Phytoplankton communities in the drinking water reservoir of Znojmo

Společenstva fytoplanktonu ve vodárenské nádrži Znojmo

Rodan G e r i š

Morava River Basin Authority, Dřevařská 11, CZ-601 75 Brno

Abstract

The reservoir was built in 1966 for drinking water supply, power generation, and irrigation. It is characterized by a very short retention time, narrow river-like shape, low average and maximum depths and high total phosphorus loading. Its catchment is large and strongly influenced by human activities. The composition of phytoplankton, zooplankton, chlorofyl-*a* concentration and chemical variables were analyzed monthly in the main vegetation seasons 1999 – 2002. The composition of phytoplankton assemblages is influenced both by high trophic status and extreme technical parameters of the reservoir. Diatoms prevailin spring, green algae and diatom *Fragilaria crotonensis* in summer. Blue-green algae occur mainly in late summer, but they have not recently constituted massive water blooms. Short retention time, intensive input of relatively cold water of the Dyje, River and consequently lower stability of the water column in summer are considered the main reasons for such a situation.

Abstrakt

Přehrada byla postavena v roce 1966 pro účely zásobování pitnou vodou, výrobu elektrické energie a zavlažování. Nádrž má velmi krátkou dobou zdržení, úzký korytovitý tvar, nízkou průměrnou i maximální hloubku a vysoký přísun celkového fosforu. Její povodí je velké a silně ovlivněné lidskou činností. V letech 1999 – 2001 bylo v době hlavní vegetační sezóny měsíčně zkoumáno složení fytoplanktonu i zooplanktonu spolu s koncentrací základních chemických parametrů a chlorofylu *a*. Složení společenstev fytoplanktonu je ovlivňováno jednak vysokou trofií a také výjimečnými technickými parametry nádrže. Na jaře převažují rozsivky, v létě zelené řasy, často doplněné silnou populací rozsivky *Fragilaria crotonensis*. Sinice se vyskytují převážně v pozdně letním období, v současné době však nevytvářejí intenzivní vodní květ, obvyklý pro nádrže s podobně vysokým přísunem živin. Hlavními příčinami pro tuto skutečnost je krátká doba zdržení, přísun studené vody z řeky Dyje a následně nižší stabilita vodního sloupce v letních měsících.

Introduction

Znojmo is a district town in southern part of Moravia (Czech Republic). Znojmo Reservoir, a river - like man-made lake with one principal inflow and highly elongated morphology, was investigated during 1999 – 2001. The reservoir has very low maximum and average depths and an extremely short retention time. Its inflow, which proceeds from the hypolimnion of Vranov Reservoir located some 25 km upstream, is very cold and rich in total phosphorus (average concentration in principal inflow is 80 $\mu g.l^{-1}$). Such a high concentration of total phosphorus is usually followed by a massive development of cyanobacterial water blooms. Contrary to it, diatoms and green algae dominate in Znojmo Reservoir, while blue green algae, which occur there in summer months too, have not recently become the prevailing phytoplankton group. As shown by HELAN et al. (1988) during their investigations in 1988, already at that time the main groups of phytoplankton were diatoms in spring and autumn and green algae together with *Cryptomonas sp.* in summer. However, in summer aweak water bloom formed by *Aphanizomenon klebahnii* occurred. Zooplankton was quantitatively poor; dominating species were little cladocerans (*Diaphanosoma brachyurum, Bosmina coregoni*), while rotifers were missing almost utterly. Such a shortage was ascribed to the absence of suitable food, i.e. small algae. Weak water bloom(*Microcystis sp.)*, which had drifted from Vranov Reservoir, was occasionally noticed by VLADIMÍR HRDINA (personal communication) in little bays and other calm sites of the reservoir's body. This paper compares three investigated vegetation seasons between 1999-2001, their phytoplankton, physical and chemical variables and searches for an explanation of the predominance of diatoms and green algae.

Material and methods

The reservoir was built in 1966 for drinking water supply, power generation and irrigation. Major part of its large catchment area is located in Austria (tab.1), in a lowland influenced by agriculture and other human activities. The stretch of the basin of the inflow Dyje between Znojmo Reservoir and upper Vranov Reservoir is protected as a National Park. Its bottom fauna and flora is exposed to extremely strong flow fluctuations (HELEŠIC et al. 2000) caused by Vranov power plant operation. The affluent Dyje River drifts up only a low amount of planktonic algae into Znojmo Reservoir (KOMÁREK & MARVAN 1999).

Tab.1 The main characteristics and values

Altitude (m a.s.l.)	227
Volume ($10^6 m^3$)	4,290
Maximum depth (m)	12
Mean annual inflow ($m^3 s^{-1}$)	10,8
Mean retention time (days)	4,6
River basin area (km^2)	2461

The transparency was measured twice a week at the deepest place near the dam. The sampling for nutrients and chlorophyll-*a* concentrations took place in approximately monthly intervals at the same spot by the dam during the main vegetation season (April – September). Integrated samples from the surface layer (0 – 4m) were collected at this site, too. Vertical stratification of temperature, pH, conductivity and dissolved oxygen were measured by device HYDROLAB 20. All data were supplied by the laboratories of the Morava River Basin Authority. Cells of phytoplankton were counted in chamber Cyrus I using appropriate determination literature (HINDÁK et. al. 1978, KOMÁREK & AGNOSTIDIS 1999).

Results

The transparency of water near the dam was very low and the majority of the measured values ranged between 1 – 2 m. The annual course of the measured values is very similar between both months and years. The state of „clear water“ was hardly apparent, but some autumn increases of transparency were recorded in 1999 (Chart 1.). The concentrations of total phosphorus (TP) ranged between 40 and 180 $\mu g.l^{-1}$ in the inflow, and 10 to 310 $\mu g.l^{-1}$at the surface layer near the dam. These high concentrations respond to eutrophy. The mixed zone in the epilimnion is very narrow, only about 2 –3 meter.

Tab. 2 Concentrations of some compounds at the surface layer near the dam

parameter	unit	maximum	minimum	average
dissolved O_2	$mg.l^{-1}$	18	7.90	12.3
BOD_5	$mg.l^{-1}$	12	0.90	3.2
$N - NH_4$	$mg.l^{-1}$	0.93	0.01	0.18
$N - NO_2$	$mg.l^{-1}$	1	0.01	0.14
$N - NO_3$	$mg.l^{-1}$	9.10	1.13	4.78
TP	$mg.l^{-1}$	0.31	0.01	0.10
pH	$mg.l^{-1}$	10.40	6.50	8.14

The concentration of chlorophyll-*a* varied from 1 $\mu g.l^{-1}$ in May 2001 to 81.6 $\mu g.l^{-1}$ in July 2000 (Chart 2.). Throughout the vegetation season, the highest concentrations of chlorophyll-*a* occur in summer from June to September. In spring, communities of centric diatoms (mainly *Stephanodiscus cf. hantzschii*) dominated, and some other diatom species (*Synedra acus, Diatoma vulgaris, Diatoma tenuis, Asterionella formosa*) were also common. *Fragilaria crotonensis* and the first assemblages of green algae (*Coelastrum sp., Scenedesmus sp.*) appeared in June. The summer peak was dominated by green algae (*Phacotus lenticularis, Coelastrum microporum, C.reticulatum, C. pseudomicroporum, Scenedesmus sp.*) and the diatom *Fragilaria crotonensis*. The later forms an important part of summer phytoplankton biomass. During summer and autumn, some cyanobacteria (*Microcystis sp., Planktothrix aghardii, Phormidium sp.* etc.) were occasionally observed. In September 2000, a negligible cyanobacterial water bloom of *Aphanizomenon issatschenkoi* developed . Massive water bloom of *Microcystis aeruginosa* was recorded only in summer 1992 near reservoir's dam. Its occurrence can be explained by extremely hot summer and consequently prolonged retention time.

Zooplankton occurred at a very poor quantity; small copepods of various stages of development and small cladocerans (*Bosmina longirostris, Bosmina coregoni, Daphnia cucullata, Diaphanosoma brachyurum*) dominated. This fact is in agreement with the results of HELAN et al. (1988). In contrast to their study, a large amount of rotifers (*Asplanchna sp., Brachionus calyciflorus, Conochilus unicornis, Polyarthra vulgaris*) was detected. Large cladocerans did not occur nearly at all.

Tab. 3 Dominants of phytoplankton communities of Znojmo Reservoir in vegetation seasons from 1999 to 2001. Number of cells of each dominant taxon in brackets, t.n. – total number of all cells per ml

	1999	2000	2001
April	t.n. 630 *Stephanodiscus sp.*(200)	t.n. 2500 *Stephanodiscus sp.* (880) *Chrysococcus sp.* (560)	t.n. 1140 *Cyclotella radiosa* (300) *Chlamydomonas sp.* (160) *Pennales.g.sp.* (558)
May	t.n. 5310 *Stephanodiscus sp.* (5040)	t.n. 3920 *Synedra acus* (408) *Asterionella formosa* (520) *Diatoma tenuis* (260) *Stephanodiscus sp.* (1600)	t.n.1440 *Stephanodiscus sp.* (800)

June	t.n.4660 *Fragilaria crotonensis* (2080) Green coccal algae (1840)	t.n. 54530 *Fragilaria crotonensis* (50000) *Coelastr.microporum* (2920) *Scenedesmus sp.* (1200)	t.n. 6300 *Centrales.g.sp.* (4400) *Cryptomonas sp.* (280)
July	t.n. 12660 *Phacotus lenticularis* (5840) *Coelastrum micr.* (2880) *Scenedesmus quadr.* (1440)	t.n. 26850 *Phacotus lenticularis* (7360) *Fragilaria crotonensis* (6720) *Coelastrum reticulatum* (4960)	t.n. 6030 *Phacotus lenticularis* (320) *Fragilaria crotonensis* (1090) *Coelastrum sp.* (2480) Green coccal algae (1840)
Aug.	t.n. 14720 *Scenedesmus sp.* *Coelastrum microporum*	t.n. 4430 *Phacotus lenticularis* *Coelastrum reticulatum* Green coccal algae g.sp.	t.n. 14980 *Fragilaria crotonensis* *Phacotus lenticularis* *Coelastrum sp.*
Sept.	t.n. 21030 *Coelastrum microporum.* (9760) *Coelastrum reticulatum* (3120) *C.pseudomicroporum* (2280) *Phacotus lenticularis* (2440) *Microcystis sp.* (1000)	t.n. 11690 *Aphanizomenon issatschenkoi* (5000) *Phacotus lenticularis* (2800) *Planktosphaeria gelatinosa* (1920) *Staurastrum pingue* (200)	t.n. 19260 *Fragilaria crotonensis* (5640) *Phacotus lenticularis* (4200) *Scenedesmus sp.* (4000) *Coelastrum sp.* (2560)

Discussion

There are two main factors which could be responsible for the absence of massive cyanobacterial water bloom in this reservoir: physical, and competitive – ecological, respectively. At first sight the ability of rapid growth pertaining to small unicellular algae, such as *Stephanodiscus*, seems to be the most important property assuring their survival in an ecosystem with rapid water exchange (with short retention time). However, the same or even greater importance may be ascribed to other physical factors directly or indirectly influencing life conditions in the reservoir.

Due to strong convection and extremely short retention time, water column in Znojmo Reservoir is stable less than usual in other reservoirs. Thermocline is very narrow and lies near the surface. Stability of water column is another important factor for the development of water bloom.

Strong convection near the bottom can result in negative influence on inoculum of some colonial cyanobacteria (*Microcystis* above all). In contrast to filamentous cyanobacteria, such as *Aphanizomenon* or *Planktothrix*, colony-forming *Microcystis* has lower specific growth rate; their ecological strategy and important advantage is in large amount of overwintering cells in inoculum. For the next season, a part of these cells can be overlaid by silt on the bottom and a part can be washed out to the River Dyje (MARVAN & MARŠÁLEK 1996).

Diatoms need for their development - besides nutrients – a sufficient supply of silicon. After depletion of silicon, their further growth is retarded. In the strongly mixed Znojmo Reservoir, diatoms can use silicon from sediments during a greater part of vegetation season. Besides, tolerance to less favorable light conditions can be a further advantage of diatoms in a reservoir with a very low transparency.

Another competitor for colonial blue green algae is the motile green flagellate *Phacotus lenticularis*. Due to its motility, it can utilize light near water surface and it can drop down when light intensity is too strong. It is a very successful representative of phytoplankton of Znojmo Reservoir. *Phacotus* is an alga of stagnant inland waters of various morphometric and ecological states: from deep stratified oligotrophic lakes to shallow polymictic hypertrophic waters, but it shows its highest densities in eutrophic waters. (SCHLEGEL et al. 1998).

An important condition for the successful development of non-motile green algae is the fact that the mixed zone in epilimnion does not exceed euphotic depth. If the mixed zone in epilimion exceeds euphotic depth by a factor of about two, growth of these algae declines (HAPPEY-WOOD 1988).

Conclusion

Despite the high level of nutrients in Znojmo Reservoir, short retention time, instability of water column, lower epilimnion temperature, possible *Microcystis* species inoculum overlying by silt, and competition of other groups of algae appear to influence the composition of phytoplankton in 1999 – 2001. Massive water bloom of cyanobacteria was suppressed and substituted by assemblages of diatoms and green algae. However, an occasional stronger development of water-bloom-forming cyanobacteria can not be excluded.

Acnowledgements

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Fig. 2: Chlorophyll-a concentrations in years 1999-2001

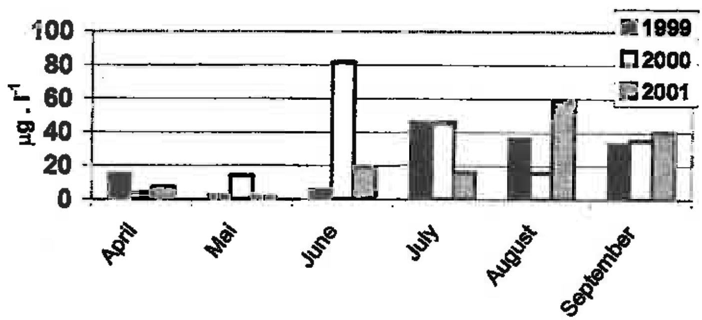

Fig. 1: Transparency of the Znojmo reservoir in years 1996-2001