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Water-chemical investigations in the Csongrád-Szeged reaches of the Tisza

J. Szépfalusi

Water Quality Control, Water Management of the Lower Tisza Region, Szeged

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Abstract

The paper is discussing some problems of the lo-year old experiences of water-chemical investigations carried out in the Csongrád-Szeged reaches of the Tisza. It gives a short characterization about the chemical composition of the water, the value of the major pollution indices and their most characteristic changes during the ten years.

This first publication is to be amplified later by elaborating a number of further details. A conclusion drawn from the technique and frequency of the water-chemical investigations is showing, at the same time, the direction of practice to be followed in this field in the future.

Introduction

The Laboratory of the Water Quality Control in the Water Management of the Lower Tisza Region has performed water quality investigations in the Csongrád-Szeged reaches of the Tisza for a decade, in the first years under control and supervision of the Scientific Research Institute for Economy of Water Supplies /Budapest/, and in the recent years under that of the Water Quality Control in the Centre of the Economy of Water Supplies of the National Water Office.

From present year, the results of our work are systematically available for the Committee of Tisza Research. And even, taking into consideration the purposes of this Committee, we are performing our systematic water-chemical investigations on the Tisza in closer connection with it.

In our first publication we should like to discuss some experiences of the investigations carried out so far, mainly which have exerted an influence on the systematic Tisza research from fundamental points of view, resp. which will influence its efficiency, in the future, too. We cannot think of elaborating all the data of investigations in the framework of a single monograph because we elaborated only in the second half year of 1966 more than 150 water samples from a single sample area.

Methods applied by the investigations

The investigations were carried out on the basis of methodics and Unitary Water-research Methods prescribed by the Scientific Research Institute for Economy of Water Supplies, resp. by the Council for Mutual Economical Assistance /COMECON/. The measurement of pH took place colorimetrically or with instruments, the determination of alkalinity alkaliacidometrically, with volumetrical analysis. The carbohydrate content was established by calculation, on the basis of the latter data. The determination of the total hardness, of calcium and generally sulphate ions, took place complexometrically in a buffered medium in the presence of eriochromeblack T. resp. of murexide indicator, and that of chloride ions argentometrically. The oxygen consumption of water was determined with Kubel-Thiemann's method, in an acidic medium with potassium permanganate and expressed in oxygen mg/l value. The dissolved oxygen was conserved in an alkali medium in the firm of manganese /IV/ hydroxide in the site of sampling, then it was determined iodometrically in the laboratory after being acidified. For determining the biochemical oxygen demand the same method was applied, the temperature of 5-day incubation being 20 °C. The dissolved salt-content was established by weighing after 100 ml filtered water being distilled and dried on 105 °C. For determining the sodium and potassium ions Z e i s s flame-photometer was used. For measuring the nitrate ions, we have applied the colorimetrical method / D u b o s c q / using brucine in a vitriolic medium. The dissolved carbon dioxide was measured on the spot at sampling. The determination of ammonia happenned similarly on the site at sampling, with the help of N e s s l e r 's reagent colorometrically.

The evaluation of water quality was carried out on the basis of the "Unitary Criteria and Norms of COMECON concerning Water Quality and Principle of Their Classification" /OVF 1964/. /I will discuss them in details in my next paper/.

Reaches investigated

The whole watershed area of the river Tisza is 157,186 sq. km /G o d a 1965/, the same till Szeged is 138,408 sq. km, from that the watershed area of the reaches investigated by us is 9,351 sq. km. At Szeged the highest water level was + 923 cm /April 15 th 1932/ and then the water output was 4000 cubic metre per sec. At the same place the lowest water level was -250 cm /October 10th 1946/, with 90 cubic metre/per sec. water output. There may be accepted as an authentic August water output of 85 p.c. 228 cubic metres per sec.

The primary water composition of the Tisza is determined by the soil of this large watershed area, by the composition of its fundamental rock and by its decaying processes. Here and there the quality of water is influenced by tributaries-taken into consideration in the watershed area. In its reaches, investigated by us, in the Great Hungarian Plain that is scanty in rainfall, there can be only the water output of Körös and Maros on principle which is suitable to change quality and composition of its water. The factors exerting a secondary influence on the composition are the natural or artificial pollutions going together with the human activity, for ex civilization, urbanization. Both the primary and the secondary compositions are, of course, considerably influenced among others by several - mainly meteorological - factors. Among them are the water output, water temperature, duration of sunshine, as well.

The sites of sampling are as follows;

at Chongrád, above the mouth of Körös .... /246 rkm/
below the mouth of Körös...............................…/240 rkm/
at Mindszent ..../216 rkm/
at Tápé, above the mouth of Maros ..../177 rkm/
below the mouth of Maros ..../171 rkm/
at the Jugoslav State border............................/162 rkm/

At the beginning, we have systematically taken water samples at several points between the sampling sites, too. The results of our investigations, however, have convinced us that these were unnecessary. The sites sampled at present systematically are the points of these reaches of Tisza that are characteristic in water-chemical respect. They take place either above or below the mouth reaches of major tributaries /Körös, Maros/ or at a characteristic point of longer reaches free from the mouth of a major river or from a polluting impulse /Mindszent/.

In the initial peroid of investigation, there were samplings on principle in more sampling places, generally twice a year, at other sampling sites at most in every season, i. e. on four occasions a year. This principle has gradually got to the practice applied to-day, and it seems to determine the future practice, as well. At present the water-chemical control of the water-course takes place at fewer sampling sites. At some emphasized, so-called basic sampling cross section however, the frequency of sampling is one a week, i. e. 52 a year. And at the other sampling sites we take at least one sample a month /Figs. 1, 2/.

The Mindszent sample is suitable for characterizing these reaches of the water-course. It contains calcium-magnesium, sometimes calcium, while the dominating anion is hydrocarbonate. There occurs very exceptionally that besides hydrocarbonate also carbonate appears or the sulphate ion becomes dominant. Its dissolved salt content is generally low, having usually a value between 150 and 400 mg/l. We can regard as characteristic a fluctuation of a limited $\pm$ 50 mg/l interval in the vicinity of the value 300 mg/l.

The values of its total hardness fluctuate between 5-16 nk^{o}. Aside from the autumn maximum, we may accept in the vicinity of 8 nk^{o} a fluctuation of $\pm$ 1,5 nk^{o} as characteristic. Its competent values are, independently from the site and year of sampling, generally above 10 nk^{o}. The percentage of the sodium of the total cation amount /sodium percentage/ is 21 p.c. Even the extreme value of fluctuation does not surpass here $\pm$ 10 p.c. Its competent values are generally between 20 to 30 per cent.

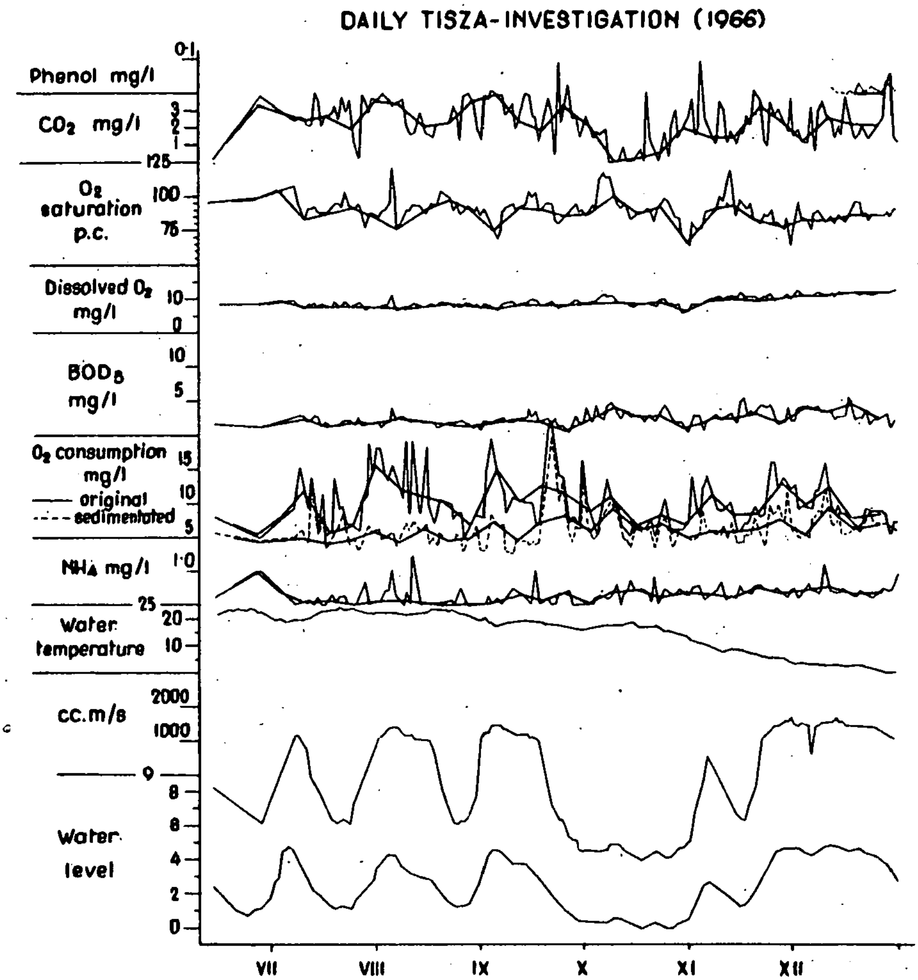

Fig.1. Tisza investigation with daily frequency 1966. /In Szeged/

Black line: Datum series of daily frequency
Red line; datum series of weekly frequency.

Among the anions the amount of chloride ions is mostly changing between 20 and 40 mg/l. In extreme values, there may occur 10 mg/l more or less than that. /Tables 1 and 2/

As to the sodium chloride ion concentration, it is worth while observing that while Körös has not generally any influence on the chemical composition of Tisza, the effect of Maros can periodically be demonstrated. At the sampling sites below the mouth of Maros we may sometimes register changes even in the type of water. From the anions, the occurrence of chloride ions is characteristic; and from the cations some times there increase perceptibly both the absolute value of the sodium amount and similarly the value of its percentage inside the total cation. All that can be attributed to quality and composition of the Maros water, the dissolved salt content of the Maros being generally higher than that of the Tisza, and the sodium and chloride ion concentration being both in absolute value and in percentage higher than the corresponding values of the Tisza. This fact is in connection with the rockbed and its process of decomposition at the upper reaches of the watershed area and the region of the source of Maros. In first approach this can be established about the effect exerted by the Maros on the Tisza.

The sulphate ion concentration of the river water can be characterized by values changing in the vicinity of 35 to 40 mg/l, while the concentration of the hydrocarbonate ion can mostly be measured between the extreme values of 110 to 310 mg/l in the vicinity of the value 200 mg/l.

Before characterizing its oxygen economy, it is worth referring to its suspended matter content. That changes, as depended upon the prevailing conditions of water motion, from values measured with the single order of magnitude through values frequently ten times as high, till the extreme values even several hundred times higher /800 mg/l/. As opposed to the Maros, this is always a characteristically low value, as there at inundations even an order thousand times higher is not rare. And what is generally known, its suspended load is, in contradistinction to the suspended matter of the river Maros, expressedly fine granular sand and silt. While in the Maros it often occurs, because of the concentration of the suspended load, that its biological qualification is hardly or not at all possible, in the Tisza that is only an exceptionally extreme case.

Its dissolved oxygen content is first of all a function of water temperature. In this way, the summer may be 7 mg/l, while the winter maximum even 13. On the other hand, a change observed also as depending on the biological production may be registered first of all together with the changing value of the dissolved oxygen saturation. This never goes below 60 per cent while it can be even as high as 130 per cent. Its standard values can mostly be found

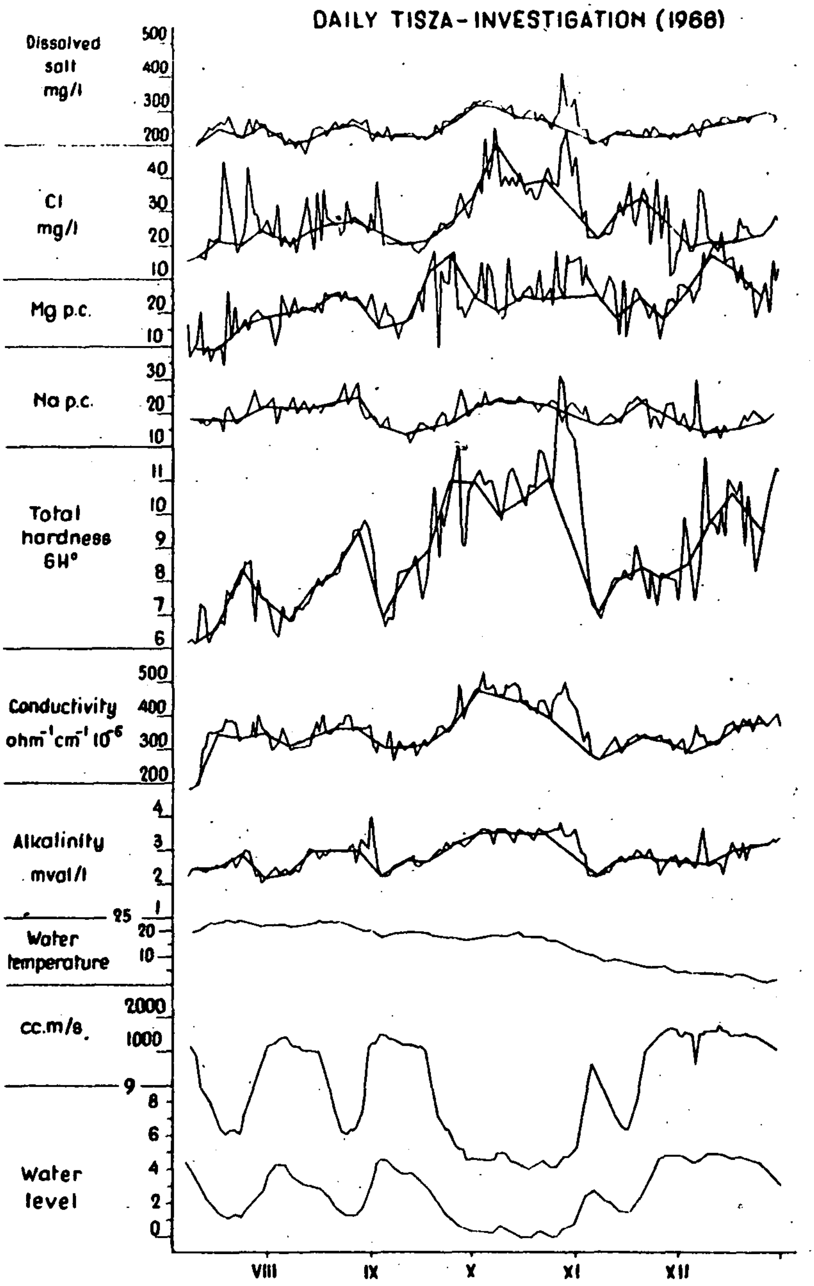

Fig.2. Tisza investigation with daily frequency in 1966 /In Szeged/
Black line; Datum series of daily frequency
Red line; Datum series of weekly frequency.

between 70 and 80 per cent.

The dissolved carbon dioxide content changes between o-5/mg/l, mostly is in the vicissitude of 2 mg/l. It may also be concluded from the datum series of the investigations carried out with a daily frequency that between the decomposition of the polluting impulses touching the river and the values of the consumption and of the dissolved carbon dioxide there may exist a loose correlation.

An interesting change can be registered on the basis of data obtained from the investigations of ten years in the data of the nitrogen uptake. It would be worth while dealing with it separately in more details. Here I should like mentioning only that the values of the ammonia content are mostly below 1 mg/l. We have often measured zero ammonia content or something approaching it. The frequent values are below 0,5 mg/l, while the maximum can be established below 2 mg/l. The nitrite ion concentration is of course low, with a numerical value presented at most in the third place of decimals. But the values of the nitrate concentration in one or two mg/l have markedly increased in the recent years. Increasing gradually in 1967, in December they got to the domain 25 to 30 mg/l. We have not seen, anyway, a similarly high nitrate content but we have found values of tenfold order on several occasions in the latter years. So we found in 1968, similarly in December, a value of 20 mg/l - but not in the sampling site at Szeged in the previous year but in Csongrád - and we have measured nitrate contents of similar value order at other dates, too. In these data we must look for the increase of the intensity of application of manures, chemical fertilizers in agriculture.

A detailed, fundamental investigation of the nitrogen uptake will be the theme of a separate monograph, in the same way, also the investigation of the material traffic of the single ions. The effect of chemical agents, fertilizers applied by the agricultural units in the watershed area, as well as that of the released sewage-water on the traffic in materials, and possibly the mutual effect of the biological processes of water and the traffic of materials; are correlative chapters that can be dealt with in separate papers in their details. At present we cannot treat of them, as yet.

Sulphide ions are never contained in the water of Tisza. They have not been observed, so far even in the vicinity of sewage disposals. Its phenol content is very low. Our programmes have contained the investigation of the anion-active detergent only for a few years. Its values cannot be determined in other waterways of ours, either. They have no importance in the water of the Tisza, as yet, even their maximum being generally far below the value of 1 mg/l. Their minimum is zero or a numerical value presented at most by the second decimal.

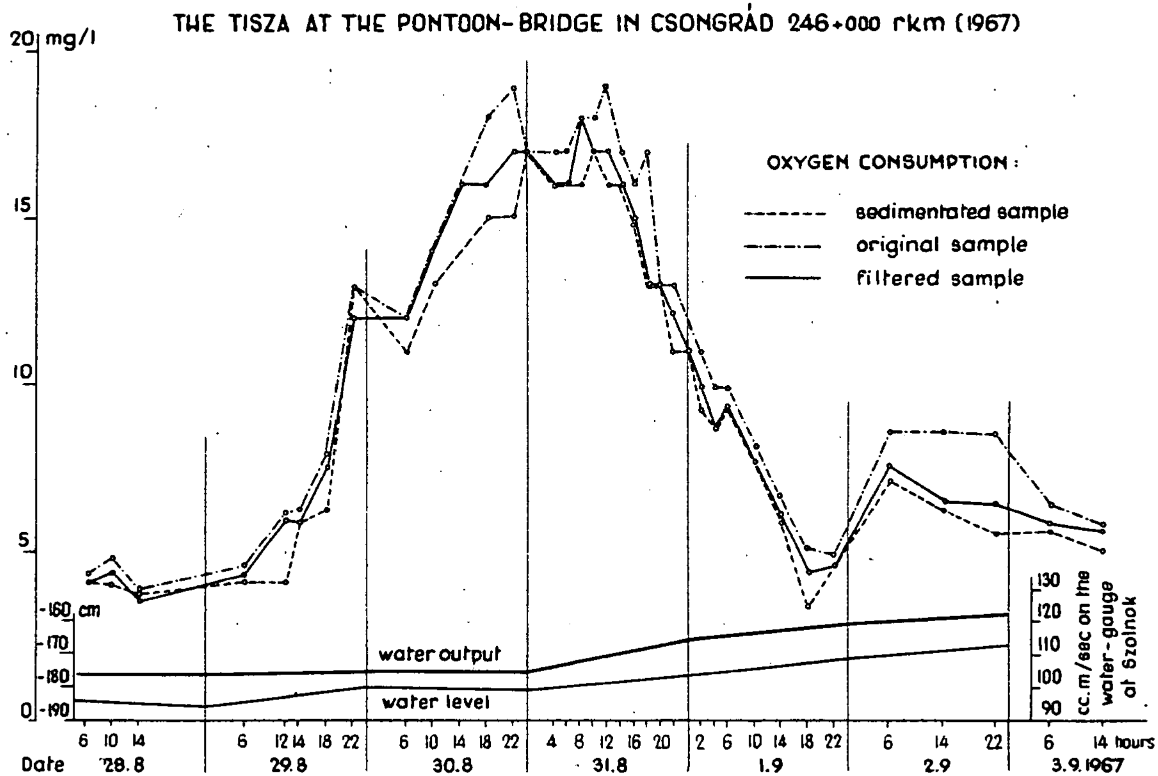

Fig.3. Passing of a sewage wave through the Tisza at Csongrád in 1967. Values of oxygen consumption. /Filtered, original, and sedimentated samples./

The classical indices of being polluted are the oxygen consumption and the biochemical oxygen demand for five days. Their measurement took already place during the first investigations. At the beginning, there have not occurred any extreme values as a result of external polluting influences. In the latter years there were some peculiarly increased values; the most outstanding ones of them were caused between August 29th and September 3rd 1967 in our boundary cross section at Csongrád by the pollution wave arriving there and by the oilpollution connected with it. /Fig.3/ That pollution wave came through the Sajó from the sulphitecellulose factory in Gemerska-Harka and culminated at a 20 mg/l value of oxygen consumption. /In the Sajo pollution wave characterized by an oxygen consuption above 1000 mg/l. The pollution wave described has passed basically unchanged through the reaches of the Tisza held under our control /Fig. 4/. Its maximum values have, of course, lessened in the meantime. The locally interested Authorities of the Water Quality Control have supervised the passing of polluted flood through the whole river under the direktion of the Water Quality Control of the National Office of Water Administration-Centre of the Economy of Water Supplies / P á s z t ó - T h u r n a y 1968/. The paper mentioned is reporting on a damage over eight million Ft in connection with that. The comparison of the two Figures /Nos. 3 and 4/ is interesting because it presents a basis for forming a true general notion of passing in the riverbed of any pollution caused by any foreign organic, non-poisonous matter that got into the river, corresponding to the discussed hydrological conditions.

At the end of summer, in the early autumn, the biological overproduction is not rare. According to the investigations of the biologist Mrs. L. D o b l e r - and also according to the data published in the literature by G. U h e r k o v i c h /1966, 1968, 1969/ - there increased that overproduction on those occasions on an unusually large scale. The ephemera /called "efflorescence" of the Tisza/ could be observed by a naked eye,too. Apart from dominate *Melosira* and *Cyclotella* species, she carried out the identification of thirty species. It was surprising that in the period of culmination *Aphanisomenon flos-aquae* became dominant in an almost unparalleled extent. It dominated the living space about in 80 p.c. And the intensity of the "efflorescence" became stronger going down the river in the Csongrád-Szeged reaches.

After outlining this definitely interesting phenomenon, we return to the classical indices of the water pollution establishing that the oxygen consumption in these reaches of the Tisza falls mostly between the values 3 to 10 mg/l. The biochemical oxygen demand is always lower than that, remaining generally below 5 mg/l, while a value of the oxygen consumption lower than 3 mg/l nearly never occurs, and a higher value than 10 mg/l is to be observed only rarely but more and more frequently. We have measured some years ago even values above 15 mg/l, as well.

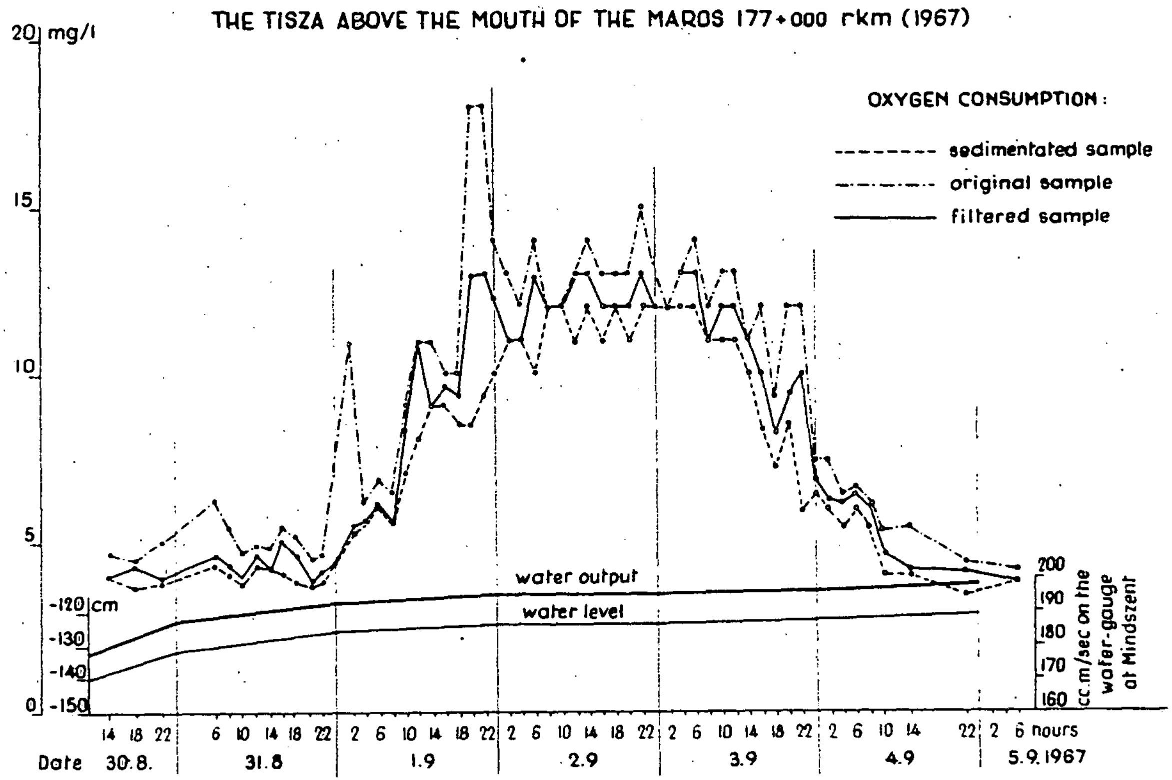

Fig.4. Passing of a sewage wave through the Tisza above the mouth of Maros in 1967.
Values of oxygen composition /Filtered, original, and sedimentated samples/.

It is characteristic of the water content of the river being inclined to extremes that the values of water level fluctuate about 8 m on the average, while the extreme values may be even as high as 11 metres here and there. The extreme distribution of precipitation, the changeable alternation of humid and arid years do increase the degree of fluctuation. This speaks for our suggestion, too, that for registering the water quality of the river, for mapping its alternations we have to increase the frequency of samplings. The quality of water that depends upon the water motion, resp. output can namely not be defined exactly without that / G o d a 1965/.

The same demand is supported also by the fact that the Tisza carries on the average 25,4 thousand million cubic m water into the Danube a year. It may be felt even at a static outlook that it is reasonable to encrease the amount of the representative water samples, collected on the basis of the practice until now, for being able to characterize more perfectly a large amount of water like that. Not to speak about that, also the security of the calculation of correlation for investigating the connection between the quality of water and any other hydrological characteristics is increased in high degree by the more data got by the more frequent sampling inside the same cross section. Similarly to the connections, found by T. D v i h a l l y, Zs. - V á g á s I. /1966/ in the Danube between the water output and flood wave and the water-chemical conditions, we can create a more secure basis also for the practical life by mapping more continuously the water-chemical conditions. It seems, therefore, to be necessary in the future to increase the frequency of samplings in any sampling site. There arises the question of telemetering, automatization, and even a continuous application of these concerning certain components. We can obtain an immense number of data in that way. And that is very good and useful. At any rate, in spite of that we can get a really clear picture about a water course only with a method like this, we must needs be satisfied with our situation inside the framework of the possibility available for us. The practical life is namely unable so far to elaborate the mass of data obtained by automatic, continuous registering. I should like, anyway, to turn the scale in this question from the situation of equilibrium in favour of accumulating the measurement data. In the following years the mechanized elaboration of data will be capable of arranging the datum series of long years and drawing the possible conclusions. The non-measured data, the informations that have not been collected in the present, will not be able to be reproduced in the future even by the most perfect system of datum elaboration.

Summary

The laboratory of the Water Quality Control in the Water Management of the Lower Tisza Region has carried out water quality investigations in

the reaches between Csongrád and Szeged of the Tisza for ten years.

These reaches of the river are represented with a good approach by the quality composition at river km No. 216 in Mindszent, from the sampling places enumerated.

In the amount of components, in the change of the classical indices of water pollution some tendency may be recognized /nitrate, oxygen consumption/. The character of water is determined by the low dissolved salt content and changing suspended load of the water of low, resp. middle hardness, with a basic content of calcium-magnesium, sometimes of calcium, hydrocarbonate.

An increase of the frequency of samplings took already place in the course of the practice so far, perfecting highly already to-day the picture made about the change of water quality of the river. A further increase of that partly may illuminate the extreme values of the single components, partly may ensure a more secure basis for the calculations of correlation between the water-chemical and hydrological and also other data.

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Table 1

Result of a water sample investigation

No.	Denomination	mg/l	mgrw/l
1.	Site of sampling; the Tisza at Mindszent.		
2.	Date of sampling; July 21st 1969. 2 p.m.		
3.	Place of the water-gauge; Mindszent, 216 + 200 rkm		
4.	Water level on the water-gauge; 278 cm.		
5.	Water output at the water-gauge; 655 cc.m/sec.		
6.	Character of the change of water level; going down		
7.	Endurance percentage of water level; 27.2		
8.	Frequency of water output in days; 3.1		
9.	Air temperature; 18 C^{o}		
10.	Water temperature; 20^{o} C		
11.	Colour; yellowish brown		
12.	Smell; odourless		
13.	Transparency; 15 cm		
14.	Oxygen consumption	5.0	
15.	Biochemical oxygen demand /for 5 days/	4.6	
16.	Dissolved oxygen;	6.8	
17.	Oxygen saturation; 75 p.c.		
18.	pH; 7.3		
19.	Conductivity; 328 $ohm^{-1}cm^{-1}10^{-6}$		
20.	Methylorange alkalinity; 2.60 mval/l		
21.	Total hardness; 8.18 GH^{o}		
22.	Carbonate hardness; 7.28 GH^{o}		
23.	Calcium	45.0	2.25

No.	Denomination	mg/l	mgrw/l
24.	Magnesium	8.3	0.68
25.	Sodium	23.0	1.00
26.	Potassium	4.3	0.11
27.	Total cation equivalent		4.04
28.	Chloride	25.0	0.70
29.	Sulphate	38.4	0.80
30.	Hydrocarbonate	158	2.60
31.	Carbonate	0	0
32.	Total anion equivalent		4.10
33.	Free carbon dioxide	1.84	-
34.	Iron	0.05	-
35.	Manganese	0	-
36.	Ammonium ion	0.45	-
37.	Nitrite	0.036	-
38.	Nitrate	2,5	-
39.	Phosphate	0	-
40.	Sulphide	0	-
41.	Silicium dioxide	11.4	-
42.	Total dissolved matter	233	
43.	Total suspended load	478	
44.	Total dry matter	711	
45.	Oil	0	
46.	Phenols	0.013	
47.	Anion-active detergent	0	
48.	Sodium percentage; 24.8 p.c.		
49.	Magnesium percentage; 23,2 p.c.		
50.	Hydrocarbonate percentage; 63 p.c.		
51.	Sulphate percentage; 20 p.c.		
52.	Chloride percentage; 17 p.c.		
53.	Water type; of calcium - hydrocarbonate		
54.	Biological state; a-b meso-saprobe		
55.	Saprobity index; S = 2.20		

Table 2

Evaluation of water samples taken at Mindszent
1969.

/On the basis the OVF Instruction entitled; "COMECON Unitary Water Quality Norms and Principle of Their Qualification" and "Water Quality Investigations and Their Evaluation"/.

/Number of evaluated water samples; 39/

		Values				Water outputs belonging to the measured values	
No.	Component;	Unit of measurement	minimum	maximum	Standard	minimum	maximum
1.	Oxygen consumption	mg/l	3.1	8.0	5.9	372	1600
2.	Dissolved oxygen saturation	p.c.	59	98	70	291	220
3.	pH	-	7.15	7.90	7.75	1600	413
4.	Total hardness	GH^o	6.36	12.78	11.93	1224	200
5.	Ammonia	mg/l	0.10	4.00	1.59	220	285
6.	Sulphide	mg/l	0.0	0.0	0.0	168	1600
7.	Total dissolved matter	mg/l	187	363	343	511	168
8.	Total suspended load	mg/l	3	706	425	301	908
9.	Oil	mg/l	0.0	0.0	0.0	168	1600
10.	Phenols	mg/l	0.0	0.64	0.03	430	413
11.	Detergents	mg/l	0.0	0.80	0.23	381	498
12.	Sodium	p.c.	11.2	32.4	27.9	511	503.
13.	Oxygen consumption with measuring solution $K_2Cr_2O_7$	mg/l	5.2	40	33	648	655