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EFFECT OF AQUATIC MACROPHYTES ON WATER TROPHY OF LOWLAND WATER BODIES IN ASPECT OF THEIR SURFACE DIFFERENTIATION

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Summary. The estimation of the trophy of waters in the vegetated zone and the open waters of shallow water bodies based on chemical parameters according to TSI was the aim of the study. The parameters of water were examined in 3 shallow lakes and 3 great ponds. 7 aquatic plant communities were distinguished (rush vegetation and submerged macrophytes). The water trophy of studied water bodies was similar to α-mesotrophy and eutrophy. In the course of the analysis a number of limitations of the applied classification methods for ascertaining the trophic conditions were found. In zones of submerged macrophytes a higher water trophy was found, compared to the zones of helophytes.

Key words: trophy, water macrophytes, small water bodies, shallow lakes, transparency

INTRODUCTION

The trophic conditions of water are often decisive when taking into consideration the potential usage of water bodies. In relation to submerged macrophytes, opinions considering the role of macrophytes in modifying the physical-chemical features of the environment of water bodies have as yet not been defined [Kłosowski 1994]. On the one hand the dynamics of water in shallow lakes is often determined by irregular processes, e.g. wind mixing [Joniak *et al*. 2000], and on the other hand overgrowing macrophytes may intake nutrients from water or restore them from sediments into the water [Jeppesen *et al*. 1997]. According to the most recent literature, mainly nitrogen compounds which are included in artificial fertilisers are a major factor responsible for accelerating the eutrophication of surface waters [Bubier *et al*. 2007]. Biophilic elements and organic sub-

stances, as well as their abiotic and biotic relations, originate in the complexes of rush and water vegetation of small water bodies undergoing anthropogenic pressure [Wetzel 1995].

From the hydrological point of view, water bodies play an important role, e.g. they contribute to moisturizing soils, however, their over-eutrophication degrades their waters almost to the point of sewage conditions [Joniak *et al*. 2006]. In the estimation of the quality of surface waters many classification systems are used, e.g. Carlson [1977] or OECD [1982], in which classic trophic terminology relates to numerical values of chosen parameters. The aim of the study was to determine the differentiation of values of the Carlson trophy index in the macrophyte zone (rush vegetation, submerged macrophytes) in comparison to open water zone of three lakes and three great water bodies of the Wielkopolska Lowland.

STUDY AREA, MATERIAL AND METHODS

The examinations of the chemical parameters of water were carried out in the summer of 2005 on 3 lakes (surface area from 11 to 15 ha, max. depth 2.7–7.4 m) located in forest and pastoral/forest landscape, and in 3 typically mid-forest ponds (surface area < 5 ha, max. depth < 0.5 m). In the studied water bodies were distinguished the rush vegetation (*Phragmites australis, Typha angustifolia, Schoenoplectus lacustris*) and submerged macrophytes (*Batrachium circinatum, Ceratophyllum demersum, Chara tomentosa, Potamogeton lucens*). The water samples for chemical analysis were taken separately from each vegetation zone – 13 stations, and from the open water – 6 stations. The electric conductivity and Secchi depth (SDV) were measured *in situ*. Total phosphorus and mineral nitrogen were measured spectrophotometrically [Hermanowicz *et al*. 1999]. The determination of chlorophyll *a* was carried out in cold 90% acetone. The trophic conditions were estimated using the trophic state index (TSI) described by Carlson [1977]. The classes of trophy were established by relating the value of total value of TSI (TSI_{Tot}) calculated by summing TSI_{TP}, TSI_{Chl} and TSI_{SDV} values, to ranges described by Kraska *et al*. [1999].

RESULTS AND DISCUSSION

The results suggest that the aquatic vegetation of the examined water bodies had a modifying effect on their chemical conditions. In the open waters of the small water bodies smaller amounts of mineral elements were noticed compared with the lakes, which reflects lower concentrations of chlorophyll *a*. Low maximal depth and water transparency reaching the bottom caused the highest values of TSI_{SDV} and considerably raised the value of TSI_{Tot} (Tab. 1). The small water

bodies create specific micro-ecosystems, where seasonal changes in the hydrochemistry reflect the dynamic balance between organisms and the environment in relation to numerous influential external factors [Joniak *et al*. 2007]. The trophic conditions of lakes Dębiniec and Wielkowiejskie were classified as α-mesotrophy (TSI_{Tot} < 180), due to high SDV (2.4–4.5 m) and low chlorophyll content (< 7.5 µg dm^{-3}). The third lake, owing to its low SDV (< 1 m) and higher content of chlorophyll *a* (> 20 µg dm^{-3}), was in the stage of strong eutrophy. The value of the TSI_{TP} index indicated that phosphorus played the most important role in creating the trophic conditions of the deepest lake (Tab. 1).

Table 1. Trophic conditions of researched water bodies in open water according to Carlson's Index (α-M – α-mesotrophy, E – eutrophy, SDV – Secchi Disk Visibility)

No	Max. depth Lake/Pond (m)		Carlson's Index				
			TSI_{TP}	TSI_{Chl}	TSI_{SDV}	TSI_{Tot}	Trophic state
1	Budzyńskie Lake	2.7	75	60	62	197	E
2	Dębiniec Lake	7.4	85	45	43	173	α-M
3	Wielkowiejskie Lake	4.3	72	51	46	169	α-M
4	Gazbruchy Małe	0.2	54	8	83*	145	α-M
5	Gazbruchy Wielkie	0.35	59	32	75*	166	α-M
6	Sycyn	0.4	63	51	73*	187	E

* value of TSI_{SDV} when depth = SDV (Secchi Disk Visibility)

A characteristic feature of the zonal layout of the lake waters was the occurrence of extremely differentiated values of chemical parameters in the zone of submerged macrophytes and open water, and in the intermediate zone of rush vegetation. The greatest differentiation was found in the case of chlorophyll *a*, the concentration of which within zones of submerged macrophytes was nearly 4-times higher than in the zones of rush vegetation and over 7-times higher than in the open water (Fig. 1). Higher concentrations of mineral nitrogen were recorded from submerged vegetation, and phosphorus from rush species. The concentration of dissolved mineral substances described as electric conductivity was similar in all the examined zones.

The trophic conditions of the ponds were classified as α-mesotrophy and eutrophy (Tab. 1). The differentiation of the values of the TSI_{TP} and TSI_{SDV} indexes was much lower there than TSI_{Chl}. A high differentiation in the chlorophyll *a* content was responsible for this – from 0.1 to 8.3 µg dm^{-3}. Analysis of the spatial distribution of mineral elements revealed a lower concentration of nitrogen in both vegetated zones compared to the open water, however, a much higher concentration of phosphorus appeared within submerged macrophytes. In this zone of macrophytes a greater development of phytoplankton was also observed, compared to rush vegetation where concentration of chlorophyll was considerably lower (Fig. 1).

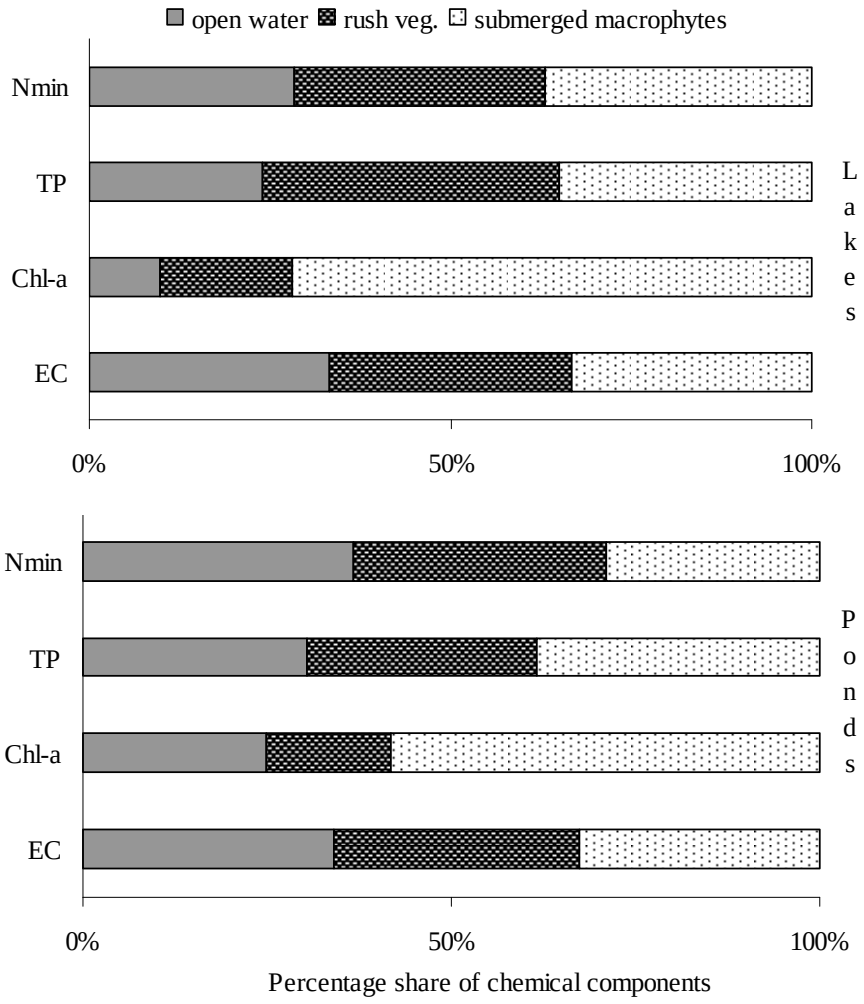

Fig. 1. Comparison of percentage share of spatial distribution of mineral nitrogen Nmin (µg N dm^{-3}), total phosphorus TP (µg P dm^{-3}), chlorophyll *a* Chl-*a* (µg dm^{-3}) and electric conductivity EC (µS cm^{-1}) concentrations in water of open water and hydromacrophytes zones of water bodies

Analysis of the trophic conditions of water within vegetated areas, distinguishing plant communities, revealed a distinctly more favourable impact on the quality of the water of rush vegetation communities compared to submerged macrophytes (Tab. 2). The strong overshadowing caused by helophytes was one of the factors which caused the restriction of phytoplankton development. Accelerated accumulation of phosphorus in the plant tissues, especially of *Phragmites australis* and *Typha* sp., during the vegetation period may have contributed to the considerable reduction of its supply [Gołdyn 2000], as was confirmed by the values of the TSI_{TP} index – much lower than among submerged

Table 2. Trophic conditions of researched water bodies in vegetated zones according to Carlson's Index (symbols as in Tab. 1)

Plant community	Carlson's Index				
	TSI_{Tp}	TSI_{Chl}	TSI_{SDV}	TSI_{Tot}	Trophic state
Phragmites australis	56	40	65*	161	α-M
Typha angustifolia	58	51	48	157	α-M
Schoenoplectus lacustris	57	36	83*	176	α-M
Total rush[1]	57	42	65	164	α-M
Batrachium circinatum	58	40	83*	181	E
Ceratophyllum demersum	71	63	73*	207	E
Chara tomentosa	85	75	48	208	E
Potamogeton lucens	58	32	70*	160	α-M
Total submerged[1]	68	52	68	188	E

*value of TSI_{SDV} when depth = SDV (Secchi Disk Visibility)
[1] mean values

macrophytes. The considerably higher values of the chlorophyll and phosphorus indexes in the communities of *Ceratophyllum demersum* and *Chara tomentosa* are particularly interesting. These values were influenced by the favourable conditions for phytoplankton development which were rather restricted by light and by nutrient condition restrictions. The overgrowing macrophytes may intake nutrients from water or restore them from sediments into the water [Jeppesen *et al*. 1997], similarly to very abundant communities of periphytic organisms [Gołdyn 2000]. In the investigated water bodies a problem arose concerning the interpretation of the obtained results of water transparency due to shallow pond depth and the correspondingly limited water transparency measured by Secchi disk (Tab. 1).

CONCLUSION

To conclude, it should be said that the commonly applied classifications of the trophy of waters may be employed only to a restricted degree in small water bodies, especially those which are shallow and/or fully macrophyte-dominated. The solution to this problem would be elaboration of methods combining physical (e.g. turbidity) or chemical indices (e.g. dissolved organic matter, yellow substances) with biological features (composition and structure of phyto- and zooplankton biocenosis), which would be based on the participation of indicator species.

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WPŁYW ZBIOROWISK ROŚLINNOŚCI WODNEJ NA TROFIĘ ZBIORNIKÓW NIZINNYCH W ASPEKCIE ZRÓŻNICOWANIA ICH POWIERZCHNI

Streszczenie. Badano zmienność przestrzenną trofii wód na podstawie wskaźników TSI, w ujęciu stref z roślinnością i bez niej, w płytkich nizinnych zbiornikach wodnych. Obiektami badań były 3 niewielkie jeziora i 3 duże zbiorniki typu stawowego. Wyróżniono 7 zbiorowisk makrofitów strefy szuwaru i roślinności zanurzonej. Zróżnicowanie trofii zbiorników było małe – od α-mezotrofii do eutrofii. W strefie roślinności zanurzonej ze względu na stężenia fosforu i chlorofilu *a* poziom trofii był wyższy niż w szuwarze. Ujawniono ograniczenia w klasyfikowaniu poziomu trofii metodą Carlsona związane z pomiarem widzialności krążka Secchiego.

Słowa kluczowe: trofia, hydromakrofity, małe zbiorniki wodne, płytkie jeziora, przezroczystość

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