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Ecological status of shallow Lake Gorbacz (NE Poland) in its final stage before drying up

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Key words: shallow lake, drying up, drought, the trophic status, perturbation

Abstract

The article assesses the ecological status of shallow Gorbacz Lake (NE Poland) in the last stage before complete drying up. For last few years hydrological regime of the lake catchment has been changed dramatically which was caused by functioning nearby peat mine and longer autumn drought periods for following years. Progressing macrophytes succession leaded complete emergent macrophytes overgrowth of the lake beginning from 2000. The analyses include records of previous samples and data for morphology, water quality, phytoplankton, zooplankton and macrophytes. The trophic status of Gorbacz Lake was verified compare to the previous studies. The results indicate that even with minimum amount of water Gorbacz Lake itself still keeps its dystrophic character with increasing of water color and of DOC, biogenic substances, chlorophyll *a* concentrations. Humic State Index (HSI) and hydrochemical dystrophy index (HDI) confirm the dystrophic status of the lake with values 71.3 and 76.2 respectively. Both typical phytoplankton representatives of eutrophic and dystrophic waters were recorded. Very high diversity of desmids in the telmatoplankton, indicates the observed process of shallowing in the reservoir. Planktonic crustacean fauna was represented by small filtrators. Rotifera community was strongly dominated by *Trichocerca simonei*. The article concludes with the main causes of the observed changes and some future remarks for the lake state.

INTRODUCTION

Lake Gorbacz is one of the last natural reservoirs in north-eastern Poland, which were beyond the range of the last glaciation, and which have survived till the present time. The lake has been under reserve protection for over 50 years. Despite this fact, since the beginning of the 21st century, we have observed a gradual disappearance of the lake. The reserve, which is 114 ha in area, was established in 1966. The area was designated for protection in order to carry out research and teaching about the unique Gorbacz Lake and the vast, surrounding peat bogs, as well as the rare protected species of plants and animals. In the early seventies, an open-pit peat mine was created at a distance of about 800 m south-west of the reservoir, which has dramatically changed the natural hydrological conditions of the drainage basin of Lake Gorbacz. The opening of the mine meant installing the extensive system of deep drainage ditches. These actions resulted in the lowering of the water level in the lake by more than 0.5 m in just three years since the beginning of extraction (Sokołowski 1975). The mine, which still functions today, essentially speeded up the process of shallowing and overgrowing of the lake. Reclamation of the land situated near the mine is further camouflaged by lowering of the surface of the dried peat (Czerwiński 1992). On average its level has lowered by 0.5 m (Krajewski 1998).

Within the area of the reserve, numerous research projects were carried out, mainly on the flora, fauna, hydrology, soil and geomorphology (Sokołowski 1975; Czerwiński 1992; Banaszuk 1995; Krajewski 1998; Mioduszewski 1999). Only a few

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works have had a purely limnological character (Baszyński et al. 1954; Czerwiński 1974; Baranowski 2002; Zieliński et al. 2004; Ilnicki 2007). Due to rapidly progressing, adverse changes in the vicinity of Lake Gorbacz, induced by human activity, the analysis of lake basin morphometry was carried out, together with the analysis of changes in the water quality, the taxonomic composition of phytoplankton, rotifers, crustaceans and macrophytes. The aim of this study was to determine the nature and direction of ecological changes in the declining lake.

STUDY AREA

Lake Gorbacz is a remnant of a large kettle lake, developed after the recession of the continental Wartanian glacier, the Mława stadial. It covers the southern part of the vast depression called the Gródek-Michałowo Basin, drained through the upper stretch of the Supraśl River. The Gródek-Michałowo Basin covers the area of approximately 65 km² and it is a large kettle basin developed ca. 100 thousand years ago through the melting of a huge dead-ice block (Musiał 1992). After deglaciation, a lake was developed, which in many places had a depth of up to 30 m and was interspersed with numerous sandy islands. Currently, in the southern end of the Gródek-Michałowo Basin the Imszar reserve is located with Lake Gorbacz in its northern part (Fig. 1). The large kettle-hole of Imszar is almost entirely filled with peat. The development of a raised bog in this area is dated from 1700-2200 years ago (Baszyński et al. 1954). The mineral bottom of Imszar Basin is deposited about 10 m below the surface of the surrounding uplands. The main part of the Imszar basin is Lake Gorbacz, situated ca. 40 km south-east of the city of Białystok, N 53°00'14", E 23°41'57", alt. = 146 m. In recent years, the surface area of the lake has decreased to about 11 hectares and since 2001, emerged macrophytes, have overgrown its whole area. At present the maximum depth in spring does not exceed 0.2 m, which determines its polymictic character. The lake has no natural surface inflows or outflows, and since it is located in the vicinity of the watershed of the Narew and Supraśl Rivers (Fig. 1), it has suffered from the water deficit for many years. The small catchment area of about 43.6 ha is supplied with water mostly from the rainfall. On the western side of the lake, an extensive raised bog is located. From the north-eastern, eastern and south-eastern side, the lake is overgrown with alder woods (Baranowski 2002). The bottom of the lake is composed of rare sediments of type Dy with a thickness of up to 3.6 m gradually turning into gyttja.

MATERIALS AND METHODS

The research was conducted in July 2008 in the Gorbacz reserve, and the results were compared with the data obtained during the summer of 1999-2000 (Baranowski 2002, Zieliński et al. 2004). Water samples were collected from the lake shore, at a site located in the northern part (N 53°00'20.8"; E 23° 41'55.2") (Fig. 1). In addition, samples of zooplankton were collected along the transect on the peat floating mat (4 points every 10 m) running in a northerly direction from the main sampling station. The temperature, pH, water conductivity, oxygen concentration and oxygen saturation of the water were measured directly in the field with the field probe Hydrolab (USA). Chemical analyses of the water were performed on the same day in the laboratory of the Department of Hydrobiology, the University of Białystok. Determinations were performed according to standard methods described by Hermanowicz et al. (1999), using reagents from the company Riedel-de-Haën. Dissolved organic carbon (DOC) was analyzed in the analyzer Shimadzu TOC-5050A (Zieliński, Górniak 1999). The SUVA parameter (Specific UV Absorbance), the relative aromaticity index, was calculated from the formula:

$$SUVA = \frac{Abs_{260} \times 1000}{DOC}$$ (Abs_{260} gC^{-1} dm^{-3}); (Chin et al. 1994, changed)

TSI trophic indices were calculated according to Carlson (1977) on the basis of $TSI_{chl\text{-}a}$ and TSI_{TP}, apart from TSI_{SD} due to extremely small depth of the lake.

The Humic State Index (HSI) was calculated by the formula:

$$HSI = \frac{100}{3} \times \log(Color - 3)$$ (Håkanson, Boulion 2001)

where: Color is expressed in mg dm^{-3} Pt.

Hydrochemical Dystrophy Index (HDI) was calculated according to the formula proposed by Górniak (2004) changed and amended as follows:

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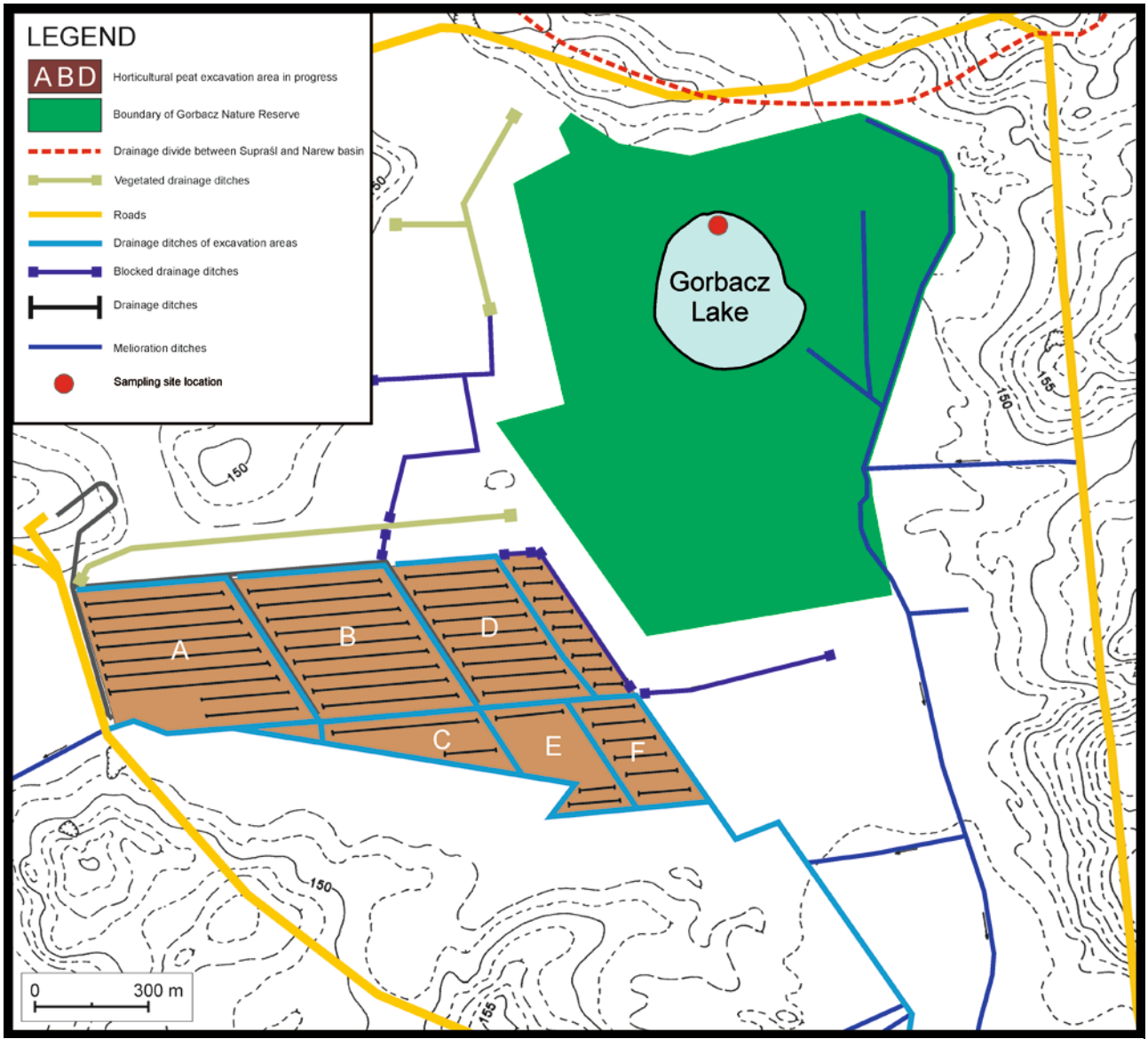


Fig. 1. The relief of the Imszar Basin together with the location of the Gorbacz Reserve, the peat pit and the water sample collection sites (Banaszuk et al. 1994, the current state).

$$HDI_{EC} = \frac{100}{\log EC}$$

where: EC – electrical conductivity in μS cm^{-1}

$$HDI_{DOC/DIC} = 10 \times \left(\frac{DOC}{DIC}\right)$$

where: DOC – dissolved organic carbon, DIC – (Dissolved Inorganic Carbon) the concentration of HCO_3 in mg dm^{-3} × 0.2

$$HDI_{pH} = (9.5 - pH) \times 20$$

where: pH - water reaction

$$HDI = \sqrt[3]{HDI_{EC} \times HDI_{DOC/DIC} \times HDI_{pH}}$$

Lakes with the value of the HDI index ≥ 50 are regarded as dystrophic lakes.

Plankton samples were collected from a depth of 0.2 – 0.3 m with a one-liter sampler. Samples of

zooplankton were being concentrated by filtering through a net with the mesh size of 30 μm and fixed with 4% formalin solution. Samples of phytoplankton were fixed with Utermöhl solution and formalin, and then concentrated by repeated leveraging to the volume of 20 ml. Phytoplankton cells were counted in Fuchs-Rosenthal chambers. To describe the taxonomic composition of aquatic vegetation, floristic inventories (lists of species present in a lake) were applied, based on observations and sampling with a rake from the shore of the lake (Palmer et al. 1992).

RESULTS AND DISCUSSION

Lake Morphometry

Lake Gorbacz, despite progressive negative hydrological changes, still preserve a nearly oval shape with the north-south axis (Fig. 2). Despite the regression of the shoreline, a small bay in the south-eastern part of the lake still preserves its shape. The current length of the lake is 412 m, and the width 372 m (Fig. 2). The bottom of the reservoir is completely flat, composed of sediments of type Dy. At present, the average depth of the lake during summer does not exceed 10 cm. The lake reaches its maximum depth in spring and the lowest depth in autumn. Since 2000, more and more cases have been recorded when the lake had completely dried up (for example, the fall of 2000, 2005 and 2007). A similar situation

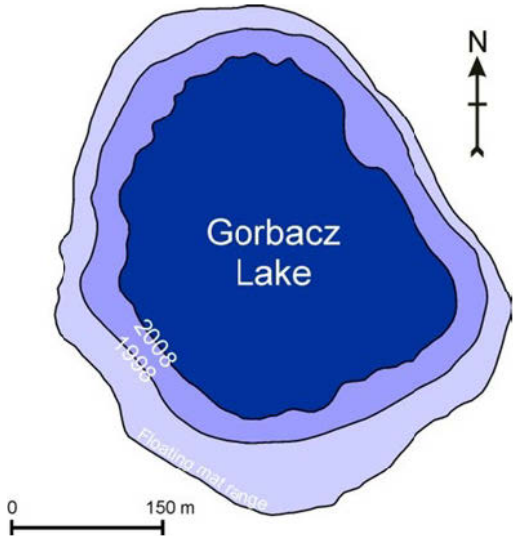


Fig. 2. Changes in the shore line of Lake Gorbacz over 10 years (1998 and 2008).

was recorded by Krajewski (1998) already in August 1992, when the water stagnated only in local depressions. When comparing the data from 1998 and 2008, no significant changes were ascertained in the coverage of the floating *Sphagnum* mat (Fig. 2). A zone of dense rushes dominated by broadleaf cattail (the plant association *Typhetum latifoliae*) has widen, which is practically devoid of surface water, thereby shifting the shoreline by up to 60 m from the south and 40 m from the north (Fig. 2). High density of macrophytes in the lake increases the evapotranspiration. The length of the lake's shoreline decreased from 1266 m to 1116 m.

The main causes of the observed changes in the morphology of the lake are:

- a small catchment area of only 43.6 ha,
- lack of tributaries and precipitation as the main water supply for the lake,
- exploitation of peat in the Imszar Basin within a small (800 m) distance from the lake,
- a high level of evapotranspiration of emergent vegetation,
- ineffective active protection in the Gorbacz reserve.

Lake water quality and trophic status

Water of Lake Gorbacz is three-ions water (HCO_3-SO_4-Ca). This is due to a lower contribution of bicarbonates in favor of other ions (Table 1). In many previous studies and conservation plans Lake Gorbacz was classified as a oligotrophic reservoir. However, based on hydrochemical analysis carried out in 1999-2000 and 2008, it was found that the lake is unarguably a dystrophic one. It meets the basic conditions of disharmony provided by Stangenberg (1936), i.e. the surface water with pH <6.5 and the content of Ca^{2+} ions <16 mg dm^{-3}. In addition to constantly acidic pH, there are also very high concentrations of dissolved organic carbon (DOC) (even above 30 mg dm^{-3}), as well as low specific conductivity and low concentrations of most ions (Table 1). The Humic State Index (HSI) was used to confirm the dystrophic status of the lake. Since 1999 the value of this index has been increasing, indicating the increasing level of dystrophy (Table 2). Based on the hydrochemical dystrophy index (HDI), Lake Gorbacz should be included among polyhumic, dystrophic lakes. The obtained HDI values are very similar to other dystrophic reservoirs of the region, such as polyhumic lakes (called "suchary") in the Wigry National Park (WNP, NE Poland) (Table 3). It

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Table 1

Comparison of physicochemical water parameters for Lake Gorbacz in 1999, 2000 and 2008. Statistically significant differences in 2008 are marked in bold.

Parameter	Unit	1999*	2000*	2008
Oxygen	(mg dm^{-3})	9.3	10.1	7.4
Oxygen staturation	(%)	95	120	87
pH	(pH)	6.2	6.1	6.5
Conductivity	(µS cm^{-1})	58.3	70.6	63.5
Water colour	(mg dm^{-3} Pt)	78.2	95.6	**141**
Ca^{2+}	(mg dm^{-3})	7.38	9.51	**16.1**
Mg^{2+}	(mg dm^{-3})	1.50	2.55	**3.19**
Na^{+}	(mg dm^{-3})	0.20	2.28	n/a
K^{+}	(mg dm^{-3})	0.09	0.65	n/a
$Fe^{2+,3+}$	(mg dm^{-3})	0.19	0.18	0.12
HCO_3^-	(mg dm^{-3})	24.9	30.1	15.3
SO_4^{2-}	(mg dm^{-3})	11.0	17.8	8.27
Cl^-	(mg dm^{-3})	7.19	9.89	10.2
Si	(mg dm^{-3})	0.68	1.15	0.28
TP	(µg dm^{-3})	75	109	56
$P - PO_4^{3-}$	(µg dm^{-3})	15	16	**22**
$N - NH_4^+$	(µg dm^{-3})	205	194	137
$N - NO_3^-$	(µg dm^{-3})	18.5	27.6	**75.6**
DOC	(mg dm^{-3})	26.9	29.7	**39.9**
SUVA	(Abs_{260} gC^{-1} dm^{-3})	9.7	16.1	**24.5**
Chlorophyll *a*	(µg dm^{-3})	9.2	15.7	**22.9**
Pheophytin	(µg dm^{-3})	2.48	2.67	**5.46**

* - Zieliński et al. (2004)

Table 2

Changes of different indices of the trophic state (HSI, HDI and TSI) for Lake Gorbacz in 1999*, 2000*, 2008. TSI was calculated for the summer period.

Index	1999*	2000*	2008
HSI	**62.5**	**65.6**	**71.3**
HDI_{EC}	56.6	54.1	55.5
$HDI_{DOC/DIC}$	56.0	51.2	133
HDI_{pH}	66	58	60
HDI	**59.4**	**57.3**	**76.2**
TSI_{TP}	64.8	71.9	62.2
$TSI_{chl\ a}$	59.6	49.4	44.3
TSI	**63**	**60.6**	**53.3**

* - calculations based on data of Baronowski 2002, Zieliński et al. 2004

Table 3

Hydrochemical dystrophy index (HDI) for Lake Gorbacz (own data) and typical dystrophic lakes of the Wigry National Park (NE Poland) (according to Górniak 2004).

Lake	Hydrochemical dystrophy index (HDI)			
	HDI_{EC}	$HDI_{DOC/DIC}$	HDI_{pH}	HDI
Gorbacz	55.5	133	60.0	**76.2**
Suchar I	93.3	78.2	64.6	**77.8**
Suchar II	77.1	50.5	71.8	**65.4**
Suchar IV	76.9	146	100.8	**104.2**
Suchar Wielki	77.0	30.3	74.0	**55.7**
Suchar Wschodni	81.3	61.0	68.0	**69.6**

appears from the research carried out in the 1950s and in the recent years (1999, 2000, 2008) that over the past forty years, significant changes occurred in the water quality of Lake Gorbacz. The trophic level of the reservoir has increased. Baszyński et al. (1954) classified it as a type of oligotrophic lakes. At present, the average value of the Carlson trophic state index TSI amounts to 53.3 which indicates a moderately eutrophic state. Using the terminology proposed by Górniak (2004), Lake Gorbacz can be classified as humoeutrophic. In this lake, apart from elevated concentrations of DOC, the intense water freshening continues together with a gradual increase of biogenic substances and pH reaction. Among the aforementioned processes, alkalization of the environment is the most progressive one, probably due to malfunctioning of desiccated raised bogs and transition mires in the vicinity of the lake.

It is particularly noteworthy that Lake Gorbacz, despite the fact that it is entirely overgrown with emergent macrophytes and the water level reaches merely 10 cm (in Summer), it still preserves the state of dystrophy in isolated small depressions scattered over the lake area. Probably floating *Sphagnum* mats together with peat strata play a huge role in this case, having a buffering effect on all supplies of mineral compounds from the small catchment area. Not without significance is the layer of Dy type sediments, which prevent the lake waters from overheating and thus accelerated mineralization. Water of Lake Gorbacz has a very high content of DOC (Table 1), almost twice as high as the average value of this parameter for other dystrophic reservoirs on the Earth. Higher concentrations were recorded only in some lakes of Canada and USA (Górniak 1996). The high content of DOC found in the water of Lake Gorbacz results probably from the inflow of humic substances from the catchment area of the reservoir, as well as from the internal enrichment with organic matter derived from organic sediments, which remain constantly semi-fluid. Lake Gorbacz is a polymictic reservoir. Therefore, supplies of the organic matter to the pelagic zone, as a result of resuspension of sediments can take place throughout the year. Dissolved organic matter of Lake Gorbacz is characterized by increased content of aromatic nuclei in the chemical structure (the increased rate of SUVA). In the last decade, a significant increase of this parameter was observed, – the value of SUVA has doubled, reaching a level typical for polyhumic lakes ("suchary") in the Wigry National Park (NE Poland) (Górniak et al. 1999) (Table 1). The recorded high values of SUVA could result from intensive degradation of the peat bogs and accelerated mineralization of organic soils. Concentrations of mineral nitrogen and phosphorus in Lake Gorbacz were similar to values recorded in WNP polyhumic lakes ("suchary"), but significantly lower than in for harmonic, polymictic lakes (Górniak et al. 1999). Only the content of ammonium ions was higher than the average value for polymictic reservoirs. The average concentration of total phosphorus (TP) decreased, while at the same time, the contribution of orthophosphate phosphorus reached the level of almost 40% (Table 1). In previous years, this contribution was significantly lower (15 – 20%), more typical for dystrophic reservoirs (Hutorowicz 2001). In the studied lake, ammonium cations considerably dominated over nitrates (Table 1) A similar situation takes place also in dystrophic reservoirs of the WNP. Probably this results from reduced nitrification in acidic conditions, frequent oxygen deficits, and mineralization of proteins in organic bottom sediments. However, a clear upward trend in concentrations of nitrates was observed (Table 1).

Phytoplankton

In the pelagic zone of the lake, representatives of eight groups of algae and cyanobacteria (Fig. 3, June 2008) were found. Chlorophyceae were represented in the largest numbers and were dominated by *Kirchneriella microscopica* Nyg., *K. contorta* (Schmidle) Bohlin, *K. irregularis* (G. M. Smith) Korš. and *Koliella* spp., which are often recorded in eutrophic reservoirs. In the biomass of phytoplankton, Zygnematophyceae (the family of Desmidiaceae) dominated over other groups of algae and cyanobacteria.

Compared to the year 2000, the role of dinoflagellates and green algae has been reduced in favor of *Zygnematophyceae*. The domination of dinoflagellates (*Peridinium volzii* Lemmm., *P. incospicuum* Lemma., *Gymnodinium* cf. *uberrimum* (Allman) Kofoid et Swezy, *G.* cf. *palustre* Schilling) and green algae (*Didymocystis planctonica* Kors.) was observed in the spring and summer, when the lake basin collected a large amount of water. In October 2000, as in June 2008, Lake Gorbacz looked more like a large puddle than a lake. At that time, smaller differences in the biomass were recorded between the groups of phytoplankton (Fig. 3).

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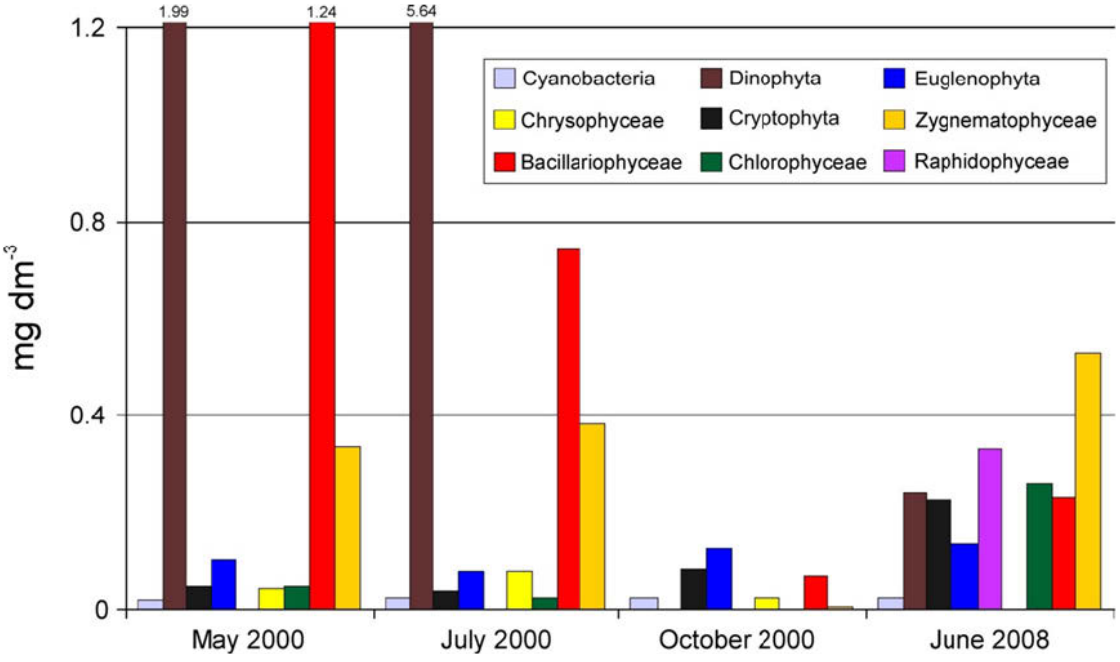


Fig. 3. Comparison of the phytoplankton composition of Lake Gorbacz in 2000* and 2008. (* - unpublished data by Grabowska).

In 2000, *Gonyostomum semen* (Ehr.) Diesing (Raphidophyceae) was not recorded in the reservoir, which is a species characteristic of dystrophic waters, acidic lobelia waters and peat pits in the northern part of Poland (Hutorowicz et al. 2006). In Lake Gorbacz, alike in the phytoplankton of dystrophic lakes of the Wigry National Park, apart from raphidophytes, also dinoflagellates and green algae are a very important component (Hutorowicz et al. 1999; Grabowska, Górniak 2004). Some desmids, such as *Staurodesmus dickiei* (Ralfs) Croasdale and *Closterium acerosum* (Schrank) Ehr. Ex Ralfs are recorded in phytoplankton of lentic and lotic waters. Most of the desmids, however, are considered as a group of algae of peaty waters. The most favorable conditions for their development are on the borderline between the floating bog mat and the pelagic zone rather than in the middle of the lake (Luścinska, Soszka 1998). In Lake Gorbacz, a higher diversity of desmids was recorded in the water (21 taxa) than at the borderline of the floating bog mat (11 taxa). This may indicate that the borderline between the floating bog mat and the open water gradually becomes blurred, which is a consequence of the process of terrestrialization of the reservoir. Among the species common for the water body and the borderline of the floating bog mat, there were among others: *Tetmemorus brebissonii* (Menegh.) Ralfs and *Euastrum oblongum* (Grev.) Ralfs. In the water, a higher species diversity was recorded among the genera of *Cosmarium, Euastrum, Micrasterias, Staurastrum* and *Staurodesmus.*

The content of chlorophyll *a* in the waters of Lake Gorbacz exceeded the level of 20 μg dm^{-3} and was slightly higher than the values recorded in dystrophic reservoirs of Finland (Arvola, Tulonen 1998). However, the concentration of this pigment in Lake Gorbacz is still lower than in some polyhumic lakes "suchary" of WNP (Hutorowicz et al. 1999, Górniak 2006). With such a low water level, part of chlorophyll is of detritus origin, as evidenced by a high concentration of pheophytin (Table 1).

Macrophytes

At the site within the reed bed, on the north side of the lake (Fig. 1), 23 species of macrophytes were identified. Broadleaf cattail *Typha latifolia* L. occurs commonly and forms a dense zone of rushes. The common reed *Phragmites australis* (Cav.) Trin. Has insular occurrence. Several species of sedges: lesser pond sedge *Carex acutiformis* Ehrh., cypress-like sedge *Carex pseudocyperus* L., beaked sedge *Carex rostrata* Stokes., giant water dock *Rumex hydrolapathum,* Hudson and water hemlock *Cicuta virosa* L. occur with a similar density. At the borderline between the

floating *Sphagnum* mat and the reed bed, the following species occur: bogbean *Menyanthes trifoliata* L., marsh cinquefoil *Potentilla palustris* (L.) Scop., swamp horsetail *Equisetum fluviatile* L. em. Ehrh., gypsywort *Lycopus europaeus* L., marsh calla *Calla palustris* L., common water plantain *Alisma plantago-aquatica* L., yellow loosestrife *Lysimachia vulgaris* L., common skullcap *Scutellaria galericulata* L., marsh fern *Thelypteris palustris* Schott, marsh willowherb *Epilobium palustre* L., and purple loosestrife *Lythrum salicaria* L. Outside the strip of rushes, within the pelagic zone, the following species were recorded: northern lily *Nymphaea candida* C. Presl, floating pondweed *Potamogeton natans*, gibbous duckweed *Lemna gibba*, common duckweed *Lemna minor*, European frogbit *Hydrocharis morsus-ranae*. Whereas previously recorded Bladderwort *Utricularia intermedia* and small bur-reed *Sparganium minimum* Wallr. were not found this time.

Fauna of Rotifers

Altogether 48 species were identified in samples collected from five sites. However, the number of species and values of the Shannon-Weaver species diversity index at particular sites are relatively low, i.e. from 8 to 24 and from 1.19 to 2.72 (respectively). In order to clarify this discrepancy, communities were compared at each site. When comparing the communities, the percentage species similarity coefficient (PSC) was used (Whittaker and Fairbanks 1958):

$$PSC = 100 - 0.5\sum(a-b) = \sum_{min.}(a,b)$$

where a and b = % contribution of species from communities of habitats A and B compared in pairs.

The analysis of values of this coefficient (Table 4) partially explains the source of species richness in small, humic lakes that are becoming overgrown with vegetation. This is largely related to distinctness of communities inhabiting the various sites. The fauna of rotifers from the water body is completely different from communities inhabiting the *Sphagnum* floating mat (Fig. 4). It is puzzling that also a community from the borderline of the floating bog mat is almost completely devoid of any species from the water body, which after all could get to this habitat by chance, having been carried there by the water movement. The community from the borderline between the floating bog mat and the water body are only in 25% similar to communities from the floating bog mat located further away from the open waters of the lake. And these sites are also in 20 – 40% different from each other.

Comparison of the dominant Rotifera species from particular sites (Fig. 4) confirms the previously described dissimilarity of these communities. The community of the pelagic zone was dominated by the species *Trichocerca simonei* De Smet, which was relatively recently described in the Polish fauna (Ejsmont-Karabin et al. 2004), and which occurs in large numbers in dystrophic lakes of north-eastern Poland. The species was accompanied by *Polyarthra dolichoptera* Idelson and *Anuraeopsis fissa* (Gosse). None of these species occurred at the other sites, despite their high abundance (1166, 127 and 84 individuals per dm^{-3}, respectively). Whereas the community of the edge of the floating bog mat was dominated by *Keratella paludosa* (Lucks), which is a typical species for this habitat, albeit not very often encountered. Both *Keratella paludosa*, as well as co-occurring and much more common *Keratella serrulata* (Ehrenberg) did not occur at the other sites. In this community, however, there were species of the genus *Lecane,* inhabiting the communities from the interior of the *Sphagnum* floating mat.

Crustacean zooplankton fauna

Planktonic crustacean fauna of Lake Gorbacz, which has been overgrown with vegetation, was represented by small filtrators feeding on bacteria, protozoa, detritus and algae. In the samples distributed along the transect running from the pelagic zone to the end of the *Sphagnum* floating mat, 15 species of Crustacea were identified, typical of small water reservoirs and connected with the vegetation of *Sphagnum* peat bogs. Moreover, rare species of crustacean zooplankton were recorded in the pelagic zone: *Scapheloberis microcephala* G.O Sars, which usually occurs in small reservoirs and peat pits among *Sphagnum*, as well as *Alona protzi* Hartwig, which occurs in the bottom sediments and among macrophytes. The latter species found here favorable conditions as the thickness of semi-fluid sediments of type Dy often exceeds the maximum depth of the reservoir (0.2 m) in the summer.

The greatest number of specimens was recorded at the edge zone of the floating bog mat (162 ind. dm^{-3}) and it was nearly three times higher than the count of Crustacea in the water body. Similar results were observed by Henrikson (1993), who stated that *Sphagnum* microhabitats have an influence on the

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Table 4

Percentage species similarity of Rotifer communities from 5 sites located along the transect running from the lake shore to the end of the *Sphagnum* bog.

Station	SM 30 m	SM 20 m	SM 10 m	SM 0 m
Lake	0.0	0.0	0.1	0.2
SM 0 m	24.5	24.9	26.8	
SM 10 m	59.4	68.6		
SM 20 m	77.3			

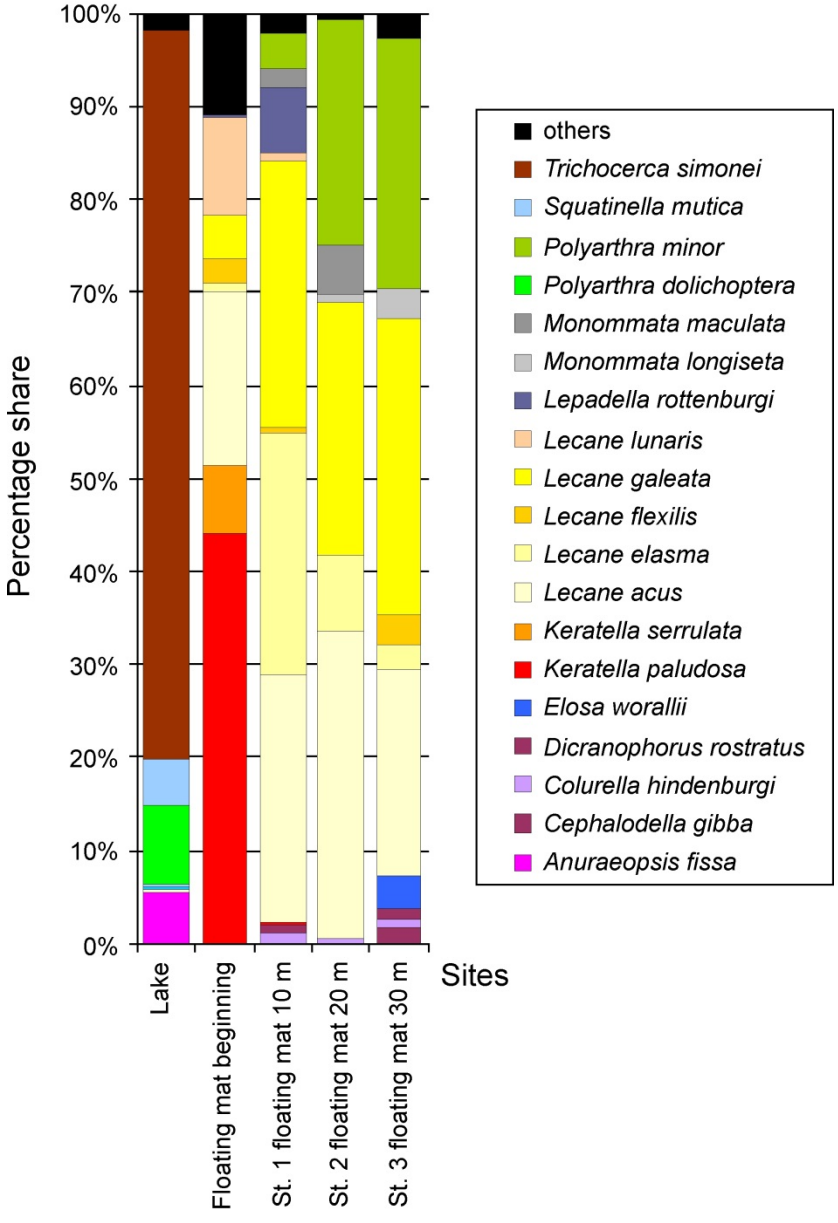


Fig. 4. Comparison of the percentage contribution of the main species in the total count of rotifers at five sites in Lake Gorbacz and *Sphagnum* bog.

increase of the number of invertebrates, even ten times in the case of Cladocera. Subsequent reports by Karabin (1999), Ejsmont-Karabin (2005) and Kuczyńska-Kippen (2008) also indicated the higher abundance of zooplankton in the transition zone between the water body and the edge of the floating bog mat, which can serve as shelter and a feeding place. At the sites located on the *Sphagnum* floating mat, at a distance of 10 m and 20 m from the water body, the count of Crustacea was very low. This may indicate further shallowing and overgrowing of the lake basin.

There were no significant differences in the species composition of the zooplankton communities from the pelagic zone and the floating bog mat. Moreover, the fauna of the pelagic zone despite its small number, demonstrates a higher species diversity. In the pelagic zone, species typical of different environments occurred: organisms associated with the bottom sediment - *Alona protzi* Hartwig; benthic - *Ectocyclops phaleratus* Koch, occurring among mosses - *Metacyclops planus* Gurney, *Alonella excisa* Fischer, macrophytes - *Percantha truncata* O.F. Müller, *Ceriodaphnia pulchella* G.O. Sars, as well as zooplankton typical of the zone of open waters(the pelagic zone) - *Mesocyclops leuckarti* Claus. In the transition zone, the species structure of Crustacea was similar to the one in the water column; however, the number of specimens was almost three times higher as compared to the borderline of the floating bog mat. The higher abundance of zooplankton was caused by the dominance of species typical for unstable and drying-out reservoirs - *Metacyclops minutus* Claus, *Alona quadrangularis* O.F. Müller, as well as species connected with the *Sphagnum* vegetation - *Alonella excisa* Fisher, *Diacyclops nanus* G.O. Sars (Rybak, Błędzki 2005). *Scapheloberis mucronata* O.F. Müller occurred only in the *Sphagnum* floating mat. It feeds mostly on the surface film of the water. In this environment it completely lost the ability of filtration and moved by feeding on plants, scraping off or filtering out the food directly from the surface of the substrate.

When analyzing the changes that had occurred in the structure and the dominance of particular species along the peat - water body transect the highest density of crustacean zooplankton was recorded on the borderline of the floating bog mat, which is a shelter and feeding place for many species. On the other hand, the sites located at a distance of 10 – 20 meters from the shore are characterized by a very low count of Crustacea. The pelagic zone (water body) was the most heterogeneous environment, in which organisms typical for: floating bog mats, bottom sediments and water bodies.

SUMMARY

A shallow, dystrophic lake during hydroclimatic changes, partially of anthropogenic origin, has been transformed into a fen, which is evidenced by the presence of aquatic plants typical of this environment. In the last phase before drying up, hydrochemical conditions prevail, typical for dystrophic waters. Lowering of the water level in such a shallow reservoir has a serious impact on its functioning. Sudden water fluctuations and periodic drying up, affect the increase in the biogenic resources in the water and the increase in the TSI level (humic eutrophication). The appearance of macrophytes over the whole the lake area inhibits the water mixing in the lake and the resuspension of bottom sediments, but it accelerates the water evaporation.

Among the identified taxa of phytoplankton, both typical representatives of eutrophic and dystrophic waters were recorded, as well as of peat-pits. The high diversity of desmids in the phytoplankton, or rather telmatoplankton, indicates the process of shallowing in the reservoir.

The community of Rotifera in the water body was dominated by *Trichocerca simonei* - the species, which was relatively recently described for the Polish fauna. It was found in great numbers in dystrophic lakes of north-eastern Poland, accompanied by *Polyarthra dolichoptera* and *Anuraeopsis fissa.*

Planktonic crustacean fauna of the overgrowing Gorbacz Lake was represented by small filtrators classified into 15 species of Crustacea. Also two species, rare in Poland, were found: *Scapheloberis microcephala* and *Alona protzi.*

Despite the undertaken emergency actions (such as blocking of drainage ditches), the total disappearance of Lake Gorbacz seems inevitable. The process of overgrowing with vegetation is irreversible for the lake, especially that the lowered level of peat bogs and their desiccation caused shallowing of the basin that could accumulate the water. Drying up of the lake will be a serious loss, not only for the reserve, but also for the whole nature of the Podlasie region. Valuable plant and animal species of swampy environments will become extinct. And only one lake of this type will remain in this part of Podlasie – Lake Wiejki, protected since

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2005. It is to be hoped that the example of Lake Gorbacz taught us how to preserve the conditions in the Wiejki reserve in order to maintain the lake ecosystem as long as possible. Its active protection seems to be most justified, although very unlikely in the light of the protection measures undertaken for Lake Gorbacz.

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