

## PHYTOLITTORAL OF SOME LAKES IN IŁAWSKIE AND ŁĘCZYŃSKO-WŁODAWSKIE LAKE DISTRICTS

Joanna Sender

Department of Hydrobiology and Ichthyobiology, Agricultural University of Lublin  
B. Dobrzańskiego str. 37, 20-262 Lublin, Poland, e-mail: joanna.sender@ar.lublin.pl

**Summary.** Phytolittoral plays a very important role in the functioning of the whole water ecosystem. Its role is more significant if macrophytes cover large water surface areas. The aim of this work was to determine the area of phytolittoral, its habitat differentiation, distribution and biomass of macrophytes in lakes with different origin, geographical location and drainage basin management. Sampling studies were made in vegetation season in 2004. The investigations were carried out in 4 lakes: Ząbrowo and Zielone – Iławskie Lakeland, as well as Skomielno and Rotcze – Łęczyńsko-Włodawskie Lakeland. The area covered with macrophytes was rather large – 67% of lake surface in lakes of Iławskie Lakeland and even 73% in lakes of Łęczyńsko-Włodawskie Lakeland. Therefore, the habitat conditions in these lakes are favourable for them, as indicated by the high values of macrophyte biomass, especially in lake Ząbrowo which was almost totally covered with vegetation. The distribution of macrophytes was slightly diverse in the investigated lakes of both lake districts. Significant differences were in the share of emergent macrophytes. Notably richer in respect of species number was phytolittoral in the lakes of Łęczyńsko-Włodawskie Lakeland.

**Key words:** lakes, macrophytes, biomass

### INTRODUCTION

Littoral it is the richest zone in lakes in respect of fauna and flora qualitative and quantitative structure. The way of this zone development depends on a lot of factors [Bernatowicz 1960]. The littoral zone is the only one place where macrophytes appear. Macrophytes are built by vascular plants and charophytes. Distribution of macrophytes occurring in littoral zone, their qualitative and quantitative structure, are very diverse in trophically differentiated lakes. The littoral covered with macrophytes – phytolittoral, plays a huge role in the functioning of all water ecosystems. Its environment-forming role is the more significant if macrophytes cover greater water surface areas. Species composition, the range of appearance and biomass of macrophytes let us to describe the trophic state of a lake [Ozimek 1983].

The aim of this work was to describe the area of phytolittoral, its habitat differentiation, distribution and biomass of macrophytes in lakes with different origin, geographical location and drainage basin management. Moreover, the range of macrophytes occurring and littoral type were determined.

## STUDY AREA, MATERIAL AND METHODS

The investigations were carried out in 4 lakes in the vegetation season in 2004. Lakes Ząbrowo and Zielone are situated in Iławskie Lakeland. They are rather shallow and eutrophic. The origin of these lakes was connected with activity of the last glaciation. They are young glacial lakes. Lakes Skomielno and Rotcze are situated in Łęczyńsko-Włodawskie Lakeland. They are also shallow, with lightly eutrophic waters, of thermokarstic origin. They are old glacial lakes [Harasimiuk *et al.* 1998].

The macrophyte studies were carried out in horizontal transects, whose distribution was dependent on their differentiation as well as on the activity in the catchment area (Fig. 1). Together with biocenotic researches, the basic physicochemical factors of water were analysed, such as: pH, visibility (SD), conductivity, oxygen concentration.

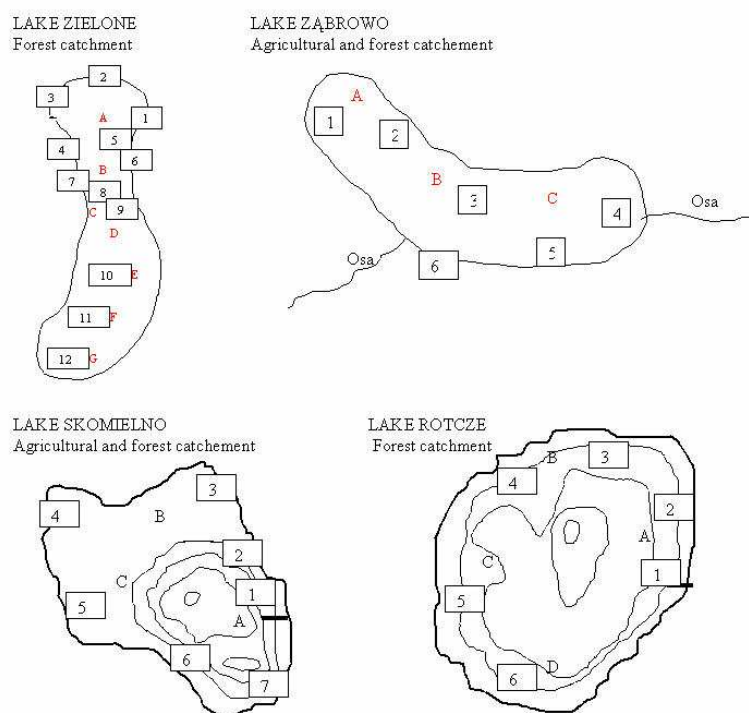


Fig. 1. Distribution of investigated transects  
Rys. 1. Rozmieszczenie stanowisk badawczych

Macrophytes were investigated in the lakes from the shallowest points of their occurrence to the outer edge of the littoral zone. The Bernatowicz type of sampler (0.16 m<sup>2</sup> sampling area) was used to obtain data on species composition, range of occurrence and biomass of macrophytes at 0.5 m depth intervals [Bernatowicz 1960]. The area of phytolittoral as well as the length of shoreline occupied by macrophytes were determined using the maps with actual vegetation of these lakes and the planimeter.

Table 1. Morphometric and physicochemical factors in the investigated lakes  
Tabela 1. Dane morfometryczne i fizyczno-chemiczne jezior

Lake – Jezioro	Ząbrowo	Zielone	Rotcze	Skomielno
Water surface area (ha)	12.7	20.2	42.7	35.8
Volume (tys. m <sup>3</sup> )	139.7	262.6		
Visibility (SD) (m)	0.9	1.2	2.7	2.0
Max. depth. (m)	1.6	2.4	4.3	3.2
Length of shoreline (m)	2290	1375	2449	2200
Conductivity (μS cm <sup>-1</sup> )	349	94	189	250
PH	8.1	8.3	9.1	7.5
O <sub>2</sub> (mg O <sub>2</sub> dm <sup>-3</sup> )	13.9	8.8	7.67	9.9
Ca (mg Ca dm <sup>-3</sup> )	73.5	25.7	34.1	43.5

## RESULTS

In the investigated lakes the area occupied by macrophytes was very different. The largest area covered with macrophytes was noted in Lake Rotcze – 89% of water surface area, as well as in Lake Ząbrowo – 86%. The smallest area covered with macrophytes was in Lake Zielone – 49% of water surface area (Fig. 3). In all investigated lakes phytolittoral was developed along shoreline, and its width was fluctuated. The narrowest belt of macrophytes was developed in Hawskie Lakeland lakes – max 4 m. In these lakes 80% of the shoreline was covered with emergent macrophytes. Whereas in lakes of Łęczyńsko-Włodawskie Lakeland macrophytes occupied from 99% (Lake Rotcze) to 100% (Lake Skomielno) of shoreline and the emergent macrophytes belt was even 30 m wide.

The share of individual ecological types of macrophytes was different in all of the investigated lakes. The emergent macrophytes share was the highest in Lake Skomielno – 83%, while in Lake Rotcze emergent macrophytes constituted 91% (Fig. 2)

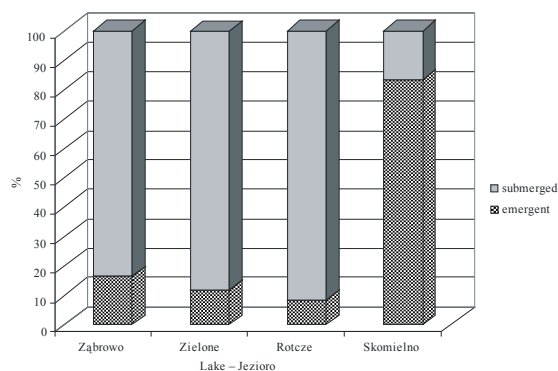


Fig. 2. Participation of individual ecological types of macrophytes in phytolittoral in investigated lakes  
Rys. 2. Udział poszczególnych typów ekologicznych makrofitytów w tworzeniu litoralu badanych jezior

In the investigated lakes the range of macrophytes occurrence was diverse and depended on the maximum depth of the lake, since the highest max. depth and the range of macrophytes were observed in lakes of Łęczyńsko-Włodawskie Lakeland (Fig. 4). Respectively, the deepest places where macrophytes appeared were in Lakes Rotcze, and the shallowest one in Lake Zielone.

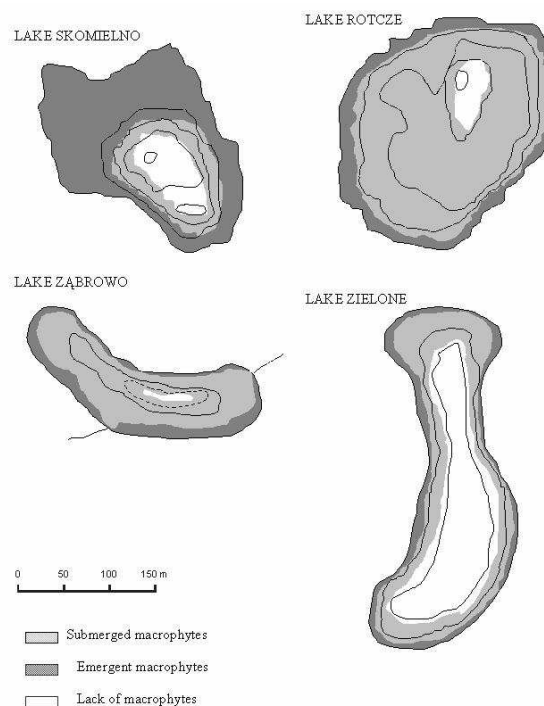


Fig. 3. Distribution of emergent and submerged macrophytes in investigated lakes  
 Rys. 3. Rozmieszczenie makrofitów wynurzonych i zanurzonych w badanych jeziorach

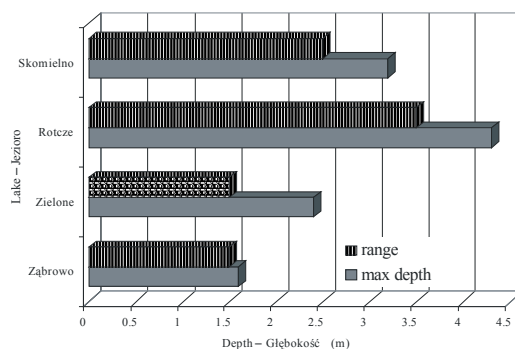


Fig. 4. Range of appearance of macrophytes and the maximum depth in investigated lakes  
 Rys. 4. Zasięg występowania makrofitów oraz głębokość maksymalna poszczególnych jezior

Different numbers of species were found in phytolittoral of the investigated lakes. These species belonged to three ecological types of water plants: emergent macrophytes, plants with floating leaves, and submerged macrophytes. The highest number of species – 25 species, built the phytolittoral in Lake Skomielno. In lakes of Iławskie Lakeland the number of species ranged from 15 to 16 species. In all the investigated lakes emergent

macrophytes were the most diverse. They were represented by 7 species in Lake Rotcze and by as many as 12 species in Lake Skomielno. In the lakes of Iławskie Lakeland there were only 2 or 3 species of emergent macrophytes (Fig. 5).

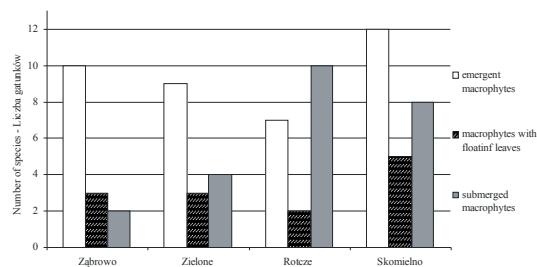


Fig. 5. Number of macrophyte species in investigated lakes  
Rys. 5. Liczba gatunków makrofitytów w badanych jeziorach

Based on distribution and qualitative structure of macrophytes in the investigated lakes, three types of littoral were distinguished: marshy phytolittoral, small-lake phytolittoral, and pond-type phytolittoral [Bernatowicz 1974]. Their share in the investigated lakes was different (Fig. 6).

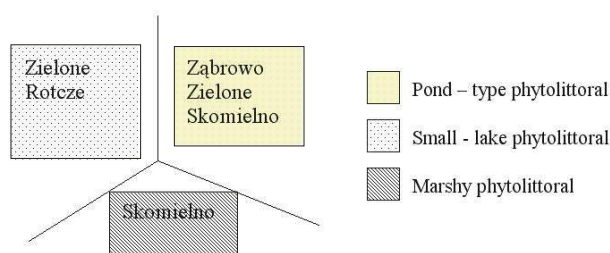


Fig. 6 Types of littoral in investigated lakes  
Rys. 6. Typy litoralu w badanych jeziorach

The highest total biomass of macrophytes occurred in Lake Ząbrowo –  $4.2 \text{ t ha}^{-1}$  of phytolittoral. Straight majority of this biomass was mostly composed of submerged macrophytes and reached  $3.9 \text{ t ha}^{-1}$  (Fig. 7).

The lowest total biomass of macrophytes, only  $1.8 \text{ t ha}^{-1}$  of phytolittoral, was observed in Lake Zielone. In this lake there was also the lowest biomass of emergent macrophytes, at only  $0.1 \text{ t ha}^{-1}$ . The highest biomass of this group of macrophytes was developed in Lake Skomielno, where it reached  $2.3 \text{ t ha}^{-1}$ . Very similar quantity of total macrophytes biomass was observed in other lakes of Łęczna-Włodawa Lakeland (Tab. 2) [Sender 2003] and in the eutrophic lakes of Masurian Lakeland [Ozimek 1983].

In the investigated lakes there was a clear diversity of biomass at particular depths. In the lakes of Iławskie Lakeland the biomass increased together with depth. Evidently the lowest biomass was observed at the depth of 0.5 m – emergent macrophytes. In the lakes of Łęczyńsko-Włodawskie Lakeland at the depth of 0.5 m the biomass of emergent macrophytes was the highest and decreased with increasing depth (Fig. 8).

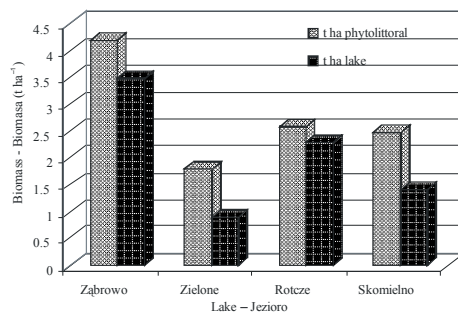


Fig. 7. Biomass of macrophytes in investigated lakes  
Rys. 7. Biomasa makrofitych badanych jezior

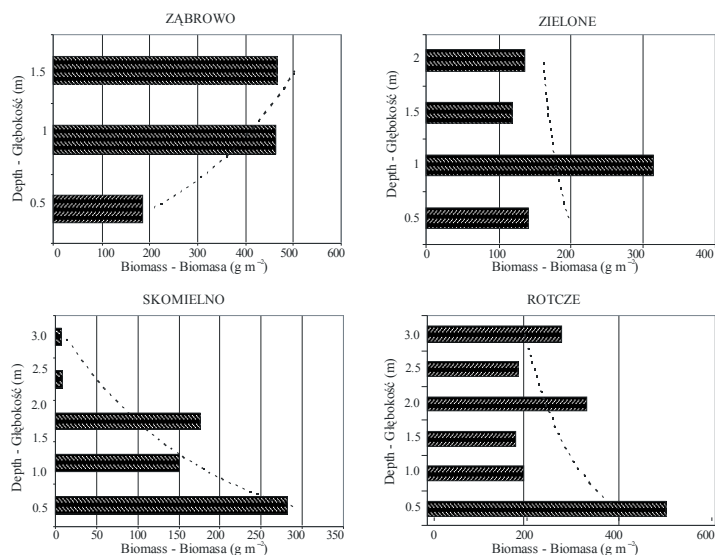


Fig. 8. Distribution of macrophytes biomass at particular depths in investigated lakes  
Rys. 8. Rozmieszczenie biomasy makrofitych na poszczególnych głębokościach w badanych jeziorach

Table 2. Biomass of macrophytes  
Tabela 2. Kształtowanie się biomasy makrofitych

Lake Jezioro	Lake surface area (ha)	Littoral surface area (ha)	Emergent macrophytes area (ha)	Submerged macrophytes area (ha)	Total biomass		Biomass of macrophytes on phytolittoral surface area		Biomass of macrophytes on lake surface area	
					W	Z	W	Z	W	Z
					(t)	(t)	(t ha⁻¹)	(t ha⁻¹)	(t ha⁻¹)	(t ha⁻¹)
Ząbrowo	12.7	10.9	1.8	9.1	3.3	42.2	0.3	3.9	0.26	3.3
Zielone	20.7	10.3	1.2	9.1	1.7	17.3	0.16	1.6	0.08	0.8
Rotcze	42.5	37.9	3.2	34.7	15.9	82.2	0.42	2.16	0.37	1.9
Skomielno	35.8	20.4	17	3.4	47.8	2.9	2.3	0.1	1.3	0.01

W – emergent – wynurzone; Z – submerged – zanurzone

## DISCUSSION

All of the investigated lakes belong to the macrophyte-dominated type of lake [Scheffer *et al.* 1993].

They are rather small, shallow and more or less eutrophic lakes, so that the area covered with macrophytes is rather large – on average 67% of water surface area in lakes of Hławskie Lakeland and 73% in lakes of Łęczyńsko-Włodawskie Lakeland. Therefore, the habitat conditions in these lakes are favourable for macrophytes, as evidenced by the high values of biomass, especially in Lake Ząbrowo.

In the 60s the average surface of phytolittoral in Polish lakes gained 31% of water surface area [Bernatowicz and Radziej 1964]. Probably the process of eutrophication of waters that followed since caused the growth of the area covered with macrophytes. But this process cannot take place endlessly. In the end macrophytes will retreat [Pieczyńska and Ozimek 1976, Ozimek 1990, Królikowska 1997, Donabaum *et al.* 1999].

The distribution of macrophytes was slightly diverse in the investigated lakes of both lake districts. Significant differences were noted in the percentage share of emergent macrophytes. In the lakes of Hławskie Lakeland they formed only a narrow belt, while in the lakes of Łęczyńsko-Włodawskie Lakeland they were very well developed.

In the lakes of Hławskie Lakeland the highest values of biomass were achieved by submerged macrophytes, while in the lakes of Łęczyńsko-Włodawskie Lakeland by emergent macrophytes.

The development of the emergent macrophytes belt could be the effect of catchment influence. In these lakes agricultural catchment dominated, while in the lakes of Hławskie Lakeland the dominating type of catchment was agricultural and forest. Macrophytes, especially emergent, constitute the main and the first receiver of nutrients flowing down from the catchment [Nagengast 1998, Ozimek 1991].

Absolutely richer in respect of species number was phytolittoral in the lakes of Łęczyńsko-Włodawskie Lakeland. Higher species diversity, especially submerged macrophytes, could signify good light conditions in the lakes. Highly significant is the share of light-loving and mezotrophic species such as charophytes. In the lakes of Hławskie Lakeland the highest share in biomass was that of species with small light needs such as: *Ceratophyllum demersum* and *Elodea canadensis* [Kłosowski and Kłosowski 2003].

The range of macrophytes occurrence is one of the main indicators of habitat conditions. The highest range means the best light conditions. Lake Ząbrowo, because of its small surface area and depth is almost wholly covered with macrophytes.

Emergent macrophytes were observed along all the shorelines in the lakes of Łęczyńsko-Włodawskie Lakeland, whereas in the lakes of Hławskie Lakeland big fragments were without it. The main reason is the way of activity in the catchment.

## CONCLUSIONS

1. In all the investigated lakes macrophytes had good conditions for development.
2. Higher diversity of macrophytes species was observed in the lakes of Łęczyńsko-Włodawskie Lakeland
3. The area covered with macrophytes was very similar in the investigated lakes

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#### CHARAKTERYSTYKA FITOLITORALU WYBRANYCH JEZIOR POJEZIERZA IŁAWSKIEGO I ŁĘCZYŃSKO-WŁODAWSKIEGO

**Streszczenie.** Fitolitoral odgrywa ogromną rolę w funkcjonowaniu całego ekosystemu wodnego. Jego środowiskotwórcza rola jest tym bardziej znacząca, im większą zajmuje powierzchnię i im bardziej jest zróżnicowany. Celem pracy było określenie powierzchni fitolitoralu, jego zróżnicowania gatunkowego, rozmieszczenia biomasy makrofitytów w jeziorach o różnym pochodzeniu, położeniu geograficznym oraz odmiennym zagospodarowaniu ziemi w zlewni. Badania prowadzono w 4 jeziorach: Ząbrowo i Zielone – Pojezierze Iławskie oraz Skomielno i Rotcze – Pojezie-



rze Łęczyńsko-Włodawskie, w sezonie wegetacyjnym w 2004 r. Powierzchnia jaką zasiedlały makrofity była duża, średnio 67% powierzchni lustra wody dla jezior Pojezierza Iławskiego i 73% dla jezior Pojezierza Łęczyńsko-Włodawskiego. Zatem warunki do rozwoju są dla nich bardzo korzystne w tych jeziorach. Świadczyć mogą o tym także wysokie wartości biomasy, a zwłaszcza w jeziorze Ząbrowo, które niemalże całkowicie porośnięte było roślinnością. Rozmieszczenie makrofity było nieznacznie zróżnicowane w jeziorach badanych pojezierzy. Istotne różnice zaznaczyły się w udziale makrofity wynurzonych. Bogatszy pod względem gatunkowym był fitolitoral jezior poleskich.

**Słowa kluczowe:** jeziora, makrofity, biomasa