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Mikrofity porośłowe w stawie zanieczyszczonym ściekami cukrowniczymi

Epiphytic microphytes in a pond polluted with beet sugar factory wastes

Mémoire présenté le 10 avril 1972 dans la séance de la Commission Biologique de l'Académie Polonaise des Sciences, Cracovie

Abstract — The present paper concerns observations (made from April to September 1967) of the development of epihytic microphytes on a synthetic medium (bunches of cellophane strips) in a pond filled with undiluted beet sugar factory wastes. The results of investigations showed full mineralization of waste waters within 8 months from the moment of releasing the waste waters into the pond; individual stages of self-purification were characterized by a different composition of periphyton and different number of particular taxons. This corresponded with biochemical changes recorded parallelly in the examined pond.

Observations of the development of epiphytes were carried out on a specially prepared synthetic medium in the pond Polny III in the pond complex on the Mnich (Experimental Fishery Farms of the Laboratory of Water Biology of the Polish Academy of Sciences at Gołysz, district Cieszyn). The pond, 9 ha in area and 1 m average depth, was filled with undiluted beet sugar factory wastes in the time period from 1. XII. 1966 to 10. I. 1967. Full information is given by: Grabacka (1973), Kyselowa (1973), Lewkowicz (1973), and Zięba (1973).

The work was carried out in the Department of Hydrobiology of the Jagiellonian University and directed by Prof. Karol Starmach.

Method of investigation

For observations of the development of epiphytes an artificial synthetic medium was used in the form of bunches of narrow strips of cellophane 15 cm long and 1 mm wide. On 4th April a number of these bunches were hung at a depth of 30 cm in two points in the middle of the pond. Every month, till the end of September 1967 2 strips were taken for investigation from each sampling point and replaced by new ones.

In order to illustrate the intensity of development of the epiphytes during the course of self-purification, a six stage scale was introduced adopting the numerical force in percentage of the occurring organisms: 5 = 75—100 per cent, 4 = 50—75 per cent, 3 = 25—50 per cent, 2 $<$ 25 per cent, 1 $\approx$ 5 per cent, + sporadic.

Quantitative composition of the epiphytes

In the collected material 62 systemic units were determined: *Bacteriophyta, Cyanophyta, Euglenophyta, Chrysophyta, Chlorophyta,* and *Protozoa* (Table I). From this number only 22 units had been previously recorded from the territory of the Experimental Farms of the Polish Academy of Sciences (PAN) and from the reservoir in Goczałkowice (Siemińska, Siemińska 1967). This relatively great amount of newly species may be explained by the fact that the hitherto carried out investigations on periphyton development (Mrozińska 1958) were performed in a normally exploited carp pond by means of another sampling method.

The following species were predominant in the examined material: diatoms (25 species) dominated over green algae (17 species) and blue-green algae (13 species); the other 3 types being present in much smaller amounts.

Changes in the development of epiphytic communities

In the course of the first two months (4th April—7th June) after the beet sugar factory wastes had been released into the pond, the water in the pond was navy blue and had a putrid smell. The periphyton was poorly developed and covered only a part of the cellophane strips. Only 7 and 15 sparsely occurring microphytes were distinguished after the first and second months respectively (Table I). *Sarcina paludosa* and *Euglena viridis*, found here, are typical polysaprobs; *Oscillatoria neglecta* lives in waters with a high content of sulphurated hydrogen and *Isocystis* and *Spirulina* are commonly in polluted waters (Liebman 1951, Haluška 1956).

The occurring organisms and the exceptionally high BOD_5 (especially in the first month), the absence of oxygen dissolved in the water (fig. 1 a, b) and the presence of considerable amounts of sulphurated hydrogen all

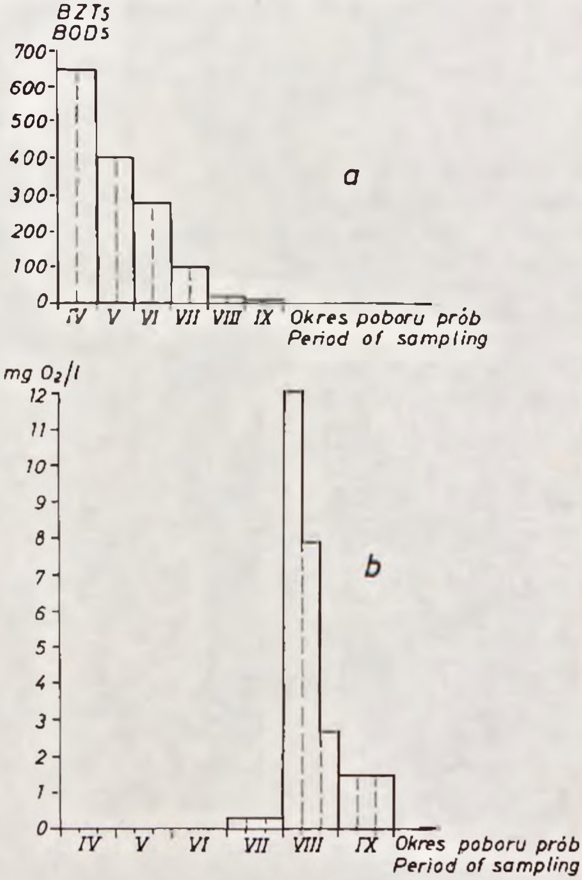
Tabela I. Zmiany ilościowe w składzie porośli oznaczonych w stawie Polny III w roku 1967

Table I. Quantitative changes in periphyton composition determined in the pond Polny III in 1967

Taxony - Taxons	Data poboru - Date of sampling					
	9.V.	7.VI.	26.VI.	26.VII.	31.VII.	30.IX.
B a c t e r i o p h y t a						
Sarcina paludosa Schroeter	1					
C y a n o p h y t a						
Anabaena oscillarioides Bory			+	1		
Anabaena sp.			+	1		
Chlorogloea microcystoides (Geitler)			+	+		
Gloeocapsa turgida Ktz.				1		
Isocystis infusionum Ktz.	+	2				
Oscillatoria irrigua Ktz. Gomont			+	2		
- neglecta (Lemmermann)	1	2				
- pseudogeminata Schmid			+	3	1	
- subbrevis (Schmidle) Claus				2		
- tenuis (Agardh)			2	1		
Rhabdoderma lineare (Schmidle) Lauterborn				1		
Pleurocapsa sp.		1	3	2		
Spirulina subtilissima Ktz.	1	2	+			
E u g l e n o p h y t a						
Euglena acus (Ehrenb.)			1	2		
- viridis (Ehrenb.)	+	+	+			
Phacus orbicularis v. caudatus (Skvor.)			+			
Trachelomonas volvocina (Ehrenb.)				1		
C h r y s o p h y t a						
Xanthophyceae						
Characiopsis longipes (Rab.) Borzi				2		
Bacillariophyceae						
Achnanthes lanceolata v. eliptica Cl.			+			
Caloneis silicula Ehr.		+				
Ceratoneis arcus Ktz.		2				
Cyclotella operculata Ag. Ktz.			1	1		
Cymbella ventricosa Ktz.			1	2		
Eunotia lunaris (Ehr.)		3	3	1		
Fragilaria intermedia Ktz.		2				
Gomphonema acuminatum v. coronatum Must.			+			
- parvulum (Ktz.) Grun.					3	1
- parvulum v. lagenulum (Ktz. Grun.)					5	3
- parvulum v. micropus (Ktz.) Cl.					4	2
- parvulum v. subelipticum Cl.					3	2
Navicula cryptocephala Ktz.		2	3	2		
- cryptocephala v. exilis Ktz.		2	2	1		
- gracilis (Ehr.)			1	+		
Nitzschia acicularis (W.Sm.)			1	1		
- palea Ktz.	2	3	3	4	5	3
- paleacea (Grun.)			1	1	+	
Pinnularia mesolepta f. angustata Cl.		+	1			
- molaris Grun.			2	1		
- obscura (Kraske) Cl.			2	1		
- viridis v. fallax (Nitzsch) Cl.		1	1			
Stauroneis phoenicentron (Ehr.)		+	+			
Surirella ovata (Ktz.)				+		
Synedra minuscula (Grun.)	+					
C h l o r o p h y t a						
Volvocales						
Protococcus viridis Ag.			1	1		
Chlorococcales						
Ankistrodesmus falcatus (Ralfs. Corda)				2	1	
Chytridiochloris acus Ettl.				5	1	
Koliella spiculiformis (Visch.) Hind.				1	1	
Lagerheimia ciliata v. minor Smidt.				1		
Scenedesmus acuminatus v. minor Smidt.				3		
- arcuatus (Lemmermann)				1		
- bijuga Turp.				2		
- bijuga v. irregularis Wille Smidt				2		
- acutus Meyen			2	3	2	
- quadricauda (Turp.)			1	2	1	
- quadricauda v. longispina (Chod.)			+	1		
- quadricauda v. Westii (Smith.)				1		
Tetraedron trigonum (Naeg.)				+		
Ulotrichales						
Microspora quadrata (Hazen)				1		
Chaetophorales						
Stigeoclonium polymorphum (Haering, Franke)					5	2
- tenue Ktz.					5	2
P r o t o z o a						
Vorticella microstoma (Ehr.)	+	+	1	2	1	+

indicate the existence of a gradually decreasing polysaproby phase in the pond during this period of time.

During June the colour of the water in the pond changed to rusty-red and the putrid smell was not so strong. By the end of the month the periphyton composition was much more varied (30 taxons). Some species



Ryc. 1. Chemizm wody wg Lewkowicza (1973), a — wartość BZT_5, b — ilość tlenu rozpuszczonego

Fig. 1. Chemisms of the water according to Lewkowicz (1973). a — BOD_5 value, b — amount of dissolved oxygen

of blue-green algae, diatoms, and green algae already occurred in considerable amounts (*Oscillatoria tenuis*, *Pleurocapsa* sp., *Navicula cryptocephala*, *Nitzschia palea*). The majority of the encountered species were typical alpha-mesosaprobs. A concomitant, relatively great decrease of BOD_5 and the absence of oxygen dissolved in the water indicated the existence of very intensive reductive — oxygenating processes in the pond. In this period of time, i.e. from the moment of filling the pond till about mid-July, heterotrophic processes prevailed — stage I (L e w k o w i c z 1973) — with algae of the order *Volvocales* (*Chlamydomonas* sp.) and *Euglenophyta* (*Euglena* sp., *Phacus* sp.) (K y s e l o w a 1973) predominant in the plankton. Only single species of euglenins (table I) were encountered in the periphyton.

In July the water slowly turned yellow-green and its putrid smell disappeared almost entirely. This was a period of vigorous development of the periphyton. The number of blue-green algae species increased still further (43 taxons). Some of them appeared in great amounts and formed distinct agglomerations: *Oscillatoria neglecta, Pleurocapsa* sp., *Nitzschia palea, Chytridiochloris acus, Scenedesmus acuminatus*, and *S. acutus*. During this month small amounts of free oxygen dissolved in the water (fig. 1b) were recorded for the first time. A considerable decrease in BOD_5 still indicated the reductive character of the processes taking place in the pond. The composition and abundance of the periphyton showed a still high degree of water pollution, the alpha-mesosaproby phase turning gradually into the beta-mesosaproby phase.

Investigations of the plankton (K y s e l o w a 1973) based upon chemical data (L e w k o w i c z 1973) indicated the stage of hyperautotrophy already from the second half of July to the middle of August. This was characterized by a great amount of algae with a prevalence of *Cryptophyceae* and concomitantly occurring chlorococcous algae of a similar composition (Table I). At this time mineralization of the organic matter introduced with the wastes was completed.

In August the water in the pond Polny III changed into a greenish colour, the same as that in the neighbouring carp ponds, its putrid smell disappearing completely. In the course of this month essential changes in the periphyton development took place. The variety of species decreased distinctly (15 taxons); instead new ones appeared, such as: *Gomphonema parvulum* and its three varieties and two species of *Stigeoclonium*, dominating absolutely along with *Nitzschia palea* (Table I). These species covered the cellophane strips almost 100 per cent, and formed distinct agglomerations. They covered the strips so densely that, in order to determine other species present, the periphyton had to be removed from them onto a glass slide and only then, in an added drop of water, could individual specimens be distinguished. The above-mentioned kinds of diatoms were also encountered in the plankton. At the same time a very great decrease in the BOD_5 and the permanent presence of oxygen dissolved in the water were observed. All this indicates the development of an almost beta-mesosaproby phase. According to L e w k o w i c z (1973) and K y s e l o w a (1973), the second transitory stage started from about the middle of August; during this stage the water community was gradually brought to the state of stabilized productive conditions.

By the end of September the dying of periphiton on the cellophane strips, with a concomitant decrease in the number of species (7 taxons), was observed. From all the algae only two species of *Stigeoclonium* survived, forming considerable agglomerations, which were accompanied by the diatoms *Nitzschia palea* and *Gomphonema parvulum* with three varieties. A similar decrease in the amount of algae during the transitory period was observed in plankton examinations. At the same time, the BOD_5 fell to sligthly under 10 mg O_2/l. The presence of a certain amount of oxygen dissolved in the water was recorded permanently; this illustrated as before, conditions characteristic of the beta-mesaproby phase.

During the course of 6 months examinations (from spring till autumn), full mineralization of the beet sugar factory wastes released into the pond at the turn of the year 1966/67 took place, with various communities of organisms participating in this process. Individual stages of self-purification of the wastes were clearly reflected in the composition of the periphyton species, as well as in the abundance of its occurrence.

STRESZCZENIE

Do obserwacji rozwoju porośli zastosowano sztuczne podłoże w postaci pęczków cienkich pasków celofanowych. Badania prowadzono od kwietnia do września 1967 r., opierając się na materiale zebranym w odstępach jednego miesiąca i utrwalonym na miejscu 4% roztworem formaliny.

Celem zilustrowania intensywności rozwoju porośli, w trakcie postępującej mineralizacji ścieków, wprowadzono sześciostopniową skalę, wyrażając stopnie w % występujących taksonów.

W zebranym materiale oznaczono łącznie 62 jednostki systematyczne, reprezentujące: *Bacteriophyta*, *Cyanophyta*, *Euglenophyta*, *Chrysophyta*, *Chlorophyta* i *Protozoa*. W peryfitonie dominowały: okrzemki 25 gat., przed zielenicami 17 gat. i sinicami 13 gat., trzy pozostałe typy były reprezentowane w ilościach o wiele mniejszych.

W ciągu dwu pierwszych miesięcy od zalania stawu ściekami peryfiton był bardzo słabo wykształcony. Zarówno skład gatunkowy, jak i bardzo wysokie BZT_5 oraz brak tlenu rozpuszczonego potwierdzały istnienie w tym okresie fazy polisaprobowej w stawie.

W czerwcu skład peryfitonu był o wiele bardziej urozmaicony. Większość spotkanych gatunków to typowe alfa-mesosaproby. Równocześnie nastąpił znaczny spadek BZT_5, co przy braku tlenu rozpuszczonego w wodzie wskazywało na zachodzące w tym okresie intensywne procesy redukcyjno utleniające.

W lipcu zaczął się bujny rozwój peryfitonu. Dominowały: *Oscillatoria neglecta*, *Pleurocapsa* sp., *Nitzschia palea*, gatunki z rodzaju *Scenedesmus*, *Chytridiochloris*. Po raz pierwszy zanotowano w stawie nieznaczne ilości tlenu rozpuszczonego. Skład peryfitonu wskazywał na silny jeszcze stopień zanieczyszczenia (faza alfa-mesosaprobowa, przechodząca stopniowo w beta-mesosaprobową). Okres ten od połowy lipca odpowiadał etapowi heterotrofii.

Skład peryfitonu w sierpniu uległ istotnym zmianom, zmniejszyła się różnorodność gatunków, pojawiły się natomiast nowe, jak: *Gomphonema parvulum* i jej trzy odmiany oraz dwa gatunki *Stigeoclonium*, które wraz z *Nitzschia palea* dominowały zdecydowanie w tym okresie. Równocześnie obserwowano dalszy bardzo silny spadek BZT_5 i stałą obecność tlenu w wodzie.

Okres od drugiej połowy lipca do połowy sierpnia nazwano etapem hiperautotrofii, w którym nastąpiła całkowita mineralizacja materii organicznej wniesionej ze ściekami.

Koniec września to dalsze zmniejszanie się liczby występujących gatunków. Pozostały tylko dwa gatunki *Stigeoclonium*, *Nitzschia palea* i *Gomphonema parvulum* z trzema odmianami. BZT_5 spadło poniżej 10 mg O_2/l. Stale stwierdzano występowanie tlenu rozpuszczonego, co w sumie odzwierciedlało warunki charakterystyczne dla fazy beta-mesosaprobowej, w trakcie etapu przejściowego (od drugiej połowy sierpnia do lutego następnego roku). Wynika z tego, że pełna mineralizacja ścieków nastąpiła w ciągu 8 miesięcy od chwili wpuszczenia ich do stawu, a poszczególne fazy samooczyszczania znalazły wyraz w składzie gatunkowym peryfitonu jak i obfitości jego występowania.

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ERRATA

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