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THE HYDROBOTANICAL CHARACTERISTIC OF FIRLEJ AND KUNÓW LAKES

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Summary. Lakes are dynamic ecosystems, changing over time. Their development lead to the enrichment and intensification of biological production. The aim of this study was botanical analysis in two eutrophic lakes with agricultural catchment, differing in morphometry and forms of anthropogenic pressure. The study included two lakes: Firlej and Kunów. In the studied lakes, 16 plant communities occurred. Studied lakes Firlej and Kunów despite proximity and similar stage of catchement development, but different anthropogenic pressures are different in terms of lake flora. Tourism seems to exert less pressure than agriculture. Lake Firlej has a good ecological state with predominance of submerged macrophyte, lake Kunów represents moderate ecological status with majority of emergent macrophytes. In both lakes during a nearly 100 years changes in the phytocenotic composition were small.

Key words: macrophytes, ecological state, phytolittoral, usage of catchment area

INTRODUCTION

Lakes are dynamic ecosystems, changing over time. Their development lead to the enrichment and intensification of biological production. This process is accompanied by changes in reservoir morphometry and physico-chemical features of water. Natural process of limnological succession proceeds usually harmonically. Filling the reservoir by sediment and overgrowing by vegetation, cause shallowing and transformation. Development of human activity may intensify this process [Danulska 2010]. Plants as a lake ecosystem are constantly evolving, the pace depends on the natural and anthropogenic pressures on the ecosystem. Plants play a role in a protection of waters against pollution runoff, and also affect the circulation of nutrients and water quality. Their role is changeable, depending on the growth phase, species and degree of fertility of the water as well as reservoir morphometry [Ławniczak 2006, Sender 2007].

In eutrophic lakes extensive changes in macrophyte species composition happen, biomass and size of the area being occupied. In general, lakes of this group accompanied a small range of plants but a high density and low diversity. Initially, growth of trophy increases species richness, which consequently reduces the occurrence of submerged macrophytes. A phytoplankton, among primary producers, begins to dominate. This process occurs differently in different lakes. However, in reservoirs with high trophy gradually leads to their disappearance, both in deep lakes and shallow [Pieczyńska 2008].

The aim of this study was botanical analysis in two eutrophic lakes with agricultural catchment, differing in morphometry and forms of anthropogenic pressure.

STUDY AREA AND METHODS

The study included two lakes: Firlej and Kunów lake located 1.5 km away from Firlej Lake. Both are situated in the furrow of the old bank Wieprz valley.

Lake Kunów is a flow-through lake. Czerwonka River flows into the lake on the southern edge of lake, and flows out to the northwest. However, it brings to the lake eutrophic water flowing from the catchment area, mainly agricultural. This results in a temporary exclusion from the recreational use of lake [Wilgat *et al*. 1994.

Lake Kunów on the basis of compliance to degradation is not very resistant [Bajkiewicz-Grabowska 1987]. It is characterized by a smaller than Firlej Lake depth, especially the average. Its shape resembles an isosceles triangle (Tab. 1). The nearest building is 25 meters from a shoreline.

Lake Firlej belongs to a group of Firlej Lakes, it has a typically agricultural catchment, in which forests account 20%. This reservoir is used mostly for recreational purposes. Nearby, sometimes just 9 m away, are located numerous recreational centers, urban buildings and summer resorts, as well as a cemetery about 35 m from the shoreline. It has almost a circle shape and a quartz bottom almost without bottom sediments. The lake has an artificial canal, which is connected with a ditch flowing into Kunów lake, in order to drain meadows separating these two reservoirs.

Table 1. Morphometric parameters of investigated lakes

Parameter	Kunów	Firlej
Surface, ha	117.5	91.3
Depth max, m	6.2	9.5
Depth mean, m	2.1	5.0
Length of shoreline, m	3850	3450
Dominant usage of catchment	agriculture	agro-forestry

The study of macrophytes was conducted during a growing season in 2011 and 2012. Plant communities were examined and identified on the based of phytosociological releves method of Braun-Blanquet [Fukarek 1967]. The syntaksonomic system was adopted according to Matuszkiewicz [2008].

Biomass, species composition and range of macrophytes were analyzed in horizontal transects from shoreline to the maximum depth of their occurrence (Fig. 1). Distribution of transects was dependent on diversity of vegetation and land use in the catchment area appointed by the index of the minimum number of transects (MLT) [Jensen 1977]. Samples were taken at 0.5 m depth, for this purpose a floristic rake was used with samples area 0.16 m^2 [Bernatowicz 1960, Sender 2004].

Phytolittoral surface and a length of shoreline inhabited by macrophytes was determined on the base of real vegetation maps of lakes using Macrostation vr 8^{th} programme. For the determination of range, maximum depth and distribution of submerged macrophytes the LOWRANCE sonar was used. Also the morphometric variation of selected species of emergent macrophytes was established [Sender 2008].

In order to determine diversity of vegetation Pielou evenness index was used [Pielou 1966], based on the number of plant communities and creating of phytolittoral and ESMI indicator for environmental assessment of the lake [Ciecierska 2008].

RESULTS AND DISCUSSION

In the studied lakes, 16 plant communities occurred. In 1918, the greatest diversity of flora occurred in Lake Kunów, where 12 phytocoenoses were identified. In the years 2011 and 2012 a significant decrease to eight communities was experienced (Tab. 2). In Firlej Lake reverse changes occurred, after nearly 100 years in the lake diversity of the communities inhabiting them has increased.

In Firlej Lake despite an increase in phytocenotic diversity, probable quantitative increased rather not much. Nearly 100 years ago, offshore rushes did not exceed 5 meters wide [Lityński 1918], now reached an average of 13.7 m (standard deviation 12), also frequently disrupted. While, submerged aquatic vegetation was defined as abundant. Currently, in relation to Kunów Lake where typical submerged macrophytes practically none, is represented frequently. In Lake Kunów reed rushes, already in the years 18 last century, came to 50 m wide [Lityński 1918]. At present, ranged from 80 m to 30 m (mean 45.9, standard deviation 18).

In the studied lakes phytolittoral surface was clearly differentiated, occupying a larger surface in lake Firlej. The main component of phytolittoral was submerged vegetation, covering as much as 71.4%. From lake's functioning point of view, dominance of submerged macrophyte is very favorable [Scheffer and Jeppesen 1998, Gross 2003]. In Firlej Lake high values of settlement and phytocenotic differentiation indexes allowed to include it into lakes with a good ecological status (Table 3). Phytolittoral in lake Kunów occupied only 15.06% of the lake surface, below the average for lakes in Łęczyńsko-Włodawskie Lakeland [Sender 2010]. It consisted mainly emergent macrophytes and ecological status assessment based on macrophyte indicators, included it into the group of lakes with moderate ecological status (Tab. 3).

Table 2. Plant communities in investigated lakes in 1918 [Litynski 1918] and 2011 and 2012

Plant community	Kunów		Firlej	
	1918	2011/2012	1918	2011/2012
Cicuto caricetum pseudociperi BOER ET SISS. IN BOER 1942		+		
Eleocharitetum palustris SCHENNIKOW 1919	+		+	++
Elodeetum canadensis (PIGN. 1953) PASS. 1964				+
Glycerietum maximae HUECK 1931	+	+	+	++
Hottonietum palustris R.TX. 1937	+		++	
Epilobio-Juncetum effusi OBERD. 1957	+	+	+	+
Myriophylletum verticillati SOÓ 1927	+		++	++
Nupharo-Nymphaeetum albae TOMASZ. 1977	+	+		
Phragmitetum australis (GAMS 1927) SCHMALE 1939	+	+	++	++
Polygonetum natantis SOÓ 1927	+			+
Potametum lucentis HUECK 1931				+
Potametum natantis SOÓ 1923	+	+		
Potametum perfoliati KOCH 1926 EM. PASS. 1964	+		++	
Ranunculetum circinati (BENNEMA ET WESTH. 1943) SEGAL 1965	+		++	
Salicetum pentandro-cinereae (ALMQ. 1929) PASS. 1961		+		
Scirpetum lacustris (ALLORGE 1922) CHOUARD 1924	+			
Typhetum angustifoliae (ALLORGE 1922) SOÓ 1927		+		+
Typhetum latifoliae SOÓ 1927				+
Number of plant community	12	8	8	10

Table 3. Basic parameters of phytolittoral in investigated lakes

Parameter	Kunów	Firlej
Phytolittoral surface, %	15.06	21.7
% share of emergent macrophytes	90.3	28.6
% share of submerged macrophytes	9.7	71.4
Range of emergent macrophytes occurrence	1.5	1.5
Range of submerged macrophytes occurrence	1.2	2.1
Pielou evenness index	0.65	0.72
Max. phytocenotic diversity index	2.08	2.3
Settlement index	0.33	0.8
ESMI	0.221	0.514
Ecological status	moderate	good

Total biomass of macrophytes in the studied lakes was very similar and ranged from 484 $g_{sm} \cdot m^{-2}$ in Lake Firlej to 499.5 $g_{sm} \cdot m^{-2}$ in Lake Kunów (Fig. 1). Emergent macrophytes dominated in biomass in Lake Kunów, reaching until 480 $g_{sm} \cdot m^{-2}$. Abundant emergent vegetation may suggest advanced processes succession [Podbielkowski and Tomaszewicz 1982]. There were also a group of plants with floating

leaves in this lake. In Lake Firlej biomass was distributed evenly between two distinguished groups of macrophytes: emergent 195 $g_{sm} \cdot m^{-2}$ and submerged 289 $g_{sm} \cdot m^{-2}$ (Fig. 1).

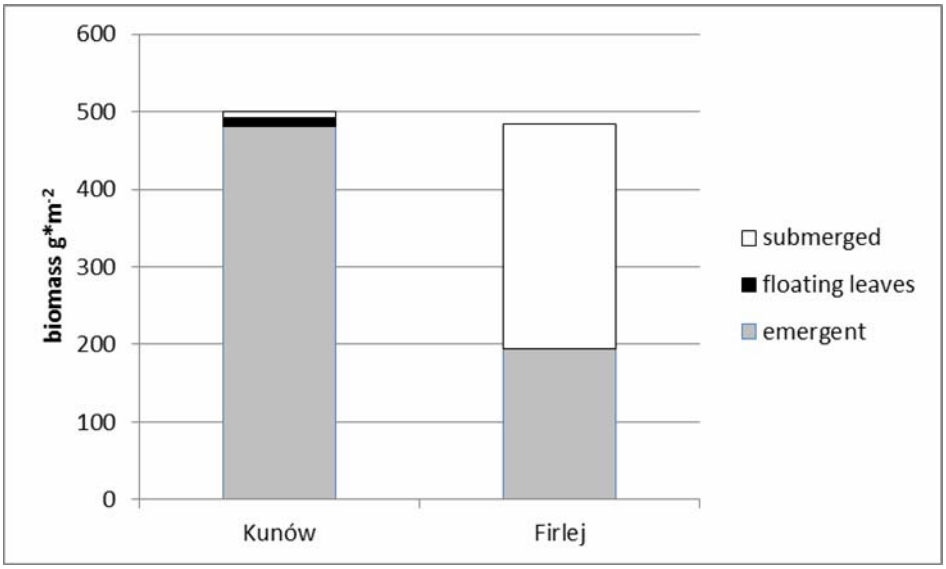

Fig. 1. Average biomass of particular groups of macrophytes in investigated lakes

Table 4. Morphometric features of selected species of emergent macrophytes in investigated lakes

Lake	Kunów	Firlej	Kunów	Firlej	Kunów	Firlej
Feature species	*Phragmites australis*		*Typha angustifolia*		*Glyceria maximae*	
Density of shoots m^2	82.4	106.5	40.2	46	17.6	16
Mass	17.9	8.9	19.7	11.4	8.8	6.7
Length, m	2.07	1.87	176.5	1.91	1.76	1.01
Diameter, mm	6.9	5.75	21	13.3	11	11.3

Morphometric analysis of selected species of emergent macrophytes showed their clear differences. All analyzed features of selected species reached higher values in the lake Kunów. The exception was the reed, which demonstrated much higher density, but with lower values of other features (Tab. 4).

CONCLUSIONS

Studied Lakes Firlej and Kunów despite proximity and similar stage of catchement development, but different anthropogenic pressures are different in terms of lake flora. Tourism seems to exert less pressure than agriculture.

Lake Firlej has a good ecological state with predominance of submerged macrophyte, Lake Kunów represents moderate ecological status with majority of emergent macrophytes.

In both lakes during a nearly 100 years changes in the phytocenotic composition were small.

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HYDROBOTANICZNA CHARAKTERYSTYKA JEZIOR FIRLEJ I KUNÓW

Streszczenie. W eutrofizujących się jeziorach występują intensywne zmiany składu gatunkowego makrofitów, ich biomasy oraz wielkości zasiedlanego obszaru. Celem pracy była analiza struktury hydrobotanicznej dwóch jezior eutroficznych zlewni rolniczej, różniących się morfometrią i formami presji antropogenicznej. Badaniami objęto dwa jeziora: Firlej oraz Kunów, położone w odległości ok. 2 km od siebie, połączone kanałem odwadniającym.
Badane jeziora, pomimo bliskości oraz podobnego sposobu zagospodarowania zlewni, ale różnej presji antropogenicznej, stanowią różne pod względem florystycznym jeziora. Turystyka wydaję się wywierać mniejszą presję na strukturę makrofitów niż rolnictwo. Jezioro Firlej charakteryzuje się dobrym stanem ekologicznym z przewagą makrofitów zanurzonych, natomiast jezioro Kunów reprezentuje umiarkowany stan ekologiczny z przewagą makrofitów wynurzonych. W obu badanych jeziorach w okresie blisko 100 lat zmiany w ich strukturze fitocenotycznej były niewielkie.

Słowa kluczowe: makrofity, stan ekologiczny, fitolitoral, sposób użytkowania zlewni