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Full Length Research Paper

Ecological status of waterfowl habitat on the Gemenc floodplain area in Hungary

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Hydrological, chemical and biological methods were applied to investigate the ecological status of the Gemenc floodplain area. The examined wetland was generally poor in planktonic organisms, however benthonic eutrophication was evident. 81 plant species and 17 associations were proved to appear during the examined years. Formation of vegetation was influenced by water-level. The hydrological regime changed extremely. Multiple floods and the almost dried-out bed were both unfavourable for the macro- vegetation. The ecological status was mostly good as indicated by the periphyton community. During floods, the chemical parameters depended on the quality of water flowing from the Danube river and during floodless times, it determined the composition of the macrophytes. The concentrations of inorganic nutrient parameters were generally not too high. The floodless times were more critical, considering the pH-value, concentration of free ammonia and deficit of dissolved oxygen. There were connections between water-balance, the chemical and biological quality of water, and the nesting and feeding conditions for waterfowls. The results showed that it is necessary to carry out further intervention in order to keep the nature of the habitat. Habitat management should mean flexible conservation and preservation practice through revitalization by ensuring the predominance of natural processes and better water supply by technical interventions.

Key words: Natural wetland, ecological status, nature conservation treatment.

INTRODUCTION

Gemenc is an 18.000 hectares conservation area belonging to the Danube-Drava National Park, in the lower basin of the Hungarian segment of Danube River. This site is an important habitat for waterfowls, which determined its inclusion on the Ramsar List (Tardy, 2007). In our time the wetlands of Gemenc, which are the floodplain of the region between dikes and the regulated river, still haboured living organisms as had been the characteristics of floodplains before river control began.

A 150 year- long river control of the Danube floodplain has led to an increase of drying processes in Gemenc. Decreases of water-level resulting from the band of the riverbed of the Danube resulted in a critically low water supply of oxbows and a gradual sedimentation of the river branches (Szlávik et al., 1995). The management of the national park has worked out several techniques in order to reduce and reverse the unfavourable processes (Zsuffa, 1993).

For example, among the areas of Gemenc the "Nyéki-Holt-Duna" oxbow lake was the first one in which the water-circulation revitalization was carried out. The aim of this nature conservational intervention was to enable the area to be inundated at least once a year with water from the flooding of Danube, which provides the means for the permanent water-covering bed (Szlávik et al., 1995). The planners considered it as a sufficient condition for the sake of the permanently water-covered bed. Nature conservational experts laid down this principle of treatment in order to locally improve the essential conditions for waterfowls, considering that these can be easily observed as obvious indicating factors in extensive wetlands. Besides the numerous nesting places of black stork (*Ciconia nigra* L.), the presence of white tailed eagles (*Haliaëtus albicilla* L.) is also a regular feature in the environment of "Nyéki-Holt-Duna". However, the state

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of the oxbow lake could not be completely restored, it remained to be an often-drying-out plesiopotamon.

Detailed hydrological and geomorphological analysis (Szlávik et al., 1995) of the area had been done but there has not been an objective study of the ecological status. This research program was started in 2003 with the aim of investigating the ecological status of the oxbow lake and to evaluate the changes in it. The assessment of our interventions and further treatment propositions are not the only purpose of our survey made at in "Nyéki-Holt-Duna". This survey is also expected to provide a profess-sional base to the interpretation and the assessment of state-changing, which depends on the water regime of oxbow lakes in the flood plain.

In plesiopotamon type dead arms, biomass of fish-stock consists of eurytop and limnophil species and changes exorbitantly in conformity with the extremely varying environmental factors (Guti, 2001). Up to the present, there have not been exact ichthyologic researches on the area of "Nyéki-Holt-Duna".

Between 2003 and 2005 there was ornithological monitoring in the "Nyéki-Holt-Duna". As a result of monitoring there are registered 109 species of waterfowls, among which 50 species were connected with this oxbow by nutrition or reproduction. According to observations in 2003, the number of individuals was mainly influenced by the changes, which were connected with the period of migration (that is April and August) and occurred within a year. However, changes which were connected to the fluctuation of water-level could be clearly detected in composition of species. Separation of zoophagous and phytophagous populations (Andrikovics et al., 2006; Deák et al., 2008) showed that zoophagous species prevailed over swimming herbivorous species, when a slow subsidence occurred and led to the improvement of those circumstances which subserved to catch fish wading in the water. During the year, the oxbow which was characterized by filling-up in spring 2003 gradually changed into ideal feeding places for several bird species. Feeding and nesting circumstances of waterbirds are influenced by state of vegetation (pondweeds, reeds) and required quantities of fish as well as certain depth of water (Oláh et al., 2006). Frequent floods in 2005 and drying out in 2004 made these circumstances worse, so the majority of waterfowls kept away.

MATERIALS AND METHODS

Study area

"Nyéki-Holt-Duna" lies west of Baja, on the floodplain of the right bank of the Danube (Figure 1). It is located relatively far from inhabited lands, on a field that is free from human impacts, and surrounded by forests which are practically in their natural state. During the natural evolution of the Danube, this oxbow had lost its contact with the main branch. Its characteristic shape of an ox- horn is owing to the sandbank, which was formed when this dead arm had been the main branch. Cutting and isolation of the oxbow may have been resulted by one of the largest floods of the 17th century.

As a result of activities carried out within the oxbow environment during the last 150 years, its draining was more frequent than necessary. Between 1998 and 2004, the complex system of the oxbow has been hydrologically revitalised by the technical interventions with the aim of improving the water- retention in the oxbow, and improving the water carrying capacity of the channel, which connects the oxbow with the river (Figure 1).

Methods of examination and evaluation

We have been dealing with ecological monitoring of the 'Nyéki-Holt-Duna' between 2003 and 2008, regularly in every month within the growing season. On the basis of river surveys which preceded the rehabilitative processes (Szlávik et al., 1995), we performed observation of the two-branched bed in those examination points which are located along the four repeatedly marked cross-sections (Figure 2). Different depth-conditions and vegetation-types are represented well by these cross-sections and sample plots. We collect the water sample to chemical and biological examinations directly under the surface. In the first three years of our research we took samples in April, May, June and August, while in the following three years we found it satisfactory to do it once a year, in June. To examine periphyton, we collected emergent and submerged plants in each place of sample taking in June. From the measured hydrological, hydro-chemical and hydro-biological parameters and examination of macro-vegetation, we concluded the changes in ecological state which result year by year.

We chose the examined hydro-chemical parameters in order to detect those chemical components which are food for waterfowls and important for fish or aquatic plants. We examined the salt balance, the pH-value, the alimentary substances and the oxygen balance. During our examinations, we applied those standard methods which are usually used in Hungarian environmental practice.

In the framework of hydro-biological examinations we examined the phytoplankton and the periphyton. The qualitative examination of algae was done by light microscope from concentrated water samples; the quantitative examination was done by fixing the samples in Lugol-tincture in count chamber, using reverse microscope process. We did hierarchical classification in order to examine the phytoplankton list of species statistically using the program package SYN-TAX 2000 (Podani, 2001). We applied the group average (UPGMA) method and the Yule coefficient. The periphyton-based ecological evaluation of state was carried out according to the non-taxonomic periphyton index (NTPI), calculated as the average of the sum of four live coat structure and operation indicators (category of weight, group of ash, chlorophyll-a type, autotrophic nature) (Lakatos et al., 2006).

For macro-vegetation examination, it was necessary to make lists of species along the sections and draw a vegetation-map of the whole bed, using aerial photographs. To describe permanent changes in the plant life of the oxbow lake, we used the method of comparing plant life maps drawn by AUTOCAD, according to photos taken repeatedly. To define each association, we reviewed the character species, the accompanying species at present in larger quantities and the physiognomy. We used the book of Borhidi (2003) to determine them. We evaluated the macro-vegetation with the help of 'degree of degradation' (Simon, 1988), based on the ratio of disturbing indicator and natural species.

In 2005, we made surveys of the bed to determine the measure of silting up. Results of these surveys have been compared with the dates of examinations of the year 1993 (Szlávik et al., 1995), and to make this more accurate, we also carried out a radiological analysis of the river-bed material. We determined the ^{137}CS-isotope activity of the samples, which were derived from other depth, by gamma-spectrometer.

To explore the relationship between the oxbow lake and various water suppliers, we evaluated the Danube water-level data and

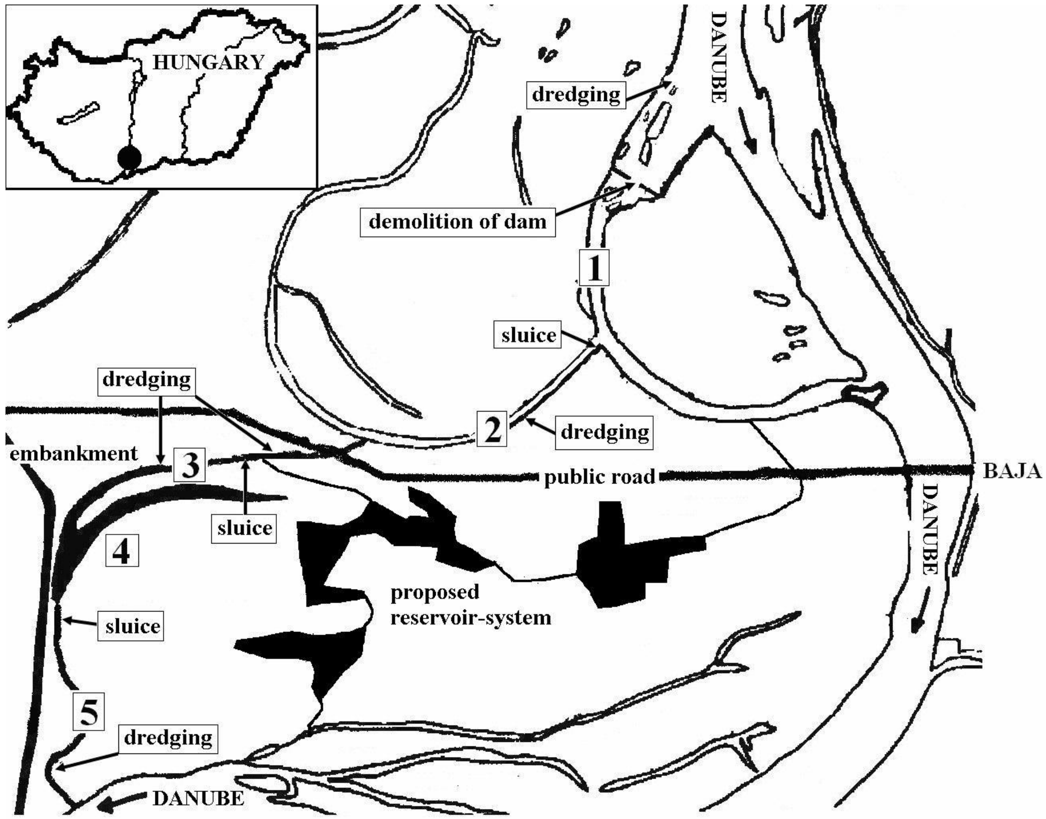

Figure 1. Parts of the water-system of "Nyéki-Holt-Duna" with the effected technical interventions and the proposed reservoir-system. 1-Vén-Duna (branch); 2-Cserta-Duna (dead-arm); 3-Sárkány-fok (channel); 4-Nyéki-Holt-Duna (oxbow lake); 5-Cimer-fok (channel).

analyzed our results of the 2005 measurement of ground-water level. We prepared the water-balance of the oxbow lake using hydrometrical monitoring data, and then compared it with the theoretical water-balance based on professional estimation (Zellei, 2003).

In order to approximate the ecological state we have compared the chemical parameters with biological status, which was induced by elected groups of flora (algae, periphyton, macro-vegetation). We drew the conclusions considering the results of examinations of June. These results were completed by the conclusions of ornithological observations. Towards the comparability of different qualification methods we have used two-tier (favourable, unfavourable) appreciation.

RESULTS AND DISCUSSION

Water-balance of the "Nyéki- Holt-Duna" depends on the changes in water level of the Danube. In the six years of our examinations, water balance of the oxbow-lake was extremely excessive. In early spring in 2003, the oxbow-lake filled up, as a consequence of higher water-level of River Danube. Thereafter, up to the spring of the year 2005, only precipitation provided water- supply for the oxbow lake because of the low water-level of the river. By autumn in 2003, average water-depth of the oxbow lake was 90 per cent lower; water-mass was 94% lower and these were at the beginning of spring. By autumn in 2004, drying up increased and led to the draining of the whole oxbow. In 2005 and 2006, the area was flooded several times and the water-levels were continually high during the growing season. In 2007 the hydrological circumstance was similar to 2004. In early spring of 2008, the oxbow filled up and the hydrological condition was similar to 2003.

At the time of floods, large quantities of soil, dry fallen leaves and twigs are drifted to the oxbow by river-water which flows through the surrounding forests. Deposition of floating silt characterized those periods when the water supplement arrived through the channels. In the last twenty years, the sedimentation of river- bed and its environment were different, average annual siltation was 3.2 cm. Nowadays the soft sediment depth is between 25 and 40 centimetres in the bed.

Our findings indicate that there is a great amount of unidentified loss, which was created according to the water-balance of the oxbow lake. The primary reason for that (according to experiments) is the influencing effect of evapotranspiration on the plant life of the bed. "Nyéki-Holt-Duna" is an oxbow lake, which is rich in pondweed species as well as associations, and can be characterized by benthonic eutrophication. By evaluating the

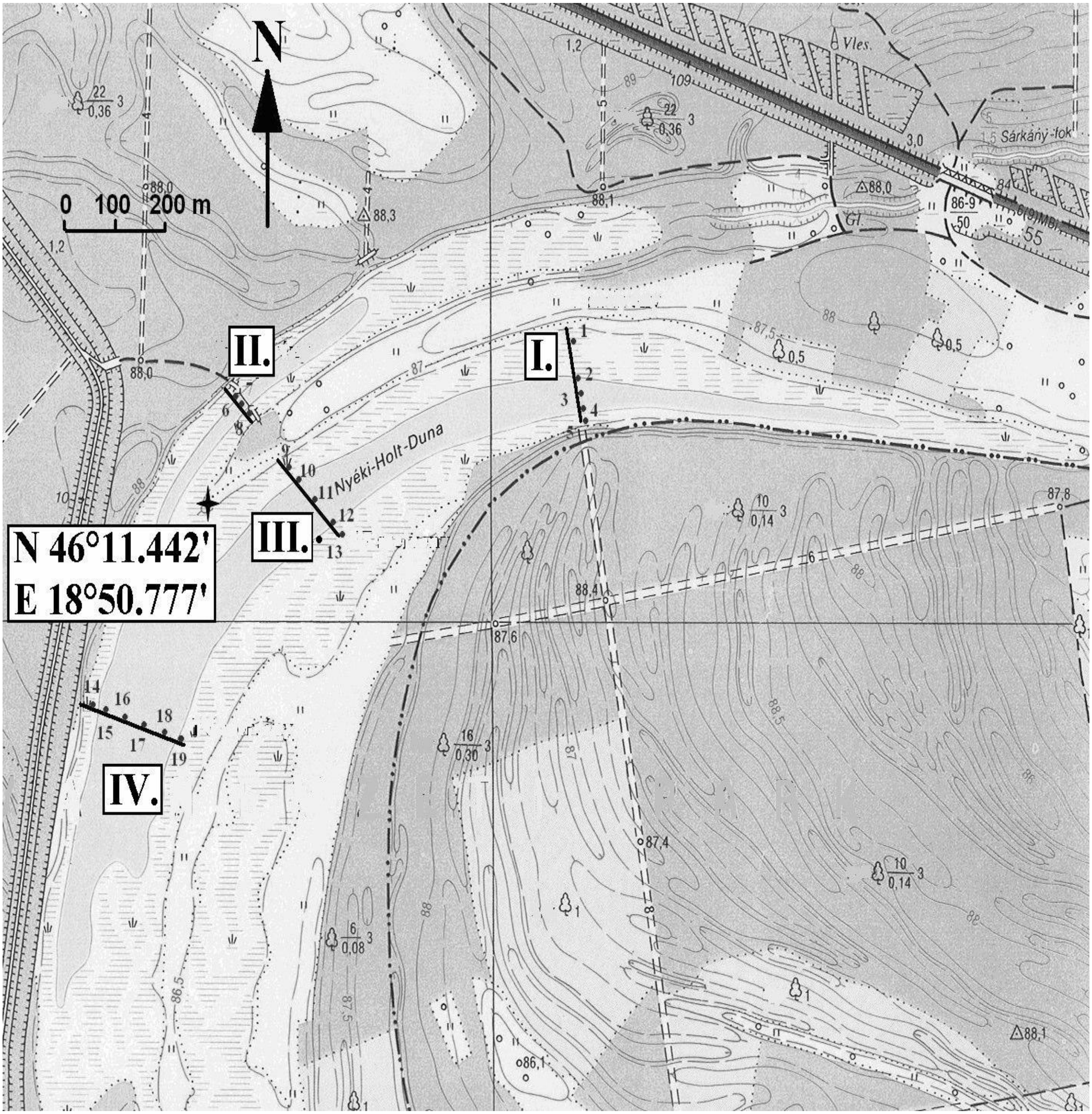

Figure 2. Cross-sections and sample plots in the "Nyéki-Holt-Duna".

the aerial photographs, which were taken of the oxbow plant life, we saw that the soundness of the coastal zonation refers to the area being close to natural state. Its most characteristic associations are water-lily *(Myriophyllетum verticillati-Nupharetum luteae* Koch 1926*)*, reed *(Phragmitetum communis)* and bulrush (*Schonoplectetum lacustris* Chouard 1924). In the river-bed we identified also 14 other associations, which were occasionally presence:

Table 1. Checklist of macrophytes in “Nyéki-Holt-Duna”.

Taxon	2003	2004	2005	2006	2007	2008
Agrostis stolinifera L.			x			
Alisma plantago-aquatica L.		x				
Alopecurus geniculatus L.		x	x		x	
Asclepias syriaca L.			x			
Aster sedifolius L.		x				
Azolla filiculoides Lam.			x			
Batrachium (Ranunculus) circinnatum (Sibth.) Spach.	x	x		x		
Batrachium (Ranunculus) rionii Lagger						x
Batrachium (Ranunculus) trichophyllum (Chaix) Bosch	x	x				
Bidens tripartitus L.			x		x	
Bolboschoenus maritimus (L.) Palla					x	
Butomus umbellatus L.	x					
Callitriche cophocarpa Sendtn.					x	
Caltha palustris L.	x	x				x
Calystegia sepium (L.) R.Br.	x	x	x			
Cardamine pratensis L.	x					
Carex acuta L.		x	x			
Carex acutiformis Ehrh.			x			x
Carex hirta L.	x	x	x			
Carex riparia Curt.			x			
Ceratophyllum demersum L.	x	x	x	x	x	x
Ceratophyllum submersum L.	x					
Colchicum autumnale L.		x				
Echinochloa crus-galli (L.) P.B.		x				
Eleocharis palustris (L.) R. et Sch.		x				
Euphorbia palustris L.		x	x		x	
Galium palustre L.			x			x
Glechoma hederacea L.		x	x		x	
Glyceria maxima (Hartm.) Holmbg.		x	x	x	x	x
Hippuris vulgaris L.	x					
Hydrocharis morsus-ranae L.	x	x	x	x		
Iris pseudacorus L.	x	x	x		x	x
Lemna minor L.	x		x	x		x
Lemna trisulca L.	x	x	x	x	x	x
Leucojum aestivum L.		x	x		x	x
Lycopus europaeus L.		x	x		x	
Lysimachia nummularia L.	x	x	x		x	x
Lysimachia vulgaris L.	x	x	x			
Lythrum salicaria L.	x	x	x			x
Lythrum virgatum L.		x			x	
Myosotis palustris (L.) Nath.em.Rchb	x	x	x	x		
Myriophyllum spicatum L.	x			x		
Myriophyllum verticillatum L.	x	x		x		x
Nuphar lutea (L.) Sm.	x	x	x	x	x	x
Nymphaea alba L.	x	x	x	x	x	x
Taxon	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Nymphoides peltata (Gmel.) Ktze.	x	x	x	x	x	x
Oenanthe aquatica (L.) Poir.	x	x	x		x	x
Phalaris arundinacea L.		x	x			x

Table 1. Contd.

	2003	2004	2005	2006	2007	2008
Phragmites australis (Cav.) Trin.	x	x	x	x	x	x
Polygonum amphibium L.	x	x	x	x	x	x
Polygonum hydropiper L.		x	x			
Polygonum mite Schrk.			x			
Polygonum persicaria L.		x	x			
Potamogeton crispus L.	x	x	x			x
Potamogeton lucens L.	x		x	x		x
Potamogeton panorminatus Bivona-Bernardi						x
Potamogeton pectinatus L.			x	x		
Ranunculus repens L.		x				
Ranunculus sceleratus L.					x	
Rorippa amphibia (L.) Bess.	x	x	x			x
Rorippa austriaca (Cr.) Bess.		x	x		x	x
Rorippa nasturcium-aquaticum (L.) Hay	x	x				
Rubus caesius L.	x	x	x		x	x
Rumex crispus L.					x	
Rumex hydrolapathum Huds.		x	x		x	x
Sagittaria sagittifolia L.	x	x	x	x	x	x
Salvinia natans (L.) All.	x	x	x	x		x
Schoenus nigricans L.					x	
Scirpus (Schoenoplectus) lacustris (Rschb.) L.	x	x	x	x	x	x
Scutellaria galericulata L.		x	x			
Sium latifolium L.	x					
Solanum dulcamara L.		x	x	x	x	
Solidago gigantea Ait.		x			x	
Spirodella polyrrhiza (L.) Schleid.	x	x	x	x	x	x
Stachys palustris L.	x	x	x	x		x
Symphytum officinale L.	x	x	x		x	x
Trapa natans L.	x	x	x	x	x	x
Typha angustifolia L.		x	x			
Urtica dioica L.		x	x		x	
Utricularia vulgaris L.	x		x	x		
Zannichellia palustris L.	x		x	x		x

Ceratophylletum demersi Hild 1956, *Ceratophyllo-nymphaeetum albae* Kárpáti 1963, *Glycerietum maximae* Hueck 1931, *Lemno minoris-Spirodeletum* Koch 1954, *Myriophylletum verticillati* Gudet 1924, *Nymphoidetum pelta-tae* Allorge 1922, *Oenantho aquaticae-Rorippetum amphibiae* Lohmeyer 1950, *Parvopotameto-Zannichellietum palustris* Koch 1926, *Polygono-Eleocharitetum ovatae* Eggler 1933, *Potametum lucentis* Hueck 1931, Potamo-Ranunculetum *circinati* Sauer 1937, *Sagittario-Sparganietum emersi* R. Tx. 1953, *Salvinio-Spirodeletum* Slavni 1956, *Trapetum natantis* Kárpáti 1963). After frequent floods of the Danube, communities of floating pondweeds appeared on the water surface. As a conse-quence of the lowest water-level, numerous uliginose plant species appeared in the communities of water-lily and pondweed. We described 81 plant species in the bed, (Table 1) out of which 10 species can be found in the Hungarian Red List: *Aster sedifolius* L., *Callitriche cophocarpa* Sendtn., *Hippuris vulgaris* L., *Leucojum aestivum* L., *Nuphar lutea* Smale., *Numphaea alba* L., *Nymphoides peltata* Ktze., *Salvinia natans* All., *Schoenus nigricans* L., *Zannichellia palustris* L. In the oxbow-bed we found 2 invasive species (*Asclepias syriaca* L., *Azolla filiculoides* Lam.), and 10 species which indicated the degradation of area. In each year under survey, more than 80 per cent of the bed was covered by vegetation, and vegetation cover showed considerably rising tendency from June to August. On the basis of 'the degree of degradation' the multiple floods (2005) and almost dried-out river-bed (2004, 2007) is both unfavorable for the macro-vegetation (Table 2). Water-level and alimentary substances supply influences the characteristics of marshy and aquatic associations. Strong changes in water level, especially near dried-out condition for a long time makes the area sensitive

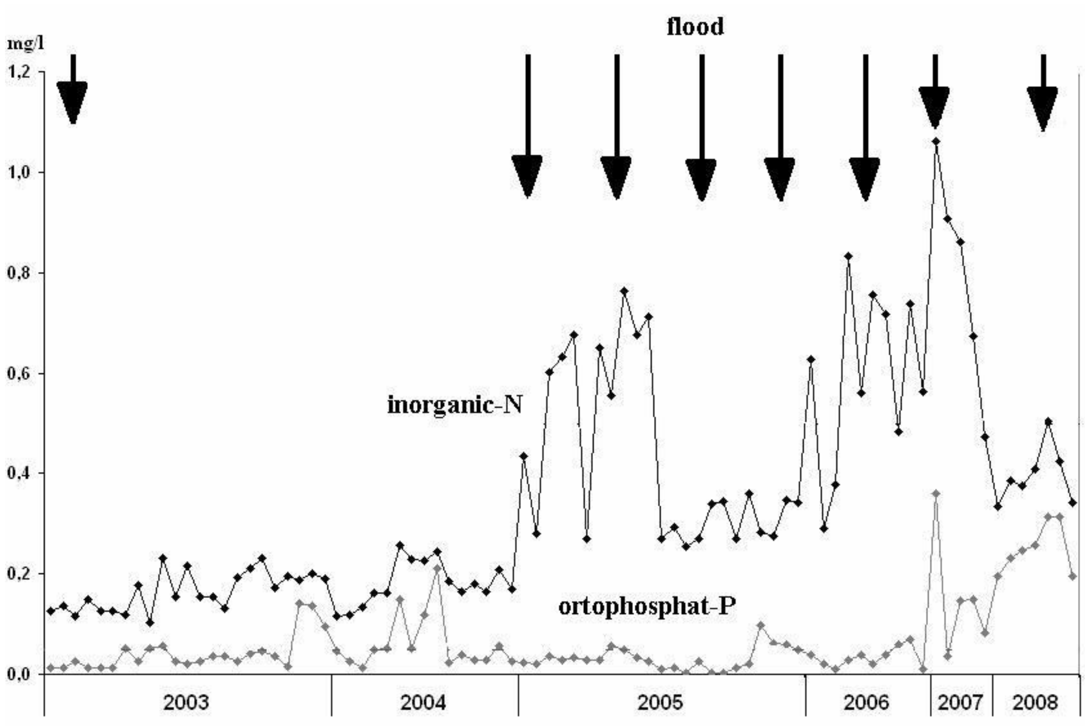

Figure 3. Concentrations of plant nutrient forms.

to the proliferation of disturbing resistant and weed species. Generally, contents of inorganic nitrogen-forms and dissolved orto-phosphate were low in the water of oxbow, as indicated by concentration of plant nutrients (Figure 3). Higher values of inorganic nitrogen coincided with water-supply of the Danube, while higher values of orto-phosphate were detected in those periods when water birds were frequent on this area. Within the period under survey, inorganic nitrogen content of Danubian water was 1 - 5 mg/l, while dissolved orto-phosphate content varied from 6 - 100 g/l. Plant nutrient content of the Danube and that of the oxbow are widely different, which is connected to the biological status and mainly the vegetation of the oxbow.

The water of the oxbow is mostly poor in planktonic producer organisms based on chlorophyll-a content of phytoplankton and periphyton, but in the floodless times (2004, 2007), when the water-level was very low, the number of planktonic producer organisms increased. During the algological examinations we identified 350 species of algae, out of which 59 were rare all over the country, among them 15 can be found in the Hungarian Red List (Német, 2005). The lists of algae, collected at different points in time, banded in accordance with hydrological condition (Figure 4). When the Danube floods reach the oxbow lake, quantity and quality of phyto-plankton were similar to the values in river, while during floodless times, their algae contents become totally different (in the river and in the separated water). We explained high number of taxa of the flagellate algae with high autochthon organic material content, which was also proven by the results of chemical oxygen demand (Table 2). On the basis of number of rare taxa, the floodless time (2003) and the inundation (2005) were favorable alike, because these years resulted in valuable algal flora.

"Nyéki-Holt-Duna" is mostly in a good ecological status as revealed by the evaluation of the non-taxonomic periphyton index. The life form of the underlay plants (floating-leaved, submerged, emergent) influences the quality and quantity of periphyton living on it. Floating-leaved plants have more favorable roles in this oxbow. On the basis of the periphyton of water-lily (*Nuphar lutea* L.) 2006 was unfavorable among the examined years. The state which was described by the physical-chemical parameters depends on the water-balance relations of the oxbow. During floods, it depends on the quality of water coming from the Danube, and during floodless times, it depends on the plant life.

During low water level in the oxbow lake the movement of the water was not typical. Therefore in these terms, areas with different water quality appeared, depending on the water depth and plant cover. There were clear relations of the Danube and the oxbow water regarding conductivity, pH-value, ion compound and N-spectrum.

Based on oxygen balance, we would qualify the "Nyéki-Holt-Duna" as risky, which was not caused by human activities but by unique hydrographical circumstances, weather and cover relations. In consequence of climatic factors and prolific vegetation, both extremely low (9%) and extremely high (258%) saturation levels of oxygen were detected in the oxbow, which is usually in a

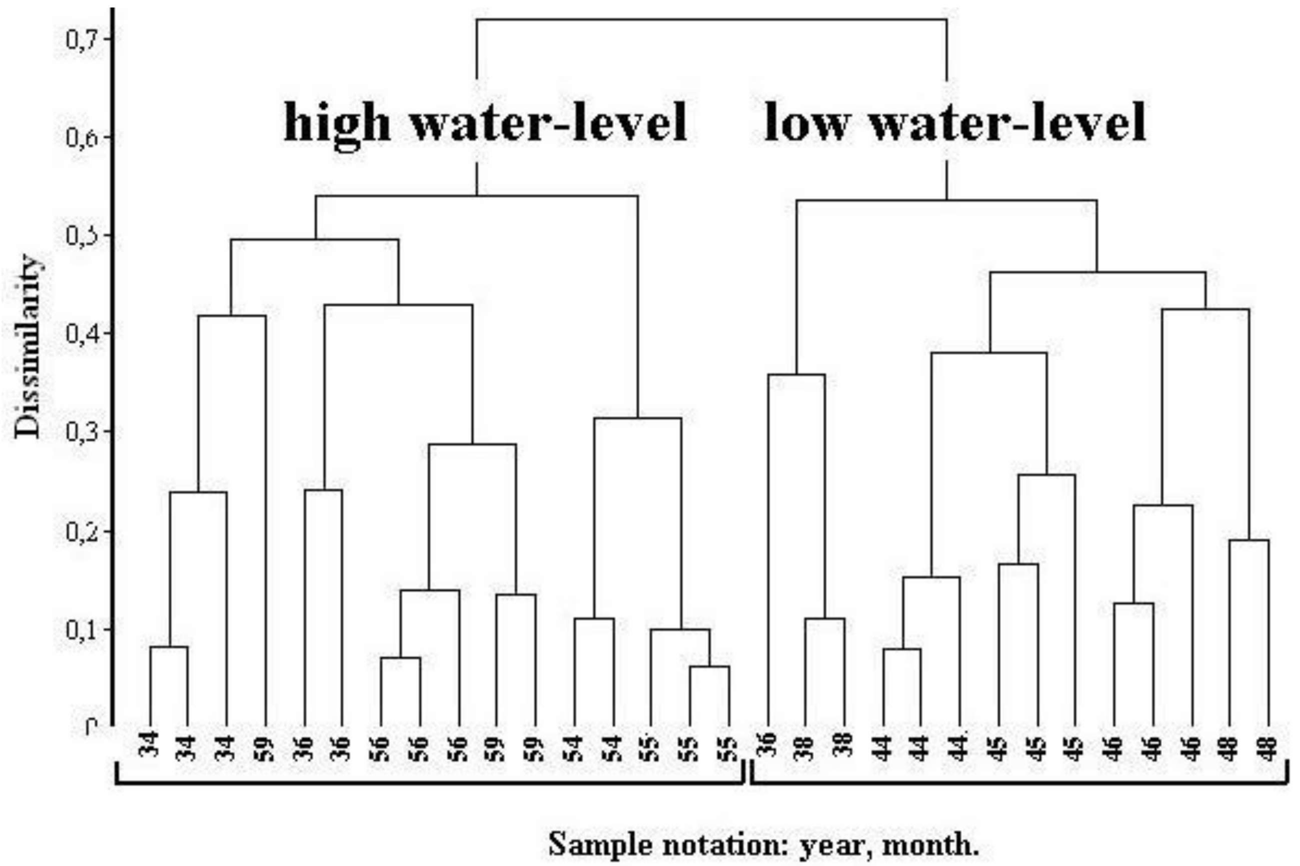

Figure 4. Hierarchical classification of algae sample (UPGMA, Yule).

Table 2. Changes of discussed parameters in "Nyéki-Holt-Duna" (considering the examinations of June).

		2003	2004	2005	2006	2007	2008
Average water-depht	cm	46	26	89	76	22	68
Number of assotiation		12	5	10	7	6	11
Degree of degradation		0.06	0.19	0.22	0.04	0.36	0.09
Number of plant species		30	34	25	45	25	33
Number 0f pondweed species		16	8	19	17	13	20
Average orthophosphate-P	mg/l	0.042	0.061	0.031	0.033	0.155	0.251
Average inorganic-N	mg/l	0.165	0.181	0.431	0.594	0.795	0.396
Average pH		7.9	8.3	7.7	7.6	8.4	7.7
Maximum pH		9.7	9.5	8.7	8.7	9.7	7.9
Average oxygen saturation	mg/l	64	79	77	152	180	147
Minimum oxygen sturation	mg/l	26	45	9	108	168	79
Average free ammoria	mg/l 0_2	0.007	0.005	0.005	0.030	0.290	0.007
Maximum free ammoria	µg/l	0.022	0.014	0.011	0.142	0.563	0.010
Average chemical oxygen demand	Mg/m^2	11.2	14.1	8.8	10.3	12.0	12.0
Average chlorophyll-a of fitoplankton		25	166	15	47	144	39
Average chlorophyll-a of periphyton		9.2	22.8	15.9	10.8		
Non taxonomic periphyton index		0.54	0.70	0.56	0.44		
Average number of algae	i/ml	7800	41000	1200			
Number of algae taxe		159	233	206			
Number of rare algae taxa		24	13	21			

changeable state and dries up at intervals. In 2005, we detected extremely low saturation level of oxygen under the floating vegetation of pondweeds. These low oxygen-levels can be perilous in ichtyo-biological respect, especially when this status persists and characterizes the whole area. Concentration of free ammonia is closely connected with inorganic nitrogen content and pH-value of the water. Therefore, summer months in years of low-water (2003, 2004 and 2007) marks proved to be critical periods, when besides levels of dissolved oxygen, pH and concentrations of free ammonia reached or exceeded the physiological limit values in several sample plots.

The largest stock of fish could be observed in 2003 and 2008, when spring floods enabled river-fish species to get into the oxbow. Feeding circumstances of water birds were improved by these riverine species, which utilized many organic matters of the shallow water organic matters (or detritus), bred in early summer and experienced rapid growth of biomass. Since floods did not occur in 2004 and 2007, the oxbow dried up and the stock of fish became minimal. In 2005 and 2006 the permanently high water-level enabled Danubian fish species to get into the oxbow, but during occasionally unfavourable hydro-chemical conditions, fish could get back to the river. The ecological status has a close relationship with the changes of the water-balance, since there was a definite relation between the hydrological state, the biological and the chemical quality. During floodless periods, resulting from low water, one or more of the chemical parameters became significantly dangerous as indicated by those organisms which are sensitive to them. Dry-out that spread almost all over the river-bed caused the deterioration of the chemical quality, which can be described by water chemical parameters, and the biological quality which is indicated by the examined flora and fauna. Return of the floods brought favorable changes regarding chemical and biological quality.

The ecological requirements of macro-vegetation are similar as the ornithological monitoring has revealed in connection with waterfowls. During the past few years, the most favorable states were the floodless periods occurring with slow diminution after the early-spring fill-up. The years which brought an almost dried-out bed were similarly unfavorable as the multiple floods with high water during one vegetation period. The “Nyéki-Holt-Duna” is a significant habitat for aquatic birds, so the primary aim of future conservational measures have to be the sustainability of ecological states in accordance with the requirements of aquatic birds. However, the aim cannot be the simulation of permanent and artificial maintenance of a state that is evaluated favorable from the point of view of both the waterfowls and the macro-vegetation. There is an important role of the ad hoc extreme states deriving from the dynamics of the river. It is essential to avoid dry-outs spreading over the most part of the bed which is evaluated ecologically unfavo-rable. That is why it is necessary and (according to ecological evaluations) enough for the bed to fill up once a year. There is an opportunity for this annually, during the spring flood of the Danube. Lack of flood would indicate the need for artificial water supply for the oxbow lake. However, further interventions are needed to effect these ideas. From ecological point of view the permanent high water -level in the bed of oxbow is also unfavourable, because it causes the change of habitat in the long run.

According to the results of analysis of Danube water-level, we have found out that the number of the days threatened by flood have decreased in the last 60 years. On the average, those years in which the floods are in frequent occurrence happen once in three years. Accordingly, we do not have to deal with the problem: avoiding the constantly high water-level in the bed of oxbow. The floods occurred in a higher level of water but also in less frequency. That is the reason why the storage of this amount of water is needed. The small and middle size water types returning in a decreasing level will cause difficulties at the water-replacement of the oxbow. The storing and the water-supply from the Channel Sió with the so-called long-channel solution (Marchand, 1993) has already arisen in 1993, which can ensure better water supply to the oxbow, from the northern boundary of Gemenc. This proposal cannot be applied nowadays owing to quantitative and qualitative problems of water of Channel Sió. The suitable solution is the establishment of artificial water -reservoir systems in the floodplain of the Danube near the oxbow (Figure 1). With the recon-struction methods (bed-deepening, damming) there could be reservoir on the floodplain developed which could function as a temporary habitat for waterfowls as well. The one-direction flow of water should be solved by the use of water-containers and other water-holding artificial objects. However, we should consider that sooner or later water-levels of the Danube will be artificially influenced in Hungary as well. Silting up of dead arms is a natural process which can only be delayed. Therefore, the oxbow will need selective dredging and improvement of water-balance, in order to preserve this habitat.

Conclusion

Since 2003 we have examined the ecological status of the “Nyéki-Holt-Duna” by determination of hydrological, hydro-chemical and hydro-biological parameters, and the macro-vegetation. The results proved that the site is slowly filling up in a natural way, and furthermore showed that there are connections between water-balance of the oxbow lake, and the water quality, and the nesting and feeding conditions for waterfowls. The running dry bed should be avoided. Therefore, the oxbow needs artificial water -supply if the flood does not occur in spring. How-ever, further interventions are needed to effect this. The work of habitat management should mean flexible conservation and preservation practice through revitalization by ensuring the predominance of natural processes and better water supply by technical interventions.

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REFERENCES

Andrikovics S, Forró L, Gere G, Lakatos G, Sasvári L (2006). Water bird guilds and their feeding connections in the Bodrogköz (North-East Hungary). Hydrobiologia 567: 31-42.

Borhidi A (2003). Magyarország növénytársulásai (The Hungarian Plant Communities). Akadémiai Kiadó, Budapest pp. 55-145.

Deák Cs, Gór D, Lakatos G (2008). Phytophilous macrofauna assessments in an important aquatic bird area: The Kis -Balaton Protection System. Acta Zool. Acad. Sci. Hung. 54: 75-83.

Guti G (2001). Water bodies in the Gemenc floodplain of the Danube. Hungary Opusc. Zool. 33: 49-61.

Lakatos Gy, Ács É, Kiss KM, Varga É, Bíró P (2006). Ecological classification of epilithon in two shallow lakes in Hungary. Verth. Internat. Verein Limnol. 29: 1782-1784.

Marchand M, Marteijn ECL, Klink A, Kalocsa B (1993). Floodplain rehabilitation Gemenc. Delft Hydraulics-RIZA-VITUKI, Budapest pp. 10-26.

Németh J (2005). Red list of algae in Hungary. Acta Bot. Hung. 47: 379-417.

Oláh JJr, Lakatos G, Andrikovics S, Oláh J (2006). Guilds of waterbirds as related to the limnology of wetlands. Canadian Wildlife Service Technical Report 474: 92-102.

Podani J (2001). Computer Programs for Data Analysis in Ecology and Systematics. Scientia Publishing, Budapest pp. 51.

Simon T (1988). Nature conservation ranks of the Hungarian vascular flora. Abstracta Botanica 12: 1-23.

Szlávik l, Sziebert J, Zellei L, Zsuffa I (1995). A Nyéki-Holt-Duna rehabilitációja (Rehabilitation of the Nyéki-Holt-Duna) Vízügyi Közlemények 3: 241-261.

Tardy J (2007). A magyarországi vadvizek világa. Hazánk ramsari területei (The Life of Hungarian Wetlands. Hungarian Areas in the List of Ramsar). Alexandra Kiadó, Pécs p. 25.

Zellei L (2003). A Nyéki-Holt-Duna vízforgalmának tervezése (Water circulation planning of the Nyéki-Holt -Duna) In: Élet a Duna ártéren (Life in the Danubian floodplain), Pécs pp. 89-97.

Zsuffa I (1993). A gemenci erd revitalizációjának vízimérnöki munkái (Technical devices of revitalization in Gemenc) Hidrológiai Közlöny 1: 53-56.