Roczniki Akademii Rolniczej w Poznaniu CCCLXXXVII

Botanika – Steciana

12, 2008, 29-33

www.au.poznan.pl/steciana

ISSN 1896-1908

TEMPORAL CHANGES IN PHYTOPLANKTON STRUCTURE IN A SMALL GARDEN POND CONTAINING PINE BARK

Sofia Celewicz-Gołdyn, Henryk Ratajkiewicz, Maciej Bosiacki, Marlena Przybyła

S. Celewicz-Gołdyn, Department of Botany, Agricultural University of Poznań, Wojska Polskiego 71 C, 60-625 Poznań, Poland, e-mail: celewicz@au.poznan.pl
H. Ratajkiewicz, M. Przybyła, Department of Plant Protection Methods, Agricultural University of Poznań, Zgorzelecka 4, 60-198 Poznań, Poland, e-mail: ratajh@au.poznan.pl
M. Bosiacki, Department of Horticultural Plant Nutrition, Agricultural University of Poznań, Zgorzelecka 4, 60-198 Poznań, Poland, e-mail: winibos@au.poznan.pl

(Received: June 5, 2008. Accepted: July 18, 2008)

ABSTRACT. Phycological and physical-chemical analyses were conducted in a small garden pond containing pine bark. Samples were collected from 13 July till 21 September 2005, once a week. Considerable temporal changes in phytoplankton structure were observed. Chlorophytes were represented by the highest number of taxa, but in terms of abundance mostly blue-green and green algae of the order Chlorococcales dominated. In the second half of the study period a water bloom was caused by *Merismopedia punctata*. Conditions in the water body were optimal for development of blue-green and green algae (high water temperature, alkaline pH, and high concentrations of nutrients). The high abundance of small green algae (*Scenedesmus ecornis*, *Tetraedron minimum* and *Hyaloraphidium contortum*) and cryptophytes (*Chroomonas acuta* and *Rhodomonas minuta*) which are r-strategies, showed that living conditions in the small pond were unstable. In the first weeks of the study a limiting effect of pine bark on phytoplankton growth was observed.

KEY WORDS: phytoplankton, small water body, *Merismopedia punctata*, green algae, pine bark

INTRODUCTION

In small garden ponds in summer, blue-green and green algae often cause water blooms. This is stimulated mostly by high water temperature and high concentrations of nutrients. Moreover, water in small and shallow reservoirs is continuously mixed, which permits the algal cells to remain in suspension and exposes them to light, often promoting their growth (Burchardt et al. 2006).

Owners of garden ponds often use various chemicals to limit algal growth. These are algicides, which can exert a negative influence on vascular plants and animals living in water. Apart from the conventional methods used to limit algal growth, also other methods are applied, which are not harmful to other organisms. One of the methods known from the literature is, for example, soaking of barley straw in the pond (Witka-Jeżewska and Hupka 2000, Wiśniewski 2002). However, according to Brownlee et al. (2003), it limits the growth of only some species, not of whole taxonomic groups of algae. According to some owners of garden ponds, also pine bark can be used for this purpose. However, no published data on effects of pine bark on algae are available.

Owners of the study pond placed pine bark in the pond in order to limit algal growth. This inspired us to carry out phycological observations. This study was aimed to analyse temporal changes in the qualitative and quantitative structure of phytoplankton, with reference to physical-chemical properties of water.

MATERIAL AND METHODS

Phycological investigations were conducted in a small garden pond, 8 m^2 in area and 1.1 m deep, located in the village of Suchy Las near Poznań (western Poland). The pond was built in 2003, in a sunny area. Fish and water tortoise were kept there in summer. The bottom was covered with a thick layer of sediment. The water body was surrounded by a lawn, which was fertilized. The pond was lined with a plastic sheet, and a jute sack with 5 kg of pine bark was placed on the bottom (on 5 July 2005), to limit algal growth. Samples for phycological analyses were collected from 13 July till 21 September 2005, every week (except one week in August). In total, 10 samples were taken. At the same time, water temperature and pH were measured. Chemical analyses of water (nitrate N, ammonium N, total P, and conductivity) were performed once a month. They were started soon before placing bark in the pond (on the same day). Chemical analyses were conducted according to STANDARD METHODS for examination of water and wastewater (1998). Every time, samples were collected with a 1.5-litre plastic bottle, from the surface water layer, and fixed with Lugol's solution. In the laboratory they were subject to sedimentation, and sample volume was reduced to 5-10 ml. Phytoplankton abundance was assessed in a Fuchs-Rosenthal Counting Chamber. Each cell was treated as one individual. In the case of trichomes, a section of 100 μm in length was considered as one individual, while in colonial blue-green algae of the genera *Merismopedia*, *Microcystis* and *Woronichinia*, an area of 400 μm^2. The species whose contribution to total abundance was at least 10% were defined as dominants.

To analyse the relationship between the analysed phycological parameters and the environmental variables, Pearson's correlation coefficients were calculated (significance at $p < 0.05$) between water pH or temperature and algal abundance (in individual taxonomic groups, and in the dominant species that were present in all the water samples). The data were processed with STATISTICA 6.0 PL 2002 software (STATISTICA FOR WINDOWS... 2002).

RESULTS

As a result of this study, 60 taxa were identified within the phytoplankton of the garden pond (Table 1). Chlorophytes, represented mainly by Chlorococcales, were the richest group of algal species (Fig. 1). The major genus was *Scenedesmus*. Also diatoms were represented by a large number of species. The least diverse were euglenoids, cryptophytes and dinoflagellates. The qualitative structure of phytoplankton did not change markedly in time, considering the contributions of most of the taxonomic groups of algae. However, euglenoids and cryptophytes were recorded only in the second half of the study period (Fig. 2).

TABLE 1. Taxonomic composition of phytoplankton in the study pond

Cyanobacteria
Chamaesiphon curvatus Nordstedt
Leptolyngbya thermalis Anagn.
Limnothrix redekei (Van Goor) Meffert
Lyngbya contorta Lemm.
Merismopedia punctata Mayen
Microcystis aeruginosa Kütz.
Microcystis incerta (Lemm.) Starmach
Oscillatoria sp.
Woronichinia rosea (Snow) Lemm.
Chlorophyta
Closterium moniliferum Bory
Coelastrum reticulatum (Dang.) Senn
Cosmarium constrictum Delp.
Cosmarium granatum Bréb. ex Ralfs
Cosmarium laeve Rabenhorst
Cosmarium rectangulare Grunow in Rabenhorst
Crucigenia tetrapedia (Kirchner) W. et G.S. West
Desmodesmus communis (Hegew) Hegew
Dictyosphaerium pulchellum Wood
Gomphosphaeria nagaeliana (Unger) Lemm.
Hyaloraphidium contortum Pascher, Koršikov
Kirchneriella contorta (Schmidle) Bohlin
Mougeotia sp.
Oocystis parva W. et G.S. West
Pediastrum boryanum (Turp.) Menegh.
Pediastrum tetras (Ehr.) Ralfs
Scenedesmus dimorphus (Turp.) Kütz.
Scenedesmus ecornis (Ehr.) Chodat
Scenedesmus obtusus Meyer
Scenedesmus opoliensis P. Richter
Scenedesmus quadricauda Meyer
Tetraedron caudatum (Corda) Hansgirg
Tetraedron minimum (A. Braun) Hansgirg
Ulothrix zonata (Weber et Moor) Kütz.
Euglenophyta
Euglena sp.
Euglena limnophila Lemm.
Phacus orbicularis Hübner
Bacillariophyceae
Achnanthes flexella (Kütz.) Grun.
Cyclotella sp.
Cyclotella comta (Grun.) Lemm.
Cyclotella distinquenda Hustedt
Cymbella sp.
Fragilaria construens (Ehr.) Grun. var. Venter Sippen
Fragilaria ulna var. *acus* (Nitzsch) Lang-Bertalot
Gomphonema sp.
Gomphonema acuminatum Ehr.
Gyrosigma attenuatum (Kütz.) Rabenhorst
Melosira varians Agardh
Navicula sp.
Nitzschia palea Kütz.
Synedra tabulata (Agardh) Kütz.
Cryptophyceae
Chroomonas acuta Utermöhl
Cryptomonas sp.
Cryptomonas marssonii Skuja
Rhodomonas minuta Skuja
Dinophyceae
Gymnodinium sp.
Gymnodinium albulum Lindemann
Peridinium sp.
Peridinium elpatiewskyi (Ostenfeld) Bourrelly
Peridinium inconspicuum Lemm.

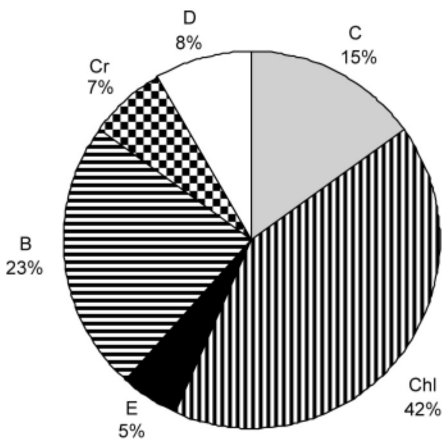

FIG. 1. Percentage contributions of individual taxonomic groups to the total number of phytoplankton species (qualitative structure) in the study pond over the whole study period (C – Cyanobacteria, Chl – Chlorophyta, E – Euglenophyta, B – Bacillariophyceae, Cr – Cryptophyceae, D – Dinophyceae)

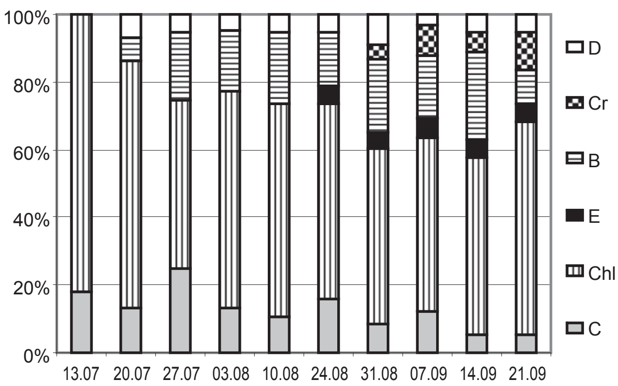

FIG. 2. Percentage contributions of individual taxonomic groups to the total number of phytoplankton species (qualitative structure) in the study pond during successive sampling sessions (C – Cyanobacteria, Chl – Chlorophyta, E – Euglenophyta, B – Bacillariophyceae, Cr – Cryptophyceae, D – Dinophyceae)

Total phytoplankton abundance in the first half of the study period was relatively low, and reached up to 60 535 ind.·ml^{-1} (on the first day of the study, Fig. 3). At that time, green algae of the order Chlorococcales and blue-green algae dominated quantitatively. The abundance of green algae generally decreased in time, while blue-green algae showed an increasing trend (Fig. 3). The lowest phytoplankton abundance (21 670 ind.·ml^{-1}) was recorded on 10 August, when green algae were the least numerous. On 24 August total abundance clearly increased (to 183 265 ind.·ml^{-1}). This was associated mostly with a water bloom caused by *Merismopedia punctata*, but also with an increased abundance of green algae (Fig. 3). In the second half of the study period, great variation was observed in total phytoplankton abundance. At that time, blue-green algae and green algae of the order Chlorococcales dominated in all samples. In September, cryptophytes were recorded and ranked third

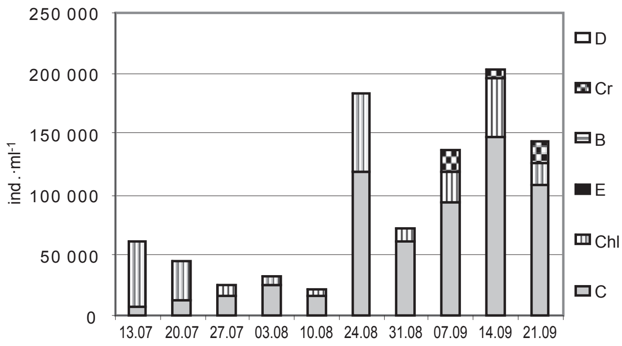

FIG. 3. Phytoplankton abundance in the study pond during successive sampling sessions (C – Cyanobacteria, Chl – Chlorophyta, E – Euglenophyta, B – Bacillariophyceae, Cr – Cryptophyceae, D – Dinophyceae)

(among all taxonomic groups of phytoplankton) in respect of abundance (Fig. 3). The highest phytoplankton abundance during the study period (203 425 ind.·ml^{-1}) was recorded on 14 September, when a water bloom was caused by *Merismopedia punctata*. When analysing the numbers of euglenoids, diatoms, and dinoflagellates, no remarkable changes in time were noticed (Fig. 3).

The dominance structure in the study pond changed in time (Table 2). A constant dominant (or codominant) in all the samples was the blue-green alga *Merismopedia punctata*, which peaked on 14 September and 24 August (Fig. 4). At the beginning of the study period, small green algae of the order Chlorococcales dominated (Table 2). From 13 July to 3 August 2005, changes in abundance of species of this group were more or less parallel, and the values generally decreased in time. In late August, other species of green algae and cryptophytes started to dominate (Table 2).

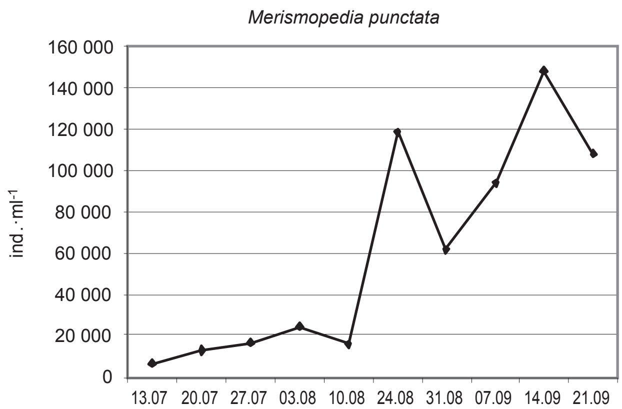

FIG. 4. Changes in *Merismopedia punctata* abundance in time

Changes in the physicochemical properties of water in time are presented in Table 3. Statistical analysis did not detect any significant correlation between the abundance of individual taxonomic groups of algae and water pH or temperature. Significant positive correlations were found only between the abundance of *Tetraedron minimum* and water temperature ($r = 0.70$) and pH ($r = 0.64$), and between the abundance of *Scenedesmus ecornis* and water temperature ($r = 0.68$).

TABLE 2. Dominance structure of phytoplankton in the study pond during successive sampling sessions (+ denotes dominance of the species in the given sample)

Species	13.07	20.07	27.07	03.08	10.08	24.08	31.08	07.09	14.09	21.09
Tetraedron minimum	+	+	+	+						
Scenedesmus ecornis	+	+	+							
Merismopedia punctata	+	+	+	+	+	+	+	+	+	+
Hyaloraphidium contortum					+	+	+	+		
Rhodomonas minuta								+		
Pediastrum boryanum									+	
Chroomonas acuta										+

TABLE 3. Values of physical-chemical properties of water in the study pond during successive sampling sessions

Parameter	05.07	13.07	20.07	27.07	03.08	10.08	24.08	31.08	07.09	14.09	21.09
pH	8.98	8.46	7.7	6.9	7.07	7.24	6.87	8.04	7.72	7.5	7.51
Temperatura (°C)	21.2	24.2	23.01	21	20	15.3	20	19	21	20	21
$N-NH_4$ ($mg \cdot l^{-1}$)	1.05	–	–	–	–	–	–	0.35	–	–	0.35
$N-NO_3$ ($mg \cdot l^{-1}$)	0.7	–	–	–	–	–	–	0.7	–	–	0.35
TP ($mg \cdot l^{-1}$)	0.67	–	–	–	–	–	–	0.23	–	–	0.23
Conductivity ($\mu S \cdot cm^{-1}$)	611	–	–	–	–	–	–	526	–	–	560

DISCUSSION AND CONCLUSIONS

Phytoplankton structure in the study pond was characterized by high dynamics, which was due to remarkable variation in physical-chemical properties of water. Due to the small area and depth of the pond, it is very sensitive to changes in environmental conditions.

The decrease in water pH in the first weeks of the study could be caused by the pine bark placed at the bottom of the studied pond. Bark pH is acidic (ANTKOWIAK 1997, TURSKI et AL. 1999). It is additionally lowered due to bark decay, because humification of organic matter results in release of weak organic acids, e.g. humic, fulvic, and hymatomelanic acids (GONET 1993). Bark added to the soil causes a reduction of the soil pH (TURSKI et AL. 1999).

During the decrease in water pH in the first half of the study period, the abundance of dominant green algae also decreased (*Tetraedron minimum* and *Scenedesmus ecornis*). Results of statistical analysis confirmed the positive correlation between the abundance of *Tetraedron minimum* and water pH.

In the study pond, water temperature was also correlated with algal abundance. On 10 August 2005, when water temperature was the lowest, also total phytoplankton abundance was the lowest, due to the lowest numbers of green algae and a decline of blue-green algae. Statistical analysis confirmed that the green algae that dominated in the first half of the study period (*Tetraedron minimum* and *Scenedesmus ecornis*) were positively correlated with water temperature. Research conducted by BURCHARDT and DROPIK (1999) in a small garden pond also showed that the abundance of *Scenedesmus* spp. is positively correlated with water and air temperature.

In the study pond, green algae of the order Chlorococcales dominated in some samples. In the second half of the study period, *Hyaloraphidium contortum* dominated. REYNOLDS (1984) and BUCKA and WILK-WOŹNIAK (2002) report that in shallow water bodies, high concentrations of nutrients are favourable for green algae of the order Chlorococcales. According to REYNOLDS (1984) and ALAM et AL. (2001), optimum conditions for green algae are usually observed in summer, which is also confirmed in the present study.

The large contribution of r-strategists to total phytoplankton abundance in the study pond (especially the small green algae and cryptophytes) confirmed that living conditions in small and shallow water bodies are unstable (BURCHARDT and MESSYASZ 2004).

The abundance of *Merismopedia punctata* varied widely in time, but this species was a dominant or co-dominant throughout the study period. Blue-green algae prefer a high water temperature (RAPALA and SIVONEN 1998, AN and JONES 2000, SVRCEK and SMITH 2004, ZEBEK 2005) and a high concentration of phosphorus (WEHR and THORP 1997, HUSZAR and CARACO 1998). Moreover, according to REYNOLDS and WALSBY (1975), PRASAD et AL. (2000), most blue-green algae reach the highest growth rate at pH 6-9. Thus conditions in the pond were optimal for *Merismopedia punctata*. Numbers of this species peaked in late August and September. A study conducted by BURCHARDT and PAWLIK-SKOWROŃSKA (2005) showed that in small water bodies, intensive growth of blue-green algae (including water blooms) is observed in late summer.

The dominance of green algae in the qualitative structure of phytoplankton, and codominance of blue-green and green algae in the quantitative structure, probably resulted from the sunny location (in the case of green algae), alkaline pH, high water temperature, and high concentrations of nutrients (especially on the first day of the study). The high concentrations of chemical compounds in water were probably due to fertilization of the lawn and feeding of the animals living there. The bottom sediments were also a source of nutrients for algae.

In the study pond, a limiting effect of pine bark on phytoplankton growth was observed. The decrease in water pH (observed in the first three weeks of the study) was sufficient to limit the growth of blue-green algae. To collect more detailed information on this issue, it is necessary to carry out further, more comprehensive investigations. It is recommendable to study more water bodies and additionally to perform laboratory experiments.

REFERENCES

Alam M.G.M., Jahan N., Thalib L., Wei B., Maekawa T. (2001): Effects of environmental factors on the seasonal change of phytoplankton populations in a closed freshwater pond. Environ. Int. 27: 363-371.

An K.G., Jones J.R. (2000): Factors regulating bluegreen dominance in a reservoir directly influenced by the Asian monsoon. Hydrobiologia 432, 1-3: 37-48.

Antkowiak L. (1997): Wykorzystanie kory niektórych drzew i krzewów. Wyd. AR, Poznań.

Brownlee E.F., Sellner S.G., Sellner K.G. (2003): Effects of barley straw (*Hordeum vulgare*) on freshwater and brackish phytoplankton and cyanobacteria. J. Appl. Phycol. 15, 6: 525-531.

Bucka H., Wilk-Woźniak E. (2002): Gatunki kosmopolityczne i ubikwistyczne wśród glonów pro- i eukariotycznych występujących w zbiornikach wodnych Polski południowej. Zakład Biologii Wód im. K. Starmacha PAN, Kraków.

Burchardt L., Dropik A. (1999): Temperatura jako czynnik stymulujący i inhibitujący rzwój populacji niektórych zielenic planktonowych w małym, przydomowym zbiorniku wodnym. Bad. Fizjogr. Pol. Zach. Ser. B. Bot. 48: 225-232.

Burchardt L., Messyasz B. (2004): Fykoflora Jeziora Trzebickiego w 2003 roku. Biul. Park. Krajobraz. Wielkopolski 10, 12: 135-168.

Burchardt L., Messyasz B., Stępniak A. (2006): Różnorodność zbiorowiska fitoplanktonu w stawach Borusa i Grundela. Teka Kom. Ochr. Kszt. Środ. Przyr. 3: 35-40.

Burchardt L., Pawlik-Skowrońska B. (2005): Zakwity sinic – konkurencja międzygatunkowa i zagrożenie dla środowiska. Wiad. Bot. 49, 1/2: 39-49.

Gonet S. (1993): Struktura substancji humusowych. Zesz. Probl. Post. Nauk Roln. 411: 189-194.

Huszar V.L.D.M., Caraco N.F. (1998): The relationship between phytoplankton composition and physical-chemical variables: A comparision of taxonomic and morphological – functional descriptors in six temperate lakes. Freshw. Biol. 40, 4: 679-696.

Prasad K.V.R., Gosh M., Gaur J.P. (2000): A reconnaissance of species-environment relationships in pond phytoplankton at Varanasi (India). Biologia 55, 1: 35-42.

Rapala J., Sivonen K. (1998): Assessment of environmental conditions that favor hepatotoxic and neurotoxic *Anabaena* spp. strains cultured under light limitation at different temperatures. Microb. Ecol. 36: 181-192.

Reynolds C.S. (1984): The ecology of freshwater phytoplankton. Cambridge University Press, Cambridge.

Reynolds C.S., Walsby A.E. (1975): Water blooms. Biol. Rev. 50: 437-481.

Standard methods for examination of water and wastewater (1998). American Public Health Association, New York.

Statistica for Windows (Computer program manual 6.0 PL). (2002). StatSoft Inc., Tulsa.

Svrcek C., Smith D.W. (2004): Cyanobacteria toxins and the current state of knowledge on water treatment options: a review. J. Environ. Eng. Sci. 3: 155-185.

Turski R., Słowińska-Jurkiewicz A., Hetman J. (1999): Zarys gleboznawstwa. Wyd. AR, Lublin.

Wehr J.D., Thorp J.H. (1997): Effects of navigation dams, tributaries, and littoral zones on phytoplankton communities in the Ohio River. Can. J. Fish. Aquat. Sci. 54, 2: 378-395.

Wiśniewski R. (2002): Attempts to eliminate cyanobacterial blooms in Lake Łasińskie. Environ. Prot. Eng. 28: 15-25.

Witka-Jeżewska E., Hupka J. (2000): Zastosowanie słomy jęczmiennej do ograniczenia wzrostu glonów w powierzchniowych zbiornikach wody. Gosp. Wod. 3: 99-102.

Zebek E. (2005): Annual succession paterns of blue-green algae as related to physicochemical water parameters in the urban Lake Jeziorak Mały in the 1998-2003 period. Oceanol. Hydrobiol. Stud. 34, 4: 33-46.

For citation: Celewicz-Gołdyn S., Ratajkiewicz H., Bosiacki M., Przybyła M. (2008): Temporal changes in phytoplankton structure in a small garden pond containing pine bark. Rocz. AR Pozn. 387, Bot.-Stec. 12: 29-33.