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General topic
Biodiversity as an indicator of aquatic ecosystem quality
and restoration of the River Danube and its tributaries
Nature Conservation Oriented Algal Biodiversity Investigations in the Main Arm and Some Dead Arms of the River Tisza I. Benthic Diatoms

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Summary: Benthic diatoms started to be studied as part of the Hungarian National Biodiversity Monitoring Programme in some dead-arms within the Pilot Project area in 1996 and continued in 2000-2001. The investigations had a nature conservation oriented biodiversity monitoring focus but besides the diversity of diatom communities, the water quality of the dead-arms was also described on the basis of benthic diatom species composition and relative abundance by using the trophic and saprobic condition scale of Hofmann. A considerable nutrient content was detected in the investigated dead-arms; besides algal blooms and the spreading of macrophytes, benthic diatom investigations always supported this fact.

On the basis of a German red list several valuable species were found in the studied dead-arm. This valuable algal flora can only be protected by the conservation of the habitats (dead-arms) and its catchments area.


Die Wasserblüten und die starke Überhandnahme der Makrophyten-Vegetation weisen darauf hin, dass die untersuchten toten Arme reich an pflanzlichen Nährstoffen sind, was auch durch die Ergebnisse der benthischen Kieselalgenuntersuchungen bekräftigt wird.


Key words: benthic algae, dead-arms, trophity, saprobity, diversity

Introduction

Benthic diatoms started to be studied as part of the Hungarian National Biodiversity Monitoring Programme (TÖRÖK, ed. 1997) in some dead-arms within the Pilot Project area in 1996 and continued in 2000-2001. The investigations had a nature conservation oriented biodiversity monitoring focus but besides the diversity of diatom communities, the water quality of the dead-arms was also described on the basis of benthic diatom species composition and relative abundance using the trophic and saprobic condition scale of HOFMANN (1994).

Materials and Methods

Sampling sites and dates together with the characterisation of the dead arms can be found in Table 1. For the exact location of the dead arms see Figure 1. Due to low water level or deep mud covering earth-roads after floods samples could not be collected from each dead arm in every sampling period.

For comparison with the algal composition of the River Tisza samples were also taken from the side of the ferry at Balsa (559 river km) where the river is the closest to the dead-arms.

Periphytic samples were collected from the submers part of different aquatic plants in the dead arms. The samples were sedimented, treated with $\text{H}_2\text{O}_2$ and three times washed with distilled water. The treated samples were mounted in Naphrax for light-microscopy and counted 400 valves. Small Pennales and Centrales species were determined using transmission electronmicroscope. Data were analysed by the OMNIS version
<table>
<thead>
<tr>
<th>Date</th>
<th>Sampling site</th>
<th>Short description of the site</th>
<th>P</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>09.10.2000</td>
<td>River Tisza at Balsa (T-B)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>09.10.2000</td>
<td>Western part of Oláh-zügi holt-Tisza (O-W)</td>
<td>Very low water level (dry in a part), turbid water in the east surrounded by garbage heaps.</td>
<td>hyper</td>
<td>tol</td>
</tr>
<tr>
<td>09.10.2000</td>
<td>Eastern part of Marót-zügi holt-Tisza (M-E)</td>
<td>Appr. 1 m water depth, moderate turbidity.</td>
<td>meso</td>
<td>eu</td>
</tr>
<tr>
<td>09.10.2000</td>
<td>Western part of Marót-zügi holt-Tisza (M-W)</td>
<td>Appr. 1 m water depth, moderate turbidity.</td>
<td>eu</td>
<td>tol</td>
</tr>
<tr>
<td>09.10.2000</td>
<td>Eastern part of Kacsátó (K-E)</td>
<td>Appr. 1 m water depth, the water is brownish from humic acids, transparent.</td>
<td>eu</td>
<td>eu</td>
</tr>
<tr>
<td>09.10.2000</td>
<td>Western part of Kacsátó (K-W)</td>
<td>Appr. 70 cm lower water level than the autumn average, moderate turbidity.</td>
<td>hyper</td>
<td>eu</td>
</tr>
<tr>
<td>09.10.2000</td>
<td>Northern part of Remete-zügi holt-Tisza (R-N)</td>
<td>2/3 of the site is dry (30x150 m water covered area) 30-40 cm maximal water depth, sedimented but the bottom is visible.</td>
<td>hyper</td>
<td>eu</td>
</tr>
<tr>
<td>09.06.2001</td>
<td>River Tisza at Balsa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>09.06.2001</td>
<td>Oláh-E</td>
<td>Full of water but no macrophyton was found. It is surrounded by garbage heaps.</td>
<td>hyper</td>
<td>eu</td>
</tr>
<tr>
<td>09.06.2001</td>
<td>Marót-E</td>
<td>Full of water with a 20% macrophyton cover.</td>
<td>eu</td>
<td>eu</td>
</tr>
<tr>
<td>09.06.2001</td>
<td>Kacsátó</td>
<td>Full of water, water chesten began to spread along the banks.</td>
<td>meso</td>
<td>eu</td>
</tr>
<tr>
<td>09.06.2001</td>
<td>Kacsátó-W</td>
<td>Full of waters, <em>Trapa natans</em> covered appr. 30% of the water surface.</td>
<td>eu</td>
<td>tol</td>
</tr>
<tr>
<td>09.06.2001</td>
<td>Remete-N</td>
<td>Full of water with a 90% coverage.</td>
<td>oligo</td>
<td>tol</td>
</tr>
<tr>
<td>10.09.2001</td>
<td>River Tisza at Balsa</td>
<td>Average water level, high turbidity.</td>
<td>meso</td>
<td>eu</td>
</tr>
<tr>
<td>10.09.2001</td>
<td>Marót-E</td>
<td>Appr. 1 m water depth, opaque water colour, a 30-80 m² algae bloom.</td>
<td>eu</td>
<td>tol</td>
</tr>
<tr>
<td>10.09.2001</td>
<td>Marót-W</td>
<td>Appr. 1 m water depth, opaque water colour.</td>
<td>eu</td>
<td>eu</td>
</tr>
<tr>
<td>10.09.2001</td>
<td>Kacsátó</td>
<td>Appr. 70 cm lower water level than the autumn average, high turbidity, extensive algal bloom.</td>
<td>meso</td>
<td>eu</td>
</tr>
<tr>
<td>10.09.2001</td>
<td>Kacsátó-W</td>
<td>Appr. 1 m water depth, the water is brownish from humic acids, moderately turbid.</td>
<td>eu</td>
<td>tol</td>
</tr>
<tr>
<td>10.09.2001</td>
<td>Remete-N</td>
<td>Nearly completely dry, the water is opaque and turbid with algal blooms.</td>
<td>hyper</td>
<td>tol</td>
</tr>
</tbody>
</table>
3.6 programme. Species were considered to be dominant if their relative abundance was at least 5% in a sample. The diversity of diatoms was calculated according to SHANNON & WEAVER (1948).

Results and Discussion

*Achnanthes minutissima* Kütz (Pennales, Bacillariophyceae), which is regarded as a heavy metal tolerant species (SABATER 1999) was the most dominant (17.45%) species in the Tisza at Balsa on 9th October, 2000. Its strong dominance is probably in connection with the two large (cyanide and heavy metal) pollution of the River Tisza earlier in 2000 with a direct effect onto the algal communities (KISS et al. 2002). Other dominant species were *Cyclotella meneghiniana* Kütz. (23.9%), *C. pseudostelligera* Hust. (8.5%), *C. atomus* Hust. (5.5%), which are planktonic and get into periphyton by sedimentation and *Achnanthes biasolettiana* Grun. (8.5%). By June, 2001, this dominance was not so pronounced (dominance of *A. minutissima* was only 3.3%). In October, 2001, 21% of periphytic diatoms were *A. minutissima*, other dominant species included *Cocconeis pediculus* Ehr., *Navicula tripartita* (O.F. Müller) Bory and *Rhoicosphenia abbreviata* (Agh.) Lange-Bertalot. The water quality of the River Tisza at Balsa was acceptable (diatom index $IBD = 12.2, 9, 12.9, TP% = 10.3, 12. 9.2$
respectively) on 9th October, 2000, 9th June and 10th October, 2001. Most periphytic diatoms indicated eutrophic and β-mesosaprobic water quality.

In the eastern part of the Kacs-tó Aulacoseira distans (Ehr.) Sim. (30.9%), A. granulata (Ehr.) Sim. (12.3%), Nitzschia incognita Legler et Krasske (11.8%), Stephanodiscus minutulus (Kütz.) Cleve et Møller (10.7%) and S. delicatus Genkal (9.5%), in the western part S. hantzschii f. tennis (Hust.) Háč. et Stoerm. (22.3%), S. delicatus (16.3%) Nitzschia fonticola Grun. (7.6%) and N. acicularis (Kütz.) W. M. Smith (5.3%) were the dominant diatoms on 9th October, 2000. In the eastern part the periphyton consisted of α-mesosaprobic and trophic tolerant (i.e. taxa that can exist both under nutrient-poor and nutrient- rich conditions) species. In the western part of the dead arm of α-mesosaprobic and eutrophic conditions were indicated by the species composition. On 9th June, 2001 organic matter-rich, α-mesosaprobic and eutrophic water quality was indicated by the periphyton with the dominance of Aulacoseira distans (37.9%), Nitzschia paleacea (Grun.) Grun. (14.6%), Stephanodiscus minutulus (13%) and Gomphonema parvulum Kütz. (5%) in the Kacs-tó near the village (eastern part). Further away from the village (western part), where the organic matter content of the water was lower, mainly β-α-mesosaprobic and eutrophic indicators were found. Aulacoseira distans (32.6%), Stephanodiscus minutulus (9.2%), Gomphonema parvulum (6.7%) and Navicula capitatoradiata Germain (5.7%) were the dominant taxa. On 10th October, 2001, Aulacoseira distans (15.7%), Achnanthes lanceolata (Bréb.) Grun. (13%), Nitzschia fonticola (6.8%) and Aulacoseira granulata (5.5%) dominated in the periphyton in the eastern part, and A. distans (8.7%), Gomphonema parvulum (6.4%), Nitzschia fonticola (5.7%) and Epithemia sored Kütz. (5.7%) in the western part. Worse (α-mesosaprobic) was indicated again near the village (eastern part) while the western part was characterised by β-mesosaprobic, eutrophic species. The dead-arm is nutrient-rich, algal blooms can occur very often (e.g. during sampling in October, 2001). Though the Bacillariophyceae flora of this dead-arm was the most diverse from the investigated sites, especially further away from the village (Figure 2) together with a diverse Chrysophyceae community it was not special from a nature conservation viewpoint (intensive angling occurred). However even if no Hungarian Red List of algae exists, seven diatom species have to be mentioned in that respect, according to a German red list (LANGE-BERTALOT 1996): Caloneis schumanni ana (declining), Cymbella helvetica (declining), C. tumidula (threatened), Eunotia pectinalis (declining), Fragilaria delicatissima
Figure 2. Diversity of the samples.
(declining), *Navicula menisculus* (declining), *Nitzschia subacicularis* (extremely rare).

In October, 2000 the periphyton in the eastern and western part of the *Marcz-zugsi-holt-Tisza* was more or less identical with a very strong (80.9% in the east, 82.8% in the west) dominance of *Aulacoseira distans*. It is a planktonic species sedimenting into the periphyton from the water column. Besides, a *Nitzschia perminuta* (Grun.) M. Peragallo (5.2%) was dominant in the east. The periphyton consisted of species indicating or tolerating oligo-β-mesosaprobic, β-α-mesosaprobic, and eutrophic conditions. *Aulacoseira distans* remained dominant (45%), in June, 2001, too. October co-dominant species were *Cyclotella pseudostelligera* (7.7%), *Achnanthes minutissima* (7.5%), *Stephanodiscus minutulus* (7%), *Nitzschia fenticola* (7%). β-α-mesosaprobic and eutrophic conditions were indicated by the periphyton then. *Aulacoseira distans* was again dominant in October, 2001 (64.5% in the eastern, 62% in the western part of the dead arm). In the western part *Nitzschia graciliformis* was also co-dominant (5.6%). β-mesosaprobic and eutrophic conditions were indicated by the periphyton in that period. This site provided diverse habitats for Chrysophyceae species while here was the less diverse diatom community (Figure 2). Eight diatom species present here are listed in the previously mentioned red list: *Cymbella helvetica* (declining), *Fragilaria delicatissima* (declining), *Navicula angusta* (threatened), *N. hustedti* (extremely rare), *N. menisculus* (declining), *Nitzschia pumila* (extremely rare), *N. subacicularis* (extremely rare), *Pinnularia microstauroon* (declining).

In October, 2000 *Achnanthes minutissima* (23.5%), *Nitzschia filiformis* (W.M. Smith) Van Heurck (21.8%) and *N. fenticola* (8.2%) were dominant in the periphyton of the *Oláh-zugsi-holt-Tisza*, which was characterised by species indicating α-mesosaprobic and eutrophic water quality. In June, 2001 *Achnanthes minutissima* (65.5%) and *Gomphonema parvulum* (6%) were dominant and the periphyton community indicated β-α-mesosaprobic water quality. Five diatom species found here are listed in the previously given red list: *Cymbella cystula* (declining), *Eunotia pectinalis* (declining). *Fragilaria delicatissima* (declining), *Navicula angusta* (threatened), *Pinnularia microstauroon* (declining). The dead arm was nutrient-rich, in October, 2001 an extensive algal bloom was recorded.
Remete-zugi-holt-Tisza was the most intact investigated dead-arm. In October, 2000 Aulacoseira distans (20.6%), Nitzschia vermicularis (Kütz.) Hantz. (12.8%), Navicula viridula (Kütz.) Ehr. (9.3%), Nitzschia gracilisformis (6.6%), Gyrosigma acuminatum (Kütz.) Rabh. (6.2%), Nitzschia palea (Kütz.) W.Smith (6.2%), in June, 2001 Achnanthes minutissima (47.7%), Nitzschia paleaceae (10%), Gomphonema parvulum (8.75%) and Amphipleura pellucida Kütz. (7.5%), in October, 2001 Aulacoseira distans (15.2%), Achnanthes minutissima (13.2%), Gomphonema acuminatum Ehr. (8%), Aulacoseira granulata (5.2%) and Nitzschia gracilisformis (5%) were dominant. In low water periods nutrient-rich water is typical with algal blooms such as in October, 2001.

The periphyton consisted of species indicating β-α-mesosaprobic and eutrophic conditions in all three sampling periods. Six diatoms species from this site are present in the mentioned red list: Fragilaria delicatissima (declining), Neidium ampliatum (declining), Nitzschia pumila (extremely rare, in this dead-arm a considerable population was detected), N. sinuata (declining), N. subacicularis (extremely rare), Pinnularia cuneola (extremely rare).

The composition of water quality related data also revealed that the investigation of periphytic diatoms and the chlorophyll a content of phytoplankton (Table 1) often resulted in similar water quality categorisation [in the periphyton indicated trophic conditions based on HOFFMANN (1994), no hypertrophic category is used while tolerant (tol) describes a community composition, which mainly consists of diatoms that are able to grow under nutrient-rich and nutrient-poor conditions. too]. The differences between the two methods are mainly due to the fact that phytoplankton indicates the actual trophicity of the water while periphytic algae adapt to the different environmental conditions for a longer period. The best example for these differences was provided by the River Tisza, which is continuously nutrient-rich, it is potentially eutrophic. It was always shown by the periphyton while the phytoplankton indicated the actual trophicity, which was mesotrophic in October 2000 and 2001 and hypertrophic in June, 2001. On the other hand, if one of the trophicity related diatom index (e.g. IBD) is analysed it follows the planktonic pattern. It decreased to 9 when the phytoplankton indicated hypertrophy while during mesotrophic conditions it was 12.2 and 13.2.
As a summary, our investigations revealed that periphytic algae rather indicate the potential trophicity of the water while the phytoplankton provides information on the actual trophicity. If there are long intervals between the samples, more that a month (e.g. in the general water quality evaluation of waters, which can not be done frequently due to the high number of samples) periphytic diatoms are more suitable for the general qualification of waters.

A considerable nutrient content was detected in the investigated dead-arms, besides algal blooms and the spreading of macrophytes, benthic diatom investigations always supported this fact.

On the basis of a German red list several valuable species were found in the studied dead-arms. This valuable algal flora can only be protected by the conservation of the habitats (dead-arms) and its catchments area (for details see KISS & ÁCS in this volume). A diatom red list should also be compiled for Hungary to help the nature conservation evaluation of waters.

References


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