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Fitoplankton stawów doświadczalnych w Gołyszu — Phytoplankton of the experimental ponds in Gołysz

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The aim of the investigations on phytoplankton carried out in the ponds at Gołysz (district Cieszyn) in the years 1956 and 1957 was the characterization of the whole group from the aspect of floristics and an attempt at classifying the investigated ponds on this basis as a definite trophic type. These ponds are part of the Experimental Pond Farm of the Laboratory of Water Biology of the Polish Academy of Sciences.

Limnologic literature commonly distinguishes three basic types of trophism of waters: oligo-, eu-, and dystrophy. However, this classification is often not sufficient where ponds are concerned, and for this reason certain other terms are introduced such as i. e. heterotrophy and hypertrophy. The idea of characterization of the trophism of these ponds by means of the physico-chemical spectra presented by Naumann (1927, 1932), seemingly logical and simple, was not found useful in practice. Essential difficulties lay in doubts as to what limits should be accepted for individual food spectra. It is known that what is determined in water by chemical methods represents only the remaining food substances not used by the organisms. Their amounts would then undergo constant fluctuations under the influence of the dynamics of development of phytoplankton. This led to the determining of the trophism of ponds and lakes also by means of the character of the plankton group.

Thus Weimann (1938), investigating plankton of the ponds in Lower Silesia, both fertilized and not fertilized, could, when using the quantity method, catch seasonal changes in the phyto- and zooplankton. On the basis of plankton development he divided the ponds into four types: ponds with clear water, ponds with slightly greenish to yellow-brownish water, ponds with intensively green water, and ponds with *Aphanizomenon*. According to the author it is difficult to define the degree of trophism of the first two types — they may be considered as oligotrophic with temporary weak eutrophisation. The third type,

weakly trophic, is the easiest to determine (*Anabaena,* protococcous algae): the fourth one, the most fertile, is connected with the development of *Aphanizomenon.*

Thunmark (1945) used a quotient representing the relation $\frac{Chlorococcales}{Desmidieae}$. The values from 0—1 according to him indicate oligotrophy, 1—5 weak eutrophy, and 5—15 strong eutrophy.

Following this line, Nygaard (1949) used quotients calculated from the number of species of individual higher systematic groups of algae differentiating:

1. the myxophycean quotient: $\frac{Myxophyceae}{Desmidieae}$
2. the chlorophycean quotient: $\frac{Chlorococcales}{Desmidieae}$
3. the diatom quotient: $\frac{Centrales}{Pennales}$
4. the euglenine quotient: $\frac{Euglenineae}{Myxophyceae + Chlorococcales}$
5. the compound quotient: $\frac{Myxoph. + Chlorococc. + Centr. + Eugl.}{Desmidieae}$

He also divided algae into groups typical for eutrophic or oligotrophic waters. He recognised as characteristic for the former *Euglenineae Myxophyceae* and a great number of *Chlorococcales* and *Centrales;* for the latter *Desmidieae.* He states that if the value of the compound quotient is smaller than 1, the water is probably oligotrophic; larger than 1 points to its eutrophy. Values from 1 to 2.5 denote weak eutrophy, 3 — 5 medium, 5 — 20 stress the fact that the lakes or ponds are distinctly eutrophied and slightly polluted, and 20 — 43 point to high eutrophy of the water, strongly polluted with organic matter.

Klotter (1953) when defining the degree of trophism of the lakes of the Black Forest (Schwarzwald) used the Nygaard compound quotient supplementing it by the introduction of the relation of alkaliphilic to acidophilic forms taking into consideration the indifferents:

$$\text{alk : ac — Quo} = \frac{\text{alkaliphilic forms + indifferent forms}}{\text{acidophilic forms + indifferent forms}}$$

He assumed that a value of the given quotient lower than 1 points to the presence in these waters of acidophilic forms, whose average

values of pH lie in the acid range; from a value 1 it results that the pH of the waters lies in the neutral point; values over 1 denote more or less alkaline waters. As not all species are attached to one type of water and are encountered in waters with varying degrees of trophism, the species which appear were listed in three groups, i. e. acidophilic, alkaliphilic and indifferent; some species Klotter could not characterize.

Szklarczyk (1956), when characterizing trophism of the dam reservoir in Kozłowa Góra, states that the usage of the Thunmark chlorophycean quotient, especially in waters rich in blue-green algae, is unreliable; the usage of Nygaard quotients, especially the compound one, is much more efficient in these cases.

Teiling (1955) investigated the phytoplankton of about 700 lakes in Sweden and taking into consideration their topography and geology he differentiated systems of species connected fairly distinctly with trophism.

Oligotrophic	Mesotrophic	Eutrophic
Desmidieta		
Dactylococcopsis ellipsoideus		
Tabellaria pelagica		
Staurodesmus sellatus	**Chlorococcaleta**	
St. crassus	*Kirchneriella*	
Staurastrum	*Tetraëdron*	
	Pediastrum	
		Diatometa
		Fragilaria crotonensis
		Attheya
		Melosira granulata
		Myxophyceta
		Microcystis aeruginosa
		M. viridis
		Lyngbya contorta
		Pediastrum Kawraiskyi

Among the desmids, diatoms, chlorococcous green algae and blue-green algae found he differentiated eurotrophic forms, met both in oligotrophic

and eutrophic lakes. Such species as *Dactylococcopsis ellipsoideus* and *Tabellaria flocculosa* var. *pelagica* indicate quite distinctly the oligotrophic character of the lake. With the decrease of oligotrophy plankton, *Chlorococcales* and especially *Kirchneriella lunaris* begin to appear. The gradual appearance of three diatoms: *Fragilaria crotonensis*, *Attheya Zachariasii* and *Melosira granulata* indicate the eutrophisation of the lake. According to Teiling diatoms are a good sign of the boundary where oligotrophy passes into eutrophy. In the more eutrophic lakes there appear blue-green algae such as *Aphanizomenon*, *Anabaena flos aquae* and *A. circinalis* forming water blooms in summer. With the increase of eutrophy there appear stenotrophic *Microcystis aeruginosa* and *M. viridis*. Teiling gives examples of small lakes with qualitatively oligotrophic plankton but with higher production than that in the lakes with species showing eutrophy.

Material and method

Material was collected from 8 ponds: Wyszni I, Wyszni II, Wyszni IV, Wyszni VI, Wyszni VII, Wyszni VIII, Baginiec II, and Lipowy from 19th April to 5th October 1956, and from 9th May to 26th September 1957 every two weeks, with the exception of the ponds Wyszni I, Wyszni VIII, Baginiec II and Lipowy where material was gathered in the year 1957 only every month. In 1956 104 samples were taken and in the next year 76. To extract the plankton a plankton bucket van Oye type 10 l capacity and silk gauze No. 20 plankton net were used; 50 l of water taken in 5 different places in the pond was strained, and the residue was fixed in 5% formaline. Simultaneously with the taking of the sample the water temperature was measured.

Tab. I

Monthly averages of air temperature in °C

month / year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1956	0,2	−12,9	0,7	6,8	12,7	15,5	17,6	16,6	13,9	8,5	−0,4	0,5
1957	−0,6	3,2	4,2	8,1	10,3	18,0	18,7	16,0	12,4	8,8	5,0	−0,1

At the same time Mrs M. Szumiec took the measurements on the territory of the farm i. e. temperature, air and rainfall (Tab. I, II). Hydrochemical analyses were made by Dr M. Bomba for the ponds Baginiec II, Wyszni I, Wyszni VIII in 1956 and 1957 and Dr S. Wróbel

Tab. II

Monthly rainfall in mm of water column

year \ month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1956	13,0	34,4	22,1	69,6	77,0	192,6	90,9	103,5	47,5	77,6	55,3	40,6
1957	23,0	43,6	57,1	81,5	60,6	49,8	197,4	91,0	89,7	17,7	14,9	43,2

for the ponds Wyszni II, Wyszni IV, Wyszni VI, Wyszni VII in 1957 (Wróbel 1959). On the basis of these data a graph of systems (spectra) of chemical factors was made according to the formula given by Stangenberg (1936, 1938).

The amount of plankton was defined by evaluation on the basis of the 5 degree scale of Starmach (1954). During quantity evaluation 5 samples were always examined, each time one drop of sample condensed to constant volume being taken. Diatoms and filamentous green algae were generally defined for genus.

Characteristic of particular ponds

Data on the area of ponds, their depth, vegetation cover and applied fertilization are given on Table III, the composition of the phytoplankton on Table IV and the chemical data and plankton quotiens on Figure 1.

The macroflora of the ponds at Gołysz was studied by Ł. Krzeczkowska.

Wyszni I. In 1956 it was fertilized with superphosphate, 35 kg/ha P_2O_5, in 1957 it was not fertilized. This was a pond with a through stream supplying water to other pond situated on a lower level.

The chemical spectra (Fig. 1) show in 1956 the average O_2, NO_3 and K_2O state and a particularly high state of pH. In 1957 they show average NO_3 and pH states and rather high K_2O.

In the phytoplankton of the described pond were determined 54 species. In this pond plankton was poor in general both in 1956 and 1957. The greatest quantity was reached by *Asterionella formosa* but only once in the sample taken on 26th July 1956. In the next year of investigation *Volvox aureus* was predominant, forming a water bloom at the beginning of June.

Among species encountered in at least 30% of samples were in the year 1956: *Pinnularia Debesi* — a new species for Poland, described separately (Siemińska, Bucka 1959), and *Ankistrodesmus falcatus*.

Tab. III

General data on ponds

Pond	Surface		average depth in metres	Kind of fertilization		Preponderating plants	
	of dykes in ha	covered by water in ha		1956	1957	1956	1957
Wyszni I	5,0	5,0	0,80	superphosphate	not fertilized	Elodea canadensis	Glyceria aquatica Elodea canadensis
Wyszni II	9,0	8,5	1,10	superphosphate	superphosphate + ammonium-sulphate	Heleocharis acicularis Sagittaria sagittifolia	Heleocharis acicularis Sagittaria sagittifolia
Wyszni IV	6,5	6,0	0,70	not fertilized	superphosphate + ammonium-sulphate	Glyceria aquatica Potamogeton lucens	Glyceria aquatica Heleocharis acicularis
Wyszni VI	7,4	5,5	0,70	not fertilized (control)	not fertilized (control)	Glyceria aquatica	Glyceria aquatica
Wyszni VII	15,0	14,8	1,10	superphosphate	superphosphate	Typha latifolia Glyceria aquatica	Typha latifolia Glyceria aquatica
Wyszni VIII	3,1	3,1	0,60	not fertilized	not fertilized (the water was not let out for the winter)	Glyceria aquatica Typha latifolia	Elodea canadensis
Baginiec II	18,0	10,0	0,90	superphosphate	not fertilized	Glyceria aquatica Carex sp. div.	Glyceria aquatica Carex sp. div.
Lipowy	6,0	6,0	0,50	not fertilized	not fertilized	Glyceria aquatica Potamogeton natans Heleocharis acicularis	Glyceria aquatica Sagittaria sagittifolia Potamogeton natans Heleocharis acicularis

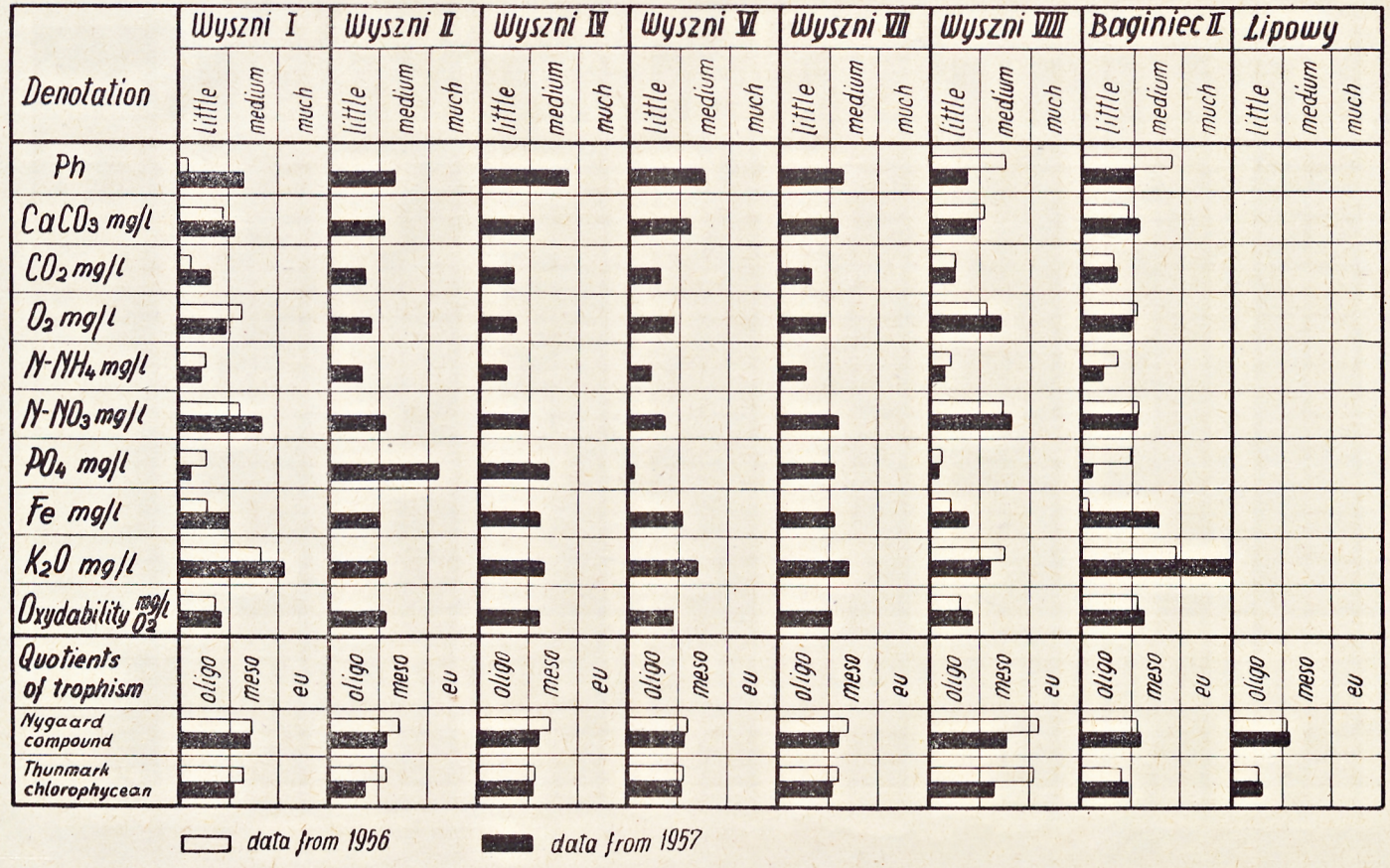

Fig. 1. Comparison of chemical spectra and plankton quotients

EXPLANATION:

Denotation	little	medium	much
pH	> 7,4	7,4 — 7,0	< 7,0
$CaCO_3$ mg/l	0 — 50	50 — 200	> 200
CO_2 mg/l	0 — 6	6 — 15	> 15
O_2 mg/l	0 — 10	10 — 20	> 20
$N\text{-}NH_4$ mg/l	0 — 0,15	0,15 — 0,6	> 0,6
$N\text{-}NO_3$ mg/l	0 — 0,1	0,1 — 0,6	> 0,6
PO_4 mg/l	0 — 0,1	0,1 — 0,5	> 0,5
Fe mg/l	0 — 0,2	0,2 — 0,8	> 0,8
K_2O mg/l	0 — 2	2 — 4	> 4
oxydability O_2 mg/l	0 — 8	8 — 15	> 15

Quotients of trophism	oligo-	meso-	eu-
Nygaard compound	0 — 1	1 — 5	5 — 20
Thunmark chlorophycean	0 — 1	1 — 5	5 — 15

In 1957 appeared: *Fragilaria crotonensis, Synedra acus, Pinnularia Debesi, Pediastrum Boryanum, P. duplex.*

The compound quotient calculated according to Nygaard's formula shows a weak eutrophy of this pond, which agrees with the chemical spectra. The chlorophycean quotient (Thunmark's scale) gives a similar indication but other quotients do not give distinct values. The species composition, with a preponderance of diatoms and a small number of desmids, confirms the average state of trophism of the water. From characteristic species for the mesotrophic phase given in Teiling's spectrum (1955) in the plankton of this pond were observed *Melosira granulata* sporadically, *Pediastrum* sp. div. in small quantities and especially numerous *Fragilaria crotonensis.*

Wyszni II. In 1956 fertilized with superphosphate in quantities of 35 kg/ha P_2O_5, in 1957 also with superphosphate in the same quantities and ammonium sulphate of 30 kg/ha N; this pond gets water from the Wyszni I pond.

Chemical components in this pond were small in quantity except $CaCO_3$, K_2O and pH which appeared in average amounts in 1956, and PO_4 which appeared in large amounts in 1957.

Altogether 78 species were determined. The most numerous were green algae, especially *Volvox aureus,* appearing in a mass at the beginning of September 1956 and June 1957, and *Volvox globator* in the first part of July 1957. Numerically important and noted in nearly all samples in both years was *Eudorina elegans;* however *Ankistrodesmus falcatus,* which was more rare, caused a water bloom on 31st July 1957. An epiphytic species, *Characium gracilipes,* which appeared on *Diaphanosoma brachyurum* in the same year should also be mentioned. The next most numerous group were blue-green algae among which *Nostoc* sp. appeared in great quantities in the first decade of August 1956, and *Aphanothece clathrata* in large quantities in the middle of June 1957. The analysis of samples showed that phytoplankton was poorer both as to quantity and quality in the first year of investigation when compared with the following year. In 1956 *Dinobryon divergens, Eudorina elegans, Volvox aureus, Pediastrum Boryanum, P. duplex, Ceratium hirundinella, Micrasterias americana* were classified as characteristic species.

In spite of fertilization the compound quotient shows weak eutrophy which is in accordance with the chemical spectra.

Wyszni IV. In 1956 not fertilized, in the next year fertilized with superphosphate at 35 kg/ha P_2O_5 (1 dose) and ammonium sulphate at 30 kg/ha N (10 equal doses every 10 days); it gets water from Wyszni VI. The chemical spectra show an average state of pH, PO_4, Fe, and K_2O, oxydability and a low state of other components.

In the pond Wyszni IV 90 species were determined. With regard to quality green algae took the first place, and the most numerous species were from the genus *Pediastrum*. However *Volvox globator* appeared in large quantities in the second half of July 1957. Other green algae such as *Volvox aureus* and *Eudorina elegans* appeared fairly numerously in some samples from both investigated years. *Dinobryon divergens* of *Chrysophyceae* appeared in large quantities at the beginning of September 1956, and near the end of this month the next year it formed a water bloom. Fairly numerous were *Ceratium hirundinella* and *Gloeotrichia echinulata* at certain times. In general the phytoplankton of this pond was much richer in 1957. Among characteristic species i. e. observed in more than 50% of samples, were in 1956: *Pediastrum duplex, Scenedesmus quadricauda;* in 1957: *Eudorina elegans, Pediastrum duplex, Scenedesmus quadricauda, Ceratium hirundinella, Staurastrum tetracerum.*

The compound quotient shows weak eutrophy, in agreement with the chemical spectra.

Wyszni VI. Not fertilized in either year, it gets water from the Wyszni VII pond, which was fertilized.

Chemical data for this pond show an average state of such components as pH, $CaCO_3$, K_2O and a low state of the remaining ones.

In this pond 90 species were determined. In the first year of investigation only *Asterionella formosa* and *Volvox aureus* were more numerous. But in the next year water blooms were observed more often here than in the other ponds. Thus *Anabaena flos aquae* formed a water bloom near the end of July; at the beginning of August it was still observed in large quantities, but later decreased in quantity. *Dinobryon divergens* caused a water bloom in the first half of August; in the next samples it was low but at the end of September again appeared in large quantities. *Ceratium hirundinella* caused only a short lasting water bloom at the end of August. Characteristic species in 1956 were *Dinobryon divergens, Pediastrum duplex,* and in 1957 *Merismopedia punctata, Eudorina elegans, Pediastrum Boryanum, P. duplex* and *Ceratium hirundinella.*

The compound quotient shows weak eutrophy which is in accordance with the chemical spectra. Although *Anabaena* appeared in this pond in mass in 1957, nevertheless a numerous appearance of other species characteristic for poor waters in later samples was marked in the weak eutrophy of this pond both in the first and second year of investigation.

Wyszni VII. In both years fertilized with superphosphate at 35 kg/ha P_2O_5; it gets water directly from the mill stream.

In this pond practically all components appeared in small amounts with the exception of pH, $CaCO_3$, NO_3, K_2O.

Phytoplankton from May and June was poor except *Spirogyra* sp. and

Dinobryon divergens which appeared numerously in the first year of investigation, and *Spirogyra* sp. and *Zygnema* sp. in the next. 79 species were determined. In July an increase in quality and quantity of plankton was observed when in 1957 near the end of this month there appeared a water bloom of *Anabaena flos aquae*, remaining till the beginning of August, with fairly large quantities of *Microcystis aeruginosa* and smaller quantities of *Merismopedia punctata* and *M. major* which were observed till the end of the investigation. In later samples in the first year only two species of green algae appeared in large quantities i. e. *Volvox aureus* (6 September) and *Eudorina elegans* (5 October) and in the next year *Dinobryon divergens* (12 August). In this pond blue-green algae were the most numerous, then green algae, among which *Pediastrum duplex* appeared in all the samples. As characteristic species i. e. appearing in more than 50% samples in 1956, were observed *Pediastrum Boryanum*, *P. duplex*, *Scenedesmus quadricauda*, *Staurastrum tetracerum*, and in 1957: *Volvox aureus*, *Pediastrum Boryanum*, *P. duplex*, *Scenedesmus quadricauda*, *Merismopedia major*, *Ophiocytium capitatum*.

Independently of the most numerous appearance of blue-green algae in 1957 compared with other groups the values of the quotients for this pond in both years are similar and prove its weak eutrophy in the mixotrophic phase in accordance with the chemical spectra.

Wyszni VIII. Not fertilized either year, it gets water directly from the mill stream.

Chemical components show average quantities of NO_3, O_2, K_2O for both years and an average state of pH in 1958, high in the next year.

In 1956 in the pond Wyszni VIII phytoplankton was represented by only a few forms, mostly of diatoms and green algae till the middle of June. Only towards the end of June *Dinobryon divergens* appeared in mass which was again formed in small quantities towards the end of July continuing numerously till almost the end of the season. The following year the phytoplankton was similar in quality composition. Throughout the whole period of investigation a greater appearance of plankton species was not observed; only *Dinobryon divergens* was fairly numerous at the beginning of July and *Pediastrum duplex* at the beginning of August when the development of other species from the green algae group also occurs. Altogether 74 species were determined. Among the characteristic species for this pond i. e. observed in more than 50% of samples, were in 1956: *Pediastrum duplex*, *Ceratium hirundinella*, *Spirogyra* sp., and in 1957 *Asterionella formosa*, *Cymbella* sp., *Navicula* sp., *Surirella* sp., *Pediastrum duplex*, *Scenedesmus quadricauda*, *Ceratium hirundinella*.

The compound quotient in 1956 was 8.66, i. e. it was within the limits of eutrophy; in 1957 it had a value of 3.22, thus showing moderate

eutrophy. This quotient is not in accordance with the chemical data. It can be explained by greater development of algae of the order of *Chlorococcales* — probably under the influence of the constant supply of nitrates by the mill stream feeding the pond.

Baginiec II. In 1956 fertilized with superphosphate at 35 kg/ha P_2O_5; in 1957 not fertilized, it gets water from the pond Wyszni I.

Chemical data for this pond in 1956 show average values of pH, NO_3, K_2O, oxydisability and a large K_2O.

This pond in comparison with others showed a great variety of species. It should be noted that besides green algae (chiefly *Conjugatae*) euglenines played an important part. 98 species were determined. In both years a distinct increase in the quality composition of species was observed chiefly in August. Species appearing in fairly large quantities periodically in 1956 were *Anabaena flos aquae, Volvox aureus* and *Dinobryon divergens,* and in the next year *Volvox aureus* and *Dinobryon divergens* forming a water bloom of short duration (3 June) with accompanying *Dinobryon bavaricum.* Characteristic species in 1956 were: *Phacus longicauda, Trachelomonas volvocina, Euglena spirogyra, E. acus, Eudorina elegans, Volvox aureus, Pediastrum Boryanum, P. biradiatum, P. duplex, P. tetras, Peridinium cinctum, Synura uvella, Euastrum verrucosum* var. *alatum, Cosmarium protractum, C. subcrenatum, C. tetraophtalmum, Closterium venus, Cl. parvulum, Staurastrum polymorphum.*

Low compound quotient in both years (1.35 and 1.62) show weak eutrophy which is in accordance with the chemical spectra. The low values of the quotients in both years were the result of the wealth of species of the group of desmids with a strong development of euglenines and chrysophytes. The authors quoted consider them, beside other groups, as typical for poor water.

Lipowy. For many years not fertilized, fed with water from the pond Wyszni V.

Similarly to Baginiec II it had a great variety of green algae especially *Conjugatae.* Quantity was poor till the end of July; in the later period in 1956 there was a definite increase in certain species only (*Synura uvella, Dinobryon divergens, Spirogyra* sp.). In 1957 *Dinobryon divergens* appeared very numerously in this pond. 92 species were determined. Among them the following characteristic species were observed i. e. found in more than 50% of samples, in 1956: *Pediastrum Boryanum, P. duplex, Spirogyra* sp.; in 1957 — *Dinobryon divergens, Eudorina elegans, Pediastrum Boryanum, P. duplex, Scenedesmus quadricauda, S. acuminatus, Xanthidium antilopaeum, Cosmarium granatum, C subtumidum.*

The degree of trophism of this pond is the nearest to that described for the pond Baginiec II. Because of the large amount of the desmids

species the values of quotient are low and in two cases close to acidotrophy.

General characteristic of the phytoplankton

The composition of the phytoplankton of the investigated ponds is given on Table IV. Altogether 134 forms were determined, that is 112 for species and 22 for genus. Among them were 41 species appearing regularly in particular ponds in two years. These species should be considered as characteristic for the given group of ponds. Of them only one, *Pediastrum duplex*, maintained continuity of appearance in all the ponds except one, Wyszni I in 1956, when it was observed as fairly numerous but not in all samples. Taking into consideration the appearance of particular species in the samples we can distinguish the following groups:

1. species characteristic for ponds, observed in 50 — 100% of samples — there were 41.
2. species observed in less than 50% of samples — there were 93.

Species found in all the ponds are the following: *Ceratium hirundinella, Dinobryon divergens, Asterionella formosa, Eudorina elegans, Volvox aureus, Pediastrum Boryanum, P. duplex, Scenedesmus quadricauda.* Baginiec II and Lipowy are among ponds exceptionally rich in species (up to 100); Wyszni IV, VI and VII are very rich (75 — 90), Wyszni I and VIII are average rich (50 — 75).

In general we may say that the phytoplankton of the investigated ponds was characterized by the special development of three groups of algae — *Chlorophyta, Chrysophyta* and *Cyanophyta.* The first were represented by the most numerous species; among them were determined 76 species and 8 genera. The following appeared most numerously and most frequently: *Volvox aureus, Ankistrodesmus falcatus, Eudorina elegans, Pediastrum duplex, P. Boryanum, Scenedesmus quadricauda,* the two first causing water blooms in the ponds Wyszni I and II. This group appeared most numerously in the pond Wyszni VIII (chiefly chlorococcous algae) and in the ponds Baginiec II and Lipowy with a preponderance of *Desmidiaceae* with such species as *Staurastrum tetracerum, Euastrum verrucosum* var. *alatum, Cosmarium protractum* and *Conjugatae* (*Spirogyra* sp.). The next group in order of number of species were *Chrysophyta.* Among them *Bacillariophyceae* appeared most numerously in Wyszni I; there were determined 7 species and 9 genera. The most numerous were *Asterionella formosa, Fragilaria crotonensis, Tabellaria flocculosa,* the first one causing a water bloom in the pond Wyszni VI in 1957. *Chrysophyceae,* of which only 6 forms were determined, were

Tabl. IV

List of species occuring in the ponds

Explanation of signs:
+ — very seldom, the given organism does not appear in every preparation
1 — singly, 1—6 specimens of the given organism appear in each preparation
2 — little, 7—16 specimens of the given organism appear in each preparation
3 — medium, 17—30 specimens of the given organism appear in each preparation
4 — much, 31—50 specimens of the given organism appear in each preparation
5 — very much, dominates absolutely and appears in quantities of more than 50 specimens

Name of species	Wyszni I		Wyszni II		Wyszni IV		Wyszni VI		Wyszni VII		Wyszni VIII		Baginiec II		Lipowy	
	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957
Microcystis aeruginosa Kütz.			+−1	+−1	+	+−2	+	1−2	+	+−3		+			+	
Aphanothece clathrata W. et G. S. West			+	1−3												
Merismopedia punctata Meyen	+		+	+−1	+−1	+−2	+−1	+−1	+−1	+−2	+	+		+	+	+−1
— *glauca* (Ehr.) Näg.													+	+	+	+
— *major* (Smith) Geitler			+	+−1	+	1	+	+−2	+−1	+−2		+			+−1	
Oscillatoria sp.						1						+				
Spirulina major Kütz.			1		+						+				+	
Aphanizomenon flos aquae (L.) Ralfs			+	+−1	+	1−2		+−1	+	+−2	+			+	+	1
Anabaena spiroides Klebahn		+			1						+			+		
— *flos aquae* (Lyngb.) Bréb.		+	+−1	+−2	+−1	+−1	+	+−5	+	1−5	+	1	+−4	+	+	+
Nostoc sp.			4	+−2									+		+	1
Gloeotrichia echinulata (J. E. Smith) P. Richter		1		1	+−1	1−3	+	+−2	+	+−2			+	+	+−1	1
Euglena spirogyra Ehr.				+	+	+−1	+	1	+		+		+	+−1		
— *acus* Ehr.		1			+−2	+−2	+	+					+−1	+−2		+
— *proxima* Dangeard													+	+−1	+	
— *tripteris* (Duj.) Klebs		+			+	1								+		
Phacus pleuronectes (O.F.M.) Duj.	1	+		+	1	+−1		+	+	+	+		+−1	1−2	+	+
— *longicauda* (Ehr.) Duj.		+−1			1	+−1				+		+	+−1	+−2	+	+
— *sp.*										+		+		+		

Trachelomonas volvocina Ehr.	+		+	+	+	1–2	1	1	+	1		+	+–1	+–2	+	+–1
— *hispida* (Perty) Stein		+–1	+	+	+	+–1	1	+	+	1	+		+	1–2	+	+
— *armata* (E.) Stein					+			+					+	+		
— sp.				+									+	+		+
Lepocinclis ovum (Ehr.) Lemm.														+–1		
— *fusiformis* (Carter) Lemm.													+	+–1		
Peridinium cinctum (Müller) Ehr.	+			+	+		+	+		+	+	+	+–1	+–1	+	
Ceratium hirundinella (O. F. Müller) Schrank	+	+–2	+	+–1	3	+–4	+–2	+–5	+	+–1	+	+–2	+	+–1	+–1	1
— *cornutum* (E.) Clap. et Lachm.	+										+	+–2		+–1	+	
Ophiocytium capitatum Wolle			+	+–1	+–1	+–1	+	+–1	+	+–2	+		+	+	+	+–1
Mallomonas caudata Iwanoff					+	1	+–2	+–2	+–1	+–1	+		1	+	+	
— sp.						+	1	+								
Synura uvella Ehr.	1		+–2	+	+	+–2	+–1	+–2	+–2	+–1	+	+–1	+–2	+–2	1–3	+–2
Dinobryon bavaricum Imhof					+–1	+	+	1	+–1		+–2		1	3	+	
— *divergens* Imhof	+–2	+	+–2	+–1	+–4	+–5	+–2	1–5	+–3	1–4	+–5	+–3	+–3	+–5	+–3	+–4
Melosira granulata Ralfs	+	+				+	+	+–1	+	+			+	+	+–1	+
Tabellaria fenestrata (Lyngb.) Kütz.		1		+							+	2				
— *flocculosa* (Roth) Kütz.		1	+	+–1		+–1	+	+	+	1	+	+–1	+–2	+–1	+	+–1
Fragilaria crotonensis Kitt.	+–2	+–1	+	+–1		+	+	+	+	+–1	+–2	+–1	+–1	+	+	+
— sp.	1	+	+													
Synedra acus Kütz.	+–1	+–2						1	+	2		+		1		
— sp.	+				+	+	+			+	+–1	+–1				+
Asterionella formosa Hass.	3	+–1	+	+–2	+–1	+–1	+–4	+–5	+–1	+–1	+	+–2	+–1	+–1	+	+–2
Navicula sp.	+–1	+	+	+	+	+–1	+–1	+	+–1	+–1	+	+–1		1	+	+
Pinnularia Debesi Hust.	+–2	+	+	+		1		+			+–1	+			+	+–1
Gyrosigma sp.						+						+				
Cymbella sp.		+–1		+		+		+			+	+–2				+
Gomphonema sp.						+						+				
Nitzschia sp.	+					+										
Cymatopleura sp.	+–1	+						+			+	+				+
Surirella sp.	+	+–1		+–1		+		1		+–1		+–1				+

Tab. IV (c. d.)

Name of species	Wyszni I		Wyszni II		Wyszni IV		Wyszni VI		Wyszni VII		Wyszni VIII		Baginiec II		Lipowy	
	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957
Eudorina elegans Ehr.	+–2	+–1	+–4	+–3	1–3	+–3	+–1	+–1	+–4	+–1	+	+–1	+–2	1–2	+–2	+–2
Volvox globator Linnaeus			+	+–4	+	1–4		1	+	+–2			+	+		
— *aureus* Ehr.	+	+–5	+–4	+–5	+–3	+–1	+–3	+–3	+–4	1–2	+–2	+–1	+–3	+–4	+	+–1
Characium gracilipes Lambert			+	+–3				+–1	+	+–2						
Tetraëdron trigonum (Näg.) Hansg.		+				1	1	+–1	+	1			+	+		
— *caudatum* (Corda) Hansg.							1	+								
— *regulare* Kütz.						+–1	1	1								
— *minimum* (A. Braun) Hansg.			+		+	+–1	+	+–1		+		1		+	+	1
— *hastatum* (Reinsch) Hansg.													+	+		
Botryococcus Braunii Kütz.		+	+								+–1	+–2	+	+		1
Selenastrum gracile Reinsch	+		+				+				+		+	+		
Ankistrodesmus spiralis (Turner) Lemm.			+				+				+			+		
— *fusiformis* Corda	1–2	+	+	1	+–2	1	+	+	+–1		+		1–2	+–1	+	+–1
— *falcatus* (Corda) Ralfs	+–2	+	+–1	+–5	+–1	+–1	+–1	+	+–1	+–1	+–1	+	+–1	1	+	+–1
Dictyosphaerium pulchellum Wood		+		+		+				+	+	+–2				
Pediastrum tetras (Ehr.) Ralfs	+	+–1	+	+–1	+	+–1	+–1	1	+	+–1		+–1	+–1	+–1		
— *Boryanum* (Turp.) Menegh.	+	+–2	+	1	+–1	+–1	+–1	+–1	+–1	+–2	+	1	+–1	+–1	+–1	+–2
— *araneosum* (Racib.) G .M. Smith													+	+	+	+
— *biradiatum* Meyen					+–1	+–1	+	+–1		1		1	+–1	+–1	+–1	1
— *duplex* Meyen	+–1	+–2	+–1	+–1	+–1	+–2	+–1	+–2	+–1	+–2	+–1	+–3	+–2	+–2	+–2	+–2
— *var. reticulatum* Lagerh.	+	1	+	+–1	+	+–1	+–1	+–1	+–1	+–1	+	+–2	+–1	+–2	+	+
— *duplex* Meyen var. *cornutum* Racib.											+		+	+	+	+–1
Scenedesmus dimorphus (Turp.) Kütz.			+	+												
— *acuminatus* (Lagerh.) Chodat.			+	+–1	+–1	+–1	+–1	+–1	+	+	+	1	+–1	+	+	+–1
— *antennatus* Bréb.							1	+–1		+		1	+	+	+	+
— *arcuatus* Lemm.				+		1	+	1	+	+–1		+	+	+–1		+

— *bijuga* (Turp.) Lagerh.				+		+	+						+	+		1		
— *serratus* (Corda) Bohlin						1		1		1				+				
— *armatus* Chodat							1		+	+−1								
— *rostrato-spinosus* Chodat								+					+	+				
— *Westii* (G. M. Smith) Chodat				+		+	+	+−1	+−1	+−1		+	+	+−1	+	1		
— *longus* Meyen var. *Nägelii* (Brèb.) G. M. Smith							+			+−2	+	1						
— *quadricauda* Chodat	+−1	+−1	+	+−1	+	+−1	+−2	+−1	+−1	+−2	+−1	+−2	+−2	+−2	+−1	+−2		
— sp.	+				+	+	+	+	+	+	+	+	+			+		
Crucigenia minima Brunnthaler	+		+			+−1					+	+	+−1	+	+			
— *tetrapedia* (Kirch.) W. West					+			+−1	+			+−1	+−1	+				
— *apiculata* (Lemm.) Schmidle											+	+		+				
— *rectangularis* (A. Braun) Gay						+−1		+−1		1				+		1		
— sp.			+		+													
Coelastrum microporum Näg.					+	+−1		+−1		1	+	+−1						
— *proboscideum* Bohlin						1			+	+		1						
— *cambricum* Archer				+	+	+					+							
— sp.			+		+	+												
Sphaerocystis Schroeteri Chodat		+−1	+−1	+−2	+−1	1		+		1				+	+	+−1		
Spirogyra sp.	2	+	+	+		+−1	1	+	3	+−3	+−2	+−1			+−3	+−1		
Zygnema sp.									+	1−3					+−2	+−1		
Closterium acerosum (Schrank) Ehr.		+		+		+							+	+	+	+		
— *Ehrenbergii* Menegh.	+−2	+		+−1		+				1				+		+		
— *moniliferum* (Bory) Ehr.													+−1	+−1	+	+		
— *venus* Kütz.			+	+−1		+				+−1			+	+−1	+−1	+		
— *parvulum* Näg.													+	+	+	+		
— sp.	+	1	+	+		+	+	+−1	+−1	+		+	+	+		+−1		
Pleurotaenium trabecula (Ehr.) Näg.				+				+		+				+		+		
Arthrodesmus incus (Brèb.) Hass.	+					+		1					+	+		1		
— *convergens* Ehr.													+−1	+	+	+		
Xanthidium antilopaeum (Brèb.) Kütz.							1	+					+	+	+−1	+−1		
Staurastrum dilatatum Ehr.				+	+	+		+		+			+	+	+			

Tab. IV (c. d.)

Name of species	Wyszni I		Wyszni II		Wyszni IV		Wyszni VI		Wyszni VII		Wyszni VIII		Baginiec II		Lipowy	
	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957
Stanastrum pilosum (Näg.) Arch.							+						+		+	+
— *gracile* Ralfs			+−1	1		1		+								
— *tetracerum* Ralfs			+	+−1	+	+−1	+	+−1	+−1	+−1		1		+−1	+	+−1
— *polymorphum* Brèb.											+	+	+	+−1	+	+−1
— sp.		+	+	+−1	+	+−1	+	+−1	1	+−1	+	+	+	+		+
Euastrum oblongum (Grev.) Ralfs										+					+	+
— *bidentatum* Näg.							+	+					+	+	+−1	+−1
— *dubium* Näg.					+	+										
— *elegans* (Brèb.) Kütz.												+	+			+
— *germanicum* (Schm.) Krieger			+				+	+	+	+−1	+			+		+
— *verrucosum* Ehr. var. alatum Wolle	+	+	+−1	+−2	+	+−1	+−1	+−1	+	+−1		+−1	+	+	+	+−1
— *insulare* (Wittr.) Roy				+		+	+	+		+					+	+−1
Micrasterias americana (Ehr.) Ralfs			+	+−2	+		1		+	1			+		+	+
— *Mahabuleshwarensis* Hobson var. *Walichii* (Grun.) West and West				+			+−1		+	+					+	
Cosmarium granatum Brèb.				+−1	+	+−1	+	1		1			+	+	+	+−1
— *subtumidum* Nordst.				+			+	1	+−1	+			+−1	+	+−1	+−1
— *obtusatum* Schmidle						1		1					+	+	+	
— *Meneghinii* Brèb.							+−1						+	+	+−1	+
— *Portianum* Arch.													+	+		+
— *protractum* (Näg.) de Bary	+	+−1	+−1	+−1	+−1	+−1		+−1	+	+−1		+	+−1	+−1	+	+−1
— *Turpinii* Brèb.				1	+	+−1	1			+−1			+	+	+	+
— *subcrenatum* Hantzsch.		+	+	1	+	+−1		+		+−1		+−1	+−1	+−1	+	+
— *subprotumidum* Nordst.				+		1		1					+−1	+	+	+
— *tetraophtalmum* Brèb.				+−1	+	+−1	+	+−1		+			+−1	+−1	+	+
— *Botrytis Menegh.*		1											+	+−1	+	
— *Quadrum* Lund.				+		1		1	1	1						
— sp.			+			+	+	+		+		1	+	+		

most numerous in the ponds Wyszni IV, Wyszni VI, Wyszni VIII and Baginiec II. Another important component of the phytoplankton of the investigated ponds were *Cyanophyta* (10 species, 2 genera) appearing most numerously in the ponds Wyszni VII and II. Such species as *Anabaena flos aquae, Microcystis aeruginosa, Merismopedia punctata, Aphanizomenon flos aquae* should also be mentioned, the first of which caused water blooms in the ponds Wyszni VI and VII in 1957. The remaining groups *(Euglenophyceae, Dinophyceae)* took a secondary place. The former appeared more numerously in the ponds Baginiec II and Wyszni IV, chiefly *Euglena acus*. The latter were numerously represented by the species *Ceratium hirundinella,* found in all the ponds.

Discussion of results

The classification of ponds with regard to trophism was based above all on the Nygaard compound quotient besides the chemical spectra carried out according to the formula of Stangenberg. Chemical analyses showed in general an average state of trophism of the water in the investigated ponds. The compound quotient generally coincided with the chemical spectra with the exception of the pond Wyszni VIII which had a comparatively high quotient and low chemical spectra. Good results were also obtained from the Thunmark chlorophycean quotient.

During the investigation the mineral fertilization of ponds did not affect particularly the character of the plankton or the indicators of trophism (the Nygaard compound quotient and the Thunmark chlorophycean quotient). Thus for instance the pond Wyszni VIII, which was not fertilized, showed eutrophy in the mixotrophic phase (mesotrophy) when the pond Wyszni VI, which was used for control, similarly as the fertilized ponds (Wyszni I, II, IV and VII) showed weak eutrophy in the mixotrophic phase. Baginiec II (fertilized) and Lipowy (not fertilized) were the poorest of the investigated ponds and with a tendency rather towards oligotrophy. It should be stressed that blue-green algae appeared more numerously in the ponds with a lower degree of trophism (pond Wyszni VII) than the most fertile pond (Wyszni VIII) which would be contrary to the observation of Wunder (1935) reckoning blue-green algae *(Anabaena, Aphanizomenon)* as typical for the most eutrophic waters. A larger or smaller appearance of species from the group of desmids had a decisive effect on the values of some Nygaard quotients.

The question should be asked as to what degree the Nygaard quotients may be useful in the determination of the trophism of water.

It seems that above all the compound and chlorophycean quotients may be successfully used for this purpose as they give the values most in accordance with the chemical spectra. Thus in spite of considerable variability in the species composition of the phytoplankton of ponds, it may be used for at least orientation characterization of the trophism of water. A closer sociological analysis of the plankton communities will certainly enlarge the data on their connection with the fertility of the water of ponds.

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STRESZCZENIE

Praca dotyczy badań fitoplanktonu, prowadzonych w latach 1956 i 1957 w 8 stawach Doświadczalnego Gospodarstwa Stawowego Zakładu Biologii Wód PAN w Gołyszu (powiat Cieszyn) oraz oceny stanu troficzności tego zbiorowiska w oparciu o jego właściwości biocenotyczne i chemiczne.

Zbierane zazwyczaj co dwa tygodnie próby opracowano pod względem jakościowym i ilościowym, stosując metodę szacunkową (Starmach 1954). Ogółem oznaczono 112 gatunków i 22 rodzajów (Tab. IV). W rozwoju fitoplanktonu wyodrębniono szczególnie 3 grupy: *Chlorophyta, Chrysophyta* i *Cyanophyta*. Pierwsza była reprezentowana najliczniej w stawie Wyszni VIII, zwłaszcza glony chlorococcowe (*Pediastrum* sp. div., *Scenedesmus* sp. div.) oraz w Bagińcu II i Lipowym głównie *Conjugatae (Staurastrum tetracerum, Euastrum verrucosum* var. *alatum, Cosmarium protractum, Spirogyra* sp., *Zygnema* sp.). Z *Chrysophyta, Bacillariophyceae* najobficiej wystąpiły w stawie Wyszni I *(Asterionella formosa, Fragilaria crotonensis)* zaś *Chrysophyceae* w Wyszni IV i Wyszni VI *(Dinobryon divergens, Synura uvella)*. *Cyanophyta* najliczniej były notowane w stawach Wyszni VII i Wyszni II, wśród nich głównie *Anabaena flos aquae, Microcystis aeruginosa, Aphanizomenon flos aquae*.

W obrębie występujących gatunków wyróżniono dwie grupy: gatunki spotykane w 50 — 100% prób z poszczególnych stawów (41 gatunków) oraz znajdowane w mniej niż 50% prób (93 gatunków). Pierwsze uznano za charakterystyczne dla danego stawu. Wśród nich jedynie *Pediastrum duplex* występował we wszystkich stawach przez cały okres dwuletnich badań, z wyjątkiem stawu Wyszni I w 1956 r., w którym notowany był dosyć licznie, jednak nie we wszystkich próbach. Niektóre gatunki tworzyły w pewnych okresach zakwity: *Volvox aureus* (w stawie Wyszni I), *Ankistrodesmus falcatus* (Wyszni II), *Dinobryon divergens* (Wyszni IV, VI, VIII, Baginiec II), *Anabaena flos aquae* (Wyszni VI, VII). Gatunkami powtarzającymi się

we wszystkich stawach były: *Ceratium hirundinella, Dinobryon divergens, Asterionella formosa, Eudorina elegans, Volvox aureus, Pediastrum Boryanum, P. duplex, Scenedesmus quadricauda.* Spośród omawianych stawów Baginiec II i Lipowy odznaczały się największą rozmaitością gatunków zielenic (zwłaszcza z *Conjugatae*); zaliczono je do szczególnie bogatych w gatunki (mniej niż 100), zaś do bardzo bogatych (75 — 90) stawy Wyszni II, IV, VI, VII, a do średnio bogatych (50 — 75) stawy Wyszni I i VIII.

Ogólnie fitoplankton badanych stawów był niejednolity i reprezentujące go grupy w zależności od swego składu ilościowego charakteryzowały nieźle troficzność.

Stopień troficzności badanych stawów określano głównie przy pomocy współczynnika złożonego Nygaarda (1949) i zielenicowego Thunmarka (1945) oraz danych chemicznych, zestawionych według wzoru Stangenberga (1936, 1938) (Fig. 1). Na ogół analizy chemiczne wskazywały na średni stan troficzności i w zasadzie pokrywały się z wartościami współczynników, z wyjątkiem stawu Wyszni VIII, dla którego zanotowano wysokie współczynniki, przy niskich spektrach chemicznych. Staw ten wykazywał eutrofię w fazie miksotroficznej (mesotrofia). Staw Wyszni VI (kontrolny) podobnie jak stawy nawożone (Wyszni I, II, IV i VII) słabą eutrofię w fazie miksotroficznej. Baginiec II (nawożony) i Lipowy (nie nawożony) były najuboższe i zbliżone raczej do oligotrofii. Warto zaznaczyć, że na wartości współczynnika złożonego wpływał w dużej mierze większy lub mniejszy udział gatunków z grupy desmidii, podczas gdy sinice (*Anabaena, Aphanizomenon*), uważane przez niektórych autorów (Wunder 1935) za typowe dla wód eutroficznych, notowano liczniej w stawach o niższym stopniu troficzności. W wyniku badań stwierdzono również, że mineralne nawożenie nie wpłynęło wyraźnie na charakter planktonu i stan troficzności. Badania wykazały, że dla określenia stopnia troficzności najdogodniejsze jest użycie współczynnika złożonego Nygaarda i zielenicowego Thunmarka; dają one najbardziej zgodne wartości ze spektrami chemicznymi, mogą więc być wyzyskane do przynajmniej orientacyjnej oceny troficzności wody.

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