ENVIRONMENTAL ANALYSIS OF WATER AND SEDIMENT SAMPLES IN LAKE MEZŐLAK AND MARCAL RIVER

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ABSTRACT
Water quality and chemical conditions of sediment were analysed in this study in the case of two water bodies: Marcal River and Mezőlak Lakes. Three sampling points were designated for both the lakes and Marcal considering water flow directions. Of water and sediment samples taken from both water bodies nitate, ammonium, phosphate, sulphate, COD and heavy metal contents were determined.
Vegetation cover, relief-geological and habitat features as well as environmental impacts were all taken into consideration during evaluation of the results. It has been found that nitrate and phosphate ion concentrations are below the threshold limits and that water is of good quality. In the case of COD effects of peat is traceable. Higher concentration of phosphate, nitrate and ammonium ion in Marcal River than in the lakes indicates anthropogenic impact. Heavy metal content of water and sediment proved to be lower than the threshold limit value and its concentration changes opposite to flow direction regarding river and lake sediments.

Keywords: environmental analysis, surface water, sediment

INTRODUCTION

Undesirable disturbance to the balance of natural waters is caused mainly by anthropogenic factors. Through introducing foreign substances and environmentally damaging materials into living waters increasing amount of agricultural, communal and industrial waste waters are responsible for the change in natural conditions. The examined area lies in the Marcal basin covering Lake Mezőlak and a section of the Marcal River parallel to the lake.
Aims of the present work are:

- environmental analysis of the water and sediment samples from the above mentioned two water bodies
- examination of the subsurface water flow systems of both the lake and the river
- surveying the cleaning effects of coastal vegetation (reed, bulrush) situated between the two water types.

Water quality

According to the Water Framework Directive water quality should be assessed not through individual measurement points, but on the basis of whole water bodies.
Water quality assessment is based on professional sampling, measurement of water quantity, as well as on-site and laboratory tests including physical, chemical, biological and bacteriologic examinations. Locality, frequency and method of these tasks are either set in standards or a guideline is given for the realization of the process (PERCSICH, 2006).

MATERIAL AND METHOD

Examined areas

Marcal River

Marcal takes its source in the foreground of the northern slope of Keszthely Mountains being part of the Bakony Region, to the south of Sümeg town, in the fields of Sümegprága village. Several smaller, mostly temporary brooks join the Marcal River at the first few kilometres of its flow, while when reaching lower lands nearby Kisvásárhely village it transforms into a permanent stream. It becomes a real river at the fields of Karakó village where it joins together with Torna Creek arriving from the Bakony. The river heads to the north and runs through a former swampy area. Nowadays this valley is covered with agricultural fields.

From the former extensive marshlands of Marcal that were situated in these lands only few isolated patches remained. Today mainly meadows, grasslands and arable lands can be found along the river.

At Kemeneshőgyész village valley of the river broadens from 2-3 km to 8 km and after Marcaltő village it flows towards the plains of the Kisalföld region. From here it runs parallel with Rába River at some kilometres distance before it reaches its confluence at Koroncó and Gyirmót villages.

On the 4th of October 2010 a dam of the Ajka Alumina plant collapsed and spilling mud with strong alkaline pollution destroyed the wildlife of Torna creek and the underneath lying section of Marcal River (http://www.marcal.hu/index.php).

Szélmező Lakes

Szélmező Lakes can be found in the northern part of Veszprém County, northwest from Pápa town, at the outskirts of Mezőlak village. This area constitutes a part of the Pápa-Devecser Plain smaller geographical unit and it is directly connected to the valley of Marcal. The river runs not far away in a distance of about 400-500 meters to the west. The smaller geographical unit of Pápa-Devecser Plain is a slightly indented alluvial fan and extends from the Bakony to the Marcal River. Creeks flowing from the direction of Bakony towards Marcal run parallel in this area oriented in a northwest-southeast direction.

Examined area covers Szélmező bog lakes where as a result of former peat exploitation holes were formed. These holes were later filled up as a consequence of both subsurface water supply and precipitation. The area of Szélmező bog lakes are affected neither by significant industrial factories nor by other high volume of chemical pollution. Water output of these lakes is not increased by creeks (SZIKLAI, 2003.)

Sampling strategy, analyses:

Three sampling points were determined for the studies of the lake and river. Sampling sites were situated nearly parallel to each other (*Figure 1.*). These are connected to each other via subsurface channels and coastal vegetation (reed, bulrush) extends between them.

Sampling was carried out with appropriate sampling tools, manually. After sampling water samples were immediately poured into storage containers. Samples were preserved according to different analytical purposes and were carried to laboratory at 4°C in cooling bags and kept in refrigerator till the analyses. Sediment samples were air-dried at room temperature.

Figure 1. Sampling sites in Marcal River and Mezőlak Lake

Measurements

Water samples were determined for sulphate *(according to MSZ 21978–49)*, chemical oxygen demand *(MSZ 448-20)*, phosphate *(MSZ 448-20)*, ammonium *(MSZ ISO 7150-1:1992)*, chloride *(MSZ 448/15-82)* and nitrate *(MSZ 448/12-82)* ion contents as well as for dissolved and total metal content after microwave digestion (HNO_3/H_2O_2) by ICP-OES.

Regarding sediment samples, calcium carbonate content was measured by Scheibler's calcimeter. Among heavy metals, concentration of cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb) and zinc (Zn) were determined after microwave digestion (HNO_3/H_2O_2) by ICP-OES. Results with considerable differences in water quality features are presented in this paper.

RESULTS AND DISCUSSION

Nitrate

Nitrate content of lakes is several orders of magnitude lower and significantly different from that of the Marcal River (*Figure 2*). This is explainable by the fact that the lake system has 15–20% of open surface and it is covered mainly by woody vegetation (reed, rush, bulrushes). These plants play a key role in the consuming of surplus quantities of nutrients, nitrate, and in filtering and absorbing of harmful substances (FEKETE ENDRE, 1991). Through taking up and building in their bodies relatively high loads of nitrate these plants not only decrease the quantity of dissolved nitrate in waters, but also prevent algae from multiplying. Algae could otherwise cause eutrophication in waters as a result of high nitrogen and phosphorus loads. Reeds are especially valuable through representing

productive zone of waters, protecting coast against abrasion, catching water scum and providing natural water clearing within their stands (WOYNAROVICH, 2003.)
Higher nitrate concentration of Marcal might be caused also by extended agricultural lands the river runs through (from the Keszthely Mountains to the confluence with Rába River at Koroncó) as these fields are being fertilized or treated with liquid manure usually yearly. Besides, Marcal is a recipient of treated communal wastewater as well. These materials contain high amounts of nitrogen which can be leached to larger basins via subsurface water flow systems or via precipitation. Therefore it has a higher concentration as opposed to a closed water body like a lake surrounded by coastal vegetation.

Phosphate

Phosphate ion concentration proved to be significantly higher in the water samples originating from Marcal River than that of the samples from the lakes at Mezőlak (*Figure 3.*). Similarly to nitrate ions reedy vegetation takes up phosphate as well. Phosphate ion concentration of the river proved to be higher due to communal wastewater (e.g. in detergents) load (PAPP, FŰRÉSZ, 2003). Because of the lack of algae and water plants there is nothing to consume it.

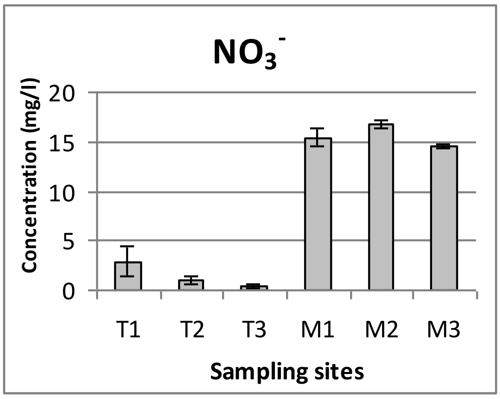

Figure 2. Water Nitrate content

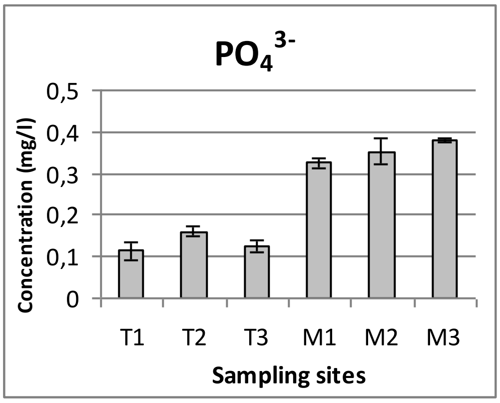

Figure 3. Water Phosphate content

Chemical oxigen demand (COD)

Owing to the peat-based environment, these lakes have high organic matter content. Constant siltation (nutrient production under anaerobic conditions) leads to decrease of open water body and accumulation of organic matter. As a consequence, water level of the lake decreases. Due to increase in organic matter content more O_2 is needed for oxidation processes. Arising from this, it has great carbon storage capacities as well. Data shown on diagram indicate that organic matter content of the lakes is three times higher than that of the river. This parameter proved to be nearly the same at the first (T1) and the third sampling points, as there is an extended land of aquatic and coastal vegetation nearby. Owing to flowage, high amounts of organic matter can not be accumulated in Marcal River. It appears to have highest values at the second sampling point (M2) after the bridge, because of leaching from the road. Downwards it becomes diluted and shows lower values (*Figure 4.*).

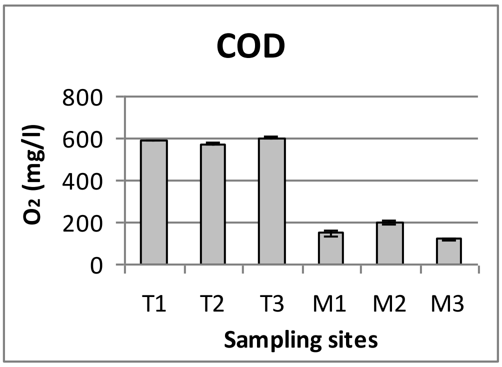

Figure 4. Water COD

Heavy metals

According to the water sample analyses results heavy metal concentration show low values in dissolution form (Figure 6). Sedimentation of heavy metals is more common as regards to sluggishly flowing rivers than transportation by sedimentary processes. This might be the reason for the several magnitudes higher heavy metal content in sediment samples (*Figure 5*).

Heavy metal concentration proved to have a regular pattern in the cases of lakes and rivers. As for the lakes, constant decrease could be observed towards eastern direction, in relation to traffic and anthropogenic impacts. From the route at the western site of the lakes heavy metals can be transported to the water via wet and dry sedimentation processes through subsurface flow systems.

In the case of Marcal River heavy metal concentration increases with streamline probably as a result of features of the terrain, as elevation of the area decreases constantly together with river velocity. Arriving to even flatter terrains, heavy metals settle down resulting in constantly higher concentration in the sediments. Regarding waters with high oxygen content (like Marcal River) compounds of heavy metals dissolute poorly and precipitate in the mud. This is why dissolute and total heavy metal concentration is lower in Marcal River. Metal ions carrying multiple positive charges bind to particles with negative charges (e.g. clay particles) and settle down impacting plants rooted in the bottom as well as bentic fauna.

From the direction of lakes these elements might be transported to Marcal River also via subsurface water flow systems from higher terrains as water potential value is lower towards the northwest.

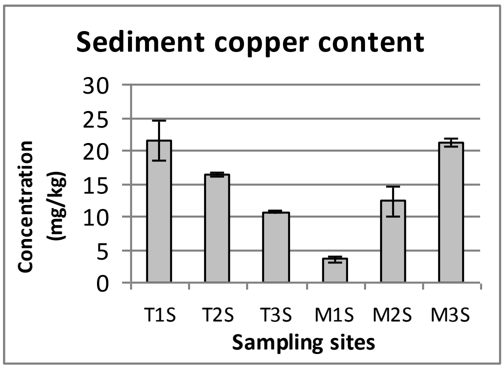

Figure 5. Sediment copper content

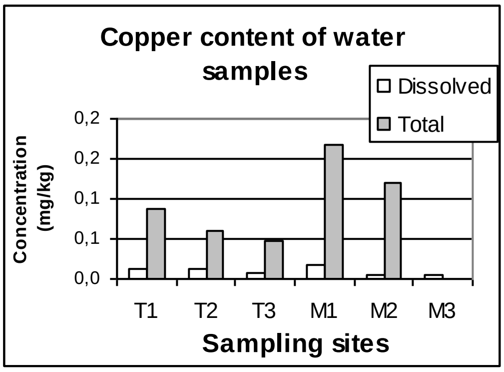

Figure 6. Water samples copper content

CONCLUSIONS

Results of the lake samples analyses show that as regards to inorganic micropollutants water is of good quality. This result is understandable as the lake and its surroundings are not connected to any freshwater flows. Although it has a subsurface water flow connection with Marcal, owing to filtering and buffering capacity of the soil very little part of harmful substances can reach the lakes (STEFANOVITS et al. 1999). Extended reed stands cause considerable self-purification between the two water bodies as well. Components of the nitrogen budget indicate good water quality, too. However, oxygen and phosphate budgets indicate a problem. In parts which are silted up and overgrown with aquatic vegetation the possibility of water exchange is little. Therefore surplus nutrient load is dangerous during hot and windless weather.

Red mud catastrophe that occurred in October 2010 caused serious water quality pollution in Marcal River. As soon as damage prevention works were finished, regeneration of the river started powerfully again and water quality data similarly to those of the state before damage are observable. Heavy metal concentration precipitated in the sediment is still traceable in considerable amounts.

Studies described in this paper can be regarded as the first step of a longer survey in which seasonal changes and water flow conditions will be taken into consideration as well.

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