Electronic Journal of Polish Agricultural Universities is the very first Polish scientific journal published exclusively on the Internet, founded on January 1, 1998 by the following agricultural universities and higher schools of agriculture: University of Technology and Agriculture of Bydgoszcz, Agricultural University of Cracow, Agricultural University of Lublin, Agricultural University of Poznan, Higher School of Agriculture and Teacher Training Siedlce, Agricultural University of Szczecin, and Agricultural University of Wroclaw.

ELECTRONIC JOURNAL OF POLISH AGRICULTURAL UNIVERSITIES

2000
Volume 3
Issue 1
Series
FISHERIES

RACZYNSKA M., ZURAWSKA J., CHOJNACKI J.C. 2000. THE PROBLEM OF QUALITY ASSESSMENT OF SURFACE LOTIC WATERS AS EXEMPLIFIED BY RIVERS TYWA AND RURZYCA **Electronic Journal of Polish Agricultural Universities**, Fisheries, Volume 3, Issue 1.
Available Online http://www.ejpau.media.pl/

THE PROBLEM OF QUALITY ASSESSMENT OF SURFACE LOTIC WATERS AS EXEMPLIFIED BY RIVERS TYWA AND RURZYCA

Malgorzata Raczynska[1], Joanna Zurawska[2], Juliusz C.Chojnacki[1]

[1]*Department of Marine Ecology and Environmental Protection, Faculty of Marine Fisheries and Technology, Agricultural University, Szczecin, Poland* [2]*Department of Biostructure, Institute of Physical Culture, Faculty of Natural Sciences, University of Szczecin, Poland*

ABSTRACT

The paper describes and compares various (chemical and biological) methods used in Poland for lotic water quality assessment; included are methods which have not been formally approved yet.

Based on ecological surveys made in 1996-1998, a quality assessment of water of rivers Tywa and Rurzyca is presented. The assessment allows to conclude that application of a single method leads to a serious misrepresentation of the lotic biota. In both rivers there were sections the water of which, when assessed with physico-chemical methods, appeared much different than when assessed with biological methods in both seasons of studies.

Key words: lotic biosystems, water quality, saprobity, biotic index, physico-chemical assessment of water.

PRINT

INTRODUCTION

Since the time when, early in the 20th century, Kolkwitz and Marson presented their saprobiological model of water quality assessment, the problem of selecting an appropriate method (biological vs. physico-chemical) has been waiting for a definite solution. All the workers involved admit that both types of water quality assessment are necessary as they are not interchangeable. Hydrobiological indices show the degree to which the ecological equilibrium in streams has been disturbed, while chemical parameters measure concentrations of pollutants and are used to identify their sources [11]. Each author, however, strives to develop his or her own, "unique" method, but there is no tendency to agree upon developing or refining one or several procedures so that they would be universally recognised and produce sufficiently objective and repeatable results [9, 11, 12, 22].

The quality of surface lotic waters is assessed in Poland mainly based on physico-chemical assays, occasionally supplemented with biological analyses which most often amount to determining chlorophyll a content and/or calculating saprobity index for plankton. On the other hand, the benthos, which best reflects the quality of a given stream, is most often disregarded, mainly because of difficulties inherent in determining the taxonomic structure, and also owing to the lack of uniform methods of using benthos for the quality assessment.

River Tywa is a small stream in Western Pomerania. It originates near the village of Góralice. Having covered a distance of 48.0 km, the river debauches into the Eastern Odra, that is into the Dolna Odra power station cooling water canal south of Szczecin (Fig. 1).
The neighbouring river Rurzyca, measuring 44.4 km, is a right-bank Odra tributary and debauches into it at its kilometre 695. The Rurzyca originates near the village Gogolice south of Trzcińsko Zdrój, while its confluence with the Odra occurs in between the villages of Widuchowa and Krajnik Dolny (south of Ognica) (Fig. 1).

The specific hydrography of the two rivers, particularly the variable flow, small depths, narrowness, and variety of benthic habitats (diversity of river bed substrata), results in difficulties when attempting to select an appropriate method to assess the water quality of both the Tywa and the Rurzyca.

MATERIALS AND METHODS

Hydrobiological and chemical data analysed in this work were collected from a total of 16 (8 in each river) permanent sampling sites distributed along the entire river length (Fig. 1).

Biological assessment of water quality

When using aquatic animals, water quality was assessed with the saprobity index and the average score per taxon (ASPT). Zooplankton and macrobenthos were sampled in the two rivers four times during the calendar year.
The saprobity index was determined with the Pantle-Buck procedure for the zooplankters and macrobenthos and calculated according to the formula [3, 26]:

Where: s_i, the values of saprobity index of taxon i in a sample

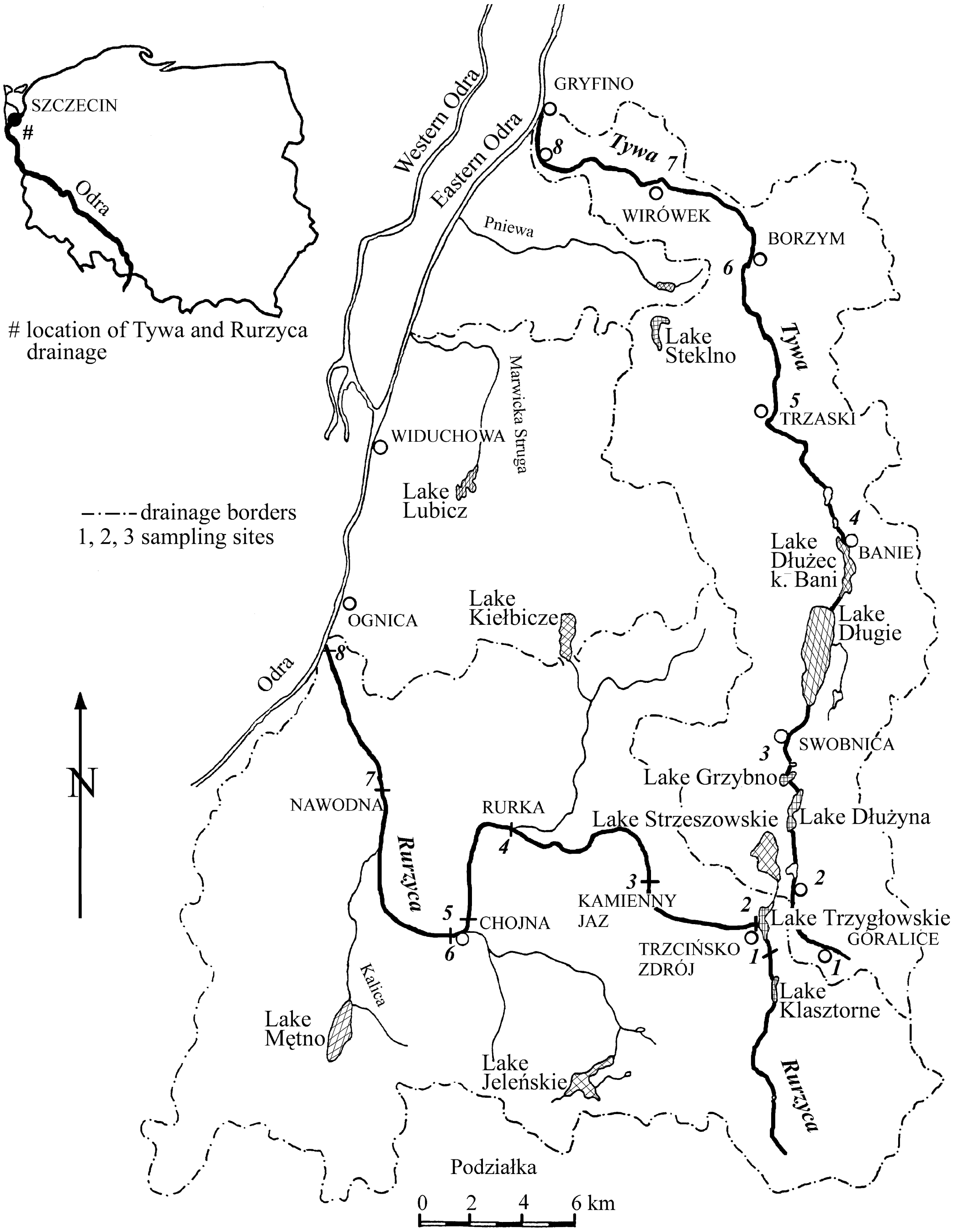
$$S = \frac{\sum_{i=1}^{n}(s_i \cdot h_i)}{\sum_{i=1}^{n} h_i}$$

h_i, relative abundance of taxon i (estimated from an approximate scale)
S, sample saprobity index

The Average Score Per Taxon (ASPT) was calculated for the macrozoobenthos only. The index is based on the assumption that the taxon richness in the benthos reflects water quality. The assessment system involves about 80 families, each being ascribed a score from 1 to 10, depending on its sensitivity to (BMWP index obtained from appropriate tables). The overall ASPT is calculated according to the formula:

$$ASPT = \frac{\text{BMWP index}}{\text{number of families}}$$

Fig. 1. Location of the Tywa and Rurzyca drainages and location of sampling sites



Physico-chemical water quality assessment

The chemical water quality was assessed with two methods: a direct method and a method utilising water quality indices (WQI). Samples for chemical assays were collected monthly throughout two years, from May 1996 until April 1998.

When using the direct method, results of assays on each parameter studied were compared with the corresponding standard for a given quality class. Subsequently, a contribution of the parameter in question to individual quality classes was calculated. The general result for the parameter is a quality class incorporating 90% of the values measured. The general assessment of water quality was arrived as by totalling the percentages of quality classes for each parameter. The method has been for a number of years used by the District Environmental Protection Inspectorate in Szczecin [1, 2, 15].

PRINT

The Water Quality indices (WQI) method was developed at the Department of Water Chemistry and Biology of the Institute of Meteorology and Water Management in Warsaw [4, 6, 20, 24]. The water quality index (WQI) is a number, from 0 to 100; the better the water quality, the higher the number. WQI values were calculated for the basic parameters (oxygen content, BOD_5, dissolved phosphates, dissolved substances, ammonia nitrogen, and nitrite nitrogen) with the squared harmonic mean formula [4, 6, 20, 24, 25]:

$$WQI = \sqrt{\frac{n}{\sum \frac{1}{x_i^2}}}$$

Where n, number of parameters;

x_i, individual index of parameter i; concentrations and contents were converted to individual indices with appropriate formulae [6, 24].

Subsequently, the guaranteed water quality index (WQI_{guar}) was calculated from the formula [4, 6, 20, 24]:

$$WQI_{guar} = WQI_m + WQI_{m+1} - WQI_m\,[P(n+1)-m]$$

Where P is a probability that the 90% guarantee level (that is p=0.9) is not exceeded;

$$P = 1 - p = 0.1;$$

n, number WQI for a given year; for 1996/1997, the Tywa and the Rurzyca had n = 11, n = 12 being the value for 1997/1998;

m, a consecutive number of WQI in an ascending series, calculated from the formula:
m = INT[P(n+1)]; m = 1 for both the Tywa and the Rurzyca, both in 1996/1997 and in 1997/1998;

$WQI_m + WQI_{m+1}$, values of the basic index located at positions m and m+1, respectively, in an ordered sample.

The final classification of the results is based on the 4-tiered water quality scale, described in the Directive of the Minister of Environmental Protection, Natural Resources and Forestry (1991). With respect to the chemical methods, water may belong to quality class I, II or III, or may fall beyond classification. With respect to biological methods, water quality classes correspond to saprobity zone: class I corresponds to xeno- and oligosaprobic zones; class II corresponds to beta-mesosaprobic zone; class III corresponds to alpha-mesosaprobic zone; water beyond classification corresponds to polysaprobic zone. The saprobity index scale used in this work was obtained from reports of the Chief Environmental Protection Inspectorate [3], while a special scale was developed for ASPT [19, 28].

RESULTS

Biological assessment of water quality

River Tywa

During the first season of studies, in 1996/1997, upstream section of the river corresponded to the alpha-mesosaprobic zone (water quality class III), mainly due to the prevalence of such saprophilous organisms as *Tubifex tubifex*, *Asellus aquaticus*, and chironomid larvae (Table 1, Fig. 2). The situation had most likely resulted from a high amount of household sewage discharged into the river from the village of Góralice. The section down to Site 3 was inhabited by the macrobenthos typical of the beta-mesosaprobic zone (quality class II). This improvement in water quality occurred due to a reduction in density of saprophilous animals (*T.tubifex*, the Tanypodinae) and the appearance of organisms characteristic of the beta-mesosaprobic and oligosaprobic zones (i.e., Simulidae, *Glossiphonia complanata*, *Hydropsyche angustipennis*, *Erpobdella monostriata*; Table 1). Water quality was observed to get worse again midstream (from Site 3 down to Site 6), the section being classified as belonging to the alpha-mesosaprobic zone. However, the section was inhabited by both the polysaprobic, alpha-mesosaprobic (i.a., *T.tubifex* and chironomid larvae), and beta- and oligosaprobic organisms (i.a., *Dendrocoelum lacteum*, *Bithynia tentaculata*, *Theodoxus fluviatilis*, *Dreissena polymorpha*). The downstream section (from Site 6 to Site 8) was inhabited by the benthos typical of the beta-mesosaprobic zone (quality class II), as indicated by an increased in density of snails, typical saproxenes (Table 1). Unfortunately, in

PRINT

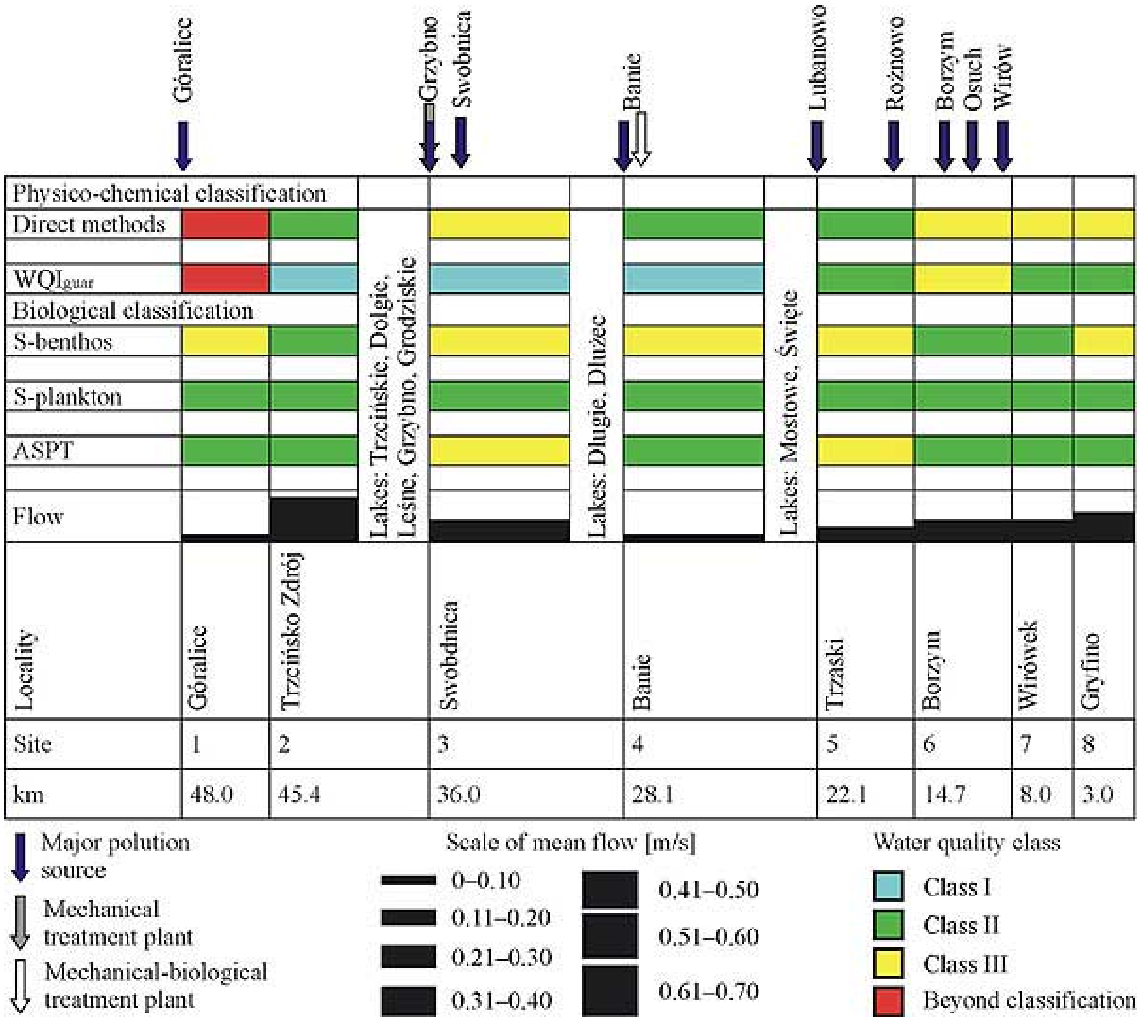
the section adjacent to the Tywa's confluence with the Odra, the macrobenthos became typical of the alpha-mesosaprobic zone (mainly because of a substantial density of *T.tubifex*), i.e., quality class III (Fig. 2, Table 1).

Table 1. Macrobenthic indicator organisms found in the Tywa in the two seasons of studies

Site	1996/1997	1997/1998
1	*Simulium* sp.(l.), *Gammarus fossarum*, *Gammarus roeselii*, *Asellus aquaticus*, ***Tubifex tubifex***	*Sialis*sp. (l.), *Simulium* sp.(l.), *Gammarus fossarum*, ***Gammarus roeselii***, *Asellus aquaticus*, ***Pisidium* sp., *Tubifex tubifex***
2	*Elmis* sp. (l.), ***Simulium* sp.(l. I p.),** *Gammarus fossarum, Gammarus roeselii, Asellus aquaticus, Erpobdella monostriata, Tubifex tubifex*	***Elmis* sp. (l.), *Simulium* sp.(l. I p.),** *Gammarus fossarum, Gammarus roeselii, Asellus aquaticus,* ***Pisidium* sp., *Glossiphonia complanata, Helobdella stagnalis, Tubifex tubifex***
3	*Simulium* sp.(l.), *Bithynia tentaculata, Viviparus viviparus, Glossiphonia complanata, Helobdella stagnalis, Erpobdella monostriata,* ***Tubifex tubifex***	*Pisidium* sp., *Bithynia tentaculata,* ***Tubifex tubifex***
4	***Pisidium* sp., *Dreissena polymorpha, Theodoxus fluviatilis, Bithynia tentaculata,*** *Glossiphonia complanata, Helobdella stagnalis, Haemopis sanguisuga,* ***Tubifex tubifex***	*Neureclipsis bimaculata* (l.), *Hydropsyche* sp. juv.(l.), *Atherix ibis* (l.), *Asellus aquaticus,* ***Dreissena polymorpha,*** *Theodoxus fluviatilis, Bithynia tentaculata, Glossiphonia complanata, Helobdella stagnalis, Erpobdella monostriata, Erpobdella nigricollis, Erpobdella octoculata,* ***Tubifex tubifex***
5	*Sialis* sp. (l.), ***Gammarus roeselii***, *Asellus aquaticus, Helobdella stagnalis, Erpobdella nigricollis,* ***Tubifex tubifex***	*Simulium* sp. (p.), *Gammarus fossarum,* ***Gammarus roeselii,*** *Asellus aquaticus, Pisidium* sp., *Dreissena polymorpha, Planorbarius corneus, Bithynia tentaculata, Piscicola geometra, Glossiphonia complanata, Erpobdella octoculata,* ***Tubifex tubifex,*** *Dendrocoelum lacteum*
6	*Elmis* sp. (l.), ***Gammarus fossarum,*** *Gammarus roeselii,* ***Pisidium sp., Theodoxus fluviatilis,*** *Glossiphonia complanata, Erpobdella nigricollis,* ***Tubifex tubifex***	*Ephemera vulgata* (l.), *Potamanthus luteus* (l.), *Elmis* sp. (l.), ***Gammarus fossarum, Gammarus roeselii, Pisidium* sp., *Theodoxus fluviatilis,*** *Bithynia tentaculata,* ***Tubifex tubifex***
7	*Halesus digitatus* (l.), *Sialis* sp. (l.), *Simulium* sp.(l.), ***Gammarus fossarum, Gammarus roeselii,*** *Asellus aquaticus,* ***Pisidium* sp.,** *Ancylus fluviatilis, Theodoxus fluviatilis, Bithynia tentaculata, Viviparus viviparus,* ***Tubifex tubifex***	*Ephemera vulgata* (l.), *Halesus digitatus* (l.), *Sialis* sp. (l.), *Simulium* sp.(l.), *Gammarus fossarum, Gammarus roeselii, Asellus aquaticus, Pisidium* sp., *Ancylus fluviatilis, Theodoxus fluviatilis, Bithynia tentaculata, Viviparus viviparus,* ***Tubifex tubifex, Dendrocoelum lacteum,***
8	*Elmis* sp. (l.), *Rhyacophila nubila* (l.), *Hydropsyche* sp. juv.(l.), ***Gammarus fossarum***, *Pisidium* sp., *Helobdella stagnalis,* ***Tubifex tubifex***, *Dendrocoelum lacteum*	***Elmis* sp. (l.), *Gammarus fossarum, Pisidium* sp., *Theodoxus fluviatilis, Tubifex tubifex***

PRINT

Fig. 2. Water quality in River Tywa in 1996/1997 as assessed with physico-chemical and biologi-cal methods, with major sources of pollution and location of sewage treatment plants

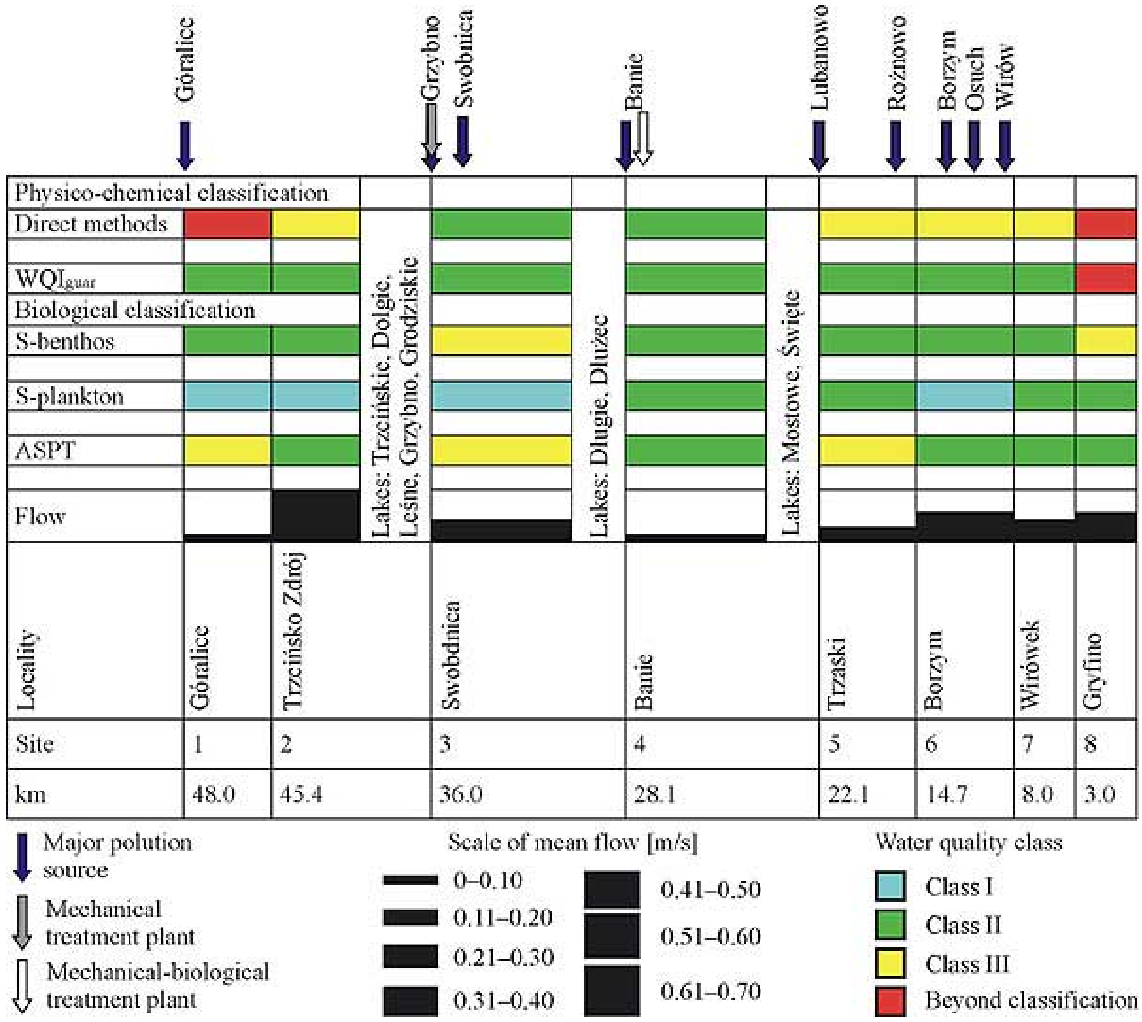


During the subsequent season of study, 1997/1998, the macrobenthos in the Tywa was found to include more species preferring weakly polluted water. It was only within the section extending from the village of Swobnica (Site 3) to the town of Banie (Site 4) as well as near the confluence that the Tywa's water corresponded to the alpha-mesosaprobic zone (a high density of saprophilous chironomid larvae and *T.tubifex*), the remaining sections corresponding to the beta-mesosaprobic zone (Fig. 3; Table 1). It was unusual to find, at Site 4 at Banie, a high concentration of *Dreissena polymorpha*, a species classified by Turoboyski [27] as saproxenic. In the beta-mesosaprobic zone, such species may occur at low densities or sporadically in summer only, while in the Tywa they were present at high densities even in winter [19]. Piechocki [17] as well as Piechocki and Dyduch-Falniowska [18] reported the bivalve to be tolerant of water pollution and to be able to live even in the beta-mesosaprobic zone, which was confirmed by our finding it in the Tywa.

The zooplanktonic indicator species recorded in 1996/1997 all along the Tywa classified the river with the beta-mesosaprobic zone, corresponding to water quality class II (Fig. 2). In 1997/1998, an improvement in water quality was observed from the sources downstream to Site 4 (Banie) where the zooplankton indicator species were even typical of unpolluted water, i.e., the oligosaprobic zone. A similar structure of zooplankton was recorded midstream between Sites 6 and 7. The remaining sections of the Tywa belonged to moderately polluted and corresponded, by zooplankton indicators, to the beta-mesosaprobic zone (Fig. 3).

In 1996/1997, as assessed with the ASPT index, the almost entire Tywa (excluding two sections) harboured a fauna typical of water quality class II (beta-mesosaprobic zone), that is was moderately polluted. It was only midstream, from Site 3 to Site 4 and from Site 5 to Site 6 that the water was classified with quality class III (alpha-mesosaprobic zone) (Fig. 2). In 1997/1998, the same sections as well as the source area of the Tywa were classified, by ASPT, as representing the alpha-mesosaprobic zone, the remaining sections housing macrobenthos typical of the beta-mesosaprobic zone (Fig. 3).

Fig. 3. Water quality in River Tywa in 1997/1998 as assessed with physico-chemical and biologi-cal methods, with major sources of pollution and location of sewage treatment plants



River Rurzyca

As indicated by the zooplankton saprobity index, the river – along its entire course and throughout the two years of study – were classified as representing the beta-mesosaprobic zone (quality class III) (Figs 4 and 5). At two sites (in the town of Chojna: Sites 5 and 6) the water quality was even indicating a shift to the oligosaprobic zone (quality class I). That fact can be explained by a slowly proceeding self-treatment process in the river, but the discharge of sewage at Chojna resulted in environmental degradation, as evidenced by a reduction in water quality to class II and the beta-mesosaprobic zone (1996/1997; Fig. 4). This situation prevailed down to the near-confluence (Site 8) (Figs 4 and 5).

Judging by the macrobenthos saprobity scale, the Rurzyca water quality placed the river within the alpha- and beta-saprobic zone (water quality classes III and II) (Figs 4 and 5). The upstream part was classified with the lower saprobity zone (alpha-mesosaprobic), particularly in 1996/1997. The saprobity method of water quality assessment, as applied to the Rurzyca, demonstrated also a degrading effect of water pollution on the benthic community at Site 2, downstream of Lake Trzygłowskie. The presence of poly- and alpha-mesosaprobic indicators *T.tubifex*, chironomid larvae, and some hirudinean species (Table 2) was recorded. A certain improvement of water quality was observed during the subsequent year (Fig. 5), when the proportion of *T.tubifex* decreased substantially in favour of the species typical of the beta-mesosaprobic and oligosaprobic zones, i.e., *Neureclipsis bimaculata* and the Simulidae (Table 2). The Rurzyca's capability of self-treatment is evidenced by the shift to the beta-mesosaprobic zone in the midstream part (Sites 4, 5, and 6) (Figs 4 and 5). The importance of such oligosaprobic and beta-mesosaprobic species as *Elmis* sp., *Rhyaophila fasciata*, *Ancylus fluviatilis*, *Pisidium* sp., *Ephemerella ignita*, and the Simulidae was observed to increase there (Table 2). This situation was not, however, maintained for long because the discharge of sewage and pollution at Chojna resulted in a deterioration of water quality to the alpha-mesosaprobic zone downstream (Site 7) (Figs 4, 5). In the confluence area, a clear improvement in the Rurzyca water quality was observed, the river re-entering the beta-mesosaprobic zone (water quality class II) (Figs 4, 5). A number of oxyphilous benthic species typical of oligosaprobic water, such as *Piscicola geometra* and *Dreissena polymorpha*, as well as beta-mesosaprobic indicators (*Stylaria lacustris*, *Unio timidus*, some snail species) were found dwelling there (Table 2).

Fig. 4. The final quality assessment of the Rurzyca, based on results of physico-chemical and bio-logical methods, with major sources of pollution and location of sewage treatment plants in 1996/1997

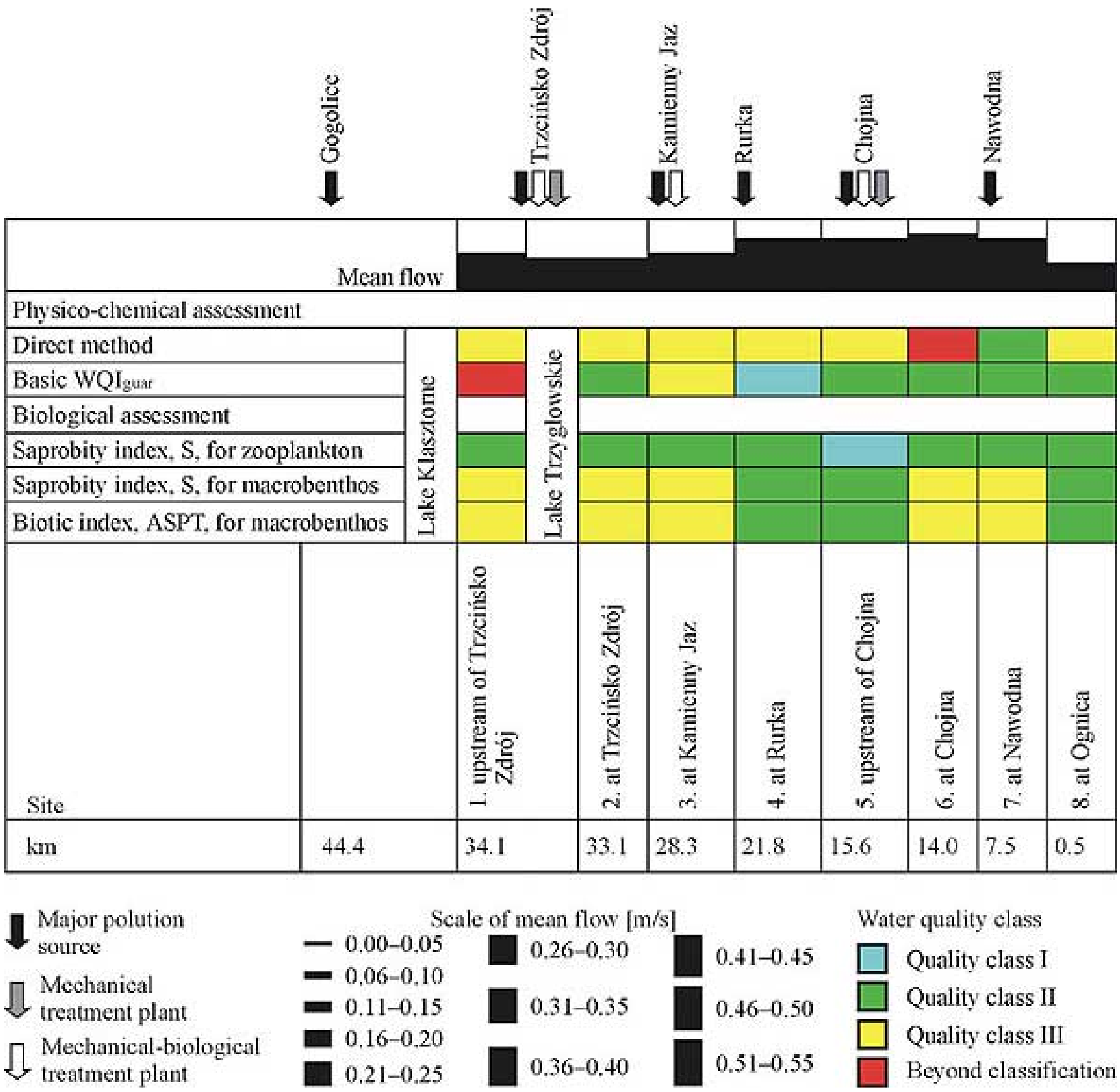
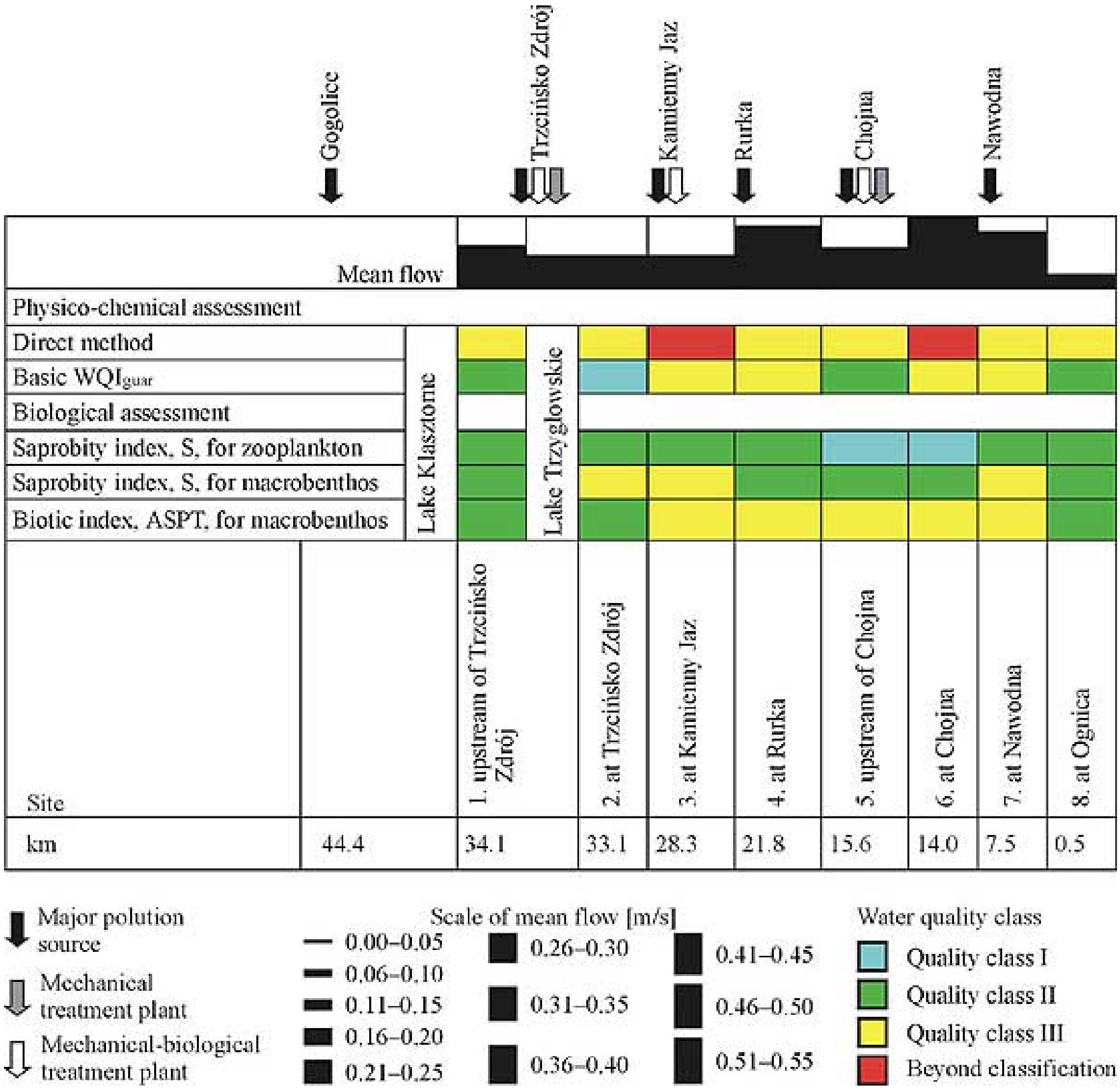


Fig. 5. The final quality assessment of the Rurzyca, based on results of physico-chemical and bio-logical methods, with major sources of pollution and location of sewage treatment plants in 1997/1998



Results obtained for the macrobenthic ASPT index in the Rurzyca were comparable, and in 1996/1997 even identical, with those arrived at with the saprobity scale, and placed the river in the water quality classes II and III (beta- and alpha-mesosaprobic zones) (Figs 4, 5). In 1996/1997 the entire river, except Sites 4, 5 and 8 ascribed to the beta-mesosaprobic zone (water quality class II), showed the characteristics of the alpha-mesosaprobic zone (water quality class III) (Fig. 4). In 1997/1998, the water at Sites 1 and 2 (Trzcińsko Zdrój) was classified as the alpha-mesosaprobic zone (water quality class III), while the near-confluence section showed the presence of benthic organisms typical of the beta-mesosaprobic zone (water quality class II) (Fig. 5).

PRINT

Table 2. Macrobenthic indicator organisms found in the Rurzyca in the two seasons of studies

Site	1996/1997	1997/1998
1	*Simulium sp.* (l.), *Neureclipsis bimaculata* (l.), *Sialis lutaria* (l.), *Asellus aquaticus, Pisidium sp., Ancylus fluviatilis, Bithynia tentaculata, Glossiphonia complanata, Glossiphonia heteroclita, Helobdella stagnalis, Erpobdella testacea, Erpobdella octoculata, Erpobdella nigricollis, Tubifex tubifex, Dendrocoelum lacteum*	*Simulium sp.* (l.), *Neureclipsis bimaculata* (l.), *Sialis lutaria* (l.), *Gammarus roeselii, Asellus aquaticus, Pisidium sp., Ancylus fluviatilis, Glossiphonia complanata, Glossiphonia heteroclita, Helobdella stagnalis, Erpobdella testacea, Erpobdella octoculata, Erpobdella nigricollis, Tubifex tubifex, Dendrocoelum lacteum, Planaria torva*
2	*Asellus aquaticus, Bithynia tentaculata, Glossiphonia heteroclita, Helobdella stagnalis, Erpobdella testacea, Erpobdella octoculata, Erpobdella nigricollis, Tubifex tubifex*	*Neureclipsis bimaculata* (l.), *Gammarus roeselii, Helobdella stagnalis, Erpobdella testacea, Erpobdella octoculata, Erpobdella nigricollis, Tubifex tubifex*
3	*Asellus aquaticus, Pisidium sp., Gyraulus albus, Bithynia tentaculata, Glossiphonia complanata, Glossiphonia heteroclita, Helobdella stagnalis, Tubifex tubifex*	*Asellus aquaticus, Pisidium sp., Bithynia tentaculata, Glossiphonia complanata, Glossiphonia heteroclita, Helobdella stagnalis, Erpobdella testacea, Erpobdella octoculata, Tubifex tubifex, Dendrocoelum lacteum*
4	*Simulium sp.* (l., p.), *Elmis sp.* (l.), *Gammarus fossarum, Gammarus roeselii, Pisidium sp., Tubifex tubifex*	*Simulium sp.* (p.), *Ephemerella ignita* (l.), *Elmis sp.* (l.), *Gammarus fossarum, Gammarus roeselii, Pisidium sp., Ancylus fluviatilis, Tubifex tubifex*
5	*Sericostoma personatum* (l.), *Gammarus fossarum, Gammarus roeselii, Pisidium sp., Tubifex tubifex*	*Gammarus fossarum, Gammarus roeselii, Pisidium sp., Tubifex tubifex*
6	*Simulium sp.* (p.), *Gammarus roeselii, Pisidium sp., Glossiphonia complanata, Helobdella stagnalis, Erpobdella octoculata, Erpobdella nigricollis, Dina lineata, Tubifex tubifex*	*Simulium sp.* (l., p.), *Gammarus fossarum, Gammarus roeselii, Asellus aquaticus, Pisidium sp., Helobdella stagnalis, Erpobdella nigricollis, Dina lineata, Tubifex tubifex*
7	*Gammarus roeselii, Pisidium sp., Erpobdella octoculata, Tubifex tubifex*	*Simulium sp.* (l.), *Elmis sp.* (l.), *Hydropsyche sp. juv.* (l.), *Gammarus fossarum, Gammarus roeselii, Pisidium sp., Glossiphonia complanata, Glossiphonia heteroclita, Erpobdella octoculata, Erpobdella monostriata, Tubifex tubifex*
8	*Ephemerella ignita* (l.), *Asellus aquaticus, Unio tumidus, Pisidium sp., Dreissena polymorpha, Ancylus fluviatilis, Theodoxus fluviatilis, Bithynia tentaculata, Viviparus viviparus, Piscicola geometra, Glossiphonia complanata, Glossiphonia heteroclita, Helobdella stagnalis, Erpobdella octoculata, Erpobdella nigricollis, Tubifex tubifex, Stylaria lacustris*	*Gammarus roeselii, Unio tumidus, Pisidium sp., Dreissena polymorpha, Viviparus viviparus, Helobdella stagnalis, Tubifex tubifex, Stylaria lacustris*

Organisms occurring at highest densities are printed in boldface; l, larvae; p, pupae

Physico-chemical assessment of water quality

River Tywa

As assessed with the direct method, the Tywa water in 1996/1997 in the section extending from Site 1 to Site 2 corresponded to the water beyond classification (Fig. 2). This poor result was brought about by the nitrite nitrogen concentration (more than 60% of samples failed to meet the quality standard) as well as by the total suspended particulates and total phosphorus (about 30% of samples failed to meet the quality standard). The river chemistry in the section from Site 2 to Site 3 showed an improvement and allowed to classify the water as class II (about 50% of the parameters reached values corresponding to those required by the class) (Fig. 2). It

PRINT

was only the suspended particulates and nitrite nitrogen than corresponded to quality class III. The water between Sites 3 and 4 corresponded to that in water quality class III (Fig. 2), because of nitrite nitrogen concentrations (more than 50% failing to meet the standard) and suspended particulates, exceeding the standard by 30%. The midstream section water, from Site 4 to Site 6, was found to belong to quality class II (Fig. 2). The water quality class limits were exceeded by the total suspended particulates, nitrite nitrogen, and total phosphorus, but this did not affect the general classification of the section [19]. The downstream part of the Tywa, from Site 6 to the confluence with the Odra, carried water belonging to quality class III (Fig. 2). The quality deteriorated due to the total suspended particulates, nitrite nitrogen, and total phosphorus concentrations [19].

In 1997/1998, the near-source part of the Tywa was categorised as falling beyond the quality classification (Fig. 3) as allowed limits for the total phosphorus, nitrite nitrogen, and total suspended particulates were grossly exceeded, as was the case the previous year. The parameters deciding that the section between Sites 2 and 3 was ascribed to quality class III were total suspended particulates, nitrite nitrogen, nitrate nitrogen, and total phosphorus. On the other hand, the section between Sites 3 and 5 had water qualified generally as class II (Fig. 3), in spite of the fact that the total phosphorus content and the total suspended particulates concentration were typical of class III or did not meet any standard. Beginning with Site 5, a deterioration of water quality, relative to 1996/1997, was observed. The downstream section, between Sites 5 and 7, corresponded to quality class III (Fig. 3), mainly because of the values recorded for nitrite nitrogen, total phosphorus, and total suspended particulates [19]. The near-confluence section, due to the high concentration of dissolved phosphates, total phosphorus, and total suspended particulates fell beyond the quality classification scale (Fig. 3).

When using the WQI_{guar} to assess the Tywa's water quality with the basic parameters which play a key role in shaping the qualitative and quantitative structure of the biota, only the near-source section fell, in 1996/1997, beyond the classification scale (Fig. 2). Upstream and midstream, the Tywa's water was very clean (quality class I), while in the downstream section between Sites 6 and 7 the water qualified as belonging to quality class III, the remaining sections corresponding to class II (Fig. 2). In 1997/1998, with the exception of the near-confluence area beyond quality classification, the Tywa's water corresponded to quality class II (Fig. 3).

River Rurzyca

When assessed with the direct method, the Rurzyca water quality oscillated between class II and the state beyond the classification scale, class III water being found in the mid- and upstream sections (Sites 1 to 4) (Fig. 4). In the second year of study, the water quality deteriorated beyond the classification scale at Site 3 in the village of Kamienny Jaz and at Site 6 at Chojna (Fig. 5). Water quality improved again (to class III) in the downstream and near-confluence sections, the class II standards even being met in 1996/1997 at Site 7 in the village of Nawodna (Figs 4 and 5). The parameters decisive for such poor state of the Rurzyca's water were the dissolved oxygen content, BOD_5, total suspended particulates, nitrite nitrogen, dissolved phosphates, total phosphorus, and – additionally in the near-confluence section – COD_{Cr}. Values of those parameters corresponded, in most samples, to quality class III standards. Not infrequently, the values of some parameters, suspended particulates, nitrites, and total phosphorus in particular, failed to meet even those standards and fell beyond the classification scale. On the other hand, a number of parameters (dissolved oxygen, pH, chlorophyll a, water mineralisation parameters) corresponded to standards of classes I and II. The heavy metals levels reached minimal values along the entire course of the river and corresponded to those of quality class I [28].

Based on the yearly basic WQI_{guar} values, the Rurzyca's water quality proved to be much better than it would appear from the assessment made with the direct method. A higher percentage of the river could be placed within quality class II, and even I (Figs 4 and 5). In 1996/1997, the downstream (Sites 5 – 8) Rurzyca's water showed a quality better than in the following year (Fig. 4) and was placed in quality class II. In 1997/1998, the chemistry of that section was less favourable for quality classification: the water quality deteriorated to class III, Site 8 only being placed in class II (Fig. 5). On the other hand, water in the upstream section (Sites 1 and 2) showed, in 1996/1997, a quality poorer than that found the following year. Water at Sites 1 and 2 had been described as beyond classification and quality class II, respectively (Fig. 4) in 1996/1997, while the following year, the quality improved to class III and I, respectively (Fig. 5).

DISCUSSION

The WQI_{guar} values obtained in this study could be taken as indicating a very low degree of pollution of the Tywa (quality class I) and a very intense process of self-treatment proceeding in the river. Along a barely 3.0 km long section (from the source down to Site 3), the water quality changed from the state beyond classification to quality class I (Figs 2 and 3). The direct method yielded less optimistic results, but a tendency toward discrete improvement in quality class between various sections could be observed as well. Along the section mentioned, water quality, as assessed with the two methods, changed from the state beyond classification to class II (Figs 2 and 3). Similarly, with respect to the quality of the Rurzyca, the WQI_{guar} yielded a more favourable classification, a larger portion of the river being placed in class II, while two sections (Sites 4 and 2) corresponded even to class I, which was not the case when using the direct method (Figs 4 and 5). The hydrochemical method of quality assessment in small rivers reflects the instantaneous water quality, the state constantly changing due to the water dynamics (changing flow) and, to a degree, to the self-treatment process. The water quality assessment according to physico-chemical criteria is, in fact, a result of a number of complex hydrological and chemical processes.

At the same time, there is a clear discrepancy between the result of assessment obtained with physicochemical and biological (both the saprobity and ASPT indices) criteria. The macrobenthos taxonomic structure in both rivers in 1996/1997 and 1997/1998 placed the water in quality classes II and III, while the zooplankton-based indices demonstrated the water quality to have corresponded, in 1996/1997, to class II in the Tywa and class I/II in the Rurzyca, class I/II being indicated in both rivers in 1997/1998 (Figs 2-5). The riverine zooplankton is a rather transient element of the biota and should be included into the water quality assessment as an additional index only. Much more reliable is an assessment based on the macrobenthos as it eliminates the influence of instantaneous effects. The bottom-dwelling organisms are more stable in terms of persisting in their habitat and ecological niches because they disappear only after having endured a prolonged period of unfavourable environmental conditions. Not all the physico-chemical parameters reach values which exceed tolerance limits of those organisms or affect them negatively. However, it was not only the water physico-chemical parameters that affected the Tywa’s and Rurzyca’s biota. Influential were also such biotope components as the substratum and the current flow, the latter frequently alleviating pollution effects; the effects of those biotope components could be deduced solely from results of biological analyses. Starmach [22] reports that the degree of water pollution has on a number of occasions been assessed with biological methods and with chemical assays, and the results compared. The comparison showed that the two kinds of methods produced compatible results in extreme cases only, that is when either strongly polluted or clean water was assessed, while the assessments applied to all the intermediate cases produced differences or wide discrepancies. The authors’ own studies on the Tywa water confirmed this conclusion in part only. It was only in 1996/1997 in the source area that comparable results were obtained: the “beyond classification” quality with the direct method and QWI and quality class III with the saprobiological evaluation. The other biological method, that employing ASPT and taking into the consideration the entire macrobenthic community produced a score corresponding to quality class II (Fig. 2). Assessment of the remaining sections of the river always produced discrepancies between biotic and abiotic methods (Figs 1 and 2). The most polluted Rurzyca’s Site 6 at Chojna fell beyond the classification scale in the chemical classification (the direct method) in 1996/197 and 1997/1998 (Figs 4 and 5). Similar were the results of the biological assessment: the water was classified as belonging to quality class III, using both the saprobity index and ASPT, in 1997/1998 only (Fig. 5). In both the Tywa and the Rurzyca, when the saprobiological method was used, a characteristic overlap of saprobic zones was observed. Apart from organisms typical of polluted water, the presence (sometimes at high densities) of species characteristics of clean habitats (Tables 1 and 2) was recorded. The cause of this coexistence should be sought primarily in the hydrology and chemistry of the water. The fast current, diverse substratum, very good oxygenation, and moderate concentrations of nutrients and organic matter created conditions appropriate for species differing in their requirements. Thus, the general assessment was influenced by those species which occurred with higher densities and were dominant in the biota, although they were accompanied by species regarded as typical of clean water, which greatly complicated the saprobity-based assessment of the degree of pollution in the river [7, 16]. Moreover, the macrobenthic species encountered in the Tywa and the Rurzyca are all eurytopic: they can dwell within a wide range of environmental parameters, thus they perform poorly in saprobiological classification. Stenotopic species do not usually reach high densities and constitute adominants, thus they do not affect the general assessment [12]. When only some species adapt to invariant environmental conditions, a shift in domination or elimination of less resistant species ensues, which is reflected in the saprobiological evaluation [23]. There are species which are capable of adapting to new conditions and appear at completely different pollution zones, particularly if the latter are well oxygenated [10}, as was the case in the Tywa and the Rurzyca.

In fact, the saprobic method of water quality classification is obsolete at present and used only in Poland and in Germany. In other western European countries as well as in the U.S., methods utilising invertebrates and based on biotic indices (Europe) or diversity indices (United States) dominate [13]. A good, albeit not infallible, index is ASPT reflecting the sensitivity of different invertebrate families to pollution [8]. The families have wider possibilities to adapt to various environmental factors than single species and are partly or completely eliminated after a drastic and/or prolonged change in abiotic conditions (e.g., sewage discharge) [23]. For this reason, calculation of ASPT provides a better reflection of water quality in a stream than the saprobiological assessment. A biotic index, when used to assess water quality, is not affected by densities of various family members, thus unfavourable and frequently spurious effects (depending, to a high degree, on the structure and local particulars of the biotope and other abiotic factors, e.g., flow velocity). On the other hand, qualification of water, based on the family- or higher taxon-level identification of animals introduces a sizeable error, because not all the species react to pollution in an identical way. For instance, the Oligochaeta receive 1 score point only, while oligochaetes are known to live both in clean and differently polluted water [8].

Finally, a problem should be addressed which of the physico-chemical methods produces a more comprehensive picture and better reflects the water quality in a stream under assessment: the direct method or WQI_{guar}? The unquestionable advantage of WQI is the simplicity of calculation; to predict changes in water quality, the knowledge on characteristic flows is not necessary. The calculation of individual indices avoids difficulties produced by the discrete way of quality assessment with the direct method. For example, the quality class I standard calls for BOD_5 to be less than 4 mg O_2/l. If, then, two sites are compared, one with BOD_5 of 3.9 and the other with 4.1 mgO_2/l, the direct method would conclude that the two sites belong to different classes! whereas the actual difference between water quality at the two sites is very small. The value of 4 mgO_2/l is artificial and arbitrary [25]. From a comparison of results for 1996/1997 for the Tywa and the Rurzyca (Figs 2 and 4), produced by the hydrochemical methods and the biological one, it could be inferred that the direct method results were more compatible with the biological assessment. However, in 1997/1998 (Figs 3 and 5), it urned out that the water quality index method results were closer to the biological assessment. This example shows why the problem is so difficult to solve. It would be helpful to recall now the physico-chemical parameters included in the WQI_{guar}: dissolved oxygen, dissolved substances, dissolved phosphates, BOD_5, nitrate nitrogen, and ammonia nitrogen, that is the parameters affecting living organisms the strongest. Should the direct method be limited to those parameters only, the Tywa water in 1996/1997 would be placed with water quality class I/II [19}, while the Rurzyca would carry water corresponding to quality class II/III [28]. The final result, then, would be close to that obtained with WQI_{guar}, although the final result would still be decided upon by a single, most unfavourable, factor. The water quality index is a composite of all the indices, and thus paints a more comprehensive picture of water quality. It seems, however, that WQI should be supplemented with a biological component, which would allow it to include natural conditions of the riverine ecosystem evaluated [14]. When assessed with the direct method, both the Tywa and the Rurzyca showed, as the most critical factors failing to meet the quality standard, the following parameters: total suspended particulates, nitrite nitrogen, and total phosphorus [19, 28]. This could be the cause of discrepancies between results obtained with the direct method and WQI, because the latter disregards those parameters. As stated by Dojlido and Woyciechowska [5], it seems that the standards set for those parameters are too rigorous. Certain corrections to the standards used in Poland are in order; this is particularly relevant with respect the allowed concentrations of, primarily, phosphate, total phosphorus, and nitrite nitrogen.

CONCLUSIONS

The quality of water in both the Tywa and Rurzyca was good, but the changing environmental conditions greatly affected the results of the final assessment. When the water was assessed with the saprobiological system involving macorobenthic indicators, the saprobic zones changed from alpha-mesosaprobic to beta-mesosaprobic, the overlap of different zones in individual sections of the river being visible. The overlap resulted from the fact than organisms typical of polluted water occurred side by side with animals regarded widely as characteristic of clean water. When zooplankters were used as indicators, the saprobity zones changed from oligosaprobic to beta-mesosaprobic, the presence of a certain species in a give place depending mostly on the flow velocity. When classified with the direct method, the near-source and near-confluence sections of the Tywa did not meet the quality standard.In the Rurzyca, the sections experiencing sewage discharge (Trzcińsko Zdroj in the upper section; Chojna in the midstream section; and locally at Kamienny Jaz) failed to meet the quality standards. Water of the remaining sections was placed in the quality class II and III. When assessed with the guaranteed Water Quality Indices (WQI_{guar}), the classification changed within wider limits than those resulting from using the direct method: from clean water (quality class I) to strongly polluted (beyond the classification scale).

The best solution would be to rely on the ecological assessment of lotic waters, already in use in numerous European countries; the assessment involving chemical and biological methods. When assessed this way, the Tywa would be found to carry water of quality class I, while the Rurzyca water would correspond to quality class II/III.

REFERENCES

1. Anonimus, Principles of assessment of surface lotic waters for the needs of regional monitoring. Ministry of Environmental Protection, Natural Resources, and Forestry, Appendix 1 of 6 Nov. 1990; Warsaw, 1990. [In Polish].
2. Anonimus, Water quality rivers subjected to regional monitoring in the hydrologic year 1994. State Inspectorate of Environmental Protection, Szczecin, 1995; unpublished manuscript. [In Polish].
3. Anonimus, A method for performing saprobity assays; Chief Inspector of Environmental Protection – 002.97-W.4, State Inspectorate of Environmental Protection, Warsaw, 1997; unpublished manuscript. [In Polish].
4. Dojlido J., Raniszewski J., Woyciechowska J., 1994, Water quality index appplied to river in the Vistula. River basin in Poland. Enviromental Monitoring and Assessment 33: 33-42.
5. Dojlido J., Woyciechowska J, 1999, Quality assessment in riverine water: a proposal for a new method, Gospod. Wod. 4: 142-147. [In Polish].
6. Dojlido J., Woyciechowska J., Morawiec P., 1997, Analysis of methods used to assess riverine water quality and verification of the currently used system, (unpublished manuscript), IMGW, Warszawa. [In Polish].
7. Dratnal E., Dumnicka E., 1982, Composition and zonation of benthic invertebrate communities in some chemically stressed aquatic habitats of Niepołomice Forest (South Poland). Acta Hydrobiol. 24 (2): 151-165.
8. Dumnicka E., 1994, Habitat preferences of invertebrates (expecially Oligochaeta) in a stream. Acta Hydrobiolog. 36 (1): 91-101.
9. Klimowicz H., 1981a, Unification of biological methods for surface water control, Gaz, Woda i Technika Sanitarna. 3: 62-63. [In Polish].
10. Klimowicz H., 1981b, Aquatic organisms as bioindicators of water pollution, Gaz, Woda i Technika Sanitarna 4: 87-88. [In Polish].
11. Klimowicz H., 1985, Applicability of hydrobiological classification of waters, Gaz, Woda i Technika Sanitarna 5-6: 134-136. [In Polish].
12. Klimowicz H., 1987, The importance of hydrobiological research in water protection, Gaz, Woda i Technika Sanitarna 4: 90-92. [In Polish].
13. Kołodziejczyk A., Koperski P., Kamiński M., 1998, A key to identification of freshwater invertebrate macrofauna for environmental bioindication, Biblioteka Monitoringu Środowiska PIOŚ, Warszawa. [In Polish].
14. Kudelska D., Soszka H., 1996, A review of methods used in different countries for assessment and classification of surface waters, Biblioteka Monitoringu Środowiska PIOŚ, Warszawa.
15. Landsberg-Uczciwek M. (red.), 1997, Report on the state of the environment in the District of Szczecin within 1995-1996, Bibl. Monit. Środow. PIOŚ, Szczecin. [In Polish].
16. Narloch L., 1975, Benthic fauna of the stream Kochłówka (Upper Silesia) against the background of saprobity indices, Arch. Ochr. Środ. 1: 177-236. [In Polish].
17. Piechocki A., 1979, Molluscs (Mollusca), snails (Gastropoda). The freshwater fauna of Poland, 7, PWN, Warszawa-Poznań. [In Polish].
18. Piechocki A., Dyduch-Falniowska A., 1993, Molluscs (Molusca). Bivalves (Bivalvia). Freshwater Fauna of Poland, 7A. PWN, Warszawa, 1993. [In Polish].
19. Raczyńska M., 1999, Diversification in the structure of invertebrate fauna as affected by conditions of River Tywa biotope in 1996-1998; PhD Thesis, Agricultural University, Szczecin. [In Polish].
20. Raniszewski J., Dojlido J., Woyciechowska J., 1993, Water quality index. Application in the assessment of the Vistula catchment quality, Wiad. IMGW 16 (2): 11-25. [In Polish].
21. Directive of Minister of Environmental Protection, Natural Resources, and Forestry of 5 November 1991 concerning water classification and standards to be met by sewage discharged to waters or into the soil] [in Polish, Dz.U. nr 116 poz.503 z dn. 16.12.1991r. [In Polish].
22. Starmach K., 1968, Polluted waters, Nauka Dla Wszystkich 67: 3-33. [In Polish].
23. Starmach K., 1972, Self-treatment of rivers as a biological problem, Kosmos Ser. A 2: 636-645. [In Polish].
24. Stojda A., Dojlido J., Woyciechowska J., 1985, Water quality assessment with water quality index, Gospod. Wod. 12, 1985, 281-284. [In Polish].
25. Stojda A., Dojlido J., Woyciechowska J., 1986, Water quality index and a method used so far, Gospod. Wod. 1: 23-25. [In Polish].
26. Szyjkowski A., Kotowicz J., Rzepecka D., Teodorowska R., 1992, Biological monitoring. Biological methods of water quality assessment (unpublished manuscript), IMGW, Wrocław zał. 4. [In Polish].

PRINT

27. Turoboyski L. (red.), 1976b, Atlas of indicator organisms for surface water quality assessment, Skrypty Akademii Rolniczo-Technicznej, Olsztyn. [In Polish].
28. Żurawska J., 1999, Effects of selected abiotic and biotic indicators of water quality on the River Rurzyca biosystem in 1996-1998. Ph.D.Thesis, Agricultural University in Szczecin. [In Polish].

Submited:

Malgorzata Raczynska, Juliusz C.Chojnacki
Department of Marine Ecology and Environmental Protection
Faculty of Marine Fisheries and Technology
Agricultural University of Szczecin
Kazimierza Królewicza 4H, 71-550 Szczecin, Poland

Joanna Zurawska
Department of Biostructure,
Institute of Physical Culture
Faculty of Natural Sciences
University of Szczecin
Al. Piastów 40b, 71-065 Szczecin, Poland