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LIMNOLOGICAL INVESTIGATIONS IN THE LONGITUDINAL SECTION OF THE RIVER TISZA

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Abstract

For characterizing the limnological state of rivers, the longitudinal section investigations are suitable. The comprehensive evaluation carried out at different flow regimen (flood, low-water period) gives a reliable picture on the change in a passing water-body and its causes. The paper tries to give an overall picture of the river and of the natural and artifical effects touching that by analising the hydrological-phycisal-chemical-bacteriological-algological- and zoological investigations preformed on the Tisza (Central-Europe) in its flood and low-water periods.

On the basis of the hydrological characteristics, there were marked out two periods of different water outputs (flood, low-water). At measuring the longitudinal section, the flow-regimen of the Tisza and its tributaries was followed with attention. For getting an identical water-body, we have ascertained the medium velocity of water in more than one section. The measure of the natural and artificial effects exerted on the river is characterized by the distribution of velocity well.

In the time of flood, the bacterial content of the suspended matter coming from a runoff from land is very high (on the average 75×10^6 ind:/ml). In the time of low-water, with a low suspended matter content, the total bacterial number was $12—38\times10^6$ ind./ml.

There is a considerable difference between the algological composition of flood and that of low-water. In case of low-water, the dynamism of the alga community gives information for determining the different natural and artificial effects exerted on the river.

With the help of matter-current diagrams, the dynamics of the different parameters can be followed with attention in the longitudinal section of the river. The suspended matter content of water is considerable, so it influences the biological life of the river decisively. The results refer to that, in case of a low-water output, the eutrophication of the river is a real danger.

The Tisza has its own zooplankton stock, constituted by a strongly selected small proportion of the species to be found in the watershed area. The picture of the plankton changes as a result of dammings, the change in stretch-character, and the tributaries.

The half of the zoobenthos of the investigated Tisza stretch was Oligochaeta. The quantity of these showed downward tendency, going down the river. The dominant species is: *Limnodrilus hoffmeisteri* CLAPAREDE.

In respect of individual number, Chironomidae take the second place. Going down the river, the individual number shows an upward tendency.

The richest was, quantitatively, the zoobenthos in the Sajó, the poorest that in the Zagyva.

If we project the data of the Table on a square metre, we may establish that in the parts of the Tisza covered with a water of 0.5—3.5 m depth, in the 12 m broad riverside zone, there were found 180—900/sq.m Chironomida larvae. From this datum, only samples 11&12 differ strongly. The

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cause of the latter is that, after hatching out, the larvae of the same age, belonging to the same species, have remained together in large numbers, even in phases II and III. In the investigated river reaches, on the basis of our data, the average larval individual number may be put at 500—900/sq-m. Leaving out of consideration the data of samples 11—12, the investigated 162 km long river stretch may be considered as uniform by reason of the amount of larvae and the species forming the stock.

Introduction

For knowing a stretch of a river in details, it is fundamentally necessary to know the river as a whole. It is only possible to determine the results of natural and artificial effects if the basic state is also known.

In the earlier years, we studied the area under the influence of the Kisköre river barrage between river-kms 467 and 380 (ÁDÁMOSI et al. 1974, BANCSI 1975, HAMAR 1975, VÉGVÁRI et al. 1975).

In 1975, when the Tisza reaches in Hungary were investigated, we organized two longitudinal-section investigations, to know river more thoroughly.

There can be listed among the advantages of the longitudinal-section investigations that:

— in a given flow regimen situation it can practically follow with attention the change in a water-body;

— the effects of tributaries, major pollutions, dammings and the change in the stretch-character of the river can be demonstrated;

— the investigated parameters can be compared with one another unambiguously;

— on the way, some important observations can be carried out from the point of view of region conservation.

Its disadvantage is that it characterizes only a given flow regimen. It is shown by the investigations so far that it is advisable to perform the longitudinal-section investigations in two periods of different flow regimen for valuing the water-quality (ÁDÁMOSI et al. 1974, VÉGVÁRI 1975) — in the time of the early-summer "green" flood and at the late-summer low-water.

Materials and Methods

In 1975, we carried out our investigations into the Tisza on two occasions: the first investigation-series took place in a flood-period, between June 8 and 16, in the stretch between Tivadar and Szeged; and the second one in a low-water period, between September 18 and 27, in the stretch between Tokaj and Szeged (Fig. 1).

The sampling sites were chosen in a way that, partly, they should be adapted to the national sampling network; partly, on the basis of reliable bed-section surveys, to ensure the possibility of output calculations. We have taken our samples for the water-chemical, bacteriological, algological, and zooplankton, investigations from the following sites: Tivadar riv.km 718, Tiszaszalka riv. km 673, Záhony riv. km 638, above the Bodrog-mouth riv. km 551, below Tokaj riv. km 545, Tiszaladány riv. km 535, Tiszalök, upper, riv. km 524, Tiszadob riv. km 506, Gyulaháza riv. km 497, Polgár riv. km 486, Tiszakeszi riv. km 467, Tiszacsege riv. km 457, Tiszafüred riv. km 433, Tiszaderzs riv. km 415, Kisköre riv. km 404, Tiszaroff riv. km 380, Nagykörü riv. km 369, Szolnok riv. km 335, Tiszavárkony riv. km 320, Martfű riv. km 306, Tiszaug riv. km 266, Csongrád riv. km 245, Szentes riv. km 234, Mindszent riv. km 211, Ludvár riv. km 194, Tápé riv. km 177, Szeged riv. km 173, below Szeged riv. km 168.

The samples were taken from the current-line of the river.

The sampling sites of the zoobenthos investigations were at a distance of 3 to 12 m from the riverside, in places of 0.5—3.5 m water depth. The samples were taken from the Tisza above the inflow of the Sajó at riv. km 497, from the river Sajó, below the Sajó at Tiszapalkonya from the Tisza (riv. km 488), as well as at Tiszacsege (riv. km 457), at Tiszafüred (riv. km 433), at Kisköre

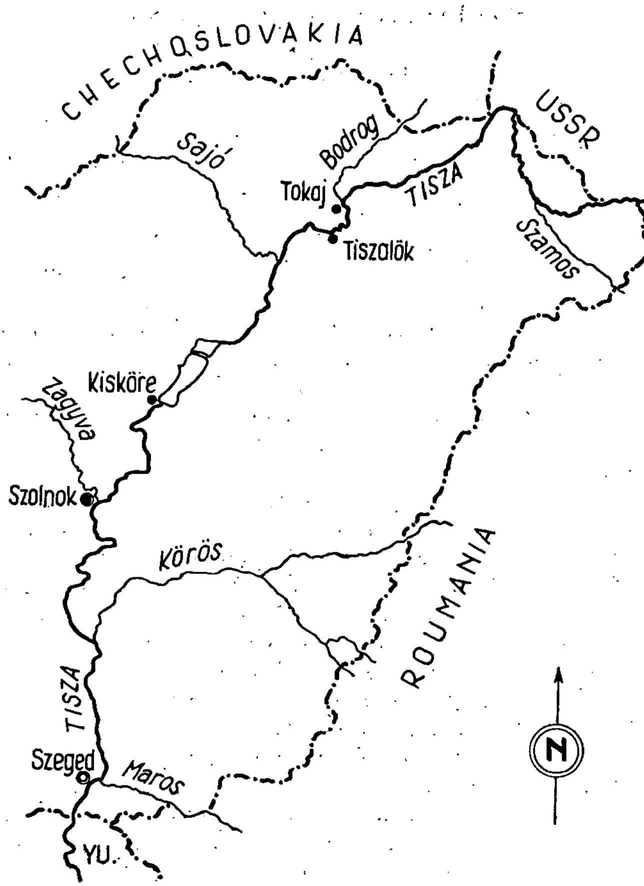

Fig. 1. Map of investigated area.

(riv. km 404), at Tiszaroff (riv. km 380), at Szolnok (riv. km 335), and at the mouth of the river Zagyva.

For water-chemical investigations we have taken a 5 l drawn sample. The measurings connected with the oxygen—carbon dioxide flow were carried out on the site. The determination of other components took place within 24 hours following sampling, at latest. The investigations were performed on the basis of COMECON: Uniform Methods of Water Investigation, as well as of FELFÖLDY's work (1974).

The water velocity was measured with a revolving water-velocity-meter (helix). The date of the next sampling was determined on the basis of the calculated values. This method made possible to follow the same water-body.

The 250 ml drawn samples, taken for quantitative algological investigations, were fixed with Lugol's solution. The elaboration was carried out with a inverted microscope. For the quantitative zooplankton investigations, in flood-periods 20 l, in low water periods 50 l water was filtered through a plankton-net of 25 IA quality (about 53). Samples were preserved with formalin. The investigation of zooflagellata took place from a living sample in the site. Deposition samples were taken out with a 425 mm long elutriating cylinder of 84 mm diameter, taking two samples from each collectingsite. Ins th e laboratory, from the matter washed through a 0.28 mm mesh metal sieve, under a cytoscope, the animals were selected by hand and preserved in 6 p. c. formalin.

HYDROLOGICAL RELATIONS

MARGIT ÁDÁMOSI

The Tisza, exposed to various natural and artificial effects, changes its hydro-ecological characteristics, that is to say, under similar hydrological conditions water-bodies of different properties pass down the river. It has therefore seemed necessary to perform the investigation of the longitudinal section of the river in a stretch attainable to us easily and for a characteristic period (flood, low water) each. In this case, the investigation of the longitudinal section meant that samplings took place from the water of the river, going together with water velocity.

The aim of investigating into the Tisza longitudinal section from June 8 to 16, 1975 was to accompany the passing of a hydrologically well-separable flood-wave. We had to chose a minor flood the water output of which did not achieve 1,000 cc.m/sec in the Kisköre section at culmination so that damming up the water should not be stopped either at Tiszalök or at Kisköre, and the effect of the river barrages should be measurable.

Another condition of realizing the investigation with success was to bring about a situation in which the water mass transferred by the more considerable tributaries was achieving or approximating the water mass of the Tisza in the given mouth-section of the river. The realization of this many-sided and complicated task must have been preceded by a comprehensive preparatory work concerning the water system of the whole Tisza and its tributaries. We had, therefore, at any rate to wait till the spring-flood, being generally connected with a large water output, was over.

On June 8, 175, after the spring-flood was over, the hydrological situation appeared favourable for starting the expedition. Parallel with the flood beginning in the Upper-Tisza on June 3, the formation of the flood-wave began in the Szamos, Bodrog, Kőrös, and Maros. The Tisza flood culminated on June 8, at Tivadar, with 211 cc.m/sec, the flood-wave of the Szamos reached the mouth on June 8, with a water output of 181 cc.m/sec. After the confluence of the Tisza and Szamos, the flood-wave got to Tokaj on June 10, where the water amount was increased by the Bodrog with a 105 cc.m/sec water output. The Sajó connected itself to the Tisza flood-wave with 40 cc.m/sec water output on June 11, the Zagyva with 10 cc.m/sec on June 14, the Hármas Kőrös with 122 cc.m/sec on June 15, and the Maros with 730 cc.m/sec water output on June 16. The flood of 211 cc.m/sec water output at Tivadar, as a result of the water amount carried by the tributaries, left the country border at Szeged, on June 16, risen to 1,662 cc.m/sec.

Together with the passing of flood-wave, the values of water level, water output, water velocity and the fall of water surface go on changing. First the increase in the fall of the water level begins and is more and more intensive. A greater fall is connected with a greater velocity. The approach of the flood-wave, the increase in the fall of water surface are followed by an increase in velocity, without inducing any change in the local water surface. This means that at an unchanged flowing through the section, due to a greater velocity, more water is streaming through the section in the time unit than before the flood-wave was approaching. *I. e.,* the water output increases. This phenomenon is called inner storage. By reason of the above-mentioned law of storage, the velocity and simultaneously the water output decrease. This process manifests itself in rising the water level.

The formation of flood-waves is shown by the water levels in June. The above-mentioned flattening-out may be observed well already 100 river-km below. In the time of the flood-wave in June, damming was not ceased either by the Tiszalök barrage or the Kisköre barrage. There could not develop, therefore, any natural situation in the Tisza.

The flood-waves in the dammed river stretches flatten out entirely. The more flattened flood-wave can be observed in the water outputs coming through.

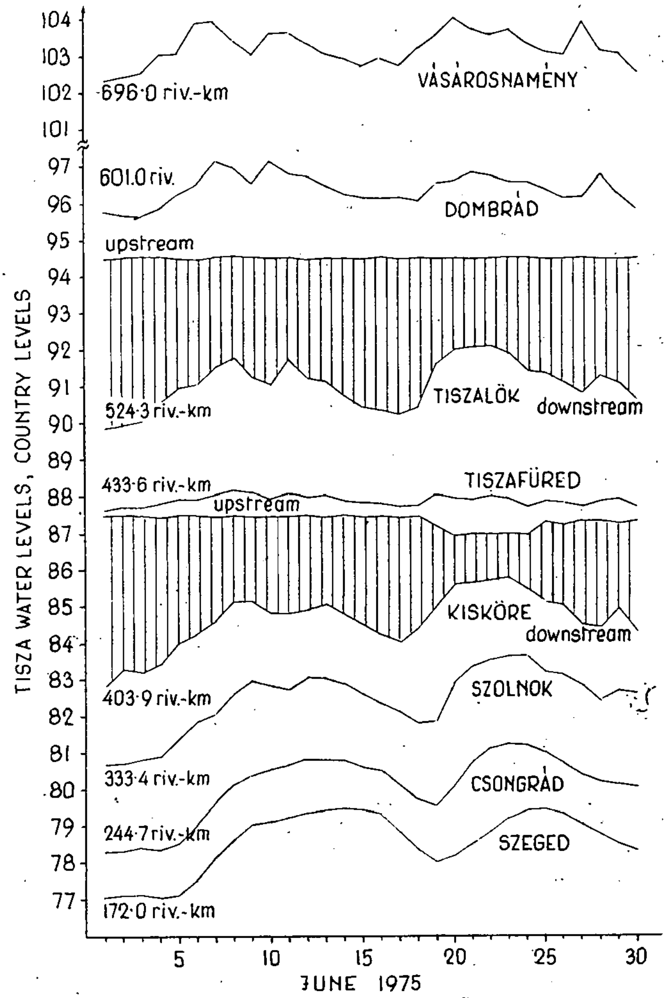

Fig. 2. Cf. the text.

The flooding secondary flows are reproduced well by the water-levels at Szolnok, Csongrád, Szeged. The flood-waves are drawn out long in the time, their height does, however, not change, they do not flatten out (Fig. 2).

In the pre-established sections of the Tisza and tributaries the water samples were taken after measuring the velocity of water flow, at dates calculated on the basis of the river-kilometres. The date of water sampling in the following section will be determined on the basis of registering the velocity data coming from the ship and the passing time of the flood wave. This method enabled us to follow the water-body along the whole Tisza stretch in Hungary.

In the course of the investigation it turned out, as well, that at floods, in case of the given water-body, as a result of the flood-waves in the tributaries, a difference may follow even in the character of the change in water. Up to Vásárosnamény, the investigated water-body coincided with the culmination of the flood. On the other hand, the flood-wave arriving from the Szamos was connected with that of the Tisza in a way that the water-body, followed closely after being united, has got into the ascending arm of the modified flood-wave. The greatest difficulty appeared in the dammed reaches before both river barrages. The water transmitting system of the barrages differs from the natural flowing conditions in the Tisza. Therefore, the position of the given water-body was to be followed with attention to a greater extent. On the basis of the data of the water output let through the river barrages and of the values of the flowing velocity was determined that the water-body investigated has got at Tiszalök into the middle of the ascending arm of flood-wave and to its upper one-third at Kisköre. This ascending arm was followed up to the Zagyva mouth. The water mass of the Tisza was not influenced by the unimportant water output of the Zagyva. Thus, we have got under similar hydrological conditions to the mouth section of the Hármas-Kőrös. Here we met the ascending arm of the flood-wave in the Hármas-Kőrös what has not modified, either, the character of water change. Below Tápé, the descending arm of the flood in Maros has arrived at the water mass investigated. In this way, the water body followed from the mouth down to the frontier of the country took place in the first one-third of the ascending arm of the modified flood-wave.

In the time of the longitudinal section investigation, as a result of the water mass of the tributaries, the water output of the investigated water-body was modified as follows. The 211cc.m/sec water output above the Szamos arose to 392 cc.m/sec after the mouth, below the Bodrog to 585 cc.m/sec, below the Sajó to 711cc.m/sec. At the date of sampling, at Kisköre 678 cc.m/sec water output was measured. Above the Zagyva 800 cc.m/sec, below its mouth 810 cc.m/sec, below the Kőrös 932 cc.m/sec and below the Maros 1,662 cc.m/sec was the output.

The aim of investigating the longitudinal section from 18 September till 27 September was to analyse the changes taking place in the Tisza stretch in Hungary during a low-water period, with particular regard to the effects of the character of the river stretch and the effects of dammings and tributaries. For this task, there were to be awaited some conditions under which neither the Tisza nor its tributaries flooded.

For the faourable occasion we had to wait until September 9th, 1975. Then flood was announced from the Upper Tisza, the lesser flood-waves of the tributaries were already culminating. This meant recession from this direction, too. The investigation began from Tivadar, on September 9. On September 10, the flood-wave coming from the Szamos with 178 ss.m/sec and a quick downflow overtook the investigated water-body and, after being mixed with that, produced such a situation that further on it did not seem to be practical to continue the investigation. We had to wait till the flood-wave was over, and the expedition began again from the section above the inflow of the Bodrog, on September 18.

Then the investigation could already be continued undisturbedly. A typical „low-water period" came about at the Tisza and its tributaries. On September 18, the Tisza with 242 cc.m/sec water output was joined by the Bodrog with 50 cc.m/sec output. At the dates of the investigation, in the Sajó 22 cc.m/sec, in the Zagyva 13 cc.m/sec, in the Hármas-Kőrös 78 cc.m/sec and in the Maros 108 cc.m/sec water outputs were measured. The water output of the Tisza was at Tiszalök 238 cc.m/sec, at Szolnok, on September 24, 266 cc.m/sec, at Csongrád, on September 26, 381 cc.m/sec, at Szeged, on September 27 550 cc.m/sec.

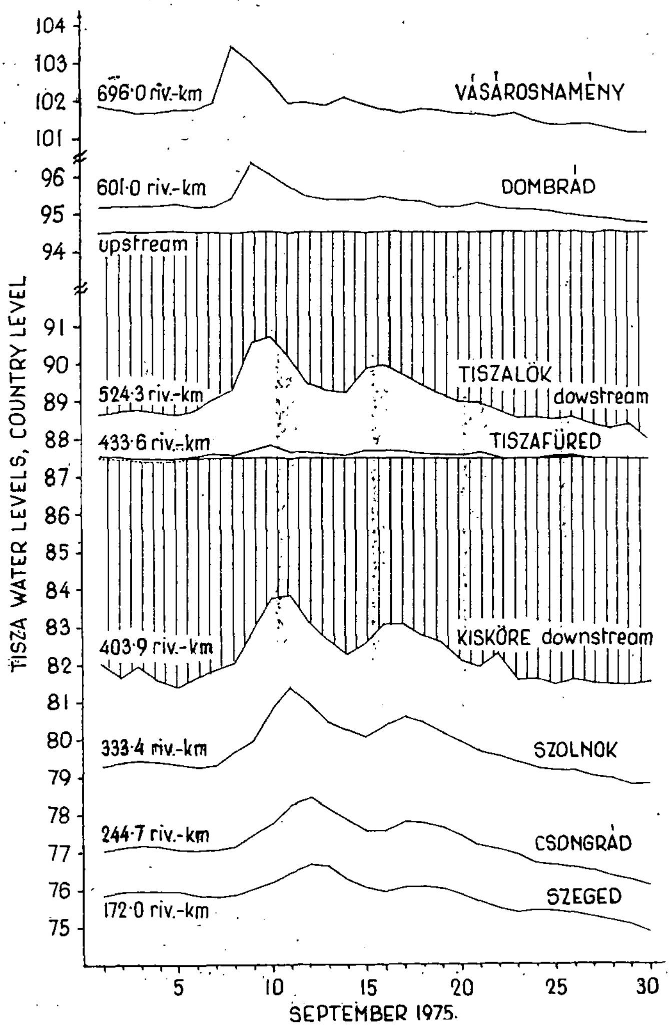

Fig. 3. Cf. the text.

The low-water period is shown by the Tisza water-levels well. It is also indicated by the so-called high "river barrages" formed out in the damming plants that the arriving and transmitted water output was little, inducing the necessary sinking of the downstream level. At the date of measuring, there has not arrived any flood-wave in the secondary flowings. Thus the effect of the earlier flood-wave, induced by the Szamos, could be demonstrated (Fig. 3).

The effects of various forces are exerted on any water mass, thus on the Tisza, as well. The water motion takes primarily place as a result of the force of gravity. In the course of motion also appears the so-called Coriolis acceleration. This is nothing else than a deflecting force, produced by the rotation of the Earth. In case of the Tisza, this force is directed towards the right riverside, there its effect on the bank is destructive. In some cases, the centrifugal force is also effective. All the three forces are influenced by the depth of water. By these forces, the velocity relations of the natural waterflow are also influenced. This manifests itself first of all in the deviations of the direction. The fluctuation of the direction of velocity, its pulsation are namely not only perpendicular but they are also effective towards the riversides, in horizontal sense, depending on the strength of the frictional force. There were also

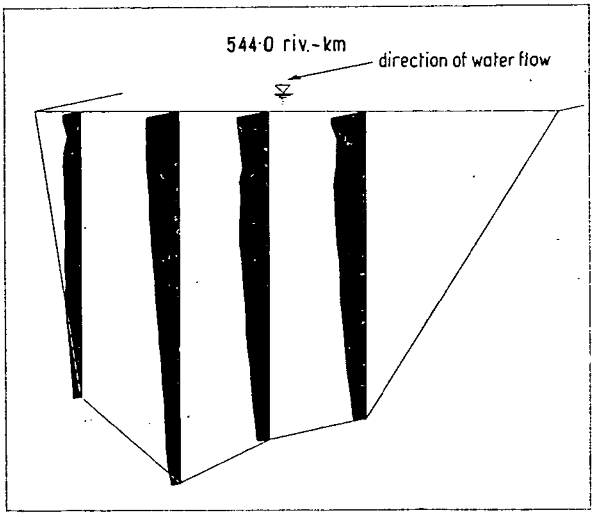

Fig. 4. Cf. the text.

investigated the distribution, extent of the velocity in the direction of advancement, according to water depth. It can be observed on the basis of the measured data that the distributions of velocity diminish as we approach the bottom. The maximum value in a vertical section is achieved in about 0.2 H distance below the water surface, where H = water depth. Their shape may generally approached by a parabola. Longitudinal speeds also change according to whether they were measured in a dammed section or in the natural stretch.

In the dammed sections, smaller velocity take generally shape but with a steadier distribution. At river-km 544, the average velocity of the section is 1.21 km/hrs (Fig. 4). The greater velocity fall to the upper one-third of the cross-section. This can be explained with the water release of the river barrage at Tiszalök where, by means of bed-damming, 94.50 m A. O. D. damming level is held. The arriving water output is released by means of upper overflow, reaching the release of the corresponding water output by rising or sinking a wicket. But at the time of producing energy, the water mass is transmitted through the turbines. The distribution of velocity at river-km 467.9 is no more showing the same picture as the former one was, although this is a dammed section, as well. The section measured was here not 20 but 70 km above the river barrage, about halfway down from Tiszalök to Kisköre. Although the effect of the Kisköre damming is observable up to Tiszalök, nevertheless, the

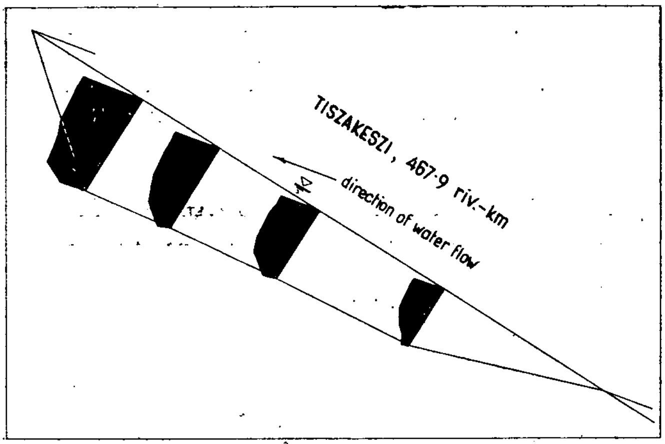

Fig. 5. Cf. the text.

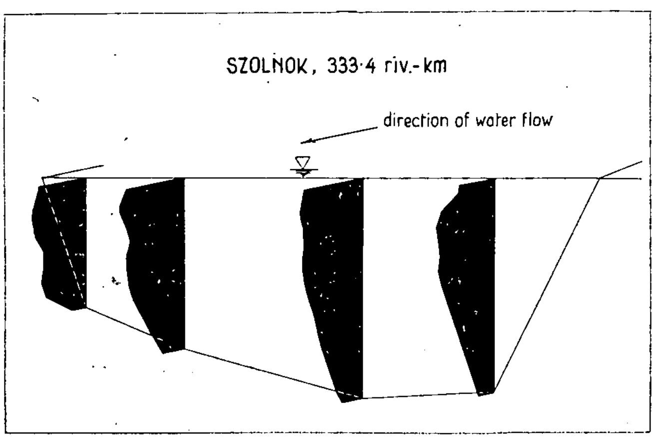

Fig. 6. Cf. the text.

distribution measured here approaches the basis of the distribution of velocities, measured in a natural state. The average-velocity value of the section is 1.94 km/hrs. This value continually decreases as the water approaches the damming plant (Fig. 5).

The operation of the Kisköre river barrage is different from that of the Tiszalök damming-plant. The water column is held by a so-called tainter (segmental) gate by lifting of which a lower water-weeping takes place, at 87.50 A. O. D. damming level. The water output, determined by calculation, is transmitted by rising, sinking the tainter gate, as well as at time of energy production, after placing the gates on the raised sill, through the tube-turbines. The other speed measurings took place in the natural stretch of the Tisza (Fig. 6).

The value of the medium velocities is 2.21 km/hrs and 2.28 km/hrs. In the different vertical sections of the bed the velocities are proportionate what means that the bed is in equilibrium. Velocity measurings were carried out at every sampling site. The date of arriving at the next section was determined in this way.

At the later supervision it turned out that the investigation was performed at the beginning of the smallest water-output period of the Tisza.

PHYSICAL AND CHEMICAL CONDITIONS IN THE LONGITUDINAL SECTION OF THE RIVER TISZA

P. VÉGVÁRI

The physical and chemical results obtained in the course of the longitudinal-section investigation performed in the Tisza in 1975, on two occasions — in the flood- and low-water periods — were showing obvious differences.

In the flood-period, the free carbon dioxide concentration of the Tisza water, its suspended matter content and output, from among the suspended matter-depending components the total iron and total phosphorus content and output, the total nitrogen and total dissolved-matter output, as well as its chemical oxygen needs measured with acid potassium permanganate and potassium dichromate were considerably higher; on the other hand, its total nitrogen content, transparency and pH were lower than in the low-water period.

The (dissolved oxygen content and oxygen saturation of the investigated water-body gradually decreased in the longitudinal section in the time of flood, and increased in the low-water period.

At investigating the plant nutrients which are important from the point of view of eutrophication, it was established that — whatever flow regimen we take as our starting-point — the quantity of the phosphorus and nitrogen in the Tisza water cannot be considered as an inhibiting factor of photosynthesis (primary production).

In the Tisza stretch in Hungary, in 1975, on two occasions — following some characteristic water-bodies — we investigated into the physical and chemical changes in the Tisza water.

At dealing with the hydrological conditions according to some determined points of view (ÁDÁMOSI, M. 1977) on June 8 to 16, in the river stretch between Tivadar (river km 718) and Szeged (river km 168), we followed with attention a floodless, so-called low-water period.

In practice, the use of the concentration of matters which are present in the water in dissolved or suspended form, *i. e.*, of the values of the various components being in 1 litre or 1 cubic metre of water, expressed in millimetres (mg/1; mg/c • m) became general. These values apply, however, only to the unit of the valume of water, leaving out of consideration the quantity of water and the river-water character.

In hydrology it is already natural that the water mass of a river is characterized by the water output, that is by the water quantity flowing through a determined section in a second. At evaluating some results of the longitudinal-section investigation, it seemed to be advisable to take into consideration, apart from concentration, the matter output, as well, which is also reflecting water quantity and the river-water character (T. DVIHALLY, ZS. 1963, DVIHALLY ZS.&VÁGÁS 1966, VÁGÁS 1963).

The output of a dissolved or suspended component (matter-output: M kg/s) can be obtained if the value of the component concentration measured in a given section (C kg/c.m) is multiplied by the water-output belonging to it (Q cubic m/s).

The matter-output — depending upon to which of the investigated components it applies — was designated with the names suspended-matter-output, sodium-output, chloride-output, etc.

Results of the investigations into the flood-period

Physical conditions

Water temperature varied during the investigation time of the longitudinal selection between 15.2 and 21.4 °C. Its mean temperature was 17.3 °C. In accordance with the early-summer weather, the day-time maxima were 2 p.c.higher than the minima of the small hours.

It was observed that in the longitudinal section the investigated water-body got gradually warmer, and the temperature values measured in identical hours below Szeged (river km 168) were higher by 5—6 °C than those measured in the upper Tisza regions.

The water which was transparent, of greenish colour until the mouth of the Szamos, has changed yellowish-yellowisch-brown after the inflow of the Szamos and this colour has remained characteristic, further on, of the investigated water-body.

The Szamos exerted the greatest effect on the transparency of the Tisza water, as well. The comparatively high transparency (55 cm) measured in the section at Tivadar (riv.km, 718) quickly decreased below the mouth of the Szamos and had a permanent value (10 cm) till the inflow of the Bodrog. The tranparency of the water-body did not change considerably from the mouth of Bodrog until that of the Kőrös. It was 9 to 11 cm, depending on the water velocity and the quantity of suspended matter. Because of the diluting effect of the Kőrös, there were measured higher values (12—14 cm) until the mouth of the Maros. By the 5 cm transparency of the rising Maros, the transparency of the Tisza water was decreased to 8.5 cm.

In the investigated period, the Tisza was arriving at the section at Tivadar (riv.km 718) with a comparatively low suspended matter concentration (30 mg/l) and output (63 kg/s). The quantity of the suspended alluvial matter of the river was considerably raised by the flooding Szamos — the suspended matter content of which was 1273.4 mg/l, the output 230.48 kg/s — and there were measured high valued (540—468 mg/l, resp. 211.7—183.5 kg/s) down to the mouth of Bodrog. The diluting effect of the Bodrog could be observed well in the sampling section (riv.km 545) below Tokaj. It was proved by the gradually rising concentration- and output-values, measured after the inflow of the Bodrog, that a rather long way (about 8 to 10 km) was necessary to mix the Bodrog water.

In the immediate range of the river barrages (between 535 and 364 riv.km), in this period, the suspended, -matter conditions of the investigated water-body was primarily determined by the operation of the river barrages (BOGÁRDI 1971). The flood-wave of precipitous course was let through by the river barrage at Tiszalök in a way that the water velocity, and with that the power preserving the drift-matter in floating, increased. As a result of this, we have measured at Tiszalök (river km 524) 378.6 mg/l, resp. 254 kg/s, and at Gyulaháza (479 riv.km 497) 463.2 mg/l, resp. 310.8 kg/s values.

Below the mouth of the Sajó "221.4 mg/l; 8.8 kg/s), the suspended matter concentration of the water of the Tisza decreased by 12.6 mg/l, its outlet, however, increased by 9.6 kg/s. In the sampling section at Polgár (riv.km 486) we have obtained a value of 450.6 mg/l, resp. 320.4 kg/s.

From Polgár on (riv.km 486), the damming effect of the Kisköre river barrage already prevailed and, with the gradually decreasing speed of flow, the suspended

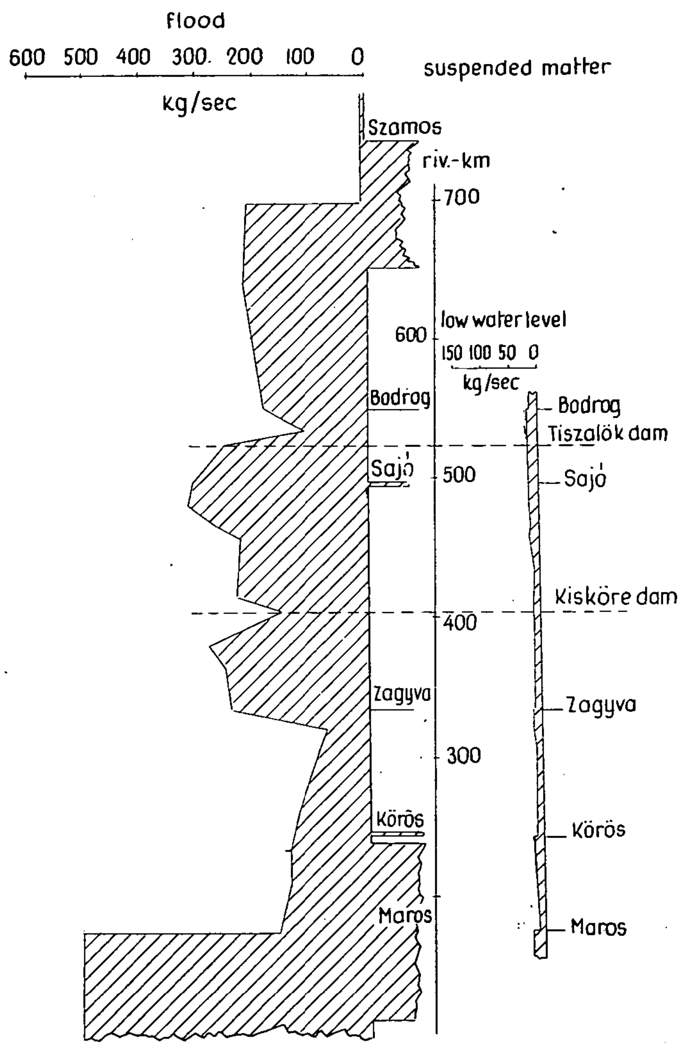

Fig. 7. Formation of the output of the suspended matter in the longitudinal section of the Tisza.

drift of the water also began depositing. In the section above the river barrage (riv.km 404), the suspended matter content of the investigated water-body was 232.2 mg/l and its output 157.4 kg/s. A smaller flood-wave — of a water output below 1000 cubic m/s — was let through by the Kisköre River Barrage in a way that damming was not terminated thoroughly. In a case like this, in the low-water side of the river barrage, the water speed is always higher than on the headwater side. Below the river barrage, the flowing velocity of the water getting outside increase--d again. With its superfluous energy it took along with itself and preserved in floating a newer quantity of the bed-matter. In the sampling section at Tiszaroff (riv.km 380), its concentration increased to 361.2 mg/l, and its output reached 289.0 kg/s.

Approaching the lower Tisza region, the water speed and the amount of suspended matter decreased — in accordance with the character of the stretch. — At Tiszavárkony (riv.km 320) — taking also into consideration the diluting effect of the Zagyva — we have obtained the values 96.4 mg/l, resp. 78.1 kg/s. At Csongrád (riv. km 245), above the inflow of the Kőrös, the values 204.4 mg/l, resp. 165.5 kg/s were obtained. The Kőrös (47.6 mg/l; resp. 5.8 kg/s) brought about — similarly to the Sajó — a decrease in the suspended matter concentration of the Tisza and a minor increase in its output.

The flooding Maros again brought a considerable quantity of suspended matter into the Tisza (436.2 mg/l; 318.4 kg/s). As a result of this, the Tisza water left the frontier of the country with a suspended matter content of 313.6 mg/l and an output of 5251.2 kg/s (Fig. 7).

Water-chemical conditions

The iron content of the water of the Tisza is of mineral origin. Its quantity changes — as a result of the geochemical character of the watershed area of the Tisza and its tributaries — in a close connection with the suspended matter content (Katona 1976). This establishment was unambiguously proved by the investigation into the longitudinal section carried out in the flood-period.

The Tisza arrived at the sampling section at Tivadar (riv. km 718) with a total iron content (1.61 mg/l) and output (0.34 kg/s) that was similar to those experienced in case of the floating matter. The iron content of the Tisza was increased by the flooding Szamos (68.27 mg/l; 12.35 kg/s) to 30-times as much as the initial concentration (48.16 mg/l) and its output to a velue 55-times as high as the initial value was (18.88 kg/s).

The total iron content was formed by the single tributaries — the Bodrog (1.41 mg/l; 0.15 kg/s), the Sajó (15.47 mg/l; 0.62 kg/s), and the Zagyva (1.29 mg/l; 0.013 kg/s) — as well as by the river barrages in the same way as the suspended content. Thus there were measured the following values: at Tiszalök (river km 524) 11.43 mg/l, resp. 7.67 kg/s; at Gyulaháza (riv.km 497) 15.09 mg/l; resp. 10.12 kg/s; at Kisköre (riv.km 404) 6.09 mg/l; resp. 4.13 kg/s; at Tiszaroff (riv.km 380) 9.75 mg/l; resp. 7.8 kg/s; at Csongrád (riv.km 245) 11.58 mg/l; resp. 9.4 kg/s. After the inflow of the Kőrös (2.71 mg/l; 0.33 kg/s), there was observed a considerable decrease in the total-iron content and output. As a result of the flooding Maros (13.77 mg/l; 10.05 kg/s), the totaliron concentration rose to 10.29 mg/l. And with its 17.1 kg/s output it approached the values measured below the Szamos (riv. km 673) (Fig. 8).

The pH of the investigated water-body did not change considerably in the longitudinal section. The values obtained were in 70.8 per cent of samples 7.1—7.2;

and in 20.9 per cent 7.3—7.4. At Záhony (riv.km 638) we have measured pH 7.65 and at Tiszaderzs (riv.km 415) 6.9.

Owing to the high suspended matter content, the production of the photosynthetic oxygen of the investigated water-body was negligible. Correspondingly, the dissolved oxygen content was determined by the atmospherical oxygen getting into the course of the movement of water and by the change in water temperature. The dissolved oxygen content of the Tisza water varied between 9.6 and 6.48 mg/l, its mean value being 7.9 mg/l. The values measured in the day-time — corresponding to the higher temperature of the water surface — were by 0.5 to 0.6 mg/l lower than those in the small hours.
In the longitudinal section — apart from the gradual warming up of the investigated water-body — there was observed — a decrease in the concentration of dissolved oxygen, as well. In the sampling section a Szeged, there were measured concentrations less by 2.0—2.5 mg/l than the initial values (*e. g.*, at Záhony (river km 638), at 13.20,8.88 mg/l, while in Szeged (riv. km 173), at 11.30, 6.48 mg/l). The oxygen saturation of the water has never reached 100 per cent in the course of the investigation.

There predominated in the Upper-Tisza Region between Tivadar (river km 718) and Záhony (riv. km 638) high values of 96—90 per cent, in the Middle-Tisza stretch between Tokaj (riv. km 545) and Csongrád (riv. km 245) medium values of 85—80 per cent, in the Lower Tisza Region between Szentes (riv. km 234) and the frontier of the country lower values of 75—74 per cent. That is to say, in the longitudinal section the oxygen saturation has also decreased.

The Tisza — its predominating kation being calcium — belongs to the group of the so-called waters of positive carbon-dioxide content. Its carbon-dioxide content makes rapid progress together with the calcium-ion concentration. The water can, therefore, store even 60 to 70 times as much carbon dioxide as 0.37 mg/l which is in state of equilibrium with the partial pressure of the carbon dioxide content of the air (FELFÖLDY 1969).

The free carbon-dioxide content of the investigated water-body was determined — apart from pH and temperature — primarily by the concentration of calcium, magnesium, and hydrogen-carbonate. Its values are very high —, what is characteristic of the flooding Tisza — in 79.2 per cent of the samples we have got quantities between 8.0 and 12.0 mg/l. The lowest concentration — 5.64 mg/l — was measured at Tivadar (river km 718), the highest one — 13.73 mg/l — at Tiszakeszi (riv. km 476) and Tiszaug (riv. km 266).

The chemical demand of the Tisza, measured with acid potassium permanganate and potassium dichromate (hereinafter called: COD aMn, resp. COD Chr), was characterized by low values up to the mouth of the Szamos (at Tivadar [river km 718] 2.49 mg/l; 8.41 mg/l). As a result of the high organic-matter and iron content, transported by the Szamos, the COD aMn and COD Chr of the Tisza water rose considerably. Thus, until the inflow of the Bodrog, we have measured 5—6-times as much as the initial values (15.65 mg/l; 13.18 mg/l), resp. 3—4-times as much (36.17 mg/l; 28.70 mg/l). In this river stretch, 25 to 50 per cent of the COD aMn and 20 per cent of the COD Chr quantities were reached by the oxygen requirement of the iron content of water (6.74 mg/l; 3.31 mg/l). Between the mouths of the Bodrog and Sajó the values were reduced. At Gyulaháza (river km 497) the chemical oxygen requirement of water was 6.96 mg/l, resp. 22.08 mg/l, a still considerable proportion of which (30 per cent, resp. 10 per cent) was given by the oxygen requirement of the

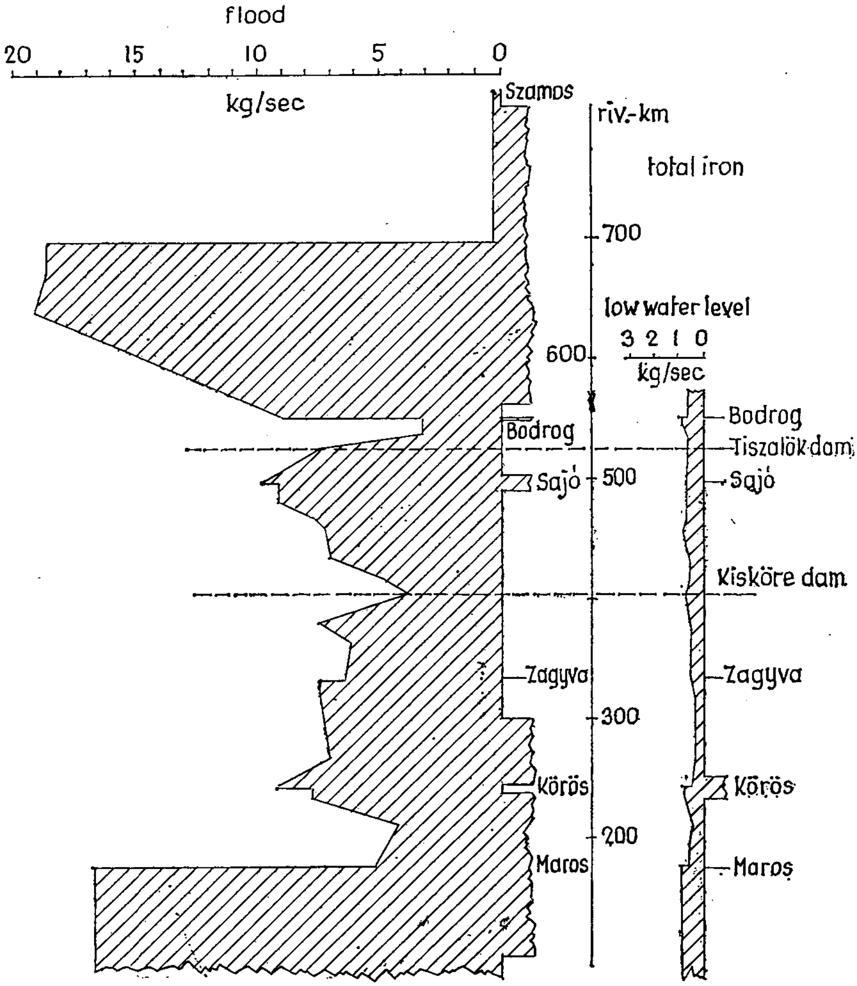

Fig. 8. Formation of the output of the total iron in the longitudinal section of the Tisza.

on content. The high COD Chr (27.35 mg/l) and COD Chr (55.04 mag/l) of the Sajó water made their effect on the Tisza, as well.

The COD aMn values changed — as the influence of the Zagyva can be considered owing to its low water output, as practically negligible — up to the mouth of the Kőrös between 11.0 mg/l and 8.0 mg/l. After the inflow of the Kőrös a decrease of 2—3 mg/l was observed. At Tápé (river km 177) 5.86 mg/l was measured.

The COD Chr of the Tisza water initially rose, under the influence of the Sajó, by 10—15 mg/l (at Tiszakeszi (riv. km 467) to 37.35 mg/l. at Tiszacsege (riv. km 457) to 35.38 mg/l); then, in its longitudinal section, a further decrease in values could e observed (Csongrád (riv. km 245) to 18.84 mg/l.

Owing to the diluting effect of the Kőrös, at Tápé (river km 177) there was already measured not more than 10.61 mg/l. The chemical oxygen requirement of the Tisza water was repeatedly increased by the flooding Maros, the CODaMn of which was 15.03 mg/l, and its COD Chr 31.45 mg/l. In the sampling section below Szeged, the COD aMn of the water was 11.96 mg/l, and its COD Chr 23.59 mg/l.

Dissolved mineral-matter content

The investigated water-body has arrived at the section at Tivadar (river km 718) with a dissolved mineral-matter content and output — sodium (10.51 mg/l; 2.2 kg/s), potassium (0,5 mg/l; 0.1 kg/s), calcium (32.1 mg/l; 6.9 kg/ s), magnesium (5.5 mg/l; 1.2 kg/s), chloride (15.6 mg/l; 3.34 kg/s), sulphate (2.26 mg/l; 0.5 kg/s), and hydrogen-carbonate (141.57 mg/l; 29.9 kg/s).

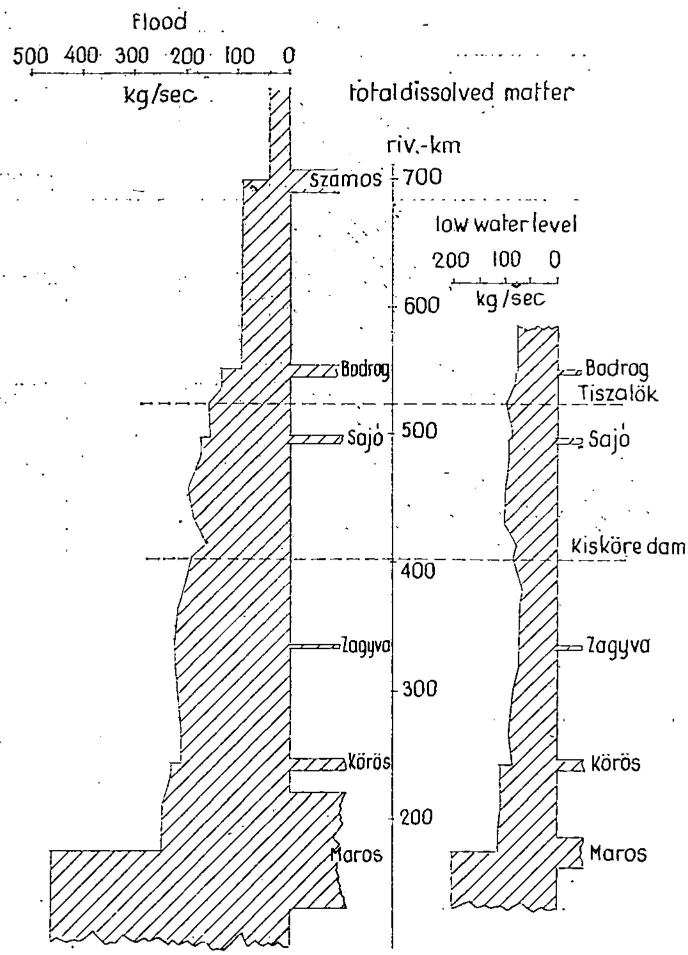

Fig. 9. Formation of the output of the total dissolved matter in the longitudinal section of the Tisza.

Under the influence of the Szamos, the dissolved mineral-matter content of the Tisza water has increased. In the sampling section above the mouth of the Bodrog, up to the frontier of the country, from among the single kations and anions, the concentration of soidum and magnesium in the longitudinal section did not increase. Potassium showed an increase of 78 per cent, calcium 45, hydrogen-carbonate 11, chloride 41, and sulphate 268 per cent increase. In the sampling section in Szeged (river km 173) 16.0 mg/l sodium, 4.0 mg/l potassium, 48,1 mg/l calcium, 9.2 mg/l magnesium, 157.43 mg/l hydrogen-carbonate, 34.4 mg/l chloride and 30.48 mg/l sulphate concentrations were measured.

In case of the dissolved mineral-matter output — depending on the quantity of the mineral matter transferred by tributaries — we have observed a still more considerable increase.

Thus, we have measured in the sampling section in Szeged (river km 174) from among the kations 12 times as much as the initial output of sodium — at Tivadar (river km 718) — (26.6 kg/s), 66 times as much as that of potassium (6.6 kg/s), 12 times as much as that of calcium (79.9 kg/s), 14 times as much as that of magnesium (15.3 kg/s). From among the anions, the output of hydrogen-carbonate rose to 10 times as much (29.9 kg/s), that of chloride to 18 times as much (59.5 kg/s), that of sulphate to 105 times as much (52.5 kg/s).

The initial concentration of the total dissolved matter (162 mg/l) has increased by 84 per cent, and its output (34.2 kg/s) by 1348 per cent in the longitudinal section. In the sampling section in Szeged (river km 174), there were achieved 298 mg/l and 495.2 kg/s values, respectively (Fig. 9).

Phosphorus and nitrogen forms

The investigated water-body arrived at the sampling section at Tivadar (river km 718) with 112 mg/cubic m total phosphorus content and 23.6 g/s output. Under the influence of the flooding Szamos (436.0 mg/c. m; 78.9 g/s), the total phosphorus content increased to 6 times as much as the initial concentration (668.0 mg/cubic m), and its output to 11 times as much as the initial value (261.9 g/s).

As at flooding a considerable part of the quantity of the total phosphorus was formed by phosphorus connected with the suspended matter (phosphorus being in the organic fragments, water-insoluble, biologically inactive calcium-, magnesium-, aluminium-, iron-, etc. phosphates), thus in the longitudinal section the concentration and output of the total phosphorus changed in connection with the suspended matter (Fig. 10).

After evaluating the data from the point of view of trophity, we have established that the investigated water-body belonged — on the basis of the total phosphorus content — into the polytrophic category. That is to say, the cessation of the inhibiting factors (much suspended matter, strong flow regimen etc.) in the whole stretch of the Tisza in Hungary would have enabled the polytrophic state to be brought about (FELFÖLDY 1974). The total phosphorus content measured in the flooding Tisza is, of course, much higher than the biologically available total phosphorus. The phosphorus quantity of the water-body, that is undoubtably exclusively accessible to the living organisms, is therefore given by the dissolved orthophosphate-phosphoric concentration. If we qualify the degree of trophity of the investigated water-body on the basis of the dissolved orthophosphate-phosphorus, then we determine the minimum trophic state that can develop in the water if the production-inhibiting factors cease to be.

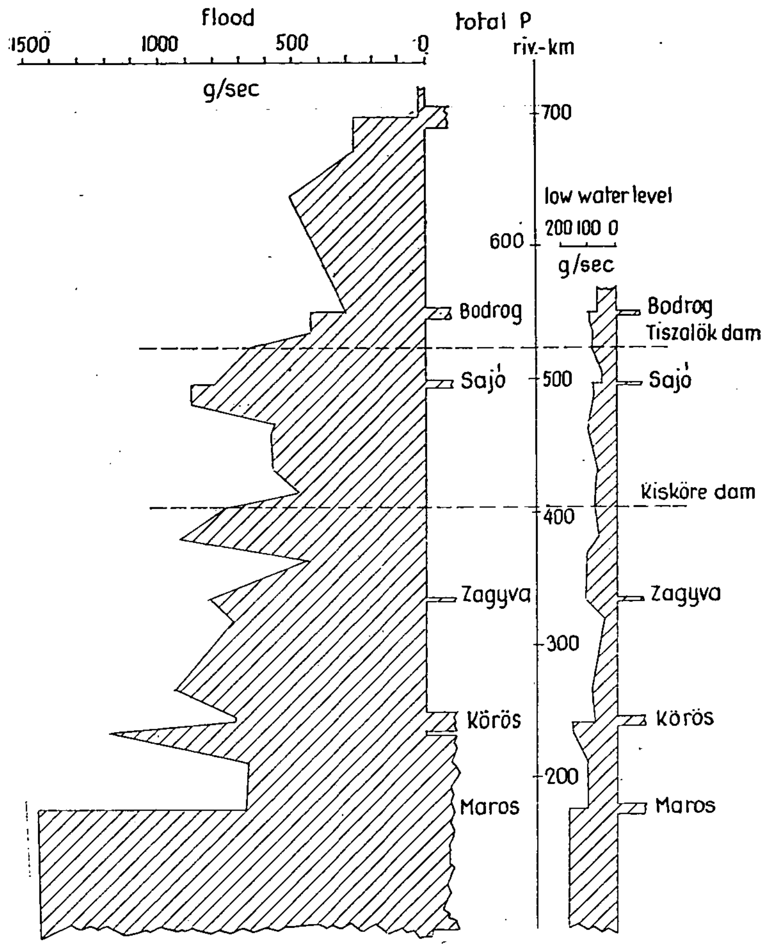

Fig. 10. Formation of the poutput of the total phosphorus in the longitudinal section of the Tisza.

The investigated water-body was up to the mouth of the Szamos oligotrophic again. From the mouth up to the frontier of the country — as a result of the Szamos water — it contained enough quantity of dissolved orthophosphate-phosphorus for bringing about the polytrophic state and exceeded, on every occasion, the 20 mg/cubic metre value which can be considered as a critical concentration of algal blooms (VOLLENWEIDER 1968).

The knowledge of the nitrogen content — in the flow of which the aquatic living world has a determinative part — is fundamentally necessary to form an opinion of trophities. The investigated water-body has arrived with 2320 mg/cubic metre total nitrogen content and 0.5 kg/s output at the sampling section at Tivadar (river km 718). After the mouth of the Szamos, the concentration of the total nitrogen increased to about two times as much and, remaining in an approximately standing

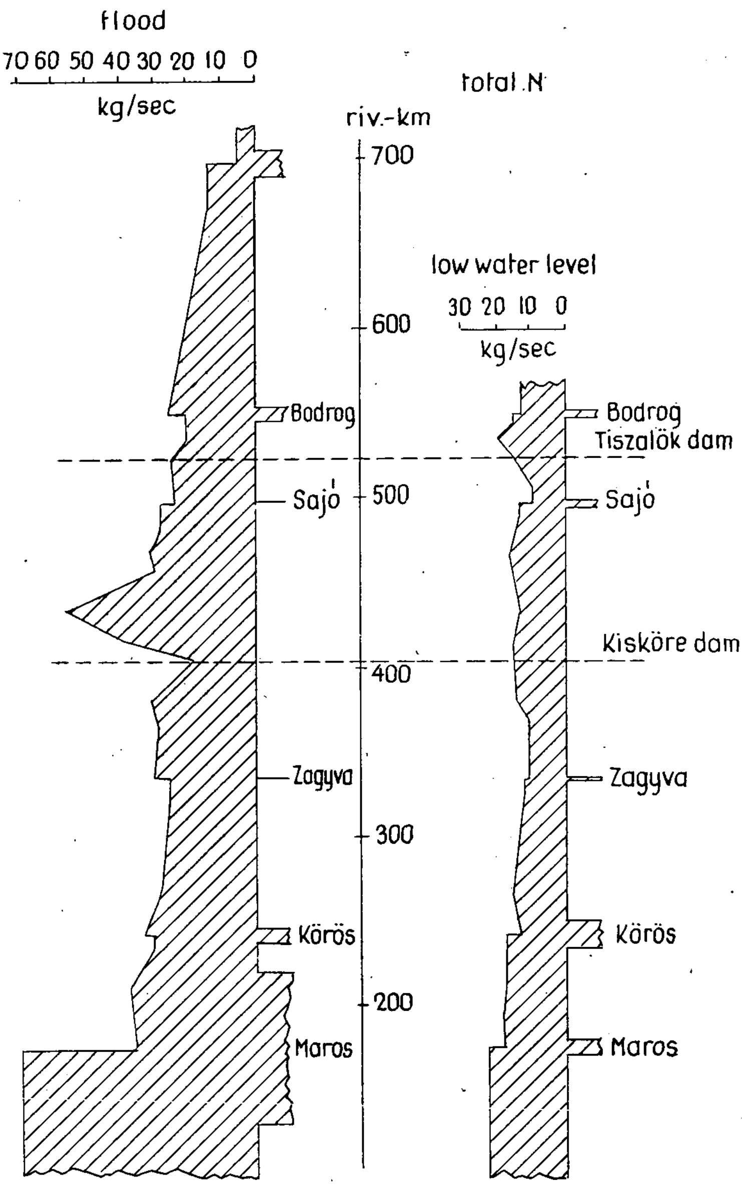

Fig. 11. Formation of the output of the total nitrogen in the longitudinal section of the Tisza.

value in the longitudinal section, left the frontier of the country with 4123 mg/cubic metre. Its output increased in the longitudinal section. We have measured after the mouth of the Szamos — at Tiszaszalka (river km 673) — 1.2 kg/s, after the mouth of the Bodrog — at Tiszaladány (riv. km 535) — 1.9 kg/s, after the mouth of the

Sajó — at Polgár (riv. km 486) 2.7 kg/s, after the mouth of the Zagyva — at Tiszavárkony (riv. km 320) — 2.5 kg/s, after the mouth of the Kőrös — at Szentes (riv. km 234) — 3.0 kg/s, after the mouth of the Maros — in the sampling section below Szeged (riv. km 168) — 6.8 kg/s values (Fig. 11).

The quantity of the mineral nitrogen (nitorgen of inorganic bond) on every occasion surpassed 300 mg/cubic metre, designated as a dangerous threshold value from the point of view of eutrophication (VOLLENWEIDER 1968, FELFÖLDY—TÓTH 1970).

The investigated water-body contained — on the basis of 895 mg/cubic metre, measured in the sampling section at Tivadar (river km 718) — sufficient quantity of mineral nitrogen for the formation of a eu-polytrophic state until the mouth of the Szamos, for that of a eu-polythrophic, resp. polytrophic state from the inflow of the Szamos until the mouth of the Sajó (1074 mg/c. metre — 1605 mg/c. metre), for that of a polytrophic state from the inflow of the Sajó until the frontier of the countra (FELFÖLDY 1974).

Results of the investigation of the low-water period

Physical conditions

In the time of the longitudinal section water temperature varied between 17.9 and 22.0 °C, the mean temperature of the investigated period was 19.9 °C. In accord ance with the temperature conditions of the late-summer — early-autumn period, there were measured less temperature differences than in June between the day-time maxima (21 to 22 °C) and the minima of small hours (18 to 20 °C).

The temperature difference decreased in the longitudinal section of the river, as well. It was established from the values measured in approximately identical hours that the water is only by 1°—1.5 °C warmer at the sampling sites below Szeged than it was initially.

The investigated water-body was characterized until the inflow of the Bodrog by a greyish-yellow, and from the mouth of the Bodrog down to the frontier of the country — corresponding to the low-water period — by a greenish-yellow colour.

Transparency of the water was 2—6 times greater than at the longitudinal section in July. After the mouth of the Bodrog — at Tokaj (river km 545) — there was measured a value of 27 cm, at Kisköre — above the river barrage (riv. km 404) — that of 45 cm, and in the sampling section below Szeged a values of 50 cm.

The suspended matter content of the investigated water-body was—corresponding to the low-water period low, in the decisive majority of samples only 12—20 per cent of the values measured in flood-time. In the longitudinal section, the suspended matter concentration fluctuated but to a lesser degree. There were obtained in the sampling section above the Bodrog (river km 551) 43.6 mg/l, at Tokaj (riv. km 545) 44.2 mg/l, aat Tiszalök (riv. km 525) 44.0 mg/l values.

In the range of the Kisköre River Barrage, there took place a visible decrease in concentration. At Kisköre (riv. km 404) the suspended matter of the water-body was 25.2 mg/l.

The suspended matter content of the water leaving the dammed reaches was increasing again. There were measured at Tiszaroff (river km 380) 35.8 mg/l, at Tiszavárkony (riv. km 320) 46.2 mg/l, at Csongrád (riv. km 235) 29.6 mg/l, and in the sampling section below Szeged (riv. km 168) 36.4 mg/l concentrations.

The suspended matter output, measured in the identical sampling sections, has only reached 3 to 8 per cent of the values obtained in the time of flood. We have observed the gradual decrease in the output of the water-body which had an almost constant, about 15—17 kg/s suspended matter output from the mouth of the Bodrog until the beginning of the range of Kisköre damming. At Kisköre, there was already measured 7.5 kg/s, the half of the initial values.

There was observed a minor increase in the suspended matter output of the water-body leaving the dammed reaches, only after the inflow of the single tributaries— as a result of the suspended matter content of them.

Thus, the suspended matter output of the water-body increased after the mouth of the Zagyva from 11.0 kg/s to 12.3 kg/s, after the mouth of the Kőrös from 8.9 kg/s to 14.3 kg/s, after the mouth of the Maros from 14.5 kg/s to 19.4 kg/s, and to 20.0 kg/s in the section below Szeged (Fig. 7).

Water-chemical conditions

The total iron content reached not more than 10 to 20 per cent of the values measured in the time of flood. In the longitudinal section — like in case of suspended matter — there was observed only a minor fluctuation. We have obtained generally about 1.7 mg/l concentrations. The total iron output was 3—10 per cent of the values measured in the time of flood.

The investigated water-body arrived at the mouth of the Bodrog with 0.6 kg/s output. The value risen under the influence of the Bodrog (0.8 kg/s) gradually decreased until Tiszalök (river km 524) then, until Tiszacsege (riv. km 457) it remained on 0.6 kg/s value. From Tiszafüred (river km 433), a minor decrease followed repeatedly and until Csongrád (riv. km 235) 0.3—0.5 kg/s values were obtained. The total iron output of the water-body was raised by the Kőrös by 0.3 kg/s, and by the Maros by 0.2 kg/s, and left the frontier of the country with 0.8 kg/s value (Fig. 8).

The pH of the investigated water-body was generally by 0.3 higher than those measured in the time of flood. In the longitudinal section a minor decrease was experienced. There were predominating until Szolnok (riv. km 355) the higher pH 7.7—7.5 and from Szolnok until the sampling section below Szeged (riv. km 168) rather the lower pH 7.5—7.4 values.

The dissolved oxygen content of the Tisza water has shown a considerable difference from that observed in flood-time.

Because of the slow watercourse, the atmospherical oxygen, getting in, due to water motion, dominated less and less. The considerably lower suspended matter content and the long-lasting sunny fine weather enabled the photosynthetic oxygen production of the water-body to be started. Thus, the oxygen engendered in the day-time rather by the production, and getting in at night — under the influence of the decrease in temperature — by the surface diffusion, decreased the dissolved oxygen content of the water. That is to say, the values measured in the day-time and the small hours became more balanced.

In the longitudinal section — in contradistinction to those experienced in the time of flood — there was observed the progressive increase in the concentration of the dissolved oxygen and the oxygen-saturation of water. From the sampling section above the mouth of the Bodrog (river km 551) until Tiszaderzs (riv. km 415) there were generally measured values about 3—4 mg/l and saturations about 40—50 per cent. At Kisköre (riv. km 404) the dissolved oxygen content rose to 5.58 mg/l and at Tiszaroff (riv. km 380) to 9.23 mg/l. Saturation reached 61 and later even 104 per cent!

From Tiszaroff (river km 380), a change followed in the weather — the sky was clouded in 10—90 per cent — thus, the dissolved oxygen content of the investigated water-body did not continue rising any more, its saturation was again reduced below 100 per cent. Until the sampling section below Szeged (river km 168) — depending on the weather—there were generally measured 6—7 mg/l concentration and 70—80 per cent saturation.

The free oxygen content of the investigated water-body was generally lower than the values measured in the time of flood, it as a rule varied between 5—10 mg/l. In the longitudinal section, a minor rise in concentration could be observed.

The oxygen requirement of the Tisza water, measured with acid potassium permanganate and potassium dichromate (further on: CODaMn and CODChr respectively), was until the mouth of the Sajó by 7—10 mg/l, resp. 10—15 mg/l lower than the values received in the time of flood, first of all owing to the low suspended matter content.

Under the influence of the Sajó—the CODaMn of which was 44.8 mg/l, the CODChr 160.0 mg/l—the CODaMn of the Tisza water rose by 4—5 mg/l and its CODChr by 2—7 mg/l, and at Kisköre (river km 404) there was measured 8.16 mg/l, resp. 19.4 mg/l.

From Kisköre, the chemical oxygen requirement of the investigated water-body more and more decreased. After the mouth of the single tributaries, however, which had arrived with a higher organic-matter content, the values again rose.

In the sampling section below Szeged the CODaMn of the water was 6.84 mg/l and the CODChr reached 25.2 mg/l.

The dissolved mineral-matter content of the investigated water-body — corresponding to the low-water period—was generally higher than in the period of flood. From among the kations, the concentration of sodium was higher by 3—20 mg/l, that of calcium by 4—12 mg/l, that of potassium and magnesium by 1—4 mg/l, and from among the anions that of chloride by 2—10 mg/l and that of sulphate by 10—30 mg/l than the values measured in flood time. In case of hydrogen-carbonate, there were measured at both longitudinal sections approximately identical quantities.

In the sampling section above the mouth of the Bodrog (river km 551), sodium was 20.75 mg/l, potassium 2.25 mg/l, chloride 29.0 mg/l, and sulphate 17.63 mg/l. In the longitudinal section — primarily under the influence of tributaries — the increase in the concentration of kations and anions was kept under observation.

The Bodrog has raised mainly the magnesium content of the water-body (by 5.3 mg/l; 70 per cent), the Sajó the calcium and sulphate contents (by 7.2 mg/l, 16 per cent, resp. by 15.9 mg/l; 60 per cent), the Zagyva the sodium and sulphate contents (by 7.0 mg/l; 27 per cent, resp. 2.7 mg/l, 72 per cent), and the Maros the calcium, chloride and sulphate contents (by 18.9 mg/l, 33 per cent; 65.0 mg/l, 203 per cent; resp. 15.4 mg/l, 32 per cent). In the samping section at Szeged (river km 173) the concentration of sodium (30.75 mg/l) has shown 48 per cent, that of potassium (9.75 mg/l) 333 per cent, that of calcium (76.2 mg/l) 65 per cent. that of magnesium (11.7 mg/l) 56 per cent, that of hydrogen-carbonate (194.04 mg/l) 33 per cent, that of chloride (97.0 mg/l) 235 per cent, and that of sulphate (61.88 mg/l) a 251 per cent increase.

The output of the kations and anions of the investigated water-body did not surpass, in the conclusive majority of cases, the outputs reached in flood time. The outputs of sodium and potassium were almost identical on the occasion of the two investigations; that of calcium was lower by 10—30 kg/s, that of magnesium by

2—10 kg/s, that of chloride by 4—12 kg/s, and that of sulphate by 4—20 kg/s than in flood time.

In the longitudinal section, the outputs of potassium, calcium, and sulphate more and more increased; in the sampling section in Szeged (river km 174) there were measured 6.7 times, 2.6 times, resp. 5—6 times as much output as the initial one.

The output of sodium began rising from the inflow of the Zagyva, and those of magnesium and chloride from the mouth of the Kőrös. At Szeged (river km 174) we have measured 9.8, 2.5, as well as 5.3 times as much as their initial output. The output of sodium began rising from the inflow of the Zagyva, that of magnesium and chloride from the mouth of the Kőrös. At Szeged (river km 174) their output increased to be 9.8, 2.5, as well as 5.3 times as much.

The output of hydrogen-carbonate remained at almost standing — about 60—70 kg/s — values.

The total dissolved matter content was higher by 3—55 per cent, the output was lower by 17—95 per cent than those observed in flood time. In the longitudinal section, the initial concentration (219 mg/l) increased by 110 per cent, and the initial output (75.3 kg/s) by 237 per cent. In the sampling section at Szeged (river km 174) we have reached 462 mg/l, resp. 254.1 kg/s (Fig. 9).

The total phosphorus content (162—495 mg/cubic m) and output (60—200 g/s) of the investigated water-body have only reached 30—40 per cent of the phosphorus content and 10—20 per cent of the output of flood time. In the longitudinal section, the values have considerably increased after the mouth of the single tributaries (Fig. 10).

In the low-water period, the water-body contained — primarily because of its low suspended matter content — considerably less formed sestonic phosphorus of inorganic bond. Its total phosphorus content was therefore given, apart from the dissolved orthophosphate phosphorus and the dissolved non-reactive phosphorus, first of all, by the biologically available formed organic phosphorus — being in dead or living organisms.

Evaluating the data from the point of view of trophity, we have established that the investigated waterbody contained phosphorus of sufficient quantity for forming — on the basis of the total phosphorus content — a polytrophic, and on the basis of the dissolved orthophosphate phosphorus an eutrophic state and, on any occasion, exceeded the 20 mg/cubic m value which can be considered as the critical concentration of algal blooms. The concentration of the total nitrogen (3036—6804 mg/cubic metre) was by 10—20 per cent higher, and its output (0.9—2.8 kg/s) 40—50 per cent lower, than those measured in flood time. In the longitudinal section — mainly under the influence of the tributaries — the values gradually increased. And in the sampling section below Szeged (river km 178) the 27 per cent increase in the initial concentration and the 89 per cent increase in the initial output was measured. In case of the mineral nitrogen content, there were achieved nearly the same amounts as those measured in flood time which have on every occasion surpassed the 300 mg/cubic metre limiting concentration, designated as a threshold value which is dangerous from the point of view of eutrophication. Evaluating these contributions from the point of view of trophity, we have established that the investigated water-body contained a sufficient quantity of mineral nitrogen for forming until the mouth of the Sajó a (1092—1309 mg/c.m) eu-polytrophic, and from the inflow of the Sajó until the frontir of the country a (1550—2746 mg/c. m) polytrophic state.

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BACTEOROLOGICAL INVESTIGATIONS IN THE LONGITUDINAL SECTION OF THE TISZA

MÁRIA B. TÓTH and J. HAMAR

It is the quantity of the heterotrophic bacteria in the water, of a larger size than 0.45 μ which can be determined by the method of direct number (OVERBECK 1974). According to our experience, the bacteria occurring in the Tisza are generally tiny cocci. Their average diameter is 0.7 μ which corresponds to 0.1795 cubic μ. They have, therefore, a very small volume. According to Overbeck (1974), the bacteria of the Plussee are of a volume between 1.2 to 6.6 μ.

The numbers of bacteria per millilitre, counted by the direct method, are extremely different and depend upon the degree of the organic-matter load, as well (BERLAND et al. 1975, OVERBECK 1972, 1974, PATIL et al. 1975, ROMANENKO 1973, SIVKO et al. 1972, TILZER 1972, RODINA 1960, 1964, OLÁH—VÁSÁRHELYI 1970). In oligotropic waters this number is lower than 100, in eutrophic water it is 10^4—10^6 ind/ml, while in sewage-water their number is of the order 10^7—10^9 ind/ml. In the mentioned literature, not one of the freshwater values is reaching the values of the total bacterial number in the Tisza (HAMAR 1976, HAMAR et al. 1975). The suspended matter content of the Tisza is very high in flood time. The organic-matter content of the suspended matter originating from the runoff from land (VÉGVÁRI 1976) is considerable. Thus, the suspended matter and the total bacterial number are in a positive correlation with each other.

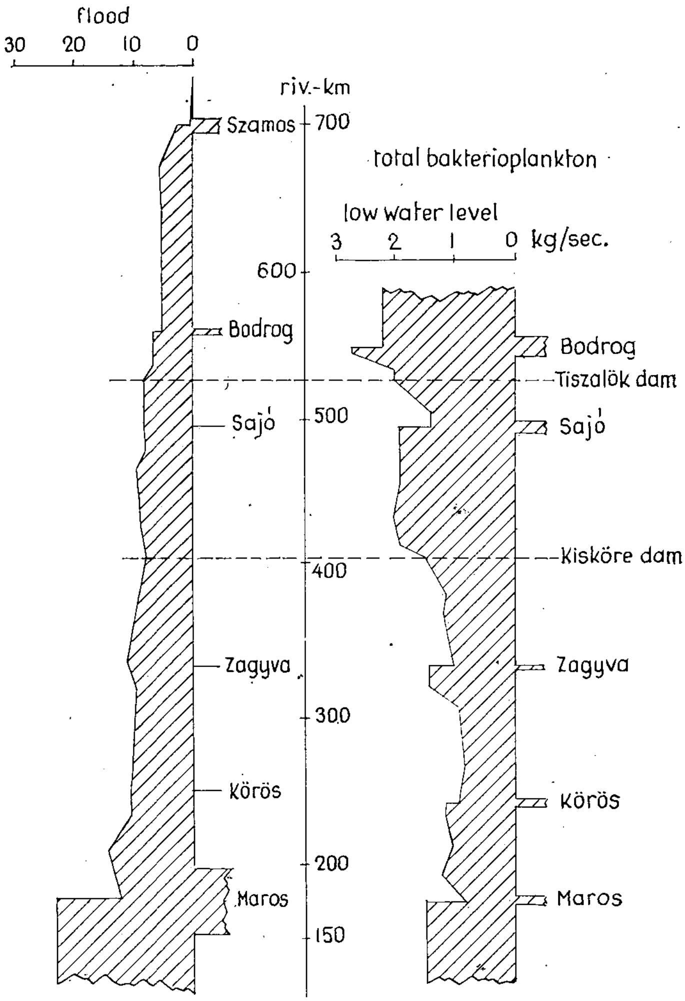

Fig. 12. Mattercurrent of the bacterioplankton in the longitudinal section of the Tisza.

(a) Flood time

In flood time, the performed longitudinal-sector investigation found a high total bacterial number connected with a high suspended matter content. In the Upper Tisza Region, when there was no flood and so the suspended matter content was low — the total bacterial number was also low (5.74 million ind/ml, 1.03 g/cubic metre). The bacterial content of the flooding Szamos (71.39 million ind/ml) determines the values of the further bacterial number in the Tisza (average is about 75 million ind/ml). Maximum is reached below the Maros at Szeged (92.27 million ind/ml; 16.56 g/c.m).

The values are rather high and they approach all the values of sewage water, as well as those of the activated mud (Overbeck 1974, Patil et al. 1975, Paluch

1965). It can be noted as a fact that the bacterial content originating from the runoff from the soil — at least in regard to its quantity — may exert a lasting effect on the river (NIEMELÄ 1973 and the literature quoted by him).

The values of the mattercurrent investigated in flood time are high. After the flooding Szamos, the value of the bacterial biomass passing through the cross-section is 2 to 25 kg/sec. From among the tributaries, the values of the flooding Szamos and particularly those of the similarly flooding Maros are high (Fig. 12).

(b) Period of low water

In case of low water, despite the low suspended matter content, the values of the total bacterial number are high (12—38 million ind/ml). The change in the values of the biomass passing through the cross-section (0.8—2.7 kg/sec) is similar to the diagram of suspended matter (Fig. 12).

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INVESTIGATION INTO THE PHYTOPLANKTON IN THE LONGITUDINAL SECTION OF THE RIVER TISZA

J. HAMAR

The Tisza has a characteristically high suspended matter content — primarily in flood time (VÉGVÁRI 1976) — and this has a decisive influence on the dynamism of the total algal number (HAMAR 1976a). In such a way, there is a considerable difference to be found between the algological conditions of flood time and low-water time (UHERKOVICH 1971).

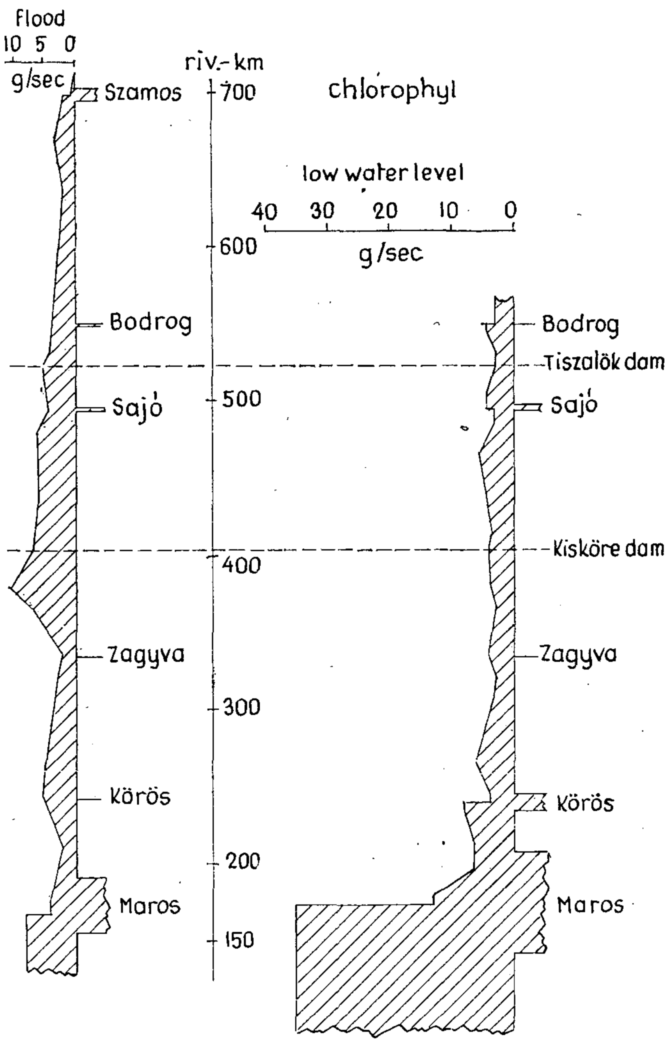

Fig. 13. Mattercurrent of the total chlorophyll content.

(a) Flood time

Owing to the character of flood, the total algal number, was very low, it varied between 96 and 252 thousand ind/l and in the longitudinal section a slow, gradual increase is to be observed. In the stock the diatoms are dominant. The rheonic elements *(Diatoma vulgare, Ceratoneis arcus, Gomphonema olivaceum, Synedra ulna)*, which are characteristic of the Upper Tisza Region, are replaced in the Middle and Lower Tisza Regions by the planktonic ones *(Nitzschia acicularis, Stephanodiscus tenuis, Cyclotella meneghiniana)*. The taxon count is very low (5—15), its rise in the longitudinal section is slow and gradual.

Apart from the Szamos — by which the character of the phytoplankton is fundamentally determined — the effect of no other tributary and polluting source can be demonstrated.

Corresponding to the flow regimen the chlorophyll content was very low, it varied between 2.15 and 13.47 mg/cubic metre "a"-(Chlorophyll 1.02—6.79), and constantly fluctuated in the longitudinal section. The values of the tributaries are low. The largest is that of the Maros, with 12.89 mg/c.m. The values of the matter-current are also low (0.3—10.5 g/sec) (Fig. 13).

(b) Low-water time

In case of low water, a euplanktic stock of considerably higher taxon- and individual numbers was observed. The taxon count in the longitudinal section more and more increases (28—62). But after dammings it decreases.

From among the blue-green algae, the picture of the stock is fundamentally determined by *Anabaenopsis raciborskii* which had presumably got into the Tisza from the Lónyai-canal (riv.km 556), joined by *Microcystis aeruginosa* and *Aphanizomenon flos-aquae*, having come from the Bodrog (riv.km 550). These three species pass through the Tisza and even some supply arrives from the tributaries. The initial individual number and the participation ratio of *Anabaenopsis raciborskii* is in the phytoplankton very high ($3150 \cdot 10^3$ ind./ml, 94 per cent), then in the longitudinal section it more and more decreases (Fig. 14).

The presence of flagellates (Euglenophyta) is negligible.

From among the dinoflagellates (Pyrrophyta), the *Cryptomonas* species proliferate as a result of damming at Kisköre and are also later present in the plankton. Their maximum individual number is 438--10^3 ind./l, their participation ratio is maximum 24.9 per cent in the Lower Tisza Region.

From the family of the yellowish-brown algae (Chrysophyceae), *Chrysococcus biporus* — indicating supposedly a eutrophic water — can be found in the longitudinal section, almost to the very end. The change in the situation of the Tisza up till now has been indicated by the occurrence of some colourless flagellates *(Heterochromas vulgaris, coronata, socialis, Monas cylindrica, uniguttata)*, not demonstrated there till now. These organisms feed on formed organic matter (*e. g.*, bacterium, alga) and, until a major pullution of water, take the part of the same food-niche as zooflagellates do (HAJDU 1975, HAMAR 1976).

After the decrease in the individual number of blue-green algae, the individual number and participation ratio of diatoms (Bacillariophyceae), and among them those of *Stephanodiscus tenuis, Melosira distans*, increase in the Middle Tisza Region (from 2.3 to 37.2 per cent at Kisköre).

The dominance of green algae is characteristic of the Lower Tisza Region. Below Szeged, they reach even 65.1 per cent. From these, the cosmopolite green

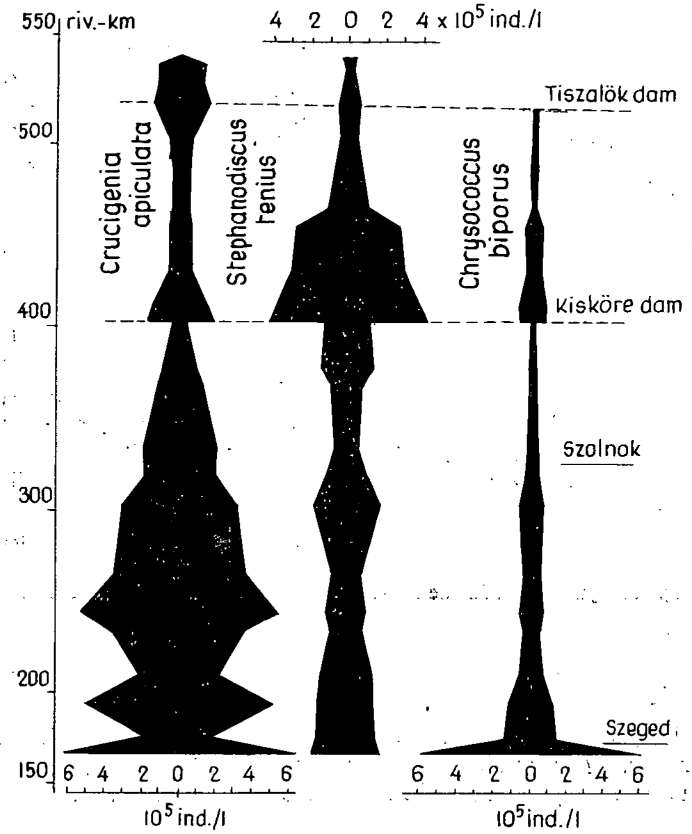

Fig. 14. Quantitative change in the phytoplankton of the low-water period.

algae (*Ankistrodesmus falcatus, Crucigenia apiculata, tetrapedia, Scenedesmus* sp.) predominate.

The individual number of more than one alga has shown definite dynamism (Fig. 15). Quantitative changes were primarily caused by damming at Kisköre and in the lower stretch.

In Table I, the drawings of some infrequent species are shown. The algae, sensitively responding to changes, give answers to several essential questions. It is worth emphasizing the most important ones of these.

1. Sources of pollution

It is shown by the diagram (Fig. 14) that the filamentous blue-green algae (Anabaenopsis raciborskii), getting in from the Lónyai-channel, are present in several millions ind./l in the samples above Tokaj (river km 551). Their mass have an important part in the Tisza stretch in Hungary until Kisköre (river km 404). And even in the sampling site below Szeged (river km 173), several hundred kms far from the origin, there can be found some thousand ind./l.

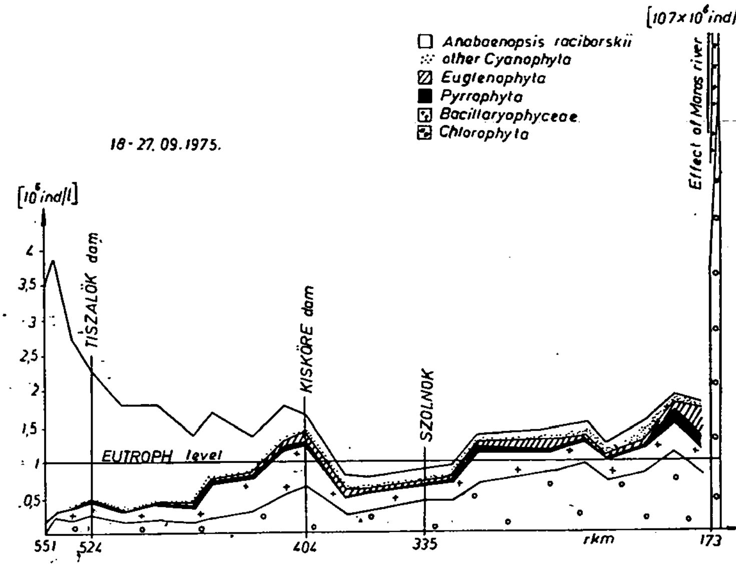

Fig. 15. Dynamism of some algae in the longitudinal section of the Tisza.

2. Tributaries

The Bodrog is known as a eutroph-indicator and its blue-green algae *(Aphanizomenon flos-aquae, Microcyctis aeruginosa)*, which engender algal blooms, like the previous blue-green algae, can be found in the water of the whole Tisza stretch in Hungary.

The algological effect of the Sajó was local, while that of the Zagyva could not be demonstrated.

In the eutrophic water of the Kőrös, a large mass of blue-green algae, similar to those in the Bodrog, could be found.

By the Maros, so large algal mass was transported into the Tisza that in the samples from below Szeged the number of algae increased to five times as much as before. First of all, a mass of green algae and diatoms have developed.

3. Dammings

The effect of dammings at Tiszalök, but primarily at Kisköre, on increasing the algal count is well shown by the graphs (Figs 14&15). The standing-water character is favourable for the proliferation of algae (HAMAR 1976).

4. Change in the stretch-character of the river

If we take for our basis the classical division which distinguishes between stretches of upper, middle and lower character then, in or case, the lower-stretch character of the river is only clearly prominent. This manifests itself in the increased number of algae and the appearance of recent species. It is to be supposed, at any rate, on the basis of the microscopic investigations that this presents itself together with the effect of the sewage waters of the town Szolnok.

5. Eutrophic state

A water containing more than 1 million ind./l algal number is generally named eutrophic (FELFÖLDY 1974). In the present case, with the exception of the reaches between Kisköre and Szolnok, the water of the Tisza is of eutrophic character, and in the reaches at Szeged — under the influence of the Maros — it is already eupolytrophic. It seems to us that the eutrophic state slowly becomes characteristic of the Tisza.

The effect of pollutions could be demonstrated on the basis of chemical and bacteriological investigations in the stretch below the Sajó and Szolnok. The investigated Tisza reaches are of a—b mesosaprobic character — that is to say, slightly polluted. It is to be feared that — as a result of the artificial interventions (river barrages, increasing pollution) — the river looses its ability for self-purification which was so far characteristic of it. It can be said of it that — owing to the high nutrient content and the effect of dammings — in the initial stretch an algal association developed which responded to the different effects first of all by changing the quantitative conditions.

Despite the low-water, the chlorophyll content was low, it varied between 8.99—20.88 mg/m^3 in the upper and middle stretches. It increased in the lower stretch and reached its maximum below the Maros (57.01 mg/cubic metre). We also get a low value after investigating the matter-current, and this is considerably increased by the influence of the Maros, as well (Fig. 13). There we have measured values between 4—31 g/sec.

The effect of tributaries

Bodrog: The taxon (30) and individual number (570 thousand ind./l) is low. *Microcystis aeruginosa* and *Aphanizomenon flos-aquae*, causing water colouration in its water, can also be found in the water of the Tisza in the reaches below its mouth.

Sajó: In its water the planktonic diatoms (*Stephanodiscus, Nitzscia* spp.) dominate. The water is, taking into consideration the total algal count, of eutrophic character.

Zagyva: In its water of low taxon (24) and individual number (570 thousand ind./l) the diatoms dominate. There are to be found several rheonic elements in it. The water is rather qualified as polluted.

Kőrös: Its water-colouration was strong (*Microcystis aeruginosa, Aphanizomenon ros-aque*). The high taxon-number (41) and individual number ($1417 \cdot 10^3$ ind./l) flefer to a eutrophic water. In its water the green algae dominated.

Maros: The taxon (47) and individual number ($15 \cdot 10^6$ ind./l) is very high. In its water cosmopolite green algae dominated. Its eutrophic water exerted a considerable effect on the Tisza (Fig. 14).

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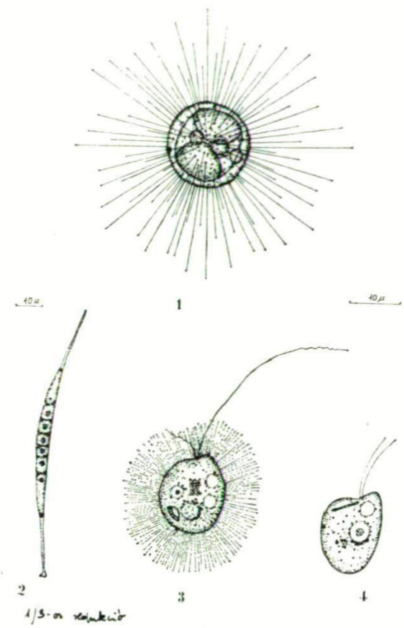

Plate I

1. *Siderocystis fusca* KORSCHIK. /*Siderotytopsis fusca* (KORSCHIK) SWALE.
2. *Lambertia gracilipes* (LAMBERT) KORSCHIK.
3. *Monas coronifera* SKUJA
4. *Cyathomonas truncata* (FRESENIUS) FISCH.

INVESTIGATION INTO THE ROTATORIA AND CRUSTACEA COMMUNITIES OF THE PLANKTON

I. BANCSI

Antecedents

The Rotatoria and Crustacea fauna of the Tisza stretch in Hungary are known in several relations on the basis of earlier investigations (BANCSI 1975, ÉBER 1955, GÁL 1963, MEGYERI 1955, 1957, 1970, 1972). Such an investigation of the Rotatoria and Crustacea fauna in the longitudinal section, however, which was studying the changes in the same waterbody, took place in case of the Tisza the first time at present.

Following the water-body chosen enables the multiplication of species to be studied. This helps us at revealing the ecological differences of the various river reaches. By extending the investigation into more than one group of living beings, a comprehensive picture can be brought about the ecological peculiarities of the river.

The results of the hydrological, water-chemical, algological and other studies performed in the course of the investigations (June 8—16, September 18—27, 1975), are contained in further papers of the article-series. In this paper I am dealing with the Rotatoria and Crustacea plankton of the Tisza and its tributaries. The results of investigations are included in Table 1.

Results

By the first longitudinal-section investigation (June 8—16), the study of the ecological, faunistical conditions of a flood time was made possible. In this period there were found altogether 53 Rotatoria, 5 Cladocera, 3 Cyclopoida and 1 Calanoida taxons in the Tisza and its tributaries. It is characteristic of most species that each of them occurs but in a single stretch of the river, then is missing for a longer or shorter time, and again appears, producing on this occasion a considerable individual density. On the other hand, it is only characteristic of fewer species that — even if in a changing individual number — they are to be found almost constantly in the same water-body.

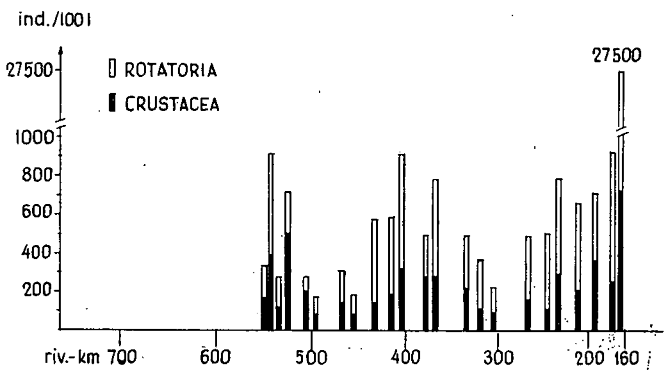

Fig. 16. Quantitative dynamism of the Rotatoria and Crustacea plancton in the longitudinal section of the Tisza, between June 8 and 16, 1975.

In the investigated period, in the about 200 km upper-stretch of the Tisza, there were found a low species number (3 to 7) and small individual density (100 to 250 ind./100 l), in respect of the Crustacea plankton (Fig. 16). In the sample taken above the Tiszalök River Barrage (river km 524) we could already demonstrate 400 ind./100 l. This datum of investigation is showing in itself that — despite the flood time — the dammed reaches ensure obviously more favourable conditions for the zooplankton organisms. There were found in the samples from the area above the Kisköre River Barrage (river km 404) 12 to 20 taxons with more than 500 to 800 ind./100 l, and between river kms 266 to 173 22 to 26 taxons. The individual density has, however, remained similar to those observed in the stretch above the Kisköre River Barrage.

In the Middle Tisza Region, the area of the town Szolnok (river kms 335—320), both the species and the individual numbers considerably decreased. — Below the Maros, the individual density of the Rotatoria and Crustacea plankton exceeded 2.000 ind./100 l.

The plankton-picture of the river constantly changes because the species forming the fauna appear and spread according to stretches. In the whole Hungarian stretch of the Tisza there could only be found a few Rotatoria species, among them *Polyarthra vulgaris, Rotaria rotatoria, Synchaeta oblonga.* The species of the *Keratella* genus *(e. g., Keratella cochlearis cochlearis, Keratella cochlearis* var. *macracantha* f. *macracantha)* were nearly constant representatives of the plankton from the dammed reaches at Kisköre on. In the lower stretch, the fauna of the river is enriched — in addition to the above-mentioned species — by the representatives of the *Brachionus* genus *(Br. angularis, Br. bennini, Br. calyciflorus* var. *dorcas* f. *spinosa, Br. leydigi* var. *quadratus).*

From the order Cladocera, the frequency of *Bosmina longirostris* is only worth mentioning which could be found in the region of Kisköre and in the Lower Tisza Region in individual density 30—70 ind./100 l.

The number of Copepoda larvae (nauplius, copepodit) is considerable in the whole investigated Tisza stretch, generally changing between 100 and 200 ind./100 l. The number of the well-developed individuals is sparse; in the upper stretch, they did not get into the samples. From the Kisköre region on, *Acanthocyclops vernalis* and *Thermocyclops oithonoides* regularly occurred. — Calanoida were represented by *Eudiaptomus gracilis.* Their well-developed individuals were found in the Middle- and Lower-Tisza Regions.

In flood time, from among the tributaries, the fauna of the Szamos was the poorest. There were found not more than three Rotatoria species and but a few Copepoda larvae.

The species composition of the Bodrog is similar to that of the Tisza. Owing to the damming at Tiszalök, in the water becoming slower before the mouth, there is an opportunity to the development of a rich zooplankton stock.

The plankton-picture of the Sajó considerably differs from that of the Tisza. This can be explained by the pollution of the river. A majority of the species getting into the Tisza only survived in a minor stretch.

The fauna of the Zagyva may be considered as rich both in respect of the number of species and in that of individuals. As its watermass is, however, negligible as compared with that of the Tisza, its effect is not perceptible in the Tisza.

Similar conditions are to be observed in case of the Kőrös, as well.

From among the tributaries, the Rotatoria fauna of the Maros was the most abounding. Several species *(Asplanchna priodonta, Brachionus calyciflorus* var. *dorcas, Pedalia mira)* could be found in its water in an almost 1.000 ind./100 l individual density.

In flood time, the Rotatoria and Crustacea faunas of the Tisza proved to be rather abundant. This may be explained by the elements getting into it from the watershed area. A large mass of zooplankton organism could namely be carried by the flood from the dead arms, borrowing pits lying in the flood-plain of the Tisza and its tributaries. In spite of that the investigated watermass had in about 8 days passed, in case of more species *(Brachionus angularis, Filinia longiseta, Keratella cochlearis, cochlearis)* the change in the individual number could be observed by sections.

The increase or decrease in the individual number of the mentioned species is well showing the effect of river barrages (Tiszalök, Kisköre River Barrages), that of the larger sources of sewage water (e. g. Sajó, the town Szolnok), and of tributaries, as well as the change in the stretch-character of the river.

In the course of the second longitudinal-section investigation (on September 18—27), there were found 51 Rotatoria, 7 Cladocera, 1 Calanoida, and 5 Cyclopoida taxons in the Tisza and the mouth of its tributaries. The individual density of the species found is low, despite the low-water period (Fig. 17). The quantitative data well demonstrate the ecological effect of dammings and change in the stretch-character: in the dammed reaches and the lower stretch of the river the plankton-

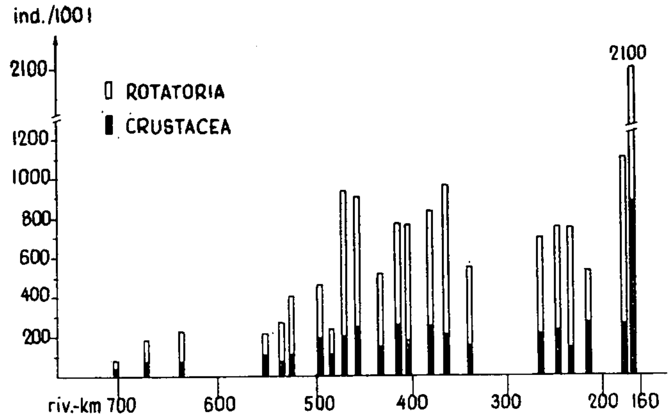

Fig. 17. Quantitative dynamism of the Rotatoria and Crustacea plancton in the longitudinal section of the Tisza, between September 18 and 27, 1975.

density of Rotatoria and Crustacea is considerably greater. — It is striking that while in the period of the previous investigation-series the number of Rotatoria was considerably higher, at present the quantity of Crustacea approaches the number of Rotatoria. The Copepoda larvae, found in a higher number, and the well-developed Cyclopoida species *(Acanthocyclops vernalis, Eucyclops serrulatus, Thermocyclops oithonoides)* are pointing to a declining period of the autumn Rotatoria maximum.

The conditions of the Tisza, which flows slower and transports less water, can be considered as a more favourable environmental factor. In the low-water period, in case of more than one Rotatoria species, we could observe their conduct in different sections of the river. The *Polyarthra* and *Synchaeta* species *(Polyarthra vulgaris, Synchaeta oblonga)* could be found in the whole investigated stretch. The *Keratella* species *(Keratella cochlearis cochlearis, Keratella qadrata)* occurred in an individual number changing according to sections. The ovulating, well-developed individuals of the *Brachionus* species *(Brachionus angularis, Br. calyciflorus* var. *dorcas, Br. diversicornis)* can be found in relatively higher numbers in the dammed reaches, resp. in the Lower-Tisza Region.

From among the tributaries, the fauna of the Bodrog and Szamos has proved to be the most abundant, now too. The majority of the species getting from the

Bodrog into the Tisza *(e. g., Filinia longiseta, Keratella quadrata, Syncheta pactinata)* can be found in the whole further stretch. In the Maros, there was found an obviously great zooplankton-density (166.000 ind./100 l). As a result of this, the earlier 700 ind./100 l individual number has also risen in the Tisza to 27,500 ind./100 l.

It is evidenced by the contributions of the two longitudinal section investigations that the Tisza has an own plankton, formed by the strongly selected small part of the species to be found in the watershed area. There occurred the ovulating fertile individuals of the majority of the species found, as well. The fact that in the region of the river dammages, and in the lower stretch of the river, the individual number of the investigated groups is higher, is indicating the sensitive response of the species forming the plankton to the changed or modified conditions.

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Table 1. *Contributions of the plankton investigation of the longitudinal-section investigation of the Tisza.*

Samplingpoints Taxon	Tisza I.	 II.	Szamos I.	 II.	Bodrog I.	 II.	Sajó I.	 II.	Zagyva I.	 II.	Kőrös I.	 II.	Maros I.	 II.
ROTATORIA														
Anuraeopsis fissa (Gosse)	+	+				+		+						+
Asplancha priodonta (Gosse)	+	+				+					+	+	+	
Asplancha siboldi (Leydig)	+	+							+				+	
Brachionus angularis (Gosse)	+	+			+	+	+	+	+				+	+
Br. bennini (Leissling)	+										+			
Br. budapestiensis Daday	+	+												
Br. calyciflorus var. *amphiceros* (Ehrb.)	+	+									+		+	
Br. caly. var. *dorcas* f. *spinosa* (Wierzejski)	+	+			+	+			+		+		+	+
Br. caly. var. *dorcas*	+	+								+				+
Br. diversicornis Daday	+	+			+									
Br. falcatus Zacharias	+	+				+								
Br. leydigi var. *quadratus* (Rousselet)	+	+												
Br. quadridentatus Hermann	+					+			+		+			
Br. quadr. var. *brevispinus* (Ehrb.)	+	+				+			+		+			
Br. quadr. var. *cluniorbicularis* Skor.		+												
Br. quadr. var. *entzi* (Francé)	+													
Br. quadr. var. *rhenanus* (Lauterborn)		+												
Br. urceolaris O. F. Müller	+	+					+		+		+			
Cephalodella catellina (O. F. Müller)	+													
Cephalodella ventripies Dixon-Nutall		+							+					
Colurella adriatica Ehrb.		+					+							
Colurella colurus (Ehrb.)	+				+				+					
Conochilus unicornis Rousselet	+													
Dicranophorus caudatus (Ehrb.)	+	+												
Dicranophorus sp.	+													
Euchlanis alata Voronkov	+													
Euchlanis dilatata Ehrb.	+				+		+			+	+			
Euchlanis triquetra Ehb.	+										+			
Euchlanis sp.	+													
Filinia longiseta (Ehrb.)	+	+			+	+			+		+		+	+
Habrotrocha sp.	+													
Itura aurita (Ehrb.)	+	+												
Kellicottia longispina (Kellicott)	+	+			+									+
Keratella cochlearis cochlearis Gosse	+	+				+								+
K. coch. var. *irregularis angulifera* Lauterbon	+	+				+								
K. coch. var. *macracantha* f. *micrracantha* Laut.	+	+	+		+	+			+			+		+
K. coch. var. *tecta* (Gosse)	+	+	+		+	+					+	+	+	
K. testudo (Ehrb.)	+				+		+						+	
K. valga (Ehrb.)					+									
K. quadrata (O. F. Müller)	+	+				+								
K. quad. var. *reducta* Fadeew		+				+								
Lecane bulla (Gosse)		+						+						
Lecane closterocerca (Schadra)	+	+							+	+	+			
Lecane flexilis (Gosse)		+												
Lecane hamata (Stokes)	+	+												
Lecane lunaris (Ehrb.)		+							+		+			
Lepadella ovalis O. F. Müller	+								+					
Lepadella patella O. F. Müller	+	+					+		+					
Lepadella rhomboides Gosse		+												
Mytilina videns Levander										+				
Notholca squamula (O. F. Müller)	+													
Notomata copeus (Ehrb.)		+												
Platyias patulus (O. F. Müller)		+												
Platyias quadricornis (Ehrb.)		+												
Pedalia mira (Hudson)	+												+	
Philodina sp.	+													
Polyarthra dolychoptera Idelson		+												
Polyarthra euryptera Wierzejski		+												
Polyarthra major Bruchhardt		+												

Table 1

Samplingpoints	Tisza		Szamos		Bodrog		Sajó		Zagyva		Kőrös		Maros	
Taxon	I.	II.	I.	II.	I.	II.	I.	II.	I.	II.	I.	II.	I.	II.
Polyarthra vulgaris CARLIN	+	+	+		+	+		+	+		+	+	+	+
Pompholyx sulcata HUDSON	+	+							+	+	+		+	
Rotatoria macroceros (GOSSE)								+						
Rotaria neptunia (EHRB.)		+												
Rotaria rotatoria (PALLAS)	+	+			+	+	+	+					+	
Synchaeta oblonga EHRB.	+	+			+	+	+		+		+			
Synchaeta pectinata EHRB.	+	+					+				+			
Trichocerca capucina (WIERZEJSKI u. ZACH)		+												+
Tichocerca cylindrica (IMHOF)		+				+			+					+
Trichocerca pusilla (JENNINGS)						+			+					
Trichotria pocillum (O. F. MÜLLER)	+				+	+								
Trichotria tetractis (EHRB.)		+												+
Taxon														
Cladocera	48	49	3	×	15	20	9	6	18	5	16	4	12	12
Alona rectangula SARS						+								
Bosmina longisostris (O. F. MÜLLER)	+	+			+		+		+					+
Ceriodaphnia quadrangula (O. F. M.)	+													
Chydorus sphaericus (O. F. MÜLLER)	+	+				+							+	
Daphnia cucullata SARS	+	+												
Daphnia longispina O. F. MÜLLER		+												+
Diaphanosoma brachiurum		+												
Disparalona rostrata (KOCH)						+								
Moina rectirostris (LEYDIG)		+												
Pleoruxus adunsus (JURINE)						+								
Taxon														
Copepoda														
Cyclopoida	4	6	—	×	1	4	1	—	1	—	—	—	1	2
Acanthocyclops vernalis FISCHER	+	+				+	+						+	
Cyclops vicinus ULJANINE		+												
Eucyclops serrulatus FISCHER	+	+												
Megacyclops viridis JURINE		+								+		+		
Thermocyclops oitthonoides G. O. SARS	+	+			+			+		+		+		+
NAUPLIUS	+	+	+		+	+	+	+	+	+	+		+	+
Taxon														
CRUSTACEA														
Cladocera	3	5	—	×		2	1	1		2	—	2	1	1
Alona rectangula SARS														
Bosmina longirostrsi (O. F. MÜLLER)	+	+			+		+		+					+
Ceriodaphnia quadrangula (O. F. M.)	+													
Chydorus sphaericus (O. F. MÜLLER)	+	+				+							+	
Daphnia cucullata SARS	+	+												
Daphnia longispina O. F. MÜLLER		+												+
Diaphanosoma brachiurum		+												
Disparalona rostrata (KOCH)						+								
Moina rectirostris (LEYDIG)		+												
Pleuroxus aduncus (JURINE)						+								
Taxon														
Copepoda														
Cyclopoida	4	6	—	×	1	4	1	—	1	—	—	—	1	2
Acanthocyclops vernalis FISCHER	+	+				+	+						+	
Cyclops vicinus ULJANINE		+												
Eucyclops serrulatus FISCHER	+	+												
Megacyclops viridis JUNINE		+								+		+		
Thermocyclops oithonoides G. O. S.	+	+				+		+		+		+		+
NAUPLIUS	+	+	+		+	+	+	+	+	+	+		+	+
Taxon														
Calanoida	3	5	—	×	—	2	1	1	—	2	—	2	—	1
Eudiaptomus gracilis G. O. SARS	+	+			+	+								
NAUPLIUS	+	+				+		+						
Taxon														
	1	1	—	×	1	1	—	—	—	—	—	—	—	—

ZOOFLAGELLATE INVESTIGATIONS IN THE LONGITUDINAL SECTION OF THE RIVER TISZA

J. HAMAR

There have been twelve species identified from the Tisza:

Bicoeca Lacustris J. CLARK
Bodo angustus (DUJ.) BÜTSCHLI
Bodo spora SKUJA
Bodo varians (STOKES) LEMM.
Codonosiga botrytis (EHRB.) KENT
Codonosiga longipes STOKES
Monosiga varians SKUJA
Pleuromonas jaculans PERTY
Rhynchomonas nasuta (STOKES) KLEBS
Bodo celer KLEBS
Salpingoeca bütschlii LEMM.

Pleuromonas jaculans and *Rhynchomonas nasuta* are cosmopolite species. *Bicoeca lacustris, Salpingoeca bütschlii,* and the *Codonosiga* species are organisms settled down on euplanktic algae — primarily on diatoms.

It is only *Bodo angustus* that occurs in sewage-waters. In its entirety, the stock never shows any pollution.

ZOOBENTHOS INVESTIGATIONS

MAGDOLNA, FERENCZ

From the middle stretch of the Tisza, zoobenthos has only been investigated, up to the present, in the Tiszafüred—Kisköre region (SZITÓ 1973, 1974). There have been no data concerning investigations of this character, as yet, in the Sajó and Zagyva.

In the course of the longitudinal-section investigation in the laboratory of river barrage Tisza II, the elaboration of deposit-samples collected in three days led to the following results.

Sampling sites and their zoobenthos fauna

Bottom-samples were taken in the Tisza-stretch between river kms 497 and 334, either from one of the riversides or from both of them (cf. Fig. 1).

1: Tisza-part above the mouth of the Sajó, river km 497, left side, 5 m from the riverside, water-depth 2.6 m. The bottom is clayey sand, with blackened vegetable debris. Zoobenthos is only Oligochaeta. Dominant species: *Limnodrilus hoffmeisteri,* CLAP.

2: At the same place, right riverside, 8 m from the riverside, water-depth 3 m. Zoobenthos is formed by six taxonic groups, in a low individual number (except for Oligochaeta). The dominant Oligochaeta species of the sandy bottom, abounding in detritus are: *Euilyodrilus danubialis* HRABE and *Isochaetides Isochaetides newaensis* MICHAELSEN.

3: Sajó, 200 m from the mouth, right side, 5 m from the riverside, water-depth 2.6 m. The bottom is gravelled coarse sand with much vegetable debris. The Oligochaeta species are in a high individual number (dominant species is: *Limnodrilus hoffmeisteri* CLAP.), in addition: a few Chironomida and Gastropoda.

4: Tiszapalkonya, river km 488. Right side, 4 m from the riverside, water-depth 2.6 m. The bottom is gravelled sand, with vegetable debris. From among the three taxonomic groups, the individual number of Oligochaeta was again high. (Dominant species is: *Euilyodrilus danubialis* HRABE).

5: At the same place, left side, 6 m from the riverside, water-depth 2.5 m. The bottom is sandy. There are four taxonomic groups, equally represented by one individual each. Oligochaeta: *Euilyodrilus danubialis* HRABE.

6: Tiszacsege, left side, 12 m from the riverside, water-depth 3.4 m. The bottom is sandy. From among the five taxonomic groups, here are dominant: Gastropoda (*Lithoglyphus naticoides* PFEIFFER). The representing species of the low-number Oligochaeta group is: *Isochaetides newaensis* MICHAELSEN.

7: At the same place, right side, 8 m from the riverside, water-depth 2.8 m. The bottom is coarse sand, rough detritus. Oligochaeta (dominant species: *Isochaetides newaensis* MICHAELSEN) have the comparatively highest individual number. Mollusca (*Unio* sp., *Dreissena polymorpha* PALLAS, *Lithoglyphus naticoides* PFEIFFER) are fewer.

8: Tiszafüred, left side, 8 m from the riverside, water-depth 2.5 m. The bottom is clayey sand, not so much vegetable debris. From among five taxons, Oligochaeta (dominant species: *Euilyodrilus danubialis* HRABE) were again dominant, with a few Mollusca (*Lithoglyphus naticoides* PFEIFFER, *Anodonta* sp.).

9: At the same place, right side, 5 m from the riverside, water-depth 2.4 m. The bottom is sandy clay, detritus. Dominant group: Oligochaeta, with one representative each: Nematoda, *Diptera-Branchycera, Unio* sp., *Anodonta* sp.

10: Kisköre, river km 406. Left side, 8 m from the riverside, water-depth 0.5 m. The bottom is muddy, with much enough, fine detritus. There are comparatively more Oligochaeta, the dominant species is: *Branchiura sowerbyi* BEDDARD. In addition: 1 Nematoda, resp. *Diptera-Brachycera puparium.*

11: Kisköre, river km 405. Right side, 10 m from the riverside, water-depth 0.5 m. The bottom is clayey-muddy, much detritus, a little fine mica-sand. Dominant taxon is: Chironomida, then *Lithoglyphus naticoides* PFEIFFER. The fewest are here: Oligochaeta (*Limnodrilus udekemianus Clap.* and two cocons).

12: Tiszaroff, river km 380. Right side, 3 m from the riverside. The bottom is sandy-clayey, not so much vegetable debris. There were here in equal individual number: Oligochaeta (dominant species: *Isochaetides newaensis* MICHAELSEN, and comparatively more *Branchiura sowerbyi* BEDDARD).

13: Above Szolnok, river km 336. Left side, 5 m from the riverside, water-depth 1.5 m. The bottom is sandy clay, gravel, and course vegetable debris. The zoobenthos was represented by 4 *Lithoglyphus naticoides* PFEIFFER and 1 Chironomida.

14: At the same place, right side, 3 m from the riverside, water-depth 0.5 m. The bottom is clayey-muddy fine sand, much enough detritus. Dominant taxon: Diptera-Brachycera, and in addition: Oligochaeta (Lumbriculida), *Lithoglyphus naticoides* PFEIFFER, and Chironomida, one from each of these.

15: Zagyva, river km 334.5: from the middle of the mouth. Oligochaeta; dominant species: *Limnodrilus hoffmeisteri* CLAP., and two Corixida-larvae.

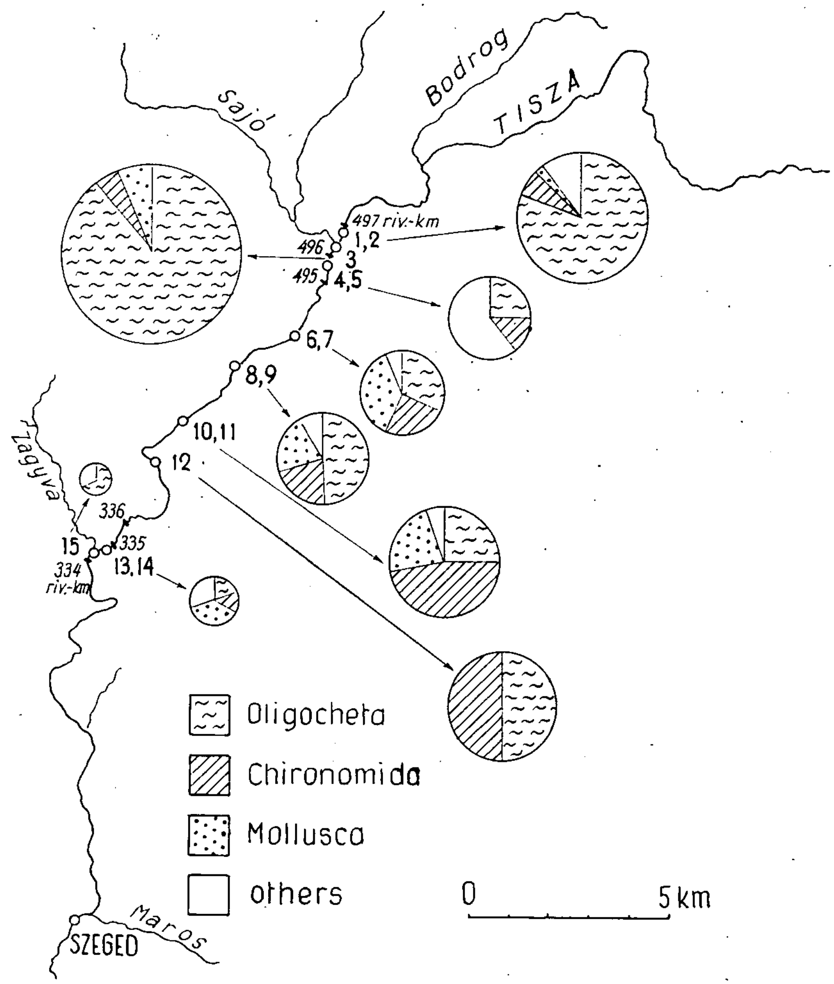

Fig. 1

Results

It was shown by the distribution of zoobenthos at sampling sites that the richest habitat was the Sajó and the poorest one the Zagyva. The most populous habitat of the river Tisza was: Nos 1+2, *i. e.* the highest sampling place (Fig. 1).

In respect of the qualitative distribution of zoobenthos, the picture is most monotonous in the Zagyva (if the Corixida taxon is not ranked among the typical bottom-living beings).

In the investigated rivers, Oligochaeta amounted to 59.5 per cent of the total zoobenthos, playing in such a way the role of the dominant group. Chironomida are 21.7 per cent, Mollusca 12.2 per cent. The other six taxons, taken as a whole, are 7.1 per cent (Diptera-Brachycera, Ephemeroptera, Nematoda, Trichoptera, Ceratopogonida, Corixida).

The determined Oligochaeta species and their percentage are as follows:

	per cent
Euilyodrilus danubialis HRABE:	27.1
Limnodrilus hoffmeisteri CLAP.:	27.1
Isochaetides newaensis MICHAELSEN:	14.3
Limnodrilus udekamianus CLAP.	11.4
Branchiura sowerbyi BEDDARD:	5.0
Euilyodrilus bavaricus ÖSCHMANN:	4.3
Tubifex tubifex MÜLLER:	3.6
Stylaria lacustria LINNÉ:	2.9
Psammoryctes moravicus HRABE:	2.1
Euilyodrilus hammoniensis MICHAELSEN:	0.7
Limnodrilus michaelseni LASTOCKIN:	0.7
Psammoryctes albicola MICHAELSEN:	0.7

The determined Mollusca species and their percentage are as follows:

Lythoglyphus naticoides PFEIFFER:	80.5
Planorbis planorbis LINNÉ:	5.5
Unio, sp.:	5.5
Dreissena polymorpha PALLAS:	2.8
Anodonta sp.:	5.5

From among the three Ephemeroptera, occuring in sampling site 2, two were *Palingenia longicauda* OLIVIER.

In the bottom samples, there occurred systematically some Kamptozoa *(Urnatelly gracilis* LEYDI) and Bryozoa organic debris.

The quantitative maximum of the zoobenthos is in the Sajó, its minimum in the Tisza-reaches at Szolnok.

The qualitative minimum of the zoobenthos is in the Zagyva.

In the Tisza, 50 per cent of the zoobenthos fell to the Oligochaeta. Dominant species: *Euilyodrilus danubialis.*

The zoobenthos of the Sajó and Zagyva consisted in still higher percentage of Oligochaeta. Dominant species in the tributaries is: Limnodrilus hoffmeisteri.

The change in the percentage of the three major taxonic groups is, going from above downwards, in sucession of sampling sites:

Oligochaeta: decreasing,
Chironomida: increasing tendency (except for Szolnok and the Zagyva),
Mollusca: maximum in the middle stretch (sampling sites 6 to 11).

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