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THE MANAGEMENT OF DRINKING WATER RESERVOIRS IN THE GERMAN DEMOCRATIC REPUBLIC

Mathematical model of the nutrients transformations in the impoundment basis includes the following parameters: oxygen concentrations and temperature in the inflow and in the basin water, coefficient of turbulent diffusion (its dependence on water body depth), vertical gradient in oxygen concentration, inflow and outflow rates, first order rate constant of microbial decomposition of the organics originating from soils and vegetation determined by laboratory experiments (its temperature dependence), as well as total oxygen demand of these substances.

1. INTRODUCTION

With its 158 inhabitants per km^2 the GDR is one of the most densily populated countries in Europe. It is, moreover characterized by a high level of industrialization, and industrialized agriculture on the one hand, and by extremely limited water resources on the other one. At present about 40% of the discharge being utilized there is an urgent need for a careful management of the water resources, in general and the supply of the drinking water in particular. Ground water resources being unsufficient in the southern low-mountain regions of the country as well as in the large areas of soft coal mining, surface water must be used. Its storage in reservoirs and the supply of densily populated areas by means of long distance pipelines are the methods applied most frequently. In the past 25 years the reservoir storage capacity in the GDR increased to 209% (Reichelt [15]).

The quality of the impounded water is subject to changes which depend on the waste water impurities and nutrient load of the inflowing water, detention time,

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type of stratification, water-sediment-interactions and, last not least, on the biological activity. In order to warrant an appropriate quality level of the drinking water, i.e. to meet the requirements of the public health authorities the management of drinking water reservoirs in the GDR is based on the obligatory standards concerning:

— protection of drinking water catchment areas including drainage areas of reservoirs;

— phosphate elimination by chemical precipitation;

— size of preimpoundment basins;

— lake water quality management.

In the GDR, drainage areas of the drinking water reservoirs are used not only for forestry, but also for agriculture, displaying high level of mineral fertilization, which shows an increasing tendency, because of the demands of agricultural productivity. If we consider, moreover the nutrients of sewage origin, the drinking water reservoirs in the GDR are exposed to an increasing nutrient load. Therefore remedial measures and preventive ones should be in many cases realized before a new reservoir starts its operation.

In view of the above a comprehensive program of sanitation measures in the drainage area has to be realized. The protection area 1, 1,2 and 3, with increasing distances from the main basin and the inflowing streams have to be determined for each reservoir. The use of land for such purposes as human settlements, feedlots and industries which interfere with the drinking water supply is prohibited in area 1 and restricted in areas 2 and 3. The preventive measures are directed not only to a decrease in the nutrient load from sewage and agricultural wastes, but may also include a conversion of field into pastures and forest areas, depending on the susceptibility of soil to erosion and nutrient losses as well as conversion of industries into a "dry" technology.

Some specific examples of design and management practices are presented in the following chapters.

2. ARRANGEMENT OF STORAGE BASINS IN SERIES

If in the considered drainage areas the elementary composition of the inflowing water is compared with a nutrient solution for phytoplankton growth, there is an evidence of a striking discrepancy between the intermediate inorganic carbon as well as the high nitrogen supply, and the relatively low concentration of dissolved inorganic phosphorus. This may be contributed to the fact, that losses from agricultural areas play usually a more important role as nutrient sources than the discharge of sewage and industrial wastes including cattle feedlots. It is also known from the other investigations, that atomic ratio N : P in the drainage water and surface runoff from field areas, resulting from the high solubility of the nitrogen and the low leachibility of the phosphorus compounds, is much higher than in domestic sewage. As, with respect to the demand of the phytoplankton, inorganic carbon and nitrogen are supplied in excess, the management of the drainage areas is directed to a decrease in the mass flow of phosphorus compounds, thus preserving the dicrepancy between demand (by phytoplankton) and supply of phosphorus. For nutrients originating from "diffuse" sources (such as surface runoff) a tertiary treatment is possible only at the mouth of the inflowing streams into the storage reservoir. This may be done by a regular water treatment with addition of alum and two-layer-filtration as proposed by Bernhardt and Schell [4]. In German Democratic Republic, a substantial decrease in the mass flow of phosphorus is obtained by means of preimpoundment basins (PB) with a theoretical detention time ranging from 1 to more than 5 days.

Of a number of water quality improvement practices (their first step being sanitary measures within the drainage area), the PB represents and additional link, which may be followed by pretreatment operations in the main basin. Many reservoirs serve as large tertiary treatment facilities removing dissolved phosphorus from the water body. In this respect plankton diatoms such as *Asterionella* or *Fragilaria* (Grim [6]) are of a particular importance. On the other hand, their incontrolled growth causes odor problems or filter clogging. If, however, the inflow part of the reservoir is separated from the main basin by means of a dam, the nutrient load per m^3 and day increased substantially resulting in mass growth of phytoplankton, which in turn, converts a great deal of the dissolved phosphorus into particulate form. This process allows to reduce the inflow of dissolved phosphorus into the main basin and the permanence of phytoplankton blooms, provided that the nutrient load does not exceed 0.3 g P/m^2a. The distal part of the main basin serves as a sedimentation tank, where a most of the inflowing particulate phosphorus becomes buried in the bottom sediment, owing to the high phosphorus-binding capacity of the sediment (cf. paragraphs 5 and 6).

As an example, the longitudinal change in the phosphorus resources of the Saidenbach Reservoir (Ore Mountains) is presented in Fig. 1. Small PBs, primarily designed as settling basins for gravel, sand and organic material, are followed by one or two distal subdivisions of the main basin; their dams are usually completely submerged. In Fig. 1 these dams are represented as dotted lines. It becomes evident that in the case considered 75 % of the total phosphorus and 79 % of the dissolved orthophosphate phosphorus are removed before the central region of the main basin is reached. This indicates that the subdivided longshaped channel-form of the reservoir exerts a substantial influence on the balance of matter, which, to a certain extent, is comparable to the effect of a piston-flow reactor. (It must be kept in mind, however, that there is no linear relationship between decrease in nutrient load and decrease in phytoplankton production.) With the total phosphorus load of $0.25\ g/m^2/a$ in the Saidenbach Reservoir the phosphorus elimination as high as nearly 80 % does not exclude the growth of diatoms such as *Asterionella*, the probability of long lasting mass development is however, greatly reduced.

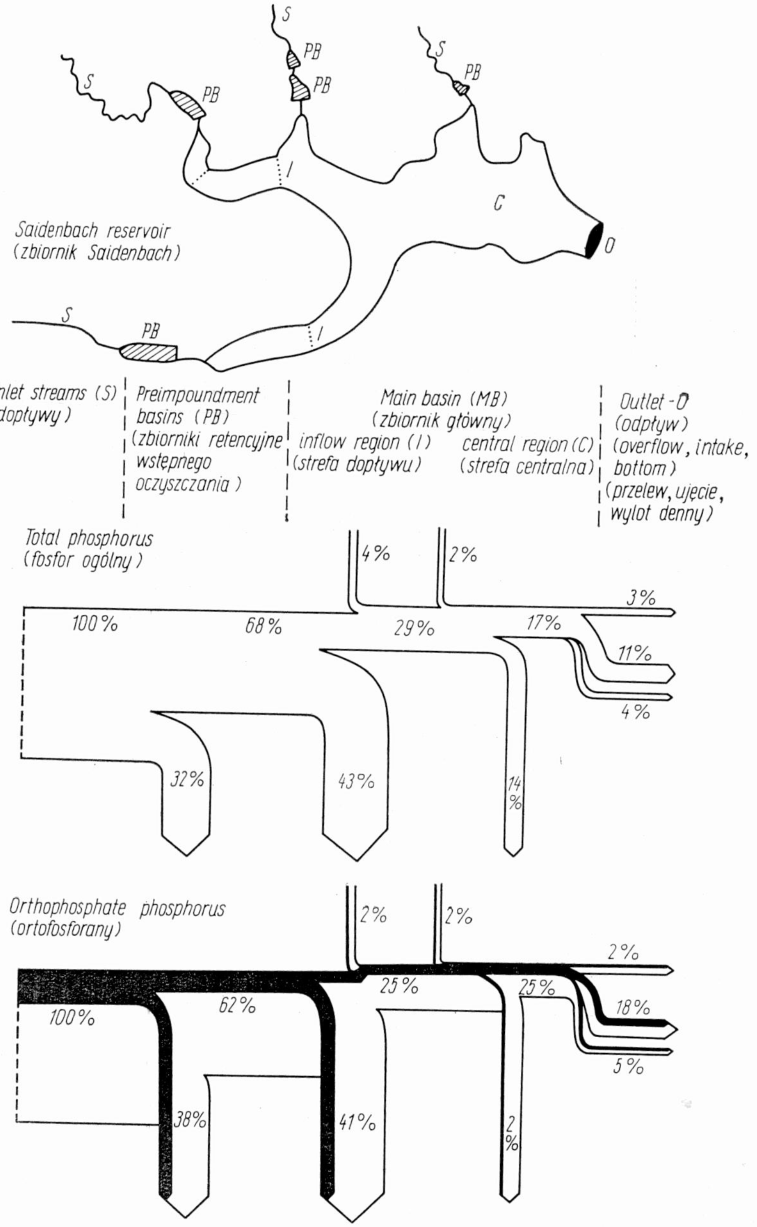


Fig. 1. The role of reservoir basins arranged in series as phosphorus sinks after Hofmann (modified); visible light: 17 cal/cm^{2}d; mass flow: TOC — 0.52 mg/dm^{3}d; BOD — 1. 0 mg/dm^3 d; N — 0.100 mg/dm^3 d; P — 0.015 mg/dm^3 d

Rys. 1. Usuwanie fosforu przez zbiorniki wstępnego oczyszczania, połączone szeregowo z głównym zbiornikiem zaporowym;
światło widzialne: 17 cal/cm^{2}d; natężenie przepływu TOC — 0,52 mg/dm^3 d; BZT — 1,0 mg/dm^3 d; N — 0,100 mg/dm^3 d; P — 0,015 mg/dm^3 d

The outflow from the PB is usually at the surface. The subdivision of the reservoir into compartments and the high length width ratio affect also the reduction of microbial pollution. In general, the average elimination rate of fecal bacteria within the Saidenbach system amounts to 90% (Saalbreiter [17]). However, in periods of increasing flow short circuits may play an important role.

3. EFFECT OF DILUTION RATE ON PHYTOPLANKTON GROWTH

At a given nutrient load the level of primary production of phytoplankton in reservoirs is determined to a great extent by physical factors, among which not only "resource factors" such as light and temperature play an important role, but also cropping factors such as sinking and dilution rate (Dickman [5], Uhlmann]19]). The dilution rate influences directly mass flow of the phytoplankton. In PB-reservoirs the latter attains the maximum at a short detention time close to the critical detention time (t_{crit}) at which outwash of the phytoplankton occurs, and biomass losses exceed gains due to growth. This results from the fact that in systems with a high flow-through rate the phytoplankton production is within certain limits in accordance with Michaelis-Menton law or with the related formulae. Fig. 2 presents the results of laboratory models for nutrient load of the same level as in reservoirs with nutrient-rich inflows, at temperatures 20 °C. Under the above condition a maximum of phytoplankton production occurs at a theoretical detention time 5 days or less. It follows also that only at 5 °C the critical detention time is about 10 days or more, and that at 10 °C the maximum is to be expected within theoretical detention time range 5–10 days.

At the nutrient level given in the inflow region of drinking water reservoirs the growth rate of the prevailing phytoplankton species can be expressed approximately as a linear function of the water temperature (Benndorf [1]). This means that at 10 °C the specific growth rate is 0.5, i.e. 10/20 and at 5 °C is 0.25, i.e. 5/20 of the growth rate at 20 °C. In case of phytoplankton growth its growth rate must equal or exceed the dilution rate; the differences between the biomass production at various temperatures and dilution rates considered (Fig. 2) are in accordance with the equation used for the computation of the phytoplankton growth rate in preimpoundment basins (Fig. 3). The application of this equation to data from the existing PBs yielded good results [1].

The influence of the detention time on phytoplankton growth has some consequence with respect to the design of sedimentation and storage basins for drinking water. If a mass development of phytoplankton is to be avoided, 5 day detention time may be too long. On the other hand, if PBs are designed for the retention of dissolved phosphorus and for protection of the main basin from severe eutrophication, then the detention time should be the optimum for a maximal elimination of

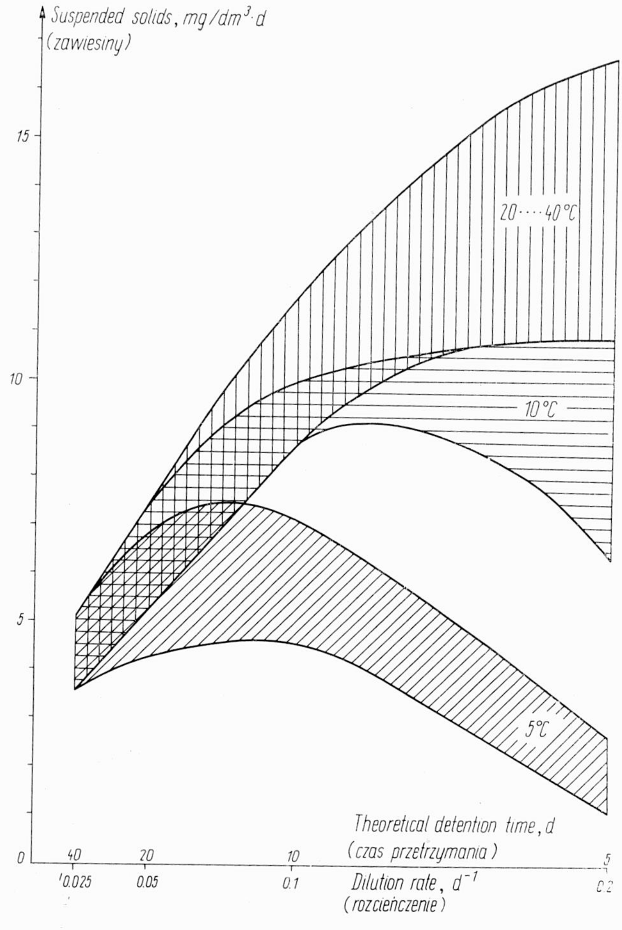
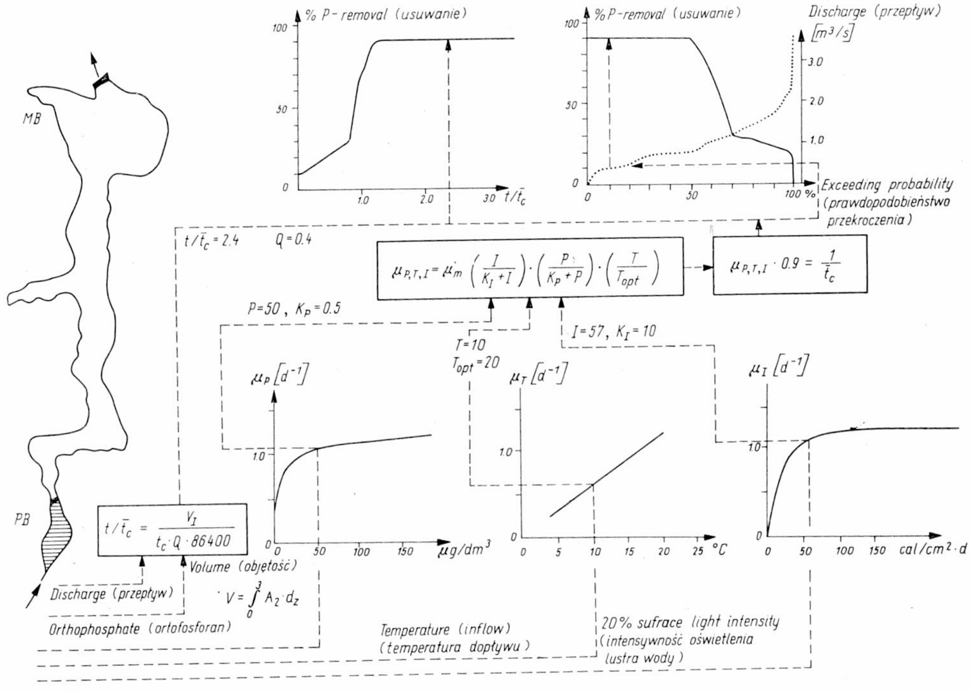


Fig. 2. Detention time vs. phytoplankton productivity in laboratory models of the illuminated water layer of reservoirs (16 dm^3 — glass vessels) at different temperatures. Inflowing water-low concentrated synthetic sewage (glucose, pepton) loading of 1 mg BOD/dm^3d

Rys. 2. Wpływ czasu przetrzymania na produkcję fitoplanktonu w urządzeniu laboratoryjnym przedstawiającym warstwę wody w zbiorniku (naczynia szklane o poj. 16 dm^3), w różnych temperaturach. Woda zasilająca (pept, glukoza), obciążenie 1 mg BZT_5/dm^3 d

dissolved orthophosphate by the phytoplankton, but at the same time as short as possible with respect to the construction costs.

That is why the design of PBs in the GDR is based on the knowledge of the elimination rate percent of dissolved orthophosphate as a function of the detention time (Fig. 3). In order to get a 90% orthophosphate removal a ratio of actual detention time to critical detention time should be 1:3. These determinants may be estimated before a new preimpoundment basin is constructed. They are computed considering a physical and chemical parameters such as discharge, volume of the water body from the surface to 3 m depth, ortophosphate concentration, temperature, and surface light intensity. In all examples considered in the paper other parameters appeared to be not important. The results thus obtained have to be related to the probability of a certain discharge values (Fig. 3).



$$\mu_{P,T,I} = \mu_m \left(\frac{I}{K_I + I}\right) \cdot \left(\frac{P}{K_P + P}\right) \cdot \left(\frac{T}{T_{opt}}\right)$$

$$\mu_{P,T,I} \cdot 0.9 = \frac{1}{\bar{t}_c}$$

$$t/\bar{t}_c = \frac{V_I}{t_c \cdot Q \cdot 86400}$$

$$V = \int_0^3 A_z \, d_z$$

Fig. 3. Calculations of dissolved PO_4 removal rate in preimpoundment basin design. Redrawn and combined from [1,2]

Rys. 3. Obliczanie % rozpuszczonego PO_4 usuniętego ze zbiornika retencyjnego [1,2]

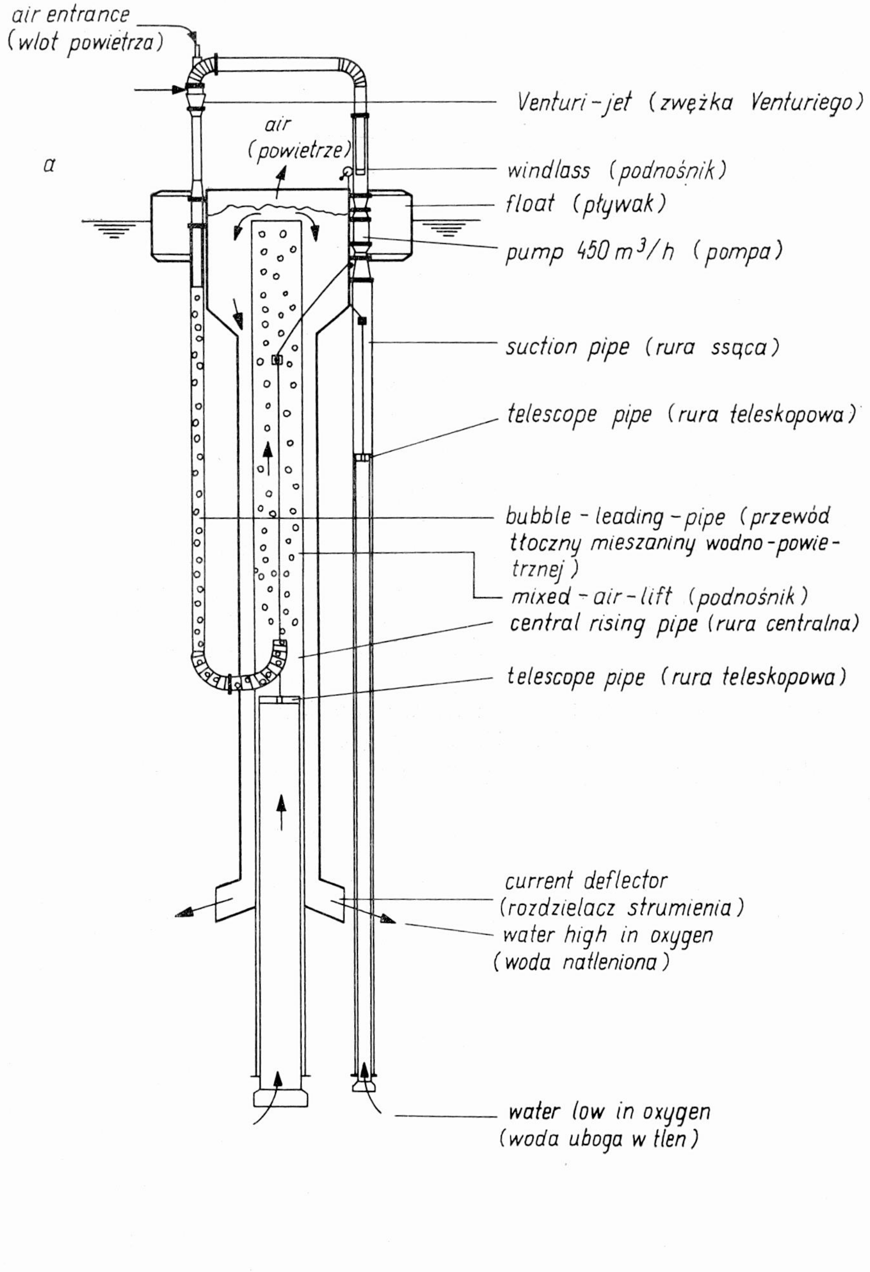
The newly formed phytoplankton and bacteria biomass are subject to flocculation and to sedimentation either in the PB or in the inflow region of the main reservoir.

In contrast to the hitherto used empirical methods this approach gives better design criteria for a PB, and it is an important task of the river basin authorities to find out optimal proportions between the capacity of the preimpoundment basin, the water treatment installations and the direct measures for reducing the nutrient discharge from the drainage area.

4. HYPOLIMNION AERATION

Considering the advantages of destratification, such as utilization of the water surface for reaeration and increasing mixing depth the hypolimnion aeration is preferred in the GDR as it allows to maintain very low temperatures of the drinking water all over the year. Comprehensive investigations on hypolimnion aeration were performed in 1971 and 1972 in pilot plant scale. The aerohydraulic lift method as proposed by Bernhardt [4] was compared with a number of methods of air-jet aeration

a



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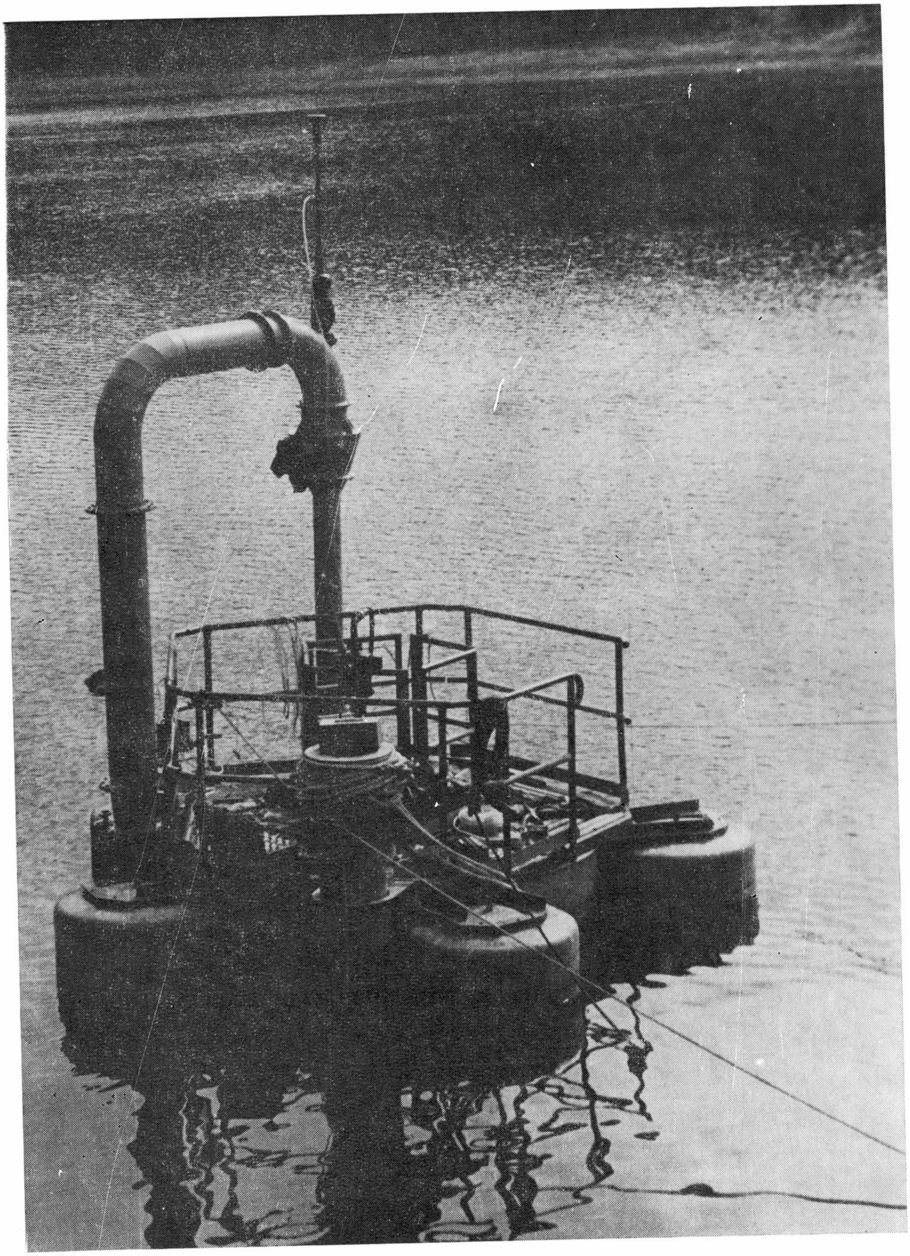

Fig. 4. Deep-water-aerator type "Sosa"
a) longitudinal section of the hypolimnion aerator, b) photo: hypolimnion aerator type" Sosa" in action
Rys. 4. Aerator wody typu "Sosa"
a) przekrój podłużny aeratora; b) zdjęcie pracującego urządzenia

developed in the GDR (cf. Fig. 5 var. III and var. I). The best effect was obtained in the case of a combined process (var. II) in which the jet-generated air-water mixture was introduced by a tube into a certain depth, then — while ascending in a central tube it functioned as an air lift elevating an additional amount of water. By means of the jet aeration, even under unfavourable conditions (with an inlet oxygen content of 4 mg/dm^3), it was possible to supply more than 2 kg O_2 per hour with a specific energy demand of 1.3 kWh/kg O_2. The variants with jet aeration and hauling by pumps were more economic than the hydropneumatic lifting by means of compressed air. The pilot plant was at first operated during the summer in a 1.5 Mill. m^3 preimpoundment basin in the Harz Mountains. The temperature stratification was not subject to any significant changes in comparison with preceding years (Fig. 7), but the dissolved manganese content decreased substantially. There was not significant decrease in dissolved phosphorus, because the sediment with high iron content did not release substantial amounts of phosphorus after depletion of oxygen. Thus switching to aerobic conditions did not result in a significant phosphate precipitation. On the other hand, in the case of lowland lakes with low iron content in sediments (northern districts of the GDR) the possibilities for an oligotrophication by means of hypolimnion aeration are better than in most artificial lakes. As Fig. 9 illustrates in laboratorary experiments much more phosphate could be bound by the sediment from the reservoir than from the lake (Klapper [11]).

Good results of the hypolimnion aeration allowed to develop standard aeration unit, which for the first time was used in 1973 in the Sosa reservoir, Ore Mountains. Its working principle is the following:

The oxygen-poor water from the hypolimnion is pumped up to the water surface from a few meters above the bottom and aerated by means of a venturi-jet. The air--water mixed liquor is forced 10 m deep via a pipe into the central aerohydraulic lift tube. The lower end of the tube is put near the bottom. This arrangement allows also to aerate the deep water poor in oxygen in the upper part of the lifting tube. The aerated water is then drained into the upper layers of the hypolimnion. The net discharge of the pump in the Sosa reservoir (Fig. 5) is 450 m^3 of water per hour, while the extra discharge 1560 m^3 per hour is due to the aerohydraulic lift. The whole construction, except for the pump being made of polyester reinforced by glass fibres, could be set up on land and transported to the destination plane by helicopter. The material though more expensive than steel is corrosion resistant.

The following reservoirs may be aerated by means of hypolimnion aeration:

— drinking water reservoirs with high contents of dissolved iron and manganese in the hypolimnion water,

— new reservoirs with a substantial oxygen consumption caused by microbial degradation in submerged soils,

— reservoirs with anaerobic hypolimnion, due to high waste pollution,

— lakes with intense fish production.

The aeration of a water body is intended not to substitute but to complete the basic measures for sewage water protection practices, especially waste water treatment.

The effect of aeration may be improved by combining it with other methods of reservoir and lake restoration. Investigations on the phosphorus-binding capacity of the bottom material indicated that sediments with high content of cations (Fe and Al) were able to bind a great amount of phosphorus even under anaerobic conditions. First attempts to precipitate phosphates in a small lake, performed in 1974, appeared

a

b

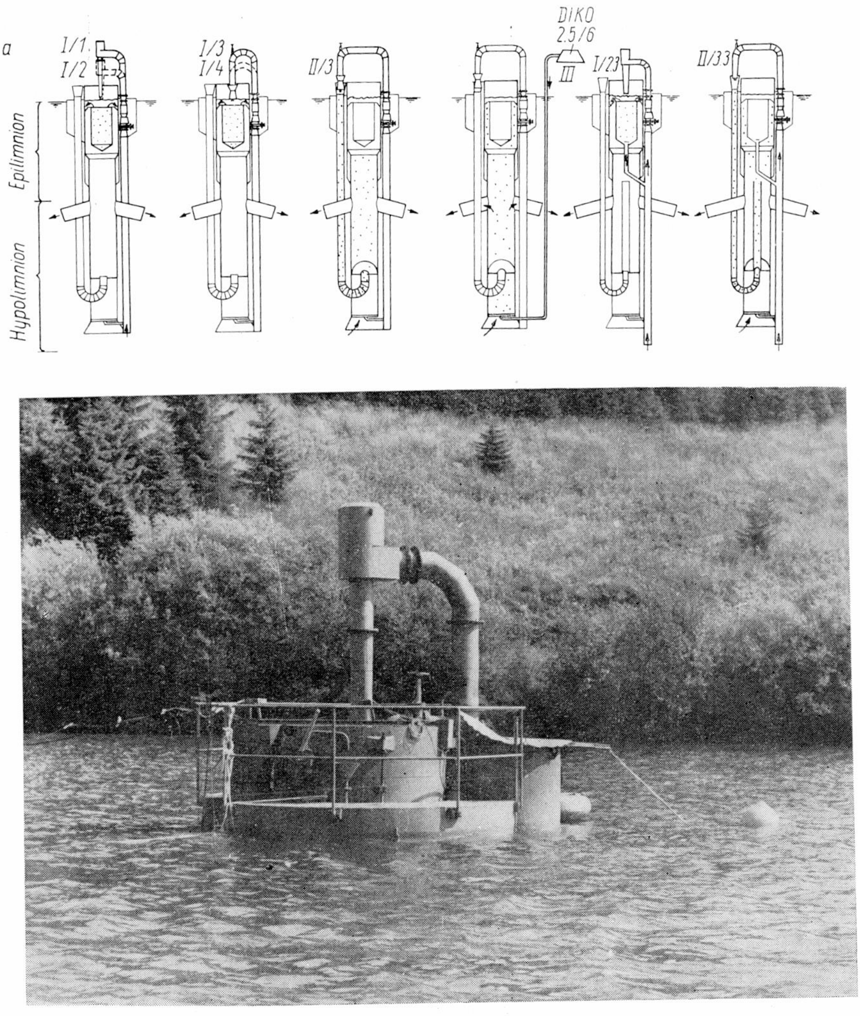

Fig. 5. Pilot plant for hypolimnion aeration with some experimental variants (a). Photo: Variant I/2 in action (b)

Rys. 5. Warianty konstrukcyjne urządzenia pilotowego do napowietrzania hypolimnium (a). Eksploatacja urządzenia wg wariantu I/2 (b) to be successful. The flocculants applied were $FeCl_3$ and bentonite, supplemented with coagulant polyacrylamide. At present the extent to which the phosphorus remains fixed in the bottom sediment is being studied.

5. IMPORTANCE OF THE HYPOLIMNION OUTLET

Natural lakes with a surface inflow and outflow act as sinks or traps of numerous nutrients. This especially refers to phosphorus and nitrogen incorporated into phytoplankton biomass, accumulated in hypolimnion water as well as in the bottom deposits. An epilimnion outflow therefore drains the water masses with the lowest content in dissolved nutrients. In consequence of turnovers the "internal fertilization" provides a still groving level of primary production. To stop the eutrophication process, i.e. nutrient accumulation and increased productivity, and to promote the opposite processes of oligotrophication the nutrients supply to the hypolimnion should be excluded.

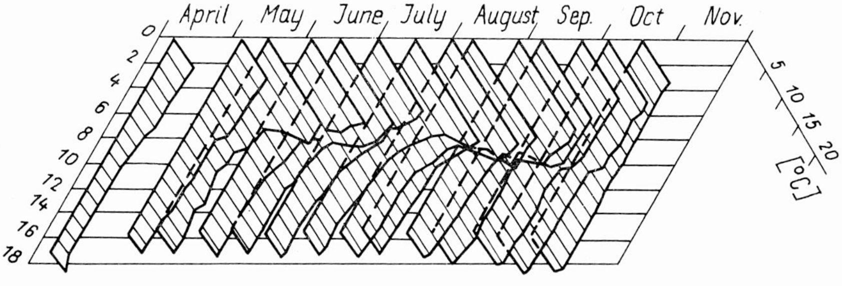

Fig. 6. Temperature stratification in Rappbode preimpoundment basin during the aeration experiments

Rys. 6. Uwarstwienie termiczne zbiornika wstępnego oczyszczania w Rappbode w okresie badań nad napowietrzaniem

Since 1970 the secondary effluent discharges had been removed from the drainage area of this lake. Nevertheless, a quick restoration with respect to the recreational and drinking water quality level is not to be expected.

The suitable measures are being taken to restore the lake Arendsee (GDR, district Magdeburg) following the method applied to the lake Kortowo in Poland (Olszewski [13], [14]). The water renewal rate amounts to only 3.6% per year. In completely stirred reactors the dilution follows the equation

$$C = C_0 \exp(-D \cdot t),$$

where

C_0 — initial concentration of a substance at the time t_0,

D — water renewal rate,

C — concentration after time t, provided that substance supply from sediment and inflow are neglected.

From this equation it follows that in the case of lake Arendsee a decrease to 50% of the initial concentration of an inert dissolved substance would take 19 years. This indicates the need for removal of dissolved phosphorus preferably from the hypolimnion. During the summer stratification at the deepest point (49.5 m) the PO_4 content is about 8 times higher while that of dissolved nitrogen 44 times higher than at the surface layer. In the near future the whole outflow will therefore originate from deep water levels by means of flexible polyethylene tubes extented to a great depth. The existing outflow will be controlled by a dam, so both water and mass flow of nutrients from the hypolimnion can be used for agricultural pur-

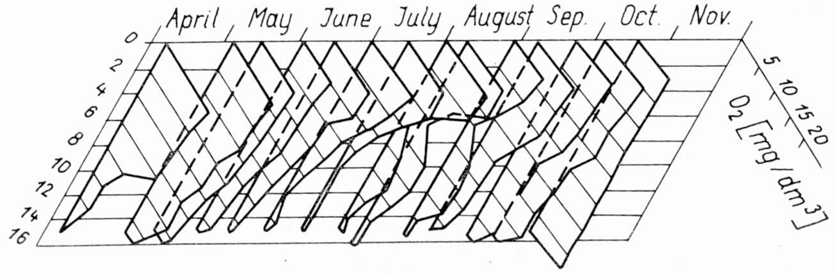

Fig. 7. Oxygen stratification 1971 in Rappbode preimpoundment basin during the deep water aeration

Rys. 7. Profile zawartości tlenu w zbiorniku wstępnego oczyszczania w Rappbode podczas badań nad napowietrzaniem

poses downstream. In most GDR drinking water reservoirs there is no surface outflow and inflow, except for flood periods, and a stable thermal stratification in summer takes place. In Saidenbach reservoir the flux of dissolved phosphates from the hypolimnion into the epilimnion (calculated on the base of the heat exchange coefficients, Hofmann [8]) within a five months stagnation period corresponded to only one per cent of the amount of dissolved phosphorus entering the reservoir in the same time via inflowing streams.

The negligeable role of the flux is due to phosphorus removal by outflow. Hence, both the accumulation of dissolved phosphates and the concentration gradient from the hypolimnion to the epilimnion are not so high as in many lakes.

The higher water flow rate, the lower is the significance of nutrient recycling. In GDR drinking water reservoirs annual flow rate is relatively high.

That is why the recycling compared with the mass flow of nutrients by inlets and outlets plays a less important role than in many lakes. On the other hand, so far there are no data allowing to direct the inflowing streams immediately into the hypolimnion. Water temperature of the inflowing streams during the summer period is usually in accordance with the epilimnion temperature. Only at the end of the summer stagnation period the inflow temperature drops considerably, so that the water passes into the metalimnion. In consequence of the hypolimnion nutrient outflow the storage reservoirs considered may be subjected to a higher nutrient load than lakes with comparable flow rate (Uhlmann [19]). Therefore in case of reservoirs (Hedlich [7]) the levels of the "critical" phosphorus loads by Vollenweider [20] must be modified.

6. NATURAL MASS-FLOW OF PHOSPHORUS BINDING COMPOUNDS

Due to high renewal rate of the water in the outflow and inflow of the reservoirs the nitrate concentrations can be nearly the same. On the other hand, in closed water bodies (in the north of GDR) where circulation of nutrients plays a predo-

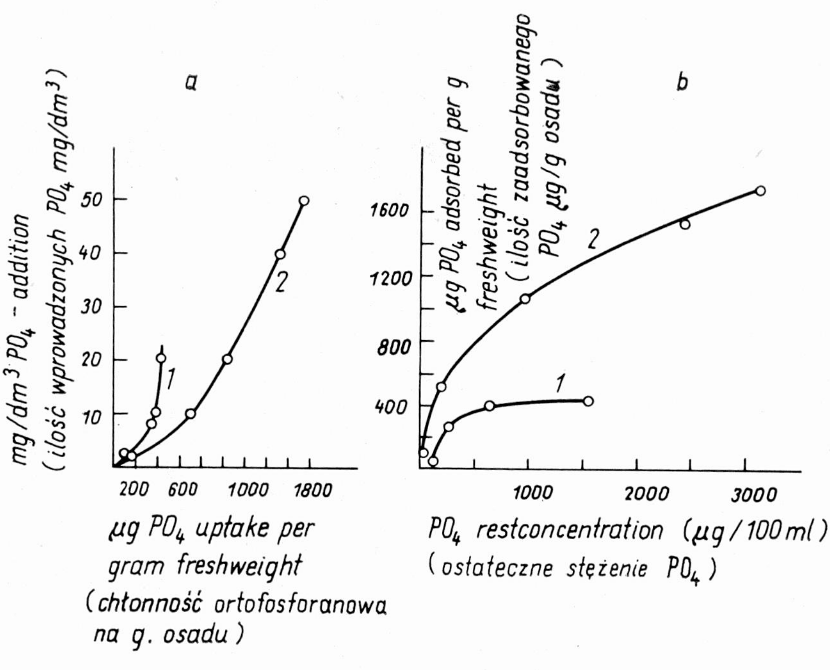

Fig. 8. PO_4-binding ability of sediments from lakes and reservoirs under aerobic experimental conditions

a) PO_4-uptake capacity of sediments from lakes and reservoirs; b) PO_4-solubility equilibrium with sediments from lakes and reservoirs; 1 — Arendsee: 47 m, 30.10.1972; 2 — Rappbodeversperre: 13 m, 4.12.1972

Rys. 8. Zdolność wiązania PO_4 przez osady jeziora i zbiornika podczas doświadczeń w warunkach aerobowych

a) chłonność ortofosforanowa osadów jezior i zbiorników, b) krzywe adsorbcji PO_4 dla osadów jeziora i zbiornika; 1 — jezioro Arend; 47 m, 30.10.1972; 2 — zbiornik Rappbode; 13 m, 4.12.1972 minant role, the decrease in nitrate content during the vegetation period is usually significant (Klapper [10]). Substantial amount of inflowing water also supplies the reservoirs with silt containing high iron and alum loads, which exert a considerable influence on the phosphate balance. The fairly high phosphorus-binding capacity of the inflowing silt and soil particles as well as of the bottom mud, yields an equilibrium concentration as low as 5 (μg/dm^3 of orthophosphate phosphorus in the adherent water layer (Rühle [16]). So far no attempts have been undertaken to control these processes with respect to phosphorus removal in the system of impoundment basins.

7. PREDICTION OF WATER QUALITY AS A BASE FOR WATER MANAGEMENT

The modelling of the structure and of the input/output relationships in the reservoir ecosystems depends to a great extent on their complexicity. The simplest case is that of a small PB, which for many practical purposes may be considered as a homogeneous system, comparable to a continuous-flow completely mixed reactors used in biochemical industries. Elongated intermediate-size reservoirs characterized by stable thermal stratification, may be considered as two-zone-systems. In these reservoirs only phytoplankton plays an important role, the litoral vegetation (of much more complex spatial structure) being usually absent. The highest complexicity is represented by large reservoirs with high area/depth ratio, extended macrophyte vegetation and three-dimensional physical and chemical gradients.

At present, the phosphorus balance of a small PB can be predicted by means of the simple model presented in paragraph 3. For two-zone reservoirs, however, a prediction of water quality parameters is possible only for some special cases, e.g. BOD calculation of the organic matter present in submerged soils during first years of the exploitation. The model proposed by Küchler and Kozerski [12] can be used in construction of a storage programme allowing to prevent oxygen depletion and accumulation of dissolved iron and manganese in the hypolimnion. As usually, there is a rapid decrease in benthic oxygen demand in consecutive years. The model also allows to manage the drinking water supply as early as at the beginning of the storage programme, avoiding additional costs related to the water treatment installations. In the case of artificial aeration of the hypolimnion the required oxygenation capacity can also be estimated using this model. Fig. 9 shows that the rate of water level increase and the thermal stratification stability as well as dissolved oxygen concentration depend on the season in which the storage is started.

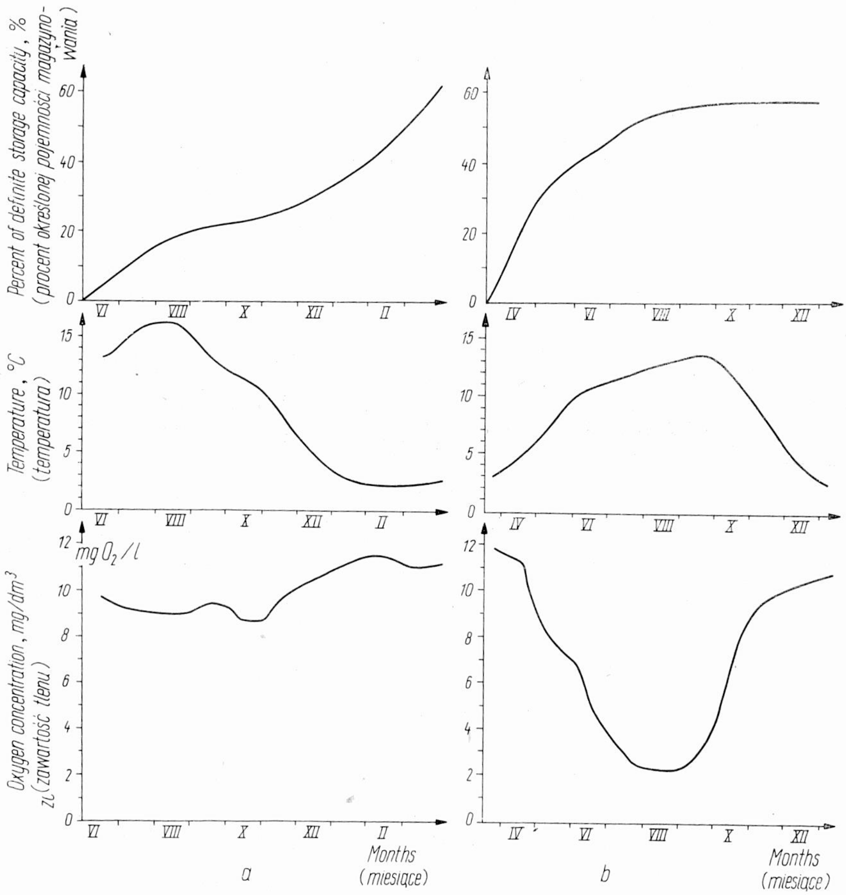

Fig. 9. Exploitation parameters of newely constructed reservoirs depending on starting period: a) summer, b) spring

Rys. 9. Zróżnicowanie warunków eksploatacji nowego zbiornika zależnie od terminu rozpoczęcia jego użytkowania a) lato, b) wiosna

CONCLUSIONS

In the southern regions of the German Democratic Republic a stable supply of high quality drinking water is based on comprehensive planning concerning the exploitation of water resources and of the surrounding land. Water quality control measures have been established, considering material balance in the drainage area and in the water body to be interrelated subsystems. Some methods of water quality prediction for local conditions such as nutrient load, land use, climate and discharge of both existing and planned reservoirs have been developed.

Long-term water management requires, however, the development of more sophisticated and comprehensive prediction methods.

GOSPODARKA ZASOBAMI WODNYMI ZBIORNIKÓW ZAPOROWYCH

Zaproponowany przez autorów model matematyczny przemiany substancji biogennych w zbiorniku zaporowym uwzględnia następujące parametry i współzależności: stężenie rozpuszczonego tlenu oraz temperatura wód dopływowych i jeziora, współczynnik dyfuzji turbulentnej (jego zależność od głębokości warstwy wody), pionowy gradient stężenia tlenu, natężenie dopływu i odpływu ze zbiornika, wyznaczoną laboratoryjnie stałą szybkości biochemicznego rozkładu organicznych składników gleby i roślinności (oraz jej zależność od temperatury), a także całkowite BZT tych substancji.

BEWIRTSCHAFTUNG DER TRINKWASSERSPEICHERBECKEN IN DER DDR

Die Verfasser schlagen ein mathematisches Modell des Nährsubstanzen-Abbaues in Speicherbecken. Im Modell werden folgende Faktoren und Verhältnisse in Betracht gezogen:

— die Sauerstoffkonzentration sowie die Wassertemperatur des Zulaufes und im Becken selbst;

— der Koeffizient der turbulenten Diffusion, welcher von der Wasserschichttiefe abhängig ist;

— der vertikale Gradient der Sauerstoffkonzentration;

— die Zu- und Abflußmenge;

— die in Laborversuchen errechnete biochemische Abbaurate (Abbaugeschwindigkeit) der organischen Bodenpartikel und der Pflanzenreste (als Funktion der Temperatur) wie auch der gesamte BSB dieser Substanzen.

ИСПОЛЬЗОВАНИЕ ВОДНЫХ РЕСУРСОВ ИЗ ПЛОТИННЫХ ВОДОЕМОВ

В изложенной авторами математической модели превращения полярных веществ в плотинном водоеме учитываются следующие параметры и взаимосвязи: концентрация растворенного кислорода и температуры входящей и озерной вод, коэффициент турбулентной диффузии (зависимость его от глубины данного слоя воды), вертикальный градиент концентрации кислорода, интенсивность притока и стока воды из водоема, лабораторно установленная постоянная скорости биохимического разложения органических компонентов почвы и растений (а также зависимость ее от температуры), наконец — полная потребность этих веществ в кислороде.

REFERENCES

[1] Benndorf J., *Prognose des Stoffhaushaltes von Staugewässern mit Hilfe kontinuierlicher und semikontinuierlicher biologischer Modelle. II. Prüfung der Prognosegenauigkeit*, Int. Revue ges. Hydrobiol. **58**, 1–18 (1973).

[2] Benndorf J., Kütz K. und Friemel M., *Die Berechnung des Nährstoffrückhaltevermögens von Vorsperren und deren Bemessung*, Acta hydrochim. hydrobiol. 3 (1974).

[3] Bernhardt H., *Aeration of Wahnbach Reservoir without changing the temperature profile*, J. Amer. Water Works Assoc. **59**, 943 (1967).

[4] BERNHARDT H. und SCHELL H., *Vorbehandlung von Oberflächenwässer zur Speisung von Trinkwassertalsperren durch Aufbereitungsverfahren*, Gewässerschutz. Wasser. Abwasser (Aachen) **4**, 277–316 (1971).

[5] DICKMAN M., *Some effects of lake renewal on phytoplankton productivity and species composition*, Limnol. Oceanogr. **14**, 660–666 (1969).

[6] GRIM J., *Der Phosphor und die pflanzliche Primärproduktion im Bodensee*, Gas- u.Wasserfach **108**, 1261-1271 (1967).

[7] HEDLICH R., *Regionallimnologische Untersuchungen an sechs Trinkwassertalsperren des mittleren und des westlichen Erzgebirges*, Diss. Techn. Univ., Dresden 1974, p. 119.

[8] HOFMANN R., *Untersuchungen zum Phosphathaushalt der Talsperre Saidenbach*, Diss. Fak. Bau-, Wasser-, Forstwesen Techn. Univ., Dresden 1971.

[9] HOFMANN R., *Untersuchungen zum Phosphatmetabolismus einer Trinkwassertalsperre*, Int. Rev. Ges. Hydrobiol. **60** (1974).

[10] KLAPPER H., *Die wachstumsbegrenzeden Nährstoffe in Seen auf dem Gebiet der Deutschen Demokratischen Republik*, Fortschr. Wasserchem. Grenzgeb. **8**, 66-81 (1968).

[11] KLAPPER H., *Die künstliche Tiefenwasserbelüftung und ihr Einfluß auf den Stoffhaushalt einer nährstoffreichen Talsperre*, Eutrophierung u.Gewässerschutz. Sympos., Reinhardsbrunn 1973. Proceedings, p. 155–159.

[12] KÜCHLER L. und KOZERSKI H.-P., *Vorhersage des Sauerstoffgehaltes im Tiefenwasser einer neuerrichteten Talsperre für die ersten Jahre des Anstaus*, Acta hydrochim. hydrobiol. **3** (1974).

[13] OLSZEWSKI P., *Versuch einer Ableitung des hypolimnischen Wassers aus einem See*, Verh. Internat. Verein. Limnol. **14**, 855–861 (1961).

[14] OLSZEWSKI P., *Fünfzehn Jahre Experiment auf dem Kortowo-See*, Verh. Internat. Verein. Limnol. **18**, 1792–1797 (1972).

[15] REICHELT H., *25 Jahre DDR — 25 Jahre erfolgreiche Entwicklung der Wasserwirtschaft in der DDR*, Wasserwirtschaft — Wassertechnik **24**, 325–331 (1974).

[16] RÜCHLE E., *Sedimentuntersuchungen an Trinkwassertalsperren des Erzgebirges*, Diss. Fak. Bau-, Wasser-Forstwesen Techn. Univ., Dresden 1970.

[17] SAALBREITER R., *Räumliche und zeitliche Verteilung von Fäkalbakterien in Trinkwassertalsperren*, Acta hydrochim. hydrobiol. (Berlin) **3** (1974).

[18] UHLMANN D., *Influence of dilution, sinking and grazing rate on phytoplankton population of hyperfertilized ponds and micro-ecosystems*, Mitt. Internat. Verein. Limnol. **19**, 100–124 (1971).

[19] UHLMANN D., *Der Einfluß der Verweilzeit auf die Massenentwicklung von Planktonalgen*, Fortschr. Wasserchemie Grenzgeb. **8**, 32–47 (1968).

[20] VOLLENWEIDER R. A., *Die wissenschaftlichen Grundlagen der Seen-und Fließgewässereutrophierung unter besonderer Berücksichtigung des Phosphorus und des Stickstoffs als Eutrophierungsfaktoren*, OECD Rep. Nr DAS/CSI/68.27, p. 242, Paris 1968.