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ASSESSMENT OF OCCURRENCE MICROPHYTES AND TROPHIC STATUS OF A SMALL WATER BODY IN THE WIELKOPOLSKA REGION (WESTERN POLAND)

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K e y w o r d s: water body, phytoplankton, trophic state index, chlorophyll *a*.

A b s t r a c t

The paper presents results of studies on microphytes found in a small and shallow water body located in the village of Drwęsa in the Dopiewo community (near Poznań). The aim of investigations conducted in 2011 was to determine the taxonomic composition, abundance and biomass of microphytes, the amount of seston and selected environmental factors. The greatest species richness was observed for green algae and diatoms, while the total abundance of microphytes was usually moderate. Flagellates predominated, mainly chrysophytes, dinoflagellates and cryptophytes. Maximum abundance were recorded in spring and their frequent dips in summer and autumn. Microphyte biomass estimated by the concentration of chlorophyll *a* was generally high and significantly correlated with the amount of seston. Indicator species comprised 35% of the microphytes taxa and eutrophic indicator species predominat. The structure of microphytes indicated mesotrophy of the water body, while the concentrations of chlorophyll *a* and seston showed eutrophy.

OCENA WYSTĘPOWANIA MIKROFITÓW A STAN TROFII MAŁEGO ZBIORNIKA WODNEGO W WIELKOPOLSCE (ZACHODNIA POLSKA)

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S ł o w a k l u c z o w e: zbiornik wodny, fitoplankton, indeks trofii, chlorofil *a*.

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Abstrakt

W pracy przedstawiono wyniki badań mikrofitów występujących w małym i płytkim zbiorniku wodnym położonym w miejscowości Drwęsa w gminie Dopiewo (w sąsiedztwie Poznania). Badania przeprowadzono w 2011 r., a celem ich było określenie składu taksonomicznego, liczebności, biomasy mikrofitów, ilości sestonu oraz wybranych czynników środowiskowych. Największym bogactwem gatunkowym charakteryzowały się zielenice i okrzemki, natomiast liczebność ogólna mikrofitów była na ogół umiarkowana. Stwierdzono dominację form wiciowych, głównie złotowiciowców, bruzdnic i kryptofitów. Maksimum liczebności mikrofitów zaobserwowano wiosną, natomiast latem i jesienią często się ona zmniejszała. Biomasa mikrofitów wyrażona koncentracją chlorofilu *a* była na ogół wysoka i skorelowana istotnie z ilością sestonu. 35% taksonów mikrofitów stanowiły gatunki wskaźnikowe, przeważały wśród nich wskaźniki eutrofii. Struktura mikrofitów wskazała na mezotrofię wód badanego zbiornika, natomiast koncentracja chlorofilu *a* i sestonu na eutrofię.

Introduction

Two basic groups of primary producers are distinguished in water bodies, i.e. small, suspended in the pelagic zone – the so-called phytoplankton (microphytes), as well as large, connected typically with the littoral zone, i.e. hydromacrophytes. Both these groups are commonly used in water quality assessment. Hydromacrophytes are relatively permanent components, undergoing relatively slow changes, while microphytes are characterized by a rapid response to changing environmental conditions due to their short life cycles. This makes microphytes one of the most dynamic groups in the ecosystem, while due to their key importance as primary producers is also one of the most frequently studied (HUTCHINSON 1957, MCCORMICK and CAIRNS 1994).

Research on microphytes concern both the species composition and their population abundance as well as biomass. Much information on their communities is used in the assessment of the quality of waters. It is commonly believed that with an increase in trophic status of the water body the diversity of algae and cyanobacteria decreases and their density and biomass increase. However, in many cases species richness and diversity of microphytes are quite unrelated to trophic state and productive capacity (KAWECKA and ELORANTA 1994, DODSON et al. 2000). Some species of aquatic microorganisms are representative of the oligotrophic waters while others are typical of the eutrophic habitats (REYNOLDS 1984, RAKOWSKA et al. 2005).

The aim of this study was to assess the trophic status of a small water body located in the rural area on the bases of the species composition and abundance of microphytes in connection with selected environmental factors. It was tested how different indicators describe trophic status this water body. Analyses concerned the number of taxa, the occurrence of indicator species for individual trophic states and density of organisms as well as concentration of chlorophyll *a*. Pond in Drwęsa in this aspect was not considered until now, despite its great recreational importance. Moreover, selected physical and chemical parameters of water were presented. Relationships between them and microphytes were determined.

Study area

The examined pond is located in the Dopiewo community in the village of Drwęsa, approx. 20 km west of Poznań (Figure 1). In terms of the physico-geographical division of Poland into regions (KONDRACKI 1998) this area belongs to the Central Polish Lowland, Macroregion – the Wielkopolska Lake District, Mesoregion – the Poznań Lake District, Microregion – the Owińska-Kiekrz Hills. The analysed pond is very small and relatively shallow. It is only 0.03 ha in area with the maximum depth of 1.9 m. The lake basin is oval and the shoreline is relatively uniform. Only in the northern part there is a small cove. The shoreline is 62 m in lenght. The maximum width of the pond is 16.5 m, while the maximum length is 23 m. The water level of the pond is at 88.07 m a.s.l.

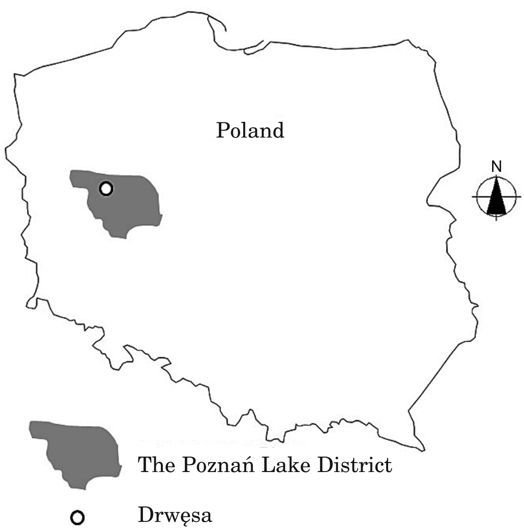

Fig. 1. Location of the pond in Drwęsa

The pond in Drwęsa is of anthropogenic origin, as it was formed as a result of deepening of a limited depression in the late 1980's, in which water accumulated after heavy rains. Rainwater from roofs of the neighbouring buildings with the total area of 380 m^2 was discharged to the northern part of the water body through a system of pipes. The water body is characterized by a variable water level. In spring the water level is as a rule the highest, while in the other seasons of the year it is gradually reduced.

The macrophytes in the study period included *Typha latifolia* L. that formed patches in the north-eastern part of the pond as well as in the small cove. At the peak of the vegetation season *Ceratophyllum demersum* L. predominated, filling almost entirely the pond basin, and it was acompanied by *Lemna minor* L., *Lemna trisulca* L. and filamentous algae.

Materials and Methods

Water samples were collected in 2011: in winter and autumn once a month, while in spring and summer biweekly. Samples were collected from the surface water layer in the centre of the water body for analyses of plankton, the concentrations of chlorophyll *a* and seston. Samples for plankton analyses were fixed with Lugol's iodine with sodium acetate (STARMACH 1963). When collecting samples, measurements for water temperature, pH and electrolytic conductivity were taken using a HANNA meter.

Spectrophotometry corrected for phaeopigments was used to measure chlorophyll *a,* in accordance with the Polish Standard. Seston dry mass was determined by gravimetry, with it being condensed on Whatman GF/F filters. Microphyte composition and density were analysed using an inverted microscope (PZO, MOD-2) and cylindrical plankton chambers of 14 ml at a magnification of 40, 150 and 600x (WETZEL and LIKENS 1991). Microphytes were determinated according to the method presented by LUND et al. (1958). For identification and nomenclature of algae and cyanobacteria Polish Flora Freshwater were used (STARMACH 1963, 1966).

Trophic state was evaluated based on indicator taxa given by HUTCHINSON (1957), HÖRNSTRÖM (1981), ROSÉN (1981), JÄRNEFELT (acc. KAWECKA and ELORANTA 1994). A three-point scale was adopted expressed in the number index, with the number 3 corresponding to eutrophy, 2 to mesotrophy, while 1 to oligotrophy (SZELĄG-WASIELEWSKA et al. 1999, SZELĄG WASIELEWSKA and GOŁDYN 2005). Moreover, it was assumed that in the gradient of trophic state values of the index ranging from 0.00 to 0.74 corresponded to oligotrophy, within the range of 0.75 to 1.24 to oligomesotrophy, 1.25–1.74 to mesotrophy, 1.75–2.24 to mesoeutrophy, 2.25–2.74 to eutrophy, 2.74–3.00 to high eutrophy. The trophic index was calculated for the numbers of indicator taxa using the formula (HÖRNSTRÖM 1981):

$$I_c = \frac{\Sigma\,(f \cdot I_t)}{\Sigma f}$$

where:
I_c – trophic index of the community;
I_t – trophic index of given species;
f – numbers of the indicator species.

Moreover, to assess the trophic state the OECD lake classification based on the criteria developed by VOLLENWEIDER (1971) and indicators of the trophic state according to CARLSON (1977) (Trophic State Index – TSI) adopting one parameter, i.e. chlorophyll *a* were used.

Statistical analysis of the results covered calculations of linear correlation coefficients between the investigated factors. It was performed using Excel 2007.

Results

Microphytes

Cyanobacteria and 8 groups of eukaryotic algae were found in the pond plankton. A total of 98 taxa were identified, with the highest number recorded for green algae (Chlorophyta) with 40 taxa, diatoms (Bacillariophyceae) with 18 and cryptophytes (Cryptophyceae) with 13, respectively. In the case of other groups (Cyanobacteria, Euglenophyceae, Dinophyceae, Xanthophyceae, Chrysophyceae) it was lower, ranging from 1 to 8. In individual months the number of taxa ranged from 10 to 28 (Table 1).

The highest number of taxa (28) was recorded in June, while the lowest was found in February, when the species richness of green algae and cryptophytes was identical. Green algae and cryptophytes occurred throughout the year, while euglenophytes, dinoflagellates, chrysophytes and diatoms appeared over a major part of the year. Representatives of cyanobacteria and xanthophytes were observed in the pelagic zone only periodically (Table 1). The number of taxa was significantly and positively correlated with the water temperature (r = 0.758). The other analysed relations were non-significant, although they were mostly positive (Table 2).

The total abundance of microphytes fell within a wide range from 0.78×10^3 cells ml^{-1} to 19.5×10^3 cells ml^{-1}, with the ratio of the maximum value to the minimum value of approx. 25. In spring the abundance was much higher than in the other seasons and it exceeded as much as three-fold the value of 10^3 cells ml^{-1}. Most frequently the density of microphytes was changed within the range of $2–5 \times 10^3$ cells ml^{-1}, while in the first half of the year the mean value was

Table 1

Number of microphytes taxa in the plankton in Drwęsa pond in 2011

Specification	31.1	28.2	30.3	20.4	07.5	25.5	15.6	30.6	14.7	28.7	10.8	31.8	18.9	30.9	14.10	31.10	16.11	07.12	Total
Cyanobacteria	–	–	1	–	–	1	–	–	1	–	1	–	2	2	1	–	–	–	4
Euglenophyceae	1	–	2	2	2	3	3	3	–	1	2	1	3	1	2	2	2	2	8
Cryptophyceae	6	4	3	4	3	3	2	3	4	3	5	4	6	5	5	5	4	2	13
Dinophyceae	1	1	–	–	1	–	3	3	1	2	1	3	1	1	2	1	1	1	7
Xanthophyceae	–	–	–	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	1
Chrysophyceae	–	1	1	5	3	3	2	3	2	1	2	–	1	–	–	1	1	1	7
Bacillariophyceae	–	–	2	5	2	7	6	2	4	3	1	4	5	7	2	1	1	2	18
Chlorophyta	4	4	6	4	5	9	12	13	12	5	3	2	7	8	6	3	3	4	40
Total	12	10	15	20	17	26	28	28	24	15	15	14	25	24	18	12	12	12	98

Table 2

The coefficients correlation of number of taxa and microphytes abundance versus selected physical and chemical parameters of water

Specification	Water temperature	Water reaction	Condu-ctivity	Seston dry mass	Chloro-phyll a	Number of taxa	Micro-phytes abundance	I_c*
Water temperature	–	–	–	–	–	–	–	–
Water reaction	0.229	–	–	–	–	–	–	–
Conductivity	–0.037	–0.344	–	–	–	–	–	–
Seston dry mass	0.024	0.494*	0.243	–	–	–	–	–
Chlorophyll a	–0.016	0.398	–0.084	0.769***	–	–	–	–
Number of taxa	0.758***	0.347	0.197	0.248	0.008	–	–	–
Microphytes abundance	–0.131	–0.466*	0.715***	–0.012	–0.212	–0.009	–	–
I_c*	– 0.017	–0.223	–0.068	–0.640**	–0.621**	0.066	0.043	–

* – Trophic State Index based on the microphytes abundane of indicator species;
** – $\alpha < 0.01$; *** – $\alpha < 0.001$).

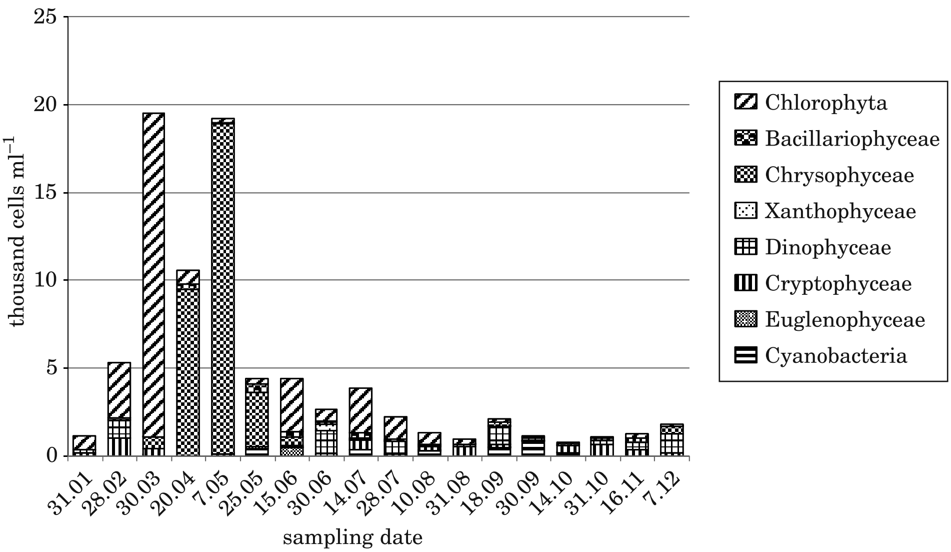

Fig. 2. Micophytes abundance in plankton in Drwęsa pond during 2011

approx. 8×10^3 cells ml^{-1} and in the second half it was almost 2×10^3 cells ml^{-1}. In March green algae were most abundant, while in April and May it was chrysophytes. Among the other groups dinoflagellates and cryptophytes were numerous and constant components of microphytes. The contribution of cyanobacteria, diatoms and euglenophytes to the total abundance were small, at max. 8.5%, 4% and 1.2%, respectively (Figure 2).

A strong positive correlation (r = 0.715) was found between the total abundance of phytoplankton and electrolytic conductivity. In turn, correlation between the total abundance and water reaction was negative and weak (r = –0.466) (Table 2). Among the identified taxa some formed highly numerous populations. The most abundant comprised *Synura uvella* Ehrenberg, *Koliella longiseta* (Vischer) Hindák, *Scourfieldia* sp., *Uroglena americana* Calkins, *Chlamydomonas* sp., *Chlorella* sp., *Spermatozopsis exultans* Koršikov, *Woloszynskia hiemalis* (Wołoszyńska) Thompson. Frequently these taxa appeared many times throughout the year of the study (Table 3).

Table 3

The most important taxa with regard to the microphytes abundance in Drwęsa pond in 2011

Sampling date	Name of taxa and abundance [cells ml^{-1}]	
31.01.2011	*Chlamydomonas* sp. (700)	*Woloszynskia hiemalis* (182)
28.02.2011	*Chlamydomonas* sp. (2900)	*Woloszynskia hiemalis* (1040)
30.03.2011	*Koliella longiseta* (11200)	*Scourfieldia* sp. (6800)
20.04.2011	*Synura uvella* (7700)	*Dinobryon sociale* var. *americanum* (1737)
07.05.2011	*Synura uvella* (12700)	*Uroglena americana* (6000)
25.05.2011	*Synura uvella* (2986)	*Aphanocapsa* sp. (408)
15.06.2011	*Chlamydomonas* sp. (1495)	*Dictyosphaerium* sp. (848)
30.06.2011	*Gymnodinium uberrinum* var. *rotundatum* (1061)	*Tribonema minus* (364)
14.07.2011	*Spermatozopsis exultans* (1091)	*Chlorella* sp. (586)
28.07.2011	*Chlorella* sp. (1131)	*Gymnodinium uberrinum* var. *rotundatum* (424)
10.08.2011	*Chlorella* sp. (606)	*Aphanocapsa incerta* (286)
31.08.2011	*Cryptomonas undulata* (330)	*Chlorella* sp. (264)
18.09.2011	*Gymnodinium uberrinum* var. *rotundatum* (1020)	*Aphanocapsa incerta* (381)
30.09.2011	*Aphanocapsa incerta* (667)	*Pseudanabeaena minima* (152)
14.10.2011	*Cryptomonas ovata* (273)	*Pseudanabeaena minima* (162)
31.10.2011	*Cryptomonas rostrata* (323)	*Woloszynskia hiemalis*(283)
16.11.2011	*Woloszynskia hiemalis*(451)	*Cryptomonas rostrata* (273)
07.12.2011	*Woloszynskia hiemalis*(1088)	*Synura uvella* (383)

Table 4

Phytoplankton indicator taxa found in Drwęsa pond during 2011

Taxa	The authors giving a taxon	Species trophic state index	Taxa	The authors giving a taxon	Species trophic state index
Aphanocapsa incerta	*e*	2,5	*Ankistrodesmus stipitatus*	*c*	2,8
Aphanocapsa sp.	*a, b, c, d*	2,5	*Elakatothrix acuta*	*c*	1,2
Oscillatoria lacustris	*d*	3	*Kirchneriella* sp.	*a*	3
Euglena acus	*a*	2	*Lagerheimia wratislaviensis*	*a*	3
Euglena sp.	*a*	2	*Monoraphidium griffithii*	*b*	1
Euglena texta	*a*	2	*Oocystis* sp.	*b*	1
Phacus longicauda var. *pyrum*	*a*	3	*Scenedesmus acuminatus*	*a, b, d*	3
Trachelomonas volvocina	*b, d*	3	*Scenedesmus acutus*	*a, b, d*	3
Gymnodinium sp.	*d*	1	*Scenedesmus armatus*	*a, b, d*	3
Gymnodinium uberrinium var. *rotundatum*	*d*	1,1	*Scenedesmus brasiliensis*	*a, b, d*	3
Kephyrion sp.	*a*	1	*Scenedesmus obliqus*	*a, b, d*	3
Synura uvella	*b*	2	*Scenedesmus quadricauda*	*a, b, d*	3
Uroglena americana	*c*	1,3	*Scenedesmus quadrispina*	*a, b, d*	3
Cyclotella sp.	*c*	1	*Scenedesmus spinosus*	*a, b, d*	3
Synedra acus	*a, c*	1,7	*Tetraedron caudatum* var. *incisum*	*b*	2
Synedra acus var. *angustissima*	*a, c*	1,7	*Tetrastrum triangulare*	*a*	3
Ankistrodesmus gracilis	*c*	2,8			

a – Järnefelt (acc. KAWECKA and ELORANTA 1994), *b* – HUTCHINSON (1967), *c* – HÖRNSTRÖM (1981), *d* – ROSÉN (1981), *e* – STARMACH (1966)

A total of 34 indicator taxa were found in microphyte communities, i.e. 34.7% of their total number, of which 56% were classified as indicators of eutrophy, 21% of mesotrophy, and 24% to indicators of oligotrophy. Within the year the value of the index changed within a wide range of values (from 1.27 to 2.59). From January to April values of the index were identical (2.0) indicating a mesotrophic character of the water body. From May this index changed dynamically with the minimum value at the end of June and the maximum value in mid-July, i.e. in the range from oligomesotrophy to eutrophy (Figure 3). Sudden changes in the value of the index might be caused by the appearance of cyanobacteria from the genus *Aphanocapsa*, green algae from the genus *Kirchneriella* or dinoflagellates from the genus *Gymnodinium*, being indicators of eutrophy or oligotrophy, respectively (Table 4). The mean water trophic state index was 1.85, which indicates mesotrophy. Trophic state index was correlated with the dry mass of seston (r = –0.640) and the concentration of chlorophyll a (r = –0.621) – Table 2.

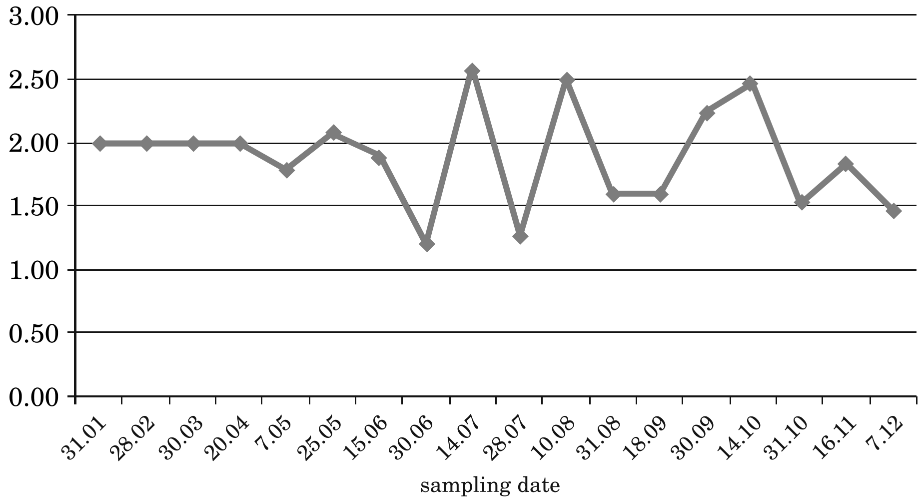

Fig. 3. Phytoplankton trophic index in Drwęsa pond in 2011

Physico-chemical properties of water

Water temperature in the pond ranged from 0.3°C to 19.7°C. Its mean value for the entire year was 11.4°C. The highest water temperature was observed at the end of June and in mid-July, while it was lowest in February. Water reaction was usually slightly alkaline and no considerable changes were observed (7.6–8.4). At the end of June the reaction was highest, while it was lowest towards the end of August. Water reaction was significantly correlated with seston dry mass (r = 0.494) – Table 2. In turn, electrolytic conductivity changed markedly throughout the year. Its value ranged from 480 μS cm^{-1} to 880 μS cm^{-1} (mean 566 μS cm^{-1}), while in the first half of the year it frequently exceeded 600 μS cm^{-1}, whereas in the second half it fell within the range from 400 to 550 μS cm^{-1} (Figure 4).

Average content of dry mass of seston was 7.3 mg l^{-1}, ranging from 2.3 mg l^{-1} (mid-October) to 16 mg l^{-1} (end of June). Throughout the year several significant increases were found in seston dry mass (February, end of June, mid-September and early December) – Figure 5. The most significant relation with correlation coefficient r = 0.769 was observed between the amount of seston and the concentration of chlorophyll a. Moreover, seston was negatively correlated with the trophic state index (Ic) (r = –0.640) – Table 2.

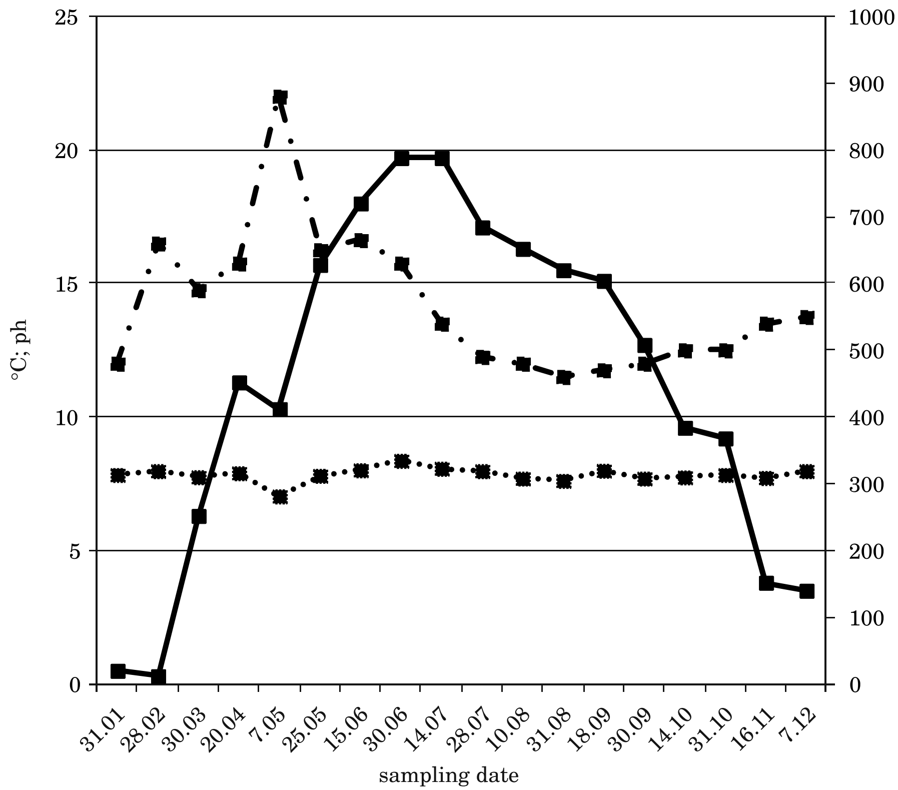

Fig. 4. Water temperature (solid line), pH (dotted line) and water conductivity (dashed line) in Drwęsa pond in 2011

Concentration of chlorophyll *a* ranged from 14.8 to 121.3 μg l^{-1} (mean 47 mg l^{-1}). The highest value was recorded in December. A high dynamic was observed for changes in chlorophyll *a* content: in the first half of the year it was generally lower, while in the second half it was much higher, correlating significantly with the seston dry mass content (Figure 5). Concentration of chlorophyll *a* was not significantly correlated with the abundance of microphytes, but the highest values were found when abundant small in size green algae (*Chlamydomonas* sp.) or large dinoflagellates (*Gymnodinium uberrimum* var. rotundatum, *Woloszynskia hiemalis*) and chrysophytes (*Synura uvella*) occurred. This situation was observed e.g. in February, May, end of June, mid-September and in December (Table 3, Figure 5). Based on the maximum value of chlorophyll *a* the pond may be classified as strongly eutrophic. Also mean value for chlorophyll *a*, amounting to 47 μg l^{-1}, indicates a high trophic state of the waters. The value of TSI based on chlorophyll *a* ranged from 57 to 78 at a mean of 66.6 (Table 5).

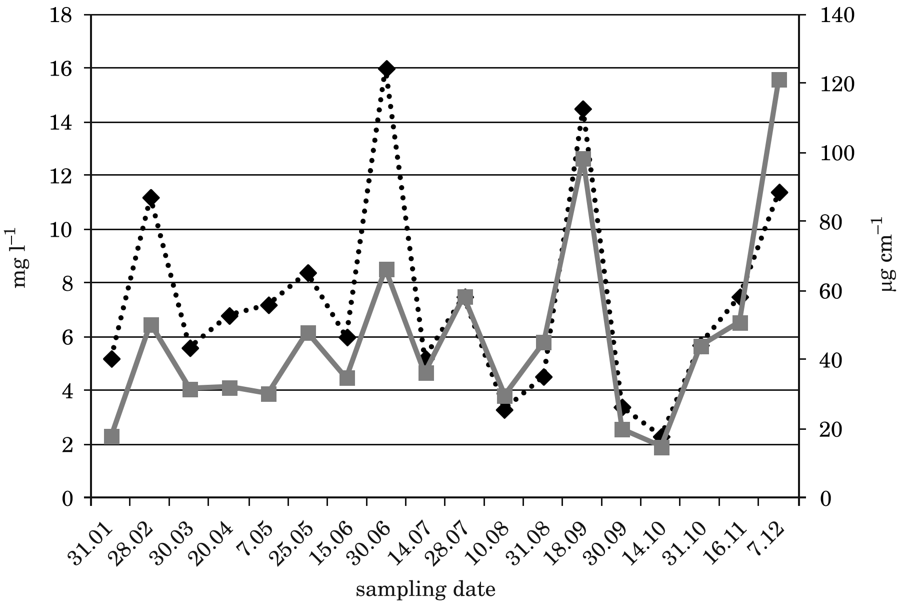

Fig. 5. Changes in seston dry mass (dashed line, mg l^{-1}), chlorophyll *a* (solid line, μg l^{-1}) in Drwęsa pond in 2011

Table 5

Seasonal changes of Trophic Lake Index based on concentration of chlorophyll *a* in 2011 (CARLSON 1977)

Sampling date	Index value
31.01	58.90
28.02	69.01
30.03	63.43
20.04	64.59
07.05	64.03
25.05	68.53
15.06	65.43
30.06	71.73
14.07	65.84
28.07	70.47
10.08	63.86
31.08	67.96
18.09	75.59
30.09	59.98
14.10	56.97
31.10	67.70
16.11	69.10
07.12	77.64
Average	66.56

Discussion

Microphytes

A total of 98 microphyte plankton taxa were identified in Drwęsa pond in 2011. This number is well within the range considered characteristic for standing water bodies in the temperature zone (TRIFANOVA 1998). However, at individual water sampling dates the species richness of microphytes was small, since the number of taxa ranged from 10 to 28. Even in the period from July to September the number of species was limited, ranging from 14 to 25, as a rule being lower than in twelve ponds of the Wielkopolski National Park (WPN) (MESSYASZ 2001). These ponds were analysed in the summer of 1996 (July – September). At that time the number of taxa ranged from 13 to 75 taxa. In the same time of the year phytoplankton of the pond in Drwęsa had as a rule a lower species richness than ponds in the Wielkopolski National Park.

In phycoflora of the examined pond almost 35% taxa were of indicator value. Most of them are indicators for eutrophic waters, e.g. green algae from the genera *Scenedesmus*, *Ankistrodesmus*, *Tetrastrum*, or *Aphanocapsa* and euglenophytes from the genera *Phacus* and *Trachelomonas* (HÖRNSTRÖM 1981, ROSÉN 1981). Some of them formed relatively numerous populations, thus resulting in an increase in the trophic state level. In turn, cryptophytes were lower in abundance, but they were characterized by a high taxonomic diversity and a lack of indicator species. Thus they had no effect on the assessment of trophic status (REYNOLDS 1984). It needs to be stressed that it is a dynamically changing group in the examined pond, since the results recorded in previous studies in 2009 and 2010 indicated their lower species richness and abundance (BAZALUK 2011).

Diatoms, despite their relatively high species number, accounted for as little as 13% of the microphytes abundance in the analysed pond. It was over two-fold less than e.g. in reservoirs on the Cybinka river (KOWALCZEWSKA-MADURA et al. 2009), or even many times less than in certain ponds in the WPN investigated by MESSYASZ (2001). Diatoms are considered to be an important group of algae in the assessment of water quality. Moreover, they are a particularly preferred group, since they are usually abundant in different types of waters throughout the year (VAN DAM et al. 1994). However, in the analysed pond their representatives were not found among the two most numerous microphytes taxa. They were not observed in the coolest season of the year (January, February). In spring or autumn, as in contrast to other water bodies they formed no abundant populations.

Cyanobacteria are a group of organisms, often creating problems in small water bodies, if appear in great abundance. It is so because they often secrete substances which deteriorate water quality, while they may also prove toxic to other aquatic organisms and water users (MAZUR-MARZEC et al. 2008). However, in the pond in Drwęsa this group was not very diverse in terms of species composition and its representatives, similarly as diatoms, formed scarce populations. The most abundant representative, i.e. *Aphanocapsa incerta*, being an indicator species for eutrophic waters, appears sporadically, only in the warm season and in not high density. As it was reported by STARMACH (1966), it may be found in the plankton of lakes and ponds, particularly in summer, while it occasionally appears on a mass scale forming the so-called blooms. Also the presence of another cyanobacteria, *Oscillatoria lacustris*, indicated a eutrophic character of pond waters (HÖRNSTRÖM 1981, ROSÉN 1981).

Physico-chemical properties of water

In the analysed pond water temperature did not play any significant role in the regulation of microphytes biomass or their abundance, as indicated by a lack of correlation between water temperature and parameters characterising microphytes, i.e. its abundance and the concentration of chlorophyll *a*. Also other studies showed a slight effect of water temperature on natural algal communities, with a diverse species composition (NYHOLM 1978). This may result from the fact that optimal temperatures are found there throughout the year, since with its increase cold water species are gradually replaced by warm water species. However, generally a positive correlation is expected between water temperature and algal biomass, since the rate of photosynthetic activity and the accompanying algal growth are dependent, among others, on temperature (SZELĄG-WASIELEWSKA 1992). In turn, a significant, positive correlation was observed between the number of taxa and water temperature – in water at a temperature of approx. 20°C the number of taxa was highest, as high as 28. Shading of the pond in Drwęsa by tree resulted in a lower mean water temperature from April to October (14.6°) than for other mid-field ponds in the Stare Czarnowo District (the Zachodniopomorskie province) (BRYSIEWICZ et al. 2012).

A slightly alkaline water reaction recorded in the pond in Drwęsa is highly frequently observed in water bodies located in the Polish Lowland (KAWECKA and ELORANTA 1994). A similar water reaction was found in small water bodies near Poznań on the Cybinka river (e.g. ponds Uli, Ósemka, Baba, Cyganek) (KOWALCZEWSKA-MADURA et al. 2009) as well as water bodies in the Wrocław Plain (ORZEPOWSKI et al. 2008). Also electrolytic conductivity in the analysed pond fell within the range of values frequently reported for water bodies in western Poland. Similar ranges of values were recorded in a small water body in the Wrocław Plain and in small water bodies in the WPN (ORZEPOWSKI et al. 2008). In spring in the pond in Drwęsa both electrolytic conductivity and the abundance of microphytes were higher than in other seasons. This resulted in a strong, positive correlation between these factors. The negative correlation between the seston dry mass and trophic index (I_c) (r = –0.640) was caused by the appearance large size species of microphytes, especially those of the *Gymnodinium* genus, which have low trophic index (I_c = 1.0). In turn, seston and the concentration of chlorophyll *a* were negatively correlated with electrolytic conductivity, which most probably resulted from the high abundance of small size microphytes, at a relatively high electrolytic conductivity.

Literature sources generally report a directly proportional dependence between the concentration of chlorophyll *a* and seston content (SOLSKI 1962, JONES 1976). Similarly, in the pond in Drwęsa a significant positive correlation was found between these parameters. Seston content well differentiates water quality throughout the year and the pond in Drwęsa may be classified, based on the criteria of KUDELSKA et al. (1981), to second class of water quality. The consistence of the course of annual changes in the levels of seston and chlorophyll *a* makes it possible to forecast amounts of seston based on the concentration of chlorophyll *a*. According to the ranges of values for chlorophyll *a* in the OECD trophic lake classification (LIETH and WHITTAKER 1975, STRAŠKRABA et al. 1979), its high value in the analyzed pond indicates the eutrophic character of these waters. Moreover, based on the Trophic State Index of chlorophyll *a* this water body needs to be considered eutrophic. In turn, taking into consideration the value of the trophic index, calculated on the basis of the abundance of microphytes (mean I_c = 1.9) the pond in Drwęsa needs to be considered as mesotrophic water body. The higher trophic level based on the concentration of chlorophyll *a* might result from the presence of numerous ciliates containing symbiotic algae in their cells (FINLAY et al. 1996). Unfortunately, there are no published results about the ciliates in pond in Drwęsa although during microscopic analyses of water samples they were observed in large numbers.

Conclussions

In the pond in Drwęsa the greatest richness of species was observed among green algae and diatoms. However, chrysophytes, green algae and dinoflagellates were found in greatest abundance. The highest total abundance of microphytes was recorded in spring, while in the second half of the year it was several times lower. Limited abundance were recorded for diatoms, which results in a limited applicability of this group considered to be a good indicator, for the assessment of trophic state of the investigated pond. Approximately 35% phycoflora of the pond comprised indicator taxa, of which as many as 56% belong to indicators of eutrophy. Water temperature, reaction and electrolytic conductivity were consistent with the ranges reported for many small water bodies. The application of different indicators in the assessment of trophic status produces inconsistent results. Microphytes structure indicated a lower water trophic status, i.e. mesotrophy, while the concentration of chlorophyll *a* and seston content indicated eutrophy. Thus the assessment would have to be extended to include microphytes biomass determined by microscopic examination, since microphyte biomass established on the basis of chlorophyll *a* concentration may be elevated by plankton ciliates containing symbiotic algae.

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