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The dynamics the quantitative changes of mycoflora in two lakes differing in trophicity (Poland). I.*

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It was demonstrated that the number of saprophytic fungi in the population of plankton in mesotrophic lake changing to eutrophic (Lake Piaseczno) was mountained a similiar level (average values) as in the eutrophic one (Lake Głębokie). The seasonal and annual changes in the number of fungi in the waters of the lake with lower trophicity were markedly stronger than those in the lake with higher trophicity.

In the mesotrophic lake this was connected with the intensity of phytoplankton development. The greatest accumulation of fungi occured in the waters of littoral zone in both lakes and in the pelagial metha- and hypolimnion of the Lake Piaseczno.

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INTRODUCTION

Cooke (1961) distingushed relatively aquatic fungi apart from the exclusively aquatic ones within the mycoflora of aquatic ecosystems. They are called geophilic fungi on account of their dissemination in the soil. The author also introduced the dilution plating method to hydromycology, which has been used in the mycological analysis of soil. It made the analysis of the number of yeast and fungi of soil origin in aquatic environment possible. Most of this research refered to waters polluted with domestic sewage (Cooke, 1961; Cooke et al., 1960; Meyers, Ahearn, Cooke, 1970; Simard, Blackwood, 1971 a, b; Wollett, Hedrick, 1970; Dynowska, 1992, 1993; and others). Very few works, however, contained some information about waters not polluted with the inflow of sewage organic matter (Collins, Willoughby, 1962; Park, 1972; Mishra, Tiwari, 1983; Quinn, 1984). They do not supply, however, any information about the occurence of relatively aquatic fungi in lakes differing in trophicity level

and the utilization the catchment area. Meanwhile, such research may contribute to the evaluation of eutrophic changes in these reservoirs. It is well known that together with the increase of water trophicity, the amount of saprophytic yeast and other relatively water micromycetes also increases (Meyers, Ahearn, Cooke, 1970; Simard, Blackwood, 1971 a, b; Niewolak, 1973; Quinn, 1984).

The aim of the present study, which is a continuation of earlier observations (Korniłłowicz, Szember, 1991), was to evaluate the number and distribution of saprophytic mycoflora in the lakes of various trophicity and catchment area utilization.

RESEARCH AREA, MATERIAL AND METHODS

The object of the study were two lakes located in the Łęczna-Włodawa Lake District (Mid-Eastern Poland), the mesotrophic Lake Piaseczno and the eutrophic Lake Głębokie. Lake Piaseczno is a reservoir used mainly for recreation. Domestic sewage coming from the recreation area are not disposed into the lake and the agriculture activity in its catchment area is of ratcher extensive character. It is not used for recreation. Lake Głębokie is located in the agricultural area. The majority of its collecting area constitute cultivated fields.

A more detailed description of the lakes and their catchment areas together with the characteristics of soil and bottom sediments was presented by Korniłłowicz, Szember (1991) and Korniłłowicz (1993).

Some data regarding to the chemical properties of water (littoral zone) of the investigated lakes are provided in Table 1. The waters of Lake Piaseczno were, in general, poorer in basic biogens affecting the productivity of water reservoirs than the waters of Głębokie. Seasonal changes in nitrogen concentration of both lakes were characterized by increase of N-total and N-organic concentrations in March, July and October and slight fluctuations of N-mineral during the year. The highest concentration of orthophosphate was noted in early spring. It declined later on and increased slowly again in autumn (Misztal, Górniak, Smal, 1987-1988; Misztal, Smal, Górniak, 1989).

Table 1

Mean concentration of some nitrogen and phosphorus compounds (mg/dcm^{-3}) in the waters of Lakes Piaseczno (1979-1989)* and Głębokie (1982-1985)**

Lake	N total	N-org.	$N\text{-}NH_4$	$N\text{-}NO_3$	P total	$P\text{-}PO_4^{-3}$
Piaseczno	1.58	1.38	0.20	0.09	0.067	0.035
Głębokie	3.44	2.94	0.46	0.07	0.116	0.049

* cited after Misztel, Smal, Górniak, 1989

** cited after Misztel, Górniak, Smal, 1987-1988

The mycological studies were carried out in the years 1987-1990 (in spring 23-29.04 and 27-30.05; early summer 3-11.07, and nearly autumn 27-29.09).

The planktonic samples (Tab. 2) were taken with a Bernatowicz dipper with the capacity of 5 dcm^3 (Lake Piaseczno). and Ruttner apparatus with the capacity of 2 dcm^3 (Lake Głębokie). The samples were stored at +4°C. The mycological analysis of these samples was carried out after 24 hours from the sampling moment.

The total number of fungi was determined by means of dilution plating method, applying Martin's medium (1950) for the isolation of fungi. The plates with fungi cultures were incubated at 20°C ± 2°C for 5-7 days. For each site and term of the experiment three to five repetitions were carried out recounting the obtained results for 1 cm^3 of water.

RESULTS

The results of the studies showed Table 2 that the general number of saprophytic microfungi in the Lakes Piaseczno and Głębokie in the years 1987-1990 fluctuated from about 20 to over 6000 in 1 cm^3 of water. The four year averages of these values for the subsequent experimental sites remained within the range of 300-850 fungi/cm3 of water in Lake Piaseczno (Table 2) and 450-750 fungi/cm3 of water in Lake Głębokie (Table 2). Surface waters of littoral and sublittoral zones of both Lakes and the waters of metha- and hypolimnion of Lake Piaseczno (Table 2) of – contained the highest number of fungi.

In the horizontal plane at the depth of 0.5-1 m the distribution of mycoflora in both reservoirs had similar tendencies: larger amounts of fungi gathered (4-year average) in the shore belt whereas a smaller number of fungi was noted interlake zone (Table 2). However, in the water profiles the distribution of the density of mycoplankton was determined by the character of the reservoir. In the polymyctic often mixed, waters of Lake Głębokie the number of fungi in the waters was maintained at a comparatively steady level. This was manifested, in respect of quantity, long--term average of the number of fungi in the waters of upper and lower sublittoral zones (Table 2). In the dimyctic Lake Piaseczno, undergoing the mixing of water twice a year the vertical distribution of fungi was more irregular with a tendency to a larger concentration of fungi populations in the waters of upper sublittoral and lower pelagial (hypolimnion) zones (Table 2).

The frequency of occurence and distribution of fungi in the depth of water in both the lakes was, however, markedly dependent on the year in which the study had been conducted. It was found that in 1987 and 1988 the total number of mycoplankton in the mesotrophic Lake Piaseczno was on a markedly lower and more steady level than in the years 1989-1990, when a rapid increase in the number of these microorganisms occurred. As compared to the years 1987-1988 the number of fungi in the studied sites of Lake Piaseczno increased even by 40 times (on the average from two to five times).

Table 2

Number of fungi in 1 cm^3 of water at particular sites in Lakes Piaseczno (A) and Głębokie (B) and dates of investigations

Year – Months		Station and depth (m)								
		Litoral zone		Sublitoral zone				Pelagial zone (A)		
		0.5-1		0.5-1		9-10	4.5	epilimnion 0.5-1	methalimnion 9	hypolimnion 25-30
		A	B	A	B	A	B			
1987	IV	210	5800	53	3910	420	1120	1050	590	610
	V	29	26	116	33	20	67	117	12	51
	VII	180	68	81	71	490	1150	82	400	23
	IX	290	1173	21	143	40	50	40	30	130
mean annual		177	1767	68	1039	243	597	322	258	204
1988	IV	90	110	60	226	43	30	150	440	110
	V	20	24	84	640	327	620	32	43	199
	VII	80	44	30	50	200	230	33	710	15
	IX	147	440	34	337	90	–	18	37	130
mean annual		84	155	52	313	165	293	58	307	114
1989	IV	1460	280	2130	117	2000	646	617	803	940
	V	1163	757	1370	480	680	370	70	3460	510
	VII	400	10	230	297	583	107	104	80	113
	IX	70	83	160	124	300	623	57	390	184
mean annual		773	283	973	255	891	437	212	1183	437
1990	IV	433	2100	5640	40	73	–	33	20	669
	V	373	330	30	680	23	54	2066	46	1100
	VII	6133	336	21	230	66	70	206	686	349
	IX	2720	437	473	613	55	1180	110	124	2343
mean annual		2415	800	1541	391	54	435	604	219	1115

The discussed effect was the weakest in epilimnion and the strongest in littoral and, shallow sublittoral (0.5-1) and in profundal zones (hypolimnion). However, at the depth of 9-10 m, i.e. in the lower sublittoral zone and pelagial methalimnion the increase in the density of fungi population density occured only in 1989. A reneved decrease in the population of these microorganisms occurred in 1990 (Table 2).

The annual fluctuations of the mycoplankton number in the eutrophic Lake Głębokie were distinctly lower than these of the mesotrophic Lake Piaseczno. The highest increase in the number of in the number of planctonic fungi was noted in 1987. In the following years two- to eleven-fold decrease in the number of these micromycetes was recorded. This phenomenon was strongly marked in 1988 (Table 2).

Seasonal changes in the occurrence of planktonic mycoflora in both lakes were marked (Figs. 1 A, B). The highest number of mycoplankton was noted more frequently in spring, in April or May, whereas the highest number of fungi was observed in summer (in July). The population of the littoral planktonic fungi in Lake Piaseczno was an exception. It had the reverse course of seasonal maximum and minimum values, with the intensification of the development in July (Fig. 1 A). The response of the planktonic fungi in early autumn (September) was dependent on the type of the reservoir. In the mesotrophic lake, a low number of micromycetes was observed (Fig. 1 A). In the eutrophic lake the increasing tendency was marked once more especially in the lower sublittoral zone (Fig. 1 B).

The investigations showed that the dynamics of the seasonal quantitive changes of mycoplankton in the mesotrophic lake were in general, stronger than in the eutrophic one.

DISCUSSION

It was demonstrated that the frequency of occurrence of relatively aquatic fungi in the plankton of the analysed lakes (on the average 300-800 in 1 cm^3 of water) surpassed the amounts of these microorganisms noted by other authors in the naturally eutrophic reservoirs (Collins, Willoughby, 1962; Niewolak, 1973; Quinn, 1984). However, in respect of the quantity of the non-aquatic micromycetes the examined lakes were similar to the reservoirs with increased trophicity caused by excessive inflow of the organic matter (Cook, 1961; Meyers, Ahearn, Cook, 1970; Niewolak, 1973). These findings would confirm the progressing eutrophication of the examined lakes (Misztal, Górniak, Smal, 1987-1988; Misztal, Smal, Górniak, 1989; Górniak, Misztal, 1991), since together with the increase in the fertility of waters the amount of saprophytic allochtonic mycoflora also increases (Batko, 1975).

The studies showed moreover, that the number of relatively aquatic fungi in the plankton of the mesotrophic lake was maintained at the same level as that of the eutrophic lake. Similar observations were also made in earlier studies of the littoral zone of these lakes (Kornilłowicz, Szember, 1991).

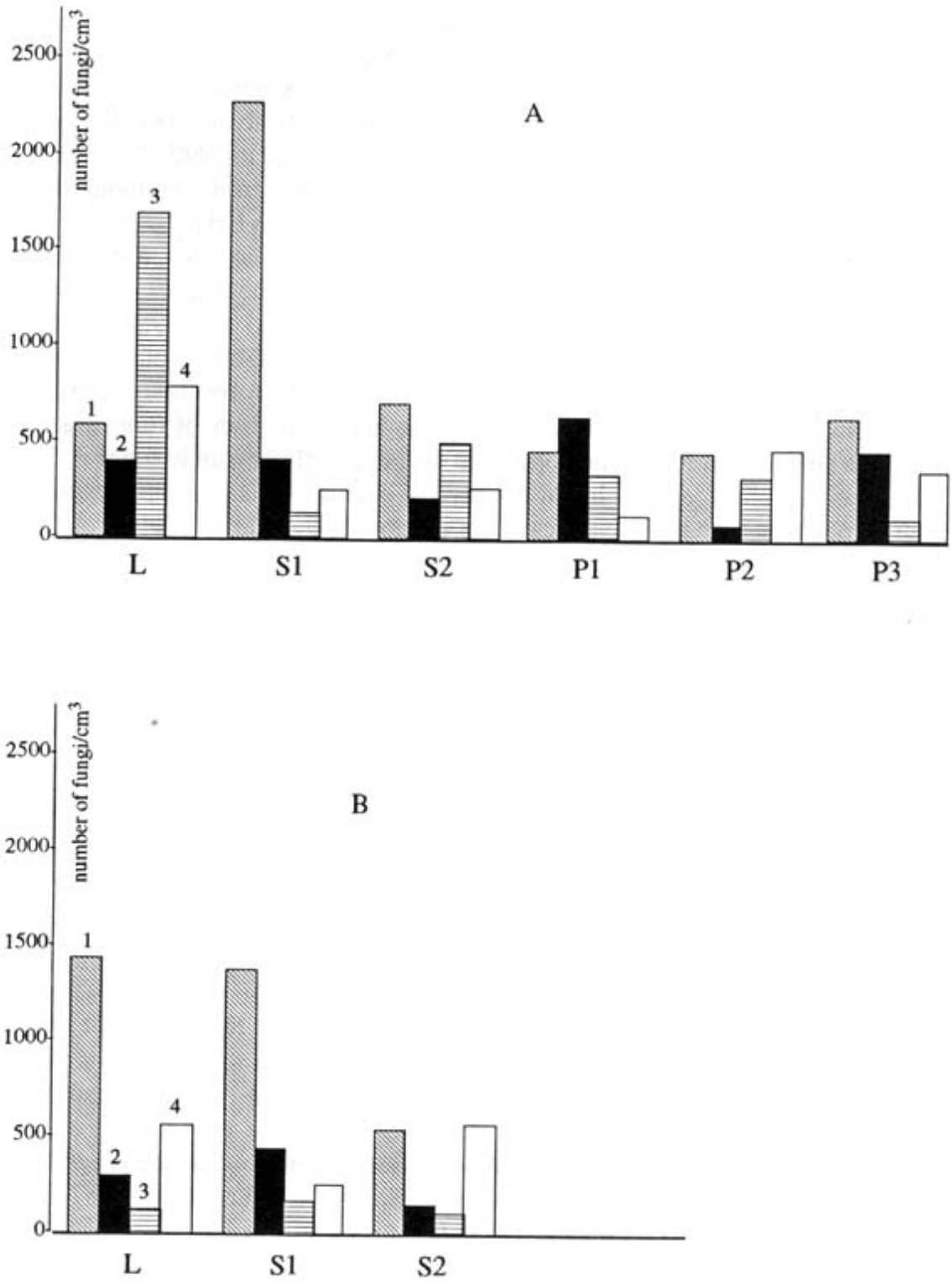

Fig. 1. Seasonal changes in number of fungi in Lake: Piaseczno (A), Głębokie (B)
(mean values for 4 years)

L – littoral zone, S1 – shallow sublittoral zone (depth of A and B – 0.5-1 m), S2 –deep sublittoral zone (depth of A – 9-10 m, B – 4.5 m), P1 – epilimnion (depth of A – 0.5 - 1 m), P2 – methalimnion (depth of A – 9 m), P3 – hypolimnion (depth of A – 25-30 m); 1 – April, 2 – May, 3 – July, 4 – September

Undoubtedly, the most important factor responsible for the increase in the number of fungi in the water of the lake with lower trophicity was the intensified development of algae – the main source of nourishment for saprophitic microorganisms in the waters. The results of studies of Czernaś, Krupa and Wojciechowski (1992, 1993), as well as and of Krupa, Czernaś and Wojciechowski (1992), indicated a gradual increase in the activity of algae communities in Lake Piaseczno in 1986-90 being maximum in 1989, when the primary production and the chlorophyll content (a biomas index) of phytoplankton increased 4.5 and 2-twice, respectively (in comparison with 1986). The present data showed that a high number of planktonic fungi was found at most sites of the mesotrophic lake, in the same year.

According to the authors cited above, the intensification of the phytoplankton activity is the result of the catastrophic eutrophication of Lake Piaseczno caused mainly by the development of recreation and a rapid, since 1986, decline of water level, contributing to the runoff of large amounts of biogens – especially from the murshing peat. This is also confirmed by the studies regarding the chemical changes of the ground waters of the coastal zone and the littoral part of Lake Piaseczno – indicating a considerable inflow of various nitrogen and phosphorus forms (Misztal, Smal, Górniak, 1989, 1992) – basic biogens stimulating the development of algae (Kajak, 1979).

The highest concentration of mycoflora was noted in the littoral zone and pelagial metha- and hypolimnion of Lake Piaseczno. The increase in the frequency of occurrence of fungi in metha- and hypolimnion could be explained by the increase in the number (Szember et al., 1989) and photosynthetic activity (Czernaś, Krupa, Wojciechowski, 1993) of the phytoplankton and the concentration of zooplankton (Radwan, Popiołek, 1989). Both the thermoclin (methalimnion) and the waters of profundal zone (pelagial hypolimnion), are considered as places of the abundant accumulation of saprophytes as a result of the organic matter accumulation (Reinheimer, 1977). However, the accumulation of fungi in the waters of littoral zone in Lake Piaseczno was higher than in the inflow of organic matter of soil origin, the underground transport of which was proved by Górniak and Misztal (1991). The role of allochtonic organic substance in the nourishment of mycoplankton of the coastal waters might be even more important than the role of autochtonic organic matter, since the number of algae (Szember et al., 1989) and the values of primary production (Czernaś et al., 1989) noted in this zone were comparatively low.

The present investigation also revealed seasonal changes in the number of mycoplankton in both lakes. In accordance with its dynamics (Niewolak, 1973; Quinn, 1984; Kornilłowicz, Szember, 1991), the maximum development of mycoplankton was noted in the spring period of phytoplankton flourishing. In the Lake Piaseczno, they occurred in May and were caused by the appearence of blue-green algae (Krupa, Czernaś, Wojciechowski, 1992; Czernaś, Krupa, Wojciechowski, 1993). The minimum development of planktonic

fungi in the examined lakes was noted in the summer stagnation period (July). The reverse reaction occurred in the population of mycoflora dwelling in the waters of littoral zone in Lake Piaseczno, which was outstanding because of the strong influence of the catchment area and different conditions from those of interlake waters. The process of accumulation of soluble organic matter of soil origin in July had a similar course (Misztal, Smal, Górniak, 1989). A renewed lower increase in the number of planktonic fungi, occurred in early autumn – in September (in the eutrophic lake). In the mesotrophic lake this only occurred in October (Korniłłowicz, Szember, 1991). According to Quinn (1984), the stimulation of the development of lake mycoplankton in autumn is caused by an increased inflow of organic matter, both of autochtonic and soil origin.

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Dynamika zmian ilościowych w mikoflorze dwóch jezior różniących się troficznością (Polska). I.

Streszczenie

W latach 1987-1990 przeprowadzono badania nad liczebnością i rozmieszczeniem saprofitycznych grzybów w planktonie jezior Pojezierza Łęczyńsko-Włodawskiego różniących się troficznością i sposobem zagospodarowania zlewni: mezotroficznego o postępującej eutrofizacji (j. Piaseczno) i naturalnie eutroficznego (j. Głębokie).

Wykazano, że liczebność saprofitycznej mikoflory w toni wodnej obydwu jezior kształtowała się średnio na zbliżonym poziomie (300-800 grzybów/cm^3 wody). Jednakże ilościowe rozmieszczenie populacji grzybów w wodzie jeziora uboższego troficznie (j. mezotroficzne) było bardziej nierównomierne. Największe nagromadzenie tych drobnoustrojów zaznaczyło się w wodach przybrzeżnych obu jezior oraz meta- i hypolimnionie j. Piaseczno. Maksymalne liczebności grzybów planktonowych w obu zbiorowiskach wodnych notowano na ogół wiosną, minimalne na początku lata. Dynamika sezonowych zmian ilościowych mikoplanktonu była silniejsza w j. mezotroficznym niż eutroficznym.