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THE MASS RATIO OF THE EPIPHYTIC PERIPHYTON OF THE NYÉKI-HOLT-DUNA

GYULA LAKATOS[1] – ILDIKÓ MÁTRAI[2] – JÁNOS KUNDRÁT[1] – ISTVÁN GYULAI[3]

[1] Department of Applied Ecology, University of Debrecen, H-4010 Debrecen, Hungary
[2] Department of Environmental Technology, Eötvös József College, H-6500 Baja, Hungary
[3] Department if Hydrobiology, University of Debrecen, H-4010 Debrecen, Hungary

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Abstract
The knowledge of the periphytic structure is important for the fact that the composition of epiphytic periphyton indicates the ecologically different habitats, the biological state of water-quality and its changes. Plants like reed, great bulrush, saligot, pondweed, and water-rose separately were collected from the different sampling sites for the epiphytic periphyton examination. We performed the comparability of the monitoring systems based on the periphyton category (mass), the group (ash%), the type (chl-a%), and the character (AI), and we used the biological indicators to determine the ecological state. Taking into consideration the examined years and the results of the analysis of the mass and the chemical composition of the periphyton, by means of the NTPI, the overweight of the good ecological state is characteristic of the Nyéki-Holt-Danube.

Keywords: Hungary, oxbow lake, epiphytic periphyton, ecological state, NTPI

1. Introduction

The specific aspect of wetlands is fundamentally determined by the hydrological factors, the water coverage, the water regime, the depth of water, and the changes in water level; these factors also provide the primary conditions for the water-related organisms (Lakatos et al. 1997). Therefore, a primary aspect of the quantity is the degree of water supply, furthermore, by means of the organisms, the importance of water quality is revealed, because hard- or soft water, water of acid pH value, or saline water provides a different environment.

In wetlands and lakes the flora has different forms of life and their connection to the water (obliged or amphybic character) has a decisive role, that is, of course the result of the evolutionary processes of a long period (Wetzel 1964; Felföldy 1981). The degree of water supply and the water quality of the wetland determine the potential vegetation and its structure. Such interactions affect between abiotic and biotic factors, which can change dynamically, and form a much more complicated system of correlation that leads to the recognition of which belongs the revelation and the explanation of the process sections.

Periphyton (Behning 1924) lives in shallow waters, therefore, can be an ideal monitor in wetlands, used to trace the water quality and the condition of the environment. Sampling is relatively simple and indicates the occurring changes reliably and in advance (Watanabe 1985; Lakatos 1989; Lakatos - Bíró 1991; Fernandes - Esteves 2003). The periphyton is the complex form of those organisms, which can be found in solid underwater soils, the materials of which differ from the bottom of the water and can be clearly separated from that (Behning 1924; Dussart 1966; Lakatos 1976). The autotrophic parts of the periphyton produce organic matters and oxygen by fixing the light energy and by taking up inorganic plant nutrition. Autotrophic and heterotrophic processes are characteristic of the periphyton, and are in constant interaction with their surroundings (Wetzel 1983), therefore, are able to provide such information, which can be used in bio-monitoring. The combination of the periphyton is determined by the factors of our environment, like the trophic state of the environment (Moschini-Carlos – Henry 1997), and also the anthropogenic effects (e.g. organic pollutants, plant nutrition loading, toxic materials).

The most important plant joining the zones of shallow water side in the temperate zone are the reeds (Scirpo-Phragmitetum). Reeds have a direct or an indirect decisive importance due to their role in the life of waters, in the forming of habitats and also in the material circulation and the energy flow (in trophic relationships). Water quality regulating functioning of the reeds is considerably increased by the periphyton, evolved in the underwater parts of the plants (Lakatos et al. 2001; Massacci et al. 2001).

Wetlands represent those values of the Danubian flood lands, that are the most significant, and are the mostly exposed to injuries. The aim of nature conversation is the maintenance of the scattered remnants of former wetlands, and, as far as possible, the reconstruction of the changed habitats. For example, the rehabilitation of the Gemenc Area (along River Danube) looks back in the past for almost 20 years, the real interventions, however, began only in 1998 (Mátrai et al. 2009), with lots of unexpected problems brought to light (e.g. water-supply, extension of reed, decrease in water-levels, etc.). An essential condition in the selection of the appropriate intervention is the regular hydrological and ecological monitoring, the state estimation of some parts of areas and the determination of the optimal ecological states of aims (Lakatos 1990).

Our aim was an ecological state estimation of the Nyéki-Holt-Danube to determine a a referenceto ensure data as a basic state for the evaluation of the effect of the further rehabilitation actions. Revealing the perphyton structure can indicate the biological state of water quality and its changes. Also, from the point of view of the EU Water Framework Directive (EU WFD), it is an important and significant biological index, because the data of the examination of the epiphytic periphyton can be effectively used for the determination and specification of the ecological state of a given water body (Szilágyi et al. 2008).

At the Ecological Department of the University of Debrecen we examined the periphyton of the aquatic plants in the wetland of Gemenc (Danube valley, Hungary) since the summer of 2003, putting into centre the examination of the emerse plants and of their epiphyton of the frequent submerse reed-grass species. As a result of their fixed lifestyle, the periphytic communities are of bio-monitoring values, their importance in material circulation, in energy flow, and in their integrated role in indicating the water quality is known (Lakatos et al. 2006).

2. Material and Methods

Study site

One of the most extensive contiguous floodplain areas of Europe is Gemenc, situated in the Hungarian Nyéki-Holt-Danube, which is the natural area of 18.000 ha in the Danube-Drava National Park. The riverside floodplains of our days are the differentiated wetlands situated between the regulated river and the dykes, containing organisms had been characteristic for the floodplains before the river regulations in the 19th century.

The Nyéki-Holt-Danube is a strictly protected natural area of the Gemenc Region of the Danube-Drava National Park (DDNP). It is situated on the floodplain, and its water regime is considerably determined by the Danube. Among the nature conservational problems of the region, nowadays the dehydration and the decrease of the water coverage is the most significant issue, which induced the change, the reorganization, and the disappearance of the characteristic stands of the floodplain (Mátrai et al. 2009).

The examination was begun of the two-branched beds of the Nyéki-Holt-Danube in two cross-sections, by the side of which 10 examination points were situated (Fig. 1.), which contains the indication of the separate sections and samples. Coordinates and results of depth as well as transparency can be found in Table 1.

Applied methods and evaluation

The water temperature, the pH value, the electric conductivity, the dissolved oxygen, the oxygen saturation, and the redoxipotential directly under the water-surface were measured. The transparency and the depth of water were studied at every examination points. Aquatic plants like reed, great bulrush, saligot, pondweed, and water-rose were collected separately from the different sampling places for the studies of their epiphytic periphyton (Lakatos 1976). In laboratories, the measuring of wet matter mass (wm) and the dry matter mass (dm) of periphyton samples were performed, the chlorophyll-a (chl-a%) and ash (ash%) content of them were determined (Lakatos 1989). For the surface of one oxbow bed-unit the wet-, the dry matter mass, the amount of chlorophyll, the mass of ash, and the ash-free dry matter mass (AFDM) were referred. The Autotrophic Index (AI; Weber 1973) known as the ratio of the content of organic matter and chlorophyll was calculated.

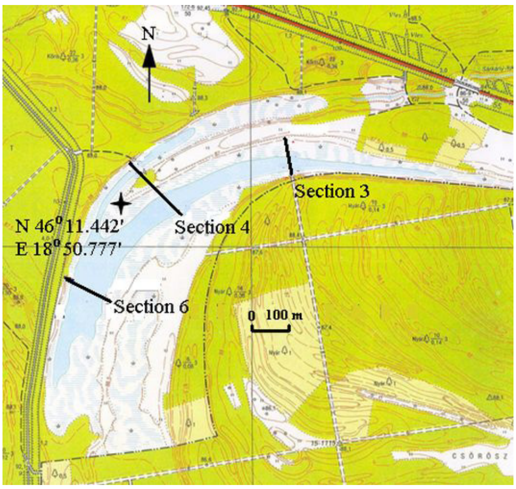

Fig. 1. Sampling places in the sections of the Nyéki-Holt-Danube

N°3 section: G1 – left-side reed, G2 – Nuphar stand, G3 – open-watered oxbow middle,
G4 – right-side Nuphar stand, G5 – right-side reed
N°4 section: G12 – left-side reed, G13 – Trapa stand, G14 – open-watered oxbow middle,
G15 - right-side Nuphar stand, G16 - right-side reed
N°6 section: G6 - right-side reed, G7 – Nymphaea stand, G8 – right-side Nuphar stand
G9 – open-watered oxbow middle, G10 - left-side reed

The Periphyton Index (PI) is the index number, constitute of the taxonomic (TPI) and non-taxonomic (NTPI) parameters of the perophyton, used to evaluate the ecological state of waters. The Non-Taxonomic Periphyton Index is the index number, that constitute of the non-taxonomic parameters of the periphyton (dry mass, content of ash, concentration of chlorophyll-a, AI, etc.), used rapidly and professionally to evaluate the ecological state of waters (Lakatos et al. 2006).

According to the EU WFD, the values of the biological qualitative elements of waters in 'excellent ecological state' (E) correspond to those values that characterise the waters under natural circumstances and they show just a little or no modification; to these waters belong water habitats that are qualified as sanctum. There are no perceptible changes in the average macrophyton- and periphyton individual density (Szilágyi et al. 2008). In case of 'good ecological state' (G) there are slight changes in the macrophyton and periphyton composition and individual density in comparison with the communities, characteristic of this type. The phytobentonic community is not harmed by the saprophytic bacterium thallus that multiplied as a result of the antrophogen effects. In a 'moderate ecological state' (M) there are average changes in the macrophyton and

Table 1. Local examination of water-samples

Sampling point	depth (cm)	transparency (cm)	coordinates	
		02.09.2004		
G6	25	25	N 46⁰11.632’	E 018⁰51.493’
G9	45	25	N 46⁰11.351’	E 018⁰51.298’
G11	30	25	N 46⁰11.370’	E 018⁰50.688’
G13	10	10	N 46⁰11.458’	E 018⁰50.912’
G14	15	5	N 46⁰11.472’	E 018⁰50.906’
G15	12	12	N 46⁰11.492’	E 018⁰50.883’
		15.06.2005		
G6	80	60	N 46⁰11.346’	E 018⁰50.782’
G7	130	120	N 46⁰11.349’	E 018⁰50.768’
G9	150	140	N 46⁰11.360’	E 018⁰50.751’
G10	150	140	N 46⁰11.366’	E 018⁰50.729’
G11	80	80	N 46⁰11.370’	E 018⁰50.688’
G13	80	60	N 46⁰11.458’	E 018⁰50.912’
G14	120	60	N 46⁰11.472’	E 018⁰50.906’
G15	80	60	N 46⁰11.492’	E 018⁰50.883’

periphyton composition and individual density in comparison with the communities’ characteristics of this type and it is much more effectively troubled than in case of G category. The signs are well marked concerning the moderate changes in the average macrphyton and periphyton individual density. In a ‘weak ecological state’ (W) the species composition of the macrophyton and periphyton stands significantly differs from the community characteristics of this type, it is more effectively troubled, that in case of M category. Visible changes can be observed in the average macrophyton and periphyton individual density. The phytobentonic stand can be significantly harmed in certain sections as a result of the anthropogenic effects. In case of a ‘polluted, bad ecological state’ (P) the species composition of the macrophyton and periphyton stands significantly differ from the community characteristics of this type, but also from W category, and only a few resisting macrophyta species and their stand is characteristic. Obviously visible changes can be observed in the average macrophyton and periphyton individual density.

The application of NTPI has been recommend, that refers to the structure and the operation of the periphyton, and provides the classification of it, such system is applied by the hydrobiological experts on national initiative in Hungary and other countries (Lakatos et al. 1999; Pizzaro - Vinocur 2000).

For the comparison of the periphyton samples and for the indication of the ecological state, as a biological indicator, we recommend the categories determined by the mass ratio of the periphyton, among which 5 (dm) categories can be developed between high-mass and low-mass periphyton, that are the two extreme evaluations. Each categories receive valueranging between 0 and 1 (practically: 0.01–0.81). The four groups that are developed on the ground of the ash content (ash%) of the periphyton are based on the ratio of the organic and the inorganic fraction. The four groups determined on the ground of the chlorophyll-a concentration (chl-a%) of the periphytic chlorophyll is based on the value of the dry matter expressed in percentage, and gives information about the potential photosynthetic function of the present alga community.

The Autotrophic Index (AI), as the value calculated for the periphyton from the ratio of the organic matter content and the chlorophyll-a concentration, provides the determination of four characters, and refers to the potential destructive operation and function of the periphyton bacterium and zoo-organisms.

To determine and classify the ecological state or ecological potential based on biological water quality factors, the hydrological-morphological quality factors and the average physical-chemical indicators are important, in case of surface water types. The determination of the ecological condition and state of waters is performed by the sum of the values calculated to the four non-taxonomic periphyton index (NTPI). The quality scale consists of five units, among the excellent ecological state (E) and the bad, polluted ecological state (P) (Table 2a), and the non-taxonomic parameters of the periphyton monitoring system (Table 2b).

3. Results and Discussion

Water plant examination results

Ferencz et al. (2004) and Mátrai et al. (2009) reported detailed examinations of the flora of the Nyéki-Holt-Danube Accordingly, 64% of the flora was hydato-helophyta (HH) related to wetlands, among which 21 were marsh plants and 24 reed grass plants. The Nyéki-Holt-Danube, which is an oxbow lake rich in reed grass species, can be characterised with benthonic eutrophication (Lakatos 1978).

The characteristic reed grass vegetation of the area was the water-rose sub-association of the water-lily water-rose reed grass (Nymphaeetum albo-luteae; Mátrai et al., 2009). In the spring of the year of 2004, that was drier than usual, the water-dropwort (Rorippo-Oenanthetum) uliginal joining, while in the autumn of the same year, the knotweed water-chestnut (Polygono-Eleocharitetum ovatae) joining appeared in a larger stand. In the over-bed water-columns of the open-water parts of the bed, the Ceratophylletum demersi was present in large quantities in all of the three years, and in some places the saligot also appeared (Mátrai et al. 2009). The epiphyton samples

Table 2a. The ecological condition and state of waters based on the four non-taxonomic periphyton index (NTPI).

excellent state (E)	0.71-1.0
good state (G)	0.51-0.70
moderate state (M)	0.31-0.50
weak state (W)	0.16-0.30
bad, polluted state (P)	<0.15

Table 2b. The non-taxonomic parameters of the periphyton monitoring system

1. mass category (g/m^2):					
1.1 Phragmites +Typha (epiphyton)			1.2. floating (floating leaves) + submerse (epiphyton)		
high	>50	0.21	large	>25.1	0.21
middle-high	41-50	0.81	middle-large	10.1-25.0	0.81
middle	31-40	0.61	middle	3.1-10.0	0.61
middle-low	30.okt	0.41	middle small	1.1- 3.0	0.41
low	<10	0.01	small	<1.0	0.01
2. ash group	ash%	value	3. chll-a type	chl-a%	value
inorganic	>75	0.21	autotrophic	>0.60	0.41
inorganic-organic	51-75	0.61	auto-htrophic	0.26-0.60	0.81
organic-inorganic	25-50	0.81	h-autotrophic	0.10-0.25	0.61
organic	<25	0.41	heterotrophic	<0.10	0.21
4. AI character	AI	value			
destructive	>1000	0.21			
destructive overweight	301-1000	0.41			
constructive overweight	101-300	0.81			
constructive	<100	0.61			

were taken mostly from the plants with floating leaves and the stems of green reed.

The alkaline pH value was more definite in case of shallower water-depth; it can even exceed the 9.5 pH value. A correlation can be defined between the values of the specific conductivity of the water and the pH values of the waters, the saturation of the dissolved oxygen exceeds the 100% saturation in every case except for one.

The mass and chemical composition of the epiphytic periphyton

In Table 3 the dry mass of epiphytic periphyton taken from the green reed and from saligot (Trapa natans), the chlorophyll-a%, the ash content, the quantity of the ash-free organic matter (AFDM), and the AI value were summarized.

In the water-covered reeds of the №6 section the organic matter mass of periphyton was 14 – 67 times bigger in 2003 than in 2005, when the reed repopulated after the previous year and already in the following year a 4 – 20 times bigger mass was characteristic. The epiphytic chlorophyll content of the green reed change between 0.050 and 0.453% and the bigger value refers to the samples of 2006, when an auto-heterotrophic type can be determined opposed to the previous hetero-autotrophic and heterotrophic type. The ash content was significantly (two or three times) lower in comparison with the reed-cover of the open-water side of Lake Balaton and Lake Fertő (Lakatos 1989; Lakatos - Bíró 1991), therefore, the organic-inorganic and the organic group were characteristic. The quantity of the ash free dry matter (AFDM) correlated with the mass of organic matter. The AI values change between 177 and 1464 in case of green reed-epiphyton samples, which conforms to the domain given by constructive overweight- and destructive types.

The examinations proved that to the leaves of the submerse, but underwater horizontal leave-positioned pondweed deposit themselves the floating-matter particles of the water, therefore, the ratio of the ash content of the periphyton taken from the perpendicular stem or from the back of the underwater leaves was twice as big as the ratio of the inorganic fraction (Table 4). Therefore, the sequence for the chlorophyll-a content was the following: Nuphar > Trapa Schoenoplectus > Phragmites > Potamogeton,

Table 3. The data of epiphytic periphyton taken from the green reed (Phragmites communis) and from saligot (Trapa natans) are published

year	sample	dry mass (g/m^2)	kl-a%	ha%	AFDM (g/m^2)	AI
Green-reed						
2003	G6	17,86	0,05	37,80	11,17	1244
	G11	29,57	0,10	47,69	15,47	503
2005	G6	1,25	0,15	34,35	0,82	429
	G11	0,44	0,06	12,00	0,39	1464
2006	G6	5,15	0,28	42521,00	3,55	249
	G11	8,69	0,45	19,92	6,96	177
saligot						
2003	G8	11,94	0,09	25,00	8,98	833
2004	G6	3,13	0,49	35,90	2,01	132
	G9	3,24	0,50	35,14	2,10	129
	G13	3,40	0,89	53,45	1,58	52
	G14	7,40	0,42	57,14	3,17	103
2005	G9	31,52	0,42	13606,00	19,84	150
	G10	5,48	0,46	15,79	4,62	182
2006	G10	7,50	0,38	50,00	3,75	132
	G15	2,19	0,89	25,00	1,64	85

Table 4. The average chlorophyll-a and ash% data of epiphytic periphyton collected from different host plants

plant	chlorophyll-a (average) %	ash %
green reed	0.182	30.47
great bulrush	0.238	37.66
water-rose	0.530	29.86
saligot	0.503	37.16
glass-leaved pondweed	0.040	86.20

in case of ash content: Potamogeton > Schoenoplectus > Trapa > Phragmites > Nuphar. While the water-rose and the saligot is in one case at the first place, in another case the last one.

The mass of the submerse, glass-leaved pondweed was of middle category, uniformly of heterotrophic type, can be classified as part of the inorganic group, and according to the AI was similar to the periphyton of the floating-leaved plants.

Based on the NTPI in the summer of 2003 the moderate ecological state was characteristic in both sections, which was modified to good ecological state until the end of the summer of the following year, and the same can be stated in the №4 section chosen because of the low water-level. In 2005 the favourable, good ecological state remained in the №4 and №6 section, and in 2006 the №6 section can be characterised again with the good ecological state, while the №4 section was only in moderate ecological state.

Taking into consideration the examined years and the results of the analysis of the mass and the chemical composition of epiphytic periphyton, by means of the NTPI, the overweight of the good ecological state is characteristic of the Nyéki-Holt-Danube, because only one sample and one habitat receive the evaluation of weak ecological state, while excellent ecological state was characteristic in five cases.

The underwater parts of the plants and their epiphytic periphyton evolved on them contributes to the natural cleaning of the waters due to its significant role as a biofilter, and its role in the food chain and energy flow is also well-known.

4. Conclusions

Our aim by the ecological state estimation of the Nyéki-Holt-Danube is to fix a basic state that we want to use as a reference-state under the evaluation of the effect of the further rehabilitation actions. The knowledge of the periphytic structure is important for the fact that the composition of periphyton indicates the ecologically different habitats, the biological state of water-quality and its changes.

We collected plants like reed, great bulrush, saligot, pondweed, and water-rose separately from the different sampling sites for the epiphytic periphyton examination. In laboratories, the measuring of wet-mass (wm) and that of drymass (dm) of samples were performed, we determined the chlorophyll-a (chl-a%) and ash (ash%) content as well as, the ash-free dry-matter (AFDM) and the Autotrophic Index (AI) were calculated. The determination of the ecological condition and state of waters is performed by the sum of the values calculated to the non-taxonomic periphytic index (NTPI).

The characteristic reed grass vegetation of the area is the water-rose sub-association of the water-lily water-rose reed grass (Nymphaeetum albo-luteae). The quota of the open-water and the water-rose, which differs in degree in every year and develops at the price of the other, evolves as a function of water-level. In 2006 an auto-heterotrophic type can be determined opposed to the previous hetero-autotrophic and heterotrophic type, according to the ash content the organic-inorganic group and the organic group is characteristic, the AI values conform to the domain given by constructive overweight- and destructive types.

The mass of the submerse, glass-leaved pondweed is of middle category, uniformly of

Table 5. Ecological state evaluation according to the non-taxonomic parameters (NTPI) of the periphyton monitoring system

sample	mass	group	type	character	ecological state
16.06.2003					
G1 Phragmites green	low	org-inorg	hetero-auto	des-overw	moderate
G2 Nuphar	m-low	org-inorg	hetero-auto	des-overw	moderate
G4 Nuphar	middle	org-inorg	hetero-auto	des-overw	good
G5 Phragmites green	low	inorg-org	hetero-auto	des-overw	moderate
G5 Nymphoides	high	inorg-org	hetero-auto	cons-overw	good
G6 Phragmites green	m-low	org-inorg	heterotrophic	destructive	moderate
G6 Shoenoplectus	low	org-inorg	hetero-auto	des-overw	moderate
G7 Nuphar	low	org-inorg	autotrophic	constructive	moderate
G8 Trapa	m-high	organic	heterotrophic	des-overw	moderate
G8 Pot. lucens	middle	inorg-org	hetero-auto	cons-overw	good
G10 Nuphar	m-high	org-inorg	hetero-auto	des-overw	good
G11 Phragmites green	middle	org-inorg	heterotrophic	destructive	moderate
02.09.2004					
G6 Nuphar	middle	organic	autotrophic	constructive	moderate
G6 Trapa	m-high	org-inorg	auto-hetero	cons-overw	excellent
G9 Trapa	m-high	org-inorg	auto-hetero	cons-overw	excellent
G11 Nuphar	middle	organic	hetero-auto	des-overw	good
G11 Trapa	high	org-inorg	hetero-auto	cons-overw	good
G13 Trapa	m-high	inorg-org	autotrophic	constructive	good
G14 Nuphar	m-high	org-inorg	auto-hetero	cons-overw	excellent
G14 Trapa	high	inorg-org	auto-hetero	cons-overw	good
15.06.2005					
G6 Phragmites green	low	organic	hetero-auto	des-overw	moderate
G6 Nuphar	m-low	org-inorg	auto-hetero	cons-overw	excellent
G6 Pot. lucens	high	inorg-org	heterotrophic	des-overw	moderate
G9 Trapa	high	org-inorg	auto-hetero	cons-overw	good
G10 Nuphar	m-low	org-inorg	autotrophic	constructive	good
G10 Trapa	high	organic	auto-hetero	cons-overw	good
G11 Phragmites green	low	organic	heterotrophic	destructive	weak
G11 Schoenoplectus	low	org-inorg	hetero-auto	cons-overw	good
G13 Pot. lucens	m-high	inorganic	heterotrophic	cons-overw	good
G14 Pot. lucens	middle	inorganic	heterotrophic	des-overw	moderate
G15 Nuphar	middle	organic	auto-hetero	cons-overw	good
18.07.2006					
G6 Phragmites green	low	org-inorg	auto-hetero	cons-overw	good
G6 Nuphar	low	organic	auto-hetero	cons-overw	good
G6 Schoeno	low	org-inorg	auto-hetero	cons-overw	good
G6 Pot.lucens	m-low	inorganic	heterotrophic	des-overw	moderate
G9 Nuphar	low	inorg-org	autotrophic	constructive	moderate
G10 Trapa	middle	org-inorg	auto-hetero	cons-overw	excellent
G11 Phragmites green	low	organic	auto-hetero	cons-overw	good
G12 Pot.lucens	middle	inorganic	heterotrophic	cons-overw	moderate
G14 Pot. lucens	m-high	inorganic	heterotrophic	cons-overw	good
G15 Nuphar	low	organic	autotrophic	cons-overw	moderate
G15 Trapa	m-low	organic	autotrophic	constructive	moderate

heterotrophic type, can be classified as part of the inorganic group, and according to the AI is similar to the periphyton of the floating-leaved plants. Taking into consideration the examined years and the results of the analysis of the mass and the chemical composition of the periphyton, by means of the NTPI, the overweight of the good ecological state is characteristic of the Nyéki-Holt-Danube, because only one sample and one habitat receive the evaluation of weak ecological state, while excellent ecological state was characteristic in five cases.

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