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Osady denne zanieczyszczonego zbiornika zaporowego w Otmuchowie

Bottom sediments of the polluted dam reservoir at Otmuchów

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Abstract — Investigations were carried out on the physico-chemical properties of sediments of the Subsudetic dam reservoir, from the point of view of their relation to the kind and actual degree of pollution of the river water (wastes of the cellulose-paper and sugar industries), on the background of some earlier data. It was found that the material accumulating in the reservoir consists almost esclusively of suspended matter. As a result of the inflow of polluted water for many years, the sediments of the Otmuchów reservoir contain several times more organic matter and mineral phosphorus than those of the other Polish dam reservoirs with pure water. The organic matter of the investigated sediments is characterized by a certain specific composition. Apart from a considerable mass of cellulose fibres resistant to decomposition, it contains an unusually high percentage of free fulvic and humic acids, undergoing relatively easy dissolution in wter and mineralization. The less complex fulvic compounds prevail. In some zones of the reservoir hydrogen sulphide and phenols were detected in the sediments. Moreover, the sediments are characterized by a very high content of bitumens, a relatively low content of calcium and sulphates, an acid reaction, and an increased iron content. The paper concludes with consideration on the detrimental effect of this kind of sediment and of the water of the river on the environment and biocenosis of the reservoir.

The quality of sediments in polluted reservoirs depends not only on the intensity of the accumulation of the material eroded from the catchment basin (chiefly mineral suspended matter) and on the amount of the produced autochthonic organic matter, but also on the initial chemical composition, kind, and degree of pollution of the water of the in flowing river. Thus, from the properties of sediments of such reservoirs some conclusions can be drawn on the degree of pollution of the river and on its effect on the environment.

The aim of the present work was to determine the physico-chemical properties of sediments of the Otmuchów reservoir from the point of view of their relation to the actual pollution of the water of the river Nysa Kłodzka, on the background of some earlier data from the year 1958 (W r ó b e l 1959).

Methods of investigation

Bottom sediments were collected from the reservoir during a period of its total inundation (2—3.VII.1968), with the aid of a tubular probe. The sampling points, marked in fig. 1, were distributed on the area of the reservoir similarly as during the investigations carried out in 1958. To obtain a better representativeness of the sample, the sediments were collected several times at each sampling point within a radius of about 20 m. One mean sample of sediments was also taken from the bottom of the river Nysa Kłodzka above the reservoir. The river sediments were collected chiefly in calm water zones, where the sedimentation of suspended matter is greatest.

The grain composition of the sediments was determined with the C a s a g r a n d e - P r ó s z y ń s k i method, the general content of organic carbon with the A l t e n method, and in humic fractions with the T i u r i n method, the total nitrogen according to K i e j d a h l, the reaction electrometrically, freely soluble phosphorus with the W o n d r a u s z o w a method, and the content of chemical macrocomponents soluble in 20 per cent HCl according to the generally accepted principles of the analysis of silicates.

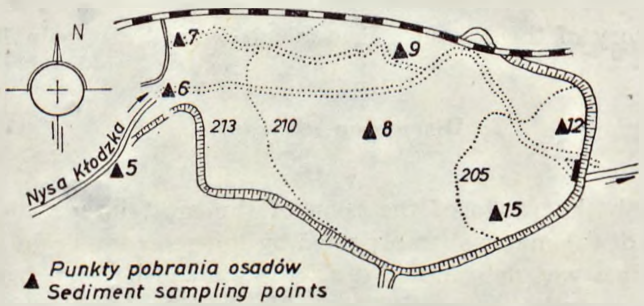
Besides, the sediments were examined for the hydrogen sulphide content.

Morphometry of the reservoir, character of the catchment basin and of the river's water

The Otmuchów reservoir was constructed in 1933 by closing with an earth dam the wide, even valley of the river Nysa Kłodzka on the foreland of the Sudeten range. It has a regular shape (fig. 1) and an area of 2040 ha. at a normal rise in the water level. Initially its maximum capacity amounted to 143 mln m^3 and its depth to 15 m. At the present time the average depth of the upper half of the reservoir ranges from 2 to 5 m. In the shallowest places of this part clumps of shrubs and trees, as well as rushes grow. The bottom has a gradient of about 4‰. The reservoir serves energetistic and flood control purposes and also to level the water

table in the navigable Oder (of all tributaries of the Oder Nysa Kłodzka has the greatest coefficient of irregularity of outflow, amounting to 38).

The catchment basin of the Nysa Kłodzka in the profile of the dam covers an area of 2348 km². The intermontane Kłodzko Basin (Kotlina Kłodzka) and terrains of the mountain foreland constitute the essential part of its area. The mountains surrounding the Basin (alt. 700—1313 m)



Ryc. 1. Plan zbiornika zaporowego w Otmuchowie
Fig. 1. Plan of the dam reservoir at Otmuchów.

form only small source areas of the river's catchment basin and tributaries. All the greater elevations and rocky slopes are generally densely forested. The Sudeten area of the catchment basin up to Bardo Śląskie is built for the most part of loam (light, medium, heavy) and fine sands with an admixture of skeletal soils, formed in the summit mountain sections and partly in the vicinity of Kłodzko on crystalline rocks (gneiss, various crystalline schists, syenites, diorites, and others), and on the other terrains on sedimentary rocks (sandstones, greywacke, marls, shales, and post--glacial and deluvial deposits). The share of rocks rich in calcium is relatively small in this area. In the poorly undulated part of the basin lying in the mountain foreland less eroded sandy soils prevail. Owing to the kind of substratum and good biological development of the steeper slopes, the average intensity of erosion is slightly weaker than in the basins of the majority of Carpathian rivers. Reniger (1958) estimated it according to the nine-grade scale at 7.2 in the mountain area and in the Kłodzko Basin, and 4.0 in the Foreland. According to Wiśniewski (1963), the index of denudation of the catchment basin of the reservoir amounts to 0,125 mm.

The water of the river Nysa Kłodzka (its mean annual discharge before the reservoir amounts to17.8 m^3) is in a high degree charged with sewage, chiefly organic, of the cellulose and paper industry, and seasonally with sugar factory wastes. In consequence, it has a weak-acid reaction (pH 6.6—7.0), a strong colouring, oxygen consumption (frequently $>$ 30 mg O_2/l), and biochemical oxygen demand, much mineral nitrogen (0.5—1.0 mg/l ammonia), and a markedly increased dryresidue (volatile matter), amount

of potassium, iron (0.3—0.6 mg Fe/l), chlorides, and phosphates. Moderate quantities of calcium and magnesium occur in it (the total hardness ranges from 7.0 to 8.0°g), as well as sulphates. In the rapidy flowing water of the river (ca. 0.5 m/sec) no marked oxygen deficiency was noted during the past years. The water becomes much more purified in the reservoir as it approaches the dam. Its oxygen consumption ranges from 19.0 to 24.0 mg O_2/l. (Stangenberg 1964, Kołaczkowski and Prais 1965, Laboratory of the People's Provincial Council at Opole 1967).

Discussion of results

To establish the range of the zone of the most intense deposition in the reservoir of the material transported by the river the grain composition of the sediments was determined (Table I). As can be seen from the data obtained, the material accumulating in the reservoir consists exclusively

Tabela I. Skład granulometryczny osadów dna zbiornika zaporowego w Otmuchowie w %
Table I. Grain composition of bottom sediments in the Otmuchów dam Reservoir in %

Nr próby No of sample	Głębokość w cm Depth in cm	Średnica cząstek w mm Particle diameter in mm						Suma Total
		1-0.1	0.1-0.05	0.05-0.02	0.02-0.006	0.006-0.002	<0.002	<0.02
6	0-15	12	13	28	24	10	13	47
7	0-15	9	12	35	20	10	14	44
8	0-15	13	12	25	23	13	14	50
9	0-15	20	15	23	18	12	12	42
12	0-15	7	3	15	36	23	16	75
15	0-15	7	3	23	30	19	18	67

of suspended matter. In the upper and middle part of the reservoir it is composed of silt and in the deepest zone near the dam of heavy loam. The considerable sedimentation of coarser particles (1.0—0.02 mm.) of the suspension in the water, above all that of cellulose fibres, has in the investigated reservoir an exceptionally distant reach, since it still occurs in its whole middle part. This, besides the hydrological conditions of the reservoir (distant influence of the river, displacement of water masses, when the generating plant is in action, symmetrical basin of the reservoir), is probably also related to the quantitative predominance of the lighter sewage organic suspension brought in with the river water. The introduction to the reservoir of a large amount of sewage suspension (as well as of mineral wastes from the sugar factory) explains why the degree of silting up of this reservoir is much higher than would result from the natural conditions of the catchment basin. According to Wi-

śniewski (1963), the cubic capacity of the reservoir decreased from the time of its construction to July 1961 by 8.5 mln m³.

In contradistinction to those of other Polish dam reservoirs, the investigated sediments have an acid reaction (Table II). This is probably chiefly related to the inflow into the reservoir of large quantities of organic matter of acid character.

Tabela II. Zawartość organicznego węgla, całkowitego azotu, substancji organicznej, łatwo rozpuszczalnego fosforu i odczyn osadów dna zbiornika zaporowego w Otmuchowie

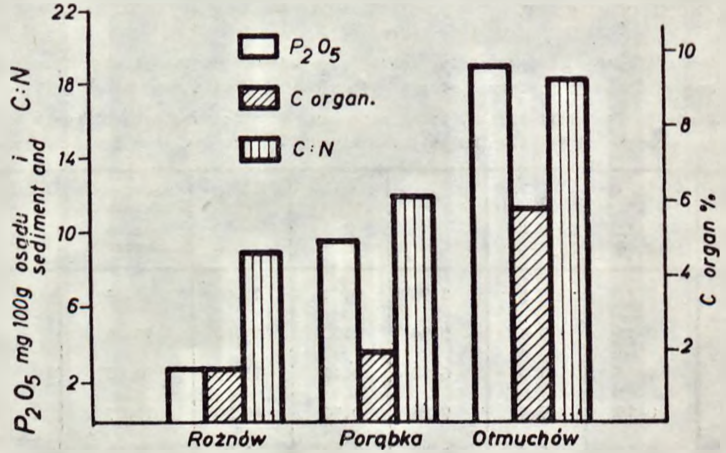
Table II. Content of organic carbon, total nitrogen, organic substances, freely soluble phosphorus and reaction of bottom sediments in the Otmuchów dam Reservoir

Nr próby No of sample	Głębokość w cm Depth in cm	pH (w H_2O)	C %	N %	C : N	Substancja organiczna Organic substance	P_2O_5 mg/100 g osadu of sediments
5	0-2	5.9	1.76	0.11	16.00	3.03	15.5
6	0-15	5.4	5.94	0.30	19.80	10.24	18.5
7	0-15	6.0	6.18	0.47	13.15	10.66	20.0
8	0-15	5.5	7.56	0.30	25.20	13.03	19.0
9	0-15	5.3	4.59	0.22	20.86	7.92	19.5
12	0-15	5.1	5.58	0.31	18.00	9.62	19.0
15	0-15	5.3	3.69	0.27	13.67	6.36	19.5

Sandy bottom sediments of the river Nysa Kłodzka collected above the reservoir contain little organic matter and nitrogen (Table II). Consequently, only a very small part of the organic suspension carried by the rapidly flowing water of the river is deposited on its bottom. Its basic mass flows with the river water into the reservoir, where, before being covered with younger sediments, it becomes partly altered and mineralized.

In spite of the high water levels in the river occuring unusually frequently in the past years with which a considerable inflow into the reservoir of mineral suspended matter eroded from the basin is related, the content of organic matter in sediments of the upper half of the Otmuchów reservoir already exceeds in some zones 10 per cent of the air-dry mass of sediments (Table II). The greatest amount of organic matter was noted in sediments of the middle part of the reservoir and the smallest in the region of the dam. As can be seen in fig. 2, the mean content of organic carbon in the whole Otmuchów reservoir is almost four times higher than in the pure submontane dam reservoir at Rożnów on the Dunajec (Reniger 1955, Wróbel 1965), and is three times higher than the content of these substances in the little polluted reservoir of this type at Porąbka on the river Soła during the period preceding the inundation of the higher lying reservoir at Tresna (Pasternak 1969). Such an intense accumulation of organic matter in the sediments of the

investigated reservoir, with a montane and submontane catchment basin, from which as from every dam reservoir part of the organic matter suspended in the water flows out, is possible only oving to a considerable charging of the river water with sewage. This accumulation is in great measure due to the previously mentioned industrial organic pollution of

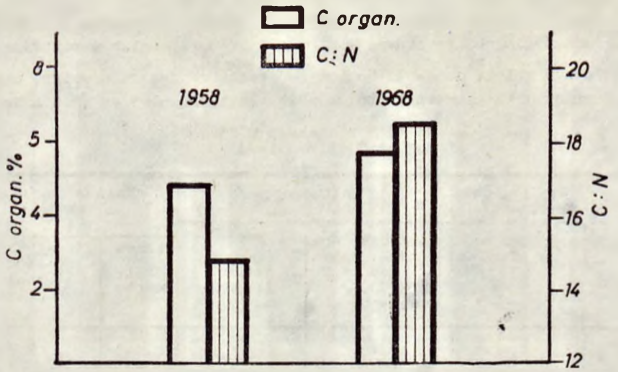


Ryc. 2. Średnie zawartości łatwo rozpuszczalnego fosforu (wg danych autora), organicznego węgla oraz średni stosunek C : N w osadach dna zbiorników zaporowych: w Rożnowie (czysta woda); Porąbce (słabo zanieczyszczona woda — przed zalaniem zbiornika w Tresnej); i Otmuchowie (woda zanieczyszczona).

Fig. 2. Mean content of freely soluble phosphorus (according to the author's data) and of organic carbon, and mean C : N ratio in sediments of the bottom of dam reservoirs at: Rożnów (pure water) Porąbka slightly polluted water — before the inundation of the reservoir at Tresna; and Otmuchów (polluted water).

the river by the little decomposed and poor in nitrogen cellulose and lignin compounds. This results from a very wide C:N ratio, characteristic of the organic matter of sediments of the upper half of the reservoir (Table II). The organic matter of other dam reservoirs, composed for the most part of autochthonic organic substances, shows a much narrower C:N ratio, lying within an interval of 9.0—12.0 (fig. 2).

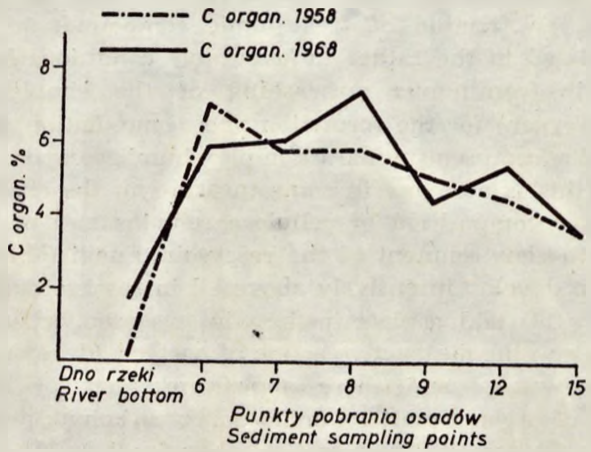
After comparing the mean content of organic carbon in sediments of the Otmuchów reservoir, noted in the present investigations, with data established ten years ago (W r ó b e l 1959), it appears that the amount of organic matter deposited in its bottom has only slightly increased (fig. 3). As can be seen in fig. 4, this increase is distinctly marked only in the middle region of the reservoir. In its upper part the accumulation of organic matter is even slightly smaller than in 1958. This may be due to an unusually large inflow of mineral suspended matter into this zone during the frequent rises of the river in 1968, or more probably, to a certain decrease during the recent period in the charging of the Nysa Kłodzka water with organic pollution.



Ryc. 3. Średnie zawartości węgla organicznego i średnie wartości C : N w osadach zbiornika w Otmuchowie z 1958 i 1968 r.

Fig. 3. Mean content of organic carbon and mean C : N values in sediments of the Otmuchów reservoir in the years 1958 and 1968.

Apart from a large amount of cellulose-lignin fibres resistant to decomposition and of organo-mineral compounds, a relatively high percentage of matter of the examined sediments is composed of humic compounds unbound with mineral ions and clayey matter (Table III). The percentage content of these free compounds (humic and fulvic acids) in the sediments of the Otmuchów reservoir was calculated in relation to the total carbon amount determined (with the Tiurin method) in samples unsifted through a 0.25 mm sieve. The results of analyses show



Ryc. 4. Porównanie ilości węgla organicznego w osadach zbiornika otmuchowskiego z 1958 i 1968 r. w poszczególnych punktach ich poboru (w podłużnym profilu zbiornika).

Fig. 4. Comparison of the content of organic carbon in sediments of the Otmuchów reservoir from the years 1958 and 1968 at the particular sampling points (in the longitudinal profile of the reservoir).

Tabela III. Zawartość w osadach dennych zbiorników zaporowych kwasów huminowych i fulwowych niezwiązanych z mineralnymi związkami lub tworzącymi z nimi sole rozpuszczalne w roztworze zasadowym (0.1 n NaOH)

Table III. Content of humic and fulvic acids in bottom sediments of dam reservoirs, unbounded with mineral compounds or forming with them salts soluble in alkaline solution (0.1 n NaOH)

*) przez sito o oczkach 0.25 mm
through a 0.25 mm sieve

Zbiornik Reservoir	Nr próby No of sample	Ogólna zawartość C % Total content		C- Bituminy Bitumens		C- Kwasów huminowych of humic acids %		C- Kwasów fulwowych of fulvic acids %	
		przesiany* sifted	nieprzesiany unsifted	zawartość C w g/100 g osadu content of C in g/100 g sediments	C- ogólnego osadu total sediments %	osadu sediments	C- ogólnego osadu total sediments	osadu sediments	C- ogólnego osadu total sediments
		osad sediments							
Otmuchów	8	5.61	6.30	0.457	7.3	0.143	2.27	0.182	2.89
"	15	3.60	3.67	0.492	13.4	0.128	3.49	0.158	4.31
Porąbka	1	1.99	-	0.048	2.4	0.044	2.21	0.065	3.26
"	4	1.95	-	0.045	2.3	0.041	2.10	0.073	3.74

(Table III) that in the case of this type of sediment the sieve acts selectively, separating together with the coarser fraction an unproportionally larger amount of cellulose fibres. The content of free humic and fulvic acids undergoing relatively more readily a further decomposition in the surface layer of the bottom, or dissolution in water, is twice or three times higher than in the sediments of the only insignificantly polluted reservoir at Porąbka. In the sediments of the two compared reservoirs, in this fraction of humic compounds, the more readily dissolving in water (also in the form of salts) and more acidic fulvic acids definitely prevail over humic acids. The predominance of these relatively low-molecular, mobile compounds in the fraction of free humic compounds of sediments is presumably related to the rather unfavourable conditions in this kind of water reservoir (continuous outwashing of the simpler compounds, deficiency of oxygen) for the formation and accumulation of humic acids and of their salts, representing more complex humic compounds. Moreover, it seems that this is also due in some measure to the share of fungi in the process of decomposition of cellulose remains and of other organic substances in the environment of the reservoir. Fungi (*Mucor*, *Fusarium*, *Penicillum*) can develop intensively above all in reservoirs rich in sewage organic matter, this taking place in the winter season, when owing to the fall of temperature the destructive action of bacteria (development of green plants) grows wekaer and there appear products of an incomplete decomposition of organic matter (amino acids, carbohydrates, and simpler humic compounds), constituting a good medium for them (M o s s e w i t s c h and G u s s e w 1958, L i e b m a n n 1962). As compared with the sediments of the relatively pure reservoir at Porąbka, the investigated sediments are also much richer in the so-called bitumens (resins, tars, fats). A particularly large amount of bituminous substances is found in the

sediments of the deepest zone of the Otmuchów reservoir (Table III, sample 15). The quantitative analysis showed that the sediments of this reservoir also contain phenol compounds.

In the chemical composition of sediments of the investigated reservoir the large amount of phosphorus is striking (Table IV). It is also striking that, in contradistinction to other reservoirs, a considerable part of this phosphorus (fig. 2) occurs in its sediments in the form of freely soluble

Tabela IV. Skład chemiczny rozpuszczalnej w 20 % HCl części osadów zbiornika zaporowego w Otmuchowie (powietrznie suchych) w % wag.

Table IV. Chemical composition of part of bottom sediments in the Otmuchów dam Reservoir, soluble in 20% HCl (air-dry sediments) in % by weight

Nr próby No of sample	6	7	8	15
SiO_2	0.59	0.62	0.53	0.61
TiO_2	śl.	śl.	śl.	śl.
P_2O_5	0.25	0.45	0.20	0.10
Al_2O_3	5.48	5.90	5.43	6.93
Fe_2O_3	4.40	4.60	4.15	4.80
MnO	0.06	0.10	0.05	0.06
CaO	0.80	1.18	0.82	0.88
MgO	1.23	1.03	1.13	1.20
K_2O	1.01	0.87	0.86	0.99
Na_2O	0.37	0.36	0.38	0.36
SO_3	0.33	0.43	0.41	0.34
Suma części rozpuszcz. w HCl Total of parts soluble in	14.52	15.54	13.96	16.27
H_2O (105°C)	2.82	3.62	2.75	3.21
Strata żarowa Loss in ignition	11.44	13.40	13.25	9.32
Suma części nierozpuszcz. w HCl Total of parts insoluble in	71.29	67.46	70.15	71.35
Suma Total	100.07	100.02	100.11	100.15

compounds, which can fairly easily pass into the water. The largest amount of phosphorus soluble in 20 per cent HCl (almost total) occurs in sediments near the mouth of the river and of the millstream and the smallest in the region of the dam (Table II). This shows that a large part of the phosphorus brought in with the river water remains in the reservoir. Since with the polluted water of the river also a large amount of mineral nitrogen and potassium flows into the reservoir, the trophic conditions of the latter increase successively (production of autochthonic organic matter) with the passage of time. This increase, after having reached a certain level, can lead, under unfavourable climatic conditions, to detrimental consequences for the life of fish in the reservoir both during the winter and summer. A particularly large charge of biogenic components (N, P, K)

is brought into the reservoir (seasonally) with the waste waters of the sugar factory (Kołaczkowski, Bierwagen 1960). According to Lewkowicz's (1969) unpublished materials, the content of potassium in the already partly purified sugar factory wastes may amount to 83.0 mg K/l. Apart from phosphorus, the content of other mineral chemical components in the sediments (dissolved in 20 per cent HCl) does not in principle much exceed the average (Table IV). As compared with those of other reservoirs, the investigated sediments (also after the combustion of organic matter) are characterized by a small quantity of calcium, a relatively large amount of iron, and a slightly greater quantity of magnesium and potassium than would appear from their content of clayey matter. On account of the quality of the water pollution, the none too high content of sulphates in their chemical composition is striking. This is probably due to the fact that the non-neutralized sulphuric acid (Garczarczyk 1955) present in wastes of the cellulose industry (sulphite method) reaches the reservoir only in very small quantities (also attached to lignin). One may also presume that it is due to the occurrence in the upper layer of sediments and in the water in contact with it of a seasonal reduction zone, which does not favour the accumulation of sulphates in the bottom (biochemical reduction to hydrogen sulphide), as was established by Nriagu (1968) in his investigations carried out in lakes, and by the present author in polluted ponds (Pasternak 1966 and unpublished materials). The lowering of the level of sulphates in the bottom zone of water of polluted lakes was also noted, among others, by Januszkiewicz and Jakubowska (1965). A certain amount of hydrogen sulphide was found only at point 15. Sediments from this station also contained a considerable of dead fish.

Conclusions

As a result of the many years' inflow into the Otmuchów reservoir of a considerable charge of organic pollution and biogenic components brought in with the river water, its bottom sediments contain at present a very large amount of organic matter, exceeding 10 per cent in its upper half. The organic matter occurring in sediments of this type of reservoirs is composed of a very large amount of cellulose-lignin and organo-mineral compounds fairly resistant to decomposition, as well as of free fulvic and humic acids relatively easily undergoing mineralization and dissolution in water, their content several times exceeding that of sediments of comparatively pure reservoirs. This is probably related to the fact that the deposition of the sewage suspension is accompanied not only by the increased primary production of the reservoir water in consequence of its high content of trophic mineral components (of sewage origin), but

also by the large production of organic matter in the heterotrophic chain (fungi, bacteria) on a substratum of detritus present in this suspensions occurring seasonally in such an environment. Thus, it is worth noting that in the case of reservoirs with this or a similar kind of pollution the knowledge of the intensity of photosynthesis does not sufficiently reflect its total basic production. The investigated sediments are also characterized by an exceptionally high content of bituminous compounds, especially in the deepest part of the reservoir.

Although the quality of sediments of the upper zone of the reservoir shows a certain amelioration of the quality of the river water, this high content of organic matter in its bottom, as well as a still considerable in one the water, may cause during a period of unfavourable climatic conditions (ice cover) a deficiency of oxygen and a secondary pollution with products of anaerobic decomposition of these substances (H_2S and others). On account of its high content of readily dissolving and decomposing components, the organic substance of the investigated sediments may act disadvantageously on the oxygen content not only in the water near the bottom but also in its larger mass. For the content of dissolved and colloidal humic compounds in surface waters on substrata rich in organic matter can be very high (Skopincev, Kryłova 1955, Ryhänen 1964). The occurrence of some oxygen deficiencies in the bottom layer of water of the deepest part of the reservoir is evidenced by the unusually high content of bitumens and the presence of hydrogen sulphide in sediments from this region. The organic matter of sugar factory wastes, occurring mostly in colloidal or dissolved form, can have a particularly detrimental effect on the biocenosis of the reservoir. They undergo mineralization much sooner than post-cellulose wastes; moreover, they are brought into the reservoir during the autumn-winter season when the process of self-purification of water grows weaker.

The inflow of a large charge of sewage suspension into the reservoir also has a detrimental effect by increasing the degree of silting up and reducing the time of its existence. The organic impurities present in the water can also act detrimentally in an indirect way. Thus, the filamentous bacteria (*Sphaerotilus natans*) and fungi developing in consequence of their presence in the water of the reservoir, apart from increasing the already large amount of organic mass in it, are deposited in masses on the installed fishing gear (or other appliances and apparatuses), making it less serviceable or damaging it. The intense deposition of the acid sewage suspension on the bottom of the upper half of the reservoir is presumably also the cause of the considerable quantitative and specific decrease in the bottom macrofauna (noted there by Kysela, 1968) constituting the basic food of fish.

One cannot expect the environmental conditions of the reservoir to improve entirely as soon as the considerable pollution of the river's water

becomes prohibited (in connection with the planned intake of water for the city of Wrocław). The very large amount of various polluting substances accumulated during the past years will act on its water for some time yet. It may be possible to shorten this time if a temporary reduction of the level of water in the reservoir can be brought about, in order to mineralize, if only partly, the excess of organic matter deposited in the sediments in its uncovered upper areas.

STRESZCZENIE

W pracy określono fizyko-chemiczne właściwości osadów zbiornika zaporowego w Otmuchowie w aspekcie ich związku z aktualnym zanieczyszczeniem wody rzeki Nysy Kłodzkiej (ścieki przemysłu celulozowo-papierniczego i cukrowniczego), na tle wcześniejszych danych z 1958 roku. Podano również charakterystykę morfometrii i zlewni zbiornika oraz składu chemicznego wody rzeki. Osady denne zostały pobrane ze zbiornika w okresie jego pełnego zalewu w 1968 r. za pomocą sondy. Punkty ich pobrania rozmieszczono podobnie jak w badaniach 1958 r. (ryc. 1).

Z uzyskanych danych wynika, że w zbiorniku akumuluje się przede wszystkim materiał unoszony. W górnej i środkowej części zbiornika ma on skład utworu pyłowego, a w pobliżu zapory gliny ciężkiej (tabela I). Sedymentacja grubszych cząstek organicznej zawiesiny ma w zbiorniku wyjątkowo daleki zasięg. W rezultacie wieloletniego dopływu zanieczyszczonej wody, badane osady, w porównaniu z osadami innych polskich zbiorników podgórskich zasilanych czystą lub prawie czystą wodą, zawierają bardzo dużo materii organicznej o szerokim stosunku C:N oraz znaczną ilość fosforu w dużej części w postaci łatwo rozpuszczalnej (tabele II i III, ryc. 2, 3). W górnej połowie zbiornika ilość materii organicznej wynosi już więcej niż 10% powietrznie suchej masy osadów. Ogólnie biorąc, zasób jej w osadach zbiornika maleje w kierunku zapory (ryc. 4). W odniesieniu do danych z 1958 r. zawartość materii organicznej w osadach w strefie najbliższej dopływowi rzeki jest nieco mniejsza. Wskazuje to między innymi na pewną w ostatnich latach poprawę stanu zanieczyszczenia wody rzeki. Substancja organiczna osadów, poza dużą masą odpornych na rozkład i ubogich w azot włókien celulozowych i związków organo-mineralnych, składa się z kilkakrotnie większej ilości niż osad prawie czystego zbiornika w Porąbce z wolnych kwasów fulwowych i huminowych, ulegających stosunkowo łatwo rozpuszczaniu w wodzie i mineralizacji. Wśród tych wolnych związków humusowych przeważają niżej molekularne i bardziej rozpuszczalne kwasy i sole fulwowe (tabela III). Ma to prawdopodobnie przyczynowy związek z tym, że osadzaniu się ściekowej zawiesiny towarzyszy nie tylko wzmożona pierwotna produkcja wody zbiornika, na skutek znacznego w niej zasobu troficznych składników (N, P, K), lecz także występująca w takim środowisku, zwłaszcza w okresie zimowym, duża dodatkowa produkcja łatwo rozkładającej się materii organicznej w heterotroficznym łańcuchu (bakterie ściekowe, grzyby) na podłożu organicznego detrytusu, zawartego w tej zawiesinie. Szczególnie duży ładunek biogenicznych składników chemicznych dostaje się okresowo do zbiornika z wodami cukrowni. W niektórych strefach zbiornika w osadzie występuje siarkowodór i fenole. Poza tym badane osady wyróżnia się bardzo dużą ilością bitumin, stosunkowo małą wapnia, kwaśnym odczynem i podwyższoną (biorąc pod uwagę skład granulometryczny) zawartością żelaza. W składzie chemicznym osadu, z uwagi na jakość zanieczyszczeń wody (obecność w ściekach H_2SO_4), zaskakuje niezbyt duża ilość siarczanów. Wiąże się to przypuszczalnie głównie z okresowym powstawaniem w osadach i w przydennej warstwie wody strefy redukcyjnej.

Jakkolwiek właściwości osadów górnej części zbiornika wskazują na pewną poprawę jakości wody rzeki, przy tak dużym nagromadzeniu się materii organicznej w jego dnie (również wolnych związków humusowych) i ciągle jeszcze dużej jej zawartości w wodzie, w zbiorniku mogą występować w okresach niekorzystnych warunków klimatycznych (gruba pokrywa lodowa) znaczne niedobory tlenowe i wtórne zanieczyszczenia produktami anaerobowego rozkładu tych substancji. Za występowaniem pewnych niedoborów tlenowych w przydennej warstwie wody najgłębszej warstwy zbiornika przemawia wyjątkowo duża zawartość w osadach bitumin i obecność siarkowodoru. Szczególnie ujemny wpływ na biocenozę zbiornika mogą mieć występujące przeważnie w koloidalnej lub rozpuszczalnej postaci substancje organiczne ścieków cukrowniczych, dostające się do zbiornika w okresie jesienno-zimowym, kiedy słabnie proces samooczyszczania. W efekcie dopływu do zbiornika dużej ilości ściekowej zawiesiny stopień jego zamulania jest znacznie większy, niż wynika to z naturalnych warunków przyrodniczych zlewni. Zjawisko to powoduje pośrednio także inne ujemne reperkusje w zbiorniku. Mianowicie rozwijające się na podłożu ściekowych związków organicznych bakterie nitkowate (*Sphaerotilus*) i grzyby, poza zwiększaniem masy organicznej w wodzie, osiadają masowo na rozstawionych sieciach rybackich (w innych przypadkach na urządzeniach i aparaturze), powodując ograniczenie ich przydatności lub niszczenie. Zasadniczej poprawy warunków środowiskowych badanego zbiornika nie należy oczekiwać już z chwilą ograniczenia do minimum zanieczyszczenia wody rzeki, gdyż nagromadzone w dnie różne substancje zanieczyszczeniowe będą oddziaływały na jego wodę jeszcze przez pewien czas.

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