elements. Their appearance and extinction often occurs at the same places according to the local specific and global conditions. The anthropogenic influence made their natural processes much faster, therefore they disappear and their protected species become locally extinct. Moreover they accumulate the pollutants and transfer them very fast to the water under the surface and to the caves, thus posing a threat for the latter.

According to the WWF project 'Protection of small water bodies' (2001) the ecological significance of smaller water bodies is big. In many of them a rich flora and fauna has evolved, for which they secure habitat and reproducing place. In short they function like a small reservoir. Actually a big amount of the lakes is in the last trophic stadium and the problem is that nowadays there are just a few lakes arising which could compensate the loss.

As karsts are especially sensitive to environmental impact, water quality control and monitoring are very important.

Our aim was to follow the water quality changes in four karst lakes in the Aggteleki and Slovak karst. They are situated in a different environment and are also differently influenced by man, so monitoring the water and sediment quality also provides information about human activity.

2. STUDY AREA AND METHODS

2.1. The study area

The study area is situated in NE-Hungary and SE-Slovakia. In Hungary it is named Aggtelek karst and in Slovakia Slovak karst but it is a geologically and geographically uniform karst plateau (Fig. 1).

Fig. 1 Location of study area

In the past the formation and development of these lakes were natural. There were also some other lakes, which disappeared with time.

Since the early 1980's researchers detected a very quick filling up of the lakes (Tereková 1984, Ščuka 1985, Háberová-Karasová 1991, Hudec 1992, Kaliser 1995, Bobro 1996, Cílek 1996, Orvan 1996, Bárány-Kevei 1999, Barančok 2001, Rozložník 2005) and they mostly assigned the cause of this phenomena to human activity and this included all the factors which may cause eutrophication.

The state of these lakes has changed remarkably over time. In this study we only address in detail the period since the mid-eighties, when the influence of intensified agriculture could be seen. That was the case of Gyökérréti-lake, near Szilice village, which used to be the biggest lake on the karst plateau, but afterwards it started to dry out and nothing could stop the process. The same destiny awaited the Aggteleki-lake, where sewage from the surrounding houses also had to be considered.

The Aggteleki-lake is situated in the NE part of Aggtelek village, and probably this lake is the most affected by man. Its area is one-fourth of the original size and it was reduced only in the last 20-25 years (Kunský 1940): 1.13 ha, today it is round 0.3 ha). According to Barančok (2001) the lake could preserve the extension of its water surface during a relatively long period. A road runs near the southern shore of the lake, while on the western and northern sides there are houses with gardens. The east side is closed by the Tó-mountain karrenfield. Its water supply comes from the precipitation directly or indirectly as inflow from the road, from the Tó-mountain and from the village.

Kender-lake is situated SE from Aggtelek village. Its surroundings are probably the most natural, there is a little wood, a bit further away a pasture and it is surrounded by fields situated at the lower elevations. The place of the Kender-lake was used for about 1000 years by iron furnaces (Bódisné et al. 2001). This activity required water and probably that is the reason why there was a fortification built in this place which could collect water from the precipitation. In the 1960's the water of the Kender-lake was used for hemp-soaking and nowadays for watering cattle. Water supply comes only from the precipitation.

The Vörös-lake (~0,7 ha, Kunský 1940) is SW from village Jósvafő in a doline of which the surface was covered with red clay. In the case of Vörös-lake the main problem was also its water supply, coming only from precipitation. The road in its vicinity led a big amount from the precipitation away and the water levels decreased. According to Huber (2006) many protected species (e.g. *Coenagrion scitulum* and *Coenagrion vernale*) became extinct during that time. In 2001 a dredge was carried out in the Vörös-lake. The state of this lake has been stabilized, since the National Park built a water-leading system from the road (with an oil-filter included). After that the water levels started to increase and now it is usually around 1,5-2 m.

The biggest of the examined lakes nowadays is the Papverme-lake (Papgödör-lake, Farárová jama), situated in Slovakia SE from Szilice village at a lower elevation. Its area is around 1 ha. On the northern side of the lake there is a road. Immediately NW of the lake there is an agricultural settlement. On the western side there are fields and the village, on the eastern side fields and in the south a forest. Line-fishing is intensive and as a result the amount of waste on the coast is notable. According to Hudec in the year 1992 the lake was strongly eutrophicated.

2.2. Methods

We've carried out monthly sampling since April 2008. Sampling points were fixed according to the points of the compass in the vicinity of the coast – in 2 or 4 directions, depending on the size of the lake – and at the inflows if there was any. According to this we assigned 6 sampling points in the Papverme-lake and 2-2 points on the 3 other lakes. In every case average surface samples were taken.

2.2.1. The examination type and the water quality classification

The evaluation of the water quality was carried out according to the operative Hungarian standard MSZ 12749:1993, which distinguishes 5 water quality categories: excellent (I.), good (II.), tolerable (III.), contaminated (IV.) and highly contaminated (V.).

Water quality assessment was carried out based on 3 parameter groups:

(i) the indices of oxygen establishment (dissolved oxygen, oxygen saturation, chemical oxygen demand)

(ii) the indices of phosphate-nitrate establishment (nitrate, ortophosphate, ammonium)

(iii) other indices (pH, conductivity, iron and manganese content)

2.2.2. Tools and methods of the water quality measuring. Statistics.

In the case of the in situ measurements pH and the conductivity were measured with WTW pH/Cond 340i. The dissolved oxygen, the oxygen saturation and the water temperature were measured with Hach Lange termoluminescent dissolved oxygen-meter. The transparency was measured with a Secchi disk.

For the laboratory measurements a Fia Star 5000 set was used for the nitrate, ortophosphate, and ammonium. The chemical oxygen demand was measured on the basis of the Hungarian standard MSZ 448-20. Iron and manganese measurments were carried out with an atomabsorbent photometer.

Data processing and visualization was done with SPSS 11.0 and Excel 2007 software.

3. RESULTS AND DISCUSSION

3.1. The Papverme-lake

On the basis of the summarized water quality score of the Papverme-lake (Fig. 2) – not taking into account the 6th sampling point (the sewage inflow) – we can state that the water quality in the year 2008 varies mainly between the 3rd and 4th water quality category. The parameters most affecting this 'tolerable' and 'contaminated' quality are oxygen saturation, chemical oxygen demand, ammonium and pH.

In the case of oxygen saturation supersaturation develops already in April, and then decreases till June while finally a maximum arises in July. In the rest of the year the values are nearly excellent and in March 2009 the water was even undersaturated (Fig. 3).

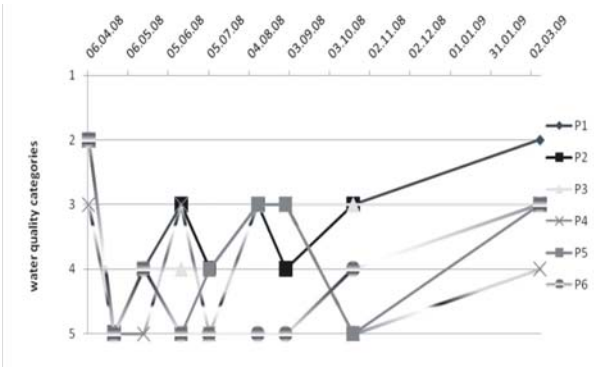

Fig. 2 Summarized water quality of the Papverme-lake

The chemical oxygen demand is in the tolerable category during the whole year except a few cases in June, July and August when it's worse.

The pH is predominantly alkaline except for the 6th sampling point, mainly in April, May and end of August, but there are also outliers like the 3rd sampling point in July (Fig. 4). It is very likely due to assimilation alkalization. The pH values in 2008 are higher than those measured in July and August 1992 by Hudec.

The high pH values together with higher ammonium and temperature values show that the ratio of free and poisonous ammonia is higher (Fig. 5).

The ammonium values are in June and October in the tolerable and in July in the contaminated category.

The inflow at the 6th point is always of worse quality for all parameters, except the pH that is in this case of better quality than the whole water body.

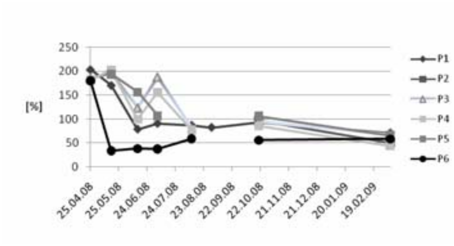

Fig. 3 Oxygen saturation – Papverme-lake

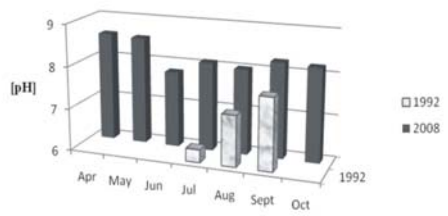

Fig. 4 pH values from 1992 and 2008 – Papverme-lake

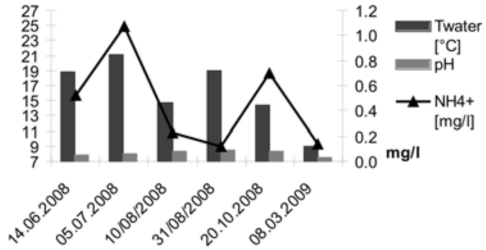

Fig. 5 NH_4^+ – in the function of temperature and pH – Papverme-lake

3.2. The Vörös-lake

Basically it can be stated that the Vörös-lake shows the best water quality. Its values on the summarized water quality table (Fig. 6) – which, according to the standard mean bad-quality contaminated water – can be considered the result of the amount of the iron, which has been measured since June 2008. However in this case the geological milieu of the lake must be taken into account; red soils surround it so presumably its fauna has adapted to this environment therefore the high iron content does not mean contamination in this case.

The COD and the oxygen saturation move in the tolerable category almost the whole year.

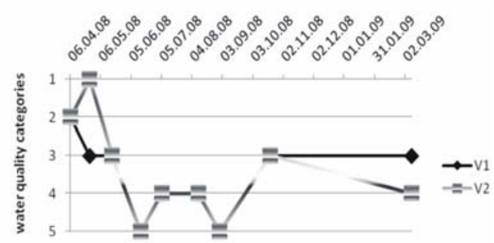

Fig. 6 Summarized water quality of the Vörös-lake

3.3. The Kender-lake

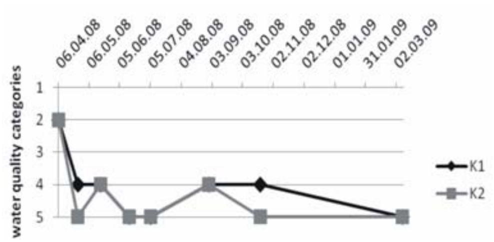

Fig. 7 Summarized water quality of the Kender-lake

The water quality of the Kender-lake is steadily in the 4th and 5th category throughout the year. (Fig. 7). One responsible is the COD, fluctuating between the contaminated and strongly contaminated categories. Iron values are also higher here but the surrounding soils are also rich in iron. In the second sampling place (K2) we measured also higher manganese values.

3.4. The Aggteleki-lake

The water quality of the Aggteleki-lake is visibly the worst according to most measured parameters (Fig. 8).

The oxygen saturation and the COD are in the contaminated and strongly contaminated category in every month and so is the ortophosphate except in April and the beginning of August. The pH is even more alkaline than in the case of Papverme-lake (7.8-10.8). Here the ratio of NH_3 is higher than in the Papverme-lake (Fig. 9).

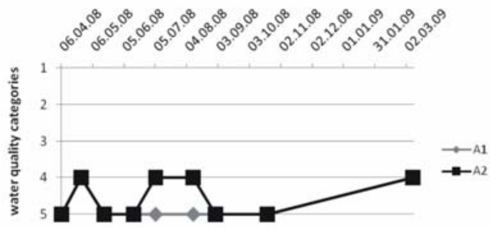

Fig. 8 Summarized water quality of the Aggteleki-lake

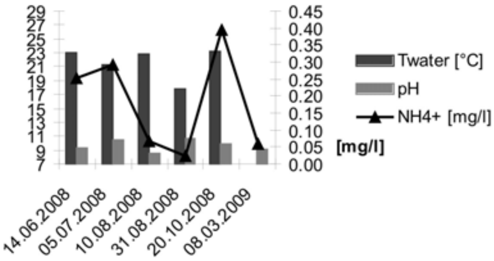

Fig. 9 NH_4^+ – in the function of temperature and pH – Aggteleki-lake

The conductivity moved between the 3rd and 4th category, except in July. The values of the iron content are varied: in July and at the end of August they are in the 1st category but in June and at the beginning of August they are just tolerable. The manganese concentration was in the contaminated category from June till August and then it improved till excellent.

3.5. Comparing the situation of the lakes

On Fig. 10 and 11 the statistical parameters of the dissolved oxygen and oxygen saturation are shown. It is visible that in the case of the Papverme- and especially the Aggteleki-lake the oxygen balance is very unstable – caused by the algae mass proliferating in these lakes. The water quality of the other two lakes is good according to these parameters.

The Papverme and the Aggteleki-lake behave similarly also in the case of the pH (Fig. 12), in both lakes is it very alkaline, while in the other two lakes it is mostly around normal.

In the case of the COD it is visible that the group formulating cause is different; here mainly the size and the water supply of the lakes play tha main role. This means that the two smaller lakes (Kender and Aggteleki) can harder process a bigger amount of organic matter (Fig. 13.).

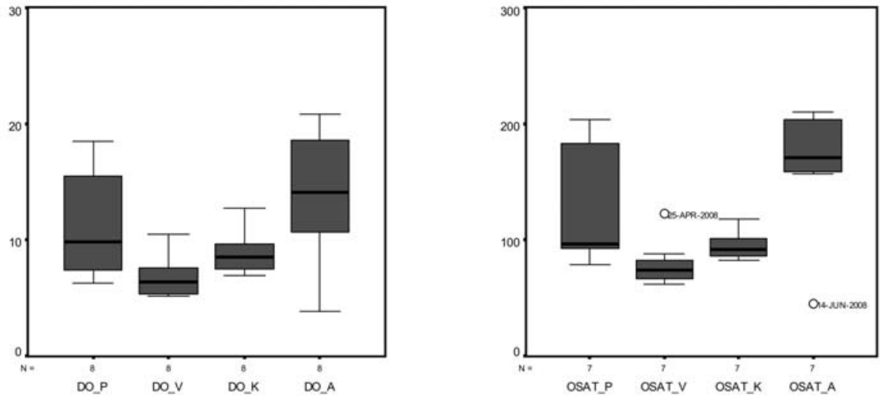

Fig. 10-11 Dissolved oxygen (DO) and oxygen saturation in the lakes

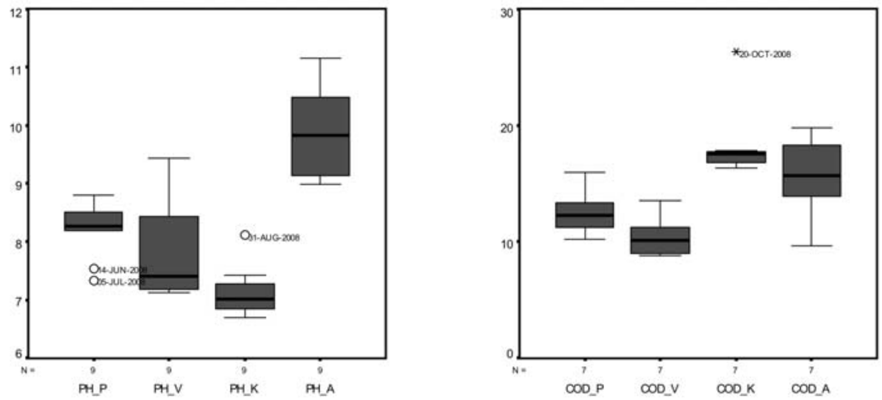

Fig. 12-13 pH and chemical oxygen demand in the lakes

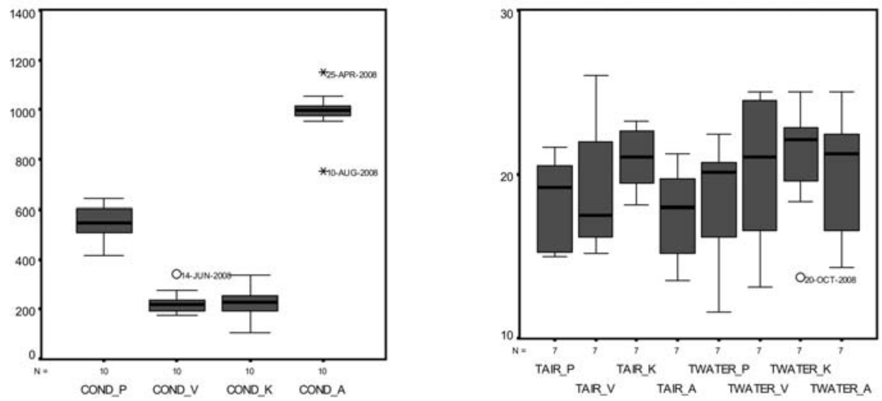

Fig. 14-15 Conductivity and temperature of the air and water in the lakes

Looking at the conductivity (Fig. 14) it is visible that the water of the Aggteleki-lake contains the biggest amount of dissolved ions; it is followed by Papverme-lake which nevertheless only contains half of the amount measured in Aggteleki-lake. In the other two lakes the conductivity and therefore the amount of dissolved ions is small.

Water and air temperature move around 18-20°C in all lakes in the year 2008. Water temperature is often higher than air temperature especially in the case of the smaller lakes (Fig. 15). By the Vörös and Aggteleki-lake there is also no shadowing.

4. CONCLUSIONS

Each of the lakes has its special surroundings and influence from the land use and they reflect these influences quite well. In the case of the lakes Papverme and Aggteleki it is visible that they are most influenced by man – according to some parameters like the oxygen saturation, pH, conductivity and orthophosphate, which indicate a far-gone trophic stadium.

Papverme-lake is in better condition – it is nowadays much larger than the other three lakes, so it is better able to process the harmful effects. It also has inflows; one collects the water from beneath the surface and the other is a point-like pollution source coming from the animal farming establishment situated next to the lake and from the village Szilice, where the canalization is not solved yet.

Vörös-lake is probably in the best state, it seems that the dredge had a good effect on it and the recently built water supplement system caused till now no decline in the water quality. However certain consequences can only be drawn from further monitoring the water quality and analyzing the lake sediment.

Moreover we can establish that the three smaller lakes also have common features as a consequence of their size and the scarce water supply. This results in higher the chemical oxygen demand in the case of this lakes especially in the Kender- and Aggteleki-lake.

Aggteleki-lake is visibly in the worst situation and there are several causes in the background like diffuse contamination from the highway and the village Aggtelek. After the proliferation of algae and macrophytes the amount of the organic material increased very fast. The dredge carried out here was not as effective as in the case of the Vörös-lake. The problem is that here it is more difficult to stop the diffuse contamination but at least the shore and surroundings of the lake could be cleaned from the macrophytes; it would be useful to save this lake from filling up and save the cave under the lake from the contaminated water.

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