

Dynamics of phytoplankton in brown-water lakes enclosed with reed-belts (Fertő/Neusiedlersee; Hungary/Austria)

Judit Padisák

Introduction

The turbid, mesotrophic and alkaline Neusiedlersee (Fertő) is one of the largest shallow lakes in Central Europe (surface area: 300 km²; length: 35 km; average width: 8.6 km; mean depth: 1.3 m; theoretical retention time: 3 years). With its numerous types of habitats, ranging from a big open water body across an extensive reed belt to a large number of marginal temporal ditches, the area offers a good opportunity for wetland studies.

As a consequence of subsequent dry years, Neusiedlersee last dried out in 1868. Since that time an extensive reed belt has developed along the shores, recently covering more than one third of the total lake area (BURIAN & SIEGHARDT 1979). However, in the deeper parts of the basin small areas have remained free of reed belts and have recently appeared as small open-water lakes with brownish or brown water color.

Research on the algae of Neusiedlersee has a long history. The first records on the algal flora are from the 1860's, and the algal flora has attracted the interest of many algologists ever since (see in KUSEL-FETZMANN 1979). In these studies the presence of an extraordinarily rich algal flora has been described. However, this high algal biodiversity refers mostly to the reed-belt area of the lake since the open water is inhabited by several characteristic species.

Our limnological knowledge of the inner ponds of Neusiedlersee is very limited. TAKÁTS (1984) mentioned several aspects of their hydrology and water chemistry. Algological studies (PADISÁK 1982, BUCZKÓ 1989, BUCZKÓ & PADISÁK 1987–88) as well as other investigations (LAKATOS 1989) focused mostly on the periphyton of the reeds at the edges of the inner ponds. Only PADISÁK's (1981, 1983) pilot studies are available on their phytoplankton.

Material and methods

Phytoplankton of 12 inner lakes was studied during the last 13 years (Fig. 1, Table 1). Samples in the southern, Hungarian part of the lake were taken with a glass-tube sampler and with approx. monthly frequency between 1979 and 1983. In the Austrian inner ponds (Haider-Seppl-Poschen-Lacke, Ruster-Poschen) surface samples

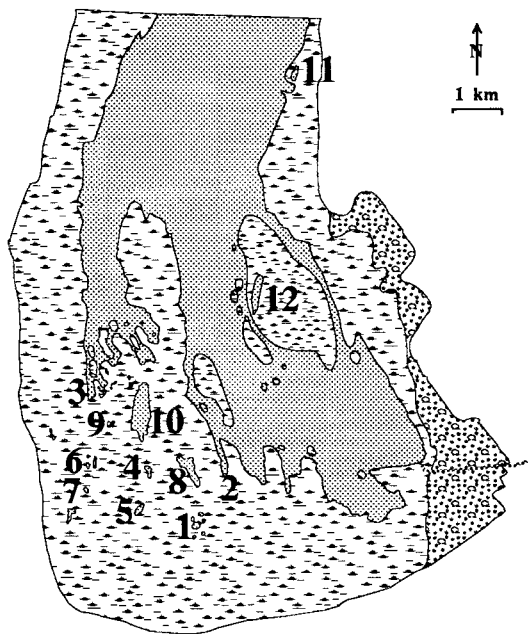


Fig. 1. Location of sampling stations in the reed-belt of Neusiedlersee. Local names of particular lakes are given in Table 1; numbering is identical.

were taken between 1987 and 1991 with weekly-bi-weekly frequency. Phytoplankton was counted under an inverted microscope; a minimum of 400 cells/sample were counted. Biomass was estimated by geometric approximation. In this paper only biomass records were considered for describing quantitative changes of phytoplankton.

Results and discussion

1. A rather rich algal flora can be recorded in phytoplankton samples deriving from the inner lakes. However, most of the species have

Table 1. Some important parameters of the studied brown-water lakes and the proportion of planktonic flagellates (PF), planktonic non-flagellates (PNF) and non-planktonic algae (NPA). The proportions were based on all the quantitative data that were obtained in the indicated lakes.

| No. | Name | origin | connection to the open lake | surface area (ha) | water depth (m) | color | turbidity | Proportion of | | |
|-----|----------------------------|------------|-----------------------------|-------------------|-----------------|------------|-------------------|---------------|-----|-----|
| | | | | | | | | PF | PNF | NPA |
| 1. | Kishatár-tisztás | natural | artificial canal | 2 | 0.8–1 | dark-brown | transp. to bottom | 46 | 10 | 44 |
| 2. | Homoki nyelv | natural | natural | 11 | 0.8–1 | brownish | turbid | 61 | 25 | 14 |
| 3. | Kádler-sarok | natural | natural | 13 | 0.8–1 | brownish | turbid | 48 | 49 | 3 |
| 4. | Nagyhatár-tisztás | natural | artificial canal | 3 | 0.8–1 | dark-brown | transp. to bottom | 71 | 15 | 14 |
| 5. | Átjáró-tó | natural | artificial canal | 3 | 0.8–1 | dark-brown | transp. to bottom | 48 | 8 | 44 |
| 6. | Oberlakni | natural | artificial canal | 2 | 0.7–1 | dark-brown | transp. to bottom | 81 | 7 | 12 |
| 7. | Pitner-strand | artificial | artificial canal | 1 | 2 | dark-brown | transparent | 92 | 6 | 2 |
| 8. | Hidegségi-tó | natural | artificial canal | 15 | 0.8–1 | dark-brown | transp. to bottom | 53 | 10 | 37 |
| 9. | Kis-Herlakni | natural | artificial canal | 1.5 | 0.7–1 | dark-brown | transp. to bottom | 48 | 12 | 40 |
| 10. | Herlakni | natural | artificial canal | 35 | 1–1.2 | brownish | turbid | 35 | 49 | 16 |
| 11. | Ruster-Poschen | natural | artificial canal | 4 | 0.9–1.1 | brown | transparent | 40 | 50 | 10 |
| 12. | Haider-Seppl-Poschen-Lacke | natural | artificial canal | 10 | 0.9–1.1 | brownish | turbid | 45 | 52 | 3 |

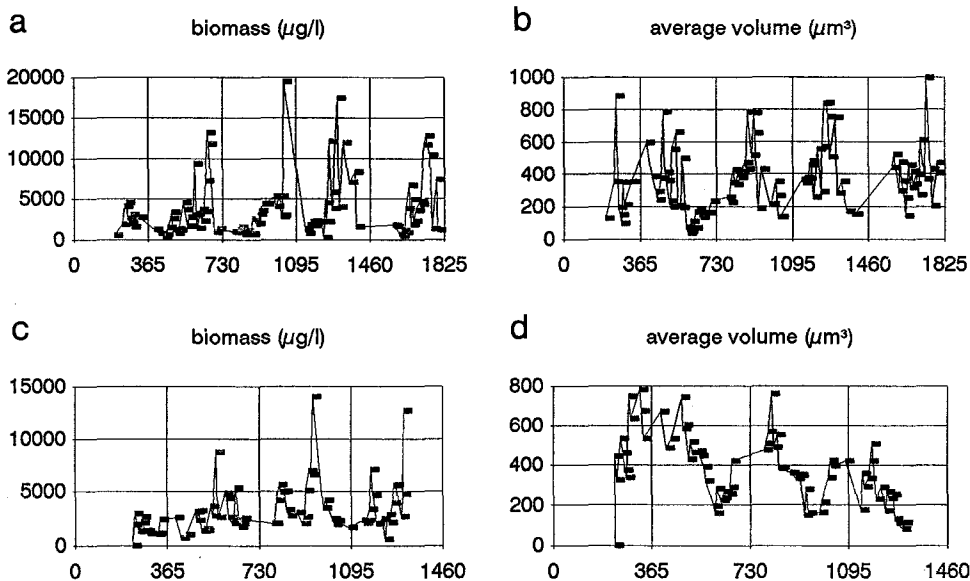


Fig. 2. Changes in biomass ($\mu\text{g} \cdot \text{l}^{-1}$) and average volume (μm^3) of phytoplankton in Haider-Seppl-Poschen-Lacke (a, b) and in Ruster-Poschen (c, d) between 1987 and 1990/1991. Time is indicated as running days; number 1 corresponds to 1st January, 1987. Vertical gridlines separate years.

epipellic or periphytic origin. Thus, as in the open lake, phytoplankton is characterized by several major planktonic species. In inner lakes with small surface areas the quantitative contribution of non-planktonic algae (large diatoms, homocytic blue-green and filamentous green algae) can be around 40% (Table 1).

2. There is a clear relationship between the taxonomic/life-form composition of phytoplankton and the size/color of the lakes. In small lakes with brown water that is transparent to the bottom, planktonic flagellates (mostly *Cryptomonas* and *Rhodomonas* species, and Phytomonadina in some cases) represent the

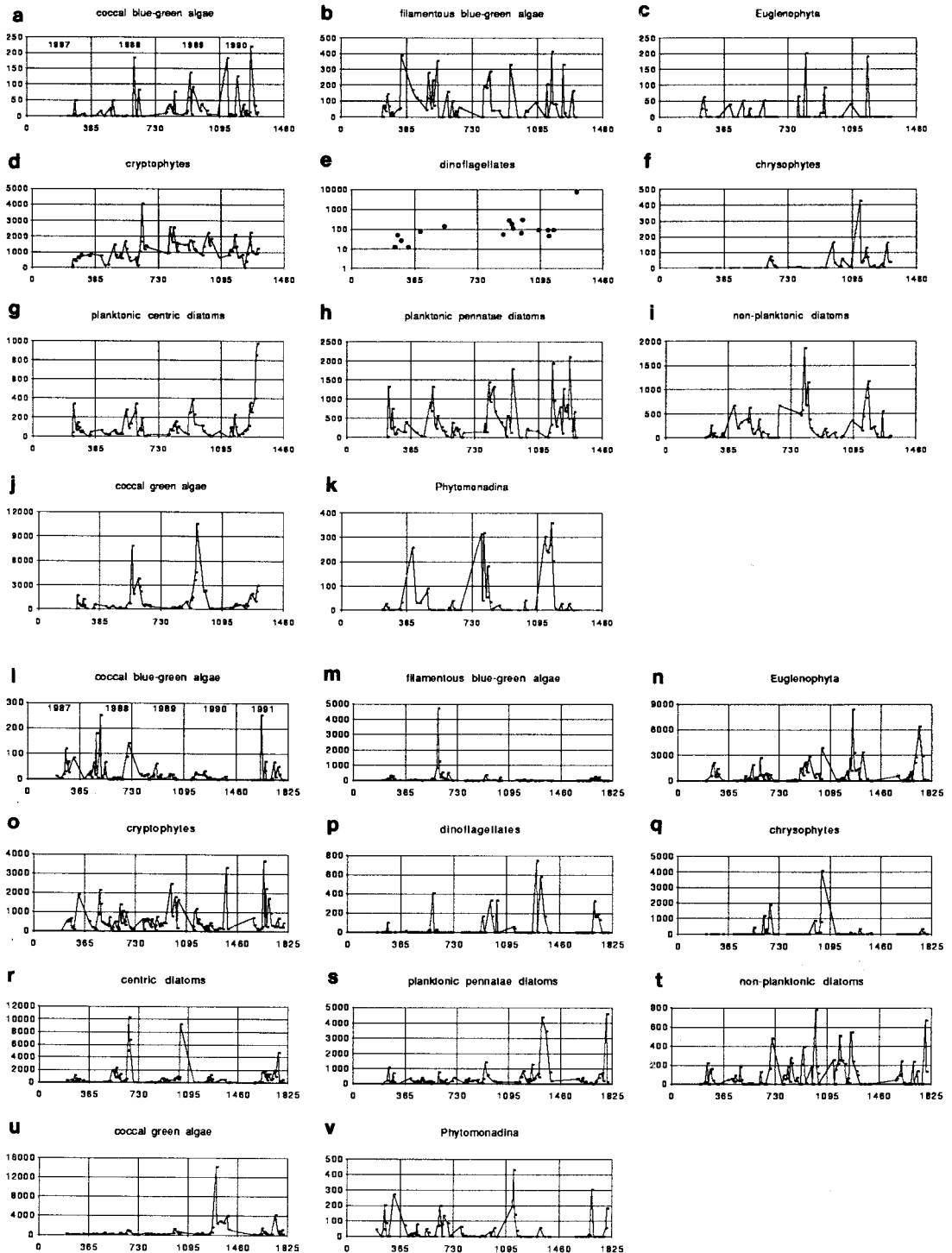


Fig. 3. Changes in biomass ($\mu\text{g} \cdot \text{l}^{-1}$) of the main algal groups in Ruster-Poschen (a–k) and in Haider-Seppl-Poschen-Lacke (l–v) between 1987 and 1990/1991. Time is indicated as running days; number 1 corresponds to 1st January, 1987. Vertical grids separate years.

most important group with about a 50 % contribution (Table 1). In bigger lakes, in which the water is turbid due to inorganic sediment, non-motile planktonic algae, which are mostly diatoms (*Chaetoceros muellerii* LEMM., *Cyclotella meneghiniana* KÜTZ., small unicellular centrics, *Nitzschia acicularis* W. SMITH and other small *Nitzschia* spp.) are important. The only consequent exception is the Ruster-Poschen, in which, despite its brown water color and considerable transparency, non-motile coccal green algae (mostly unidentifiable unicellular spherical or ellipsoid forms) made the greatest contribution to total biomass. In the summer of 1988, a large number of pseudofilaments of *Romeria* sp. (which most closely resemble *Romeria crassa* HINDÁK) appeared in the plankton of Haider-Seppl-Poschen-Lacke. In this lake euglenophytes (a smaller and a bigger form of *Euglena oxyuris* SCHMARDT and *E. acus* EHR.) were also characteristic.

3. Changes in phytoplankton quantity showed definite seasonality in the above two lakes. Seasonal development of phytoplankton was characterized by a mid- or late-summer peak biomass. Considerable spring bloom of algae was not observed.
4. The average volume (a division of the volumetric biomass [$\mu\text{m}^3 \cdot \text{l}^{-1}$] by the number of individuals) of species peaked in spring or mid-summer in both lakes and reached its seasonal minima during the seasonal peak biomasses. Consequently, that the peak biomasses in these lakes consist of algae that are easily grazeable even for smaller, non-selective zooplankton species.
5. Seasonal dynamics of phytoplankton assemblage was found to be quite individual in the two lakes compared here. The summer biomass peak consisted of coccal green algae in one of the lakes, while diatoms reached a large density in the other. This coccal green/diatom peak developed each year with high fidelity. In this respect the enclosed lakes differ greatly from the open water of Neusiedlersee, in which an extraordinarily low level of seasonality can be observed (PADISÁK & DOKULIL 1991).
6. Despite what is observed in most of the other natural lakes in which phytoplankton dynamics are characterized by annually recurrent sequences of the dominant species, the seasonal development appeared to be quite unpredictable: the peak biomass is likely to be provided by different species each year.

7. The interannually observed increase in phytoplankton peak biomass in both lakes coincided with a drying-out period. This can be well demonstrated by the periodically increasing conductivity records. During the period $\text{PO}_4^{3-}\text{-P}$ increased, and dissolved N forms ($\text{NO}_3^{3-}\text{-N}$ and $\text{NH}_4^{+}\text{-N}$) decreased. As a consequence, the N/P ratio decreased significantly. An increase in dissolved oxygen was recorded (PADISÁK in press) in one of the lakes. These changes can be considered as parallel developments of both physico-chemical and biological changes. Experimental investigations are necessary for a better understanding of the real causal interconnections. However, results of this study suggest that the recurrent drying-out periods significantly affect the planktonic habitats in a wetland system.

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Author's address:

Balaton Limnological Institute of the Hungarian Academy of Sciences, H-8237 Tihany, Hungary.