PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE MAROS (MUREŞ) RIVER

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Introduction

The expedition-like examination of the longitudinal section of a river is an efficient method for discovery of the typical changes in a longitudinal section. The analyses of the sediment are especially informative because the sediment integrates the effects of a longer period (several months, eventually several years).

The most examinations of longitudinal sections in the Carpathian Basin have been conducted on the Tisza River. In 1979, a detailed study of the sediment was performed (Győri, Végvári, 1981; László, Berta, 1981), in 1986, the toxic metal contents of the water and the sediment were examined (Waijandt, Bancsi, 1989), and in 1989, detailed chemical and biological examinations were performed in the water body and in the sediment (Waijandt et al, 1990).

Materials and methods

Samples were taken along the longitudinal section of the Maros at 15 sampling sites on the following dates:

12.08.1991 at sample sites 1-5
20.08.1991 at " " 6-10
26.08.1991 at " " 11-15

Water samples were taken from a bridge, ferry, or boat in the median of the river; the sediment samples were taken by Eckman sampler.

The temperature of the air and the water, the smell, the colour, the transparency, the dissolved O_2, the free CO_2, and water velocity were determined at the site. The conservation of water samples was made there, too.

The sampling, the conservation and the examination of the chemical components were performed according to Hungarian Standards. For surface waters we used the Hungarian Standards MSZ 12750 series. For sediment, we used the HS MSZ 12739 series. The examination of the toxic elements (metals and arsenic) was performed by atomic absorption spectrometer type VARIAN 20BQ.

Results and discussion

Physical characteristics and suspended solids

The measurements of the colour of the Maros at the five upper sampling sites showed colourless or mildly yellowish water colour. It was greenish below Tîrgu Murcº, grayish downstream to Luduº and light yellowish on the lower section as far as the mouth of the river.

In the upper reaches the water was odorless while different smells were noticed at lower sections, related to some kind of pollution (Table 1)

The transparency of water, which is fundamentally determined by the concentration of suspended solids (especially by the number of planktonic algae), is the greatest in the colourless upper section where the quantity of suspended solids and the number of algae were small at the same time (see chapter of algalogical discussion). The transparency decreased at the five middle sections and the five lower sections of the river.

The temperature of the water was the lowest (12.5 °C) at the sections near the source and the highest at the lower reaches of the river (Table 1). In the next table values of specific concentrations are plotted against the river kilometres.

The concentration of the suspended solids is very low at the upper section. At the middle section (between sample sites 6-10) it increases significantly. At the lower section (between sample sites 11-15) it increases gradually (Figure 1).

Inorganic components

The free CO_2 content of the river in the upper section where the total number of algae was very low was fundamentally influenced by the spring water (so called "wine water") with relatively high concentrations of CO_2. The free CO_2 content is relatively high in this section, it is less in the middle section, and it disappeared in the lower section (Figure 1).

The pH-value changed in total harmony with the carbon dioxide content. In the two upper sections pH-values between 7.5 and 7.9 were measured, in the lower sections the values increased; they were between 8.1-8.6 (Figure 1). It is assumed to be in connection with the increased algal activity, which means more unfavourable water quality.

The concentration of the total dissolved matter (and its other form of expression, the value of the conductivity) is low 110-209 mg/l in the upper section of the Maros. It was increased more than threefold (Figure 2) by Tîrnava in the middle section, and it changed only as a function of the discharges and the regime after the little dilution effect of the Sebes (Sebcº) and the Sztrigy (Strei).

Fig. 3. shows that the biggest part of the mineral salt increase goes from the Küküllõ (Tîrnava) to the Maros in the form of NaCl. The water hardness was increased by the influence of the Tîrnava, but in a smaller degree. The percentage of Sodium (Na %-value) increased from 8.5- to 36% in the longitudinal section.

Fluoride content could be measured in the lower section (Table 1).

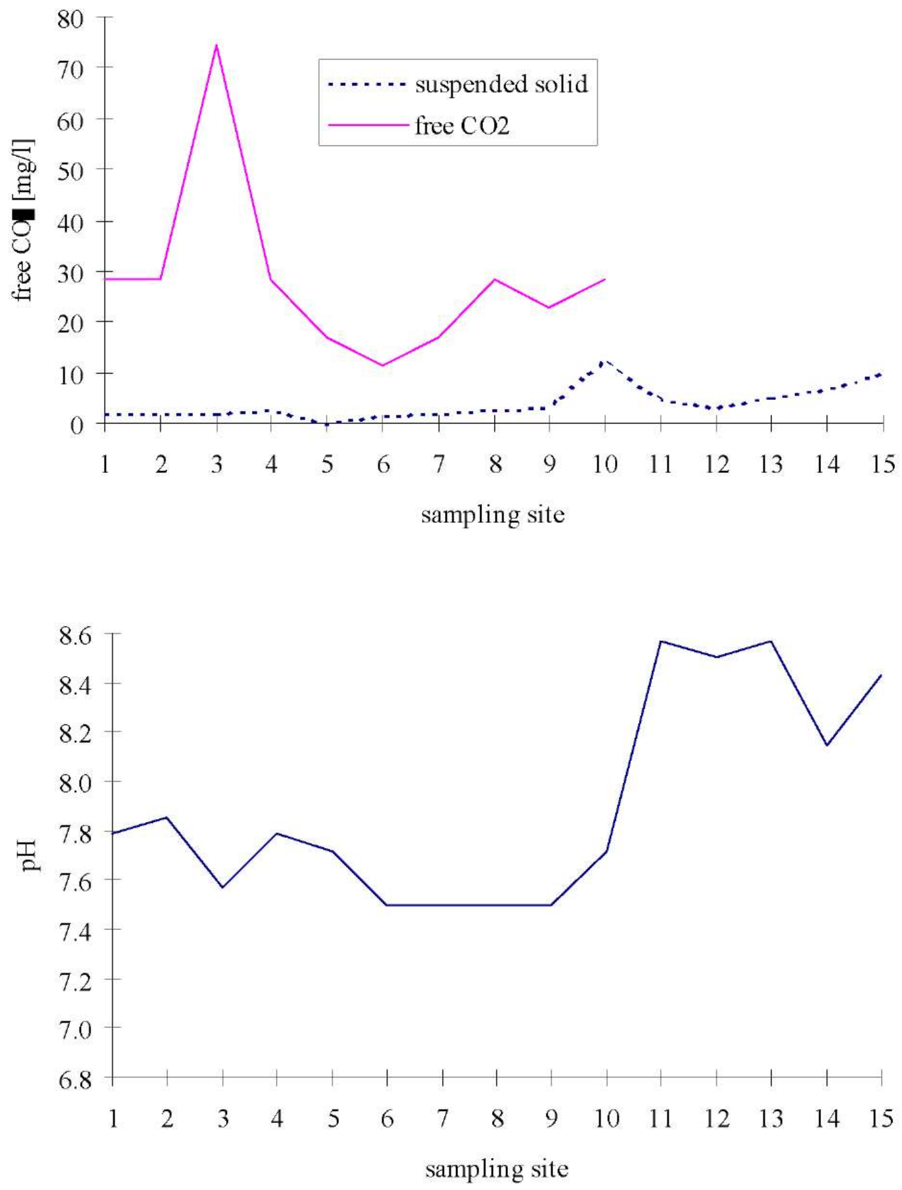

Fig. 1. The suspended solid and free CO_2 concentrations, and pH-values in watre of the Maros (1991).

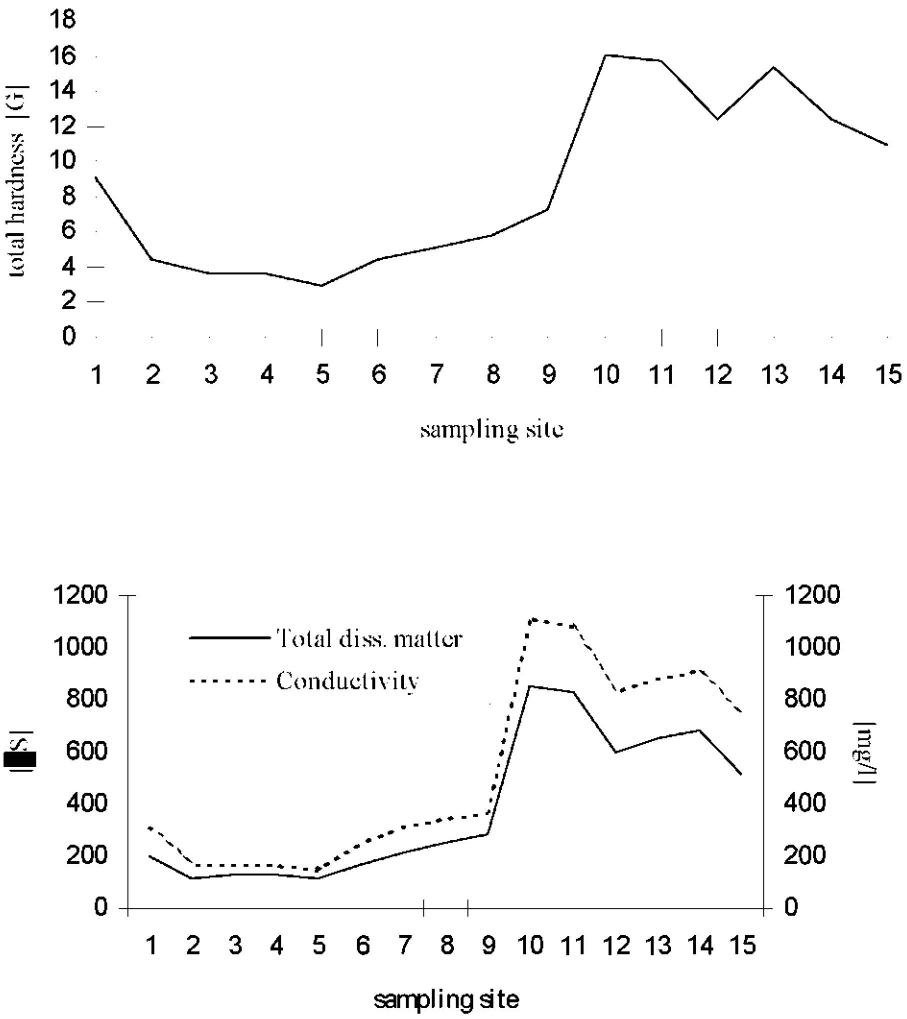

Fig. 2. Values of total hardness, total dissolved solids and conductivity in water of Maros at 15 sampling sites (1991)

Table 1. Some physical and chemical characteristics of the Maros at different sampling sites

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Colour	CL	Y	Y	Y	Y	G	G	GR-Y	Y	Y	Y	Y	Y	Y	Y
Smell	OL	OL	OL	OL	OL	M	CL	CL	OL	MU	MA	CL	OL	OL	MU
Transparency (mm)		800	900	800	800	600	600	500	500	350	600	650	500	400	250
Wether	CR	CR	CR	CY	CY	CY	CR	CR	CY	CY	CY	CY	CY	CY	CY
Air temp. (°C)	18	15	25	24	23	14	17	27	23	24	16	21	22	26	21
Water temp. (°C)	13	12.5	15	19.5	20.5	16	18.5	20	21.5	22	19.5	19,5	20,5	22	21.5
pH	7,8	7,9	7,6	7,8	7,7	7,5	7,5	7,5	7,5	7,7	8,6	8,5	8,8	8,1	8,4
Free CO_2 (mg/l)	3,75	3.5	9,7	3,5	2.4	1,75	2,85	3.5	2,65	3,95	0	0	0	0	0
CO_3 (mg/l)	0	0	0	0	0	0	0	0	0	0	18	18	24	12	12
HCO_3 (mg/l)	193.4	111	83.6	76.9	54.9	79.9	81.1	98,8	97	119,6	25	47,6	87,2	118,3	111
Total Hardness (Germ.)	9	4,6	3,8	3,5	3,8	4,3	5	6	6,9	16,9	15,8	12,6	15	14,7	12,7
Sodium (mg/l)	6.9	6.9	7	9.2	8.1	20.7	24.2	25,3	23	101,2	105,6	80,5	78,2	80,5	62,1
Potassium (mg/l)	0,6	0,8	0,8	2,3	2	4,3	5,1	6,6	5,5	10,2	10,2	9	9	9,4	8,8
Chloride (mg/l)	8.9	3.6	5.3	7.1	7.1	28,1	33.7	33,7	34	257	254	186	183	179	139
Sulfate (mg/l)	4,8	2,4	7,2	12	14,4	21,6	33,6	40,8	50,4	72	113	76,8	76,8	77	64,8
Fluoride (mg/l)	0	0	0	0	0	0	0	0	0	0	0.1	0,2	1,4	0,4	0,45
Sodium percent (%)	8,5	15,2	18	23,4	25	35,2	35,2	32,2	27,9	41,1	43,8	42,5	37,9	38,9	36,1
Conductivity (uS/cm)	314	174	163	165	141	258	313	342	359	1117	1088	827	906	923	742
Total dissolved solid (mg/l)	209	122	127	128	110	190	216	250	267	869	837	595	678	683	525
Suspended matter (mg/l)	17	18	20	24	3	15	18	26	28	100	39	38	39	57	81
NH_4 (mg/l)	0,15	0,3	0,3	0,35	0,25	0,3	1,8	0,75	0,35	0,4	0,3	0,2	0,2	0,35	0,2
NO_2 (mg/l)	0,036	0,026	0,026	0,075	0.042	0.085	0,42	0.42	0,22	0,14	0.085	0,15	0.06	0.07	0,03
NO_3 (mg/l)	6	1,7	2	3,4	3,4	2,6	8	11,5	6,5	9,5	8	7	8,5	8,5	8
Total inorganic N (mg/l)	1.5	0.6	0.7	1.1	1.0	0.7	3.0	2.9	1,5	2.1	2.1	1,8	2,1	2,2	2.0
Total N (mg/l)	2,0	1,0	1,1	1,5	1,2	0,9	3,4	3,4	1,8	2,5	2,9	2,7	2.7	2.6	2,4
Dissolved PO4 (mg/l)	0,11	0,07	0,19	0,16	0,13	0,15	0,48	0,65	0,2	0,34	0,04	0.04	0,01	0,26	0,32
Total P (mg/l)	0,04	0,05	0,07	0,07	0,06	0,12	0,16	0,26	0,14	0,24	0,13	0,13	0,14	0,22	0,26
COD-Mn (mg/l)	4.8	7.2	6.1	6.1	5.8	4.8	6.1	6,2	4	7.4	11.5	10	10	7,6	8.8
COD-Cr (mg/l)	12	22	14	14	14	13	15	17	10	22	26	29	32	22	29
Dissolved O2 (mg/l)	8.4	9.4	9.4	9	9	7	7.8	4.3	7.8	7.2	12.5	11.1	11.9	9	9.4
Oxygen sat. (%)	60	89	94	99	101	71	84	55	89	83	137	102	133	104	107
Phenols (ug/l)	2	0	0	2	2	6	8	8	10	8	6	8	6	8	6
ANA Detergents (mg/l)	5	10	5	5	0	20	30	25	20	5	5	5	10	35	15
Water quality (I clear, II–polluted)	I	I	I	I	I	I	I	I	I	II	II	II	II	II	II
Water velocity (cm/s)	4	110	90	50	60	10	20	20	25	30	15	5	15	25	20

Table 2. Toxical element content in the water and sediment of Maros at different sampling sites

Toxical elements in WATER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total Cu (mg/l)	2.3	2.2	3.7	2.2	3.6	0.5	2.3	5.8	37	25	13	11	15	19	19
Total Cd (mg/l)	< 0.2	< 0.2	< 0.2	0.2	0.3	< 0.2	< 0.2	< 0.2	0.3	2	0.8	0.7	0.5	0.8	0.8
Total Ni (mg/l)	2.6	1.4	2.5	0.8	6.4	0.5	0.8	0.5	0.6	4	1.2	0.6	0.6	0.8	0.6
Total Zn (mg/l)	4	2.8	8	31	11	6	14	12	80	147	73	71	66	84	82
Total Pb (mg/l)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	12	30	5.7	6.3	12	18	19
Total Cr (mg/l)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	75	53	35	22	24	13
Total Hg (mg/l)	0.26	0.1	0.4	0.19	1.1	0.06	1.5	1.2	3	9	0.3	2.1	3.9	2.2	0.9
Total As (mg/l)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.8	< 0.5	< 0.5	0.6	1.3	0.6	1.4	1	0.9
Total Fe (mg/l)	1.2	1	0.8	1.1	0.8	0.6	0.8	0.9	1.5	2.4	0.3	0.4	0.6	1.5	1.7
Total Mn (mg/l)	0.12	0.18	0.1	0.07	0.06	0.07	0.1	0.09	0.21	1.8	0.1	0.18	0.15	0.16	0.14
Water quality	I	I	I	I	I	I	I	I	II	II	I	II	II	II	II
SEDIMENT															
Cu (mg/kg)	13.8	18.9	18.3	20.6	22.4	37.7	10.5	29.3	68.1	114	524	417	73.1	80.9	77.2
Cd (mg/kg)	0.1	0.1	0.1	0.75	0.48	0.9	0.1	0.53	0.19	6.7	5.9	11.3	2.3	3.6	5.3
Ni (mg/kg)	8.4	16.5	3.4	8.3	3.5	26.9	13.2	24.1	12	21.6	37.6	31.7	22.5	23.4	23.2
Zn (mg/kg)	93.6	67.9	41.9	83.5	92.1	126	50.2	96.5	151	664	991	1380	367	468	558
Pb (mg/kg)	19.2	12.1	11.6	38.2	17.5	29.2	13.2	20.2	161	133	215	375	56.2	140	94.4
Cr (mg/kg)	10.8	7.8	2	8.7	3.5	15.7	1.8	26.3	4.6	53.9	61.9	242	28.5	56.1	55.8
Hg (mg/kg)	0.02	0.24	0.02	0.008	0.04	0.39	0.07	0.08	0.124	3.9	0.83	3.3	0.33	0.63	0.51
COD-Mn (g/kg)	65	28	12	28	58	74	8.2	33	2.8	12	23	40	11	16	15
COD-Cr (g/kg)	103	50	29	53	108	119	18	53	6.6	25	47	106	21	38	32
Organic matter (g/kg)	125	57	42	59	103	131	20	56	13	37	62	99	48	43	41
Total N (g/kg)	1.5	0.9	3.22	0.84	2.2	3.3	0.8	1.2	0.54	0.74	1.6	3	0.64	1.2	1.2
Total P (g/kg)	0.39	0.39	0.35	0.88	1.1	1	0.43	0.8	0.31	0.55	0.73	1.9	0.71	0.76	0.93

Nutrients

Values of NH_4-ion concentrations were relatively low because of the high water temperature in summer and the fast nitrification, except below Tîrgu Mureº and Ludu°, where the values indicate some sewage discharges (Figure 4).

It is strange that nitrate ions (1.7-6.0 mg/l) occurred even in the water of the upper section. Its concentration increased up to 8 mg/l downstream to Tîrgu Mureº and it maintained with small variation all along to the mouth (Figure 4).

There were no significant nitrite concentrations measured down to Tîrgu Mureº, indicating that no significant pollution sources are present. The major part of the total N in the water was in inorganic form (Figure 5), especially in the form of nitrate. In the upper section of Maros almost all of the total phosphate consisted in ortho-phosphates. Both P forms increased in the middle section. In the lower section down to Zam, there was hardly any PO_4 ion, then the total P increased to the mouth (Fig. 5).

Components of the oxygen budget

The COD values measured by the method of dichromate were not high in the upper sections of the river, the easily oxidable matter fraction (COD-Mn) belonging to the COD-Cr was about 5mg/l (Figure 6). It increased slightly in the middle section below Tîrgu Mureº and Ludu°, and increased considerably due to the influence of Tîrnava. It is possible that the high content of organic matter was caused by the secondary production of organics due to algal activity.

For a given distance from the spring, the O_2 saturation of the water was nearly 100% (Figure 7). The decrease of concentrations of dissolved O_2 at the middle section indicates organic matter pollution which can easily be degraded. The most unfavourable conditions were downstream to Ludu°, where the dissolved oxygen concentration decreased to 4.3 mg/l. Along the lower section, the saturation was more than 100% (due to high algae populations) which decreased all along to the mouth.

Other components

The values of phenol index (which was determined by the 4-amino-antipyrin method) were worth mentioning only in the middle and the lower sections (Table 1).

Concentrations of anion active detergents were low along the Maros relatively higher values were measured in the sections downstream to Tîrgu Mureº and Arad (Table 1).

Qualification

The present valid standard has three categories and it is too liberal. (MSZ-10-172/1-83. Evaluation and classification of surface water quality.)

The water of the Maros belonged to Class I down to sample site 9. From that point on, it belonged to the Class II. pH-values and concentrations of nitrite ions were in Class III at some sampling sites.

Toxic elements in the waters of the Maros River

In the upper section of the Maros River, Fe and Mn contents of the water are relatively high for geological reasons. The Fe concentrations were 1 mg/l or higher, the same for Mn were 0.1-0.2 mg/l. The maximum values were measured downstream to Tîrnava (Table 2).

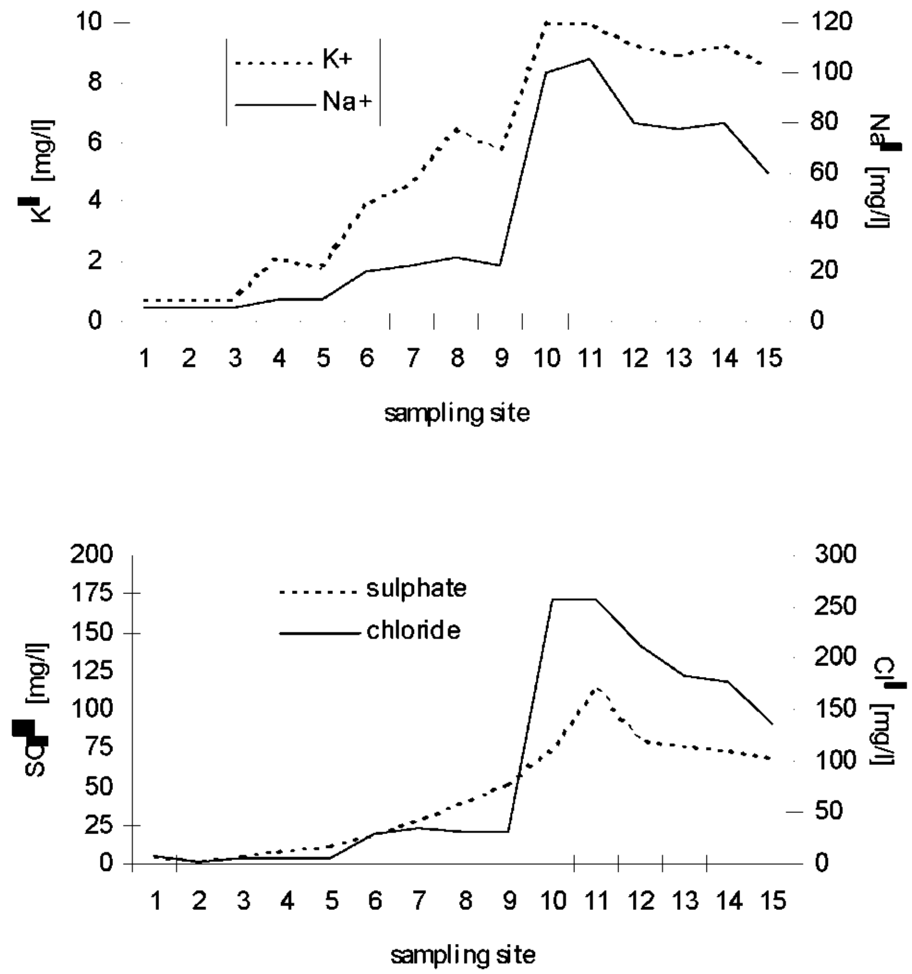

Fig. 3. Concentration of Na^{+}, K^{+}, Cl^{-} and SO_4^{2-} ions in water of Maros (1991)

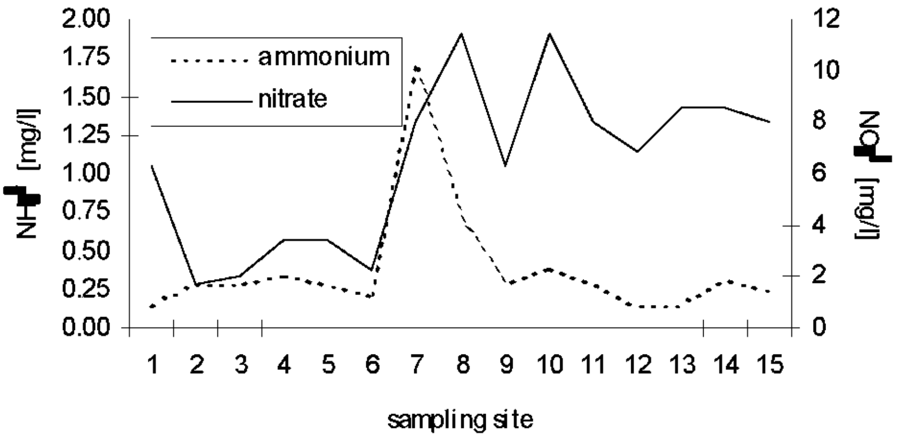

Fig. 4. Concentration of ammonium and nitrate ions in water of Maros (1991)

Arsenic concentrations were under the measuring limit or were found slightly over it, occurring at some sampling sites in the lower sections of the river.

The values of Ni and Cd concentrations were very low, they did not change considerably in the longitudinal section (Table 2).

Concentrations of Zn, Cr, Pb, Cu and Hg probably can be considered as being geological background values all along to the sampling site (8) at Ludus. Downstream to the mouth of Aries, the Zn, Cu and Hg concentrations were increased very much (Fig. 8). Downstream to the mouth of Tîrnava, the Zn and Hg concentrations were still increased, and high Cr and Pb values were measured. The above mentioned metals were found in much higher concentrations downstream to the sampling sites 8 and 9 along the river down to the mouth, than in the upper section.

On the basis of the limits given in the integrated qualification, the water quality of the Maros River was Class I down to the mouth of Aries and Class II downstream of it except for one sampling point.

Limit values of metals in water.

1-MI-10-172/3-85. Hungarian technical guideline for limit values. Classification on the basis of the 80% value of the duration curve. Limit values in the integrated requirement system.

2-Proposal of the European Economic Committee. Classification on the basis of median value.

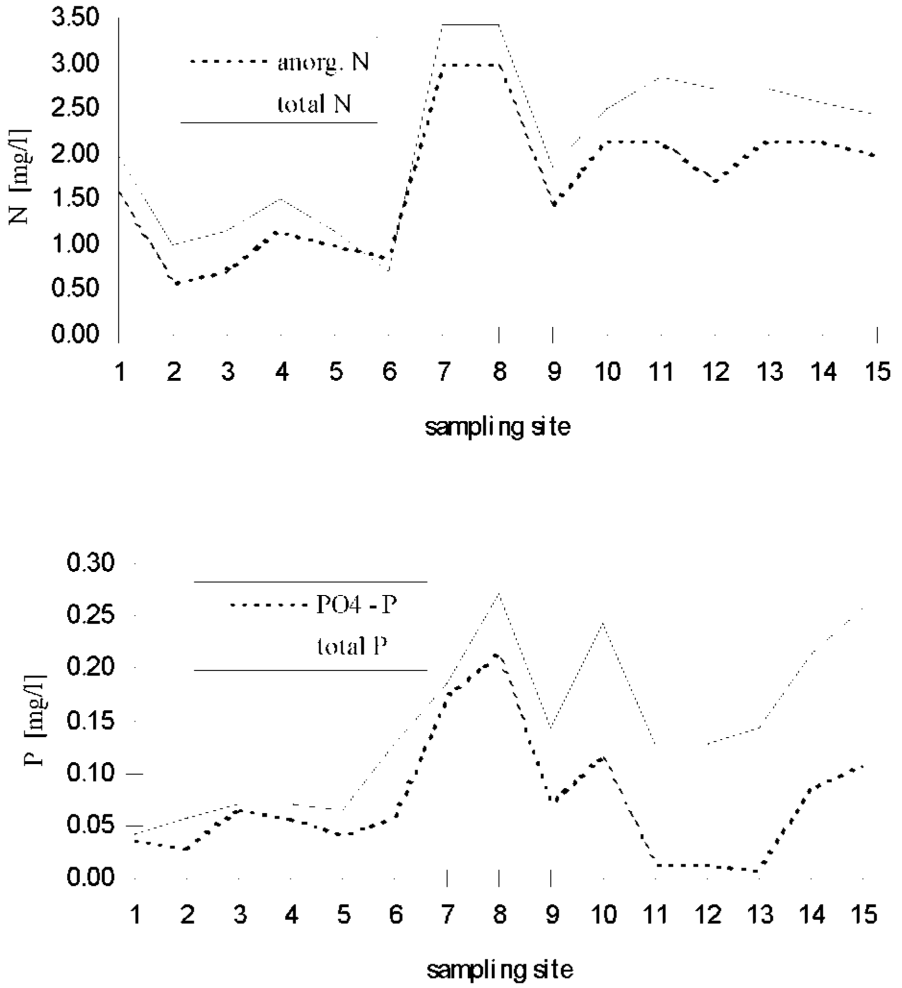

Fig. 5. The nutrient content in water of Maros (1991)

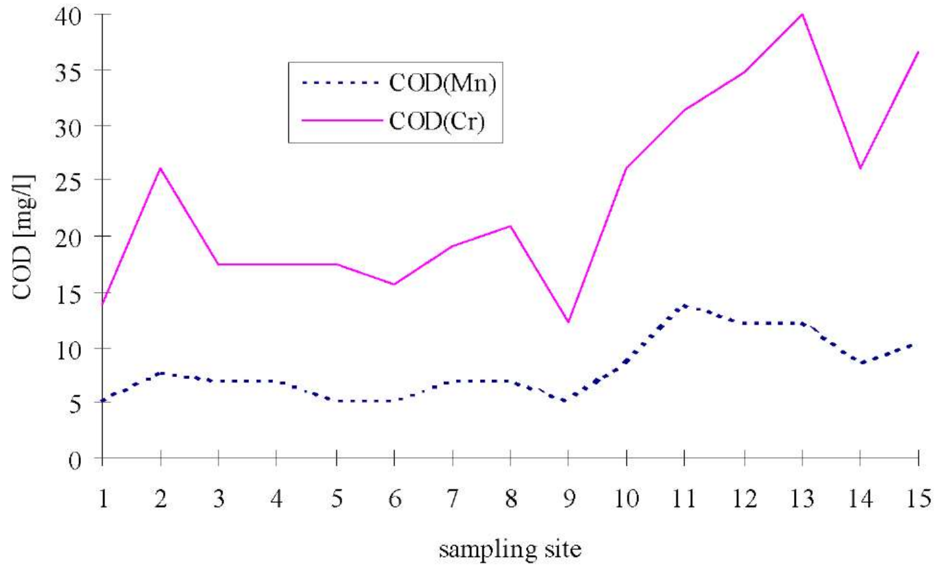

Fig. 6. Chemical oxygen demand of the water of Maros (1991)

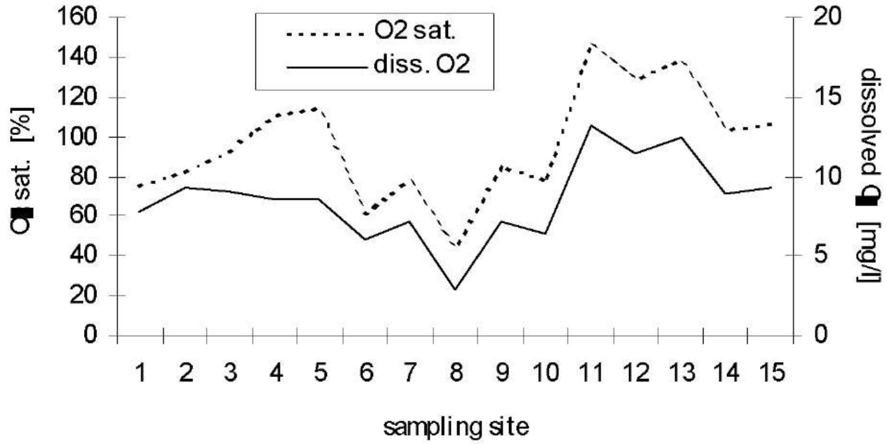

Fig. 7. Dissolved oxygen and oxygen saturation values in water of Maros (1991)

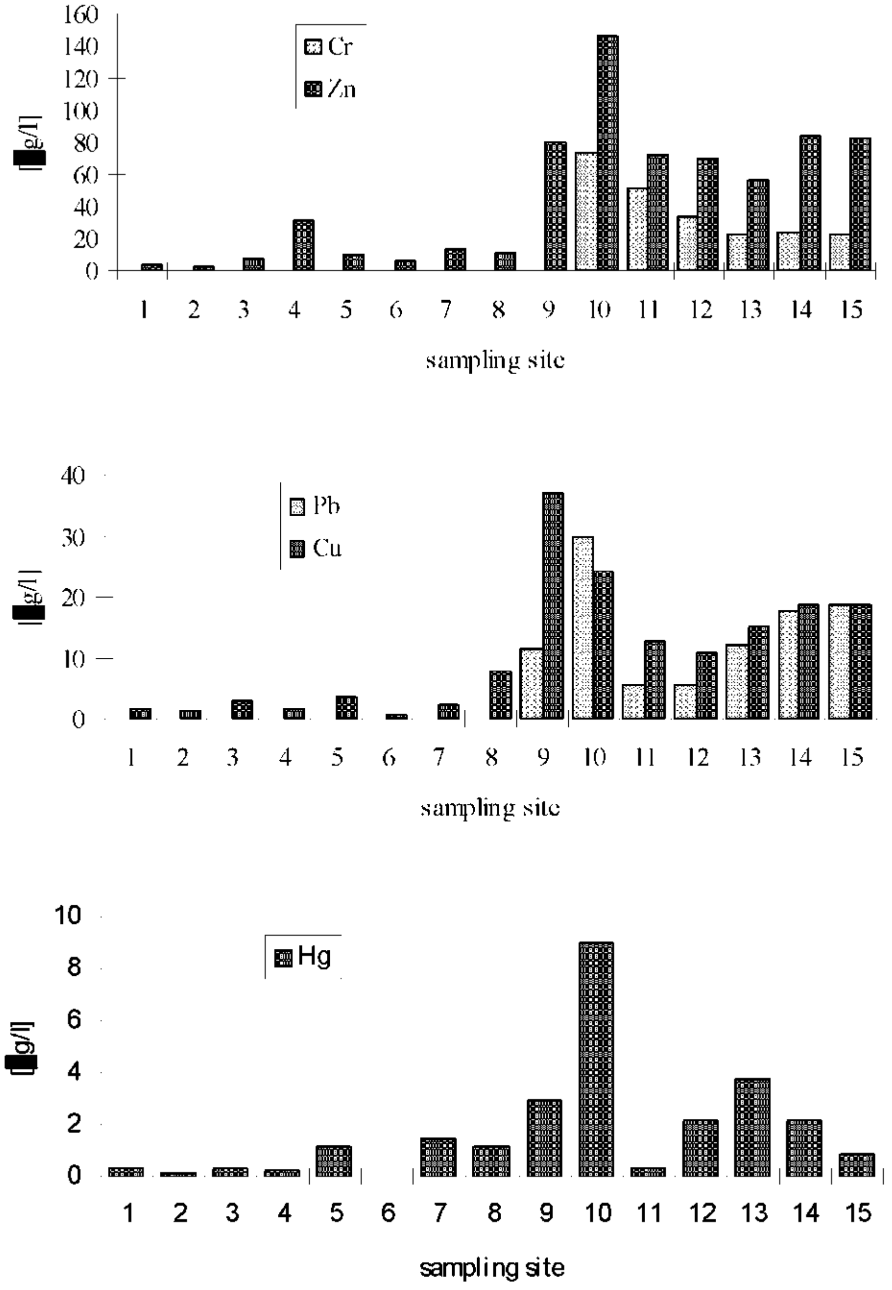

Fig. 8. Heavy metal concentrations in water of Maros (1991)

Results of sediment examination

Concentrations of chemical components in the sediment depend mainly on the grain composition of the sediment and naturally on the contamination of the water. This was the conclusion of earlier investigations made on the Tisza River (Györi and Végvári 1981; László and Berta 1981), and it was supported by other authors (Waijandt et al, 1990) and investigating Tisza River sediment in Kisköre Reservoir (Végvári and Waijandt, 1989).

The organic matter content of the sediment in the longitudinal section of the Maros which was measured by two different methods, and the total N and total P concentrations showed similar figures, which proved indirectly that grain size distribution could play an important role (Fig. 9). The highest values were measured at sampling points in the retained-water sectionsnear Tîrgu Mure° and below Deva. Characterizations of organic matter content by modely incineration at 650 C and by measuring COD-Cr, were in good correlation with each other (Table 2). The ratio of the total and the easily oxidatable organic matter (COD-Cr/COD-Mn) changed between 1.6-2.4, the main value was 2.0.

I would like to stress the importance of the finding that the total N and total P concentration values did not differ considerably from each other in particular in the lower section of the river. The sediment quality showed significant changes in functions of the changing river profile in the two upper sections of the river, while downstream to Zam and continuing to the mouth, it was quite balanced.

The concentrations of some metals in 1979 (László and Berta, 1981), many metals in 1986 (Waijandt and Bancsi, 1989) and in 1989 (Waijandt et al, 1990) were higher at the sampling site near the Maros' mouth and the sampling site on the Tisza River below the mouth of the Maros than at the sampling points on the Tisza upstream to the source of the Maros.

The metal content of the sediment indicated prolonged pollution. Below the mouth of the Arie°, the Cu and Pb content in the sediment increased considerably (Fig. 10) in harmony with the concentration values in the water (Fig. 9.). Below the mouth of the Tîrnava, the concentration of Zn, Cu, Cr, Cd and Hg increased suddenly. Most of the metals reached their maximum values below Deva at sampling site 12. Along the 246 km section of the Maros between Zam and Szeged the concentration of the metals were similar and much higher than the upper section of the river, partly because the sediment is spread out by the current.

Conclusions

Water quality showed fundamental differences at the three sections of the Maros. The sampling of the sections were made in three different weeks. The upper section is in a natural state characterized by mineral and pollutant concentration. In the middle section deterioration of water quality was found due to the considerable pollutant load, moreover the Tîrnava tributary increased fundamentally the concentrations of inorganic components in the water. The quality of the lower section, which represents more than half of the total river length, is relatively unfavorable and is classified as Class II. The concentrations of some components indicating anthropogenic effects showed slow increase.

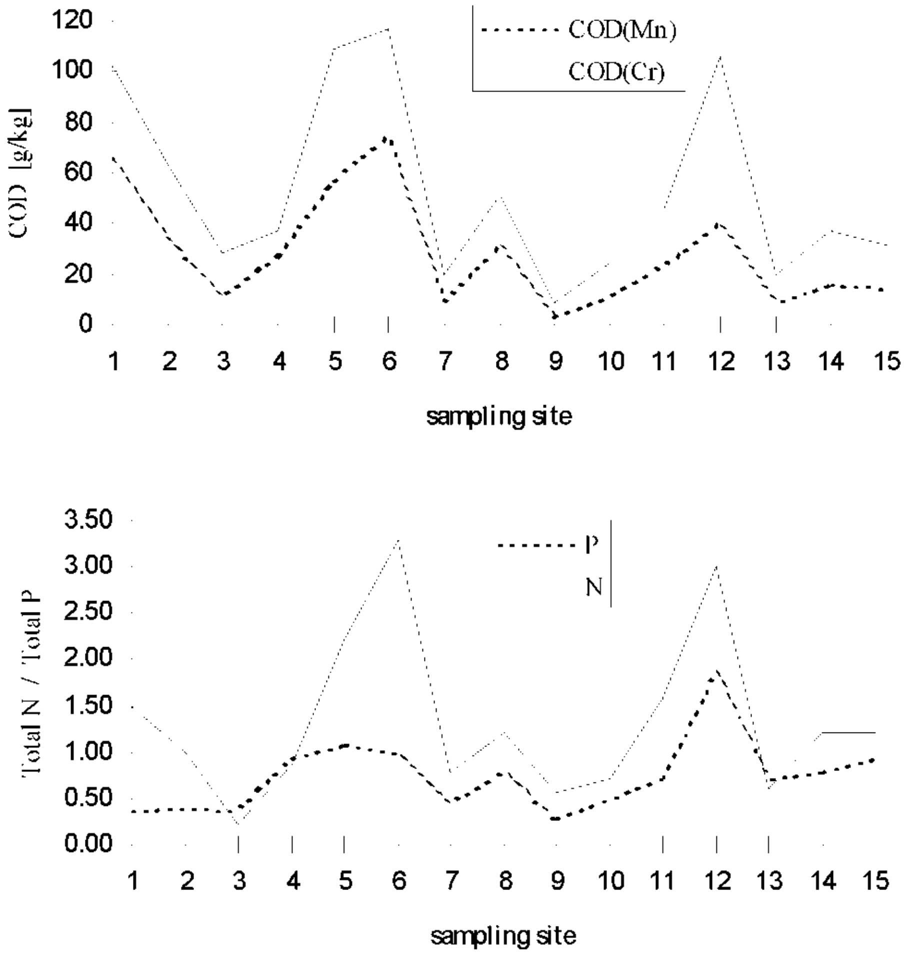

Fig. 9. Chemical oxygen demand and nutrient concentrations in the sediment of Maros (1991)

Metal concentrations, namely Pb and Cu downstream to Aries and Zn, Cu, Pb, Cr, Cd, Hg concentrations downstream to the mouth of Tîrnava were particularly high. Due to the sedimentation of the above-mentioned heavy metals, usually high toxic metal concentrations were produced in the sediment. Spreading of this toxic rediment could be measured on the lower river section as well.

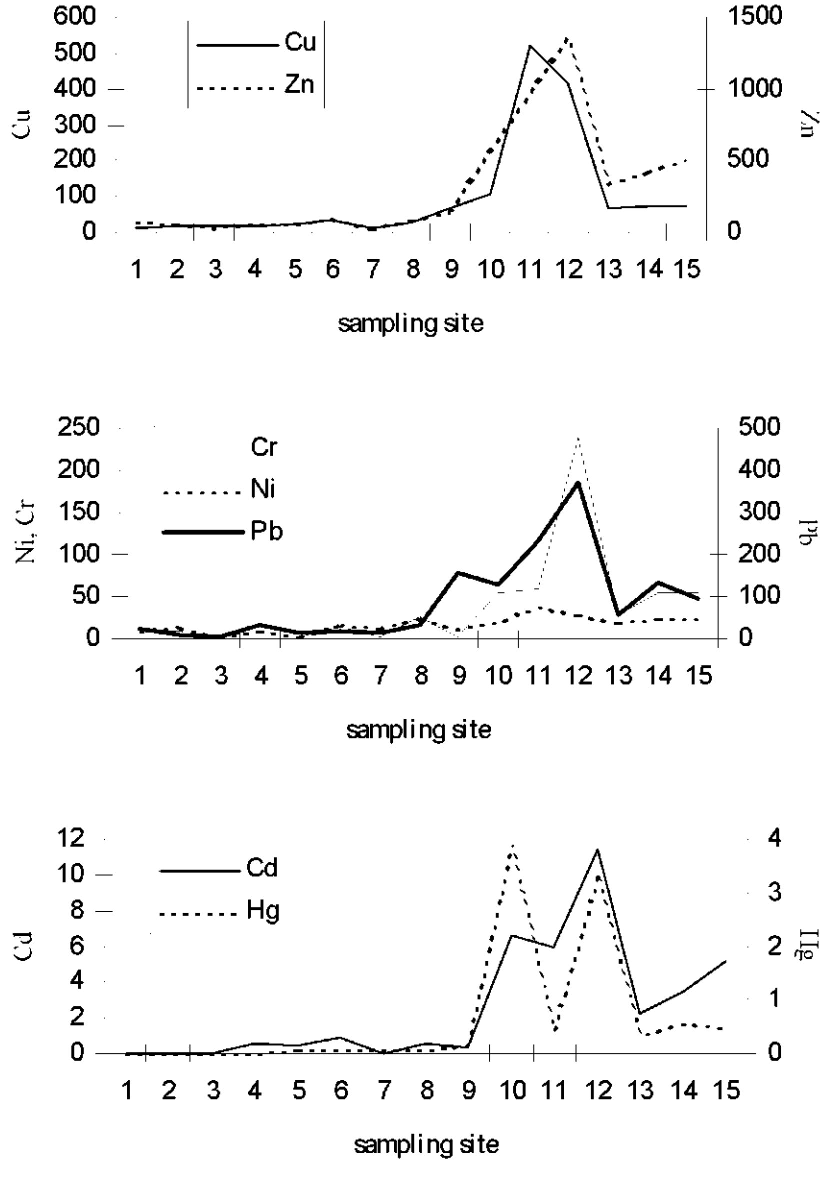

Fig. 10. Heavy metal concentrations in the sediment of Maros (1991)

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