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HYDROCHEMICAL CONDITIONS OF THE RIVER TISZA 2. SEASONAL DYNAMISM OF THE OXYGEN HOUSEHOLD AND NITROGEN-PHOSPHORUS FORMS

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Abstract

The paper is dealing with the oxygen household and plant food circulation of the Tisza-stretch dammed up between Tiszacsege and Tiszaroff (river-km 456—380). It is treating of these factors — that are important in respect of the water quality of the future Kisköre reservoir — with a view to saprobity and trophity.

Introduction

In the Middle-Tisza Region of Hungary the building of a shallow-water reservoir is going on. At present the damming of the river-bed is taking place, the area will be filled up in 1978. For storing the water of the Tisza is used. The previous systematic chemical and biological investigation of that is a fundamental requirement from the point of view of protecting the water quality of the future Kisköre Reservoir.

The water quality of reservoirs is equally influenced, apart from the factors that can be determined previously and measured comparatively well, by the oxygen conditions, too, indicated with much less safety and connected with the activity of living beings. It was based on this reasoning that we carried out the investigations of the Tisza giving water supply to the future Kisköre Reservoir.

The number of the hydrochemical investigations dealing with the Tisza is small. PAPP (1965) is publishing data concerning the Tisza and its tributaries. SZÉPFALUSI (1970—1971) is dealing, as well, with the hydrochemical conditions of the Tisza-stretch between Csongrád and Szeged and the tributaries.

Material and method

Our investigations were performed in 1974, in the river-stretch between Tiszacsege and Tiszaroff, from five sampling points, with fortnightly frequency (Tiszacsege river-km 456, Tiszafüred river-km 433, Tiszaderzs river-km 415, Kisköre river-km 404, Tiszaroff river-km 380). But from the Kisköre profile we took samples with weekly frequency.

For chemical investigations we dipped out a 5 l sample. For determining the dissolved oxygen and free carbon dioxide we used a special sampler.

Our analyses were carried out on the basis of the "COMECON" Unitary water-research methods, issued by the "VITUKI" (1970) and Felföldy's lecture notes: Biological Water Qualification (1974).

The mineral matter circulation in the Tisza is treated of by Végvári's paper (1975). In addition to the chemical investigations, we have performed biological studies, as well (BANCSI 1975, HAMAR 1975).

Evaluation of results

The increase in the oxygen content of waters is induced by the amount of atmospheric oxygen getting in by means of the surface diffusion and owing to the water movement, as well as by that of molecular oxygen released in the course of the photosynthesis of the plants of chlorophyll content. On the other hand, its decrease is caused by the respiration of the vegetable and animal organisms, the decomposition of organic matters, the rise in water temperature, etc. At river waters, the oxygen supply is generally favourable, because of the intensive water movements.

The formation of the *dissolved oxygen content* of the Tisza was determined by the changes in the atmospheric oxygen, got in in the course of the water movement, and the changes in water temperature. The high suspended matter content, namely, resulting from the floods of 1974, impeded the photosynthesis, and the flood-waves, following one another, produced a considerable water movement, mixing, and whirling.

It can be established from the results of the investigations in 1974 that both the dissolved oxygen content and the oxygen saturation were greatest in the Winter period, in Spring they decreased, and the lowest values were measured in the summer period. In Autumn, a rise followed again, but its value did not reach the winter maxima.

The annual average value of the dissolved oxygen was 9.32 mg/l, and the oxygen saturation was 81.5 per cent that can be considered as suitable.

The quantitative relations of the dissolved oxygen and free carbon-dioxide contents of backwaters are treated of in connection with one another. The results are brought into connection with the activity of autotrophic and heterotrophic living beings (DÉVAI *et al.* 1969—1970).

The floods following one another in 1974, engendered unfavourable light conditions. Therefore, the photosynthesis of a negligible degree did not influence either the amount of dissolved oxygen or that of free carbon dioxide to such an extent that we could speak there either of a daily rhythm or of any other connection that could be demonstrated.

The *changes in the free carbon dioxide* were determined first of all by the composition of the waters coming from the reservoirs, their quantitative proportions, respectively the concentration of the components (hydrogencarbonate, calcium, magnesium) influencing the amount of the free carbon dioxide.

In the period passed from January till the beginning of the spring-flood, the free carbon dioxide content was 2.67 mg/l, as an average of 60 samples. This rose, in the period of the spring- and autumn-floods passing, about 2.5-fold, to 6.57 mg/l, as an average of 84 samples.

Of the carbonate and hydrogencarbonate conditions in the waters of the Tisza some data were published by VÉGVÁRI (1975).

The degree of the chemical oxygen requirement measured with *acid potassium* permanganate (C. O. D. Mn) and *potassium dichromate* (C. O. D. Cr) was determined by the organic component of the suspended matter transported by the flood-waves following one another, the organic-matter amount of the water reflowing from the flood-plain, the effect of the tributaries loaded with waste-water, and the self-purification of the Tisza.

On the occasion of floods, the formation of the amount of the chemical oxygen requirement was influenced first of all by the suspended matter content. After the

flood passing, however, there was prevailing rather the effect of other factors (tributaries, flood-plain, waste-waters, etc.).

The Kisköre Reservoir will be filled up with Tisza-water. The effect of the chemical oxygen requirement of the organic matter carried by the feed-water upon the water quality of the reservoir is, therefore, to be taken into consideration.

On the basis of the investigations in 1974, taking into account the average value of the chemical oxygen requirement (6.27 mg/l), and the average value of the dissolved — oxigen content (9,32 mg/l), as well as the water mass to be stored in the reservoir (300 million cc.m), it can be calculated that after the oxidation of the organic matter carried by the water supply, 4.7 mg/l dissolved oxygen still remains in the water if we apply the quantities calculated to the reservoir as a static model. It appears from the data that the organic-matter loading of the feed-water does not mean any danger to the water quality of the reservoir, that is to say, it hasn't any considerable influence to the saprobity of water.

In the life of the water ecosystems, parallel with the oxygen conditions, their vegetable food supply, too, has an important part. Eutrophication, this slow biological reaction that means the aging of lakes, the gradual deterioration of water quality (FELFÖLDY 1974), may take place in case of artificial lakes or ponds at a much quicker pace. In that process, the productivity of waters has a very important part, for the forecast of which it is necessary to know the nitrogen and phosphorus forms coming by means of the water supply.

On the course of our investigations, the determination of the following phosphorus forms was carried out:

- dissolved non-reactive phosphorus (sum of inorganic condensed phosphates and dissolved organic phosphorus),
- dissolved reactive phosphorus (dissolved orthophosphates),
- sestonic phosphorus formed (any phosphorus bound to solid particles, essentially the phosphorus content of the suspended matter, quite apart from the fact if it is biologically active or inactive).

There is a well-perceptible connection between the biologically available total phosphorus and trophity. The total phosphorus content of the settled deep lake water means essentially the biologically accessible total phosphorus, while in shallow lakes it is disturbed by the inorganic sestonic phosphorus forms stirred up from the bottom sediment (FELFÖLDY 1974).

In case of the Tisza water, some other disturbing elements, too, do play a part.

- In a lasting small-water period, the value of total phosphorus, measured in the river-stretch dammed up, approaches the concentration of the biologically accessible total phosphorus mostly.
- At the beginning of the flood the phosphorus bound to the suspended matter considerably increases the amount of the phosphorus formed (Fig. 1).
- The amount of the organic phosphorus formed, found in the living organisms at flood, may be neglected because of the small number of these.
- The ratio of suspended matter and the phosphorus bound to that is very different; it depends on the surface and weight of the suspended matter, the amount of the organic waste. the geochemical properties of the watershed area, the quantitative conditions of the waters coming from there, etc.
- Together with the suspended matter content decreasing before the culmination of the flood-wave, the amount of the phosphorus formed, too, decreases; at the flood passing, however, the organic phosphorus built in the

plankton organisms of the water reflowing from the flood-plain results in a repeated increase in the amount of phosphorus formed.

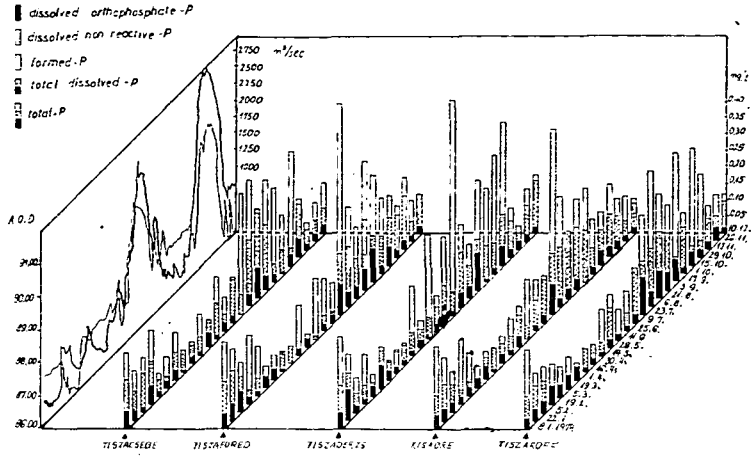

Fig. 1. Formation of the phosphorus forms of the Tisza-stretch investigated

Balancing the disturbing effects described above, at investigating the trophity of feed-water, we have taken the concentration values of the dissolved orthophosphate phosphorus available for the autotrophic organisms, for our basis.

The dissolved orthophosphate phosphorus content of the Tisza at Tiszacsege from January 8th till January 16th was 0.025 mg/l, its maximum value being 0.090 mg/l. At Tiszafüred we measured generally higher values. As approaching to Kisköre, these values have gradually decreased but from the sampling point below the river barrage (Tiszaroff) they rose again (Fig. 1).

On the basis of 25 samples, the average value of the dissolved orthophosphate phosphorus is:

Sampling point	*Average mg/l*
Tiszacsege	0.028
Tiszafüred	0.033
Tiszaderzs	0.031
Kisköre	0.027
Tiszaroff	0.035

The dissolved orthophosphate concentration was not influenced considerably by the small-water period, the minor flood-waves, and the beginning of flood.

At passing of the major flood-waves, however, we experienced a considerable increase, appearing at Tiszacsege still less but at Tiszafüred and Tiszaderzs to a greater extent. The results are referring to that the orthophosphate content of the water reflowing from the flood-plain — that may have originated from the mineralization of the organic matter existing there (VÉGVÁRI, 1975) — has played a part in increasing the concentration. That is proved also by the maxima measured at Tiszafüred and Tiszaderzs (0.103 mg/l; 0.115 mg/l).

The lakes may be considered, on the basis of the 20—40 mg/cc.m total phosphorus, as meso-eutrophic (FELFÖLDY 1974). The average value of the dissolved ortho-

phosphate content of the Tisza is 28 mg/cc.m. According to FELFÖLDY (1974), however, we have to regard as the degree of eutrophication of the lake not the average but the most eutrophic state of that. In case of the Tisza, this value means 90 mg/cc.m dissolved orthophosphate phosphorus, on the basis of which the water can be considered as eupolytrophic.

Taking into consideration 60 per cent of the total phosphorus of the Tisza-water (leaving 40 p. c. out of consideration due to the disturbing effects), then we had to reckon with 111 mg/cc.m total phosphorus on the average or, in respect of the highest concentration, with 232 mg/cc.m of that. This would mean in both cases a polytrophic water.

R. A. VOLLENWEIDER (1968, in: HANNAN et YOUNG 1974) established that the 20 mg/cc.m total phosphorus content may be the critical concentration of algal blooms.

We are reminded by the comparison of results to reckon in case of the Kisköre Reservoir with the danger of eutrophication because of the high phosphorus content of the river.

The other vegetable food showing the degree of trophity is *nitrogen*, in the circulation of which the aquatic living world plays a determinative part. In some lakes, from time to time, nitrogen proved to be an impeding factor of photosynthesis or production (FELFÖLDY 1974).

As investigating the water of the Tisza, we have carried out the determination of the following nitrogen forms:

— nitrate nitrogen (1)
— nitrite nitrogen (2)
— ammonia-nitrogen (3)
— ammonium-nitrogen (4)
— nitrogen of organic bond (5).

The sum of the concentration of forms 1, 2, 3, 4 gives the mineral nitrogen (nitrogen of inorganic bond), the some of the amount of the five forms the total nitrogen. The mineral nitrogen is an important factor at evaluating trophity, and the nitrogen of organic bond plays a part at establising the degree of saprobity.

In respect of eutrophization, 300 mg/cc.m mineral nitrogen is described as a dangerous threshold value (VOLLENWIEDER 1968, FELFÖLDI—TÓTH 1970). The inorganic nitrogen content of the water of the Tisza is averagely 2200 mg/cc.m, its maxima are 4598 mg/cc.m. On the basis of these data it is qualified as polytrophic.

It can be observed from the results of the investigations in 1974 that in small-water periods the nitrogen content of inorganic bond is very high, on the average 3—4 mg/l (Fig. 2).

At the beginning of the summer flood — supposedly as a result of dilution — we experienced a slight decrease (1.7—2.2 mg/l). At inundating the flood-plain, the developing micro-and macro-vegetation consumed the mineral nitrogen almost completely (VÉGVÁRI 1975). In this way, at the flood passing, the water reflowing from the flood-plain considerably reduced the mineral nitrogen concentration of the Tisza (0.8—1.0 mg/l).

At the autumn flood passing, the decrease in the amount of mineral nitrogen was of much less degree because of the (due to the season) slower mineralization and the building in being more equalized.

That is shown by the slower development and smaller number of the stand of

phyto- and zooplankton than those in Summer, as well as by the very high bacterial count, too (HAMAR 1975, BANCSI 1975).

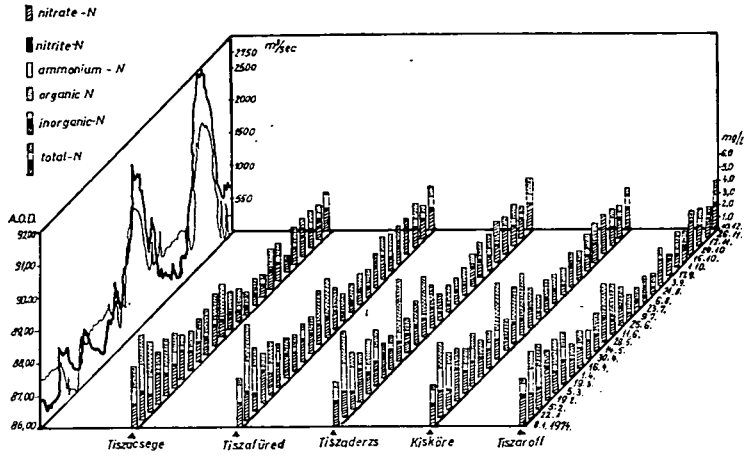

Fig. 2. Formation of the nitrogen forms of the Tisza-stretch investigated

The amount of the nitrogen of inorganic bond in the water of the Tisza is considerably influenced by the degree and duration of floods, by length of the small-water periods and quality of the water reflowing from the flood-plain. In annual relations, however, the content of mineral nitrogen of the water flowing into the stretch investigated by us and leaving that does not change considerably (Fig. 2).

At evaluating trophity, resp. eutrophication, the considerable vegetable foods, like phosphorus and nitrogen in the feed-water of the Kisköre Reservoir, can be found in a very high quantity in the Tisza-water. Their concentration is much above the dangerous threshold value. On the basis of the literary data concerning deep lakes, the water of the Tisza can be qualified as polytrophic in respect both of phosphorus and of nitrogen.

Summing up, we may establish that the oxygen household of the water of the Tisza is suitable from the point of view of the water quality in the Kisköre Reservoir. The formation of the factors determining the plant food circulation, however, calls our attention to the danger of eutrophication.

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