Acta Agrophysica, 2006, 7(2), 401-413

BIODIVERSITY IN THREE LOBELIAN LAKES IN RELATION TO THE CATCHMENT AREA INFLUENCE*

Marek Kraska, Ryszard Piotrowicz, Piotr Klimaszyk, Natalia Kuczyńska-Kippen, Elżbieta Szeląg-Wasielewska

Department of Water Protection, Adam Mickiewicz University
ul. Drzymały 24, 60-613 Poznań, Poland
e-mail: makra@amu.edu.pl

A b s t r a c t. The problem of anthropological transformation of the natural environment and the resulting species and habitat impoverishment is particularly important in relation to sensitive changes of ecosystems undergoing protection and being dependent on the surrounding ecosystems that have already been transformed. This often applies to soft-water lakes of a low trophy that are called 'lobelian lakes' due to the presence of a specific kind of vegetation. Such lakes are often situated within the transformed catchment areas. As a result of weakly buffered waters they often undergo accelerated processes of dystrophication and humification, while others undergo eutrophication. This paper presents an analysis of the present condition and changes within the last decade in the ecosystems of three reserve lobelian lakes.

K e y w o r d s: soft-water lakes, lobelian lakes, catchment area, water chemical properties, plankton, vegetation

INTRODUCTION

The problem of anthropogenic transformations of the natural environment that result in the impoverishment of species and habitat diversity is particularly essential in relation to the sensitive ecosystems of protected areas which remain in connection with surrounding transformed ecosystems. This concerns e.g. soft-water lakes of a low trophy – because of their specific vegetation called 'lobelian lakes' – which are often surrounded by more or less transformed catchment areas. Due to weakly buffered waters they are extremely sensitive to all changes in the catchment areas and to other external influences. Some of them undergo accelerated processes

* The paper was presented and published in the frame of activity of the Centre of Excellence AGROPHYSICS – Contract No.: QLAM-2001-00428 sponsored by EU within the 5FP.

of dystrophication and humification, while others undergo eutrophication [7]. In this paper an attempt was made to verify the above thesis, and furthermore to describe the biotic structure and the trophic status together with changes that have taken place in three ecosystems of examined lobelian lakes – reserve areas – in relation to the characteristics and changes in the catchment area maintenance.

MATERIAL AND METHODS

The structure of the catchment area was mapped based on physical-geographical features, taking into consideration parameters such as the surface area, the mean slope of the catchment area and its type of maintenance. The catchment area of the lakes was marked on topographical maps on a scale of 1: 10000. The character of the catchment area maintenance was determined according to above mentioned maps and to individual field examinations. The general influence of the catchment area on the lake and its natural susceptibility to degradation was calculated according to the Bajkiewicz-Grabowska [1] system.

Samples were collected in the deepest part of each lake in order to determine the stratification of water and to find the depth of particular thermal layers. During the period of summer stratification a thermal-oxygen profile was made and samples from each thermal layer (epi-, meta- and hipolimnion) were collected. The material was sampled using the water sampler "Toń" for every 1m in depth and then poured together within each thermal layer. The physical-chemical and biological analyses were made according to standard methods in accordance with the Polish Standards. Phytosociological studies included vegetation that made up an integral part of the lake ecosystem. The classical method of Braun-Blanquet was applied. Qualifying plant patches into a particular association was carried out according to Dąmbska [3], Matuszkiewicz [10] and Brzeg and Wojterska [2] classifications. Maps of lake vegetation were prepared using the transect method in the field, which allowed a comparison to be made of the structure of the phytolittoral of the examined water bodies.

RESULTS AND DISCUSSION

Characteristics of the lakes and their catchment areas

The examined lakes are small – of an area of between 10 and 15 ha – located in the upland area of Pomerania, at a height of 136 to 178.2 m a.s.l. They are non-throughflow – only Piekiełko Lake has periodical throughflow. That lake, due to its great depth, is also characterized by greater water volume compared to the two remaining reservoirs (Tab. 1).

Table 1. Basic morphometric features of the examined lakes and their catchment areas

Parameters	Piekiełko	Czarnówek	Iłowatka
Area (ha)	9.9	11.88	14.7
Max depth (m)	28	9.5	8.7
Mean depth (m)	12.6	4.3	3.6
Volume (thou m^3)	1335.6	508.5	529.2
Catchment area (ha)	**50.2**	**36.96**	**102.4**
Including: forests (ha)	26.5 (52.8%)	36.96 (100%)	36.2 (35.4%)
agricultural cultivation and waste land (ha)	23.7 (47.2%)	-	66.2 (64.6%)
Mean slope of catchment area (‰)	4.5	28.6	4.6

In the catchment area of Lake Piekiełko sand-clay soils dominate. Over half of its area is taken up by semi-natural beech forest with the addition of pines that overgrow the sloping parts of the catchment area reaching nearly as far as the lake bank. However, the greatest part of the surrounding agricultural area, comprising almost half of the catchment area, where cultivation activities have ceased in recent years, is now maintained extensively as live-stock pasture.

In the catchment area of Czarnówek lake podzol and peat soils dominate, and the catchment area is covered partly by pine forests with spruce plantings at the peat-bogs and peat pine forest habitats in the land depressions – where seasonally (in the spring) excess brown water rich in humic substances flows – partly through choked drainage systems – into the lake. This catchment area is only 3 times larger than the lake surface and is characterized by great area acclivity and its borders are indicated by a steep slope of lake gully.

The banks of Iłowatka Lake are partly sandy-stony, mostly slightly sloping in the direction of the lake. The lake is surrounded by narrow lines of trees, single in parts, particularly along the south-west bank, separating the lake from uncultivated fields. In the catchment area forests cover 35.4% of its area, the remaining part is swamp and fallows. The fragmentation of the forest area is large. There are remains of acidic beech forests, with the addition of oak and pine. There are also alder swamps and other swampy environments in the surrounding area, which in recent years have been partly drained by connecting them with drainage systems discharging into the lake. The water brought by these channels – during the spring thaw – contains considerable amounts of nutrients and humic substances.

The estimation of the natural susceptibility of lakes to degradation (according to the Bajkiewicz-Grabowska system, [1]) classifies lakes Piekiełko and Czarnówek in the group of those which are moderately resistant to external influences (category II). In the case of the first lake, a very advantageous feature, increasing its resistance to degradation, is its considerable depth and the great water volume of the lake basin. However, Lake Czarnówek is only slightly dependent on its catchment area due to the small size of the catchment area and the circular shape of the lake basin. Additionally, its considerably small mean depth, small water volume and low percent-

age of stratified waters indicate the intensity of matter circulation and the potentially high productivity of this lake.

Iłowatka lake was classified among those which are little resistant to external influences (category III), which was mainly a result of the great size of its catchment area, small volume, considerable length of its bank line and insufficient water stratification.

The estimation of the catchment areas of the investigated lakes as a potential source of organic matter transported into lakes revealed that these catchment areas are characterized by restricted opportunities for launching the area loads and small export of organic matter. Calculated loads of biogens reaching Piekiełko and Czarnówek lakes are similar and export from the catchment area is so low that one of the main sources of nutrient enrichment is atmospheric fall – in Czarnówek Lake it exceeds the inflow from the forest areas in the catchment area (Tab. 2). However, nutrient loads deposited in the Iłowatka Lake are nearly twice as large and the major part (over 60%) comes from agricultural cultivation areas.

Table 2. Load of nitrogen and phosphorus exported from the catchment area and flowing into the lake

Source	Piekiełko		Czarnówek		Iłowatka	
	Nitrogen (kg)	Phosphorus (kg)	Nitrogen (kg)	Phosphorus (kg)	Nitrogen (kg)	Phosphorus (kg)
Export from forest area	132	2.65	225.36	7.51	182.3	3.65
Export from fields and fallows	189.6	7.11	–	–	528.0	19.8
Inflow from atmospheric falls	288.4	7.21	378.0	9.45	431.0	10.5
Total	610	16.97	603.36	16.96	1141.3	34.25
Inflow to lake (g $year^{-1}$ m^{-2})	5.92	0.16	4.47	0.126	7.41	0.22

Physicochemical features of water

The waters of lakes Piekiełko and Czarnówek were characterized by high transparency (even though in the waters of the second lake considerable amounts of humic substances colouring the water brown were recorded), contrary to the water in Lake Iłowatka where Secchi disc transparency was much lower. Piekiełko Lake has waters of reaction close to neutral (though, going deeper in the lake the lowering of pH up to 5.98 in hypolimnion is observed). The characteristic feature of Lake Czarnówek is the acid reaction of water. According to criteria suggested by Stangenberg (pH < 6.5 and calcium concentration < 10 mg l^{-1}), lake Czarnówek should be classified as a dystrophic reservoir.

The characteristic feature of the compared lobelian lakes is the proportionally low amount of dissolved mineral salts, as reflected by their low electrolytic conductivity. The highest conductivity – nearly 70 μSm cm^{-1} – and concentrations of most mineral salts were found in the case of the water of Iłowatka Lake. In addition, the concentra-

tions of biogenic elements in waters of the described lakes were at quite a low level. It should be noticed that the highest concentrations of both nitrogen and dissolved (available for primary producers) forms of phosphorus occurred in Iłowatka lake (Tab. 3).

Table 3. Physical-chemical features of water of the epilimnion layer (summer stratification, 2003)

Parameters	Unit	Piekiełko	Czarnówek	Iłowatka
Transparency	m	5.2	4.05	2.05
Colour	mgPt dm^{-3}	10	15	32
BZT_5	mgO_2 dm^{-3}	1.6	1.2	3.8
ChZT with $K_2Cr_2O_7$	mgO_2 dm^{-3}	26.4	31.1	60.4
Conductivity	µSm cm^{-1}	39	27	69
pH	–	7.09	5.60	7.38
Ammonium nitrogen	mgN dm^{-3}	n.d.	0.29	0.32
Nitrite nitrogen	mgN dm^{-3}	n.d.	n.d.	n.d.
Nitrate nitrogen	mgN dm^{-3}	0.022	0.28	n.d.
Mineral nitrogen	mgN dm^{-3}	0.022	0.56	0.32
Organic nitrogen	mgN dm^{-3}	0.85	0.61	0.9
Total nitrogen	mgN dm^{-3}	0.872	1.17	1.22
Total phosphorus	mgP dm^{-3}	0.023	0.022	0.018
Dissolved phosphorus	MgP dm^{-3}	0.007	0.005	0.014
Alkalinity	mg$CaCO_3$ l^{-1}	0.17	0.09	0.38
Manganese	MgMn dm^{-3}	0.023	0.06	0.038
Potassium	MgK dm^{-3}	0.71	0.46	0.91
Sodium	mgNa dm^{-3}	2.15	1.49	1.97
Calcium	mgCa dm^{-3}	2.71	1.28	9.71
Magnesium	mgMg dm^{-3}	0.78	0.52	0.52
Hardness	^{o}n	0.56	0.3	1.48
Chlorophyll *a*	µg dm^{-3}	1.07	3.21	2.69

n.d. – not detected.

The oxygen conditions in the studied lakes were significantly differentiated (Fig. 1). The worst conditions were found in the open water zone of Iłowatka Lake. A well oxygenated zone was recorded at depth of 2 m from the surface layer, below this a sudden oxycline appeared, and from the depth of 4 m the water was completely deoxidized. In Czarnówek Lake the oxycline appeared at 4 m, and in Piekiełko at 6 m.

According to some papers [5,6,11], it should be mentioned that the physical-chemical parameters of the waters of the examined lakes have changed during the last 10 years. In Iłowatka Lake the concentrations of total phosphorus, mineral forms of nitrogen, organic matter and water colour have increased, while oxygen conditions have worsened. In Czarnówek Lake during the last decade the nutrient concentrations in water have not changed, however the water colour has intensified

to a much deeper brown. Moreover, the content of organic matter has increased (double increase of ChZT values).

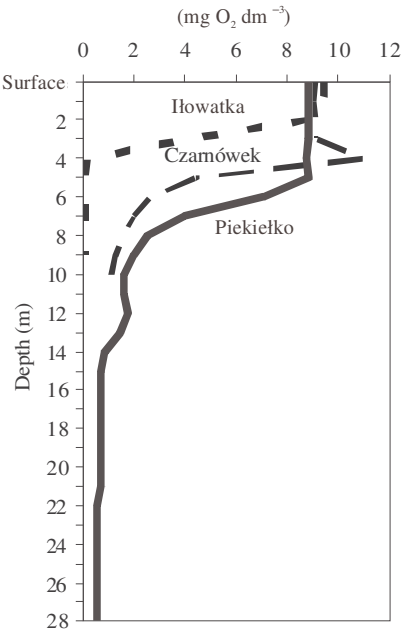

Fig. 1. Oxygen profiles of the examined lakes – August 2003

Vegetation of the examined lakes

Littoral layout of Piekiełko Lake offers limited possibilities of growth of the vegetation. The littoral is narrow and it drops sharply into the lake. The slope reaches over 50 degrees. In these conditions species characteristic for lobelian lakes prevail (Tab. 4). The plants are adapted to the occupation of extreme oligotrophic habitats. *Isoetes lacustris* is common in the lake, *Lobelia dortmanna* and *Littorella uniflora* are less often found there. In turn, there is an abundance of *Myriphyllum alterniflorum* which grows only in one big area.

Vegetation characteristic for lobelian lakes consists of four subgroups of *Isoeto-Lobelietum* and one group of *Myriophylletum alterniflori.* The zone occupied by patches of subassociation *I.-L. lobelietosum* and *I.-L. littorelletosum* as well as by the group *M. alterniflori* occurs at the western banks of the lake. The phytocenoses of the two first subassociations are represented by numerous dwellings of *L. dortmanna* or *L. uniflora.* Patches of the subassociation *I.-L. typicum* are common in places where the two above-mentioned kinds of plants characteris-

tic for lobelian lakes together with scarce existence of *I. lacustris* predominate. *L. dortmanna* and *L. uniflora* usually grow to the depth of 1 meter. *M. alterniflorum,* along with a small amount of lobelia, *I. lacustris* and moss *Warnstorfia trichophylla* dominate till the depth of 1.5 to 2 m. The isobath of 0.5 m sets the limit of the patches. The subassociation of *I.-L. isoetosum* patches is the most common in the lakes. The dominance of a species that distinguishes the *I. lacustris* subgroup occurs mainly on the western banks of the lake. It grows not only on southern banks but also on northern ones. It is found to the depth of 4 m in density not higher than 60%. *W. trichophylla* and *Drepanocladus sordidus* can also be observed in the places, however their amount is changeable.

Table 4. Structure of vegetation of investigated lakes

Vegetation	Piekiełko		Czarnówek		Iłowatka	
	m^2	%	m^2	%	m^2	%
Patches of Cl. *Phragmitetea*		**1.6**		**14.0**		**33.3**
Caricetum lasiocarpae Os.1923 em. Koch 1926			386	0.8	141	0.2
Caricetum rostratae Rubel 1912			1250	2.6	11109	16.9
Sagittario-Sparganietum erecti R. Tx. 1953	946	1.0				
Phragmitetum (Gams. 1927) Schmale 1939	588	0.6	1105	2.3	9353	14.2
Sparganietum erecti Roll. 1938			775	1.6		
Glycerietum maximae Hueck 1931			890	1.9		
Eleocharitetum palustris Schenn. 1919			1952	4.1	751	1.1
Typhetum latifoliae Soo 1927			350	0.7		
Equisetetum limosi					603	0.9
Patches of All. *Nymphaeion*		**1.0**				**44.5**
Nupharo-Nymphaeetum albae Tomasz. 1977					3505	5.3
Nupharetum pumili					21694	32.9
Potametum natantis Soo 1927	907	1.0			2584	3.9
Polygonetum natantis					1564	2.4
Patches of Cl. *Littorelletea*		**66.7**		**11.6**		**7.7**
Isoeto-Lobelietum lobelietosum	3317	3.6	3050	6.3	949	1.4
Isoeto-Lobelietum littorelletosum	6218	6.7	108	0.2	768	1.2
Isoeto-Lobelietum isoetosum	37157	40.1	2469	5.1	3004	4.6
Myriophylletum alterniflori	6488	7.0			357	0.5
patches with M. alterniflorum.+ L.dortnmanna + L. unflora	8628	9.3				
Patches of submersed bryophytes		**30.6**		**74.3**		**14.4**
patches with Sphagnum denticulatum			35712	74.3		
patches with Drepanocladus sordidus					9518	14.4
patches with Warnsdorfia trichophylla	20876	22.5				
patches with Warnsdorfia trichophylla + Isoetes lacustris	7552	8.1				

The sequence of subassociation and association patches described above is realized on a relatively short area of the southern bank. The remnants of the bank as well as a part of the northern bank are unsettled. Only closer to the western end of the lake can we observe dense occurrence of *I. lacustris, L. dortmanna* and *L. uniflora*. Patches of association *Potametum natantis* and phytocenosis *Sagittario-Sparganietum emersi* occur sporadically.

The lake is characterized by rich resources of water moss. The fact concerns especially very rare taxa called *W. trichophylla* and *D. sordidus.* A listed species *Warnstorfia fluitans* occurs scarcely along with the two above mentioned species.

The research carried out on Piekiełko Lake in the years 2000-2003 proved the stability of phytocenotic systems and their structure. The lake is not in danger of strong anthropopressure. European beech stands growing on the banks of the lakes are the only threat to the vegetation. The water surface is shaded by the trees, which limits the growth of species characteristic for lobelian lakes which are photophilous. The banks being shaded causes the extinction of the vegetation as well as covering the banks by falling European beech leaves.

In the Czarnówek Lake characteristic vegetation is represented by *Isoeto-Lobelietum* varied into four basic subassociations and several variants (Tab. 4). From these *I.-L. lobelietosum* belongs to the most common subassociations. On the border of lobelian spread, that is at the depth of 1 to 1.5 m, it is possible to observe an increase of *L. uniflora.* Patches of the species can be identified as the phytocenosis of *I.-L littorelletosum* sub-group.

Along with *L. uniflora* individuals of *I. lacustris* can be found. The floral composition of theses patches implies the existence of subassociation *Lobelietum typicum.* However, patches of sub-group *I.-L. isoetosum* are more often to be found. Peat moss *Sphagnum denticulatum* is the most common floral element in patches of the subassociation. Peat moss rule starts at the depth of 2 m and reaches up to 5 m. Vegetation that grows above the water surface is widely spread and phytocenosis *C. rostratae* and *C. lasiocarpae* can be observed.

At the western bank phytocenosis *Eleocharitetum palustris* is commonly present. It is sometimes replaced by *Glycerietum maximae.* Individual patches of *Phragmitetum communis, Typhaetum latifoliae* and *Sparganietum erecti* have also been listed.

The populations of species which are characteristic for lobelian lakes have perfect vegetation conditions in Czarnówek Lake. Big resources of the taxa as well as great condition shown by wide range of individuals prove the above statement.

In the Iłowatka Lake plants characteristic for lobelian lakes cover small patches of the phytolittoral surface (Tab. 4). *Isoetes lacustris* belonging to this species covers narrow belts of the phytolittoral to 1.0 m depth. Based on the following species the subassociation *Isoeto-Lobelietum isoetosum* was distinguished. *L. dortmanna,* the second taxon, occupies small parts of the phytolittoral. Never-

theless, the subassociation *Isoeto-Lobelietum lobelietosum* in variant with *Carex rostrata* develops in the Iłowatka Lake. The third taxon, *L. uniflora,* also occurs in small amounts in the phytolittoral zone. Patches of subassociation of *L. uniflora – I.-L. littorelletosum* – develop in the lake in various characters, the most widespread variant being that with *C. rostrata*.

All the species characteristic for lobelian lakes cover greater parts of the erosional zone of littoral, with the exception of *M. alterniflorum* whose small population was confirmed close to the reed belt, as a small remnant of a population widely spread in past years [9].

Contrary to the remains of small numbers of patches with the obligatory species of the lakes, vegetation belonging to the *Potametea* class develops intensively. This primarily concerns the species *Nuphar pumila* which covers shallow and parts of the lake, protected from waves and winds. *N. pumila* occurs there almost exclusively with *Nuphar lutea* and *Nymphaea alba.* Patches with *Polygonum amphibium* are found there, too, but sporadically. *Potamogeton natans,* another species belonging to the *Potametea* class and predominant and characteristic for the association has disappeared partly from previously occupied places. The existence of water moss *D. sordidus* which was recognized in Poland in lobelian lakes is worth emphasizing. Next to the few reed-belts patches in bank zones, there are two predominant elements: *C. rostrata* and *Carex lasiocarpa* which create well developed associations patches.

The extinction of the populations of vegetation characteristic for the lobelian lakes is caused by inflow of humic substances from neighbouring peat lands. As a result of changed vegetation conditions, mainly light penetration to the depth of water, the resources of these species: *L. dortmanna, I. lacustris, L. uniflora* and *M. alterniflorum* have shrunk.

Phytoplankton

Among the studied lakes, the phytoplankton of Piekiełko Lake was characterized by medium taxonomical richness which – after nearly 10 years – has increased by about 25% (Tab. 5). The greatest changes were observed among green algae (*Chlorophyceae*). Their participation in the phytoflora, mainly thanks to species of the order *Chlorococcales*, has increased up to nearly 40%. The greatest densities of phytoplankton in the first year of examination were found in the hypolimnion and next in the epilimnion. In both periods this was due to the development of nanoplanktonic cells: cyanobacteria, *Romeria elegans* (Wołosz.) Kocz. and *Merismopedia tenuissima* Lemm., species that can develop in the low light radiation in the deeper parts of the water, and green algae, mainly of genera *Chlorella* and *Monoraphidium.*

Table 5. Number of taxa and individuals of phytoplankton

a.) in August 1994

Vegetation	Piekiełko			Czarnówek			Iłowatka		
	Number	indiv. ml^{-1}		Number	indiv. ml^{-1}		Number	indiv. ml^{-1}	
Group	of taxa	epi-	mean	of taxa	epi-	mean	of taxa	epi-	mean
Cyanophyceae	5	302	4855	1	2	3	13	1907	2189
Euglenophyceae	1	0	0	1	0	0	1	0	3
Cryptophyceae	3	20	32	3	20	151	5	416	280
Dinophyceae	3	4	8	3	784	573	3	8	9
Raphidophyceae	0	0	0	0	0	0	0	0	0
Chrysophyceae	5	12	11	2	4800	1947	5	448	496
Bacillariophyceae	3	55	23	0	0	0	2	37	43
Haptphyceae	0	0	0	0	0	0	0	0	0
Prasinophyceae	0	0	0	0	0	0	1	0	496
Chlorophyceae	11	60	98	7	841	1028	20	574	491
Conjugatophyceae	7	46	19	3	20	11663	2	142	119
Total	**38**	**499**	**5046**	**20**	**6467**	**15365**	**52**	**3532**	**4126**

b.) in August 2003

Vegetation	Piekiełko			Czarnówek			Iłowatka		
	Number	indiv. ml^{-1}		Number	indiv. ml^{-1}		Number	indiv. ml^{-1}	
Group	of taxa	epi-	mean	of taxa	epi-	mean	of taxa	epi-	mean
Cyanophyceae	6	880	560	1	53	115	12	309	228
Euglenophyceae	3	2	8	2	0	2	4	8	4
Cryptophyceae	4	46	23	4	24	17	4	22	129
Dinophyceae	2	9	5	4	29	14	2	8	4
Raphidophyceae	1	3	1	1	73	43	0	0	0
Chrysophyceae	2	15	9	9	263	525	6	95	38
Bacillariophyceae	1	11	8	1	0	0	6	0	6
Haptphyceae	0	0	0	0	0	0	1	250	128
Xanthophyceae	1	3	1	0	0	0	0	0	0
Chlorophyceae	19	1064	745	9	564	1137	18	925	579
Conjugatophyceae	9	85	73	4	8	4	2	12	18
Total	**48**	**2118**	**1433**	**35**	**1014**	**1857**	**55**	**1629**	**1134**

In Czarnówek Lake the differences between the periods of investigation were less significant and concerned the taxonomical structure of phytoplankton as well as dominating species, the size of their populations and their distribution in the open water. In the first part of the study the phytoplankton was numerous and was concentrated in the hypolimnion. *Conjugatophyceae* from genus *Cosmarium* and *Chrysophyceae* from genus *Dinobryon* dominated quantitatively. In 2003 a significant increase in the species richness (up to 15 taxa) was observed, while the densities, in the epilimnion as well as mean values for the water column, decreased considerably which suggests an improvement in trophic conditions.

Moreover, the occurrence in the second period of the lake examination of a numerous population of *Gonyostomum semen* (Ehr.) Diesing, species characteristic for phytoplankton communities of small mid-forest lakes undergoing eutrophication, indicates an increase of trophic conditions in the water of this water body.

The structure of the phytoplankton community of lake Iłowatka was characterized by high diversity, the highest of the three investigated lakes (Tab. 5). Also the differences between particular periods were very small. However, the total abundance of phytoplankton in the epilimnion decreased by half and the mean value in the water column around 3 times. It should be emphasized that phytoplankton community structure was unfavourable due to the high participation of cyanobacteria and/or green algae in the total densities as well as due to the presence of taxa characteristic for eutrophic lakes: *Limnothrix redekei* (Van Goor) Meffert, *Aphanizomenon gracile* Lemm, *Scenedesmus* spp., *Tetrastrum* spp

Zooplankton

Analysing the zooplankton of the examined lakes it was found that the taxonomically richest communities were found in Piekiełko Lake (26 species). Moreover, among these the presence of *Holopedium gibberum* Zaddach, a cladoceran characteristic for lakes of arctic Europe and North America, was recorded. This species prefers cold, oligotrophic water bodies of low hardness and low pH [4]. The densities of zooplankton communities ranged, depending on depth, from 149 to 553 ind dm^{-3}. There were also found 5 species indicating eutrophy and 5 mesotrophy, however, eutrophic species constituted only between 2% and 17% of total zooplankton abundance, while mesotrophic 14% to 47%.

In Czarnówek lake only 16 species were identified, which was probably due to the very low pH of the water, which negatively influences species richness. Additionally, among the quality structure the presence of two species indicating the acid reaction of water – *Keratella serrulata* f. *curvicornis* (Rylov) and *Polyarthra minor* Voight was found. The first species also belonged to one of the dominating forms of this lake. Also the numbers of individuals were quite low, reaching the mean values of 75 ind. dm^{-3}. The participation of eutrophic species was also very low, reaching only between 0.5% and 14% of the total densities.

The taxonomical structure of Iłowatka Lake was the richest compared to the two previous lakes (31 species). The presence of the northern cladoceran *Holopedium gibberum* was also recorded in this reservoir. The zooplankton abundance reached the mean values of 133 ind. dm^{-3}. But, analysing the participation of species characteristic for eutrophy, it was found that they accounted for between 17% and 34% of the total zooplankton densities, indicating considerably high trophy of the waters of Iłowatka Lake.

CONCLUSIONS

1. Lakes Piekiełko and Czarnówek – and Iłowatka to a lesser extent – have unfavourable conditions for maintaining unchanged trophic status in the absence of external interference. This is a result of the reduced activity of the catchment area in supplying the lakes with biogens and organic matter.

2. Every change in the usage of the catchment area – drainage of swamp areas within the catchment area, development of agricultural cultivation, intensification of tourism, destruction of barriers – may be followed by disturbances in the functioning of these ecosystems, including the increase of trophy – symptoms which were clearly observed in Iłowatka Lake. Also the accelerated process of dystrophication of Lake Czarnówek is a result of attempts undertaken in the past to dry the peatbogs in the catchment area.

3. Both of the above-mentioned processes have led to the elimination of characteristic plant species and indicating forms for oligo- and mesotrophic waters of phyto- and zooplankton communities.

REFERENCES

1. **Bajkiewicz-Grabowska E.:** The assessment of the natural susceptibility of lakes to the decline and the role of the drainage area in this process. Wiad. Ekol., 33 (3), 279-289, 1987.
2. **Brzeg A., Wojterska M.:** Plant assotiations of Wielkopolska Great Poland, of getting to know them by the state and threatening. [In:] Wojterska M. (ed.): Flora and vegetation of Great Poland and West Pomeranian Lakeland. Guide for field sessions of 52. PTB meeting (in Polish), Poznań, 24-28.09.2001, 39-110, 2001.
3. **Dąmbska I.:** Vegetation of littoral zone of lobelian lake in Kartuskie Lakeland (In Polish), PTPN, Prace Kom. Biol., 30, 3, 55, 1965.
4. **Flössner D.:** Kiemen- und Blattfusser, Branchiopoda, Fischlause, Branchiura. VEB Gustav Fisher Verlag, Jena, 1972.
5. **Klimaszyk P.:** The materials essential for the preservation plan of the nature reserve „Jezioro Piekiełko" (in Polish)., Poznań, (mscr), 42, 2004.
6. **Kraska M.:** The materials essential for the preservation plan of the nature reserve „Jezioro Iłowatka" (in Polish), Poznań, (mscr), 32, 2004.
7. **Kraska M., Piotrowicz R.:** Lobelian lakes: specificity, trophy, vegetation and problems of the preservation. [In:] Preservation of lakes and bogs of the Central Pomerania (in Polish). Towarzystwo Ekologiczno-Kulturalne w Bobolicach, Biul., 3, 5-27, 2000 (in Polish)
8. **Kraska M., Piotrowicz R., Klimaszyk P.:** Lobelian lakes in Poland (in Polish), Chrońmy Przyr. Ojcz., 52, 3, Kraków, 5-25, 1996.
9. **Kraska M.** (ed.) Stocktaking of unique lobelian lakes of West Pomerania and determining stores of protected plant species. (in Polish), Poznań, (mscr), 113, 1996.
10. **Matuszkiewicz W.:** Guidebook for meaning plant communities of Poland (in Polish), PWN, Warszawa, 1982.
11. **Piotrowicz R.:** The materials essential for the preservation plan of the nature reserve "Jezioro Czarnówek" (in Polish), Poznań, (mscr), 43, 2004.

RÓŻNORODNOŚĆ BIOLOGICZNA W TRZECH JEZIORACH LOBELIOWYCH W KONTEKŚCIE ODDZIAŁYWAŃ ZLEWNI

Marek Kraska, Ryszard Piotrowicz, Piotr Klimaszyk, Natalia Kuczyńska-Kippen, Elżbieta Szeląg-Wasielewska

Zakład Ochrony Wód. Uniwersytet Adama Mickiewicza
ul. Drzymały 24, 60-613 Poznań
e-mail: makra@amu.edu.pl

S t r e s z c z e n i e. Problem antropogennych przemian środowiska przyrodniczego prowadzących do ubożenia różnorodności gatunkowej i siedliskowej jest szczególnie istotny w odniesieniu do wrażliwych na zmiany ekosystemów obszarów chronionych powiązanych z otaczającymi je przekształconymi ekosystemami. Dotyczy to m.in. miękkowodnych jezior o niskiej trofii – zwanych ze względu na specyficzną roślinność „jeziorami lobeliowymi" – które często otoczone są mniej lub bardziej przekształconymi zlewniami. Z powodu słabo zbuforowanych wód część z tych jezior ulega przyspieszonej dystrofizacji i humifikacji, a inne eutrofizacji. W pracy przeanalizowano stan i zmiany w ciągu ostatnich kilkunastu lat w ekosystemach 3 jezior lobeliowych – rezerwatów przyrody. Bezpośrednie otoczenie jednego z tych rezerwatów jeziornych stanowią seminaturalne lasy bukowe w typie buczyny pomorskiej i ugorowane tereny rolnicze. Ekosystem tego jeziora lobeliowego należy określić jako „zrównoważony". Drugie z tych jezior ma stosunkowo niewielką zlewnię całkowicie pokrytą borami sosnowymi, borami bagiennymi i torfowiskami wysokimi – w przeszłości antropogennie przekształconymi poprzez nasadzenia sosny i świerka oraz próby osuszania torfowisk przez odprowadzanie bogatych w związki humusowe wód bezpośrednio do jeziora. Efektem jest postępująca dystrofizacja i humifikacja wód jeziora oraz stopniowe ograniczanie występowania charakterystycznych dla jezior lobeliowych gatunków roślin. Natomiast zlewnia trzeciego jeziora – rezerwatu została silnie antropogennie zmieniona, a w jeziorze obserwuje się wyraźne symptomy humifikacji i eutrofizacji w wyniku, której nastąpiła eliminacja izoetidów.

S ł o w a k l u c z o w e: jeziora lobeliowe, zlewnie, fizyko-chemia wód, plankton, roślinność