Chemical water quality of the upper section of River Tisa (the Ukrainian and NE Hungarian part of the catchment area)

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Introduction

The first detailed international control of the water quality of River Tisa and its main tributaries took place in September 1992. A longitudinal sampling series was carried out along River Tisa in August 1995. The investigations included the river section extending from the source area of rivers Chorna and Bila Tisa to Tiszaszalka.

Keywords: water chemical analysis, Upper Tisa

Material and method

Water samples were collected from 11 cross sections of the river. River Tisa has two source tributaries. One of them is Chorna Tisa (main tributary, 2) and the other is Bila Tisa (1) which were the first and second sampling sites. These tributaries originate from the mountainous area of Ukraine. The first section of the river, even after the confluence of the tributaries, has a relatively great fall and high velocity. The third sampling point was at the village Rahiv (3), and the next at Delove (4). There were no sampling sites near the Ukrainian-Romanian border line. The next point was before the mouth of River (5) and after the confluence of the two rivers (6). The next site was at Viskove (7), and the following was not far from Vinonogradiv (8), after River Rika, which is the largest tributary of River Tisa on its right hand side. The next point was at the Hungarian-Ukrainian border Vilok which place is an international monitoring station (9). The two last sampling sites were on the Hungarian part of the catchment area of River Tisa before (at Tivadar 10) and after River Szamos (at Tiszaszalka 11), which is the main tributary of the Upper Tisa in Hungary.

The total catchment area of River Tisa to the mouth of River Szamos is about 13.172 km^2.

The chemical parameters of the water and sediment samples of River Tisa were analysed in accordance with the specifications laid down in Hungarian Standards. Besides some general parameters (pH, conductivity, macroions etc.), the components of the oxygen and nutrient budget of the river were studied. Concentrations of inorganic micropollutants (metals) were measured by AAS.

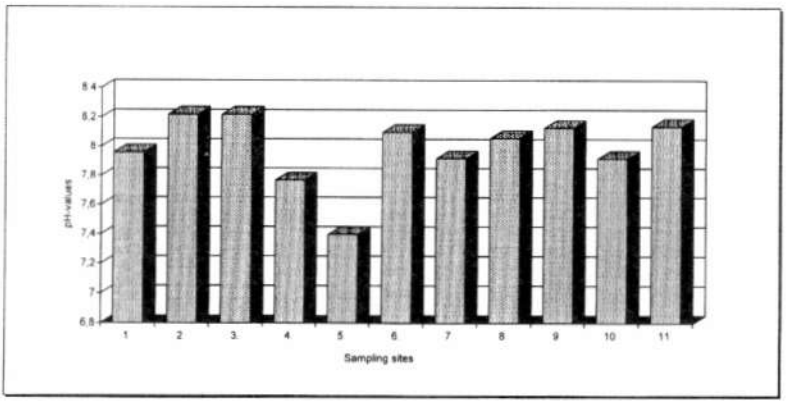

Figure 1. pH values in the upper section of River Tisa

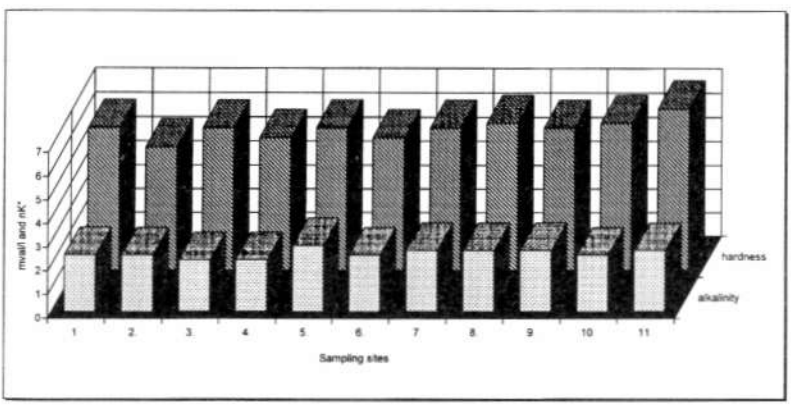

Figure 2. Alkalinity and total hardness in the upper section of River Tisa

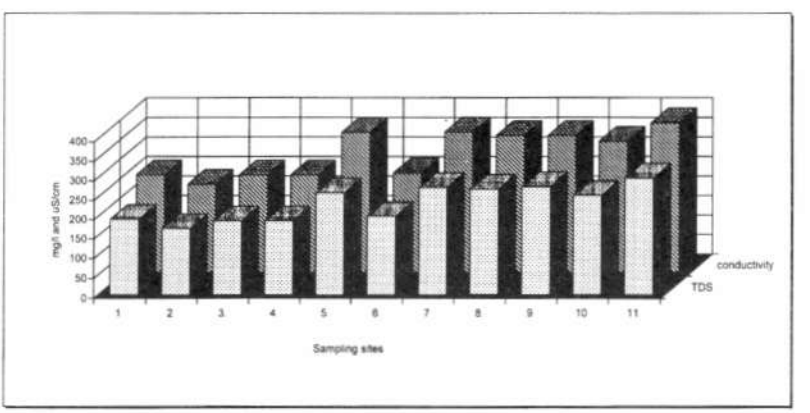

Figure 3. Conductivity and total dissolved solids in River Tisa

Results and evaluation

General features

Recorded **pH values** (Figure 1.) were found to change between 7,40-8,22, meaning that at some places the water was alkalic. It is supposed that the reason was intensive algal production. The lowest value was measured before the mouth of River Tereblia.

The **alkalinity** of the whole river was very moderate and low, and the **total hardness** (expressed in German centigrade) shown in Figure 2. was lowest in River Chorna Tisa, and highest after the mouth of River Szamos.

In Figure 3. values of **conductivity** and concentrations of total dissolved solids can be seen. Conductivity values varied between 226-383 uS/cm, the minimum was measured in River Chorna Tisa, and the maximum was due to the influence of the salt concentration of River Szamos. The values were relatively low in the water, and showed excellent water quality, according to Hungarian standards.

TDS concentrations were in a good relation with conductivity, because of the relatively low salt content of the water. Total concentration was the lowest in the first section of the river, and from sampling site 5 it slightly increased.

Only two main cations and anions were measured, thus the ion type of the water was not determined. **Calcium** and **magnesium** concentrations appear in Figure 4., while sulphate and chlorine concentrations are shown in Figure 5. Concerning cations, there were no significant differences between sampling points. Concentrations of calcium did not exceed 40 mg/l, and magnesium concentrations changed between 2,6 and 6,9 mg/l. The highest value was measured at Rahiv.

Concentrations of **sulphate** were almost equal along the entire section, but chlorine concentrations varied significantly (Figure 5.). Concentrations were relatively low at the first half of the river section (8-10 mg/l), but increased considerably from the mouth of River Vişeu: concentrations here were threefold or fourfold. At the next point concentrations decreased because of the dilution effect of River Tereblia, but below this point all the investigated sites had chlorine concentrations exceeding 30 mg/l.

Parameters of oxygen budget

Concentrations of dissolved oxygen were extremely high at every sampling site along the river. It seems that some sampling or methodological problem may have occurred. Formerly, dissolved oxygen content had never been found to be higher than 30 mg/l in River Tisa, not even in the case of great photosynthetic activity characterised by the abundance of planktonic algae.

COD values were measured by two types of oxidation compounds, such as chromate and permanganese. Concentrations of COD_{Mn} and COD_{Cr} (Figure 6.) changed in the same tendency in the river. The highest values were measured in River Bila Tisa (11,5 mg/l and 30 mg/l respectively), and under the mouth of River Vişeu. The highest values reached the water quality class III. (fair) according to Hungarian standards.

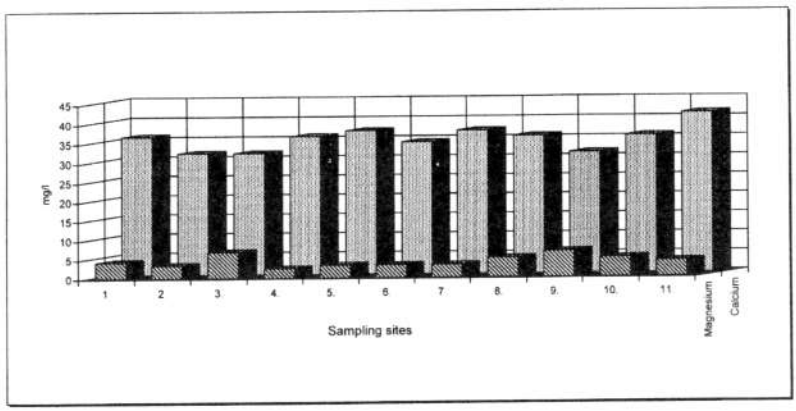

Figure 4. Calcium and magnesium concentrations in the upper section of River Tisa

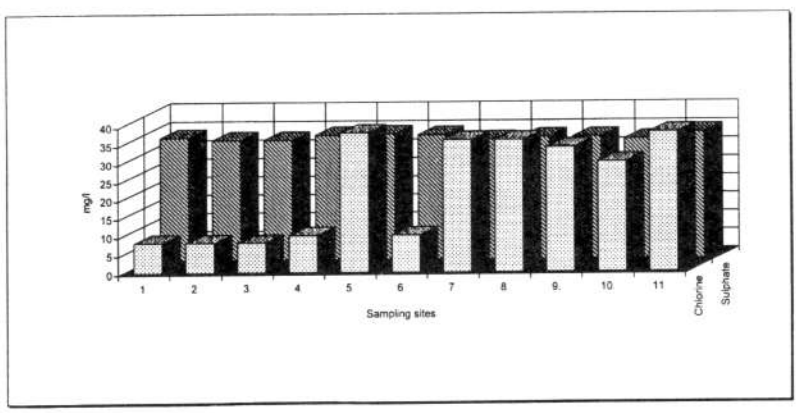

Figure 5. Sulphate and chlorine concentrations in River Tisa

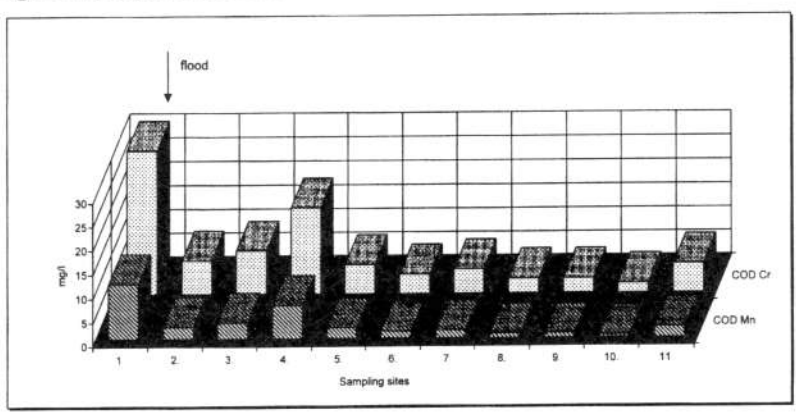

Figure 6. Chemical oxygen demand in River Tisa

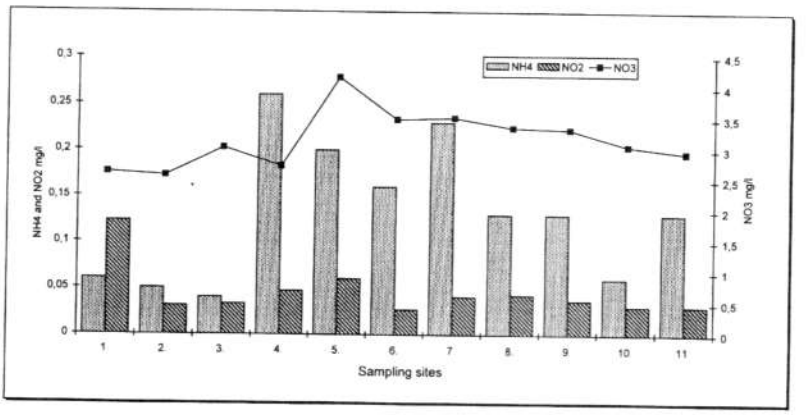

Figure 7. Concentrations of different nitrogen compounds in River Tisa

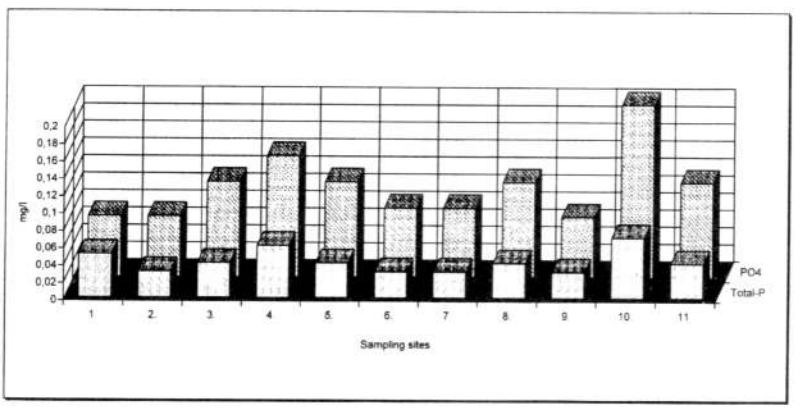

Figure 8. Concentrations of ortho-phosphate and total phosphorus in River Tisa

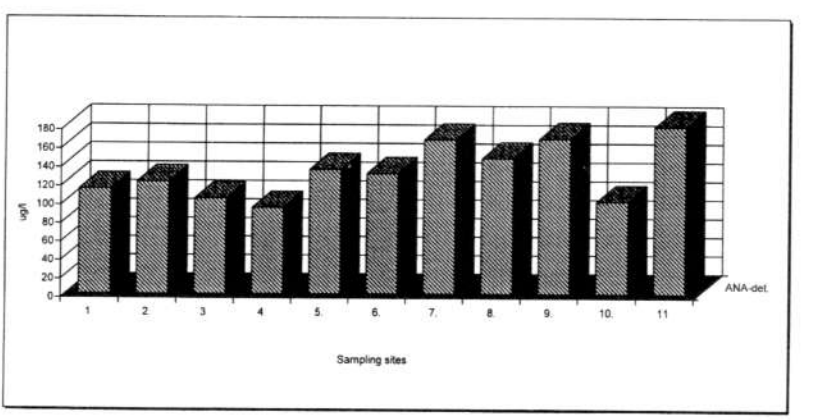

Figure 9. Concentrations of anionactive detergents in River Tisa

Parameters	unit	Number of sampling sites										
		1	2	3	4	5	6	7	8	9	10	11
pH	----	7,96	8,22	8,22	7,77	7,40	8,10	7,92	8,06	8,13	7,92	8,14
Conductivity	µS/cm	250	226	250	250	359	255	360	351	351	336	383
Total dissolved solids	mg/l	192	168	188	188	260	200	274	270	276	254	298
Alkalinity	mval/l	2,4	2,4	2,2	2,2	2,8	2,4	2,6	2,6	2,6	2,4	2,6
Total hardness	NK°	6,0	5,2	6,0	5,6	6,0	5,6	6,0	6,2	6,0	6,2	6,8
Calcium	mg/l	35,8	31,5	31,5	35,8	37,2	34,3	37,2	35,8	31,5	35,8	41,5
Magnesium	mg/l	4,3	3,5	6,9	2,6	3,5	3,5	3,5	5,2	6,9	5,2	4,3
Chlorine	mg/l	8,0	8,0	8,0	10,0	38,0	10,0	36,0	36,0	34,0	30,0	38,0
Sulphate	mg/l	33,4	32,7	32,7	34,0	34,2	34,0	32,7	33,3	33,3	32,7	34,5
Dissolved oxigen	mg/l	31,1	32,8	33,0	37,5	33,5	34,6	34,0	33,0	34,8	----	----
COD Mn	mg/l	11,5	2,6	3,4	7,0	2,3	1,5	1,7	1,0	1,0	0,6	2,3
COD Cr	mg/l	30,0	7,0	9,0	18,0	6,0	4,0	5,0	3,0	3,0	2,0	6,0
Ammonium	mg/l	0,06	0,05	0,04	0,26	0,20	0,16	0,23	0,13	0,13	0,06	0,13
Nitrite	mg/l	0,123	0,031	0,033	0,047	0,060	0,027	0,041	0,043	0,037	0,031	0,031
Nitrate	mg/l	2,64	2,59	3,04	2,74	4,18	3,50	3,53	3,37	3,34	3,07	2,96
Orto-phosphate	mg/l	0,07	0,07	0,11	0,14	0,11	0,08	0,08	0,11	0,07	0,20	0,11
Total phosphorus	mg/l	0,05	0,03	0,04	0,06	0,04	0,03	0,03	0,04	0,03	0,07	0,04
Total Fe	mg/l	0,61	0,65	0,61	0,54	1,00	0,92	0,67	0,60	0,54	0,54	0,86
Total Mn	mg/l	0,03	0,02	0,02	0,04	0,06	0,05	0,06	0,05	0,04	0,05	0,07
ANA-detergent	µg/l	113	121	103	93	134	130	166	146	167	100	180

Table 1.

The organic pollutant load at other river sections was low, and water quality was excellent, since COD concentrations did not exceed 5 and 12 mg/l.

Nutrients

Nutrients included different types of nitrogen and phosphorus compounds. Figure 7. shows the changes in the concentrations of inorganic nitrogen forms: **ammonium, nitrite** and **nitrate.** Ammonium concentrations were the lowest at the upper part of the Ukrainian section of the river, but all values were relatively low (0,06-0,26) and concentrations indicated excellent water quality.

Concentrations of nitrate were low, too. The highest concentration values were measured above the mouth of River Tereblia (4,18 mg/l), and generally at the middle section of the river in the Ukrainian areas, between Delove and Viskove.

Nitrite concentrations were the highest in the first half of the river section, with the maximum value being measured in the water of River Bila Tisa (0,123 mg/l). This concentration indicates polluted water (class IV.), based on Hungarian water quality standards. The results suggest that the major part of inorganic nitrogen compounds in River Tisa is nitrate.

Concentrations of **ortho-phosphate** and **total phosphorus** are shown in Figure 8. Each concentration fits for class I. water quality (excellent) according to Hungarian standards.

Organic micropollutants

Only anionactive detergent (ANA) concentrations were measured. The amount of this important pollutant did not change significantly. Values were between 93-180 ug/l (Figure 9.). The maximal concentration was measured in River Tisa, under the mouth of River Szamos.

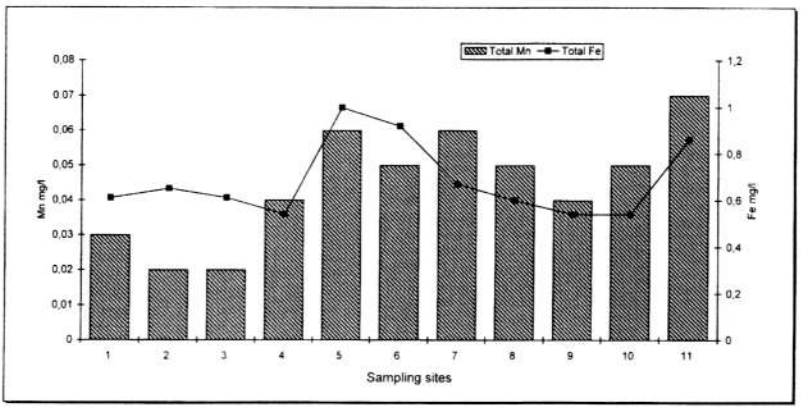

Figure 10. Iron and manganese concentrations in River Tisa

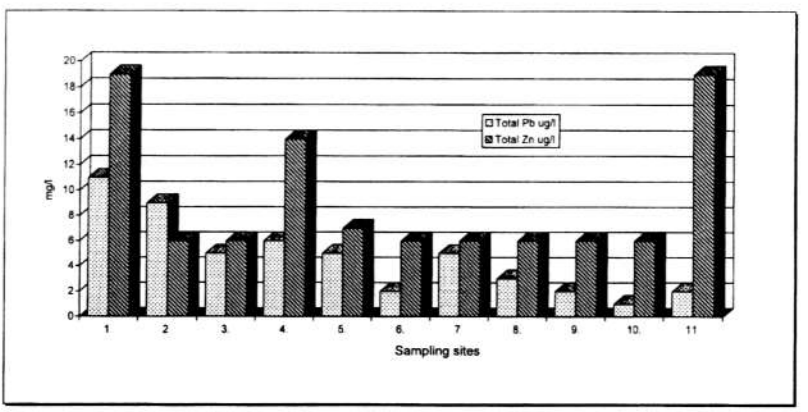

Figure 11. Concentrations of zinc and lead in River Tisa

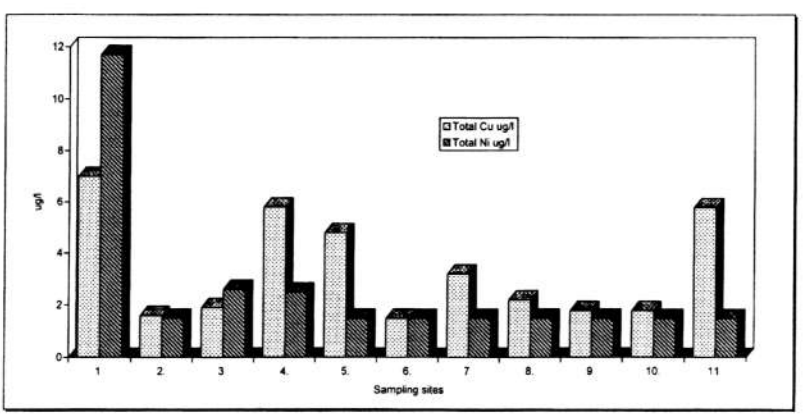

Figure 12. Concentrations of cuprum and nickel in River Tisa

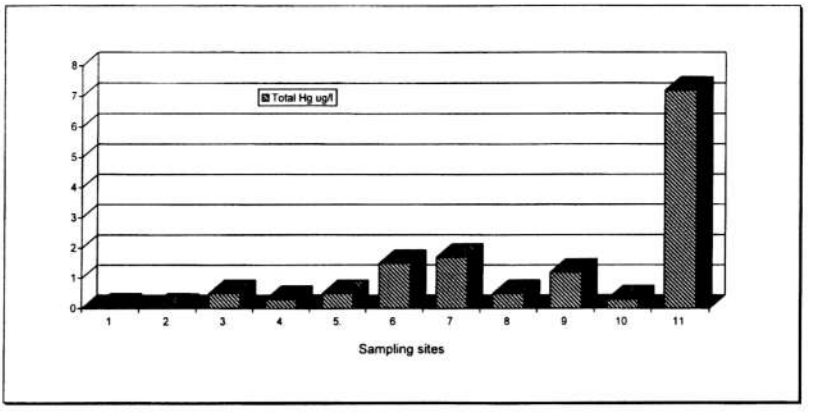

Figure 13. Concentrations of mercury in River Tisa

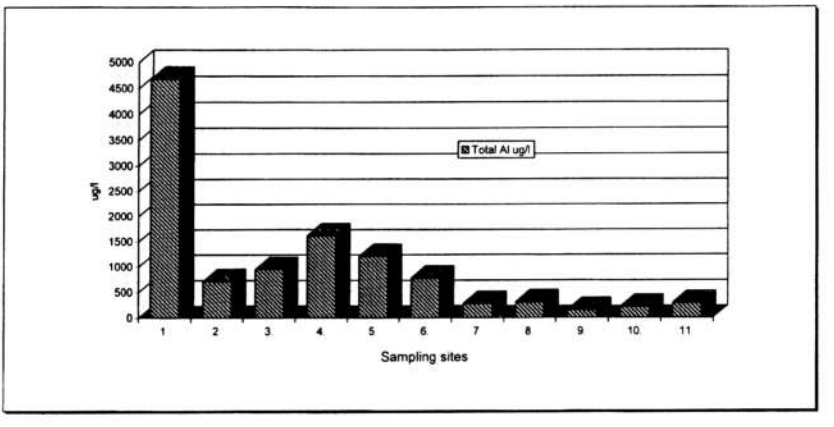

Figure 14. Concentrations of aluminium in River Tisa

All the concentrations were low, and water quality was excellent or good at every sampling point, in respect of ANA concentrations.

Metals

Due to the geological conditions of the catchment area the concentration of **iron** was relatively high in the water at every sampling site. The water is categorised as polluted according to Hungarian water quality classification. Concentrations were found to range between 0,54-1,00 mg/l (Fig 10.) The highest value occurred at the mouth of River Tereblia.

The concentration of total **manganese** was relatively low, the highest value was detected after the water of River Szamos admixed with River Tisza.

Parameters	unit / site	1	2	3	4	5	6	7	8	9	10	11
Total Cu	µg/l	7,0	1,6	1,9	5,8	4,8	1,5	3,2	2,2	1,8	1,8	5,8
Total Cd	µg/l	0,3	<0,1	0,1	0,1	<0,1	0,1	<0,1	<0,1	<0,1	0,2	0,1
Total Ni	µg/l	11,7	<1,5	2,6	2,5	<1,5	<1,5	<1,5	<1,5	<1,5	<1,5	<1,5
Total Zn	µg/l	19	6	<6	14	7	<6	<6	<6	<6	<6	19
Total Cr	µg/l	<6,2	<6,2	<6,2	<6,2	<6,2	<6,2	<6,2	<6,2	<6,2	<6,2	<6,2
Total Pb	µg/l	11	9	5	6	5	2	5	3	2	<1	2
Total Al	µg/l	4680	720	950	1620	1210	780	280	310	157	220	290
Total Hg	µg/l	<0,05	<0,05	0,5	0,3	0,5	1,5	1,7	0,5	1,2	0,3	7,2
Total As	µg/l	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Table 2.

Besides **aluminium** and **mercury**, concentrations of all the measured essential and toxic inorganic micropollutants (metals) were low in the water of the upper section of River Tisa.

Concentrations of **zinc** and **lead** can be seen in Figure 11. Every single concentration value of the two metals indicated excellent water quality of the whole river section. In the case of zinc relatively high concentrations were measured in River Bila Tisa, and in sections influenced of the water quality of River Szamos, but this value (19 ug/l), too, fits for the standards of class I.

The concentration of **nickel** and **cuprum** (Figure 12.) were the highest in River Bila Tisa, yet, water quality was excellent or good (classes I. and II.). Nickel concentrations were near the measurement limit value (1,5 ug/l) at most of the sampling sites.

The maximum concentration of **cadmium** was measured in River Bila Tisa, nevertheless, water quality was excellent concerning cadmium in the whole section of River Tisa. At every sampling site, the concentration of **arsenic** indicated water quality class I. (excellent), ranging near the methodological limit value.

Mercury concentrations were quite variable. The highest value was caused by River Szamos. Its concentration measured after the mouth of River Szamos indicated heavily polluted water quality (7,2 ug/l). Relatively high concentration was measured at the middle section of the river too, after the confluence with River Tereblia (Figure 13.).

Among metals, the concentration of aluminium was extremely high in the water of the two source tributaries of River Tisa. The maximum value in River Bila Tisa was over 4 mg/l (Figure 14.). Further on, concentrations decreased, but water quality remained polluted down to the mouth of River Tereblia. Concentrations significantly decreased in the lowest section.

In respect of heavy metals there is a great influence of River Szamos on River Tisa's water quality. The water of upper tributary (Bila Tisa) contains a relatively large amount of heavy metals, but the concentrations are not beyond the limits.

The results of sediment analyses indicated that the concentrations of different heavy metals in the riverbed were low. Only the concentration of zinc at some points was higher than the target value as shown in the following table. Aluminium concentrations were high along the entire river section, since pollution in sediment was the same as in the water body.

Standards for bed sediment of running waters (Water Resources Research Centre)

Parameters	Target values	Acceptable
Cromium mg/kg dried matter.	100	120
Nickel mg/kg dried matter.	50	60
Cuprum mg/kg dried matter.	50	60
Zinc mg/kg dried matter.	50	60
Cadmium mg/kg dried matt.	1.0	1.5
Mercury mg/kg dried matter.	0.5	1.0
Lead mg/kg dried matter.	100	120

Table 3.

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