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DIRECTIONS OF CHANGES IN THE MACROPHYTE STRUCTURE OF TWO DEPRESSION RESERVOIRS IN ŁĘCZNA-WŁODAWA LAKELAND

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Summary. The area of Łęczna-Włodawa Lakeland is the land of unique natural value due to the large variety of hydrogenic landscapes [Chmielewski 2009]. These include reservoirs, which have resulted from conducted in the area of mining activity The aim of the study was to determine the directions of changes in the structure of macrophyte in depression reservoirs which are part of the agricultural landscape of Łęczyńsko-Włodawskie Lakeland. In investigated reservoirs, over the last decade, clear reconstruction of aquatic vegetation was observed. Especially emergent macrophytes increased participation in phytolittoral and diversity. Vegetation in Szczecin reservoir subject to very significant changes, the reservoir was more intense overgrown and became shallower while vegetation has been fragmented. The Nadrybie reservoirs vegetation was subject to slow changes in the direction of increased diversity. Best conditions for their development occurred in the Nadrybie Small reservoir.

Key words: depression reservoirs, macrophytes, long term changes, Łęczna-Włodawa Lakeland

INTRODUCTION

The area of Łęczna-Włodawa Lakeland is the land of unique natural value due to the large variety of hydrogenic landscapes [Chmielewski 2009]. These include reservoirs, which have resulted from conducted in the area of mining activity. Depression reservoirs is an element often found in such a landscape. Formed basin subsidence are part of the region's sustainable development strategy. Water in the natural environment, particularly agriculture which represents the studied region, fulfills several functions. As a means of production determines the amount and reliability of yield, an essential factor for economic development and rural civilization is also necessary to conservation of natural values. Poland has a small water resources, often of poor quality [Zieliński and Słota 1996]. The deterioration of the water balance affectamong others inappropriate technical and economic

approach, which resulted in adverse changes in the natural environment. Water resources are created mainly in agricultural areas and forests, where there are retention and partially consumed [Mioduszewski 1999]. Water reservoirs are an essential element of so-called small retention, they improve the water balance of land, are also of great importance to life and survival of many plants and animals species. Water reservoirs are, as a rule, multi-functional in the environment because they increase water resources and enrich the natural and landscape values, and may serve different economic purposes. The studied reservoirs act as a buffer zone because, stabilizing water relations especially in the Poleski National Park region.

The aim of the study was to determine the directions of changes in the structure of macrophyte in depression reservoirs which are part of the agricultural landscape of Łęczna-Włodawa Lakeland.

STUDY AREA, MATERIAL AND METHODS

The study included two depression reservoirs Nadrybie and Szczecin. They are small reservoirs, but constantly expanding. Nadrybie reservoir was formed in 1993, temporarily wet areas with well developed peat grassland communities and two small sized ponds.

Szczecin reservoir was created in 1984 in the basin subsidence resulting from coal mining. It will serve as multifunctional reservoir Szczecin with dominant rotational function in the system Wieprz-Krzna [Borchulski and Łyszczarz 2000].

The study was conducted between 2001 and 2011 at the peak growing season, in entire littoral zones of water reservoirs Nadrybie and Szczecin. In Nadrybie reservoir distinguished two reservoirs: small and big with regards to its clear division of local road made of waste rock.

In phytosociological investigations, Braun Blanquet's method [1951] was used. Phytosociological units were distinguished on the basis of systematic system and follow Matuszkiewicz nomenclature [2008]. In order to demonstrate changes in the diversity of plant phytocenotic diversity index was determined [Ciecierska 2008].

Macrophytes quantitative analysis was carried out at selected transects based on: analysis of species composition, biomass, as well as range of emergent and submerged macrophyte occurrence. Furthermore, the surface of phytolittoral and its constituent communities were determined based on analysis of aerial photographs and vegetation maps using MicroStation vr 8th.

RESULTS AND DISCUSSION

Investigated reservoirs are shallow but diverse as regards of area (Tab. 1). In Szczecin reservoir, during decade clear changes, resulting from a deterioration of visibility, and high water alkaline as well as, oxygen saturation occurred. While in Nadrybie reservoir this trend was reversed (Tab. 1).

Table 1. Some phisical and morphometrical properties of water in investigated reservoirs (July 2001, 2011)

Reservoir	Nadrybie big		Nadrybie small		Szczecin	
	2001	2011	2001	2011	2001	2011
Water surface, ha	25		5		80–105	
Depth, m	1.5	1.4	1.6	1.5	0.7	0.65
visibility of Secchi disk, m	0.25	0.25	0.2	0.45	to bottom	0.10
pH	9.5	9.26	9.2	8.31	7.4	10.58
Temperature, ^{o}C	23.1	23.9	25.4	26.3	24.1	26.3
Conductivity, $\mu S\ dm^{-3}$	440	441	401	371	279	350
Oxygen dissolved, $mgO_2\ dm^{-2}$	15.9	9.36	7.12	5.11	9.5	10.38
% O_2	170.2	102.4	82.4	62.3	99.9	112.3

In the following years of research there was a clear dynamics of vegetation inhabiting the studied reservoirs. Qualitative structure changed, and the amount of communities inhabiting them.

Short-term changes in the last 3 years were also important, they concerned mainly quantitative changes less qualitative [Sender 2007]. In Nadrybie reservoirs the phytolittoral surface increased slightly while the share of submerged macrophytes decreased significantly, especially in the Nadrybie big reservoir. In Nadrybie small reservoir the area inhabited by the rush vegetation slightly decreased while increase in proportion share of submerged macrophytes. In Szczecin reservoir phytolittoral has decreased drastically, especially built by submerged vegetation (Tab. 2).

Table 2. Phytolittoral surface and participation of particular groups of macrophytes

Phytolittoral surface %	Nadrybie big		Nadrybie small		Szczecin	
	2001	2011	2001	2011	2001	2011
Emergent and pleuston	82	93	80	72	21	93
Submerged	18	7	20	28	77	7
Total phytilittoral surface	29.1	35	95	96	87.7	38

Total phytolittoral studied reservoirs consisted of 14 plant communities. Most, as many as 9 occurred in the Nadrybie small reservoir. In the rest equally after 7. Moreover, indicated a clear tendency to increase the diversity of emergent communities in all the analyzed reservoirs. From the Nadrybie big and Szczecin reservoirs resolved completely submerged vegetation (Tab. 3).

In most of studied reservoirs among phytocoenoses dominated *Polygonetum natantis*. It is characterized as assemblage of the early stages of succession [Kłosowski 1999].

A measure of the littoral vegetation transformations both natural and anthropogenic is phytocenotic diversity index [Ciecierska 2008]. Among investigated reservoirs only in Szczecin reservoir there was a slight fall, which was the result of homogenization of communities. It is true that slightly increased their number

Table 3. Surface of particular plant communities in investigated reservoirs

Plant community \ Reservoir	Szczecin		Nadrybie big		Nadrybie small	
	2001	2011	2001	2011	2001	2011
Pleustonic plants						
Lemno-Spirodelletum	5.2	2.5				4.5
Plants with floatring leaves						
Potametum natantis	10.4					
Polygonetum natantis		0.2	5.7	3.1	8.3	3.6
Elodeids						
Ceratophylletum demersi	56					22.5
Myriophylletum spicati			2.5		7.5	
Zb. Z Utricularia vulgaris						0.4
Emergent plants						
Typhetum angustifoliae	11.5	23.5		6.7		
Typhetum latifoliae	4.4	4.3		3.2		11.7
Phragmitetum australis		4.8	17.3	18.9	58.5	46.5
Glycerietum maximae		1.3				2.3
Sparganium erecti			2.5	1.1	6.7	
Caricetum rostratae			1.1	0.8	14	2.4
Phalaris arundinaceae	4.6	1.4				2.1
Salicetum pentandro-cinereae				1.2		`
Total number of plant communities	6	7	5	7	5	9

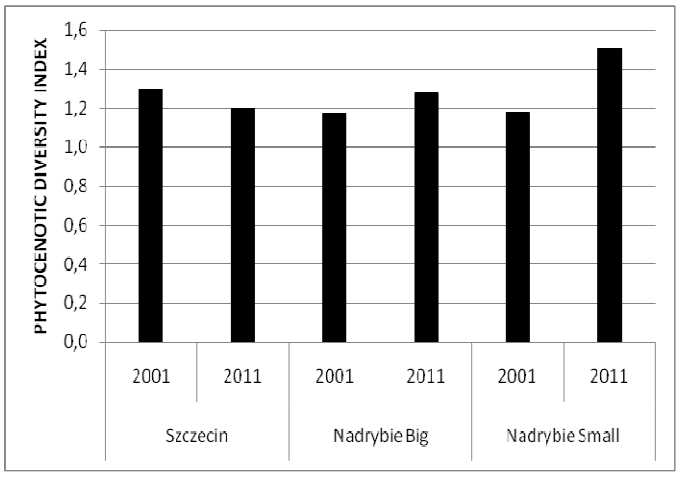

Fig. 1. Phytocenotic diversity index (H) in investigated lakes

but dominated by one community, the remaining part was negligible. In other reservoirs, the index increased, and the largest increase was in the Nadrybie small reservoir (Fig. 1). This means that the contribution of individual communities in the entire phytolittoral aim to their balanced share.

In Nadrybie reservior, during decade was marked increase in the number of emergent vegetation communities as well as the surface occupied by them. In

2011, in the analyzed stands there are new communities *Salicetum pentandro-cinereae, Typhetum angustifoliae*, while in the shallows *Phragmitetum australis*. Whereas clearly reduced the range of occurrence *Polygonetum natantis* (Fig. 2).

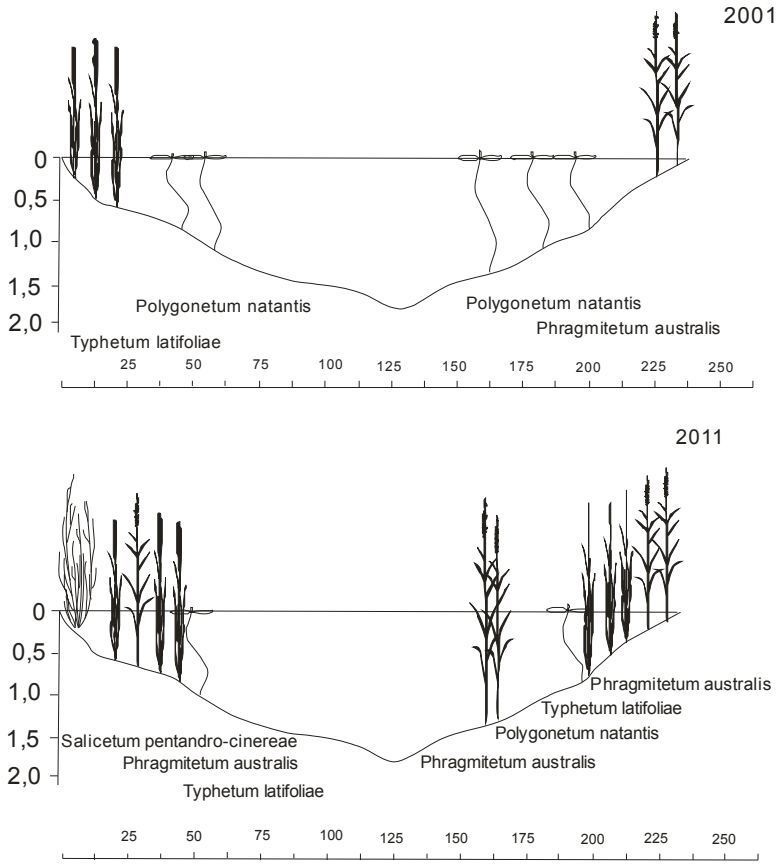

Fig. 2. Distribution of plant communities in the Nadrybie big reservoir in 2001, 2011

Vegetation in Szczecin reservoir, over 10 years was subject to very significant changes. In 2001, the bottom of the reservoir covered *Ceratophylletum demersi* completely, in 2011 there was a lack of that community totally. Only individual *Ceratophyllum demersum* species as an admixture of rushes appeared, in the northern part of the reservoir. There has been clear increase in rush and pleustonic communities (Fig. 3). The phenomenon of submerged macrophytes disappear in this reservoir was connected with a clear deterioration of light conditions, enough to that disappeared from it extremely resistant to bad light conditions species [Podbielkowski and Tomaszewicz 1982, Blindow 1992]. This tank with a typical pure water – with the dominance of macrophytes, has become a reservoir with algal dominance – turbid water [Weisner *et al*. 1997].

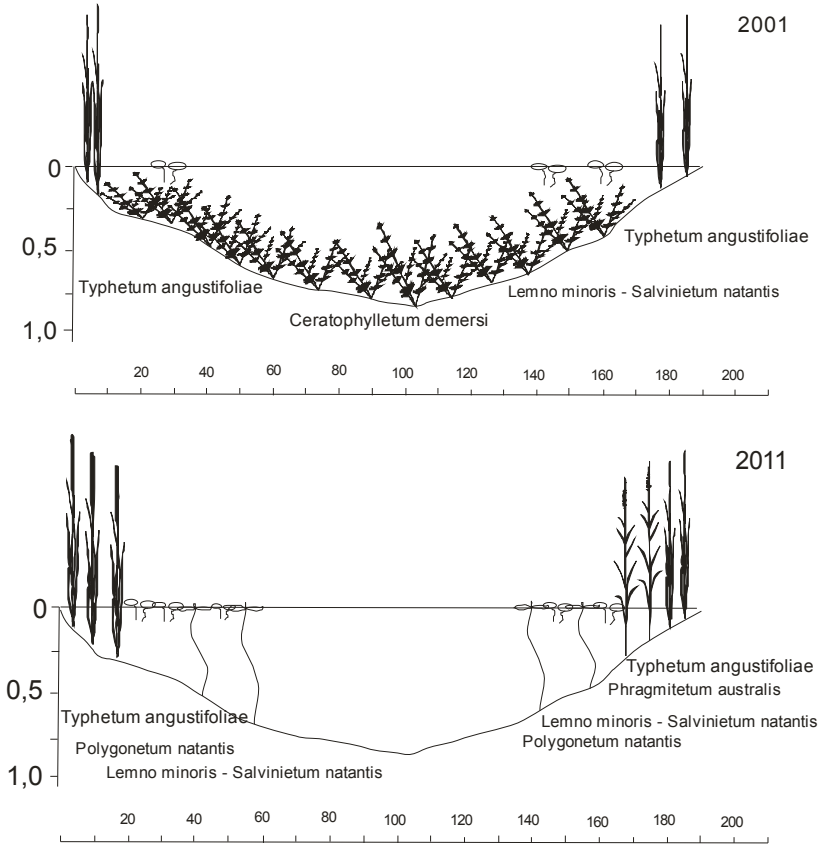

Fig. 3. Distribution of plant communities in the Szczecin reservoir in 2001, 2011

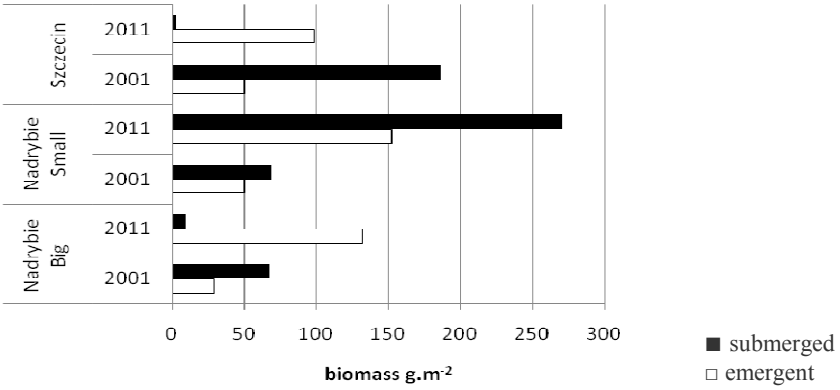

Fig. 4. Biomass of macrophytes in investigated reservoirs

Changes in species composition are also reflected in the mass vegetation of these reservoirs. The main component of biomass in lakes are plants especially rush vegetation followed by plants with floating leaves, then submerged and pleustonic plants [Kraska 1988]. Macrophyte biomass inhabiting the investigated reservoirs subject to very clear changes in subsequent years of research. In all the reservoirs, due to increased number and area occupied by vegetation rush reached the highest values this group of plants. Due to the inclusion of pleustonic species as a group of submerged macrophytes in Szczecin reservoir showed their presence. Based on these values, the most suitable changes occurred in the Nadrybie small reservoir, where in total biomass dominated of submerged macrophytes, there was also the highest diversity. In other investigated reservoirs there was similar tendency. Biomass of submerged macrophyte decreased while increased of emergent (Fig. 4). Such situation, dominance of emergent macrophytes, and the low values of total biomass – up to 200 g dry weight per 1 m^2, is typical for very fertile lakes, hypertrophic [Sender 2010].

CONCLUSIONS

In investigated reservoirs, over the last decade, clear reconstruction of aquatic vegetation was observed. Especially emergent macrophytes increased participation in phytolittoral and diversity.

Vegetation in Szczecin reservoir subject to very significant changes, the reservoir was more intense overgrown and became shallower while vegetation has been fragmented.

The Nadrybie reservoirs vegetation was subject to slow changes in the direction of increased diversity. Best conditions for their development occurred in the Nadrybie small reservoir.

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KIERUNKI ZMIAN STRUKTURY MAKROFITÓW DWÓCH ZBIORNIKÓW DEPRESYJNYCH NA POJEZIERZU ŁĘCZYŃSKO-WŁODAWSKIM

Streszczenie. Obszar Pojezierza Łęczyńsko-Włodawskiego to teren o wyjątkowych walorach przyrodniczych przede wszystkim ze względu na dużą różnorodność krajobrazów hydrogenicznych. Wśród nich znalazły się zbiorniki, które powstały w wyniku prowadzonej na tym obszarze działalności górniczej. Celem opracowania było określenie kierunków zmian w strukturze makrofitów zbiorników zapadliskowych będących elementem krajobrazu rolniczego Pojezierza Łęczyńsko-Włodawskiego. W badanych zbiornikach nastąpiła w ciągu dekady wyraźna przebudowa roślinności wodnej. Udział w fitolitoralu oraz różnorodność zwiększyły zwłaszcza makrofity wynurzone. Roślinność zbiornika Szczecin podlegała bardzo istotnym zmianom, zbiornik ten intensywniej zarastał i wypłycał się, zaś roślinność podlega fragmentacji. W zbiornikach Nadrybie roślinność podlegała powolnym zmianom w kierunku wzrostu różnorodności. Najdogodniejsze warunki do ich rozwoju panowały w małym zbiorniku Nadrybie.

Słowa kluczowe: zbiorniki zapadliskowe, makrofity, zmiany długoterminowe, Pojezierze Łęczyńsko-Włodawskie