Fishpond trophic status assessment based on nutrients and bioindication I. Phytoplankton

Hodnocení trofie rybníků podle nabídky živin a bioindikačních metod I. Fytoplankton

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Abstract

Two-year-study of selected environmental variables, phytoplankton abundance, structure and species composition at 12 fishponds was used for the evaluation of their trophic state.
Favourable conditions of Bouzov fishponds are probably influenced by their disposition in the landscape. On the contrary, fishponds near Hradec Králové are strongly endangered by rapid eutrophication. The negative development of fishponds can be mitigated only by rigorous management excluding intensive fish or duck production, recreation, and agriculture in the surrounding fields. Prevention of external and internal loading and forestation of wide surroundings can be recommended.

Introduction

Fishponds are man-made shallow water bodies in which water level, fish stock and, to some extent, nutrient and fish-food input are under human control (FOTT et al. 1980). Moreover, pond ecosystem is highly labile, and open to almost unpredictable random external disturbances (WEIMANN 1942). Czech fishponds were constructed in the Middle Ages, but they have often lost any artificial appearance and look like small lakes beautifully harmonizing with the landscape (KOŘÍNEK et al. 1987). The source of nutrients is partly from fertilization of ponds, through additional feeding of fish with corn and granulated food, and by run-off from agricultural land. Every pond has a rich nutrient pool in its bottom sediments. During the past few decades, the original

oligotrophic or mesotrophic character of the fishponds has changed to eutrophic, and even hypertrophic, state. This is a result of intensified management for fish-production, changes in agricultural practices in the catchment area, and the use of fishponds as wastewater recipients. Both external and internal loading caused the present situation. The projects of fishponds restoration can lead to improvements in near future. New fishponds have been constructed within the projects of landscape renewal. The development of these new fishponds depends on initial conditions and suitable management. The utilization of centenary experience and hindsight is an important presupposition for the success of these projects.
This study focuses on the comparison of phytoplankton and selected environmental variables at 12 fishponds and the assessment of their trophic status.

Material and methods

Investigations were carried out during the years 2001-2002.
Selected environmental variables (pH, oxygen, temperature, conductivity) were measured in situ using mobile instruments (WTW company). Samples for chemical analyses were taken to plastic bottles. Phosphates, nitrates, and ammonium ions were checked with a DR 2000 spectrophotometer by HACH (HEKERA 1999).

Phytoplankton samples were taken once a month from the surface layer (20 cm below the surface) at the windward side of the fishponds. The quantitative evaluation of the main groups of phytoplankton in the samples was carried out by centrifugation (1500 rpm, time 5 minutes) and counting in a Bürker chamber. The following algal groups were in the centre of our interest: diatoms, green algae, cyanophytes, euglenophytes, chrysophytes, and others. The abundance is expressed as a number of specimens (coccal algae) or filamentous units (1 filament unit = 100µm) per 1 ml of sample.

Samples were taken from three new fishponds near Bouzov (Central Moravia, Czech Republic), and three new fishponds near Hradec Králové (East Bohemia, Czech Republic). The same investigations were carried out at comparative sites near Prostějov (Central Moravia, Czech Republic) and Lednice (South Moravia, Czech Republic). Comparative sites are represented by three old eutrophic fishponds with stabilized management and intensive fish farming (Plumlov, Gala, Prostějov, Hlohovecký, Prostřední, Mlýnský). Table 1 presents the morphometric characteristics of the investigated fishponds.

Bouzov area

The investigated area forms a part of the Javořička Brook basin and is situated in Drahanská Highlands (500 m a. s. l.). Approximately 200 years ago, there were several fishponds in this region. New rebuilt fishponds were finished in 2000. They are mostly surrounded by forests; the shading of their water surface ranges from 10 (Bouzov 1) to 50%. Recently, the fishponds serve for fish farming (fish stock 500 kg. ha $^{-1}$).

Table 1. Morphometric characteristics of the investigated fishponds

Locality	MAX depth [m]	AVG depth [m]	Area[ha]	Volume[m^3]
Bouzov 1	3.8	1.6	1.2	16 500
Bouzov 2	2.2	0.9	1.3	10 305
Bouzov 3	1.8	1.1	0.9	11 136
Rohlíčky	*	2	2.3	17 852
Frešle	2.2	*	2.4	32 162
Kaltouz	2	*	2.3	30 000
Prostějov	1.8	1.3	1.4	18 388
Plumlov	3.5	1.8	14.3	330 729
Gala	1.6	0.9	0.9	10 000
Hlohovecký	3.5	*	104.6	1 841 720
Prostřední	3.5	*	46.7	768 830
Mlýnský	3.5	1.5	105.8	1 994 200

* missing information

Hradec Králové area

The investigated area is a part of the Librantický Brook (fishpond Rohlíčky) and Malostranský Brook (fishpond Kaltouz) basins near the village of Librantice (Hradec Králové, East Bohemia). Fishpond Frešle is a sky pond without any inflow. Fishponds are situated in a lowland (altitude 260 m a.s.l.), surrounded by fields. Shading is fractional, except for the fishpond Kaltouz (30%), which is partly surrounded by forest (western part). The ponds were constructed in an open, agricultural countryside and finished in the years 1996 (Frešle), 1998 (Rohlíčky) and 1999 (Kaltouz). Fishponds serve for fish and duck farming.

Prostějov area

The fishponds were constructed in a lowland (altitude 225 - 282 m a.s.l.), probably in the18th and 19th centuries. The area is a part of the Hloučela Brook basin and fishponds Plumlov (Podhradský fishpond), Gala and Prostějov (Drozdovice fishpond) are situated below Plumlov reservoir. The fishponds serve for fish farming (fish production 1400 – 1900 $kg.ha^{-1}$). Shading is fractional (4% Plumlov, 14% Prostějov, 30% Gala).

Lednice area

Lowland fishponds (altitude 165 m a.s.l.) are used for intensive fish farming (fish production to the year 1996 was 911 - 1151 kg $.ha^{-1}$; HETEŠA & SUKOP 1997). The reduction of fish stock since the year 1996 has not brought any improvement yet. The fishponds were constructed in the Mikulovský Brook basin in 1418. They are lined by trees and bushes and surrounded by meadows and fields. The littoral vegetation, dominated by *Phragmites australis* and *Typha angustifolia*, occupies 5% of their total area. Due to their large area, there is almost no shading .

Results and discussion

Table 2 presents selected environmental variables of the investigated fishponds.

According to OECD scale, the evaluation of eutrophication is usually based on the annual averages of TP (total phosphorus). This scale was created for large lakes and, therefore, is not suitable in the case of our fishponds. They were assessed as hypertrophic or came out of the scale, although the algal species composition in some cases indicated better state (KITNER & POULÍČKOVÁ in press.). Hradec Králové area has the lowest TP values, but the NH_4 concentrations are higher than in Bouzov area. The highest nitrate concentrations and increased TP values are typical for Prostějov area. The highest TP values and NH_4 concentrations are characteristic for Lednice area.

A necessary consequence of pond eutrophication is a high biomass of phytoplankton (KOŘÍNEK et al. 1987).

Thus, the evaluation of pond trophic state can be based on annual averages of chlorophyl-a concentrations. Although chlorophyll *a* is not an ideal measure of phytoplankton biomass (DESORTOVÁ 1981), it has a unique advantage in the ease of measurement. Other parameters reflecting the phytoplankton biomass can be also successfully used, for instance phytoplankton abundance or biovolume. While chlorophyll-a concentration is a more general parameter, we can evaluate the phytoplankton structure and species composition through algal counting.

Figure 1 presents the comparison of average annual algal abundances in the investigated fishponds. The algal abundances in new fishponds ranged from 700 to 18 000 specimens per 1ml. The forest fishponds near Bouzov had the lowest abundances. Abundances in old eutrophic fishponds near Prostějov ranged from 14 000 to 38 000 specimens per 1 ml, but they can reach even higher in hypertrophic fishponds. Hypertrophic conditions are represented by three fishponds near Lednice with the highest phytoplankton abundances (HETEŠA & SUKOP, 1997; these data are not in specimens per 1 ml, but in cells per 1 ml).

Another compared parameter - the proportion of basic algal groups - is also in agreement with the previous findings. Figure 2 summarizes the annual average representation of 7 phytoplankton groups. A higher proportion of the group Chrysophyceae characterises the new fishponds. With the increasing eutrophication, the representation of this group decreases for the benefit of cyanophytes and green algae. The phytoplankton structure becomes more monotonous with only two groups at hypertrophic sites (Lednice, HETEŠA & SUKOP 1997). The occurrence of some cyanobacteria or algae is influenced not only by the nutrients concentration, but also by the presence of sufficient "inoculum". For this reason, such species can be absent at newly constructed fishponds in the initial years. Although Bouzov fishponds were free of cyanobacteria in 2001, the occurrence of *Microcystis aeruginosa* was observed in 2002. Similar situation was observed in Hradec Králové in 2002.

Figure 3 presents the results of hierarchical clustering analysis (Ward's method) on the basis of phytoplankton species composition. Localities are divided into two groups – Lednice area and the rest of fishponds. Significant dissimilarity of the fishponds near Lednice is caused by their highest trophic level and high conductivity. Many halotolerant species were observed there (Tab. 3). The remaining fishponds constitute also two groups – Prostějov area differs from the new fishponds near Hradec Králové and Bouzov.

Conclusion

Two–year-study of selected environmental variables, phytoplankton abundance, structure and species composition served for the evaluation of trophic status of several fishponds.

Fishponds near Bouzov are forest fishponds with relatively low nutrient concentrations, low phytoplankton abundances, diversiform phytoplankton structure, a high proportion of Chrysophyceae, and a low proportion of cyanophytes (especially in 2001). The favourable initial conditions are probably influenced by the ponds' disposition in the landscape. Their future development will depend on their management. According to the development in 2002, the danger of eutrophication is relevant.

Fishponds near Hradec Králové are halfway loaded field fishponds with higher phytoplankton abundances than previous sites, and with an increased representation of cyanophytes. Due to their location in the landscape, these fishponds are strongly endangered by rapid eutrophication. This negative development can be mitigated only by rigorous management excluding intensive fish or duck production, recreation, and agriculture in the surrounding fields. Prevention of external and internal loading and forestation of wide surroundings can be recommended.

Fishponds near Prostějov were not loaded as much as we expected. In any case, they represent the worse part of the trophic spectrum - eutrophic sites. For the improvement of this situation, the changes in management are necessary. With the intensive fish farming and recreation they would catch up with the hypertrophic sites very quickly.

Fishponds near Lednice represent the result of a long term intensive fish production and a totally unsuitable management. The improvement of this situation will be very expensive and will require a complex approach including the decrease in the internal and external loading. A pure decrease in fish stock cannot be sufficient under the present conditions.

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Table 2: Annual averages of selected parameters

Fishpond/Variable	Conductivity	pH	NO_3^- mg.l^{-1}	NH_4^+ mg.l^{-1}	Total phosphorus mg.l^{-1}	OECD classification**
Bouzov 1	160*	8.3±0.1	0.899±0.761	0.0777±0.043	0.178 ± 0.064	hypertrophic
Bouzov 2	210*	8.2±0.3	0.639±0.358	0.947±0.052	0.165±0.041	hypertrophic
Bouzov 3	120*	8.2±0.1	0.428±0.198	0.813±0.096	0.192±0.084	hypertrophic
Rohlíčky	102*	8.5*	0.850±0.280	2.896±1.479	0.149±0.072	hypertrophic
Frešle	862*	8.9*	0.523±0.097	2.319±2.017	0.147±0.044	hypertrophic
Kaltouz	277*	9.8*	0.438±0.182	2.641±2.333	0.150±0.052	hypertrophic
Prostějov	277.4±57.2	8.5±0.6	1.399±2.748	0.952±0.415	0.284±0.155	hypertrophic
Plumlov	281.3±62.1	8.3±0.7	1.946±2.654	1.637±1.832	0.355±0.107	hypertrophic
Gala	278.0±63.5	7.8±0.5	0.245±0.238	1.097±1.287	0.394±0.140	hypertrophic
Hlohovecký	1553*	8.5*	0.437±0.129	3.620±1.120	0.519±0.041	hypertrophic
Prostřední	1431*	8.6*	0.484*	2.602*	0.683*	hypertrophic
Mlýnský	1375*	8.6*	0.471±0.031	2.601±0.560	0.697±0.160	hypertrophic

** OECD classification according to annual average total phosphorus: oligotrophic ≤0.01 mg.l^{-1} ; mesotrophic 0.01-0.035 mg.l^{-1}; eutrophic 0.035 – 0.1 mg.l^{-1} ; hypertrophic ≥ 0.1 mg.l^{-1}

* single sampling

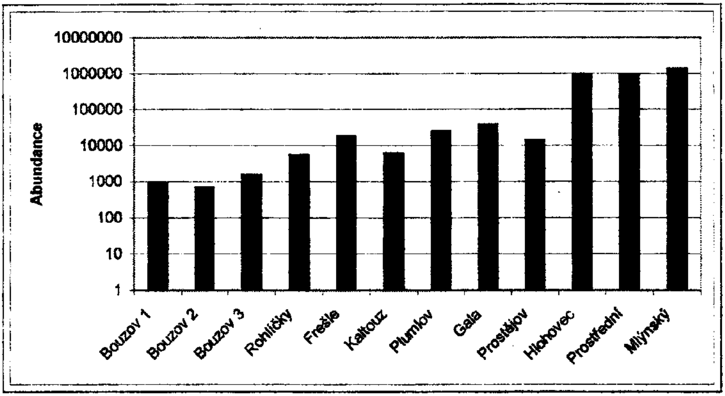

Fig. 1: Annual averages of phytoplankton abundance at investigated fishponds (abundance in individuals per 1 ml – logarithmic scale)

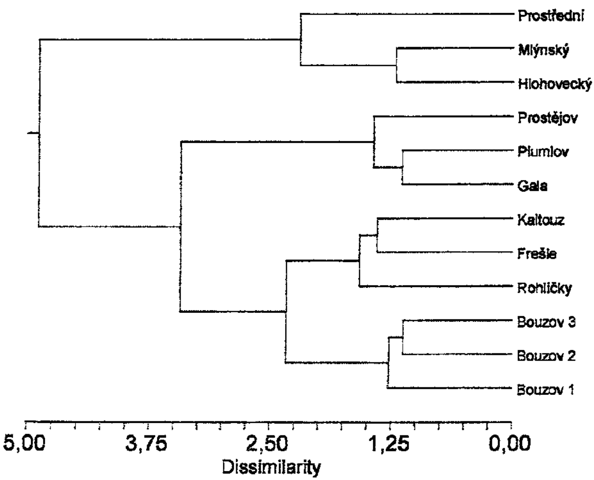

Fig. 3: Results of cluster analysis (Ward's minimum variance) of the investigated ponds based on phytoplankton species

Taxon/Locality	Bouzov	Hradec	Prostějov	Lednice
Acanthosphaera zachariasii LEMM.		1	1	
Actinactrum hantzschii LAGERH.		1	1	1
Achnanthes lanceolata (BRÉB.) GRUN.	1			
Amphora ovalis (KÜTZ.) KÜTZ.		1	1	1
Anabaena circinalis RABENH			1	
Anabaena flos-aquae BR. ex BORN, FLAH				1
Anabaena lemmermannii RICH.				1
Anabaena solitaria KLEB.				1
Anabaena sigmoidea NYGAARD				1
Anabaenopsis cf. *arnoldii* APTEK.		1		
Anabaenopsis elenkinii MILL.				1
Ankistrodesmus bibraianus (REINSCH) KORŠ.	1			
Ankistrodesmus gracilis (REINSCH) KORŠ.	1	1		1
Ankyra ancora (G. M. SMITH) FOTT				1
Ankyra juday (G. M. SMITH) FOTT				1
Ankyra lanceolata (KORŠ.) FOTT				1
Anomoeoneis sphaerophora (EHRENB.) PFITZER			1	
Aphanizomenon flos-aquae (L.) RALFS et BORNET et FLAHAULT				1
Aphanizomenon gracile (LEMM.) LEMM.				1
Aphanizomenon issatschenkoi (USAČ.) PROŠK.-LAVR.				1
Aphanocapsa holsatica (LEMM.) CRONBERG et KOM.			1	
Aphanocapsa incerta (LEMM.) CRONG. et KOM.				1
Aphanothece nidulans RICHT.			1	
Aphanothece stagnina (SPRENG.) A. BR.			1	
Asterionella formosa HASS.	1		1	
Aulacoseira ambigua (GRUN.) SIMON.			1	
Aulacoseira granulata (EHRENB.) SIMON.			1	1
Botryococcus protuberans W. et. G. S. WEST				
Caloneis amphisbaena (BORY) CL.				1
Centritractus belenophorus LEMM.			1	1
Centronella reicheltii VOIGT			1	
Ceratium hirundinella (O. F. MULLER) SCHRANK		1		1
Chlamydomonas bichlora PASCH. et JAHODA	1			
Chlamydomonas reinhardtii DANG.				1
Chlorella emersonii SHIH.et KRAUSS		1		
Chlorella homosphaera SKUJA		1	1	
Chlorella minutissima FOTT et. NOVÁKOVÁ	1		1	
Chlorella vulgaris BEIJERINCK	1		1	
Chlorogonium elongatum DANG.				1
Chlorosarcina superba SKUJA	1			
Chroococcus cf.*minutus* (KÜTZ.) NÄG.		1	1	
Chroomonas caudata GEITLER				1
Chrysococcus cordiformis NEUMANN	1			
Chrysococcus rufescens KLEBS		1		
Chrysococcus triporus MACK	1	1		
Closteriopsis acicularis (G. M. SMITH) BELCH. et SWALE	1			
Closterium acerosum (SCHRANK) EHRENB.		1		1
Closterium limneticum LEMM.			1	1
Cocconeis pediculus EHRENB.	1			
Cocconeis placentula EHRENB.	1			
Codomonas pascheri VAN - GOOR		1		1
Coelastrum astroideum DE-NOTARIS			1	1
Coelastrum cambricum ARCHER			1	
Coelastrum microporum NÄG.	1	1	1	1

Coelastrum pseudomicroporum KORŠ.		1	1	
Cosmarium pygmaeum ARCH.				1
Crucigenia fenestrata (SCHMIDLE)		1		
Crucigenia quadrata MORREN			1	
Crucigenia tetrapedia (KIRCHN.) W. et G. S. WEST		1	1	1
Crucigenia triangularis CHOD.			1	
Crucigeniella apiculata (LEMM.) KOM.			1	1
Crucigeniella rectangularis (NÄG.) KOM.		1	1	
Crucigeniella neglecta (FOTT et ETTL) KOM.				1
Crucigeniella pulchra (W. et G. S. WEST) KOM.				1
Cryptomonas cf. *marsonii* SKUJA	1	1	1	1
Cryptomonas cf. *reflexa* SKUJA	1	1		
Cryptomonas curvata EHRENB.	1	1		1
Cryptomonas cylindrica EHRENB.	1			
Cyclotella atomus HUST.		1		
Cyclotella cf. *comta* (EHRENB.) KÜTZ.		1		
Cymatopleura librilis (EHRENB.) PANT.		1		
Cymatopleura elliptica (BRÉB.) W. SMITH				1
Diatoma elongata (LYNGBYE) AG.				1
Diatoma vulgaris BORY		1		
Dichotomococcus curvatus KORŠ.				1
Dictyosphaerium cf. *pulchellum* WOOD		1		1
Dictyosphaerium cf. *tetrachotomum* PRINTZ		1	1	
Dictyosphaerium ehrenbergianum NÄG.		1		
Dictyosphaerium primarium SKUJA		1		
Dictyosphaerium subsolitarium VAN GOOR				1
Didymocystis planctonica KORŠ.				1
Didymocystis inconspicua KORŠ.				1
Dinobryon divergens IMH.	1	1	1	
Dinobryon sociale EHRENB.		1		
Elakatothrix genevensis (REVERD.) HIND.				1
Eudorina elegans EHRENB.	1			1
Eudorina ilinoisensis (KOFOID) PASCH.	1			
Euglena acus EHRENB.		1		1
Euglena cf. *caudata* HUBN.	1		1	
Euglena cf. *intermedia* (KLEBS) SCHMITZ		1		
Euglena cf. *velata* KLEBS.		1		
Euglena ehrenbergii KLEBS		1		
Euglena geniculata DUJARDIN				1
Euglena gracilis KLEBS	1			1
Euglena oxyuris SCHMARDA		1		1
Euglena proxima DANG.	1	1		
Euglena polymorpha DANG.				1
Euglena spirogyra DANG.				1
Eutetramorus fottii (HIND.) KOM.				1
Eunotia incisa GREGORY	1			
Fragilaria crotonensis KITT.		1		
Fragilaria delicatissima (W. SMITH) LANGE-BERT.		1		
Fragilaria ulna (NITZSCH) EHRENB.		1		1
Franceia ovalis (FRANCE) LEMM.			1	
Gloeotila spiralis				1
Golenkinia radiata CHOD.		1		1
Golenkiniopsis solitaria (KORŠ.) KORŠ.		1		
Gomphonema ventricosum GREGORY			1	
Gomphosphaeria pusilla (VAN GOOR) KOM.			1	

Goniochloris fallax FOTT				1
Goniochloris laevis PASCHER				1
Goniochloris mutica (A. BR.) FOTT				1
Goniochloris sculpta GEITLER				1
Goniochloris spinosa PASCH.				1
Goniochloris smithii (BOURR.) FOTT				1
Granulocystis helenae HIND.				1
Gyrosigma acuminatum (KÜTZ.) RABENH.			1	
Heterothrix debilis VISCH.		1		
Hyaloraphidium contortum PASCH. et KORŠ.		1	1	
Kephyrion mastigophorum G. SCHMID	1			
Kephyriopsis cincta SCHILLER	1	1		
Kephyriopsis conica SCHILLER	1			
Kephyriopsis cylindrica (LACKEY) FOTT	1			
Kephyriopsis entzii (CONRAD) FOTT	1	1		
Stenokalyx monilifera G. SCHMID	1			
Kirchneriella contorta (SCHMIDLE) BOHL.		1	1	1
Kirchneriella irregularis (G. M. SMITH) KORŠ.		1		
Kirchneriella lunaris (KIRCHN.) MOEB.		1		
Kirchneriella obesa (W. WEST) SCHMIDLE		1		
Kirchneriella rotunda				1
Koliella longiseta (WISLOUCH) HIND.	1			1
Koliella spiculiformis (WISLOUCH) HIND.	1		1	1
Lagerheimia ciliata (LAGERH.) CHOD.				1
Lagerheimia genevensis CHOD.		1	1	1
Lagerheimia longiseta (LEMM.) WILLE		1	1	
Lagerheimia marssonii LEMM.				1
Lagerheimia subsalsa LEMM.			1	
Lagerheimia wratislaviensis SCHROD.		1		
Lepocinclis ovum (EHRENB.) LEMM.				1
Lepocinclis texta (DUJARD.) LEMM.		1		1
Limnothrix cf. *redekei* (VAN GOOR) MEFERT.		1	1	1
Limnothrix planctonica WOLOSZYŃSKA			1	
Lobomonas apla PASCH.			1	
Mallomonas acaroides PERTY			1	
Mallomonas cf. *fastigata* ZACHARIAS	1			
Melosira varians AG.				1
Merismopedia elegans A. BRAUN in KÜTZ.			1	
Merismopedia glauca (EHRENB.) KÜTZ.			1	
Merismopedia punctata MEYEN		1		1
Merismopedia tenuissima LEMM.		1	1	1
Merismopedia warmingiana LAGER.			1	
Mesostigma viride LAUTERB.				1
Micractinium bornhemiense (CONR.) KORŠ.		1		
Micractinium pusillum FRES.		1	1	
Microcystis aeruginosa (KÜTZ.) KÜTZ.		1	1	1
Microcystis ichthyoblabe KÜTZ.				1
Microcystis novacekii (KOM.) COMPÈRE			1	
Microcystis viridis (A. BRAUN in RABENH.) LEMM.			1	
Monomorphina pyrum (EHRENB.) MEREŠK				1
Monoraphidium arcuatum (KORŠ.) HIND.	1	1	1	1
Monoraphidium circinale (NYG.) NYG.				1
Monoraphidium contortum (THUR.) KOM. - LEGN.	1	1	1	1
Monoraphidium convolutum (CORDA) KOM. - LEGN.	1		1	
Monoraphidium griffithii (BERKELEY) KOM. - LEGN.	1		1	1

Monoraphidium komarkovae NYGAARD				1
Monoraphidium minutum (NÄG.) KOM. - LEGN.		1	1	1
Monoraphidium nanum				1
Monoraphidium pusillum (PRINTZ) KOM. - LEGN.		1		1
Monoraphidium tortile (W. et G. S. WEST) KOM. - LEGN.				1
Navicula cryptocephala KÜTZ.	1			
Navicula lanceolata (AG.) KÜTZ.	1			
Navicula radiosa KÜTZ.	1			
Neodesmus danubialis HIND.				1
Nephrochlamys subsolitaria (G. S. WEST) KORŠ.		1		
Nephrochlamys willeana (PRINTZ) KORŠ.				1
Nitzschia cf. *dissipata* (KÜTZ.) GRUN.	1			
Nitzschia acicularis W. SMITH	1	1	1	1
Nitzschia sigmoidea (EHRENB.) W. SMITH				1
Oocystis lacustris CHOD.		1	1	1
Oocystis marssonii LEMM.		1	1	1
Oocystis parva W. et G. S. WEST			1	1
Oocystis solitaria WITTR.		1		
Oocystis verrucosa ROLL.			1	
Ophiocytium capitatum WOLLE			1	
Ophiocytium lagerheimii LEMM.				1
Pandorina morum (O. F. MÜLLER) BORY				1
Pediastrum angulosum (EHRENB.) MENEGH.			1	
Pediastrum boryanum (TURP.) MENEGH.	1	1	1	1
Pediastrum cf. *subgranulatum* (RACIBORSKI) KOM.			1	
Pediastrum duplex MEYEN	1	1	1	1
Pediastrum integrum LEFÊVRE				
Pediastrum simplex MEYEN		1	1	
Pediastrum tetras (EHRENB.) RALFS	1	1	1	1
Phacotus lenticularis EHRENB.		1	1	1
Phacus longicauda (EHRENB.) DUJARDIN	1			1
Phacus manguinii LEFÈVRE				
Phacus orbicularis HUBN.	1	1	1	
Phacus pleuronectes (O. F. MÜLLER) DUJARDIN	1		1	
Phacus pyrum EHRENB.	1		1	
Phacus tortus (LEMM.) SKVORC.	1	1		1
Phacus triqueter (EHRENB.) DUJARDIN				1
Pinnularia biceps GREGORY			1	
Planktothrix agardhii (GOMONT) ANAGN. et KOM.		1	1	1
Planktosphaeria gelatinosa G. M. SMITH			1	
Planctonema lauterbornii SCHMIDLE				1
Pseudosphaerocystis lacustris (LEMM.) NOVÁKOVÁ			1	
Pseudanabaena catenata LAUTERB.				1
Pseudanabaena limnetica (LEMM.) KOM.				1
Rhodomonas rubra GEITLER			1	
Rhodomonas lacustris PASCH. et. RUTTNER				1
Rhoicosphenia curvata (KÜTZ.) RABENH.				1
Scenedesmus abundans (KIRCHN.) CHOD.	1	1	1	
Scenedesmus acuminatus (LAGERH.) CHOD.	1	1	1	1
Scenedesmus acutus MEYEN	1	1	1	1
Scenedesmus alternans REINSCH	1	1	1	
Scenedesmus bicaudatus (HANSG.) CHOD.				1
Scenedesmus brasiliensis BOHLIN	1		1	
Scenedesmus denticulatus LAGERH.	1			
Scenedesmus dimorphus (TURP.) KÜTZ.	1	1	1	1

Scenedesmus disciformis (CHOD.) FOTT et KOM.			1	1
Scenedesmus dispar BRÉB.			1	
Scenedesmus ecornis (RALFS) CHOD.			1	1
Scenedesmus gutwinskii CHOD.			1	
Scenedesmus intermedius CHOD.	1		1	
Scenedesmus linearis KOM.	1	1	1	1
Scenedesmus obliquus (TURP.) KÜTZ.	1		1	
Scenedesmus opoliensis RICHTER	1			1
Scenedesmus pannonicus HORTOB.			1	1
Scenedesmus pecsensis				1
Scenedesmus qudricauda (TURP.) BRÉB.	1	1	1	1
Scenedesmus sempervirens CHOD.			1	1
Scenedesmus serratus (CORDA) BOHL.			1	
Scenedesmus subspicatus CHOD.				1
Scenedesmus velitaris KOM.		1		
Scenedesmus verrucosus ROLL.			1	
Schizochlamys gelatinosa A. BRAUN	1			
Schroederia nitzschioides				1
Schroederia robusta KORŠ.				1
Schroederia setigera (SCHRÖD.) LEMM.			1	1
Schroederia spiralis (PRINTZ) KORŠ.	1		1	1
Skeletonema potamos (WEBER) HASLE			1	1
Snowella arachnoidea KOM. et HIND.			1	
Snowella atomus KOM. et HIND.			1	
Spirulina maior KÜTZ. ex GOM.		1		1
Staurastrum cf. *chaetoceros* (SCHRODER) G. M. SMITH		1		
Staurastrum gracile RALFS	1	1		
Staurastrum paradoxum MEYEN	1	1	1	
Staurastrum planctonicum TEIL.	1		1	
Stenocalyx incostans SCHMID	1		1	
Stenocalyx monilifera SCHMID	1			
Stenocalyx spiralis (LACKEY) FOTT		1		
Stephanodiscus hantzschii GRUN.	1			1
Stephanodiscus minutulus (KÜTZ.) CLEVE et. MOLLER	1			
Stichococcus cf. *bacillaris* NÄG.			1	
Stichococcus contortus (CHOD.) HIND.				1
Stichococcus minor NÄG.				1
Strombomonas gibberosa (PLAYF.) DEFL.		1		
Surirella ovata KÜTZ.		1		1
Synedra tabulata (AG.)KÜTZ.				1
Synedra acus KÜTZ.		1		1
Synura uvella EHRENB. em. KORŠ.		1		
Tetraëdron caudatum (CORDA) HANSG.	1	1	1	1
Tetraëdron incus (TEIL.) G. M. SMITH	1			
Tetraëdron minimum (A. BR.) HANSG.	1	1	1	1
Tetraëdron platyisthmum (ARCH.) G. S. WEST		1	1	
Tetraëdron quadratum (REINSCH) HANSG.		1		1
Tetraëdron triangulare (KORŠ.)		1		1
Tetrastrum cf. *punctatum* (SCHMIDLE.) AHLSTR.	1		1	
Tetrastrum elegans PLAYF.		1	1	
Tetrastrum glabrum (ROLL) AHLSTR.		1		1
Tetrastrum staurogeniaeforme (SCHROD.) LEMM.	1	1	1	1
Tetrastrum triangulare (CHOD.) KOM.		1		1
Trachelomonas armata (EHRENB.) STEIN		1		
Trachelomonas hispida (PERTY) STEIN em. DEFL.	1	1	1	

Trachelomonas irregularis SVIR.	1			
Trachelomonas planctonica SVIR.		1	1	
Trachelomonas stokesiana PALMER	1			
Trachelomonas verrucosa STOKES			1	
Trachelomonas volvocina EHRENB.			1	1
Trachelomonas volvocinopsis SVIR.	1	1	1	1
Treubaria schmidlei SCHRÖD.				1
Treubaria cf. *varia* TIFF. et AHLSTR.			1	
Treubaria planctonica (G. M. SMITH) KORŠ.			1	
Treubaria triappendiculata BERN.			1	
Uroglena americana CALKINS		1		
Volvox aureus EHRENB.		1		
	81	109	120	145

Fig. 2: Annual average representation of the main phytoplankton groups (Cy – Cyanophyta, Chry – Chrysophyceae, Bac – Bacillariophyceae, Cry – Cryptophyta, Eu – Euglenophyta, Gre – green algae, Ot – others)