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Directional changes in communities of the bottom macrofauna against the background of changing hydrochemical parameters of the River Vistula, above the Goczalkowice Reservoir (southern Poland)

Henryk Kasza, Edward Krzyżanek

Polish Academy of Sciences, Institute of Freshwater Biology,
Hydrobiological Station, 43-230 Goczalkowice, Poland

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A b s t r a c t - On the basis of data from many years an increase was found in the degree of mineralization and fertility of the water of the River Vistula. Quantitative and qualitative changes in the bottom macrofauna against the background of changing physico-chemical conditions of the River Vistula were shown by a constant increase in the share of larvae of Chironomidae and Oligochaeta and a decrease in that of Ephemeroptera and Plecoptera.

Key words: rivers, ionic composition, nutrients, Chironomidae, Oligochaeta, Trichoptera, Ephemeroptera, Plecoptera.

1. Introduction

The interrelations of organisms with the environment are varied, for example they depend on nutrients and the physico-chemical transformation of the environment. The differing abundance of benthos over a few or several years results from the various systems of abiotic and biotic conditions. Frequently, they are changes connected with a directional change in the environmental conditions. These changes may be rapid, e.g., resulting from pollution of the river, or slow, e.g., connected with the process of eutrophication. The gradual increase in trophicity and the changes associated with it, accompanies the change in the composition of benthos, which, at a certain level, increases in abundance (Sowa 1965, Dratnal 1976, Kasprzak, Szczęśny 1976, Bagge, Salmela 1978, Dumnicka, Pasternak 1978, Srokosz 1980, Sowa, Szczęśny 1989, Szczęśny 1991).

The aim of the present work was to reveal the quantitative and qualitative changes of the bottom macrofauna over many years in the River Vistula its junction with the Goczałkowice Reservoir against the background of the changing physico-chemical conditions of the water.

2. Material and methods

The investigations on the bottom macrofauna were carried out in the years 1969-1970, 1976-1979, 1982-1983, and 1987 and 1991. Samples were drawn 4-6 times a year. The investigations were carried out at one station on the River Vistula, situated 3 km above the Goczałkowice Reservoir (fig. 1), which is representative for a several kilometer section of the river. In this place the Vistula has the character of a submontane river with a stony bottom and a mean water flow obtained from several years of $7-8 \text{ m}^3 \text{ s}^{-1}$. The samples were taken by means of a dredge from stones covering a total area of 500 cm^2 of the bottom. Their content was rinsed in a 0.5 cm mesh net. The selected animal forms were then preserved in 4% formalin. The results obtained were calculated for an area of 1 m^2 . In 1969-1970 only the numbers was specified but in the remaining years also the biomass was determined according to the methods used in investigations of the bottom macrofauna of the Goczałkowice Reservoir (K r z y ż a n e k 1991). The nomenclature of Chironomidae was based on L e h m a n ' s work (1971), and of other groups according to I l l i e s (1978).

Physico-chemical analyses of water were carried out on the basis of the methods of J u s t and H e r m a n o w i c z (1964), G o l t e r m a n and C l y m o (1969), and H e r m a n o w i c z et al. (1976).

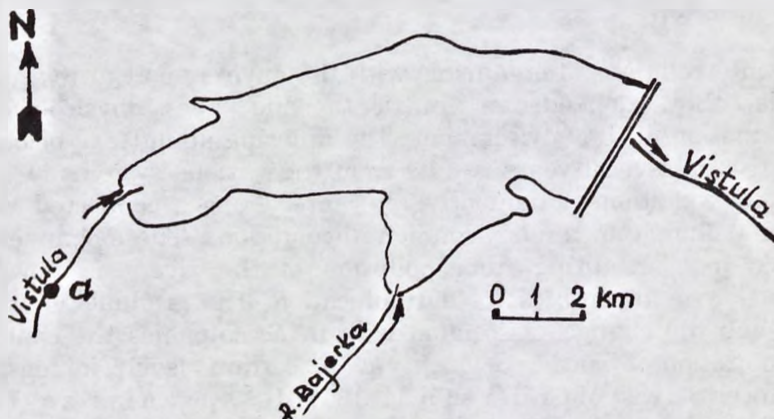


Fig. 1. Location of the sampling station (a)

The results of chemical analyses of the water (published in part by K a s z a 1992) were presented for the years 1957-1991 in order to show the trend of changes occurring in its composition. Details were given in K a s z a 's paper (1992).

3. Results

3.1. Changes in some parameters of physico-chemical characteristics of the Vistula water

The changes in some of the parameters of physico-chemical properties of the water, revealed by the annual means, permitted determination of their trend in its chemical composition. During more than 30 years a slight increase in electrolytes was observed in the ion composition of the Vistula water. The total of chemical equivalents of basic cations and anions here increased by about 35%. Among cations, the greatest increase was in calcium, whereas among anions the greatest rise was in chlorides (fig. 2A). In the analysed period the fertility of the Vistula water also increased. The quantity of nitrates, i.e. the basic form of mineral nitrogen, about doubled, but the amount of total phosphorus during 20 years increased fourfold (fig. 2B, C). The content of the organic matter expressed by oxidability underwent no essential change and the annual means in a decided majority cases varied in a narrow range from 3-4 mg O₂ dm⁻³ (fig. 2D).

3.2. General characteristic of the bottom macrofauna and its changes in the years 1969-1991

During the whole period of the investigations the greatest numbers and biomass were formed by larvae of Chironomidae (figs 3, 4). The dominance of this group increased with the passage of years. Fifteen taxa were distinguished in it, among which *Cricotopus* sp., *Ablabesmyia* sp., *Psectrocladius* spp., and *Cricotopus sylvestris* (F a b r.) occurred most numerously. In the years 1969-1983 *Brilla* spp., *Eukiefferiella* spp., and *Potthasia gaedii* (M g.) appeared periodically, and in 1987 and 1991 *Procladius* spp., *Cryptochironomus defectus* and *Dicrotendipes* sp. (? *D. nervosus* S t a e g.).

A second, somewhat less numerous group in respect of numbers and biomass were Ephemeroptera, chiefly from the genus *Caenis*. However, their numbers and biomass decreased from year to year. Periodically, in particular in 1991, the occurrence of larger numbers of Trichoptera (mainly *Oecetis ochracea* C u r t., and *Mystacides azurea* L.) and in 1987 and 1991 Oligochaeta was recorded.

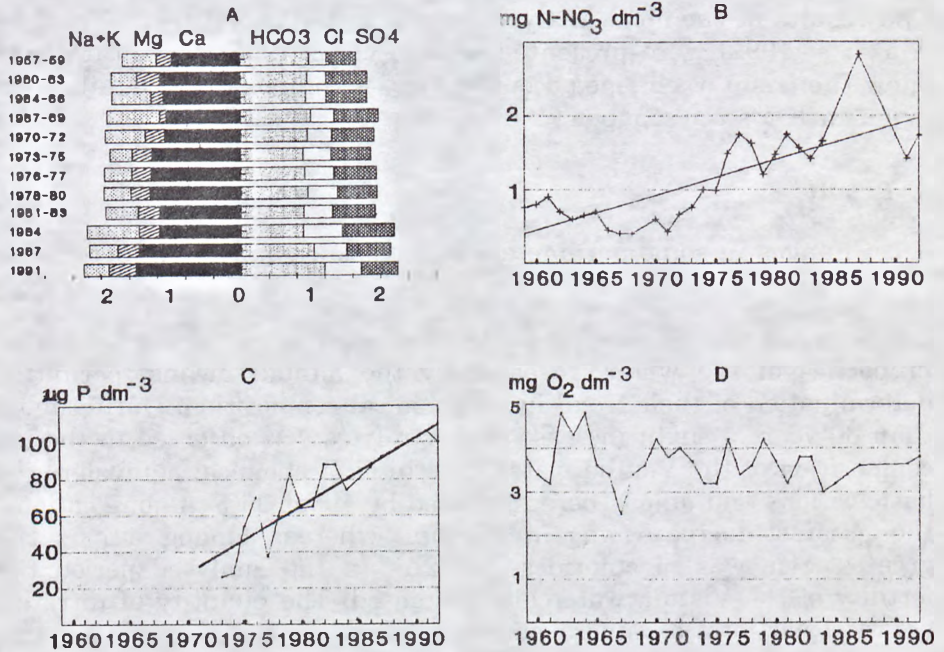


Fig. 2. Mean ion composition (mval dm⁻³) (A), content of nitrates (B), content of total phosphorus (C), and oxidability (D) in the Vistula water above the Goczałkowice Reservoir. Straight lines (figs B and C) define the trend of changes. Data up to 1989 acc. to K a s z a 1992

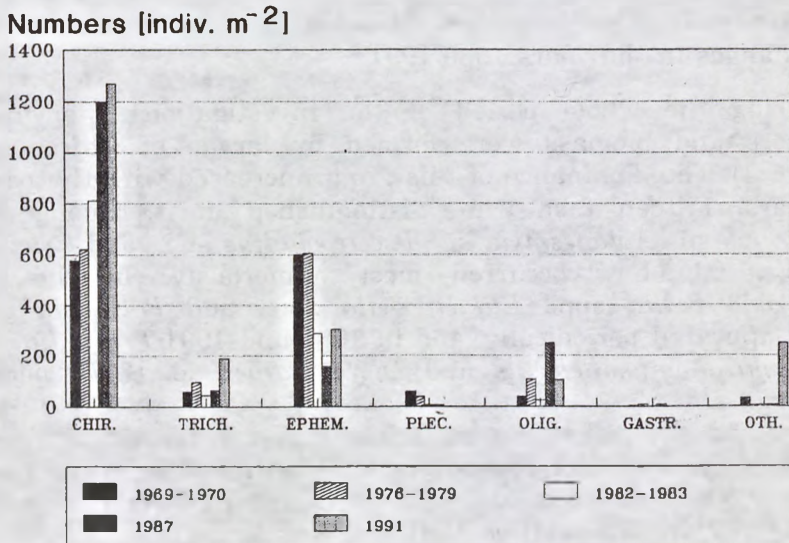


Fig. 3. Numbers of the bottom macrofauna of the River Vistula. CHIR - Chironomidae, TRICH - Trichoptera, EPHEM - Ephemeroptera, PLEC - Plecoptera, OLIGL - Oligochaeta, GASTR - Gastropoda, OTH - others

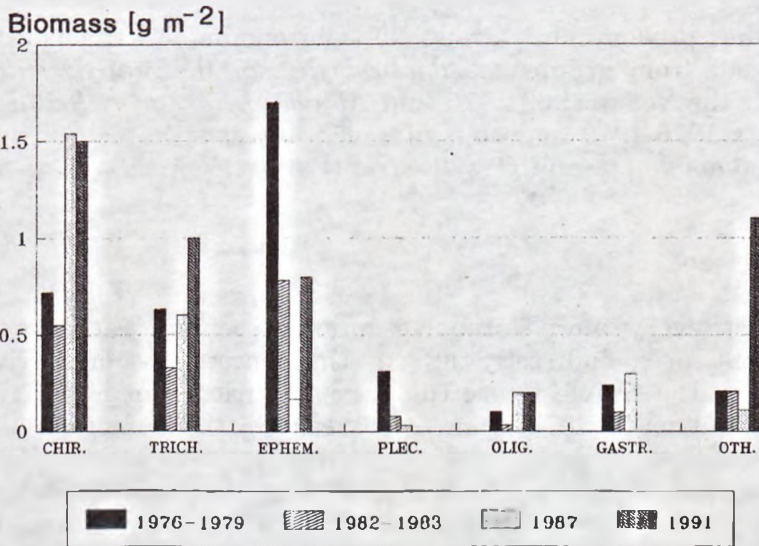


Fig. 4. Biomass of the bottom macrofauna of the River Vistula. Designations as in Fig. 3

The larvae of Plecoptera were found principally in 1969-1970 and 1976-1979 whereas in 1982-1983 and in 1987 they were found very rarely in 1991 and were not recorded at all. Gastropoda (*Lymnaea peregra* Müll. and *Ancylus fluviatilis* Müll.) and also others such as Hirudinea and Ceratopogonidae were noted sporadically, mainly in 1991.

The ecological succession of the bottom macrofauna (Table I) progressed from a group of "Ephemeroptera to one of Chironomidae" type (1969-1970 and 1976-1979), when the two groups occurred in similar numbers (about 41-44% each of the total numbers) to those of Chironomidae type, beginning from 1982 (in 1982-1983 they were 68%, in 1987 - 71%, and in 1991 - 60% of the total numbers).

Table I. The scheme of ecological succession of the bottom macrofauna of the River Vistula at the station above the Goczalkowice dam reservoir

Kind of dominance	1969-1979	1976-1979	1982-1983	1987	1991
Dominant groups and percentage of general forms	Ephemeroptera (41%) Chironomidae (42%)	Chironomidae (42%) Ephemeroptera (44%)	Chironomidae (68%)	Chironomidae (71%)	Chironomidae (60%)
Dominant taxa of Chironomidae	<i>Ablabesmyia</i> sp., <i>Eukiefferiela</i> spp.	<i>Ablabesmyia</i> sp., <i>Brillia</i> sp.	<i>Cricotopus</i> spp., <i>Ablabesmyia</i> sp.	<i>Cricotopus sylvestris</i> (F a b r.), <i>Psectrocladius</i> spp.	<i>Cricotopus sylvestris</i> (F a b r.), <i>Dicrotendipes</i> sp.

In the predominant group of Chironomidae, the succession progressed from groups of *Ablabesmyia* sp. to *Eukiefferiella* spp. types in the years 1969-1970 and *Ablabesmyia* sp. to *Brilla* sp. in the years 1976-1979 to groups in which usually two taxa dominated, i.e. *Cricotopus* spp. and *C. sylvestris* (F a b r.).

4. Discussion

Almost every more intensive human economic activity in its catchment area indirectly affects the biocoenosis of a river or stream. In the simplest case this is, e.g., enrichment of the river in mineral nutrients causing an increased growth of microphytes and in consequence changes in the invertebrate communities. Usually, however, the negative effects observed in the biocoenosis are the result of an inflow of excessive amounts of organic matter in the form of sewage (S z c z ę s n y 1991).

The causes of the increasing degree of mineralization and fertility of the Vistula water above the Goczałkowice Reservoir were dealt with in detail in the paper by K a s z a (1992). Broadly speaking, the reason for this increase are the intensified processes of urbanization in the catchment area, the discharging of municipal wastes with a simultaneous lack of development and building of a new sewage treatment plant and the introduction of high-phosphorous washing agents and the use of mineral fertilizers.

D o j l i d o and W o y c i e c h o w s k a (1989), studying the pollution of the Vistula water in 1987 classified its water at the point under consideration, according to the classification system applied in Poland as belonging to the II and III class of purity (on the basis of biogenic compounds and indicators of organic pollution), but according to biological indicators (*Coli* titre and saprobity) as being beyond classification. The bad quality of the Vistula water and also the progressing eutrophication undoubtedly caused quantitative and qualitative changes in the numbers and biomass of the bottom macrofauna (K r z y ż a n e k 1986, D u m n i c k a et al. 1988).

The studies of the bottom macrofauna, carried out since 1969 on the Vistula above the Goczałkowice Reservoir permitted determination of the general direction of changes. These consisted in a constant increase in the share of Chironomidae, Trichoptera, and Oligochaeta larvae and in a decrease in Ephemeroptera and Plecoptera. Similar changes in the bottom macrofauna in rivers were described by V o r o p a j e v and A v a k y a n (1986).

Quantitative and qualitative changes in the macrozoobenthos found in recent years demonstrate that biological nature of the river has altered. The very numerous groups of the bottom macrofauna (Plecoptera, Ephemeroptera) typical of a moderately clean submontane river have been exchanged for more numerous ones, characteristic of lowland rivers (Chironomidae, Oligochaeta), giving evidence of the progressing eutrophication of the River Vistula. The results of biological investigations confirm those chemical ones.

5. Polish summary

Kierunkowe zmiany zgrupowań makrofauny dennej na tle zmieniających się parametrów hydrochemicznych rzeki Wisły powyżej zbiornika Goczałkowice (Polska Południowa)

Celem pracy było ukazanie trendu zmian ilościowych i jakościowych makrofauny dennej w wieloletnim w rzece Wiśle na tle zmieniających się warunków fizyko-chemicznych jej wody. Badania prowadzono na jednym stanowisku położonym 3 km przed zbiornikiem Goczałkowice (ryc. 1).

Stwierdzono niewielki wzrost elektrolitów w składzie jonowym wody wiślanej. Ogólna suma równoważników chemicznych podstawowych kationów i anionów w wodzie Wisły wzrosła o około 35% (ryc. 2A). W analizowanym okresie wzrosła też żyzność wody Wisły (ryc. 2B, C), a zawartość materii organicznej wyrażona utlenialnością nie uległa istotnej zmianie (ryc. 2D).

W całym okresie badań najwyższą liczebność i biomasę tworzyły larwy Chironomidae (ryc. 3, 4). Dominacja tej grupy wzrastała z upływem lat (tabela I). Wyróżniono w niej 15 taksonów. Drugą, nieco mniej liczną grupą były Ephemeroptera. Ich liczebność i biomasa jednak z roku na rok malała. Larwy Plecoptera spotykano głównie w latach 1969-1970 i 1976-1979, natomiast w następnych latach badań stwierdzano je rzadko, a w 1991 r. nie notowano ich w ogóle. W 1991 r. stwierdzono liczniejsze występowanie Trichoptera, Oligochaeta, Hirudinea i Ceratopogonidae.

Opisane zmiany dowodzą, że zmienił się chemiczny i biologiczny charakter rzeki.

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