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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.

Zusammenfassung: Im Rahmen des Ungarischen Nationalen Biodiversität Monitor Programmes (Török, ed. 1997) haben wir 1996 mit der Untersuchung der benthischen Kieselalgen in einigen toten Armen der Theiss angefangen. Die Untersuchungen, bei denen die Proben auf dem Probeentnahmegebiet des Pilotprojektes, in einigen toten Armen der Theiss, von der Oberfläche untergetauchten Makrophyten abgekratzt wurden, wurden in den Jahren 2000 und 2001 fortgesetzt.

Primäres Ziel der Untesuchungen war der Biodiversität Monitor für den Zweck des Naturschutzes, doch ausser der Bestimmung der Vielfalt von den Kieselalgengemeinschaften auch Wasserqualitätanalysen wurden in den Untersuchungen einbezogen. Die Wasserqalität wurde nach der Bestimmung der Artenzusammensetzung und relativer Abundanz der benthischen Kieselalgen anhand der Trophität- und Saprobität-Skala Hofmanns bewertet.

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.
Etliche Arten, die nach den Angaben der deutschen „Roten Liste" wertvoll sind, sind in den toten Armen gefunden worden. Die einzige Möglichkeit zur Aufbewahrung der wertvollen Algenflora bietet der Schutz des ganzen Biotops (der tote Arm) und dessen Einzugsgebietes.

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 H_2O_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 1. Data and location of sampling and a short description of sampling site and their trophic level according to the chlorophyll-*a* content of phytoplankton (P) and to the benthic diatoms (B); meso = mesotrophic, eu = eutrophic, hyper = hypertrophic, tol = tolerant.

Date	Sampling site	Short description of the site	P	B
09.10.2000	River Tisza at Balsa (T-B)		meso	eu
09.10.2000	Western part of Oláh-zugi holt-Tisza (O-W)	Very low water level (dry in a part), turbid water in the east surrounded by garbage heaps.	hyper	tol
09.10.2000	Eastern part of Marót-zugi holt-Tisza (M-E)	Appr. 1 m water depth, moderate turbidity.	meso	eu
09.10.2000	Western part of Marót-zugi holt-Tisza (M-W)	Appr. 1 m water depth, moderate turbidity.	eu	tol
09.10.2000	Eastern part of Kacsa-tó (K-E)	Appr. 1 m water depth, the water is brownish from humic acids, transparent.	eu	eu
09.10.2000	Western part of Kacsa-tó (K-W)	Appr. 70 cm lower water level than the autumn average, moderate turbidity.	hyper	eu
09.10.2000	Northern part of Remete-zugi holt-Tisza (R-N)	2/3 of the site is dry (30x150 m water covered area) 30-40 cm maximal water depth, sedimented but the bottom is visible.	hyper	eu
09.06.2001	River Tisza at Balsa		hyper	eu
09.06.2001	Oláh-E	Full of water but no macrophyton was found. It is surrounded by garbage heaps.	meso	eu
09.06.2001	Marót-E	Full of water with a 20% macrophyton cover.	eu	eu
09.06.2001	Kacsa-E	Full of water, water chestent began to spread along the banks.	meso	eu
09.06.2001	Kacsa-W	Full of waters, *Trapa natans* covered appr. 30% of the water surface.	eu	tol
09.06.2001	Remete-N	Full of water with a 90% coverage.	oligo	tol
10.09.2001	River Tisza at Balsa	Average water level, high turbidity.	meso	eu
10.09.2001	Marót-E	Appr. 1 m water depth, opaque water colour, a 30-80 m^2 algae bloom.	eu	tol
10.09.2001	Marót-W	Appr. 1 m water depth, opaque water colour.	eu	eu
10.09.2001	Kacsa-E	Appr. 70 cm lower water level than the autumn average, high turbidity, extensive algal bloom.	meso	eu
10.09.2001	Kacsa-W	Appr. 1 m water depth, the water is brownish from humic acids, moderately turbid.	eu	tol
10.09.2001	Remete-N	Nearly completely dry, the water is opaque and turbid with algal blooms.	hyper	tol

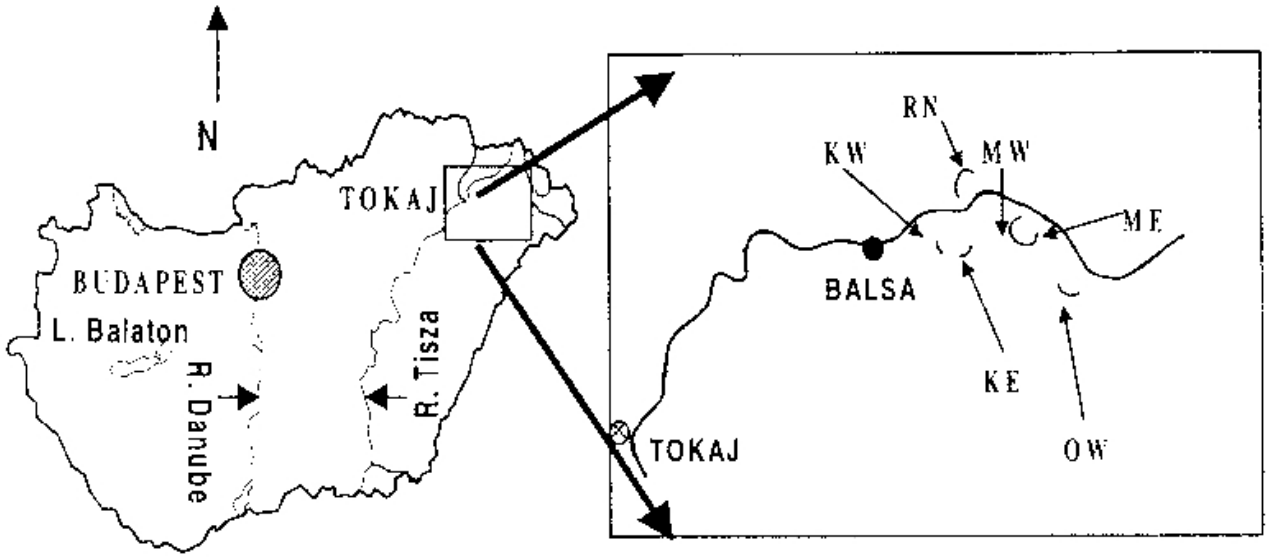

Figure 1. Sketch map of Hungary with the sampling sites [Balsa = main arm of River Tisza at Balsa (T-B), dead arms: K-W = Kacsa-tó west, K-E = Kacsa-tó east, R-N = Remete-zugi-holt-Tisza north, M-W = Marót-zugi-holt-Tisza west, M-E = Marót-zugi-holt-Tisza east, O-W = Ölyh-zugi-holt-Tisza west].

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 tripunctata* (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 ß-mesosaprobic water quality.

In the eastern part of the Kacsa-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 Moller (10.7%) and *S. delicatus* Genkal (9.3%), in the western part *S. hantzschii* f. *tenuis* (Hust.) Håk. 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-mesosaprob 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 Kacsa-tó near the village (eastern part). Further away from the village (western part), where the organic matter content of the water was lower, mainly ß-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%) dominanted in the periphyton in the eastern part, and *A. distans* (8.7%), *Gomphonema parvulum* (6.4%), *Nitzschia fonticola* (5.7%) and *Epithemia sorex* 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 ß-mesosaprobic, eutrophic species. The dead-arm is nutrient-rich, algal blooms can occur very often (e.g. during sampling in October, 2001). Though the Bacillariopyceae 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 schumanniana* (declining), *Cymbella helvetica* (declining), *C. tumidula* (threatened), *Eunotia pectinalis* (declining), *Fragilaria delicatissima*

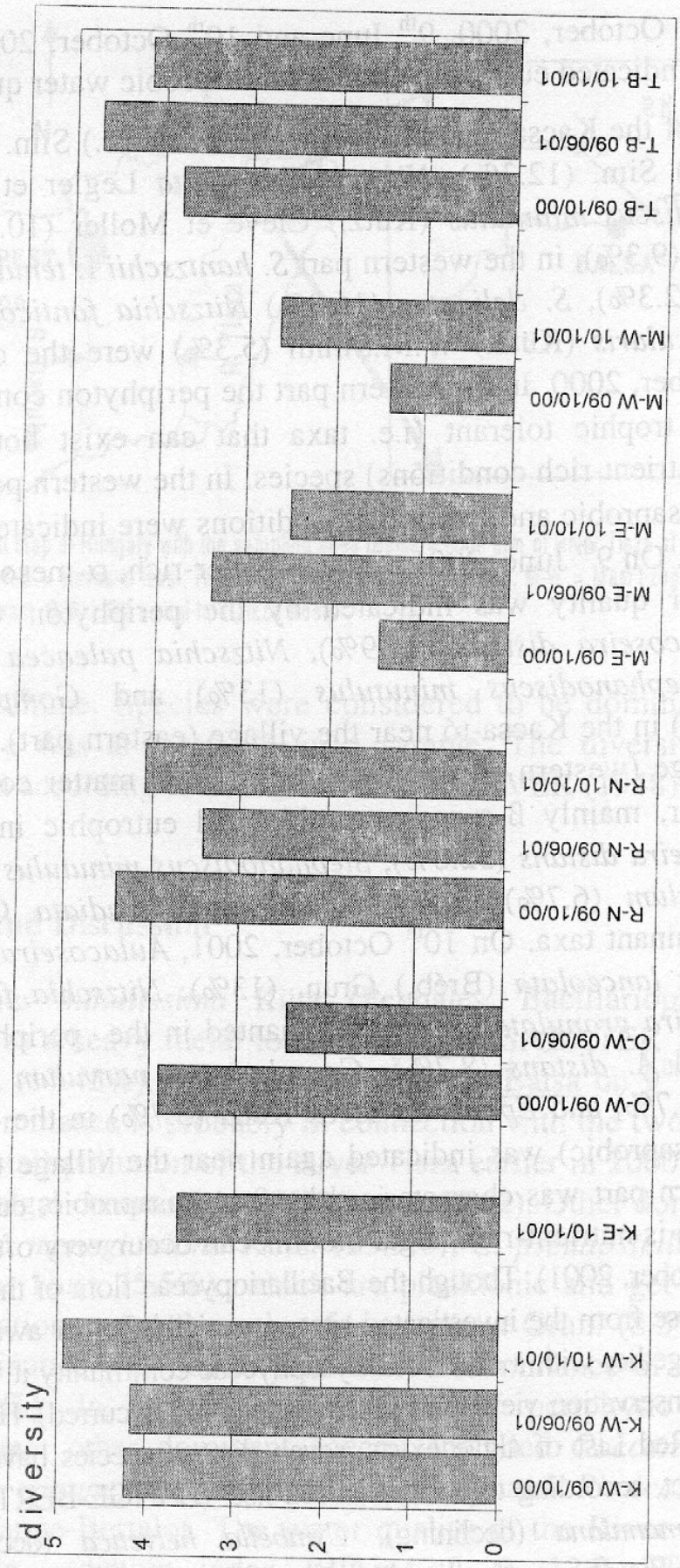

Figure 2. Diversity of the samples.

(declining), *Navicula menisculus* (declining), *Nitzschia subacicularis* (extremely rare).

In October, 2000 the periphyton in the eastern and western part of the Marót-zugi-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 fonticola* (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. hustedtii* (extremely rare), *N. menisculus* (declining), *Nitzschia pumila* (extremely rare), *N. subacicularis* (extremely rare), *Pinnularia microstauron* (declining).

In October, 2000 *Achnanthes minutissima* (23.5%), *Nitzschia filiformis* (W.M. Smith) Van Heurck (21.8%) and *N. fonticola* (8.2%) were dominant in the periphyton of the Oláh-zugi-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 microstauron* (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.) Hantzs. (12.8%), *Navicula viridula* (Kütz.) Ehr. (9.3%), *Nitzschia graciliformis* (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 graciliformis* (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.

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