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Species composition of zooplankton in surface waters near the Upper Silesia in the aspect of water quality*

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Abstract — The qualitative composition of zooplankton was investigated in four rivers, a pond, a dam reservoir, and a flooded sand pit in the Upper Silesian Industrial Region. The occurrence of 26 *Rotatoria* taxons, 22 species of *Cladocera*, 11 species of *Cyclopoida* and *Calanoida*, and 1 species of *Harpacticoida* was noted. The qualitative composition of zooplankton of the dam reservoir at Kozłowa Góra and in the pond in the park at Świerklaniec suggests the eutrophication of these water bodies. The very poor composition of zooplankton in the Rivers Stoła and Graniczna Woda is caused by high concentrations of heavy metals, and in the River Mała Panew also by oxygen depletion.

Key words: zooplankton, heavy metals, toxicity, rivers, reservoirs, ponds.

1. Introduction

Laboratory experiments have yielded numerous data on the toxicity of heavy metals for planktonic animals: Anderson (1948), Biesinger, Christensen (1972), Pawlaczyk-Szpilowa et al. (1972), Baudouin, Scoppa (1974), Winner, Farell (1976), Shcherban (1977), and Moraïtou-Apostolopoulou, Veriopoulos (1982). However, the multiplicity of factors appearing in

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the natural environment can to a great degree weaken or intensify the action of a given substance on these animals. The chief aim of the work, which was carried out in environments polluted with various heavy metals and amounts of nutritive substances, was therefore to determine the extreme concentrations of heavy metals and other chemical compounds at which living planktonic animals are still encountered. The work was carried out in rivers and water bodies in an area which for several decades had been affected by 1) pollution with heavy metals from non-ferrous metal plants (atmospheric pollution and direct discharges), 2) municipal pollution, and 3) compounds leached from soils in that part of the catchment basin which was used for agriculture. Analyses of macro- and microelements in the water and rainfall (Bombówna 1985 and unpublished data, Reczyńska-Dutka 1984, 1985a) were carried out simultaneously, this making it possible to investigate the relation between the composition of zooplankton and the inorganic compounds dissolved in water.

2. Study area

The investigation was carried out from May 3, 1978 to May 3, 1979 in surface waters in the vicinity of Kozłowa Góra in Upper Silesia (50° 25' N, 18° 57' W) (fig. 1). The study covered four rivers, a dam reservoir, a pond, and a flooded sand pit. All the stations (12) lie in the catchment basins of the Rivers Mała Panew and Brynica. The Mała Panew basin is afforested while the prevailing part of the Brynica basin is under cultivation. Table I presents a concise characteristic of the stations. The type and place of the chief sources of pollution are given in fig. 1. A detailed description of the area has been given by Zięba (1985) and Bombówna (unpublished data).

3. Material and method

Zooplankton samples were collected with a Patalas bathometer or with a pail. 50 to 100 dm^3 of water were filtered through a No 25 plankton net of 50 μm mesh. The samples were preserved in formalin. The qualitative composition of samples was determined in the laboratory. The collected material was quantitatively elaborated by Krzeczkowska-Wołoszyn (1985).

The results obtained by Bombówna (1985 and unpublished results) in standard chemical analyses and by Reczyńska-Dutka (1984, 1985a, b) in the determination of microelements in rainfalls and surface waters were used in the work.

Table I. Some hydrological data concerning the investigated stations

No of station	Localization in the area	Width of riverbed [m] or area of the reservoirs [km^2]	Depth [m]	Current	Remarks
1	River Brynica at Zendek	0.5 - 1.5	0.2 - 0.5	medium	
2	River Brynica at Niezdara	3.0 - 4.0	0.2 - 0.7	slow	Q_{10}=0.44 m^{3}s^{-1}
3a,b	Reservoir Kozłowa Góra upper section		0.5 - 1.8		
3c,d	Reservoir Kozłowa Góra lower section	mean 4.62	1.8 - 3.0		
3e	Reservoir Kozłowa Góra near the dam	maximum up to 6.21	up to 5		
4	River Brynica near the dam	1.0 - 1.2	0.2	medium	
5	River Brynica below the dam 1.5 km	2.0 - 3.0	0.3 - 0.7	slow	bed lined with stones
6	The park pond at Swierklaniec	0.06	1.2 - 1.5		
7a	Inshore point of passage at Chechło	0.66	0.3 - 0.6		
7b	Central point of passage at Chechło	0.66	2.3 - 2.5		
8	River Mała Panew at Miotek	5.0 - 8.0	0.3 - 0.7	medium	Q_{10}=1.05 m^{3}s^{-1}
9	River Mała Panew at Brusiek, 7 km below paper mill	3.0 - 5.0	0.3 - 0.7	medium	
10	River Graniczna Woda at Tworóg	2.0 - 2.5	0.15 - 0.35	slow	
11	River Stoła at Tworóg	4.0 - 6.0	0.5 - 0.8	slow	
12	River Mała Panew at Krupski Młyn	6.0 - 8.0	1.0 - 1.5	medium	Q_{10}=4.93 m^{3}s^{-1}

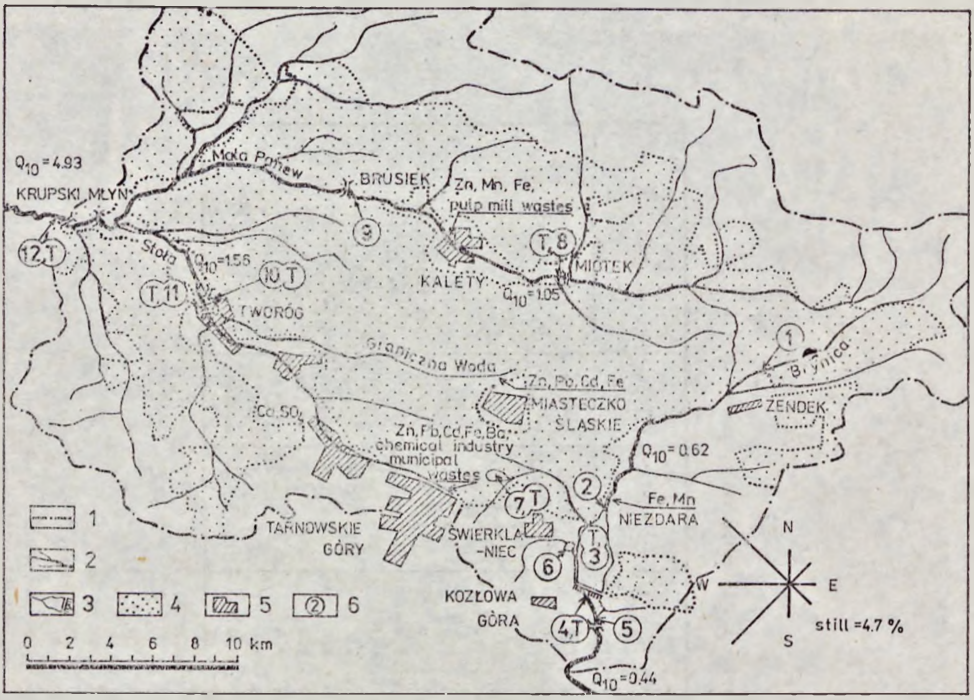

Fig. 1. Distribution of stations in the upper sectors of the Rivers Mała Panew and Brynica catchment basins, main pollution, wind rose. 1 — borders of the catchment basin; 2 — rivers; 3 — dam reservoir; 4 — forest; 5 — built-up areas; 6 — numbers of stations. T — stations where samples for biotests were collected. Q_{10} — mean 10-year water discharges ($m^3\ s^{-1}$)

4. Results

In the waters of the investigated region 26 *Rotatoria* taxa, 22 *Cladocera* taxa, 9 species of *Cyclopoida*, 2 species of *Calanoida*, and 1 species of *Harpacticoida* were found. Table II shows the occurrence of species at 12 investigated stations in the different seasons of the year.

At station 1 in the forest the rotifers *Dissotrocha macrostyla* and *Lecane opias* were found where there was a small concentration of Cu, Pb, Cd, Co, Ni, Mn, and Fe and an increased content of total zinc: 0.0408 mg dm^{-3}. Stations 1 and 8 have soft water and the content of Co, Ni, and Pb is, by about 100 times or even more, lower than the values of EC_{50} quoted for the rotifer *Philodina acuticornis* (B u i k e m a et al. 1974). Thus, the metals mentioned above are not dangerous for the population of rotifers. The content of zinc reached 0.3348 mg dm^{-3} at station 1 and 0.3299 mg dm^{-3} at station 8. These values approximate the value of 0.5 mg of zinc in the form of $ZnCl_2$ which caused a reduction in the numbers of a rotifer

Table II. Occurrence of species in surface waters of investigated area

Species	Occurrence at station	Month of occurrence	Species	Occurrence at station	Month of occurrence
ROTATORIA			Alonella exigua Lilljeborg	7	VIII
Asplanchna priodonta Gosse	5,7,8	V,VI	- nana Baird	6,7	V,VIII
Brachionus angularis f. bidens Plate	3,5,6,8	V	Bosmina coregoni Baird	3,4	VI
- calyciflorus Pallas	5	V	- longirostris O.F.M.	1,3,5,6,7	V,VI,VIII,X
- urceolaris var. rubens Ehrb.	6	V	Ceriodaphnia pulchella Sars	6	VIII
Cephalodella gibba Ehrb.	8	VIII	Chydorus globosus Baird	3,6,7	V,VI,VIII
Diaschiza macrostyla Ehrb.	1	VIII	- piger Sars	2,6	VI
Epiphanes senta O.F.M.	11,12	V	- sphaericus O.F.M.	2,5,6	VIII,X
Habrotrocha sp.	4	X	Daphnia cucullata Sars	3,4,5,7	V,VI,VIII,X
Kellicottia longispina Kellicott	3,4,5,7,8	V,VI,VIII,X	- hyalina Leydig	7	VI
Keratella cochlearis cochlearis Gosse	3,5,7,8	V,VIII	- longispina O.F.M.	3,6,7	VI,VIII
- - f. tecta Lauterborn	3,8	V,VIII	- pulex Leydig	6	VIII
- quadrata O.F.M.	3,6,7,8	V,VI	Diaphanosoma brachyurum Fischer	7	X
Lecane ludwigii Eckstein	5	VIII	Eurycercus lamellatus O.F.M.	4	VIII
- lunaris lunaris Ehrb.	7	V	Ilyocryptus acutifrons Sars	5	X
- opias H. and M.	1,5,8	VIII	Sixcephalus vetulus O.F.M.	4	VIII
- sp.	8	V	CYCLOPOIDA		
Lepadella glossa Wulf.	5	VIII	Acanthocyclops robustus Sars	2	VI
- ovalis O.F.M.	2	VIII	- viridis Jurine	3,5	V,VIII
Notholca acuminata Ehrb.	2,5,6,7,8	V,X	Diacyclops languidoides Claus	3,4,5,7	V,X
- squamula O.F.M.	2,8	V	Cyclops vicinus Uljanine	3,5	V,X
Polyarthra vulgaris Carlin	3	V,VIII	Eucyclops serrulatus Fischer	2	VI
Pompholyx sulcata Hudson	3	VIII	Macrocyclops albidus Jurine	2,6,7	V,X
Synchaeta sp.	3,6	V,X	Mesocyclops leuckarti Claus	6	VI
Trichocerca similis Wierzejski	7	VIII	Thermocyclops crassus Fischer	3,4,6,7	VI,VIII,X
- stylata Gosse	7	VIII	- oithonoides Sars	3,7	VIII,X
Trichotria pocillum pocillum O.F.M.	3,5,6,7	V,VI	CALANOIDA		
CLADOCERA			Eudiaptomus gracilis Sars	3,7	V,VI,VIII
Acroperus harpae Baird	4	VIII	- vulgaris Schmeil	7	VI
Alona affinis Leydig	2,6	VI,X	HARPACTICOIDA		
- costata Sars	6	X	Bryocamptus zschokkei Schmeil	1,6	V,VIII
- intermedia Sars	7	X			
- quadrangularis O.F.M.	2	VIII			
- rectangula Sars	3	X			

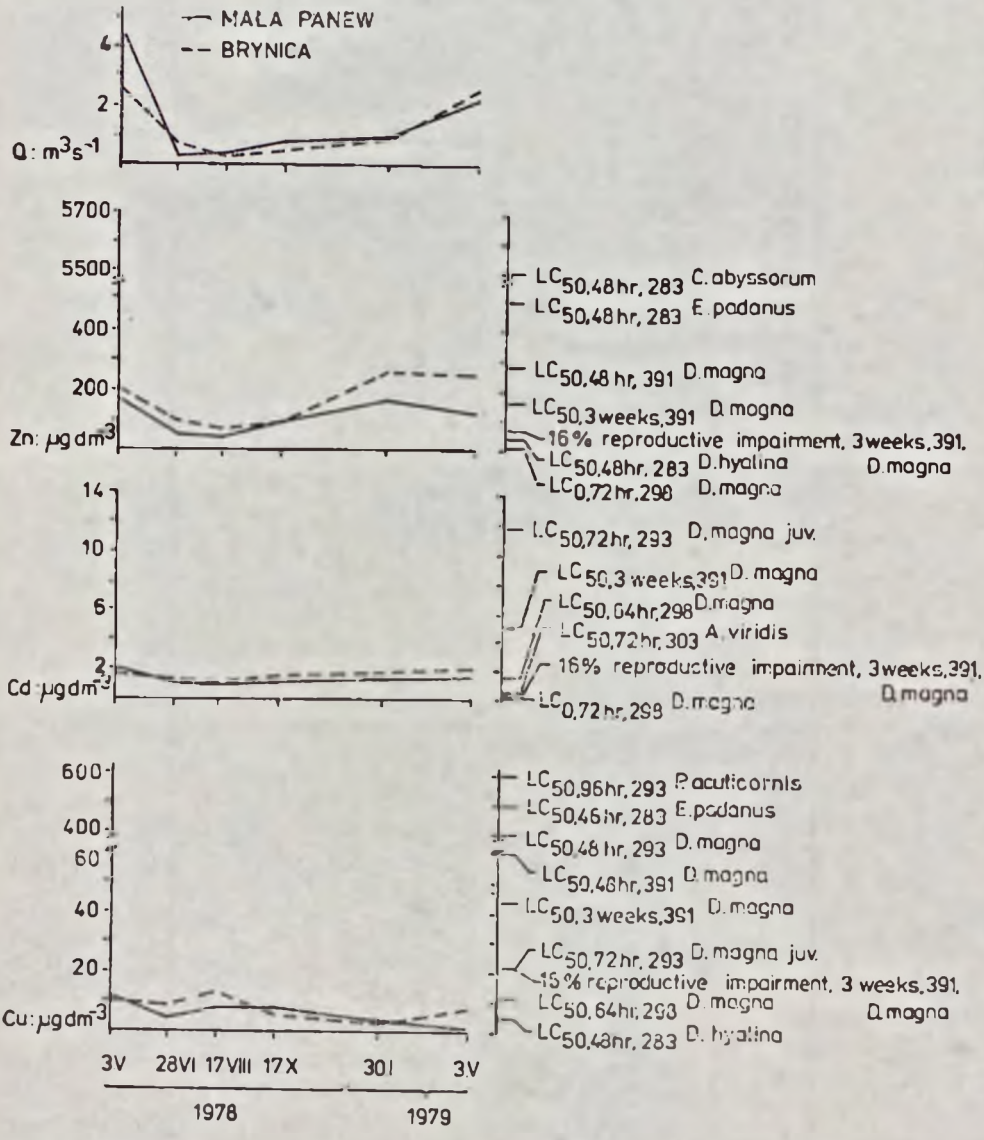

Fig. 2. Magnitude of water discharges ($m^3 s^{-1}$) in the Rivers Mała Panew and Brynica and changes in the concentrations of Mn, Cd, and Cu (according to Reczyńska-Dutka 1985a) against time and on the background of lethal concentrations of these metals for different planktonic species. The LC subscripts stand for the following: percentage of population mortality, time of exposure, temperature in °K. C — *Cyclops*; E — *Eudiaptonius*; D — *Daphnia*; A — *Acanthocyclops*; P — *Philodina*

population by 81.8% after 17 days under natural conditions (Maximov 1977). Therefore, it may be inferred that this was the main noxious cation of metals found in the head waters of the investigated rivers.

In the period of high water (May) such euplanktonic species as *Notholca acuminata*, *N. squamula*, *Kellicotia longispina*, and *Keratella quadrata* were most probably washed in from water bodies which were periodically connected with the river.

Crustaceans, and especially *Cladocera*, are more sensitive to the action of heavy metals. They did not appear in the samples from station 1 while at station 8 *Bosmina longirostris* was sporadically found at a concentration of Zn 176.6 μg dm^{-3} and *Bryocamptus zschokkei* appeared at concentration of Zn 204.6 μg dm^{-3}.

The pH values noted at the two stations, i.e. 6.5—7.6, favoured the ioccurrence of cations of both Zn^{++} and zinc hydroxide. Properties of cadmium similar to those of zinc were also observed: only when the product of solubility for $Cd(OH)_2 \downarrow \rightleftharpoons Cd(OH)_2$ was 4 and the precipitation of Cd^{++} at pH as high as 8 did a real possibility of their toxicity for *Cladocera* occur (fig. 2). The range of cadmium concentration of 0.7—3.0 mg dm^{-3} found at these stations seems to have no influence on rotifers and copepods.

A copper content of 1.2—47.3 mg dm^{-3} should not have any significant effect on zooplankton because at pH 6.5 the occurring copper compounds are weakly soluble, this bringing about a low concentrations of Cu^{++} ions. According to Andrew et al. (1977), the survival time of *Daphnia magna* is directly associated with the concentration of Cu^{++}, being independent of the total concentration of copper. Andrew et al. (1977) quoted the approximate threshold of lethal toxicity in soft water as 0.0635—0.3175 μg dm^{-3} Cu^{++}.

At station 12 in the River Mała Panew the concentrations of heavy metals brought in by the River Stoła were markedly increased. The occurrence of the rotifer *Epiphanes senta* was observed twice during a rise in the water level. The following concentrations of metals in μg dm^{-3} were found: Zn sometimes above 13 270; Pb up to 231; Cd 9.7—342.5; Fe 900.7—14 130.

In the River Stoła (station 11) the rotifer *Epiphanes senta* was noted once under the following conditions: temperature 8.6°C; conductivity 429.2 μS; Zn 17 043.3; Cd 791.9; Pb 308; Cu 41.5 μg dm^{-3}.

The River Graniczna Woda was so strongly poisoned with heavy metals (in μg dm^{-3}: Zn 252.5—60 239.4; Pb 10.0—463.6; Cd 11.7—2144; Fe 585—4437.1; pH 5.7—7.2) that neither rotifers nor crustaceans were encountered there. During the summer fungi, protozoa, and bacteria were found in the samples.

At station 2 in the River Prynica the occurrence of the rotifers *Notholca acuminata* and *N. squamula* were observed at zinc concentration

of 469.5 μg dm^{-3}. At this station clumps of *Ranunculus aquatica* and *Potamogeton elongatus*, and also *Rumex hydrolapatum*, *Iris pseudoacorus*, *Myosotis palustris*, and *Salix* sp. grew at the bank.

The dam reservoir at Kozłowa Góra (station 3) has medium mineralized water with a conductivity of 282—362 μS. The most constant species occurring throughout the year was *Kellicotia longispina*, accompanied by euplanktonic species of the littoral and bottom zone (Table II).

Station (5) below the dam of the Kozłowa Góra reservoir had a qualitative composition of zooplankton similar to that found in the reservoir. The difference appeared in the greater number of species associated with such littoral plants as *Lecane opias*, *L. ludwigii*, *Lepadella glossa*, *Asplanchna priodonta* etc.

In the surrounding ditch (station 4) the occurring species were characteristic for small water bodies, while such euplanktonic species as *Kellicotia longispina*, *Daphnia cucullata*, and *Bosmina coregoni* appeared accessorily.

5. Discussion

Detailed studies on potamoplankton carried out in Poland by Pawłowski (1968) in the River Grabia showed that rotifers sometimes constituted over 80% of the total of zooplankton species there. Usually copepods and the least numerous *Cladocera* occupied the next place. Similar proportions between the numbers of rotifers and crustaceans were observed at station 8 in the River Brynica. In the River Mała Panew, however, this ratio was 1 : 1 and the qualitative composition was extremely poor. Krzeczkowska-Wołoszyn (1985) reports that the quantities of these species were also very small.

In the two rivers increased concentrations of heavy metals were observed in the winter at low water and in the summer after rain in the period of high water level in rivers. Reczyńska-Dutka (1984) found that the concentration of heavy metals and the magnitude of water discharges were positively correlated, this showing that the metals were leached from the soils of the catchment basin.

Low concentrations of cobalt (under 10 μg dm^{-3}) and lead did not threaten life in the waters of the River Brynica and headwaters of the River Mała Panew. Nor should nickel play any important role since at pH about 7 basic salts or complexes of nickel appear and the Ni^{++} cation is practically absent (Charlot 1969).

Hakkari (1972) claimed that the industrial wastes from paper plants discharged into large water bodies bring about an increase in the number of species typical for eutrophic waters, and in small water bodies eliminate a great many species of animals. The conditions in the River

Mała Panew were deteriorated by wastes from a paper mill lying above station 9 to such a degree (oxygen 0.0—9.28 mg dm^{-3}, conductivity 300—509 μS, Zn 80.7—517.5 μg dm^{-3}, Fe 752.1—15 429 μg dm^{-3}) that no planktonic animals were encountered there.

The qualitative composition of zooplankton in the Kozłowa Góra reservoir showed a marked eutrophication level of this water body. According to Pejler (1965), the abundant occurrence of *Daphnia cucullata* is an indicator of the eutrophication. In Poland this species occurs in different types of lakes (Patalas, Patalas 1966). Also for *Keratella cochlearis* f. *tecta* and *K. quadrata* Hakkari (1978) showed a significant preference for a eutrophicated environment. Stemberger and Gannon (1977) regard *K. cochlearis*, *Pompholyx sulcata*, *Brachionus angularis*, and *Polyarthra vulgaris* as good indicator species of eutrophication. According to Deevey (1942) and Hasler (1947), *Bosmina longirostris* occurring in the reservoir is also an eutrophic species. Moreover, the occurrence of such species as *B. angularis* f. *bidens*, *B. urceolaris* var. *rubens*, *Trichotria pocillum pocillum*, or *Keratella quadrata* in the pond in the Świerklaniec park suggests the eutrophication of its water. In this pond the rotifer *Notholca acuminata* was observed at a temperature of 12.1°C, the opinion of Stemberger, Gannon (1977) that this was a cold stenothermic species thereby being supported.

6. Polish summary

Skład gatunkowy zooplanktonu w wodach powierzchniowych w pobliżu Górnego Śląska w aspekcie jakości wody

Badano skład jakościowy zooplanktonu w różnego typu wodach powierzchniowych w dorzeczu Małej Panwi i Brynicy. Badania prowadzono w cyklu rocznym. Wody w tym rejonie pozostają pod wpływem zanieczyszczeń atmosferycznych, rolniczych, komunalnych, przemysłu celulozowego i hutnictwa metali kolorowych. Dane hydrologiczne badanych stanowisk podano w tabeli I, a rozmieszczenie stanowisk i główne rodzaje zanieczyszczeń wprowadzanych do odbiorników na ryc. 1.

W badanym rejonie stwierdzono występowanie 26 taksonów wrotków, 22 gatunki *Cladocera*, 11 gatunków *Cyclopoida* i *Calanoida* oraz jeden gatunek *Harpacticoida* (tabela II). Analiza danych fizykochemicznych w środowisku i danych według różnych autorów (ryc. 2) wskazuje, że za bardzo ubogi skład gatunkowy lub brak zooplanktonu w rzekach Mała Panew, Stoła, Graniczna Woda najprawdopodobniej odpowiedzialne są cynk i kadm, a poniżej fabryki celulozy w Kaletach także zaniki tlenowe. Ścieki przemysłu papierniczego odprowadzane do Małej Panwi nie pozwalały na rozwój wrotków i skorupiaków na odcinku co najmniej 15 km. Niektóre gatunki, jak *Epiphanes senta*, spotykano przy koncentracji cynku całkowitego 17.043 μg dm^{-3} i kadmu 791.9 μg dm^{-3}.

Skład gatunkowy zooplanktonu zbiornika zaporowego w Kozłowej Górze i stawu parkowego w Świerklańcu wskazuje na eutroficzny charakter ich wód.

7. References

Anderson B. G., 1948. The apparent thresholds of toxicity to *Daphnia magna* for chlorides of various metals when added to Lake Erie water. Trans. Amer. Fish. Soc., 78, 97—113.

Andrew R. W., K. E. Biesinger, G. E. Gloss, 1977. Effects of inorganic complexing on the toxicity of copper to *Daphnia magna*. Wat. Res., 11, 309—315.

Baudouin M. F., P. Scoppa, 1974. Acute toxicity of various metals to freshwater zooplankton. Bull. Environ. Contam. Toxicol., 12, 745—751.

Biesinger K. E., G. M. Christensen, 1972. Effects of various metals on survival, growth, reproduction, and metabolism of *Daphnia magna*. J. Fish. Res. Bd Can., 29, 1691—1700.

Bombówna M., 1965. Ecology of some waters in the forest-agricultural basin of the River Brynica near the Upper Silesian Industrial Region. 2. Chemical composition of water and atmospheric precipitation. Acta Hydrobiol., 27 (in press).

Buikema A. L. Jr., J Cairns Jr., G. Sullivan, 1974. Evaluation of *Philodina acuticornis* (*Rotifera*) as a bioassay organism for heavy metals. Wat. Res. Bull., 10, 648—661.

Charlot G., 1969. Les réactions chimiques en solution. L'analyse qualitative minérale. Paris, Masson et Cie.

Deevey E. S. Jr., 1942. Studies on Connecticut Lake sediments. 3. Biostratonomy of Linsley Pond. Amer. J. Sci., 240, 233—264.

Hakkari L., 1972. Zooplankton species as indicator of environment. Aqua Fenn., 46—54.

Hakkari L., 1978. On the productivity and ecology of zooplankton and its role as food fish in some lakes in Central Finland. Biol. Res. Rep. Univ. Jyväskylä, 4, 3—87.

Hasler A. D., 1947. Eutrophication of lakes by domestic drainage. Ecology, 28, 383—395.

Krzeczkowska-Wołoszyn Ł., 1985. Ecology of some waters in the forest-agricultural basin of the River Brynica near the Upper Silesian Industrial Region. 7. Zooplankton — quantitative relations in various systematic groups. Acta Hydrobiol., 27 (in press).

Maximov V. N., 1977. Specific problems in studies of pollutants combined action on biological systems. Hydrobiol. Zh., 13, 4, 34—45.

Moraïtu-Apostolopoulou M., G. Verriopoulos, 1982. Individual and combined toxicity of three heavy metals: Cu, Cd, and Cr for the marine copepod *Tisbe holoturiae*. Hydrobiologia, 87, 83—87.

Patalas J., K. Patalas, 1966. The crustacean plankton communities in Polish lakes. Verh. Int. Ver. Limnol., 16, 204—215.

Pawlaczyk-Szpilowa M., M. Moskal, J. Weretelnik, 1972. The usefulness of biological tests for determining the toxicity of some chemical compounds in waters. Acta Hydrobiol., 14, 115—127.

Pewłowski L. K., 1968. Nouvelles observations sur les rotifères de la rivière Grabia. Łódz. Tow. Nauk., Wydz. 3, 48.

Pejler B., 1965. Regional-ecological studies of Swedish fresh-water zooplankton. Zool. Bijdrag., 36, 408—515.

Reczyńska-Dutka M., 1984. Heavy metals in rain water collected over the reservoirs at Kozłowa Góra and at Goczałkowice. Ekol. Pol., 32, 679—691.

Reczyńska-Dutka M., 1985a. Ecology of some waters in the forest-agricultural basin of the River Brynica near the Upper Silesian Industrial Region. 3. Heavy metals in the water. Acta Hydrobiol., 27 (in press).

Reczyńska-Dutka M., 1985b. Ecology of some waters in the forest-agricultural basin of the River Brynica near the Upper Silesian Industrial Region. 4. Atmospheric heavy metals pollution of bottom sediments of the Kozłowa Góra Reservoir. Acta Hydrobiol., 27 (in press).

Shcherban E. P., 1977. Toxicity of some heavy metals ions for *Daphnia magna* Straus depending on temperature. Hydrobiol. Zh., 13, 4, 86—91.

Stemberger R. S., J. E. Gannon, 1977. Multivariate analysis of rotifer distribution in Lake Huron. Arch. Hydrobiol., 8, 38—42.

Winner R. W., M. P. Farell, 1976. Acute and chronic toxicity of copper to four species of *Daphnia*. J. Fish. Res. Bd Can., 33, 1685—1691.

Zięba J., 1985. Ecology of some waters in the forest-agricultural basin of the River Brynica near the Upper Silesian Industrial Region. 1. Introduction — range and aim of investigations with the characteristics of the environment. Acta Hydrobiol., 27 (in press).