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PROPOSAL OF MEASUREMENT AND VISUALIZATION METHODS FOR DOMINANCE STRUCTURES IN THE SAPROBE COMMUNITIES

PROPOZYCJA POMIARU PODOBIEŃSTWA STRUKTURY DOMINACJI ZBIOROWISK SAPROBIONTÓW I WIZUALNEJ PREZENTACJI ZMIAN TEJ CHARAKTERYSTYKI

Summary: A large taxonomic diversification of saprobes causes difficulties in practical use of saprobic system for biomonitoring purpose. In such a case taxonomic levels higher than species level became more popular. Methods based on biocenotic structure can be also used in bioindication. It is known that application of the Shannon-Wiener biodiversity index based not only on numbers and abundances of species but also on numbers and abundances of easily identified morphological-functional groups gives the same information as saprobe measurements. Moreover, the other structural indices together with the Shannon-Wiener index can be used to obtain more complete characteristics of saprobe communities. It enables more precise interpretation of biomonitoring results based on dominance structure of organism groups settled an examined object. The obtained results of the quantity nature can be compared with free accuracy, however they are difficult to be perceived. The aim of the present work is calculating a similarity of dominance structures characterizing saprobe communities as well as presenting modified method for visualisation of these structure changes.

Keywords: sewer systems, physical-chemical sewage parameters, biofilm, activated sewage sludge, bioindication, biomonitoring, saprobe communities, heterotrophic biomass

Urban sewer systems are settled by saprobe communities which form biofilm on the walls of the sewers and backbones alike to activated sludge. These organisms cause decrease in pollutant load in sewage before they reach a wastewater treatment plant [1-4]. Species structure of mentioned communities is similar to activated sludge or biofilm in the bioreactor of sewage treatment plant. It is also similar to the structure of organism communities of saprobic zones specified for water bodies. The sewage parameters can be established, based on the presence of microorganism representatives from the saprobic system living in the sewerage and using sewage as a source of nourishment [5-7].

A large taxonomic diversification of saprobes causes difficulties in practical use of saprobic system. Thus, taxonomic levels higher than species level became more popular for biomonitoring purposes. Methods based on biocenotic structure (organism distribution among species) can be also used in bioindication [8]. It has been shown that application of the Shannon-Wiener biodiversity index gives the same information as saprobe measurements. It is known that this information can be obtained using index calculation based not only on numbers and abundances of species but also on numbers and abundances of easily identified morphological-functional groups [5, 9].

Besides the Shannon-Wiener index, other structural indices as: species richness Δ_{Sr}, maximum value of the Shannon-Wiener index H_{max}, evenness index V, MacArthur's index E and proportionality index P can be used for bioindication purposes. These indices give

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more complete characteristics of saprobe communities, in so doing they permit for more precise interpretation of biomonitoring results based on dominance structure of organism groups settled an examined object. The obtained results of quantity nature can be compared with free accuracy, however they are difficult to be perceived. The graphical methods for comparison of the dominance structure for saprobe communities have been presented in our previous publications as suitable visualisation tools [7, 9]. However, these methods have some inconveniences which implicate the necessity of their modifications. Thus, the aim of the paper is calculating a similarity of dominance structures characterizing saprobe communities as well as presenting modified method for visualisation of these structure changes.

Material and methods

The material used for our previous and present study came from Klimowicz's elaboration [10]. The author presented species composition and individual abundances for communities of activated sludge in specified wastewater classes (characterized by biological oxygen demand ranges: 0÷10, 11÷20, 21÷30 and > 30 g O_2 m^{-3}). On the basis of the Klimowicz's data set relative abundances of distinguished morphological-functional groups were calculated (Π_i). The relative abundances mentioned above were multiplicated by 100 to obtain percent fractions. The percent fractions were used in calculations of Renkonen's similarity coefficients for the compared communities of activated sludge [11]. The obtained values of Renkonen's coefficients were sorted using Czekanowski's diagram [12]. Both Czekanowski's and Renkonen's methods are used in phytosociology to sort results of the floral inventory and to specify plant associations.

The percent fractions of morphological-functional groups were graphically visualized using "radar" plots also called "AMOEBAs" since the publication of the Ten Brink's paper [13]. During preparation of "AMOEBAs" plots original fractions and their natural logarithms were marked.

Results

The study results are presented in Figures 1 and 2. It can be seen that changes in pollution level influence dominance structure of described communities (Fig. 1). The changes in dominance structure are clearly visualized by radar plots with original fractions (grey colour). In the community I (BOD_5 range: 0÷10 g O_2 m^{-3}) attached ciliates are dominants and rotifers are subdominants (Fig. 1a). The community II (BOD_5 range: 11÷20 g O_2 m^{-3}) is characterized by attached ciliates as dominants and swimming ciliates as subdominants (Fig. 1b). In the community III (BOD_5 range: 21÷30 g O_2 m^{-3}) attached ciliates also play role of dominants and new subdominants as flagellates appear (Fig. 1c). Finally, in the community IV (BOD_5 range: >30 g O_2 m^{-3}) the dominance of flagellates is observed and amoebas become subdominants (Fig. 1d). The described changes of dominance structure are not presented so clearly using logarithms of fractions. However, their application enables the extremely low fractions of morphological-functional groups to be observed (Fig. 1a and 1b - black colour).

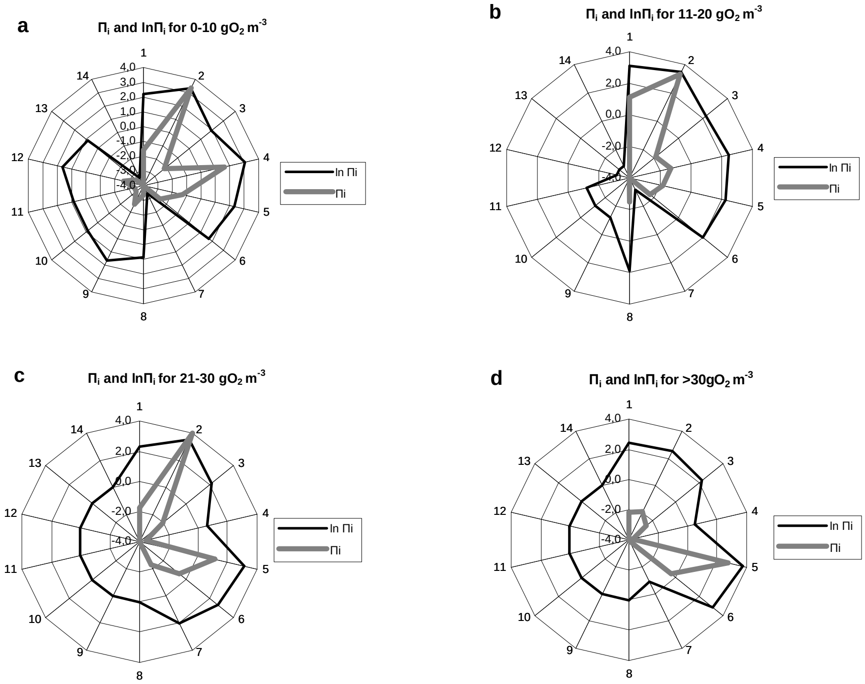
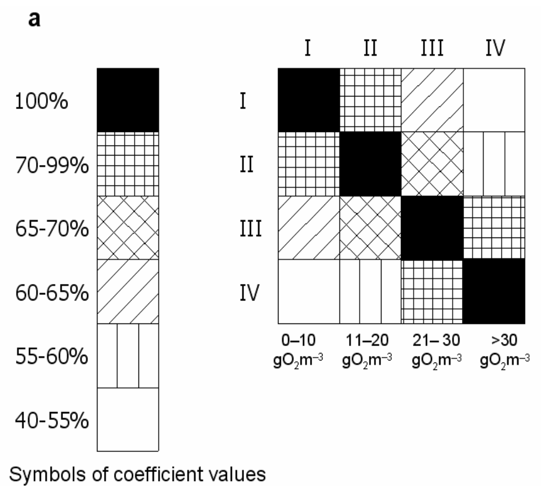


Fig. 1. Relative abundances of morphological-functional groups in specified classes of purified sewage. Explanation: 1 - swimming ciliates, 2 - attached ciliates, 3 - crawling ciliates, 4 - rotifers, 5 - flagellates, 6 - amoebaes, 7 - nematodes, 8 - oligochaetes, 9 - gastrotriches, 10 - arachnids, 11 - tardigrades, 12 - copepods, 13 - cladocers, 14 - turbellarians



b

BOD_5	I 0 – 10 gO_2m^{-3}	II 11 – 20 gO_2m^{-3}	III 21 – 30 gO_2m^{-3}	IV >30 gO_2m^{-3}
I 0 – 10 gO_2m^{-3}	100	73.45	60.93	46.13
II 11 – 20 gO_2m^{-3}	73.45	100	69.14	52.14
III 21 – 30 gO_2m^{-3}	60.93	69.14	100	70.90
IV >30 gO_2m^{-3}	46.13	52.14	70.90	100

Coefficient values

Fig. 2. Coefficients of taxa similarity for specified classes of purified sewage

In studied material two different groups of activated sludge communities can be distinguished (Fig. 2a and 2b). They are present in wastewater classes with BOD_5 range: 0÷20 g O_2 m^{-3} and > 21 g O_2 m^{-3}, respectively. Parallely, the community present in class with BOD_5 range: 21÷30 g O_2 m^{-3} is similar to those from classes characterized by BOD_5 range: 11÷20 and >30 g O_2 m^{-3} to the same degree (about 70%).

Conclusions

1. Changes in wastewater pollution level cause differences in dominance structure of saprobe communities.
2. Percent fractions of taxa calculated for biomonitoring purposes can be also used for determination of similarity coefficients between compared communities.
3. Czekanowski's diagrams can be used for sorting of communities considering their taxa similarity.
4. Changes in dominance structure are the best observed using radar plots called "AMOEBAs".
5. Saprobe fractions below 1% are clearly visualized as logarithm values.

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Streszczenie: Zróżnicowanie taksonomiczne systemu saprobów wiąże się z trudnościami w jego zastosowaniu do celów biomonitoringu. Dlatego też wprowadzenie do bioindykacji jednostek taksonomicznych wyższych rangą od gatunku oraz metod opartych na strukturze biocenotycznej staje się powszechne. Zastosowanie indeksu bioróżnorodności Shannona-Wienera, bazującego nie tylko na liczbie i ilościowości gatunków, lecz również na liczbie i liczebności łatwo identyfikowalnych grup morfologiczno-funkcjonalnych, jest tak samo przydatnym źródłem informacji jak pomiary saprobowości. W celu otrzymania pełniejszej charakterystyki badanego obiektu obok indeksu Shannona-Wienera stosowane są także inne indeksy struktury biocenotycznej. Użycie tych indeksów umożliwia bardziej precyzyjną interpretację wyników biomonitoringu uwzględniającego strukturę dominacji. Ze względu na ilościowy charakter danych wyniki mogą być porównywane z dowolną dokładnością, jednakże są mało czytelne w odbiorze. Celem prezentowanej pracy jest wyznaczenie podobieństwa struktury dominacji zbiorowisk saprobów i przedstawienie zmodyfikowanej metody wizualizacji zmian badanych struktur.

Słowa kluczowe: system kanalizacji, parametry ścieków, błona biologiczna, osad czynny, bioindykacja, biomonitoring, zbiorowiska mikroorganizmów, biomasa heterotroficzna