Oceanological and Hydrobiological Studies
International Journal of Oceanography and Hydrobiology
Vol. XXXIX, No.4

Institute of Oceanography	(157-171)	University of Gdańsk
ISSN 1730-413X	2010	eISSN 1897-3191

DOI 10.2478/v10009-010-0058-9
Original research paper

Received: January 22, 2009
Accepted: February 10, 2010

Phytoplankton dynamics in the reservoir lake "Żur" on the pomeranian Wda River

Marzena Wiśniewska[1]

Department of Environmental Development and Protection
Faculty of Civil and Environmental Engineering
University of Technology and Life Sciences
ul. Sucha 985-796 Bydgoszcz, Poland

Key words: reservoir lake, phytoplankton, seasonal variation, biomass, chlorophyll, physico-chemistry of waters, trophy

Abstract

Onehundredthirtyeight taxa of plankton algae were identified in the Żur Reservoir (Cyanoprokaryota 27, Dinophyta 5, Euglenophyta 4, Chrysophyceae 6, Bacillariophyceae 40, Chlorophyta 56). The biomass of spring and summer plankton consisted mainly of diatoms. Based on the species composition, phytoplankton biomass, concentration of chlorophyll *a* and TSI, the Żur Reservoir was generally classified as moderately eutrophic with distinct trophic diversification of the water at particular studied sites.

[1] *marwis@utp.edu.pl*

Copyright© by Institute of Oceanography, University of Gdańsk, Poland

INTRODUCTION

Phycological research is a commonly accepted measure that enables one to assess a number of characteristics of aquatic ecosystems including trophy and water quality. Phytoplankton communities, which constitute the main community of primary producers in artificial dam water bodies, are sensitive detectors of transformations that take place in the water. Phytoplankton communities also enable increased understanding of water quality and changes in water quality. It is a stable indicator which is not influenced by rapid and profound fluctuations, such as concentrations of particular chemical compounds. Finally, since phytoplankton constitutes the first link in the long chain of trophic relations, it enables one to extrapolate the results to other similar water bodies.

The Żur Reservoir creates significantly different conditions for phytoplankton organisms than those found in a river or a lake. This is due to the fact that a mosaic of habitats developed here with a different intensity of features from these two aquatic ecosystems. The reservoir has existed here for more than 80 years, which should be a sufficient time to eliminate the drastic transformations of the environment that took place here during the first years of the artificial lake, and to develop some stable communities of algae.

The structure of phytoplankton, as well as its seasonal and spatial variability in small rheolimnic, lowland water bodies, are not yet well explored as compared with larger dam reservoirs (Puchalski et al. 1995, Gołdyn 2000, Wiśniewska 2001). Communities of phytoplankton in large and average-sized lowland water bodies are described for such reservoirs as: Sulejów (Galicka et al. 1990, Rakowska and Rakowski 1992, Tarczyńska and Zalewski 1994), Włocławek (Dembowska 2002a, 2002b, 2005), Siemianówka (Górniak and Grabowska 1994, 1996; Grabowska 2006), Jeziorsko (Galicka and Kruk 1999, Tarczyńska et al. 1997), Zegrzyński (Kajak 1990) or the Koronowo Reservoir (Wiśniewska 1998). The main common feature of these reservoirs is the expansion of blue-green algae brought about mainly by the increased trophy of these waters. More data on population changes in phytoplankton communities in relation to abiotic factors are available for piedmont dam reservoirs (Bucka and Wilk-Woźniak 2007, Wilk-Woźniak and Pociecha 2000, Wilk-Woźniak 2009). In this case, the so-called non-trophic factors are more significant for the development of phytoplankton.

At present, knowledge of the significance of phytoplankton communities in artificially altered ecosystems is particularly important, because of the continued discussions and works on the development of biological indicators based, for instance, on phytoplankton and used for the evaluation of the ecological potential of dam reservoirs, required by the Water Framework

Copyright© by Institute of Oceanography, University of Gdańsk, Poland

Directive. Although lowland dam reservoirs share many common features with lake ecosystems, the two cannot be treated in the same way in order to understand their functions and evaluation them (Wilk-Woźniak 2009, www.rdw.org.pl).

The objective of the undertaken research was to explore the flora of plankton algae in a small, lowland water body called Żur Reservoir, their structure, as well as quantitative and domination relations. On the one hand, this research will allow the researchers to make an inventory of plankton algae occurring in the Żur Reservoir. In addition, it will enable them to determine the significance of plankton algae communities within the functioning of such an ecosystem. The researchers also tried to define which abiotic factors have a crucial influence on the development of phytoplankton in this artificially transformed, small ecosystem. The research will also specify its functional values for recreation and retention, and consequently should provide some guidelines on practical undertakings aimed at protecting the Żur Reservoir.

MATERIALS AND METHODS

The Żur Reservoir was created in the south-eastern landscape of the Tuchola Forest in the 1930s (the main work was conducted in 1929-30). At that time, about 14.5 m of the Wda River was dammed up at the 33,800 km of its course by an earth dam. The main objective of that investment was to produce electricity for the developing port of Gdynia by a parallel hydro-electric power plant built in the town of Żur. One should emphasize that at the national scale, the Żur Reservoir is one of the smaller and less significant reservoirs in terms of energy production. It is, however, the second largest dam reservoir in Pomerania after the Koronowo Reservoir. The Żur Reservoir is situated within the catchment area of the Wda River, within its lower reaches, and it stretches from the town of Piekło (upstream from the village of Tleń) to the village of Żur, assuming an elongated shape and nearly southern direction. The area of the Żur Reservoir amounts to 440 ha. The volume of stored water it holds is ca. 16 mil. m^3. The maximum depth by the dam comes to 14.4 m., the average depth is 3.6 m., the length of the reservoir is 9,310 m and its maximum width is 700 m. It is a reservoir with a short water retention time - on average 14 days - and thus the total exchange of water repeats 26 times per year. Apart from the Wda River, the Reservoir is fed with waters of the Rivers Ryszka and Prusina, as well as two smaller watercourses. According to the typology of dam reservoirs proposed by Staskraba (1999), the Żur Reservoir can be classified as a small, shallow dam reservoir located in the main stream of the river, with a short retention time of water and stratification.

The drainage basin of the Żur Reservoir is covered with pine and mixed forests, whereas the moraine upland is covered with mixed lime-oak-hornbeam forests together with fragments of oak and riverine forests, as well as alder swamp woods (Boinski 1996). Altogether, the forests constitute 67.2% of the drainage area; the remaining 32.5% is covered with arable land. Morphometry of the Żur Reservoir is very diverse. The shores of the reservoir are flat in flooded areas (the village of Tleń) and steep along its central part. Based on morphometric, hydrographic and drainage data, the degradation susceptibility was determined as category II, which places the Żur Reservoir within the group of basins relatively resistant to external impacts. Only a high value of the Schindler's coefficient indicates a strong influence by the drainage basin, mainly the Wda River, on the water quality in this reservoir.

Over time as the reservoir has merged into the landscape, its primary functions have shifted from energy objectives to those related to contemporary leisure, tourism and recreation. In 1993 the Wdecki Landscape Park was created, which was very significant in enhancing the tourist and recreational functions of the reservoir. The Park comprises the Żur Reservoir, situated in its central part, as well as a considerable part of the extensive sandur of the Wda River.

So far, no comprehensive phycological study of the Żur Reservoir has been completed. The objective of the research undertaken in 1998, 2000, 2005, 2006 and 2008 was to study the plankton algae in this reservoir, and then its structure, quantitative relations and domination with reference to physical and chemical parameters significant for the water quality. The captured dynamics presented by changes in the algae domination structure over time, should characterize the water conditions. Phycological analysis of waters in the Żur Reservoir was carried out based on samples collected at four sites, which comprise microhabitat types most characteristic of the reservoir:

- Site 1 - located near a railway bridge in the upper part of the reservoir. A strong water current, characteristic of this site and due to the outlet of the Wda and Prusina Rivers, upstream from this site (depth of ca. 5.8 m).
- Site 2 - located in the broadest part of the Żur Reservoir, at the mouth of Osie Stream (depth of ca. 6.5 m).
- Site 3 - a bay near the village of Grzybek (depth of ca. 4.0 m).
- Site 4 - located near a railway bridge, on the way from Osie to Grzybek, with a strong water current towards the Żur dam (depth of ca. 10.5 m).

Collection of samples in 2008 was limited to the first three sites.

Samples for phytoplankton studies, as well as for physical and chemical analyses, were collected at places with the maximum depth (multiparameter probe CB570 WTW) at the following times: June and August 1998 (site 2),

Copyright© by Institute of Oceanography, University of Gdańsk, Poland

April and July 2000 (sites 1-4), July and September 2005 (sites 1-3), April and July 2006 (sites 1-3), as well as in May, July and September 2008 (sites 1-3).

Qualitative samples were collected with a plankton net no. 25. They were preserved in situ with formalin. Uncondensed quantitative samples were collected with a Limnos sampler from the vertical profile; the water was decanted every three metres and samples were fixed with Lugol's solution.

The count of algae was determined with the use of an inverted microscope in sedimentation chambers of 10 ml capacity according to the method described by Utermöhl (1958). The biomass was determined by the volumetric method with the assumption that 1 mm^3 = 1 mg of fresh algae mass. Concentration of chlorophyll *a* was determined using the method of Strickland and Parsons (1963), modified by Lorenzen (1967).

RESULTS

Physicochemical properties of the water

The water of the Żur Reservoir was subject to detailed physicochemical analysis in the years 1996-97 (Cieściński et al. 1998). The research carried out in 2000 and 2008 indicates mainly a small variation in physicochemical water properties at four different study sites. Due to a very large amount of physicochemical data (they can constitute the subject of a separate paper), their use in this paper is restricted to creating a background in order to present the development of phytoplankton. Averaged results from three sites come from the year 2000.

Water transparency (measured as SD) was between 2.00 m (site 1) and 3.05 m (site 4) in spring, whereas in summer it amounted to ca. 1.8 m at all sites.

Electrolytic conductivity ranged from 333 µS cm^{-1} in spring (site 1) up to a maximum of 361 µS cm^{-1} (site 1) in summer. Water reactivity fluctuated between pH 6.7 in spring and pH 8.5 in summer.

Thermal and oxygen profiles completed during the study period indicate good oxygenation of waters in the Żur Reservoir in the entire water column of four selected sites.

In April, spring water mixing was recorded with an even temperature of about 8°C and an even distribution of oxygen in water depths of about 12 mg dm^{-3} O_2. In the summer, distinct oxygen stratification was observed only at sites 2 and 4 with the increased oxygen concentration at the water surface (ca. 15 mg dm^{-3} O_2) and with a significant drop at the bottom of site 2 (3.2 mg dm^{-3} O_2), and the concentration of 5.0 mg dm^{-3} O_2 at sites 1 and 4. None of the sites revealed oxygen deficiency during the study period.

Significant fluctuations in the concentration of PO_4-P were observed, from 0.09 mg dm^{-3} (sites 3 and 4) to 0.14 mg dm^{-3} (sites 1 and 2) in spring, whereas in summer, the increased values were recorded only above the bottom (sites 3 and 4) - up to 0.34 mg dm^{-3} PO_4-P. Concentrations of Ca^{2+} were subject to smaller fluctuations - ca. 75 mg dm^{-3} and Fe^{2+} ca. 0.2 mg dm^{-3}. The above data, as well as low concentrations of the total phosphorus and ammonia nitrogen classify the Żur Reservoir as an ecosystem with moderate trophy.

This conclusion is also supported by the calculated indices of trophy (TSI) for the water of the reservoir, based on the visibility of the Secchi disc (SD) expressed in meters, the concentration of chlorophyll *a* in mg m^{-3} and the concentration of the total phosphorus (TP) in mg dm^{-3}, according to the formulas by Carlson (1977), the values of which, from 0 to 100, describe the trophy of waters from extreme oligotrophy to hypertrophy. Values of the indices for the water of the Żur Reservoir amounted to:

- $TSI_{(SD)}$ - from 43.2 (site 3) to 50 (sites 1 and 2) in spring and from 50.7 (site 1) to 52.8 (site 3) in summer.
- $TSI_{(Chl\ a)}$ - from 49 (site 3) to 56.5 (site 2) in spring and from 56 (site 1) to 70.5 (site 2) in summer.
- $TSI_{(TP)}$ - from 53.2 (sites 3 and 4) to 59.1 (sites 1 and 2) in spring and from 59.1 (site 3) to 67.4 (sites 1 and 2) in summer.

According to the classification by Carlson (l.c.), the Żur Reservoir can be classified as a transitional ecosystem, between meso- and eutrophy.

The results were also compared with the trophic classification of harmonious lakes of the temperate climatic zone proposed by Hillbricht-Ilkowska and Kajak (1986). Based on the following values (concentration of the total phosphorus (TP), visibility of the Secchi disc (SD), concentration of chlorophyll (Chl) and the total algae biomass), the trophic state of the Żur Reservoir was defined as highly eutrophic.

Phytoplankton

One hundredthirtyeight algal taxa were identified in the phytoplankton of the Żur Reservoir. Chlorophyta (56 taxa), Bacillariophyceae (40 taxa) and Cyanoprokaryota (27 taxa), were the most diverse groups. The other phyla were represented by a small number of representatives. Species richness in particular taxonomic groups is presented in Fig. 1. During all the research years, the spring phytoplankton consists mainly of diatoms, with the following most frequent species: *Aulacoseira granulata* (Ehr.) Simons, *Asterionella formosa* Hassal, *Fragilaria ulna* v. *acus* (Kütz.) Lange-Bertalot and *Fragilaria crotonensis* Kitton. In the spring of 2000, at all the studied sites, the highest species richness was recorded within Bacillariophyceae, with the following

Copyright© by Institute of Oceanography, University of Gdańsk, Poland

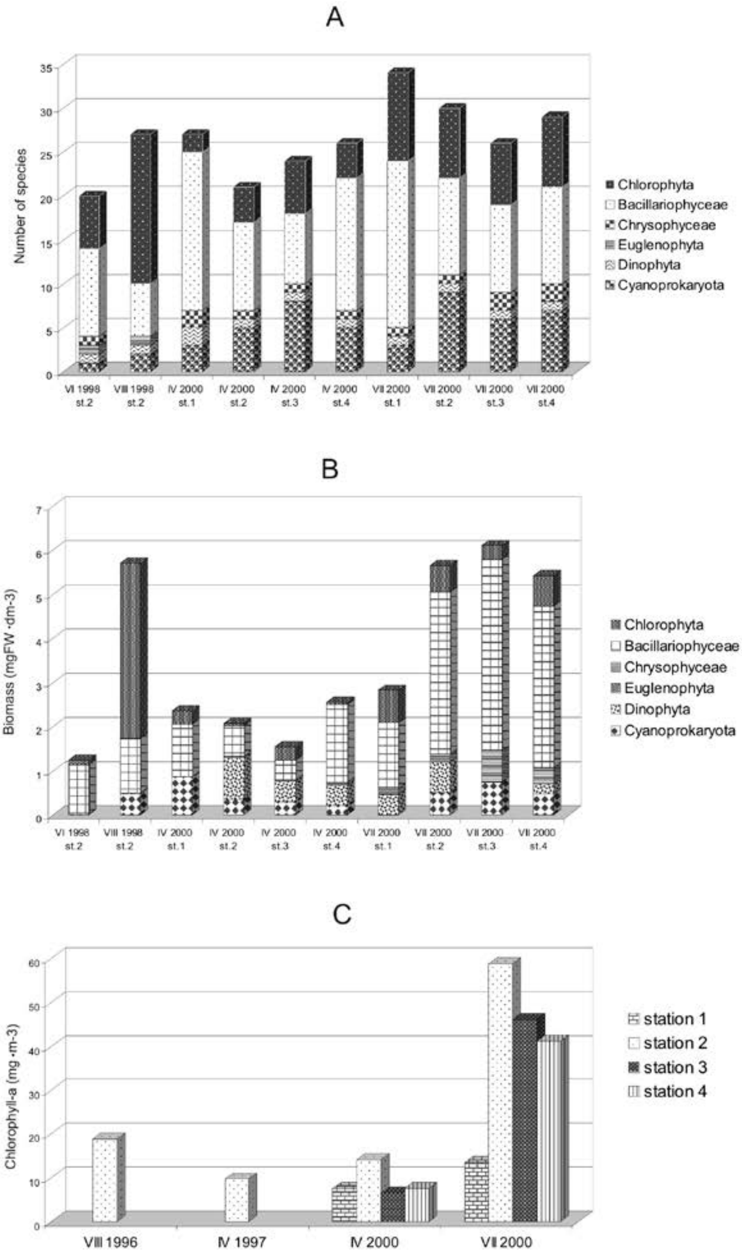

Fig. 1. A) Number of plankton algae species in Żurski Reservoir, B) Changes of phytoplankton biomass in Żurski Reservoir, C) Changes of chlorophyll *a* concentration in phytoplankton in Żurski Reservoir.

most frequent species: *Aulacoseira granulata* (Ehr.) Simons., *Asterionella formosa* Hassal, *Fragilaria ulna v. acus* (Kütz.) Lange-Bertalot and *Cyclotella* sp. However, April samples in 2000 were dominated by blue-green alga at all the sites - *Limnothrix redeckei* (Van Goor) M.-E. Meffert, accompanied in large numbers by *Pseudoanabaena limnetica* Lemm. and *Planktothrix agardhii* (Gom.) Anagn. et Kom. April samples at sites 3 and 4 were dominated mainly by zooplankton, which is typical of spring. Spring biomass of phytoplankton was low at all sites, between 1.54 mg dm^{-3} at site 3 and 2.55 mg dm^{-4} at site 4, where the main biomass was composed of diatoms (Fig. 2).

Eight years later, the structure of the phytoplankton community in spring looks similar (Fig. 1a). In May 2008, equally low biomass values were recorded: between 2.49 mg dm^{-3} at site 1 and 1.58 mg dm^{-3} at site 3 (Fig. 2a). *Asterionella formosa* was the dominant species at all sites.

In summer 2000, restructuring of the phytoplankton species structure took place, but also within diatoms only. At flow-through site 1, diatoms *Diatoma tenuis* Ag. and *Diatoma vulgaris* Bory dominated. Blue-green algae were not recorded, and other phyla were represented only occasionally with a somewhat higher contribution of *Scenedesmus communis* E.H. Hegew. Diatoms were the main components of the small biomass at site 1, which amounted to 2.82 m dm^{-3}. At the other sites, the highest richness of diatoms was also recorded in the phytoplankton structure, represented mainly by the species *Diatoma tenuis*, but also by a considerable contribution of *Aulacoseira granulata* and *Cyclotella* sp. The occurrence of a higher number of blue-green algae at site 2, was an atypical observation (*Aphanizomenon floras-aquae* (L.) Ralfs, *Pseudanabaena limnetica* Lemm. and other). However, they did not significantly contribute to the total biomass, which amounted at this site to 5.64 mg dm^{-3} (Fig. 1 and 2). At site 3, *Dinobryon sociale* Ehr. from Chrysophyceae was a new component among numerous species of diatoms. Within the surface layer at site 3, the biomass of phytoplankton reached the highest value during the study period, amounting to 6.1 mg dm^{-3}. This explains bay characteristics of this part of the Żur Reservoir. Site 4 with a strong water current was also characterized by rich diatom populations, with the dominant *Diatoma tenuis, Cyclotella* sp. and *Asterionella formosa*.

The analysis of summer samples from July 2008 does not bring any special changes in the species structure of phytoplankton recorded years ago (Fig. 1a). The exception is broads-type site 2, where blue-green algae evidently dominated in the summer, but this time from the genus Anabaena: *Anabaena planktonica* Brunth., *A. smithii* (Kom.) M.Watanabe, *A. flos-aquae* Breb. ex Born et Flah *A.spiroides* Kleb. At that time, the biomass oscillated between 0.22 mg dm^{-3} at site 3 and 15.27 mg dm^{-3} at site 1 (Fig. 2a).

Copyright© by Institute of Oceanography, University of Gdańsk, Poland

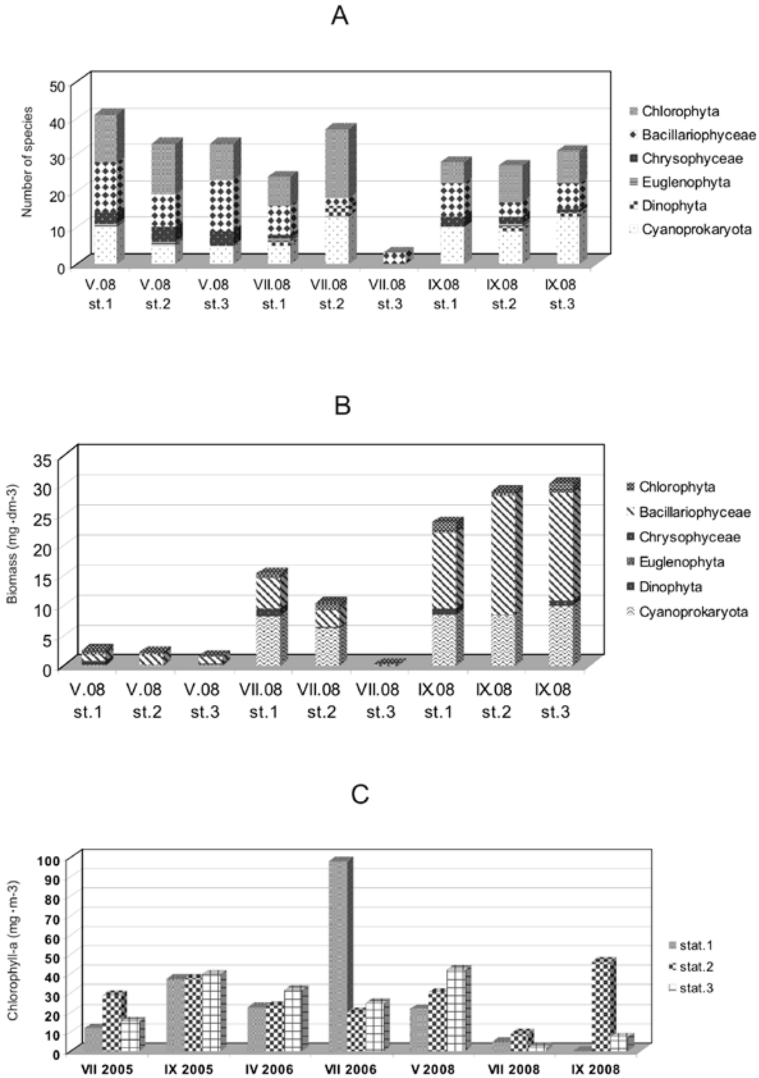

Fig. 2. A) Number of plankton algae species in Żurski Reservoir. B) Changes of phytoplankton biomass in Żurski Reservoir. C) Changes of chlorophyll *a* concentration in phytoplankton in Żurski Reservoir.

Only September samples in 2008 provide more information on the water fertility in the Żur Reservoir. Phytoplankton blooms were observed at all studied sites. They were formed mainly by diatoms, with clear codomination of blue-green algae.

The Biomass ranges from 23.84 mg dm^{-3} (site 1) through 28.94 mg dm^{-3} (site 2) up to the maximum value of 30.2 mg dm^{-3} at site 3 (Fig. 2a). At all sites, *Aulacoseira granulata* was the dominant diatom and among blue-green algae - *Pseudanabaena limnetica* was frequent.

Similarly a one-time collection of samples in June and August of 1998 did not bring any significant differences in the species structure, domination and quantitative relations within phytoplankton of the studied sites. June phytoplankton is diatomaceous with the dominant species *Aulacoseira granulata*, which also forms the main biomass, amounting to 1.24 mg dm^{-3}. In the sample count, a small green alga *Monoraphidium cortortum* (Thur.) Kom.-Legn. had a considerable contribution. The August phytoplankton is characterized by significantly higher richness, mainly among green algae, out of which *Pediastrum boryanum* Menegh. and diatoms makes up the main biomass of 5.7 mg dm^{-3} altogether. Also, the high contribution of the cyanobacterium *Pseudanabaena limnetica* in the summer phytoplankton is worth noting.

No significant differences in the species and domination structure during particular months were found in the results of observations from 2005 and 2006. In July 2005, *Anabaena planktonica* dominates at three sites and is accompanied by numerous *Aulacoseira granulata*. In September the species structure was restructured, with the distinct domination of diatoms, mainly *Aulacoseira granulata*. During that time, site 1 is characterized by a significant increase in zooplankton contribution with the predominance of Copepods.

April samples from 2006 are typical diatomaceous communities, with low count and a predominance of *Asterionella formosa*. At site 1 in July 2006, water blooming was observed, created mainly by *Aulacoseira granulata* and the accompanying numerous blue-green algae.

Concentrations of chlorophyll *a* in the phytoplankton of the Żur Reservoir at four sites in the spring of 2000 were low and fluctuated within the range of 7.5 mg m^{-3} (sites 1 and 4) and 14.1 mg m^{-3} within the overflow area (site 2). In the summer, the concentration of chlorophyll *a* significantly increased to 58.7 mg m^{-3} at site 2, and 46.1 mg m^{-3} at site 3 and 41.2 mg m^{-3} at site 4., the concentration of chlorophyll *a* in the phytoplankton was lower only in the flow-through place of site 1 where it amounted to 13.49 mg dm^{-3}.

The calculated concentrations of chlorophyll *a* in 2005, 2006 and 2008 are presented in Fig. 3a.

The recorded concentrations of chlorophyll *a* in the phytoplankton at particular sites mostly confirm the calculated values of the phytoplankton

Copyright© by Institute of Oceanography, University of Gdańsk, Poland

biomass at those places during the study period. Only the low concentrations of chlorophyll *a* from September 2008 at sites 1 and 3 do not reflect high values of biomass calculated for the same samples.

Only during the summer, concentrations of chlorophyll *a* in marginal habitats at research sites 2 and 3 significantly exceed the "threshold" values of chlorophyll *a* (10 mg m^{-3}) accepted by Kajak (1979) and others (Kawecka and Eloranta 1994, Lampert and Sommer 1996) for eutrophy.

In the species composition of phytoplankton from the Żur Reservoir, no rare species were recorded, nor were species previously unrecorded in the Tuchola Forest found there. Also many species typical of the littoral zone (e.g. *Nitzschia angustata* (W.Smith) Grün., *Ulotix* sp. or *Mougeotia* sp.) occurred in water depths which could be carried with the water current.

DISCUSSION

The Żur Reservoir is a flow-through lake, significantly affected by waters of the Wda River, which certainly has a strong influence on trophic conditions of this water body.

Physicochemical data on the water of the Żur Reservoir from the years 1996-97, as well as contemporary data from 2000 and 2008, confirm the low trophic and mesotrophic status of the studied reservoir. Also thermal and oxygen profiles completed at four locations, typical of the Żur Reservoir, indicate good oxygenation of waters, with distinct summer stratification in marginal places (sites 2 and 3) but without any oxygen deficiency at the bottom.

Phytoplankton of the Żur Reservoir in spring and summer was diatomaceous, with the dominant species *Diatoma tenuis, Asterionella formosa, Aulacoseira granulata* and *Cyclotella* sp. The abundant occurrence of the blue-green alga *Limnothrix redekei* in spring samples is noteworthy. In summer, apart from diatoms, blue-green algae from the genus Anabaena occur in large numbers.

The following species were dominants and subdominants: in spring - *Asterionella formosa, Cyclotella* sp, *Planktolyngbya limnetica* (Lemm.) Kom-Legn.&Cronb., *Limnothrix redekei* (Van Goor) Meffert; in summer - *Aulacoseira granulata, Cyclotella* sp, *Anabaena planktonica, Pseudanabaena limnetica*.

The species structure of phytoplankton in spring and summer is diatomaceous, with the abundant summer occurrence of blue-green algae, typical of water bodies with increased trophy. However, during the research period, blue-green algae never clearly dominated in the phytoplankton community; they always only accompanied the diatoms. This could prove that nutritional reserves in the water of the reservoir were too poor for this group of algae. Also, the low abundance of potentially toxic blue-green algae from the genus *Microcystis* or *Aphanizomenon* seems to be a significant observation. *Anabaena* is the third cyanobacterial dominant in toxic blooms, the most frequently occurring genus in the water of the Żur Reservoir. It is believed that microcystins are produced by such species as *Anabaena floras-aquae, A. circinalis, A. lemmermanni* and *A. viquerii* . These species were recorded in the phytoplankton community of the Żur Reservoir, however they did not form water blooms.

During the long-term scientific studies, the water blooming in the Żur Reservoir was observed only in July 2006, caused by mass development of *Aulacoseira granulata,* as well as in September 2008, when also the main biomass was composed of *Aulacoseira granulata,* but with a high contribution of blue-green algae, which nowadays pose the biggest problem for preservation of good water quality in dam reservoirs.

When comparing the data on structural changes of plankton algae in other lowland dam reservoirs, first of all a common trend appears towards more and more expansion of blue-green algae, mainly in the late-summer period (see the Introduction) or even communities of small coccal green algae in small water bodies (Puchalski et al. 1995), or larger ones, e.g. the Reservoir of Zegrzyń (Kajak 1990). This is also confirmed by research on the Koronowo Reservoir, situated in the vicinity of the Żur Reservoir, where the mass occurrence of blue-green algae was also observed (Wiśniewska 1998). The main features of the seasonal dynamics of phytoplankton in the Żur Reservoir can be regarded as typical of lowland dam reservoirs (Puchalski 1994). In the studied reservoir, among such characteristics one can mention the domination of diatoms in spring (*Aulacoseira granulata)* and summer development of blue-green algae (*Anabaena*). However, one should emphasize that no water blooms of blue-green algae were observed during the entire research period; they always occurred as accompanying species of diatoms, which composed the main biomass. The abundant contribution of blue-green algae in the community of plankton algae already present in the spring, such as: *Limnothrix redeckei, Planktothrix agardhii* and *Pseudanabaena limnetica*, is an atypical phenomenon. According to Reynolds (1996), the aforementioned species are characteristic of hypertrophic waters.

The research results do not permit any overall evaluation of the water in the Żur Reservoir, because they significantly differentiate its zones. At sites 2 and 3 in lake zones, the increasing trophy is undoubtedly the main factor in triggering adverse changes in the form of blue-green algae domination. This is as opposed to the two fluvial sample sites (sites 1 and 4), where water flow has the most significant influence on the phytoplankton community.

Copyright© by Institute of Oceanography, University of Gdańsk, Poland

It seems that the structure and phytoplankton dynamics in the Żur Reservoir are influenced mainly by trophic factors and light conditions in the lake zone, whereas in the fluvial zones, non-trophic characteristics are decisive, such as: the water flow, mixing, and stress. Those are the factors that determine the development of plankton algae in piedmont (Wilk-Woźniak 2009) and small dam reservoirs (Puchalski et al. 1995). According to many authors (Tarczyńska et al. 2000, and others), water retention time in the reservoir is an equally important factor for the development of water blooms. In the Żur Reservoir, the short water retention time together with lower temperatures and higher concentrations of phosphates can be favourable to the increased biomass of diatoms and higher contribution of zooplankton. Those conditions can also bring about unfavourable conditions for the development and blooms of blue-green algae.

And thus, the dynamics of changes in the structure and quantitative relations of phytoplankton, observed over the studied years, was minor and differentiated only different research sites. This could prove small changes in the dynamic system of waters in the Żur Reservoir over a longer period.

However, the comparison of long-term changes in quantitative and qualitative phytoplankton characteristics may also indicate the beginning of blue-green algae expansion. In the near future, this may have an adverse effect on recreational values of the Żur Reservoir. At present, this kind of situation is observed in the waters of the Koronowo Reservoir, situated not far away from the aforementioned reservoir.

The current problem is the fact that the reservoir in the village of Tleń becomes more and more shallow. The research revealed that due to the accumulation of rubble from the Wda River, the reservoir quickly becomes more and more shallow, with the recorded average thickness of bottom sediments ca. 90 cm and annual increases of 1.15 cm (Cieściński et al. 2008).

REFERENCES

Boinski M., 1996, *Nature sights of the Wdecki Landscape Park*, (guidebook), Toruń (in Polish)

Bucka H., Wilk-Woźniak E., 2007, *Pro- and eukaryotic algae of phytoplankton communities in water bodies of Southern Poland*, IOP PAN Institute of Nature Conservation, Polish Aacademy of Sciences, Kraków

Carlson R.E., 1977, *A trophic state index for lakes. Limnol. and Oceanogr*, 22(2): 361-369

Cieściński J. et al, 1998, *Analysis of the clarity status selected from among lakes in Wdecki Landscape Park based on examined physical and chemical parameters*, Publishing institute "HABITAT", Bydgoszcz (in Polish)

Cieścinski J. et al., 2008, *Preliminary evaluation of the shallowing rate in the central part of the Żur Reservoir. Diagnosis of the environmental state. Research methods – forecasts*, Comprehensive research and nature conservation, Bydgoskie Towarzystwo Naukowe, Bydgoszcz

Dembowska E., 2002a, *Spatial diversity of phytoplankton in the Włocławek Reservior*, AUNC Limnol. Pap. 22: 3–30
Dembowska E., 2002b, *Summer phytoplankton in the Włocławek Reservior*, AUNC Limnol. Pap. 22: 31–51
Dembowska E., 2005, *Tentative assessment of the phytoplankton in the Vistula between Płock and Toruń (with the Włocławek Reservior), Poland*. – AUNC Limnol. Pap. 24: 19 – 43
Galicka W., Korczyńska A., Drożdżyk A., 1990, *Limnological characteristic of the Sulejowski Reservoir during the years 1972 – 1987* [In:] Kajak Z. (ed.), *Functioning of aquatic ecosystems. Their protection and recultivation. Part I Ecology of dam reservoirs and rivers*. – SGGW – AR Press Warsaw (in Polish)
Galicka W., Kruk A., 1999, *Structure of phytoplankton of the Jeziorsko Reservoir (central Poland) in the spring – autumn period of 1996*. – Acta Hydrobiol. 41(1): 17 – 35
Gołdyn R., 2000, *Changes in biological and physico-chemical characteristics of the river water quality under the influence of its damming up in the initial lowland dam reservoirs*. Seria Biologia 56, UAM Poznań, 185 pp
Górniak A., Grabowska M., 1996, *Limnology of the Siemianówka dam reservoir (eastern Poland). 3. Formation of phytoplankton communities in the first years after filling*. Acta Hydrobiol., 38: 99-108
Górniak A., Grabowska M., 1994, *Phytoplankton of the Siemianówka dam reservoir* [In:] Proc. XVI Hydrobiological Polish Society. Wrocław (in Polish)
Grabowska M., 2006, *Cyanoprokaryota blooms in the polihumic Siemianówka dam reservoir in 1992-2003*, Oceanol. Hydrobiol. St., 34:73-85
Hillbricht-Ilkowska A., Kajak Z., 1986, *Parameters and rates useful to control the functional and structural changes in lake ecosystems that go under eutrophication process*, [In]: Hillbricht-Ilkowska A. (ed.), *Lake systems monitoring*, Ossolineum, Wrocław, 25-45 (in Polish)
Kajak Z. (red.), 1990, *Ecology of dam reservoirs and rivers*. Wydawnictwo SGGW-AR, Warszawa
Kajak Z., 1979, *Eutrophication of lakes*. PWN, Warszawa
Kawecka B., Eloranta P.V., 1994, *Introduction to ecology of algae from freshwater and terrestrial environments*. PWN. Warszawa.
Lampert W., Sommer U., 1996, *Ecology of inland waters*, PWN, Warszawa.
Lorenzen C.J., 1967, *Determination of chlorophyll and pheo-pigments spectrophotometric equations*, Limnol. and Oceanogr., 12: 343-346
Puchalski W., 1994, *Factors regulating the density and dynamics of phytoplankton in dam reservoirs* [In:] Zalewski M. (ed.) *Integrated strategy of conservation and management of aquatic ecosystems*. PIOŚ Łódź, pp. 67–77 (in Polish)
Puchalski W., Burchardt L., Paszkowiak- Kopeć N., 1995, *Dynamics of phytoplankton in small dam reservoirs* [In:] Zalewski M. (ed.) *Biological processes in conservation and recultivation of lowland dam reservoirs*, PIOŚ Łódź, pp.101–110 (in Polish)
Rakowska B., Rakowski M.,1992, *Phytoplankton of the Sulejów Reservoir (central Poland)*, Acta Hydrobiol. 34(4): 329–340
Reynolds C.S., 1996, *The plant life of the pelagic*, Verh. Internat. Verein. Limnol., 26: 97-113
Staskraba M., 1999, *Retention time as a key variable of reservoir limnology* [In:] Staskraba M. and Tundisi J.G. (Eds), *Theoretical Reservoir Ecology and its Applications*, 385-410
Strickland J.D.H., Parsons T.R., 1963, *A practical handbook of seawater analysis*, Fish. Res. Board of Canada., Ottawa, 1-21
Tarczyńska M., Izydorczyk K., Zalewski M., 1997, *Blooms of blue-green algae in the Jeziorsko Reservoir – causes and consequences*, [In:] Glinkowska G. (Ed), *Report on environmental conditions in the province of Sieradz in 1995-1996*, Bibl. Monit. Środ., Warszawa: 145-152

Copyright© by Institute of Oceanography, University of Gdańsk, Poland

Tarczyńska M., Romanowska-Duda Z., Zalewski M., 2000, *Toxic cyanobacterial bloom in drinking water reservoir-causes, consequences and management strategy.* Proceedings of IV International Conference "Water supply and water Quality", Kraków

Tarczyńska M., Zalewski M., 1994, *The toxicity of Cyanophyta blooms in eutrophic water basins*, [In:] *The integrated strategy of protection and management of water ecosystems*, Biblioteka monitoringu środowiska, pp. 7989

Utermöhl H., 1958, *Zur Vervollkommung der quantitativen Phytoplankton - Methodik*, Mitt. Internat. Verein. Limnol., 9: 5-46

Wilk-Woźniak E., Pociecha A., 2000, *Dynamics of plankton communities as a tool in the studies on the water of dam reservoirs*, [In:] *Dam reservoirs. Research methods and water quality assessment*

Wilk-Woźniak E., 2009, *Changes in phytoplankton communities and the life strategies of artificially changed aquatic ecosystems*, Studia Naturae 55, IOP PAN, Kraków

Wiśniewska M., 1998, *Cyanophyta blooms in Koronowski Reservoir in the background of environmental conditions*, Oceanological Studies, 1: 45-52

Wiśniewska M., 2001, *Phytoplankton of the Żur Reservoir*, [In:] *Natural studies on selected types of environments in the eastern part of the Tuchola Forest*, Wydawnictwo FIL, Bydgoszcz

www.rdw.org.pl