

LONG-TERM CHANGES IN THE MACROPHYTES OF THE ZAGŁĘBOCZE
LAKE IN THE LUBLIN POLESIE

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A b s t r a c t. Phytosociological studies on the littoral vegetation of the Zagłębocze Lake conducted in the summer of 1999 showed a considerable transformation of the phytolittoral. Extensive meadows with rare *Lychnothamnus barbatus* and *Nitella flexilis* disappeared completely. Formerly noted species: *Chara mucronata*, *Myriophyllum alterniflorum* (covering large areas) and other vascular plants were not found any longer. The place once occupied by vegetation with narrower ecological requirements was taken by photocenoses of *Ceratophyllum demersum* and *Elodea canadensis*; *Phragmites australis* superseded *Potamogeton lucens*, *Scirpus lacustris* and *Heleocharis palustris*.

K e y w o r d s: macrophytes, associations, vanishing species, lake

INTRODUCTION

Lakes belong to the most valuable natural ecosystems in the Łęczna-Włodawa Lake District. Deterioration of their ecological condition has been observed for many years [17]. The most common forms of anthropopressure are agriculture and recreation. Construction of the Wieprz-Krzna Canal with its reclamation system resulted in the land over-drying. The area of lakes located in this region decreases gradually [8], and their trophic condition becomes worse [19]. Lowering of the water level and water deficit are global problems at present. However, they are of primary importance in the region discussed, as waters can be found here at a very shallow level. Lacustrine vegetation, directly affected by water quality, is subjected to radical changes. Some lakes are used for recreation, which results in a diminishing or a

complete disappearance of littoral communities, can be an example here the Piaszno Lake [1,4].

The aim of the studies was to describe changes that took place in the littoral vegetation of the Zagłębcze Lake during the last 30-40 years.

MATERIAL AND METHODS

The Zagłębcze Lake is located in the protected zone of the Landscape Park the "Łęczna Lake District" (latitude of $51^{\circ}26'-51^{\circ}27'$ north, longitude of $23^{\circ}01'-23^{\circ}02'$ east). The Lake covers an area of 59.0 ha. Its maximum and average depth is 25 m and 7.3 m, respectively. The Lake is 942 m long and 798 m wide; its shoreline length is 2 879 m [21]. This is an inland lake of a dimictic type. The catchment basin area is 463.64 ha, including meadows and pastures – 34.5%, forests – 33.5%, arable land – 12.4%, shrubs, bushes, trees – 2.7%, recreation and other areas – 2.1% [7].

In the summer of 1999, the aquatic and rush vegetation of the Zagłębcze Lake was studied by a phytosociological method [2]. Phytosociological units are given after Matuszkiewicz [15].

RESULTS

Results present the former and present condition of macrophytes of the Zagłębcze Lake. Phytosociological examinations allowed to distinguish 17 associations. The areas occupied by particular phytocenoses are given in Table 1. Forty-three phytosociological records are presented in Tables 2-4. A list of some rare species registered at present and before (by other researchers) in this region is also included (Table 5 [6,11-13]).

The phytolittoral of the Zagłębcze Lake was subjected to considerable qualitative and quantitative transformations over the past years. The total number of communities changed slightly (Table 1). It was difficult to determine which plants formed phytocenoses and which constituted a "minority" only (in Tables the occurrence of the communities described in references is denoted by crosses). It was assumed that in the years 1965-1978 four phytocenoses from the *Charetea* class were described [11,12,14]. Fijałkowski [6] reported that in parts S and E of the littoral he observed numerous *Chara fragilis* plants, which could form an association there. The stonewort zone was locally dominated by *Nitellopsis obtusa* alone or with a large share of *Lychnothamnus barbatus* [12,13]. The role of other stoneworts, i.e., *Chara fragilis* var. *hedwigii*, *Nitella flexilis*, *N. mucronata*, in the struc-

Table 1. Communities of vegetation in the phytolittoral of the Zagłębcze Lake of the Łęczna-Włodawa Lake District

Communities	*	1999(%)
Number of communities	15	17
Cl. Charetea:	1956-78	
O: <i>Charetalia fragilis</i>		
All: <i>Nitellion flexilis</i>		
1. <i>Nitelletum flexilis</i>	+	
All: <i>Charion fragilis</i>		
2. <i>Nitellopsidetum obtusae</i>	+	0.7
3. <i>Charetum aculeolatae</i>		0.4
4. <i>Charetum fragilis</i>	+	0.1
5. <i>Charetum contrariae</i>	+	
6. Ass. with <i>Lychnothamnus barbatus</i>	+	
Cl. Potametea:	1955-57	1.2
O: <i>Potametalia</i> :		
All: <i>Potamion</i> :		
7. <i>Ceratophylletum demersi</i>	+	26.7
8. <i>Elodeetum canadensis</i>		22.2
9. <i>Potametum lucentis</i>		0.5
10. <i>Myriphyllletum spicati</i>		0.2
All: <i>Nymphaeion</i> :		49.6
11. <i>Potametum natantis</i>		3.6
12. <i>Hydrocharitetum marsus - ranae</i>	+	3.1
13. <i>Nymphaeetum candidae</i>		0.2
Cl: <i>Litorelletea uniflorae</i> :		6.9
O: <i>Litorelletalia uniflorae</i> :		
All: <i>Lobelion</i> :		
14. <i>Myriphylo-Littorelletum</i>	+	
C.: <i>Phragmitetea</i> :		
O: <i>Phragmitetalia</i>		
All: <i>Phragmition</i> :		
15. <i>Phragmitetum austriale</i>	+	35.1
16. <i>Scirpetum lacustris</i>	+	1.8
17. <i>Typhetum angustifoliae</i>	+	4.4
18. <i>Eleocharitetum palustris</i>	+	0.3
All: <i>Magnocaricion</i> :		41.6
19. <i>Caricetum rostratae</i>	+	0.3
20. <i>Caricetum acutiformis</i>		0.2
21. <i>Caricetum ripariae</i>		0.1
22. <i>Caricetum gracilis</i>	+	
23. <i>Caricetum elatae</i>	+	
		0.6

**Charetea* (1965-78) by Karczmarz *et al.* [13,14], the remaining part (1955-57) by Fijałkowski [6]

Table 2. Communities of the class Charetea

Community*	1	2	3
Number of relevés	2	1	1
Cl. Charetea:			
<i>Nitellopsis obtusa</i> (Desevaux) J. Groves	II ⁵ 8750	I ² 1750	
<i>Chara fragilis</i> f. Hedvigii Ag.		I ⁴ 6250	
<i>Chara fragilis</i> Desvaux	I ² 1750		
<i>Chara aculeolata</i> Kutz.			I ⁵ 8750
<i>Lychnothamnus barbatus</i> (Meyen) v. Leonhardi	II ¹ 500		
<i>Chara delicatula</i> Ag.	I ¹ 500		
Cl. Potametea:			
<i>Elodea canadensis</i> Michx.	I ² 1750	I ² 1750	I ⁺ 10
<i>Ceratophyllum demersum</i> L.	I ¹ 500	I ⁺ 10	I ⁺ 10

*1 – *Nitellopsidetum obtusae* (Sauer 1937) Dąbwska 1961 1961, 2 – *Charetum fragilis* Fijałkowski 1960, 3 – *Charetum aculeolatae* (Coryllion 1957) [5]

ture of phytocenoses was limited. They formed a 10-15 (18) m belt on the NW, N and NE shores of the lake, at a depth of 3.5-4.5 m. Water transparency varied from 3 to 8 m [18]. In 1999 it was at a level of 3.0-3.3 m. At present only two phytocenoses with the domination of *Nitellopsis obtusa* were found: the smaller one in part SE, the bigger one in part SW of the Lake. *Lychnothamnus barbatus* was not numerous there, and did not form phytocenoses of its own (Table 2). This species was also observed in the phytocenoses of other associations, e.g., *Potametum lucentis*, *Scirpetum lacustris* (Tables 3 and 4). The place once occupied by *Nitellopsis obtusa* and *Lychnothamnus barbatus* was then taken by *Elodeetum canadensis* and *Ceratophylletum demersi*. The vanishing of *Lychnothamnus barbatus* its localities in Poland and Europe are few [5,10], indicates deterioration of the habitats condition and replacement of stenotopic species (such as the stoneworts) by the eurytopic ones. In the Polesie Lubelskie, the only areas occupied by *Lychnothamnus barbatus* can be found on the Rogóžno Lake. Neither associations nor single plants of *Nitella flexilis* or *N. mucronata* were found in the present studies (Table 5). The occurrence of *Chara contraria* was not confirmed, either. A single phytocenosis with *Charetum fragilis* was noted in part N of the Lake.

A new association, not mentioned by other authors, is *Charetum aculeolatae*. Its single phytocenosis was found in part WE of the Lake (near a beach), 1 000 m² in the belt with *Elodea canadensis* and *Ceratophyllum demersum*. *Chara delicatula* – not noted before – was observed in a phytocenosis with *Nitellopsidetum obtusae* in part SW of the Lake (Tables 2 and 5).

Table 3. Communities of the class *Potametea*

Community*	1	2	3	4	5	6	7
Number of relevés	5	4	2	2	1	3	1
Cl. Potamogetonetea:							
<i>Ceratophyllum demersum</i> L. s.s.	V ⁴⁻⁵ 7750	III ⁺² 590	II ¹⁻² 1125	II ¹ 500	I ¹ 500	III ⁺¹ 337	
<i>Elodea canadensis</i> Michx.	II ² 1750	IV ⁴⁻⁵ 7500	II ² 1750	II ² 1750		III ⁺² 753	I ⁺ 10
<i>Potamogeton lucens</i> L.	II ¹⁻³ 2125	I ² 478	II ⁴ 6250		I ² 1750		
<i>Myriophyllum spicatum</i> L.	III ⁺¹ 337	I ¹ 125		III ⁵ 8750	I ¹ 500	II ¹ 333	I ⁺ 10
<i>Potamogeton natans</i> L.	I ⁺ 10				I ⁵ 8750		I ¹ 500
<i>Stratiotes aloides</i> L.	II ⁺² 880	II ²⁻³ 2750		I ² 875		III ³ 3750	I ³ 3750
<i>Nymphaea candida</i> C. Presl	I ¹ 500	I ¹ 125			I ² 1750	I ⁺ 3	I ³ 3750
<i>Ranunculus circinatus</i> Sibth.	IV ⁺² 1003	III ⁺³ 1420	I ⁺ 5	I ⁺ 5	I ⁺ 10	II ⁺¹ 170	I ¹ 500
<i>Nuphar lutea</i> (L.) Sibth. et Sm.		I ⁺ 3					
Cl. Charetea:							
<i>Lychnothamnus barabatus</i> (Meyen) v. Leonhardi			I ¹ 125				
<i>Nitellopsis obtusa</i> (Desevaux) J. Groves					I ⁺ 10	I ² 583	
Cl. Phragmitetea:							
<i>Typha angustifolia</i> L.					I ⁺ 10		

*1 – *Ceratophylletum demersi* Hild. 1956, 2 – *Elodeetum canadensis* (Pgn. 1953) Pass. 1964, 3 – *Potametum lucentis* Hueck 1931, 4 – *Myriophylletum spicati* Soe 1927, 5 – *Potametum natantis* Soe 1923, 6 – *Hydrocharitetum morsus – ranae* Langendenck 1935, 7 – *Nymphaeetum candidae* Miljan 1958

Table 4. Continued

Community*	1	2	3	4	5	6	7
Number of relevés	4	2	5	3	3	2	2
Cl. Potamogetonetea:							
<i>Potamogeton lucens</i> L.	I ¹ 125		III+ 10				
<i>Elodea canadensis</i> Michx	IV ⁺² 690	II ⁺ 10	II ⁺ 7	IV ⁺² 1052	II ⁺ 10		III ⁺² 753
<i>Ceratophyllum demersum</i> L.	III ⁺² 878	I ² 875	II ⁺¹ 583	II ⁺¹ 102	I ¹ 250		II ⁺¹ 170
<i>Myriophyllum spicatum</i> L.	II ⁺ 5		III ¹ 500	I ⁺ 2	II ² 1750		II ⁺² 587
<i>Stratiotes aloides</i> L.	I ¹ 125	I ¹ 250	I ⁺ 3	II ⁺¹ 102			
<i>Nuphar lutea</i> (L.) Sibth. et Sm.		I ² 875					
<i>Nymphaea candida</i> C. Presl		I ¹ 250		I ² 350			
<i>Potamogeton natans</i> L.		II ¹⁻² 1125		II ⁺¹ 102	I ⁺ 5		
<i>Polygonum amphibium</i> f. natans			I ³ 583				
<i>Ranunculus circinatus</i> Sibth.	I ¹ 125			I ⁺ 2	I ⁺ 5		I ⁺ 3
<i>Hydrocharitetum morsus-ranae</i> L.					I ⁺¹ 255	II 250	

Table 4. Continuation

Community*	1	2	3	4	5	6	7
Number of relevés	4	2	5	3	3	2	2
Cl. Charetea:							
<i>Lychnothamnus barabatus</i> (Meyen) v. Leonhardi	I ¹	125					
Accompanying species:							
<i>Lycopus europaeus</i> L.					I ⁺ 2	II ⁺¹ 225	I ⁺ 5
<i>Juncus effusus</i> L.							I ⁺ 5
<i>Epilobium hirsutum</i> L.							I ⁺ 5
<i>Potentilla palustre</i> (L.) Scop.					I ¹ 100		
<i>Lemna trisulca</i> L.				I ⁺ 3	I ⁺ 2		
<i>Solanum dulcamara</i> L.						I ⁺ 5	
<i>Polygonum amphibium</i> f. tresrrre				I ⁺ 3			I ¹⁺² 880
<i>Bidens tripartita</i> L.						I ¹ 250	I ¹ 250
<i>Bidens cernua</i> L.							
<i>Eupatorium cannabinum</i> L.							I ⁺ 5
<i>Alnus incana</i> (L.) Moench							I ⁺ 5
<i>Mentha aquatica</i> L.						I ⁺ 5	I ⁺ 5
<i>Cirsium palustre</i> (L.) Scop.						I ¹ 250	
<i>Salix cinerea</i> L.							I ⁺ 5
<i>Lysimachia vulgaris</i> L.							I ⁺ 5

Sponginella lacustris on the *Phragmites australis* in the Nord Zagłębcze Lake. 1 – *Scirpetum lacustris* (Allorge 1922) Chouard 1924, 2 – *Typhetum angustrifoliae* (Allorge 1922) Soe 1927, 3 – *Eleocharitetum palustris* (Eennikov 1919, 4 – *Phragmitetum australis* (Gams 1927) Schmale 1939, 5 – *Caricetum ripariae* (Soe 1928, 6 – *Caricetum acutiformis* Sauer 1937, 7 – *Caricetum rostratae* Ruubel 1912

Table 5. List of rare species in the Zagłębcze Lake in the years: A – 1957-72 [11], 1953-57 [6]

Taxons	A	B
1. <i>Nitella flexilis</i> (L.) Agardh	+	
2. <i>Nitella mucronata</i> (A. Be.) Miquel	+	
3. <i>Nitellopsis obtusa</i> (Desvieux) J. Groves	+	+
4. <i>Lychnothamnus barbatus</i> (Meyen) v. Leonhardi	+	+
5. <i>Chara contraria</i> Kutz.	+	+
6. <i>Chara aculeolata</i> Kutz.		+
7. <i>Chara fragilis</i> Desvieux	+	+
8. <i>Chara fragilis</i> f. <i>Hedvigii</i> Ag.	+	+
9. <i>Chara delicatula</i> Ag.		+
10. <i>Myriophyllum alterniflorum</i> DC.	+	
11. <i>Potamogeton filiformis</i> Pers.	+	
12. <i>Najas marina</i> L.	+	
13. <i>Butomus umbellatus</i> L.	+	
14. <i>Sparganium minimum</i> Wallr.	+	

Phytosociological records show that the floral diversity of the class *Charetea* is not as wide as it used to be. The number of species decreased from 3-13 (8 on average) to 3-4 (4 on average).

Apart from stoneworts, *Myriophyllo-Littorelletum* phytocenoses (the variant with *Myriophyllum alterniflorum* only) could also be found in the immersed plant zone. *Myriophyllum spicatum*, *Polygonum amphibium*, *Potamogeton perfoliatus* and *Elodea canadensis* were observed in this association as well [6]. *Ceratophylletum demersi* phytocenoses developed in parts S and E of the Lake shore. Nowadays they dominate over other plants in this zone, constituting more than 1/4 of the phytolittoral area. Together with *Elodeetum canadensis*, they form an immersed plant zone (Table 1). This suggests that water quality deteriorates, as among immersed plants *Ceratophyllum demersum* displays the highest tolerance for shading [9]. *Myriophyllo-Littorelletum* phytocenoses (the variant with *Myriophyllum alterniflorum*) are an indicator of oligotrophic waters [20], so their disappearance is a sign of deterioration of ecological relations. The occurrence of some *Potametum lucentis* phytocenoses in the belt with *Elodea canadensis* indicates growing trophy of the ecosystem [16]. The range of plant occurrence diminished and the trophogenic zone (i.e., the zone of plant access to light) became smaller. The index of colonization, reflecting the extensiveness of this zone, is 1.28 in the Zagłębcze Lake, whereas in the Rogóżno Lake which is morphometrically similar, located in the close vicinity and equally deep – it reaches 1.46 [3]. In the Lake Rogóżno, 42.4% of the phytolittoral are compact areas covered by *Lychnothamnus barbatus*. Its catchment basin is afforested, and is not subjected to such intensive

anthropopressure as that of Zagłębcze Lake. Over 1/3 of the shoreline of the latter one is open for recreation. There are many beaches, piers and summerhouses there, and cars are permitted to park on its shores. The immersed plant zone constitutes ca. 50% of the phytolittoral (Table 1).

The zone of plants with floating leaves consists mainly of *Polygonetum nantatis* (not noted before, an indicator of eutrophic waters) and *Hydrocharitetum morsus-ranae* (the variant with *Stratiotes aloides*, already described).

The rush zone also underwent significant changes. *Phragmites australis* superseded *Scirpus lacustris* and *Heleocharis palustris* [6]. It forms a belt, almost surrounding the Lake, at a depth of 1-1.5 m. It is a well-known fact that the area covered by reed increases when habitat quality deteriorates.

CONCLUSIONS

As a result of intensive anthropopressure, the littoral vegetation of the Zagłębcze Lake underwent the following changes:

- the zone of plants from the class *Charetea* became species-poor, at the cost of such phytocenoses as *Nitelletum flexilis* and *Lychnothamnus barbatus* (very rare in both Poland and Europe);
- the place once occupied by communities from the class *Charetea* and phytocenoses with *Myriophyllum alterniflorum* was taken by those with *Ceratophylletum demersi* and *Elodeetum canadensis*;
- the area covered by *Phragmitetum australis*, earlier occupied by phytocenoses with *Scirpus lacustris* and *Heleocharis palustris*, increased;
- the index colonization of the littoral vegetation decreased and water transparency diminished, which indicates deterioration of the ecological condition of the Lake Zagłębcze.

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DŁUGOTERMINOWE ZMIANY ROŚLINNOŚCI JEZIORA ZAGŁĘBOCZE
NA POLESIU LUBELSKIM

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S t r e s z c z e n i e. Badania fitosocjologiczne roślinności jeziora Zagłębcze przeprowadzone latem 1999 roku wykazały dużą przebudowę fitolitoralu. Całkowicie zginęły rozległe łany z rzadką ramienicą *Lychnothamnus barbatus* oraz *Nitella flexilis*. Nie odnaleziono również wcześniej notowane gatunki *Chara mucronata*, *Myriophyllum alterniflorum* (tworzył duże powierzchnie) oraz inne rośliny naczyniowe. Miejsce roślinności o węższych wymaganiach ekologicznych zajęły fitocenozy *Ceratophyllum demersi*, *Elodeetum canadensis*, *Potamogeton lucens* oraz *Scirpus lacustris* i *Heleocharis palustris* został wyparty przez *Phragmites australis*.

S ł o w a k l u c z o w e: jeziora, makrofity, zespoły roślinne, gatunki ginące