ARCHIVES OF ENVIRONMENTAL PROTECTION
ARCHIWUM OCHRONY ŚRODOWISKA
vol. 31 no. 1 pp. 31 - 42 2005

PL ISSN 0324-8461

HYDRO-CHEMICAL CHARACTERISTIC OF THE BYTOMKA RIVER

WITOLD NOCOŃ, MACIEJ KOSTECKI

Instytut Podstaw Inżynierii Środowiska Polskiej Akademii Nauk
ul. M. Skłodowskiej-Curie 34, 41-819 Zabrze

Keywords: Bytomka River, hydrochemistry, Upper Silesia, water classification.

CHARAKTERYSTYKA HYDRO-CHEMICZNA RZEKI BYTOMKI

W niniejszej publikacji przedstawiono wyniki badań jakości wody rzeki Bytomki przeprowadzone w okresie wrzesień 2003 – styczeń 2004. Scharakteryzowano jakość wody pod względem ogólnych wskaźników fizyczno-chemicznych. Bardzo niskie stężenia tlenu rozpuszczonego, a także wysokie stężenia azotu amonowego i ChZT spowodowane są prawdopodobnie zrzutami nieoczyszczonych ścieków bytowo-gospodarczych. Wysokie zasolenie wody spowodowane jest odprowadzaniem do rzeki wód pochodzących z kopalń węgla kamiennego zlokalizowanych na terenie zlewni. W zakresie omawianych wskaźników (poza odczynem i azotem azotanowym) rzeka Bytomka prowadzi wody pozaklasowe. Porównując jakość wody na przestrzeni ostatnich kilkunastu lat, pomimo prowadzenia na terenie zlewni działań z zakresu ochrony środowiska, nie zauważa się znaczącej poprawy jakości wody, a zasolenie rzeki systematycznie wzrasta. Zmiana tego stanu w rzece Bytomce wymaga zdecydowanej poprawy gospodarki wodno-ściekowej w zlewni rzeki.

Summary

This study includes the results of investigations carried out on the Bytomka River which were made from September 2003 to January 2004. The results emphasized the changes of physico-chemical parameters of water quality. Low concentration of dissolved oxygen and high concentration of ammonium nitrogen and COD are probably caused by the discharge of municipal waste-water. High salinity is caused by coal-mines water from the river basin area. All of the discussed parameters of water quality (except for pH-index and nitrate nitrogen) are beyond official classification. Although in the river basin area there are currently activities which protect the environment, no changes of water quality have been observed except for the salinity which is growing up all the time. Improvement of the existing situation will be possible only if firm waste-water managements action is taken.

INTRODUCTION

The central part of Upper Silesia is one of the most transformed regions of Poland [2–4, 12]. Superficial and deep-seated mining exploitation, urbanization and other industrial activities had resulted in irreversible changes in geographic environment [1]. Exploitation of mineral stuffs caused intensive industrial expansion and afflux of people [2].

Upper Silesia rivers may be divided into two groups: rivers with agricultural basin area (the Drama, the Potok Toszecki), and rivers with industrial basin area (the Kłodnica, the Potok Bielszowicki, the Czarniawka). Agricultural basin area rivers are known for high concentrations of mineral substance, ammonium nitrogen, orthophosphates and COD [6, 7]. Water in industrial area rivers is characterized by a high salinity and changes in suspended solids concentration and quality.

Last few years in Poland have resulted in many considerable changes: seclusion of many coal-mines and heavy industry factories, some of which changed manufacturing profile and introduction of technical solutions which reduce contamination of natural environment. These changes influence the present river pollution.

Such activities have taken place in the Bytomka basin area too, where thousands of people live and many factories, coal-mines, sewage-treatment plants; waste-water collectors are located. Runge and Zadrożny [11] state that the percentage of urban areas in the Bytomka basin in 1983 was between 50% and 75%. The Bytomka basin is under huge anthropogenic influence. Intensive exploitation of coal in the first years of XIX century caused considerable settlement in the Bytomka basin [1]. This study includes influence of these elements on the existing water quality.

It is important to mention that despite the fact that many activities are carried in order to protect the environment of the Bytomka River, this area is still contaminated and some water quality parameters have deteriorated in the past dozen years.

Literature which describes the Bytomka River is very scarce, so this article may be an essential supplement.

BASIN CHARACTERISTIC

The length of the Bytomka River is 22.0 km (19.2 km [9]) and the basin area is 147.8 km^2 [8]. The Bytomka River is a tributary of the Kłodnica River. The river-head is located about 275 m above sea level and the estuary is about 223 m above sea level. Medial depression is 3.2‰ [1]. This river has not a natural source – it begins at Rów Karbowski which is a municipal waste-water [9]. The river flows through Bytom, Ruda Śląska, Zabrze and Gliwice. Most of the water course flows through highly urbanized areas. Most of the water course is canalized and the bed is packed by stony pavement or harnessed concrete blockhead [1]. The river between Bytom and Ruda Śląska flows through the reed valley only. The river basin area is very modest, inflowed by the coal-mine water, effluents from factories, municipal waste-water and rainfall water [9]. Many trenches and collectors discharge plenty of strongly polluted water which sometimes makes up to 80–90% of the rivers flow [1].

Major tributaries of the Bytomka River – Potok Miechowicki, Rów Graniczny and Potok Mikulczycki are contaminated with municipal and industrial waste water [9].

METHODS OF INVESTIGATION

SITES OF SAMPLES COLLECTION

Five sites were chosen for determination of changes in water quality in the Bytomka profile. These stations are situated as follows:

Station 1 – Ruda Śląska/Bytom, ul. A. F. Modrzewskiego (4.9 km of the river course)
Station 2 – Zabrze-Biskupice, ul. Trębacka (10.8 km)
Station 3 – Zabrze, ul. Trocera (15.8 km)
Station 4 – Zabrze, ul. Kondratowicza (17.8 km)
Station 5 – Gliwice-Sośnica, ul. Odrowążów (21.5 km)

METHODS OF INDICATION

Collected water, suspended materials and bottom sediments: indicated temperature, dissolved oxygen (measurer type CI-401, "Elmetron", Poland with temperature and oxygen electrodes), pH-index (pH-meter type CI-316, "Elmetron", Poland), conductivity (conductometer type CC-317, "Elmetron", Poland), alkalinity (PN-90/C-04540/03), ammonium nitrogen (PN-ISO 5664:2002), nitrite nitrogen (PN73/C-04576/06), nitrate nitrogen (ISO 7890-1:1986), orthophosphates (PN-89/C-04537/02), COD (PN-74/C-04578/03).

Organic carbon was determined at carbon analyzer TOC-5000A "Shimadzu", Japan. Suspended solids were determined by gravimetric method with cellulose nitrate membrane filters – pore 0.4 μm.

Bottom sediments, suspended solids and heavy metals concentration in the water will be discussed in next studies.

RESULTS OF INVESTIGATION

Results of investigation are discussed below.

pH-index

16.09.2003: The lowest pH-index between 7.32 and 7.88 pH was noticed.

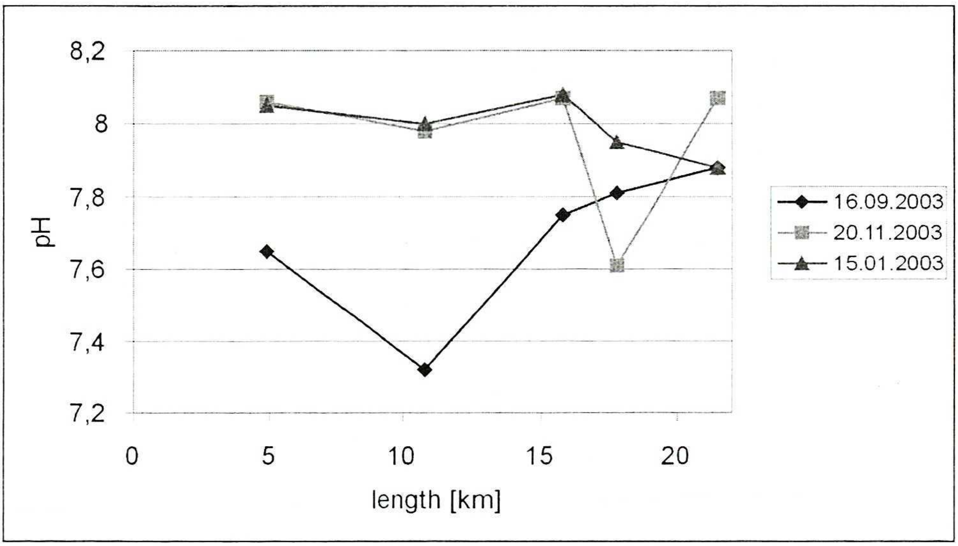

Fig. 1. Changes of pH-index in water of the Bytomka River – hydrographic profile

20.11.2003: pH-index between 7.61–8.07 pH.
15.01.2004: In the winter fluctuations between 7.88 and 8.08 pH were observed.

Dissolved oxygen

16.09.2003: At Station 1 dissolved oxygen 1.10 mg O_2/dm^3 was noticed, at Station 2 the value rose to 3.55 mg O_2/dm^3. Next it rapidly fell to 0.28 mg O_2/dm^3 at Station 3. Then it rose from 0.34 mg O_2/dm^3 at Station 4 to 1.02 mg O_2/dm^3 at Station 5.

20.11.2003: The concentration of dissolved oxygen rose from 1.32 mg O_2/dm^3 at Station 1 to 2.66 mg O_2/dm^3 at Station 2. At Station 3 dissolved oxygen concentration fell down to 2.32 mg O_2/dm^3 and in the estuary it was 0.53 mg O_2/dm^3.

15.01.2004: Dissolved oxygen concentration at Station 1 was 3.05 mg O_2/dm^3 which rose to 5.73 mg O_2/dm^3 at Station 3. Then a slight fall to 5.31 mg O_2/dm^3 at Station 4 and 5.14 mg O_2/dm^3 at Station 5 was observed.

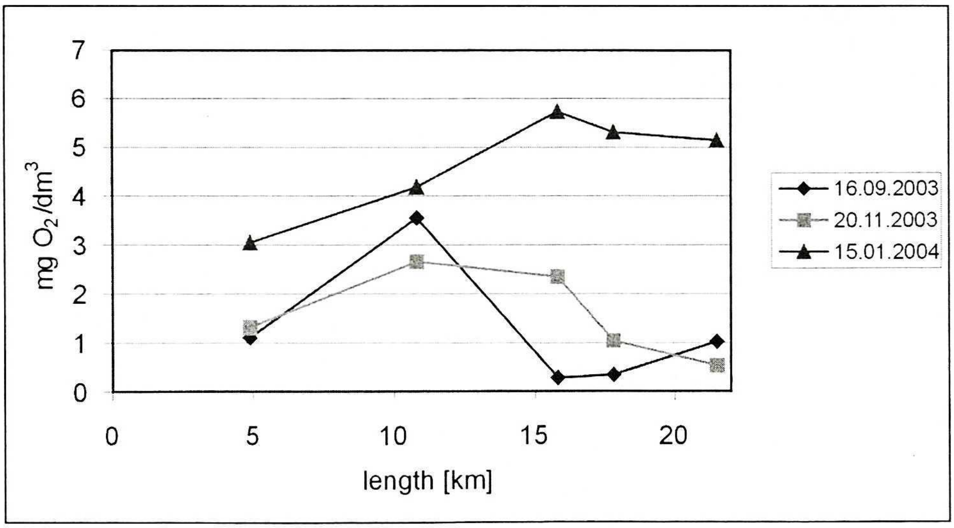

Fig. 2. Changes in the content of dissolved oxygen in water of the Bytomka River – hydrographic profile

COD

16.09.2003: At station 1 the COD concentration was 116.95 mg O_2/dm^3. The highest concentration was noticed at Station 2 – 163.02 mg O_2/dm^3, which then dropped to 131.13 mg O_2/dm^3 at Station 5.

20.11.2003: The lowest concentration was noticed again at Station 1 – 105.04 mg O_2/dm^3. Then the COD concentration rose along the river course. At Station 4 it was 222.68 mg O_2/dm^3. Then it dropped to 172.27 mgO_2/dm^3 in the estuary.

15.01 2004: The highest COD concentrations were observed at Station 1 and 2 – 244.00 mg O_2/dm^3. The lowest concentration (172.00 mg O_2/dm^3) was at Station 5.

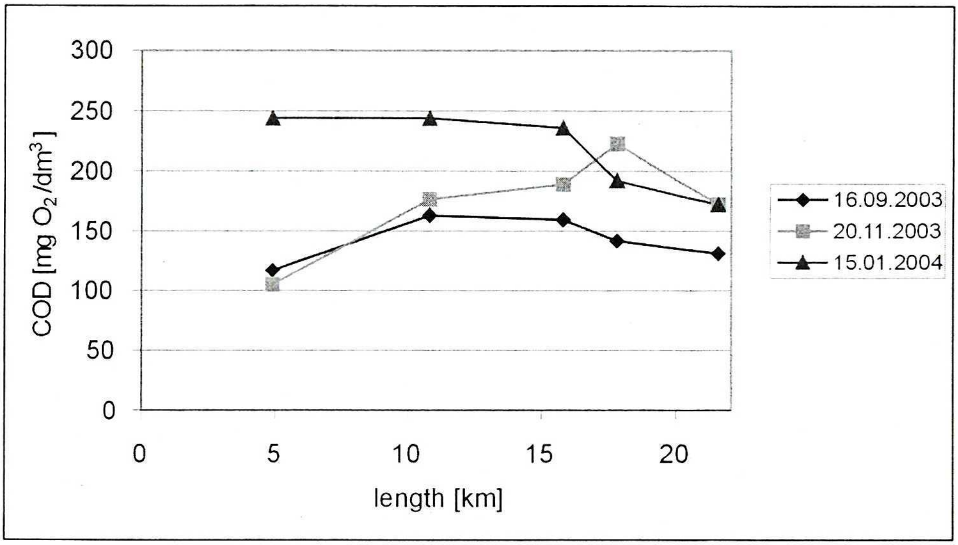

Fig. 3. Changes of COD in water of the Bytomka River – hydrographic profile

Organic carbon

16.09.2003: At Station 1 organic carbon concentration was 14.12 mg C_{org}/dm^3, and then it dropped to 12.79 mg C_{org}/dm^3 at Station 2. At Station 3 – 24.78 mg C_{org}/dm^3 was noticed, then fall to 17.51 mg C_{org}/dm^3 at Station 5 was observed.

20.11.2003: Organic carbon concentration in the water rose from 11.13 mg C_{org}/dm^3 (Station 1) to 18.47 mg C_{org}/dm^3 at Station 4. In the estuary it was 17.64 mg C_{org}/dm^3.

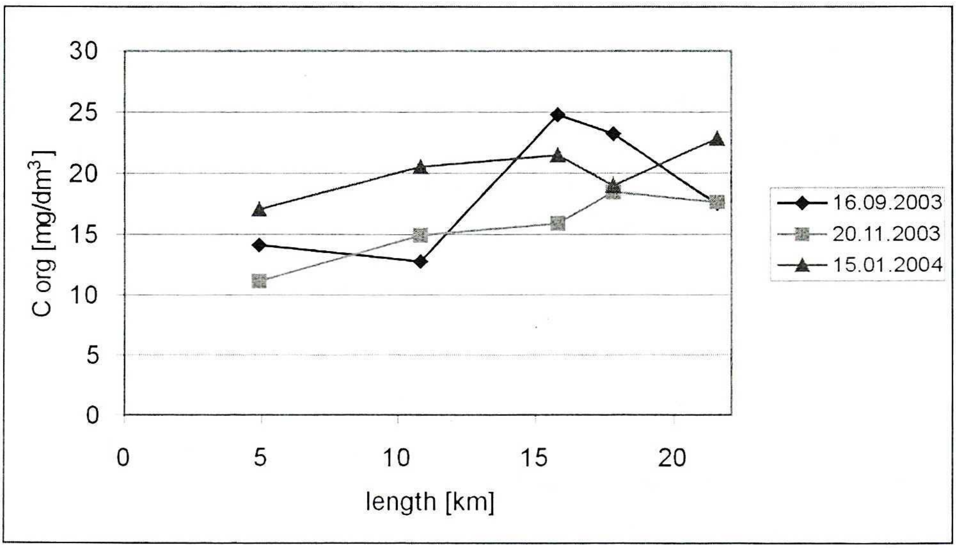

Fig. 4. Changes in the content of organic carbon in water of the Bytomka River – hydrographic profile

15.01.2004: The lowest organic carbon concentration was noticed at Station 1 – 17.04 mg C_{org}/dm^3, it went up to 21.48 mg C_{org}/dm^3 at Station 3, and dropped to 18.99 mgC_{org}/dm^3 at Station 4. The highest concentration – 22.83 mg C_{org}/dm^3 was observed at Station 5.

Nitrate nitrogen

16.09.2003: The concentration of nitrate nitrogen was noticed at Station 1 (0.23 mg/dm^3). Small fluctuations from 0.17 mg/dm^3 at Station 2 to 0.21 mg/dm^3 at Station 3 were observed. At Station 4 an important rise to 1.33 mg/dm^3 was noticed. At Station 5 it was 1.01 mg/dm^3.

20.11.2003: At Station 1 its value was 0.47 mg/dm^3 which then fell down to 0.09 mg/dm^3 at Station 3. The rise to 1,08 mg/dm^3 at Station 4 and a fall to 0,82 mg/dm^3 at Station 5 was observed.

15.01.2004: The concentration of nitrate nitrogen grows along the river course: Station 1 – 0.45 mg/dm^3 and in the estuary area, at Station 5 – 1.98 mg/dm^3.

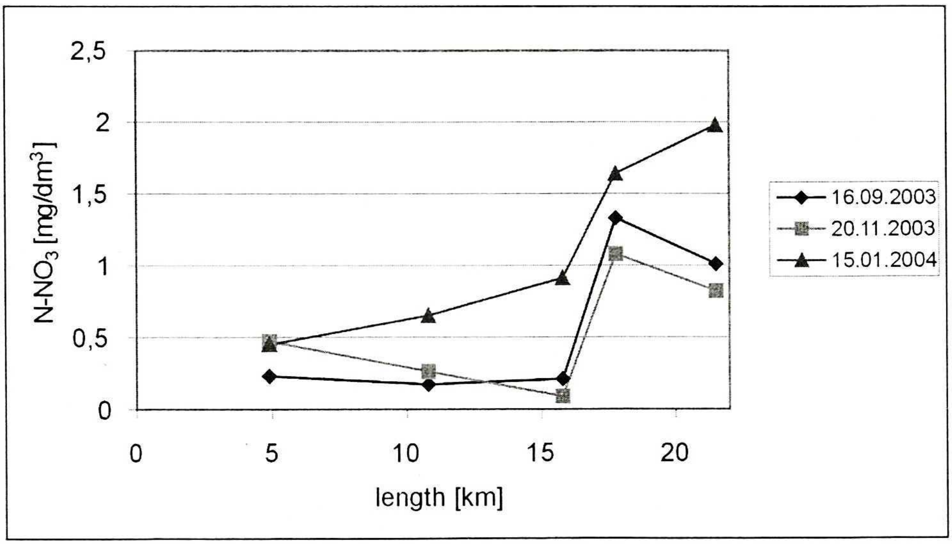

Fig. 5. Changes in the content of nitrate nitrogen in water of the Bytomka River – hydrographic profile

Nitrite nitrogen

16.09.2003: The concentration of nitrite nitrogen at Station 1 was 0.080 mg/dm^3. It rose to 0.094 mg/dm^3 at Station 2. At Station 3 it was 0.024 mg/dm^3. At Stations 4 and 5 it was 0.045 mg/dm^3 and 0.109 mg/dm^3 respectively.

20.11.2003: The concentration at Station 1 was 0.123 mg/dm^3, at Station 2 – 0.200 mg/dm^3, and at Station 3 0.113 mg/dm^3. Then it fell to 0.094 mg/dm^3, and rose to 0.150 mg/dm^3 in the estuary.

15.01.2004: At Station 1 it was 0.129 mg/dm^3, at Station 2 – 0.197 mg/dm^3, at Station 3 – 0.211 mg/dm^3, 0.208 mg/dm^3 and 0.370 mg/dm^3 at Stations 4 and 5 respectively.

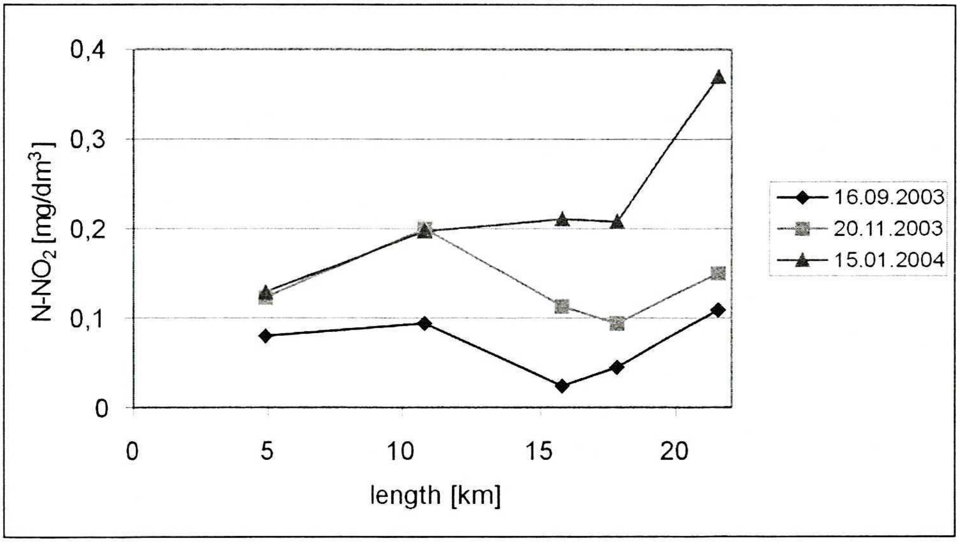

Fig. 6. Changes in the content of nitrite nitrogen in water of the Bytomka River – hydrographic profile

Ammonium nitrogen

16.09.2003: At Station 1 ammonium nitrogen was 9.51 mg/dm^3, it fell down to 8.84 mg/dm^3 at Station 2, then roşe to 14.41 mg/dm^3 at Station 3 and dropped to 12.64 mg/dm^3 at Station 4 and 10.60 mg/dm^3 at Station 5.

20.11.2003: The lowest concentration of ammonium nitrogen at Station 1 was 5.13 mg/dm^3. The ammonium nitrogen content was growing with the

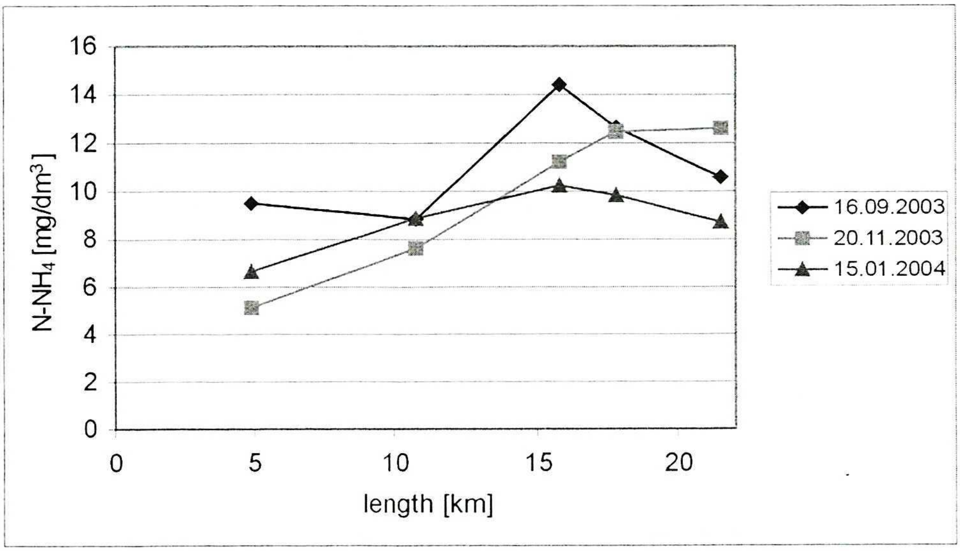

Fig. 7. Changes in the content of ammonium nitrogen in water of the Bytomka River – hydrographic profile

course of the Bytomka River. In the estuary area (Station 5) it was 12.61 mg/dm^3.

15.01.2004: The minimal concentration of ammonium nitrogen at Station 1 (6.65 mg/dm^3) and maximal concentration at Station 3 (10.25 mg/dm^3) were noticed. Then a drop of concentration to 9.84 mg/dm^3 at Station 4 and 8.73 mg/dm^3 at Station 5 was noticed.

Orthophosphates

16.09.2003: The lowest concentration of orthophosphates was noticed at Station 1 – 0.723 mg/dm^3. It rose to 2.388 mg/dm^3 at Station 4. In the estuary (Station 5) it was 2.247 mg/dm^3.

20.11.2003: The lowest concentration was noticed at Station 1 – 0.608 mg/dm^3. Along the river course it rose to 1.775 mg/dm^3 at Station 5.

15.01.2004: At Station 1 the concentration of 0.735 mg/dm^3 was noticed. The orthophosphates concentration was growing with the course of the river to 1.072 mg/dm^3 at Station 3. Then it fell to 0.830 mg/dm^3 at Station 5.

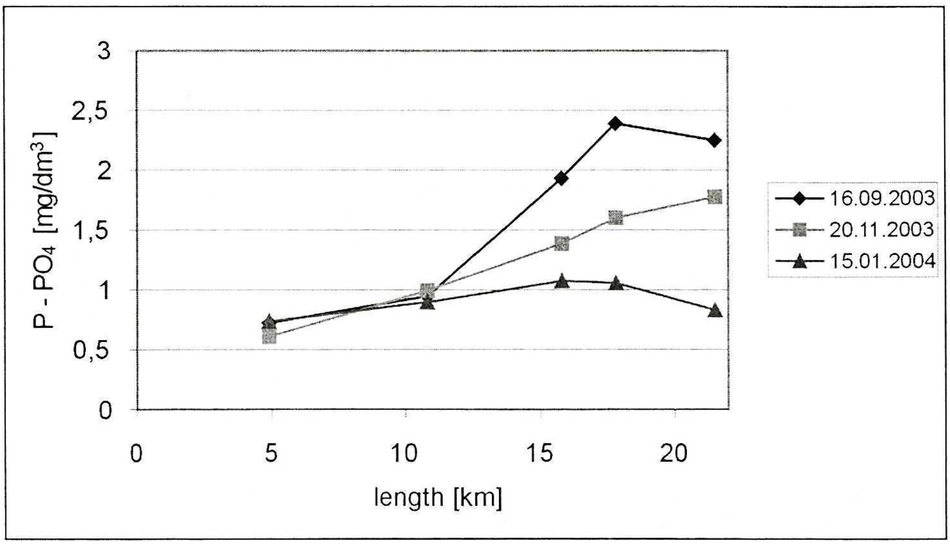

Fig. 8. Changes in the content of orthophosphates in water of the Bytomka River – hydrographic profile

Conductivity

16.09.2003: At Station 1 conductivity was 7340 μS/cm, it rose to 7800 μS/cm at Station 3, then dropped to 5530 μS/cm at Station 4. In the estuary it was 6560 μS/cm.

20.11.2003: The lowest conductivity was at Station 1 – 7420 μS/cm. The highest was at Station 2 – 10330 μS/cm, and then it dropped to 7660 μS/cm at Station 5.

15.01.2004: At Station 1 it was 6580 μS/cm. The highest value was observed at Station 2 – 8110 μS/cm. Then it dropped to 5630 μS/cm at Station 5.

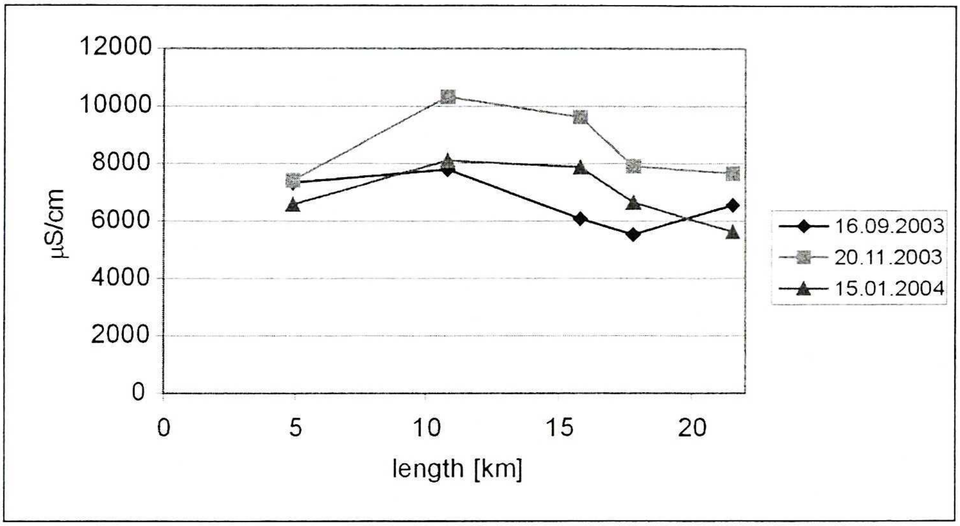

Fig. 9. Changes of conductivity in water of the Bytomka River – hydrographic profile

Suspended solids

16.09.2003: Suspended solids concentration was 61.3 mg/dm^3 at Station 1, it rose to 79.9 mg/dm^3 at Station 3, and then it dropped to 50.2 mg/dm^3 in the estuary.

20.11.2003: Concentration of suspended solids at Station 1 was 45.6 mg/dm^3, it rose to 110.3 mg/dm^3 at Station 3. In the estuary it dropped to 88.9 mg/dm^3.

15.01.2004: At Station 1 the concentration of 154.7 mg/dm^3 was noticed, it then dropped to 77.7 mg/dm^3 at Station 3. At Station 4 a rise to 176.7 mg/dm^3 was observed. Then a drop to 67.9 mg/dm^3 at Station 5 was noticed.

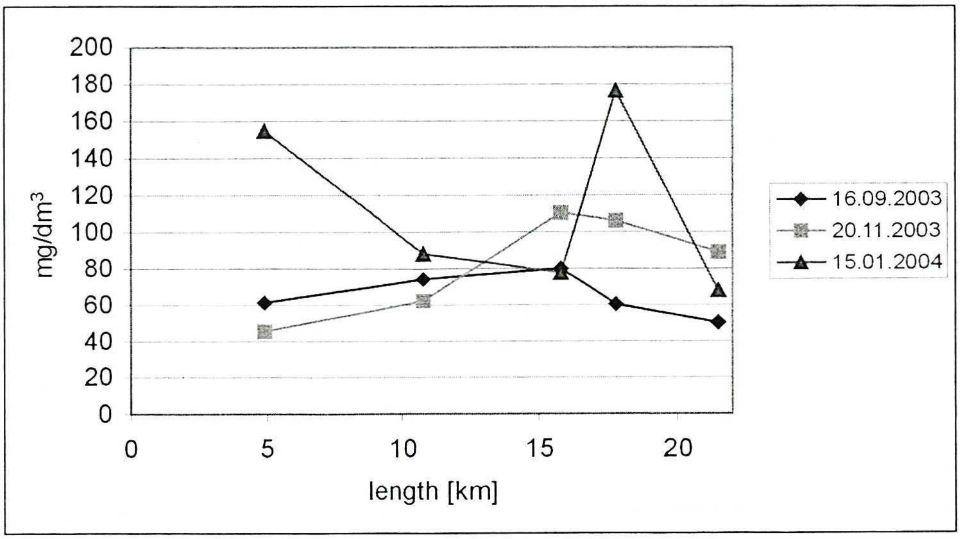

Fig. 10. Changes in the content of total suspended solids in water of the Bytomka River – hydrographic profile

DISCUSSION

The Bytomka River is characterized by disadvantageous organic indicators. A concentration of dissolved oxygen, especially in the autumn, is very low. In the winter a slight improvement of this parameter was observed.

According to "Raport..." [13] in Bytom area salty coal-mine water from "Szombierki-Centrum" coal mine, industrial waste-water and rainfall water from other industrial works is discharged as well as a fine waste-water from the Bytom sewage-treatment plants. The town of Ruda Śląska discharges municipal waste-water from industrial works, fine waste-water from sewage-treatment plants and waste-water from drains. Another big city which leads a big amount of municipal waste-water is Zabrze. The most waste-water comes from "Zabrze" ironworks and fine municipal waste-water comes from sewage-treatment plants. Twenty-three collectors are responsible for the discharge of rainfall water. In Gliwice area the Bytomka River is a collector of industrial water from PKP (Polish Railways) works, rainfall water and waste-water from other industrial works localized in the Bytomka basin area.

All of the parameters of water quality (except the pH-index and nitrate nitrogen) are beyond official classification. A high concentration of nitrates and phosphates was noticed. A relation of these parameters suggests contamination from municipal waste-water. There is also a high transgression of standard water quality observed for ammonium nitrogen, nitrite nitrogen, orthophosphates, COD, and suspended solids. A rise of nitrate nitrogen and a drop of ammonium nitrogen at Station 4 is probably caused by water inflow from the Zabrze-Śródmieście plant.

A high salinity of the Bytomka River – sometimes higher than 10 000 μS/cm – is caused by the big inflow of coal-mine water.

A concentration as well as a character of suspended solids confirms strong pollution from municipal waste-water of the Bytomka River. Fluctuations of suspended solids in January may be due to the run off surface from streets, car-parks etc.

Table 1. Classification of water quality of the Bytomka River (according to maximum concentrations of individual parameters)

Parameter	Water quality classification
pH	I
COD	under classification
$N\text{-}NO_3$	I
$N\text{-}NO_2$	under classification
$N\text{-}NH_4$	under classification
$P\text{-}PO_4$	under classification
conductivity	under classification
suspended solids	under classification

CONCLUSION

The Bytomka River is still one of the most polluted rivers in the Upper Silesia. This situation is caused by municipal waste-water, coal-mine and industrial water inflow.

Table 2. Comparison of the Bytomka River water quality parameters (minimum and maximum concentration of individual parameters)

Parameter	Unit	1992	1998	2003/2004
COD	mg O_2/dm^3	129.7–243.2	–	105.04–244.00
dissolved oxygen	mg/dm^3	–	1.30–8.70	0.28–5.73
$N\text{-}NO_3$	mg/dm^3	6.10–8.95	0.38–9.00	0.09–1.98
$N\text{-}NO_2$	mg/dm^3	–	0.020–0.515	0.024–0.370
$N\text{-}NH_4$	mg/dm^3	7.16–12.10	0.52–19.47	5.13–14.41
$P\text{-}PO_4$	mg/dm^3	–	0.37–8.13	0.608–2.388
conductivity	µS/cm	2840–3750	586–6430	5530–10330
suspended solids	mg/dm^3	20.0–157.0	11.0–625.0	45.6–176.7

In comparison to 1992 and 1998 no improvement of the Bytomka River water quality can be observed. In fact, in the last few years the salinity has even grown. Improvement of the existing situation will be possible only if firm waste-water management actions will be taken. The most important are:

1. Reduction of the inflow of waste-water especially from Bytom and Ruda Śląska.
2. Reduction of the inflow of salty coal-mine water.
3. Preservation of reed territories on Bytomka valley.

Pracę wykonano w ramach projektu badawczego 3P04G03823 (nr umowy 169/P04/2002/23) finansowanego przez Komitet Badań Naukowych w Warszawie w latach 2002–4.

REFERENCES

[1] Czaja S.: *Zmiany stosunków wodnych w warunkach silnej antropopresji (na przykładzie konurbacji katowickiej)*, Wydawnictwo UŚ, Katowice 1999.

[2] Jankowski A. T., M. Rzętała: *Wyżyna Śląska i jej obrzeża – stan i antropogeniczne zmiany jakości wód powierzchniowych*. Stan i antropogeniczne zmiany jakości wód w Polsce (pod red. J. Burcharda), 143–154, Wydawnictwo UŁ, Łódź 2000.

[3] Kondracki J.: *Geografia fizyczna Polski*, PWN, Warszawa 1965.

[4] Kondracki J. *Geografia regionalna Polski*, Wydawnictwo Naukowe PWN, Warszawa 1998.

[5] Kostecki M., J. Kozłowski:, *Wykonanie analiz wód w rzekach i potokach na terenie miasta Zabrze*, Praca IPIŚ PAN, temat C_2-193/92 maj 1992.

[6] Kostecki M., J. Kozłowski, A. Domurad, B. Zych: *Charakterystyka hydro-chemiczna Potoku toszeckiego w aspekcie oddziaływania na zbiornik zaporowy Pławniowice*. Archiwum Ochrony

Środowiska, **27**, 125–140 (2001).
[7] Kostecki M., J. Kozłowski, E. Kowalski, A. Domurad: *Badania limnologiczne zbiornika zaporowego Dzierżno Małe cz. I Charakterystyka hydrochemiczna rzeki Dramy*, Archiwum Ochrony Środowiska, **24**, 27–44 (1998).
[8] Pistelok F.: *Program „Czysta Kłodnica"*, Spotkanie warsztatowe „Kłodnica", 5 października 1995.
[9] *Raport o stanie środowiska w Bytomiu – 2001 r.*, Wydział Ekologii UM w Bytomiu.
[10] *Raport o stanie środowiska w Zabrzu – 1999*, OBiKŚ, Katowice – Zabrze, lipiec 2000.
[11] Runge J., T. Zadrożny: *Delimitacja konurbacji katowickiej*, Struktury i procesy społeczno-demograficzne w regionie katowickim, Pr. Geogr. IGiPZ PAN, 151 (1989).
[12] Starczyńska A., W. Krajewski: *Ocena stopnia zanieczyszczenia i stanu sanitarnego zbiornika Dzierżno Duże*, Problemy ochrony zasobów wodnych w dorzeczu Odry, VII Międzynarodowa Konferencja Naukowo-Techniczna, Lądek Zdrój 27–30 Maja 2001.
[13] Urząd Miejski w Rudzie Śląskiej: *Raport dot. rzeki Kłodnicy i jej dopływów na odcinku od źródła do ujścia do kanału Gliwickiego*, Spotkanie warsztatowe „Kłodnica", 5 października 1995.
[14] Wojewoda Śląski: *Monitoring powierzchniowych wód płynących w województwie katowickim w 1998 roku, Część 3, Stan czystości powierzchniowych wód płynących rzek zlewni Odry*, Wydział Ochrony Środowiska i Rolnictwa Urzędu Wojewódzkiego, Katowice – kwiecień 1999 r.

Received: March 3, 2004; accepted: November 18, 2004.