Teka Kom. Ochr. Kszt. Środ. Przyr. – OL PAN, 2009, 6, 277–284

HYDROBOTANICAL CHARACTERISTIC OF LAKES USED FOR RECREATIONAL PURPOSES OF ŁĘCZNA-WŁODAWA LAKELAND

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Summary. The aim of the work was to determine the ecological state of lakes used for recreational purposes, based on abiotic conditions as well as on qualitative and quantitative structure of macrophytes. Investigations were conducted in lakes Piaseczno and Białe Włodawskie. The values of analysed parameters permitted the lakes to be classified among mesotrophic ones. In investigated Lakes Piaseczno and Białe Włodawskie there occurred 16 plant associations. The surface area occupied by macrophytes ranged from 31.1 to 40.4%. In the studied lakes *Charetea* made up dominant group of plants overgrowing the bottom of the reservoir. The studied lakes are typical *Chara* lakes, especially sensitive to every kind of human activity.

Key words: mesotrophic lakes, macrophytes, *Chara*, human activity

INTRODUCTION

In spite of the typological variety of lakes in the Łęczna-Włodawa Lakeland, there are not many lakes used for recreational purposes, the most popular and willingly visited by tourists being two – lake Piaseczno and Lake Białe Włodawskie.

Till the beginning of the 21st century there were 60 lakes with surface area over 1 ha in the Łęczna-Włodawa Lakeland [Chmielewski 2005].

Every water ecosystem is subjected to constant transformations on its way to „maturity". The pace of these changes can be different and dependent on many external and internal factors. Those are, among others, the morphometry of a reservoir, which determines the existence of many abiotic factors zones and the related variety of biotic elements, the way of catchement area use, as well as one of the main factors of degradation – recreational use. Macrophytes are one

of the visible elements of changes in lake conditions. Macrophytes include higher aquatic vascular vegetation as well as *Charetea*. Their role in water ecosystems depends on the plants variety, their quantitative relations, and the way of their distribution in the littoral zone [Szmeja 2006].

The aim of the work was to determine the ecological state of lakes, used for recreational purposes in the period from spring till late autumn, based on abiotic conditions as well as on qualitative and quantitative structure of macrophytes

MATERIAL AND METHODS

Investigations were conducted on lakes Piaseczno and Białe Włodawskie. The examined lakes are situated in the Lanscape Park of the Łęczyńskie Lakeland, in the eastern part of Poland.

These reservoirs are the two deepest, dimictic lakes of Łęczna-Włodawa Lakeland (Tab. 1). In the 1950's, the lakes were characterised as oligotrophic [Fijałkowski 1959]. Nowadays they are classified as mesotrophic lakes [Harasimiuk *et al.* 1998]. The lakes are surrounded by relatively large catchment areas, from 230.47 ha – Lake Białe Włodawskie, to 284.88 ha – lake Piaseczno, but also the most recreationally developed. However, more than a half of the catchment areas have retained the natural forms of land use [Harasimiuk *et al.* 1998].

Table 1. Limnological characteristic of investigated lakes

Lake	Lake surface area, ha	Depth max, m	Length, m	Capacity, thousand m^2	Mid. inclination of lake bottom	Visibility, m
Piaseczno	84.7	38.8	1464	10674	4˚50'	5.8
Białe Włodawskie	106.4	33.6	1616	14998	4˚40'	3.9

The investigations were carried out in 2007 and 2008, during the spring, summer and early autumn. The basic physical and chemical parameters were analysed with the aim to determine habitat conditions. The measurement of visibility was achieved using the Secchi discs. Water quality was characterised by water reaction (pH), temperature, conductivity, dissolved oxygen, total N, and total P concentrations. These variables were analysed according to the Polish Standards [Hermanowicz and Dojlido 1999].

Plant associations were determined and examined according to the Braun-Blanquet method [Fukarek 1967]. The syntaxonomic system was adopted after Matuszkiewicz [2005]. Moreover, the range of occurrence, distribution and macrophyte biomass were studied [Bernatowicz 1960, Szmeja 2006].

RESULTS AND DISCUSSION

The water reaction of studied lakes has alkaline character (Tab. 2). Large quantity of dissolved substance in water reduces its quality and it is adverse for some organisms because it disturbs the natural balance. Too high water conductivity (above 2200 µS cm^{-1}) [Szmeja 2006] can damage sensitive plants, while too low can stop the development of water life. In the studied lakes the values of water conductivity were low, and imperceptibly higher in Lake Białe Włodawskie (Tab. 2).

Oxygen in water comes from two sources – from the atmosphere and from the process of photosynthesis. Its concentration in water is connected with temperature.

Table 2. Characteristic of physical and chemical parameters of investigated lakes

Lake	Year	Parameter zone	Temperature °C	pH	Conductivity, µS cm^{-1}	Oxygen, mg O_2 dm^{-3}	Nitrates, mg N dm^{-3}	Phosphates, mg P dm^{-3}
Białe Włodawskie	2007	littoral	18.6	8.7	172.5	11.4	0.12	0.03
		SD	6.4	0.4	18.7	0.6	0.01	0.00
		pelagial	18.1	8.7	174.5	11.0	0.12	0.03
		SD	6.7	0.4	18.7	0.9	0.00	0.01
	2008	littoral	17.5	8.5	199.5	10.2	0.15	0.02
		SD	3.2	0.1	24.8	1.0	0.13	0.01
		pelagial	17.4	8.6	204.5	10.4	0.06	0.02
		SD	3.6	0.1	31.2	0.9	0.05	0.01
Piaseczno	2007	littoral	19.0	8.5	83	10.9	0.11	0.07
		SD	6.4	0.3	5.7	0.9	0.01	0.04
		pelagial	18.6	8.5	82.8	10.1	0.10	0.06
		SD	7.3	0.1	8.2	0.4	0.01	0.02
	2008	littoral	17.9	8.1	89.4	9.7	0.18	0.26
		SD	2.9	0.58	4.4	1.5	0.12	0.28
		pelagial	18.6	8.7	88.2	9.8	0.17	0.25
		SD	3.9	0.5	3.6	1.9	0.08	0.14

The oxygen is used up both by manufacturers – plants, and consumers – animals which need the most of it. Also reducers – bacteria need a lot of oxygen, they close in water the chain of circulation of organic matter through mineralisation of dead organic matter. The oxygen conditions in studied lakes were good (Tab. 2).

Phosphates (PO_4) play a very important role in correct development of plants, they are as sugar for synthesis. Their optimum level ranges from 0.5 mg l^{-1} to 1.5 mg l^{-1}, and above 3 mg l^{-1} algae can suddenly develop. Nitrates (NO_3) are the

Table 3. Plant associations occurring in investigated lakes

Plant association	Piaseczno	Białe Włodawskie
Cl. *Charetea* (Fukarek 1961 n.n.) Krausch 1964 **O. *Charetalia fragilis* Sauer 1937** ***Charion fragilis* Krausch 1964**		
Charetum fragilis Fijałkowski 1960	+	+
ass. with *Chara delicatula* Desev.	+	+
Nitellopsidetum obtusae		+
Charetum asperae		+
Nitellion flexilis Corillion 1957		
Nitelletum flexilis Corillion 1957	+	
Cl. *Potametea* R.Tx.et Preisg. 1942 **O. *Potametalia* Koch 1926** ***Potamion* Koch 1926 em. Oberd. 1957**		
Elodeetum canadensis (Ping. 1953) Pass. 1964	+	
Ceratophylletum demersi Hild. 1956	+	+
Myriophylletum spicati Soe 1927		+
Potametum lucentis Hueck 1931		+
Cl. *Littorelletea uniflorae* Br.-Bl. et R. Tx. 1943 **O. *Littorelletalia uniflorae* Koch 1926** ***Lobelion* (Vanden Berghen 1944) R.Tx. et Dierss. ap. Dierss 1972**		
Myriophyllo-Littorelletum Jaschke 1959	+	
Cl. *Phragmitetea* R. Tx. Et Prsg 1942 **O. *Phragmitetalia* Koch 1926** ***Phragmition* Koch 19026**		
Eleocharitetum palustris Šennikov 1919	+	+
Phragmitetum australis (Gams 1927) Schmale 1939	+	+
Typhetum angustifoliae (Allorge 1922) Soo1927		+
Scirpetum lacustris (Allorge 1922) Chouard 1924		+
Cl. *Scheuchzerio-Caricetea* (Nordh. 1937) R.Tx. 1937 **O. *Scheuchzerietalia palustris* Nordh. 1937** ***Caricion lasiocarpae* Vanden Ber. ap. Lebrun et. all 1949**		
ass. with *Juncus articulatus* L.	+	
Cl. *Utricularietea intermedio-minoris* Den Hartoget Segal1964 em. Pietsch 1965 **O. *Utracularietalia intermedio-minoris* Pietsch 1965** ***Sphagno-Utricularion* Müll. et Görs 1960**		
ass. with *Utricularia vulgaris* L.	+	
Total number of plant assoaciations	10	11

final effect of nitro compound transformation; they are natural fertilisers for plants. However, their excessive levels inhibit plant development and are dangerous for fish life. In the studied lakes their contents were very low (Tab. 2). The values of analysed parameters permit the lakes to be classified as mesotrophic ones.

In investigated lakes Piaseczno and Białe Włodawskie there occurred 16 plant associations in, respectively, 10 and 11 communities (Tab. 3). In both studied lakes representatives of the rich group *Charetae* were noted. Plants with floating leaves were observed only locally in Lake Białe, while pleustonic macrophytes were noted in lake Piaseczno (Fig. 1).

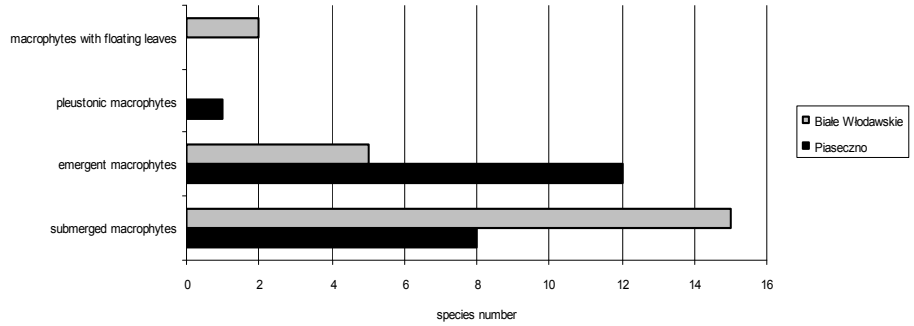

Fig. 1. Numbers of species of particular groups of macrophytes in investigated lakes

In lake Białe Włodawskie emergent macrophytes were characterised by higher diversity (Tab. 3). They occurred at depths down to 1.5 m, while an irregular belt of them was developed along the shoreline and ranged from 1 to even 20 m in width. In lake Piaseczno rushes were observed along the whole shoreline, with small 20–50 m spaces used as beaches. The width, extending almost to the helophyte belt, ranged from 4 to even 40 m.

Table 4. Macrophyte surface area and biomass (dry matter) in investigated lakes

Lake	Phytolittoral surface area, %	Phytolittoral surface area, ha		Biomass of macrophytes (overgrown surface), t ha^{-1}	Biomass of macrophytes in the whole lake, t ha^{-1}
		emergent	submerged		
Piaseczno	40.4	13.5	20.04	3.1	1.3
Białe Włodawskie	31.1	8.7	23.2	3.9	1.2

The average surface area covered with macrophytes in the lakes of Łęczna-Włodawa Lakeland amounts to 47.8% of the surface of a lake [Sender 2003], while in the mesotrophic lake Majcz Wielki on the Mazurian Lakeland it is 42.2% [Ozimek 1983]. In the studied mesotrophic lakes the area occupied by macrophytes was smaller and ranged from 31.1% in Lake Białe Włodawskie to 40.4% in lake Piaseczno. In both lakes emergent macrophytes built a considerable part of the phytolittoral and occurred at depths ranging from 0.5 m to even 5.5 m (Tab. 4).

The biomass of macrophytes in the lakes under study was a bit higher (Tab. 4) than in lakes with similar trophic status in the Mazurian Lake district [Pieczyńska and Ozimek 1976]. The distribution of macrophyte biomass of studied lakes was differentiated. It also changed in the successive years of investigations. In lake Piaseczno the maximum values of the biomass were recorded at depths of 3.5–4.5 m, while in Białe Włodawskie from 1.5 to 3.5 m (Fig. 2). In both lakes, in the shallow littoral zone, emergent macrophytes developed very well and achieved the highest biomass (Fig. 2).

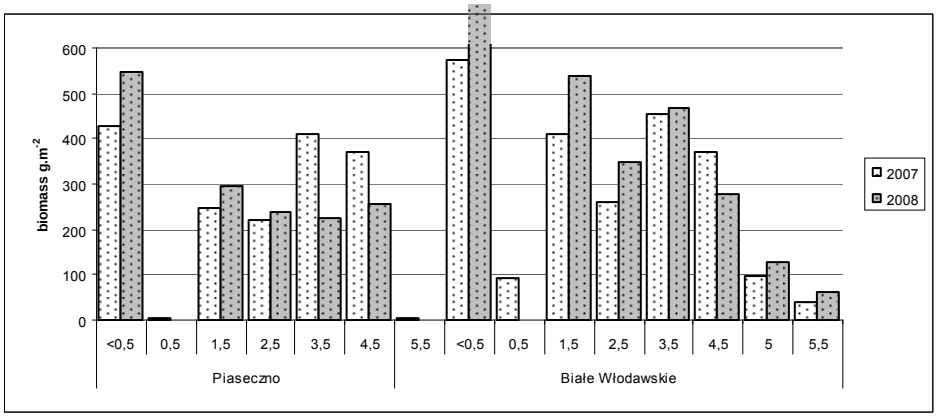

Fig. 2. Distribution of macrophyte biomass in investigated lakes

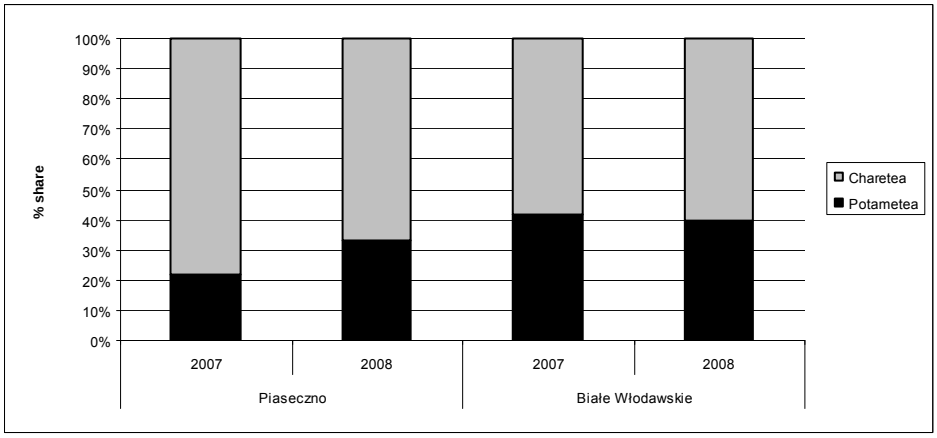

Fig. 3. Percentage share of *Charetea* in total biomass of submerged macrophytes

In the studied lakes *Charetea* constituted the dominant group of plants overgrowing the bottom of the reservoirs (Fig. 3). The lakes were characterised, in spite of large seasonal recreational pressure, by high visibility and emerald colour of water caused, among others, by a large quantity of calcium ions.

So-called *Chara* meadows were also built with participation of different groups of hydromacrophytesn. Such a situation is alarming because too large a participation of pondweeds can lead to the elimination of *Charatea* by shading, and it is one of the symptoms of a rise in the trophy of a reservoir. A majority of *Charatea* do not keep the concentration of phosphates in water above 0.02 mg dm^{-3}, and an excessive drop in their concentration may cause limitation of the surface of *Chara* meadows.

Charatea, pioneer species, disappear gradually as a the result of light limiting, competition of other plants, or the natural evolution of the reservoir. This disappearance can be intensive if mechanical removal of the plants in beach areas is applied [Van den Berg *et al*. 1999].

The *Chara* associations, covering considerable surfaces of the lake bottom, regulate the relations in the whole ecosystem and hold back the processes of the unfavourable changes in the quality of waters. This vegetation is the favourite place of fish spawning [Kufel and Kufel 2002].

The studied lakes are typical *Chara* lakes, especially sensitive to every kind of human activity. Therefore, all reservoirs in which *Chara* meadows occur should is protected. In the case of the recreational use, it is necessary to determine the principles of such use.

CONCLUSIONS

Lakes Piaseczno and Białe Włodawskie, in spite of their very intensive recreational use, are characterised by high visibility of water and generally good ecological state.

Light conditions in studied lakes belong to the best among the lakes of the Łęczna-Włodawa Lakeland.

The low values of macrophyte biomass and the large participation of *Charatea* can justify their stabilising influence on the ecological state of the studied lakes.

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Acknowledgment. Paper prepared within the framework of research projekt N305 087 31/3325 *Transformations of ecological structure and currant conditions of functioning of hydrogenic landscapes of the „West Polesie" Biospere Reserve and prospects of conservation of their nature values,* financed by the Ministry of Science and Higher Education.

CHARAKTERYSTYKA HYDROBOTANICZNA JEZIOR KĄPIELISKOWYCH POJEZIERZA ŁĘCZYŃSKO-WŁODAWSKIEGO

Streszczenie. Celem pracy była ocena stanu ekologicznego jezior, użytkowanych rekreacyjnie w okresie od wiosny do późnej jesieni, na podstawie czynników abiotycznych oraz struktury jakościowej i ilościowej makrofitów. Badania przeprowadzono na jeziorach Piaseczno i Białe Włodawskie, usytuowanych w makroregionie Pojezierze Łęczyńsko-Włodawskie, we wschodniej Polsce. Wartości analizowanych parametrów fizyczno-chemicznych pozwalają uznać te jeziora za mezotroficzne. Badane jeziora zasiedlało 16 zbiorowisk roślinnych. Powierzchnia zajmowana przez makrofitty wahała się od 31,1 do 40,4%. Ramienice stanowiły dominującą grupę roślin porastających dno zbiornika. Badane jeziora to typowe jeziora ramienicowe, szczególnie wrażliwe na wszelkiego rodzaju antropopresję.

Słowa kluczowe: jeziora mezotroficzne, makrofity, *Chara*, antropopresja