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POLLUTION OF THE RIVER NYSA ŁUŻYCKA IN TUROSZÓW COAL MINING REGION

PART I. PHYSICOCHEMICAL EVALUATION OF POLLUTANT

The purpose of the paper, being the first part of the larger study, was to apply physicochemical criteria for the evaluation of the pollution state of the river Nysa Łużycka in Turoszów coal mining region. It has been stated that the river examined was heavily polluted along the distance between the outles of the tributaries Biedrzychówka and Witka and that in many cases the pollution degree exceeded the Polish admissible standards for inland waters. Within the river segment examined the oxygen contents in the waters were, however, fairly high, which in the case when the measures of water protection were observed would enable an efficient course of biodegradation. The disturbances in the cycle of nutrients (phosphorus and nitrogen) occurring in large amounts that have been observed probably influenced the development of biocenosis. Substantial amounts of suspended matter occurring in the river water exerted probably various disadvantageous effects on the biotope being studied.

1. INTRODUCTION

In view of the intense industrialization of Turoszów region the problem of surface waters protection in this area is of a special importance. The main sources of the river Nysa Łużycka pollution along the distance between the outlets of the rivers Biedrzychówka and Witka are [1]:

discharged of polluttants from brown coal strip mine TURÓW,

pollution washed out by precipitation from dumps localized in the brown coal mine TURÓW and from the catchment area,

gaseous pollutants diffusing from the atmosphere to surface waters, especially sulphur

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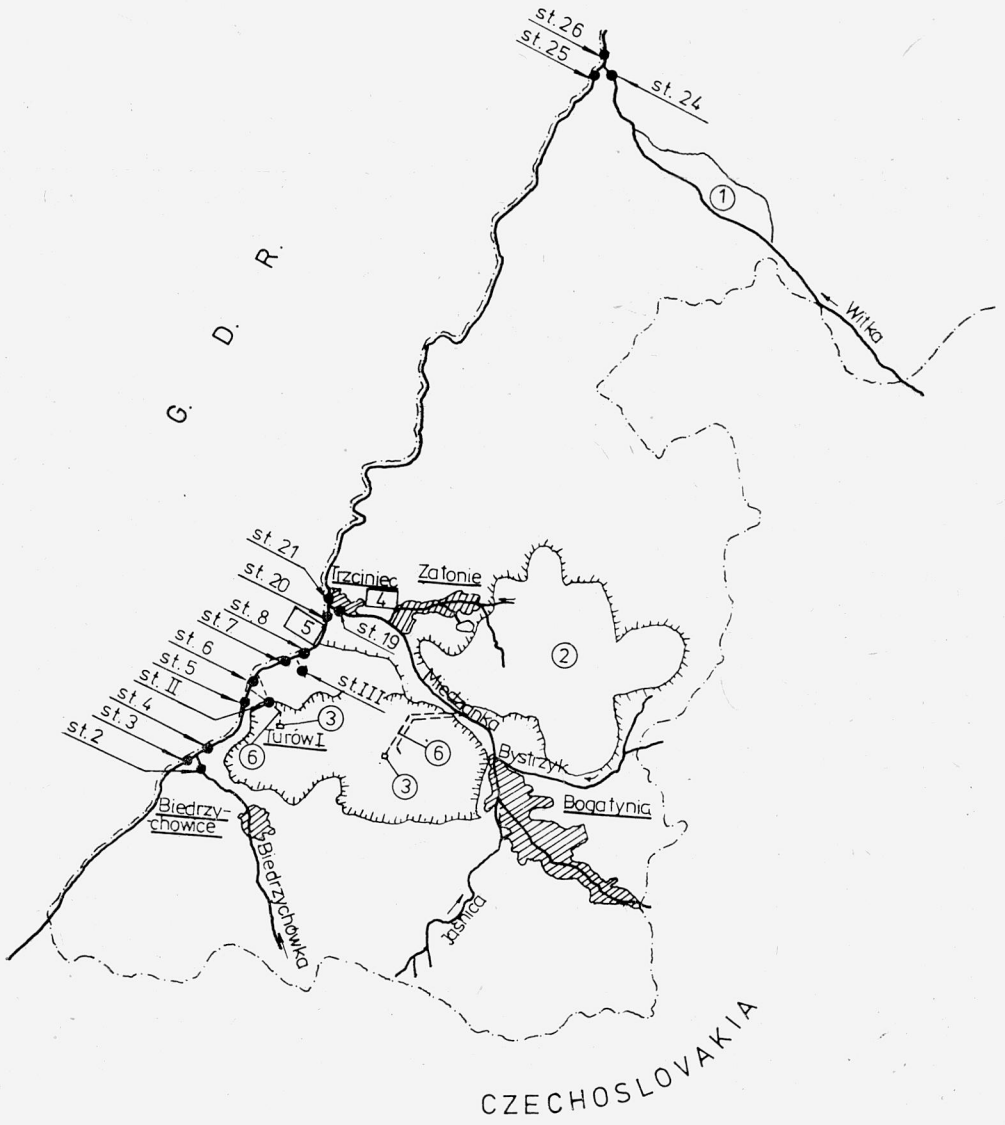

Fig. 1. Schematic map of the investigated area of Turoszów brown-coal field

● station 2 — sampling stations located on surface affluents, ● station II — mine-water discharges, 1 — reservoir "Witka", 2 — dump, 3 — pumping station , [4] — power station "Turów", [5] — power station "Hirsh", 6 — water diversion

Rys. 1. Szkic sytuacyjny objętego badaniami Turoszowskiego Zagłębia Węgla Brunatnego

● stanowisko 2 — punkty pomiarowe na ściekach powierzchniowych, ● — stanowisko II — zrzuty wód obiektów kopalnianych, 1 — zbiornik „Witka", 2 — hałda, 3 — pompownia, [4] — elektrownia „Turów", [5] — elektrownia „Hirsh", 6 — odprowadzenia z obiektów kopalnianych

and carbon dioxides large amounts of which are produced in brown coal combustion in power plants within this region.

It should be also emphasized that the pollution state of Nysa Łużycka is directly influenced by the river Miedzianka loaded with wastewaters from the town of Bogatynia and cotton industry plants, as well as by the pollutants introduced into the river above the segment examined, coming especially from Czechoslovakia. Consequently, the water at Czechoslovakia–Poland border does not meet the bounding standards [1, 5].

The purpose of the present paper was to determine the pollution conditions of the river Nysa Łużycka from the results of physicochemical, bacteriological, and hydrobiological investigations and from the calculation of saprophytic index. First part of the paper presents the characteristics of physicochemical background of the environment examined, that decides upon qualitative and quantitative composition of biocenosis. The direction and intensity of metabolic transformations of this complex were, in turn, the factor deciding upon the ability and progress of water selfpurification.

2. MATERIAL AND METHODS

The investigations included a segment of the river Nysa Łużycka (left-bank tributary of the river Odra) from 191.8 km to 166.4 km of its course. The sample were taken in one-month intervals during one year. The investigations were started in September 1976 and ended in August 1977.

3. CHARACTERISTICS OF THE SAMPLING STATIONS

Nine sampling stations have been distributed along the examined segment of the river at its characteristic points, thus above and below the estuaries of the rivers Biedrzychówka, Miedzianka, and Witka, as well as the runoff of mine waters (fig. 1).

4. PHYSICOCHEMICAL EXAMINATIONS

A full physicochemical analysis of water samples has been performed according to the methods given by HERMANOWICZ et al. [2]. In the present paper the most characteristic parameters, i.e. temperature, dissolved oxygen content, iron, sulphates and suspended matter contents, as well as the amounts of nutrients (inorganic and organic nitrogen and phosphates) have been assumed.

5. RESULTS OF INVESTIGATIONS

Variations in water temperature, amounts of oxygen dissolved and nutrients in the river Nysa Łużycka waters occurring in the separate months of the one-year cycle are presented in figs. 2–12. Within the segment examined the water of the river Nysa Łużycka showed seasonal temperature variations, ranging from 3°C in January 1977 (fig. 5) to 21°C in June and July 1977 (figs. 10 and 11) [6] and typical of the Polish rivers. In April 1977 within the whole segment examined one observed a substantial drop in the temperature of water (fig. 8) with respect to the previous month (fig. 7), which was followed by its rapid increase in May (fig. 9).

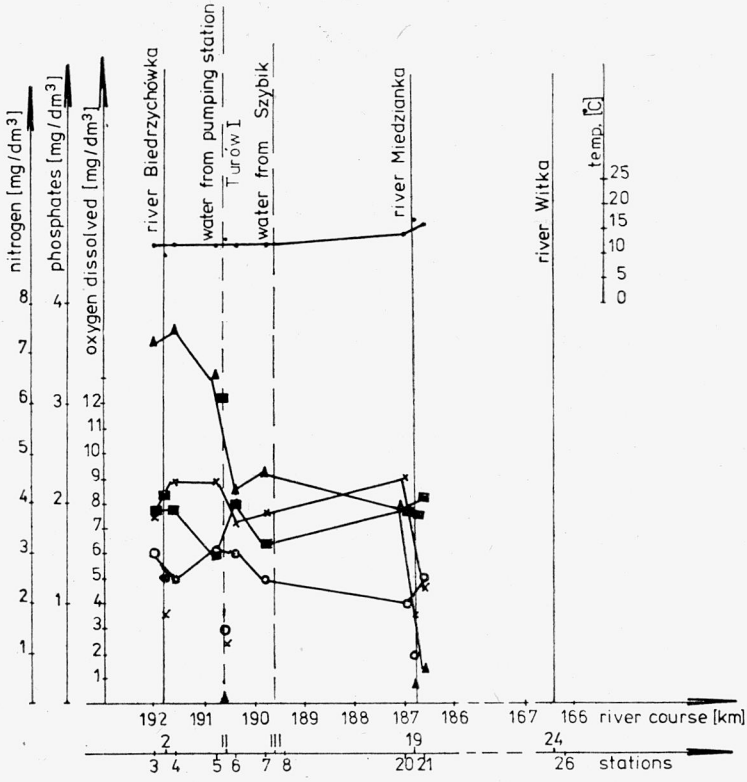

Fig. 2. Variations in water temperature, quantities of dissolved oxygen and nutrients in the waters of Nysa Łużycka in September 1976

● — temperature, ■ — dissolved oxygen, ▲ — phosphates, o — organic nitrogen, x — mineral nitrogen

Rys. 2. Zmiany temperatury wody, ilości rozpuszczonego tlenu i pierwiastków biogennych w wodach Nysy Łużyckiej we wrześniu 1976 r.

● — temperatura, ■ — tlen rozpuszczony, ▲ — fosforany, o — azot organiczny, x — azot mineralny

During the whole period of examinations it was observed that the temperature of the river Nysa Łużycka increased due to warmer waters of the river Miedzianka and of waters coming from the pumping station and from the so-called „Szybik" (small shaft). Only in February 1977 (fig. 8) temperature of the river Miedzianka waters was lower than that of the river Nysa Łużycka.

Oxygen conditions in the water of Nysa Łużycka were, in general, good. The amount of oxygen dissolved in water varied from 5.6 mg O_2/dm^3 in June 1977 (fig. 10) to 19.8 mg O_2/dm^3 in January 1977 (fig. 5). It has been observed that the waters coming from the pumping station Turów I exert an advantageous effect on oxygen conditions in the river Nysa Łużycka, whereas the river Miedzianka waters caused the decrease of dissolved oxygen, because of the increasing temperature as well as due to the high amounts of non-biodegraded organic pollutants.

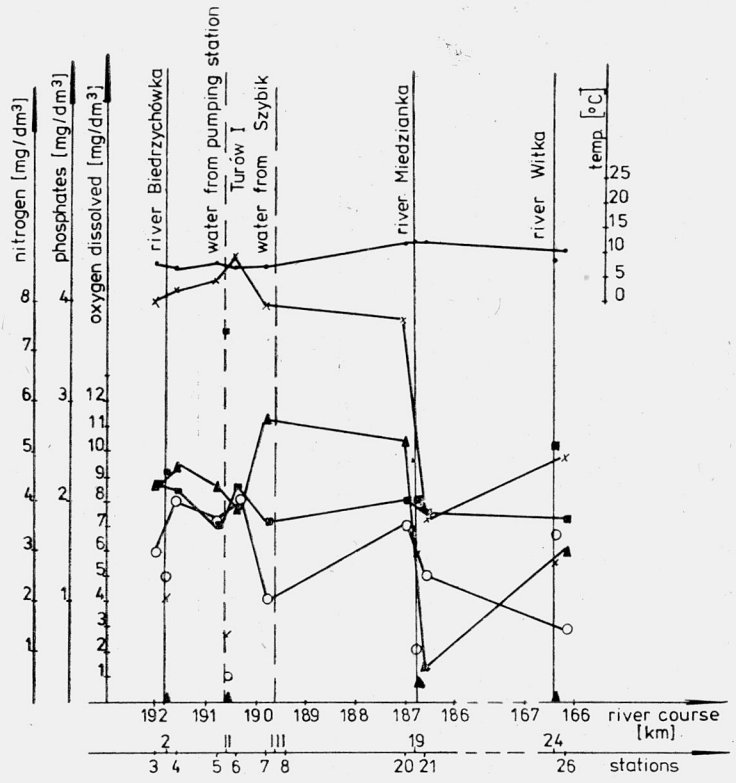

Fig. 3. Variations in water temperature, quantities of dissolved oxygen and nutrients in the waters of Nysa Łużycka in October 1976

For explanations see fig. 2

Rys. 3. Zmiany temperatury wody, ilości rozpuszczonego tlenu i pierwiastków biogennych w wodach Nysy Łużyckiej w październiku 1976 r.

Objaśnienia jak na rys. 2

During the whole period of investigations the amounts of suspended matter varied from trace to 2158 mg/dm^3 along the river segment examined (tab. 1). In Nysa Łużycka the admissible amounts of suspended matter for I and II classes of water purity [5] occurred only sporadically, generally exceeding the standards. Enormous amounts of suspended matter were introduced by the river Miedzianka. The amount of suspended matter observed in June 1977 at the outlet of the river Miedzianka to Nysa Łużycka (station 19) amounting to 4666 mg/dm^3 (tab. 1) is a drastic example.

The quantities of total iron in the river Nysa Łużycka waters at station 6 varied from trace to 3.3 mg Fe/dm^3 in February 1977 (tab. 2). Substantial quantities of iron occurred in November 1976 and February, March, June, and July 1977. In the remaining months the amounts of iron ranged within the values admissible for I class of water purity [5] (tab. 2). The quantities of sulphates within this same period ranged from 45 to 312 mg SO_4/dm^3 (tab. 3).

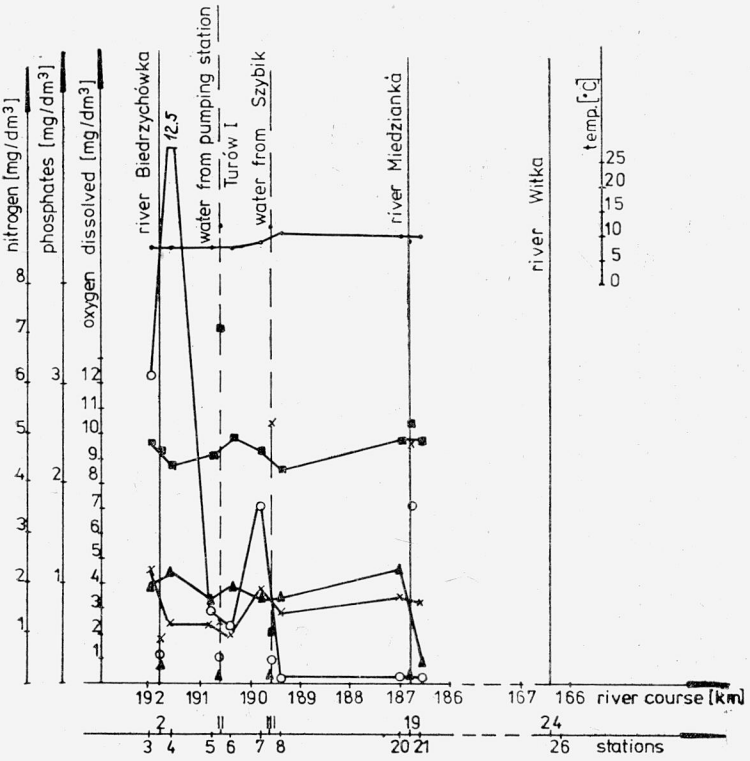

Fig. 4. Variations in water temperature, quantities of dissolved oxygen and nutrients in the waters of Nysa Łużycka in November 1976

For explanations see fig. 2

Rys. 4. Zmiany temperatury wody, ilości rozpuszczonego tlenu i pierwiastków biogennych w wodach Nysy Łużyckiej w listopadzie 1976 r.

Objaśnienia jak na rys. 2

In general, it should be stated that the quantities of sulphates were not large, being higher only in February and June 1977 (tab. 3). The quantities exceeding the standards admitted for inland waters were stated only at the station 21 in June 1977, thus below the outlet of the river Miedzianka. During the whole period of investigations there occurred elevated quantities of sulphates in waters coming from pumping station of Turów I (tab. 3) which, however, had not any influence on the change of this parameter in the water examined.

As far as the biocenosis and water protection problems are concerned, the quantities of nutrients (nitrogen and phosphorus) are of a great importance.

The amounts of phosphorus in the river Nysa Łużycka waters varied from 0 to 3.75 mg PO_4/dm^3. Large quantities of phosphates were observed especially along the distance between the stations 3 and 20. In most months the quantities of phosphates exceeded the

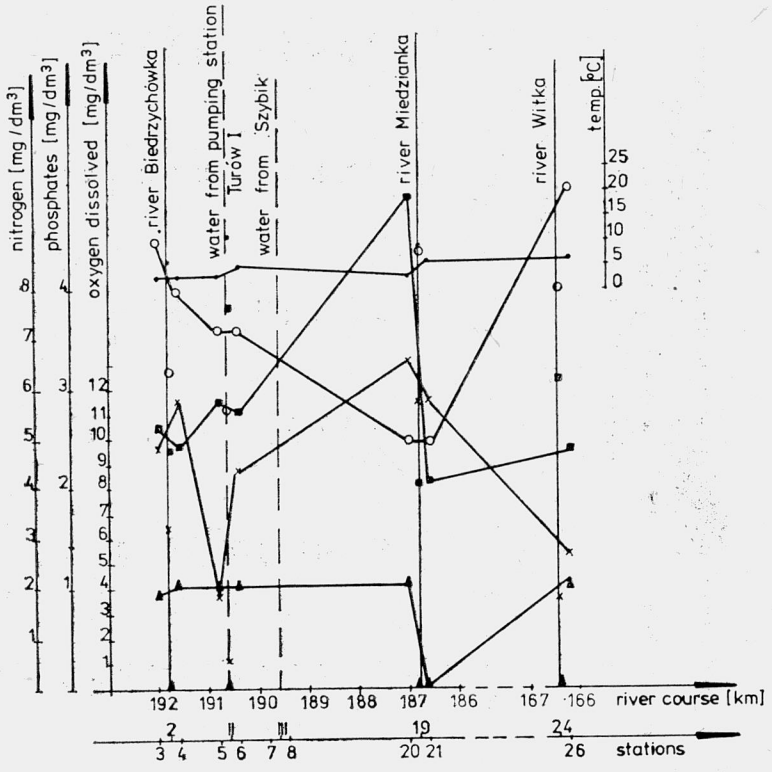

Fig. 5. Variations in water temperature, quantities of dissolved oxygen and nutrients in the waters of Nysa Łużycka in January 1977

For explanations see fig. 2

Rys. 5. Zmiany temperatury wody, ilości rozpuszczonego tlenu i pierwiastków biogennych w wodach Nysy Łużyckiej w styczniu 1977 r.

Objaśnienia jak na rys. 2

Table 1

Suspended matter (mg/dm³) in water of the river Nysa Łużycka and its affluents at the sampling station (IX 1976–VIII 1977)

Ilość zawiesin (w mg/dm³) w wodzie Nysy Łużyckiej i cieków uchodzących do niej na stanowiskach badawczych w cyklu rocznym (IX 1976–VIII 1977)

Sampling station	Term of sampling										
	21 IX 76	28 X 76	30 XI 76	12 I 77	21 II 77	23 III 77	20 IV 77	25 V 77	15 VI 77	12 VII 77	24 VIII 77
3	92	10	173	40	82	45	91	trace	132	70	79
2	47	trace	trace	40	—	—	—	—	—	—	—
4	175	trace	202	69	620	82	104	437	108	60	82
5	46	trace	151	112	10	28	343	trace	101	68	50
II	96	40	51	92	241	108	928	127	51	139	65
6	58	14	172	154	101	135	343	104	152	99	74
7	54	20	415	—	60	—	—	60	103	trace	36
III	—	—	29	—	—	—	—	—	—	—	—
8	—	—	121	—	—	88	trace	—	—	—	—
20	50	23	79	82	353	39	trace	235	trace	trace	102
19	1002	179	254	1071	1273	58	43	trace	4666	836	172
21	1211	199	353	1495	899	115	146	116	2158	262	140
24	—	trace	—	trace	—	93	—	0	—	0	—
26	—	trace	—	71	—	38	—	208	—	trace	—

Table 2

Concentrations of iron (mg Fe/dm^3) in water of the river Nysa Łużycka and its affluents at the sampling station (IX 1976–VIII 1977)

Ilość żelaza (mg Fe/dm^3) w wodzie Nysy Łużyckiej i cieków uchodzących do niej na stanowiskach badawczych w cyklu rocznym (IX 1976–VIII 1977)

Sampling station	Term of sampling										
	21 IX 76	28 X 76	30 XI 76	12 I 77	21 II 77	23 III 77	20 IV 77	25 V 77	15 VI 77	12 VIII 77	27 VIII 77
3	0.31	0.04	1.7	0.32	0.52	0.72	0.32	0.6	0.9	3.2	1.0
2	0.56	0.46	2.3	1.5	—	—	—	—	—	—	—
4	0.11	0.2	2.3	0.32	0.72	0.36	0.32	0.6	0.9	0.92	0.5
5	0.08	0.04	0.9	0.32	0.72	1.92	0.32	0.6	0.9	0.92	0.45
II	0.11	trace	0	0.54	1.12	4.12	0.02	1.56	0.9	0.5	0.25
6	0.08	0.04	1.7	0.34	3.3	0.84	0.32	0.6	0.9	0.72	0.6
7	0.4	0.04	1.9	—	1.12	—	—	1.0	0.6	0.92	0.8
III	—	—	4.6	—	—	—	—	—	—	—	—
8	—	—	1.7	—	—	13.6	0.72	—	—	—	—
20	0.09	0.03	1.7	0.32	1.48	1.48	0.32	1.56	1.4	0.9	0.4
19	0.33	0.01	0.15	0.94	0.62	1.92	1.6	0.6	2.6	1.4	0.7
21	0.15	0.02	0.96	0.94	1.24	1.8	1.03	1.0	2.6	1.25	0.7
24	—	0.03	—	0.16	—	0.24	—	0.9	—	0.16	—
26	—	0.01	—	0.38	—	0.36	—	0.9	—	0.92	—

admissible ones for inland waters (figs. 1–3, 5, 9, 11) [5]. Elevated quantities of phosphates occurred also in November 1976 (fig. 4). In the remaining months their amounts did not exceed the standards for II class of water purity [5] except for the station 6 in August 1977 (1.19 mg PO_4/dm^3).

No elevated quantities of inorganic nitrogen were observed during the whole period of investigations. Only in October 1976 increased amounts of ammonium nitrogen (5 mg NH_4/dm^3) belonging to inorganic nitrogen were stated at the stations 3–4. Whereas till November 1976 ammonium nitrogen was the chief constituent of inorganic nitrogen, then starting with January 1977 up to the end of experiments nitrate nitrogen prevailed quantitatively [3]. The quantities of organic nitrogen varied in a different way, being characteristic of the III class of water purity [5] during the whole period of investigations and exceeding the standards for inland waters [5] in November 1976 at station 4 (fig. 4), in January 1977 at the station 26 (fig. 5), and in March 1977 at the station 20 (fig. 7), thus proving that the waters of the river Nysa Łużycka are substantially polluted with organic compounds.

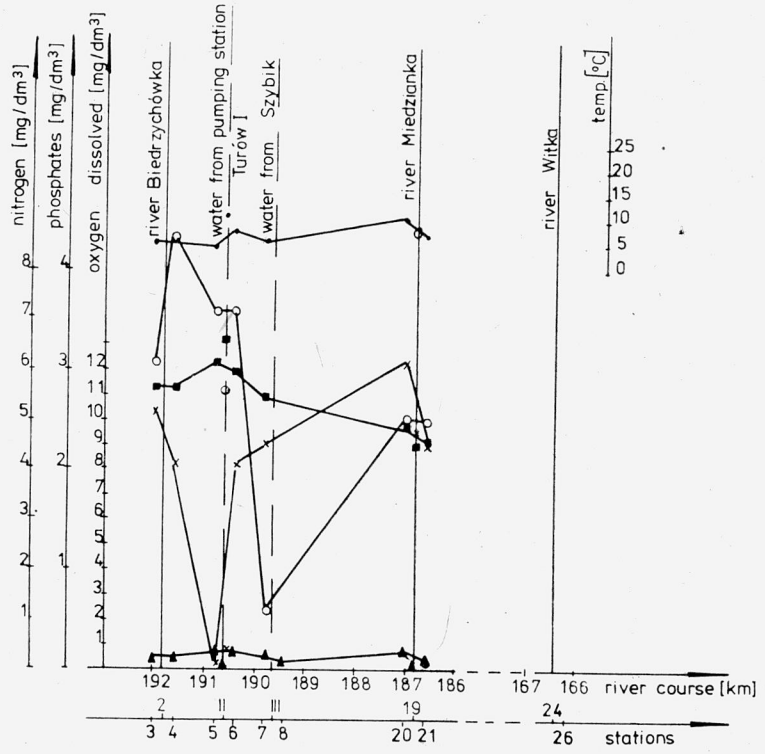

Fig. 6. Variations in water temperature, quantities of dissolved oxygen and nutrients in the waters of Nysa Łużycka in February 1977

For explanations see fig. 2

Rys. 6. Zmiany temperatury wody, ilości rozpuszczonego tlenu i pierwiastków biogennych w wodach Nysy Łużyckiej w lutym 1977 r.

Objaśnienia jak na rys. 2

Table 3

Contents of sulphates (mg SO_4/dm^3) in water of the river Nysa Łużycka and its affluents at the sampling stations (IX 1976–VIII 1977)

Ilość siarczanów (mg SO_4/dm^3) w wodzie Nysy Łużyckiej i cieków uchodzących do niej na stanowiskach badawczych w cyklu rocznym (IX 1976–IX 1977)

Sampling station	Term of sampling										
	21 IX 76	28 X 76	30 XI 76	12 I 77	21 II 77	23 III 77	20 IV 77	25 V 77	15 VI 77	12 VII 77	24 VIII 77
3	65	65	83	75	117	75	91	91	90	95	77
2	58	45	96	66	—	—	—	—	—	—	—
4	57	67	73	51	202	72	75	49	90	85	77
5	53	58	70	66	174	51	54	90	48	49	75
II	263	220	443	244	290	253	287	227	276	276	465
6	67	106	116	70	200	136	54	92	135	67	98
7	75	79	83	—	120	—	—	50	71	93	75
III	—	—	82	—	—	—	—	—	—	—	—
8	—	—	121	—	—	88	trace	—	—	—	—
20	80	80	204	128	170	83	100	182	91	108	137
19	170	107	228	165	165	87	104	91	272	111	136
21	160	105	204	157	159	149	104	138	312	100	193
24	—	39	—	50	—	50	—	45	—	60	—
26	—	86	—	87	—	75	—	91	—	87	—

6. SUMMARY

The performed physicochemical analyses allow us to state that the river Nysa Łużycka waters show seasonal temperature variations, typical of polish rivers [6]. The somewhat warmer water of the river Miedzianka caused a local increase of the temperature of the water in the river Nysa Łużycka by 2–3°C. During the whole cycle of investigations oxygen conditions in the examined river waters were good. An advantageous influence being exerted by the waters from Turów I pumping station.

It seems that large amounts of suspended matter observed during investigations had a diversified effect of the biotop examined. They, among others, inhibited the penetration

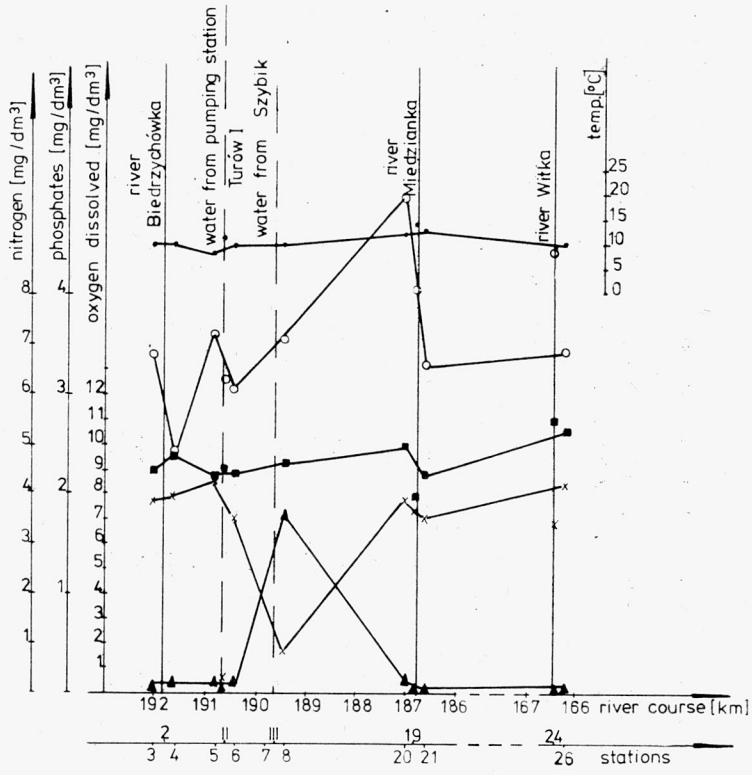

Fig. 7. Variations in water temperature, quantities of dissolved oxygen and nutrients in the waters of Nysa Łużycka in March 1977

For explanations see fig. 2

Rys. 7. Zmiany temperatury wody, ilości rozpuszczonego tlenu i pierwiastków biogennych w wodach Nysy Łużyckiej w marcu 1977 r.

Objaśnienia jak na rys. 2

of light what might reduce the development of algae and other aquaeous plants. Their influence on the changes in heat circulation is also essential. It is known that the sediments coming from coal mines are deposited on the bottom, thus making impossible the development of benthos.

Substantial amounts of iron occurring periodically most probably came from mine waters. It is known that excess of this element is undesirable because of economic reasons [2], but small amounts of iron are, however, of a great importance for production of some enzymes in bacteria, plants, and animals.

During the whole investigation cycle sulphates did not occurr in amounts which would be significant for water protection. Larger amounts of these compounds appearing sporadically came probably from mine waters. The fact, that sulphates result from transformations of hydrogen sulphide and sulphites (reduced forms of sulphur), as well as from sulphur dioxide diffusing into water, is also not meaningless in this respect.

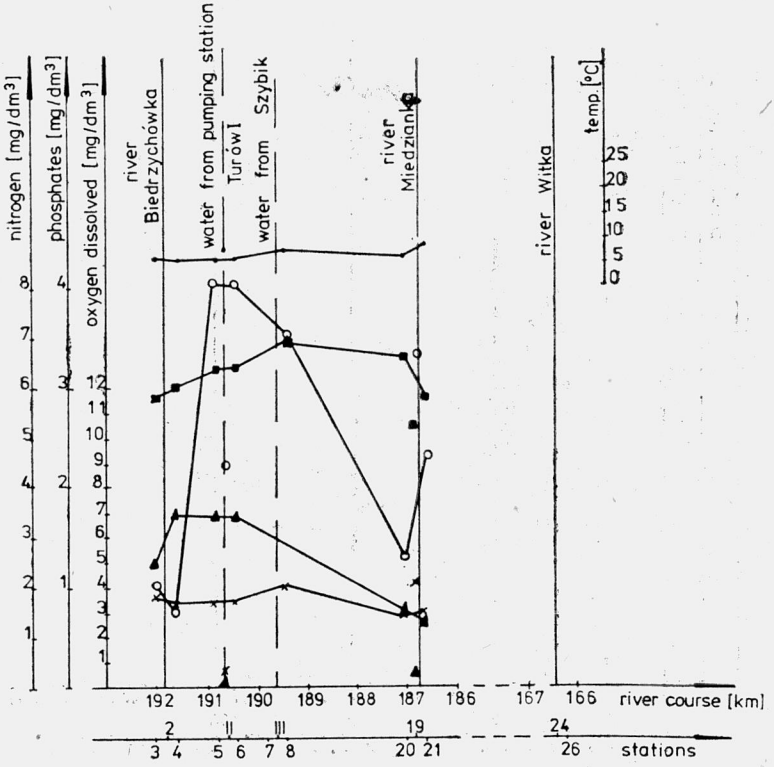

Fig. 8. Variations in water temperature, quantities of dissolved oxygen and nutrients in the waters of Nysa Łużycka in April 1977

For explanations see fig. 2

Rys. 8. Zmiany temperatury wody, ilości rozpuszczonego tlenu i pierwiastków biogennych w wodach Nysy Łużyckiej w kwietniu 1977 r.

Objaśnienia jak na rys. 2

A much important problem is the concentration of nutrients in water [4]. During the whole investigation period variations in the amounts of phosphates in the river Nysa Łużycka water have been observed.

Under normal conditions phosphorus contents decrease in spring and summer, being utilized by plants, and increase in autumn and winter. Such a regularity has not been found in the river Nysa Łużycka waters. Substantial amounts of phosphates occurring periodically came most probably from municipal sewage. The amounts of phosphorus discharged is a limiting factor for the biological production and its content may influence the qualitative composition of algae. During the whole investigation cycle large amounts of nitrogen, chiefly organic ones, have also been stated. Like in the case of phosphates, the natural cycle of transformations of nitrogen compounds was disturbed. No increase of inorganic nitrogen at the cost of organic nitrogen was observed. Large amounts of organic nitrogen, occurring in almost entire investigation cycle, came most probably, directly from the effluents of

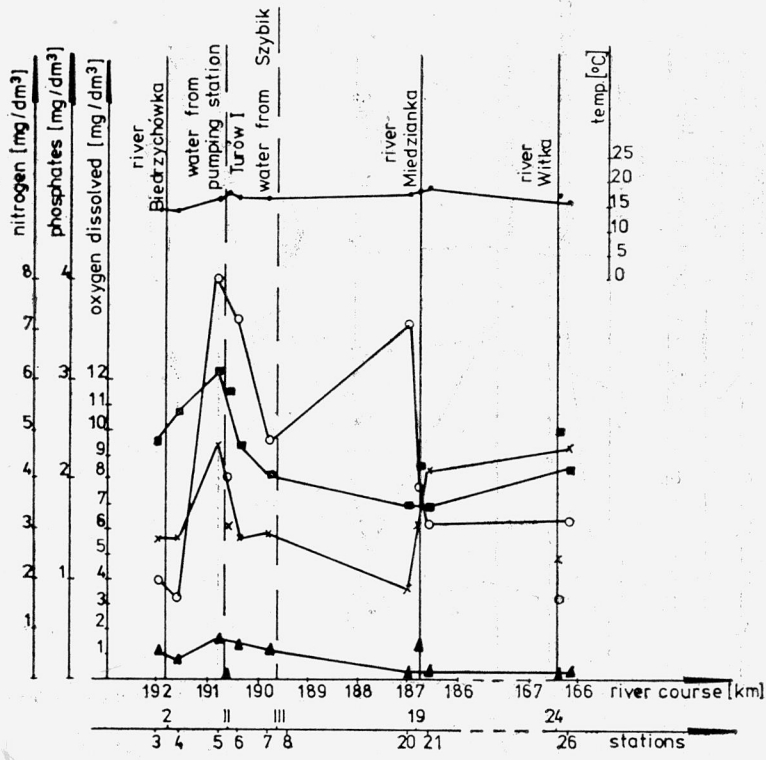

Fig. 9. Variations in water temperature, quantities of dissolved oxygen and nutrients in the waters of Nysa Łużycka in May 1977

For explanations see fig. 2

Rys. 9. Zmiany temperatury wody, ilości rozpuszczonego tlenu i pierwiastków biogennych w wodach Nysy Łużyckiej w maju 1977 r.

Objaśnienia jak na rys. 2

municipal sewage and industrial wastewaters, and in a less degree from the deadened parts of plants and animals. Disturbance in the transformation cycle of nutrients influences the development of biocenosis giving the evidence to its irregular functioning which consequently disturbes the selfpurification process.

Summing up, in view of the investigations performed, it should be stated that along the segment investigated the river Nysa Łużycka waters were strongly polluted and that in many cases they did not meet the standards assumed for inland waters [5] due to the excess of suspended matter and phosphates. The remaining parameters ranged within the values admissible for II and III classes of water purity.

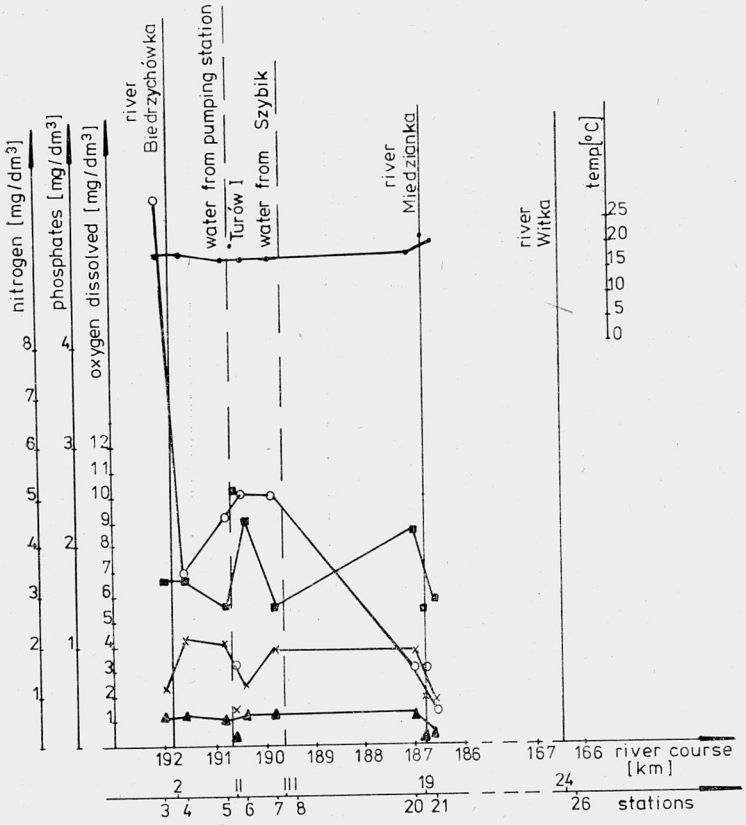

Fig. 10. Variations in water temperature, quantities of dissolved oxygen and nutrients in the waters of Nysa Łużycka in June 1977

For explanations see fig. 2

Rys. 10. Zmiany temperatury wody, ilości rozpuszczonego tlenu i pierwiastków biogennych w wodach Nysy Łużyckiej w czerwcu 1977 r.

Objaśnienia jak na rys. 2

The performed assessment of the Nysa Łużycka water pollution, based on physicochemical criteria, is the background against which the biocenosis of the river and changes in its ecological conditions can be determined.

7. CONCLUSIONS

1. The carried out physicochemical examinations of the Nysa Łużycka have shown that along the segment investigated its waters were strongly polluted exceeding in many cases the admissible standards for inland waters [3].

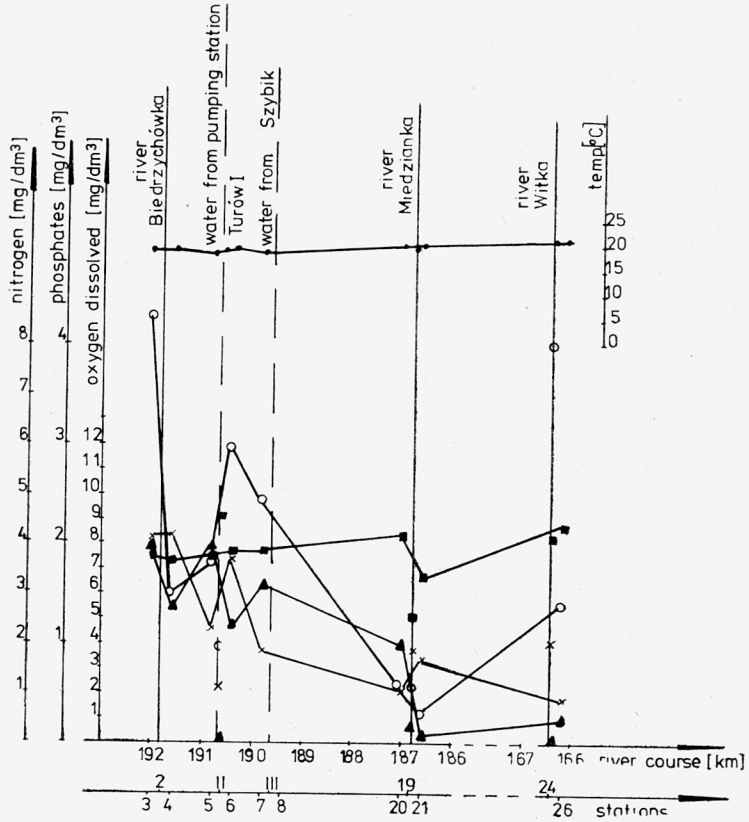

Fig. 11. Variations in water temperature, quantities of dissolved oxygen and nutrients in the waters of Nysa Łużycka in July 1977

For explanations see fig. 2

Rys. 11. Zmiany temperatury wody, ilości rozpuszczonego tlenu i pierwiastków biogennych w wodach Nysy Łużyckiej w lipcu 1977 r.

Objaśnienia jak na rys. 2

2. Good oxygen conditions along the segment examined would enable an efficient course of biodegradation, providing that the measures of water protection are observed.

3. Some disturbances have been observed in cycles of nitrogen and phosphorous. These nutrients occurring in large amounts have probably a deciding effect on the development of biocenosis and, consequently, on selfpurification process.

4. Substantial amounts of suspended matter, stated in investigations, exerted probably a diversified and disadvantageous effect on the biotope being investigated.

5. Large amounts of iron occurring periodically in water along the examined segment of the river Nysa Łużycka came from mine water.

6. No significant, from the viewpoint of water protection, quantities of sulphates have been observed in the river Nysa Łużycka water.

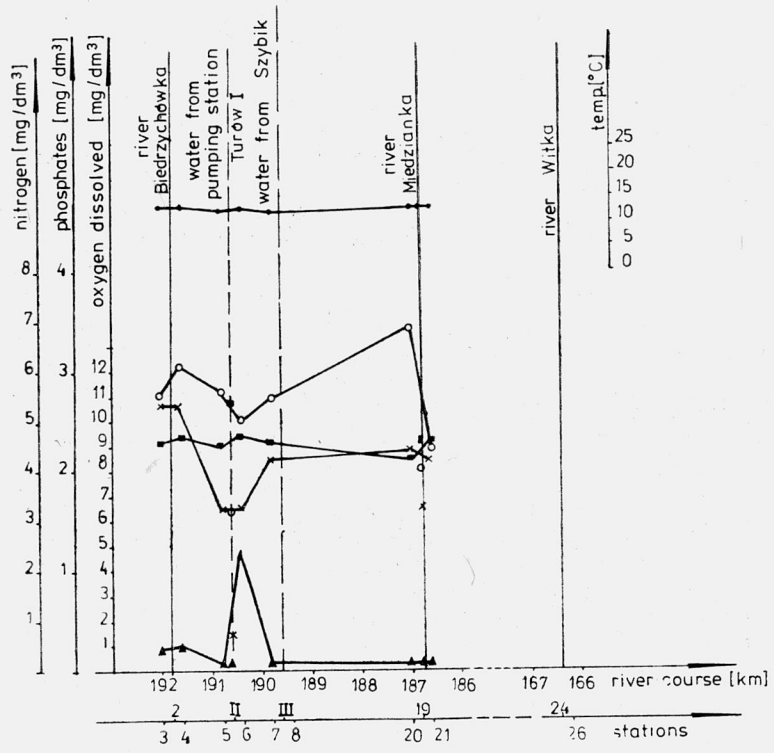

Fig. 12. Variations in water temperature, quantities of dissolved oxygen and nutrients in the waters of Nysa Łużycka in August 1977

For explanations see fig. 2

Rys. 12. Zmiany temperatury wody, ilości rozpuszczonego tlenu i pierwiastków biogennych w wodach Nysy Łużyckiej w sierpniu 1977 r.

Objaśnienia jak na rys. 2

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STAN ZANIECZYSZCZENIA NYSY ŁUŻYCKIEJ W REGIONIE TUROSZOWSKIM CZĘŚĆ I. OCENA FIZYCZNO-CHEMICZNA

Celem pracy było określenie stanu zanieczyszczenia Nysy Łużyckiej na podstawie wyników badań fizyczno-chemicznych. Stwierdzono, że Nysa Łużycka na odcinku od ujścia Biedrzychówki do ujścia Witki była silnie zanieczyszczona i że często normy dopuszczalnych zanieczyszczeń wód śródlądowych były przekroczone. Na badanym odcinku rzeki wody były jednak dość dobrze natlenione, co umożliwiałoby sprawny przebieg procesów biologicznego rozkładu pod warunkiem zachowania dyscypliny ochrony wód. Zaobserwowano zakłócenia w obiegu pierwiastków biogennych, azotu i fosforu, które występują w znacznych ilościach, co zapewne miało decydujący wpływ na kształtowanie się biocenozy. Duże ilości zawiesin w wodzie Nysy Łużyckiej wywierały wieloraki, niekorzystny wpływ na badany biotop.

DIE VERSCHMUTZUNG DER LAUSITZER NEISSE IM REGION VON TUROSZÓW TEIL I. BEURTEILUNG DES PHYSIKALISCH-CHEMISCHEN VERSCHMUTZUNG

Ziel der Arbeit war die Beurteilung der physikalisch-chemischen Verschmutzung der Lausitzer Neiße. Auf dem Abschnitt zwischen der Biedrzychówka-Mündung und der Witka-Mündung ist der Fluß äusserst stark verschmutzt. In zahlreichen Fällen werden die Grenzwerte der Verschmutzungen, die für Oberflächengewässer festgelegt wurden, weit überschritten. Auf dem untersuchten Flußabschnitt wies zugleich das Wasser einen hohen Sauerstoffgehalt, auf der — bei Einhaltung einer entsprechenden Disziplin des Gewässerschutzes — den Selbstreinigungsvorgang fördern kann. Beobachtet wurde eine Störung des Kreislaufs der biogenen Substanzen — des Stickstoffs und des Phosphors, die in beträchtlichen Konzentrationen vorkommen. Das spielt eine ausschlaggebende Rolle bei der Entwicklung einer spezifischen Biozönose. Hohe Suspensionskonzentrationen üben einen vielseitigen, ungünstigen Einfluß auf den untersuchten Biotop.

СОСТОЯНИЕ ЗАГРЯЗНЕНИЯ В НЫСЕ ЛУЖИЦКОЙ В ТУРОШОВСКОМ РАЙОНЕ ЧАСТЬ. I. ФИЗИКО-ХИМИЧЕСКАЯ ОЦЕНКА СОСТОЯНИЯ ЗАГРЯЗНЕНИЯ

Цэлью работы было определение состояния загрязнения Нысы Лужицкой на основе результатов физико-химических исследований. Отмечено, что Ныса Лужицка на участке от устья Беджихувки до устья Витки была сильно загрязнена. Во многих случаях нормы допускаемых загряз-

нений внутренних вод были превышены. Однако на исследуемом участке реки воды были довольно хорошо насыщенными кислородом, что способствовало бы соответствующему протеканию процессов биохимического разложения при условии соблюдения дисциплины охраны водных бассейнов. Были замечены нарушения в циркуляции биогенных элементов — азота и фосфора, которые выступают в значительных количествах, что, несомненно, имело решающее влияние на формирование биоценоза. Большие количества суспензий в воде Нысы Лужицкой оказывали многообразное влияние на исследуемый биотоп.