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The dynamics of quantitative changes of mycoflora in two lakes differing in trophicity (Poland). II

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It was demonstrated that waters of the mesotrophic lake undergoing accelerated eutrophication had a higher number of yeast fungi in comparison with the waters of an eutrophic lake. The greatest concentration of yeasts occurred in the littoral zone supplied with soil organic matter as well as in the waters of metha- and hypolimnion distinguished by a high phytoplankton activity Filamentous fungi concentrated most numerously in the coastal and surface waters of both lakes. However, they did not show any distinct relationship with the trophicity of the reservoir. The maximum numbers of yeasts and geophilic moulds was mainly noted in spring whereas as minimum numbers occurred in early summer.

INTRODUCTION

The mycoflora of waters comparises fungi conventionally called non-aquatic fungi apart from typically aquatic fungi represented by zoospore fungi and aquatic *Hypomycetes* (Park, 1972 b). Soil born filamentous fungi (geophilic) and yeast fungi are numerous among non-aquatic fungi (Cooke et al., 1961; Park, 1972 a, b). Some authors (Simard, Blackwood, 1971 a, b; Batko, 1975) recognize aquatic yeasts as a natural component of hydrocenosis. Among the above mentioned ecological groups, yeasts are the only fungi capable of developing freely in natural liquid environments (Batko, 1975). However, the occurrence of saprophytic moulds, even those typically aqueous ones is associated with stable organic substrate which are mainly detritus particles in the water depth (Batko, 1975; Reinheimer, 1977).

Various authors (Cooke, 1961; Park, 1972 a, b; Quinn, 1984) agree that preserving non-aquatic fungi in the aqueous environment is conditioned by the sufficient level of organic matter. It is also known that the increase of the pollution of water with organic substance of sewage origin is accompanied by an increase in

the number of yeasts (Meyers, Ahearn, Cooke, 1970; Wollett, Hedrick, 1970; Simard, Blackwood, 1971 a, b; Niewolak, 1973) and geophilic moulds (Batko, 1975). The inflow of native (phytoplankton) and soil organic matter also contributes the increase of the development of fungi in the depth of lake waters (Kornilłowicz, 1993 b).

The aim of the present study was to determine the relationships between the quantitatve distribution of both the "non-aquatic" components of micromycetes: yeasts and filamentous fungi and the trophicity of the examined lakes.

MATERIALS AND METHODS

Two lakes situated in the Łęczna-Włodawa Lake District differing in level of fertility and the way of the catchment area utilisation were included in the research: the mesotrophic Lake Piaseczno, with the proceeding eutrophisation as a result of agriculture and recreation development, and the eutrophic Lake Głębokie located in the agricultural area. The description of the research area, comprising basic physical and chemical properties of waters, bottom sediments of lakes and surrounding soils was presented well as in the earlies papers (Kornilłowicz, Szember, 1991; Kornilłowicz, 1993 b).

Materials and methods were also described earlier (Kornilłowicz, 1993 b). The number of filamentous fungi and yeast cells were given in relation to 1 cm^3 of water. The proportion of both analysed ecological groups of mycoplankton was calculated in relation to the total number of fungi in the subsequent sites and terms of the study (Kornilłowicz, 1993 b).

RESULTS

The mean values for the total number of yeast and filamentous fungi in the mycoplankton of both lakes in the years 1987-1990 are presented in Figs 1 and 2. The data indicate that the number of yeast in 1 cm^3 of water in the mesotrophic Lake Piaseczno fluctuated from 150 to 750 cells and in the eutrophic Lake Głębokie from 200 to 400 cells. The number of filamentous fungi amounted to 50-500 and 80-360 propaguli respectively.

In Lake Piaseczno, the waters of the littoral zone had the highest density of yeast fungi (on the average 120-1700 cells/cm^3) followed by the methalimnion (120--860) and hypolimnion (100-620) waters of pelagial. Filamentous fungi were the most abundant in the waters of littoral (on the average over 100 propaguli/cm^3) and shallow sublittoral zones (on the average 500 propaguli/cm^3) of this reservoir (Fig. 1, 2).

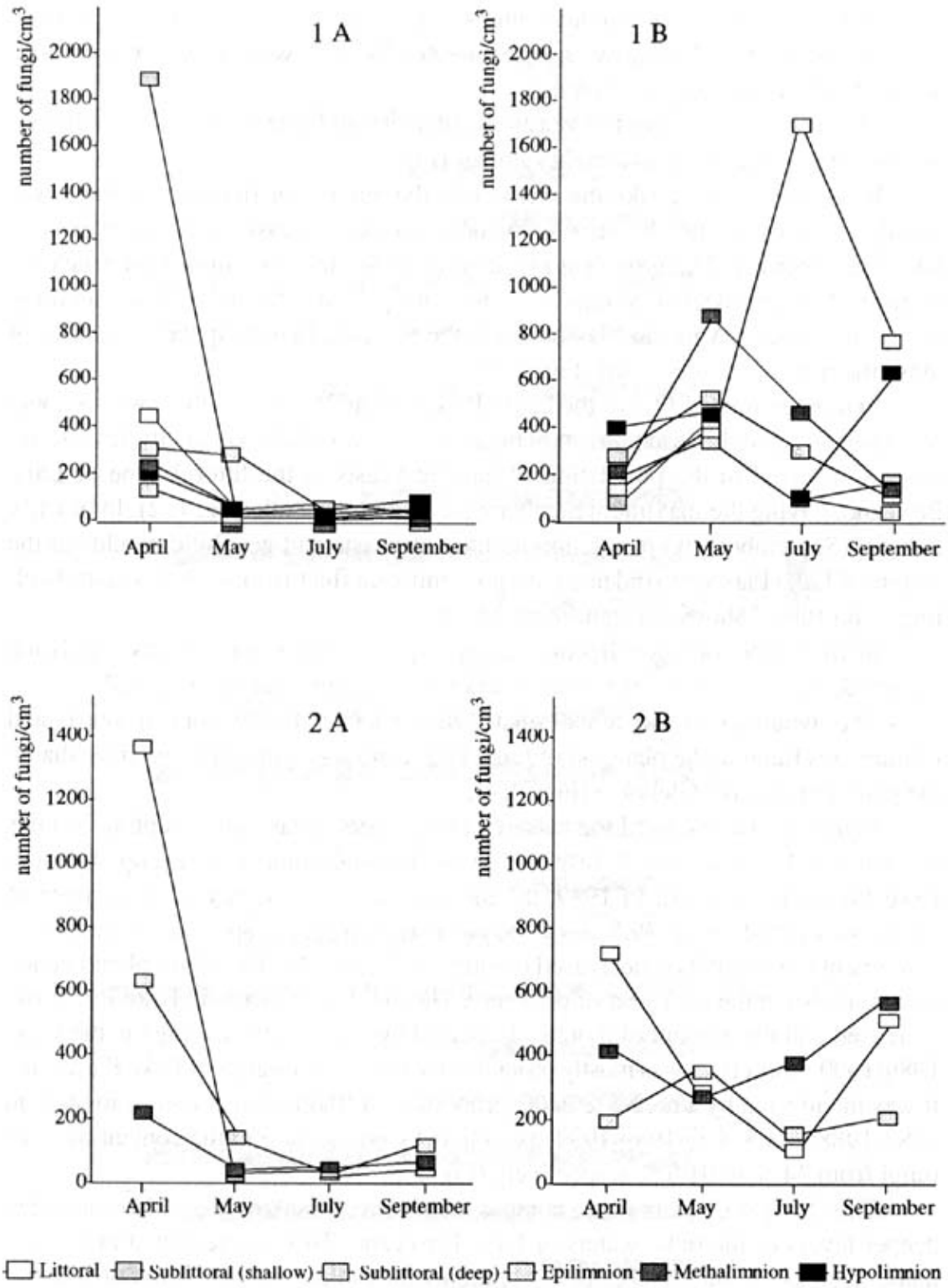

Fig. 1-2. Dynamics of seasonal changes in the number of filamentous fungi (A) and yeasts (B) in the water of Lakes: 1 – Piaseczno, 2 – Głębokie

depth (m): littoral zone – 0.5; shallow sublittoral zone – 0.5-1; deep sublittoral zone – 9-10; epilimnion – 0.5-1; methalimnion – 9; hypolimnion – 25-30

In Lake Głębokie the highest number of yeasts was found in the waters of lower sublittoral zone (on the average about 400 cells/cm^3), while moulds were mostly noted in littoral zone (up to 350/cm^3).

The maximum numbers of yeasts anf filamentous occurred in spring. Whereas the lowest number was noted early summer (Figs 1, 2).

In the mesotrophic lake the increase in the number of filamentous fungi was mainly noted in April; a the same time, alow number of yeasts in the waters of this lake was recorded. The growth stimulation of these fungi began in May when the number of moulds decreased rapidly. In the eutrophic lake the number of both fungi groups increase in April. In May however the decrease in the population density of these micromycetes was noted (Fig. 1, 2).

In most examined sites of the Lakes Piaseczno and Głębokie, the lowest amount of yeasts and geophilic moulds in plankton occurred in July. Distinctly reverse response occurred in the population of aquatic yeasts in the littoral zone of Lake Piseczno, having the maximum number exactly in this month (Fig. 1, 2). In of early autumn (September) the population number of yeasts and geophilic moulds in the waters of Lake Piaseczno did not undergo significant fluctuations. Only yeasts dwelling in profundal showed a significant growth.

In all the sites of Lake Głębokie, however, the increase in the yeasts population occurred, and the amount of moulds did not considerably change (Fig. 1, 2).

The dynamics of the annual quantitative changes in the flora of yeasts and filamentous fungi in the plankton of Lake Piaseczno was quite different from that in the plankton of Lake Głębokie (Figs 3, 4).

In the first two years of the research (1987-1988), yeasts and geophilic moulds comparised 49.5 and 50.5 % respectively of the total number of mycoplankton in Lake Piaseczno (Fig. 3). In 1989, the increase in the frequency of occurrence of yeasts was noted (from 49.5 % to 88 %). However, the proportion of moulds in mycoplankton population decreased (from 50.5 % to 14 %). The above phenomenon occurred also in the next year of the study. The number of yeasts in Lake Piaseczno increased and the amount of moulds decreased by 36 % on the average in the years 1989-1990. This effect was mostly pronunced in the coastal waters of Lake Piaseczno. It was manifested by a decrease in the proportion of filamentous fungi from 66 % in 1987-1988 to 8.5 % in 1989-1990, as well as by on increase in the content of yeast fungi from 34 % to 91.5 % respectively (Fig. 3).

The changes in quantitative composition of mycoplankton were also marked in deeper layers of interlake waters of Lake Piaseczno. This was reflected in a systematic decrease in the number of geophilic moulds in the methalimnion of pelagial zone (from 57 % in 1987 to 6 % in 1990) and a simultaneous increase of the proportion of yeasts in this zone (43-94 % respectively). The fluctuations in the content of yeasts and filamentous fungi in the mycoplankton of pelagial hypolimnion had almost identical course (Fig. 3).

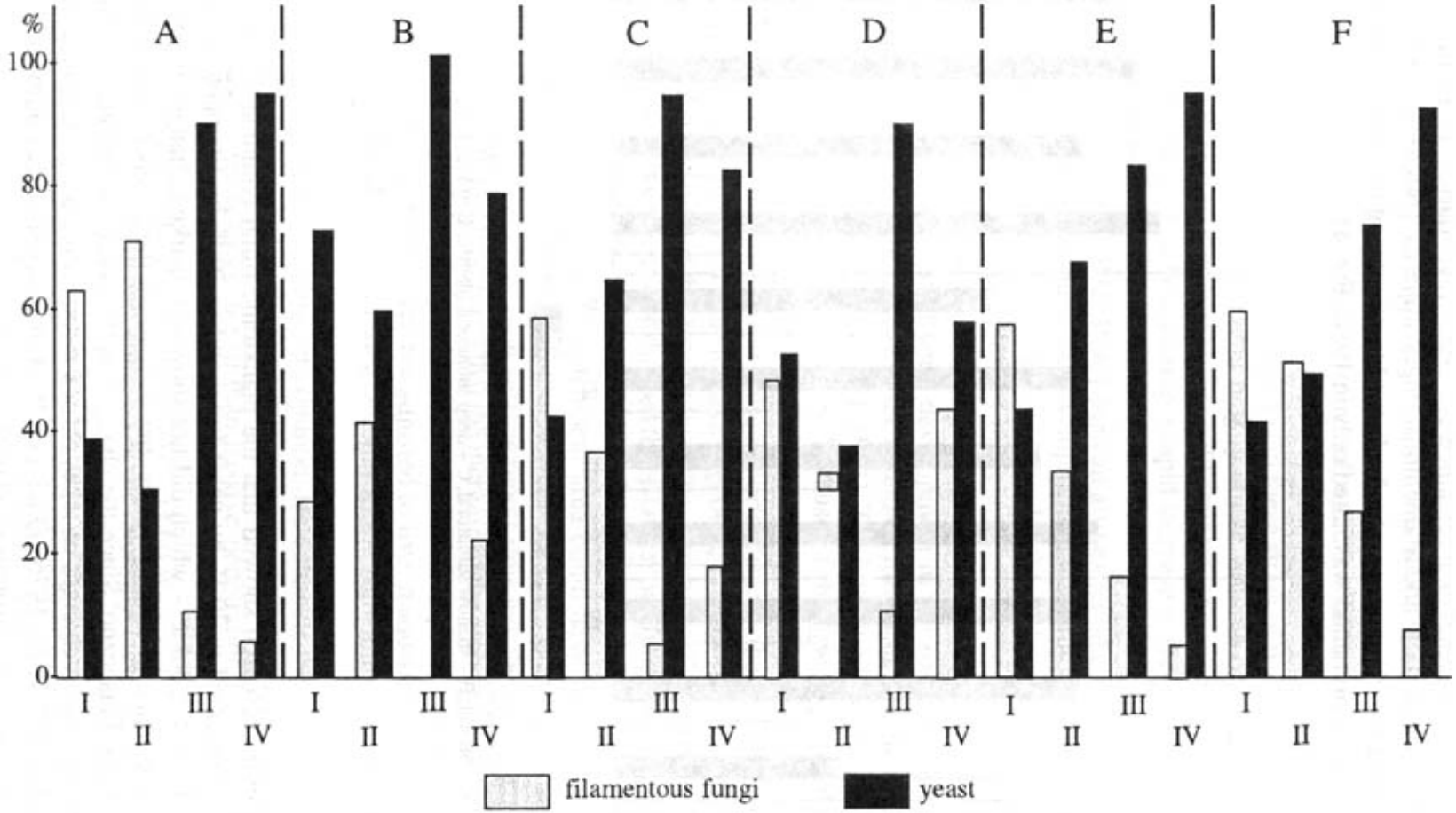

Fig. 3. Percentage of yeasts and filamentous fungi in the mycoplankton of Lake Piaseczno
A – littoral, B – shallow sublittoral, C – deep sublittoral, D – epilimnion, E – metalimnion, F – hypolimnion (depths as to Fig. 1-2); I – 1987, II – 1988, III – 1989, IV – 1990

Contrary to Lake Piaseczno, the proportion of yeasts and filamentous fungi in mycoplankton of Lake Głębokie remained at a stable level during the entire period of the research. Yeast fungi and filamentous fungi comparised 60-80 % and 20-40 % of mycoplankton population respectively. In the littoral zone of the reservoir in question the reverse phenomenon was noted only in 1988 (Fig. 4).

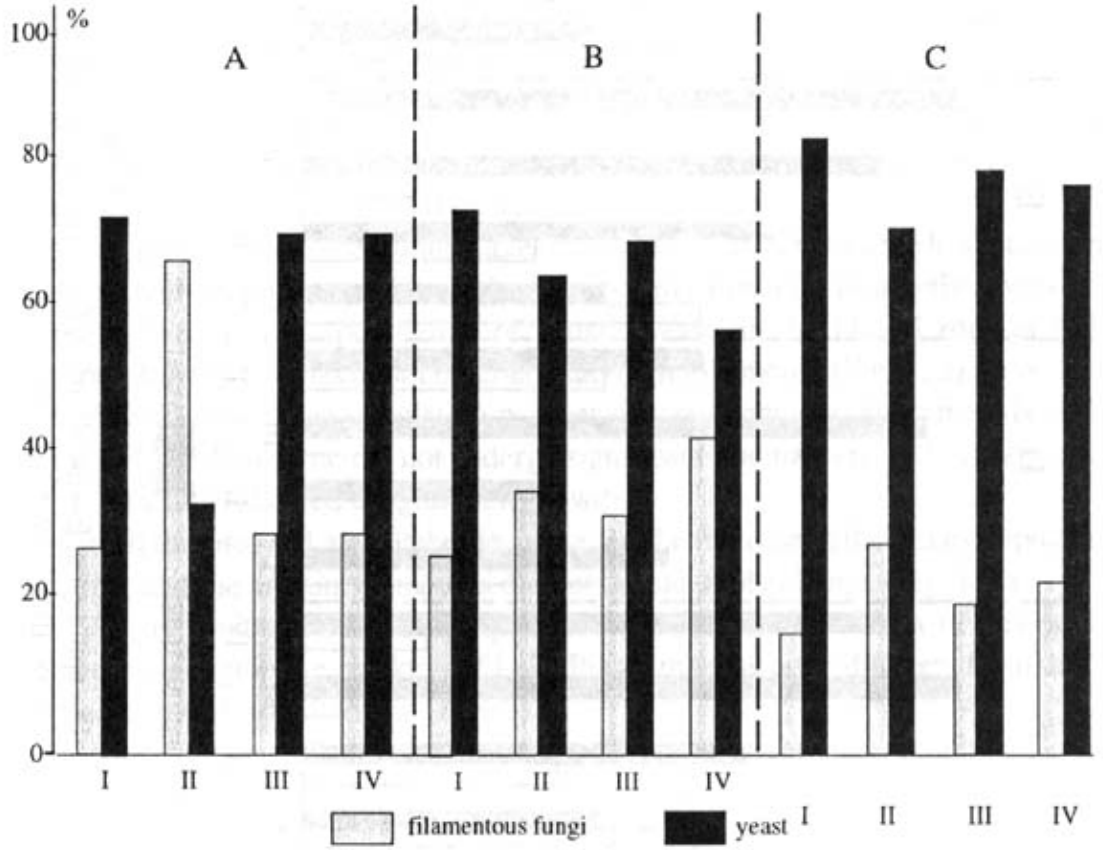

Fig. 4. Percentage of yeasts and filamentous fungi in the mycoplankton of Lake Głębokie
A – littoral, B – shallow sublittoral, C – deep sublittoral (depths as to Fig. 1-2);
I – 1987, II – 1988, III – 1989, IV – 1990

DISCUSSION

The present research showed that the planktonic fungi communities of both lakes were represented in 70 % by yeast fungi and in 30 % by filamentous fungi. Contrary to Lake Głębokie – which did not show any marked changes in the frequency of occurrence of aquatic yeasts, the increase in the number of these fungi occurred in Lake Piaseczno. Since the changes in the yeast number are associated with the eutrophication changes of lakes (Meyers, Ahearn, Cook, 1970; Niewolak, 1973, 1975, 1976; Quinn, 1984) the increase in its number would confirm the progressing eutrophication of this reservoir.

The highest concentration of yeasts in the water of mesotrophic lake was noted in the littoral zone as well as metha- and hypolimnion of pelagial zone. These observations are in agreemenet with the data of N i e w o l a k (1975, 1976) who noted the maximum number of yeasts in the coastal and near bottom waters. Higher frequency of occurrence of yeasts in deeper zones of water could be associated with the increased concentration of easily available organic substances secreted first of all by the intensively developing phytoplankton in these strata of water (S z e m b e r et al., 1989). Yeasts celled "sugar" fungi mainly utilize, soluble organic matter. S p o d n i e w s k a (1988) reported that algae could emit into the environment up to tens per cent of the assimilated carbon. Noting a rapid increase in the primary production of the phytoplankton in Piaseczno in the years 1986-1990 (C z e r n a ś, K r u p a, W o j c i e c h o w s k i, 1992, 1993) one can also expect the increase in the amount of organic substance stimulating the development of these fungi. The remineralization of the organic substance emitted by algae under the influence of microorganisms would contribute to the quick return of biogenes responsible for the increase of water fertility to the circulation.

The strong stimulation of yeast development in the zone of coastal waters in Lake Piaseczno was associated with the abundant inflow of soluble organic matter of soil origin (G ó r n i a k, M i s z t a l, 1991). The importance of the native organic matter in this zone was probably small, because of the low phytoplankton activity (S z e m b e r et al., 1989; C z e r n a ś et al., 1991). However, the autochtonic organic matter content palyed a far more important role in the stimulation of aqueous yeast development in littoral zone in Lake Głębokie. The development of phytoplankton in the coastal waters of this reservoir was very intensive (S z e m b e r et al., 1989).

The present investigations showed that filamentous fungi were mainly concentrated in the coastal and surface waters of both lakes. It seems that the penetration of these microorganisms from the catchment area could have been very significant. The intensive penetration of allochtonic mycoflora takes place in spring, when the waters from melting snow and soil surface runoff flow into the lakes (D o n d e r s k i, 1983). The present results showed that the increase in the amount of geophilic moulds in the water of both lakes only occurred in April. Subsequently many of these fungi might have died since they were not adjusted to live in aqueous environment which would explain the decrease in their amount in the remaining months of the study period.

Q u i n n (1984) is of different opinion. He connects the spring stimulation of the number of filamentous fungi of soil origin in the lake waters rather with the stimulation of their activity in situ than passive penetration from the surrounding catchment area.

On the basis of earlier research (K o r n i ł ł o w i c z, 1991) it seems that this phenomenon could concern only some geophilic micromycetes. The sufficient amount of organic matter – the indispensable factor enabling the preservation of non-aquatic fungi in aqueous environment (C o o k e, 1961; P a r k, 1972 a, b; Q u i n n, 1984), and also weak competitiveness with yeast flora and aquatic bacteria in early spring would be, first of all, favourable to their preservation in aqueous environment apart

from the features of the very fungi. Both microbial groups mentioned above showed the stimulation of growth later, which results from my research as well as from Furczak's observations (1988).

It was proved in the present paper that the maximum number of yeasts in the phytoplankton in waters of mesotrophic lake occurred in spring. This was confirmed by the relationship between the spring increase in the yeast growth and the inflow of autochtonic organic matter noted by other authors (Simard, Blackwood, 1971 a, b; Cooke, 1976; Quinn, 1984). The decrease in the amount of these microorganisms occurred in the period of summer stagnation of lakes. Such phenomenon was also noted by Simard and Blackwood (1971 a, b), Niewolak (1973) and Quinn (1984). Only in the coastal zone of Lake Piaseczno the amount of yeasts markedly increased in this period because of a high transport of allochtonic organic matter (Górniak, Misztal, 1991). Similar course of maximum and minimum amounts of yeasts was noted in the eutrophic lake. However, the increase in the amount of yeasts occurred again in this reservoir, in autumn. According to Quinn (1984) the autumn increase in the development of yeasts is caused by the inflow of both the native (phytoplankton dying after summer occurrence) and soil born (shedded leaves, twigs etc.) organic matter.

The increased amount of yeasts is indicative not only of the enrichment of lakes with organic matter but in may also testify to the pollution of water with domestic sewages. The number of yeast fungi in waters of the examined lakes was identical to that of the reservoirs polluted with mixed domestic-industrial sewages (Niewolak, 1973, 1975, 1976). However pink yeasts of *Rhodotorula glutinis* (Korniłłowicz, 1991) – one of the indicators of water pollution with sewages (Hinzelin, Block, 1985; Dynowska, 1992, 1993) prevailed in these populations of microorganisms. The inflow of domestic sewages might have affected the waters of Lake Piaseczno (intensively utilized for recreation) in which the fungi species characteristic for the bottoms of waters polluted with municipal sewages occurred (Korniłłowicz, 1993 a).

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Jakościowe zmiany dynamiki mikoflory w dwóch jeziorach różniących się troficznie

Streszczenie

Celem badań była ocena liczebności grzybów drożdżoidalnych oraz grzybów strzępkowych lądowego pochodzenia w wodzie dwóch jezior (Pojezierze Łęczyńsko-Włodawskie) różniących się troficznością i sposobem zagospodarowania zlewni.

Badania wykazały, że w latach 1987-1990 liczba drożdży w planktonie mezotroficznego j. Piaseczno podlegającego przyśpieszonej eutrofizacji wahała się średnio od 150-750, a grzybów strzępkowych od 50-500 w 1 cm^3 wody; w eutroficznym j. Głębokie notowano odpowiednio 200-400 komórek drożdży i 80-360 strzępek grzybów. Dynamika rocznych zmian ilościowych badanych grzybów wskazała na wzrost liczby drożdży w mikoplanktonie jeziora o postępującej eutrofizacji. Wzrost ten zaznaczył się w latach wzmożonego rozwoju fitoplanktonu w tym zbiorniku (Czernaś, Krupa, Wojciechowski, 1992, 1993). Rozmieszczenie flory drożdżaków i geofilnych grzybów pleśniowych w toni wodnej badanych jezior było nierównomierne. Większa ilość tych grzybów występowała w płaszczyźnie horyzontalnej w wodach przybrzeżnych, mniejsza w śródjeziorzu. W profilu jezior, drożdże nagromadzały się głównie w wodach przydennych i metalimnionie. Liczebność ich nie wykazywała wyraźnego związku ze stratyfikacją pionową zbiornika. Maksima liczebności drożdży występowały w kwietniu (j. eutroficzne) lub maju (j. mezotroficzne), minima – na ogół w lipcu. Odwrotną zależność przejawiała populacja drożdży litoralu j. mezotroficznego podlegającego silnej presji zlewni. Grzyby strzępkowe obu jezior w największej liczbie pojawiały się w kwietniu, w następnych miesiącach ich liczebność gwałtownie spadała.