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The water quality state in the middle section of River Tisza, Hungary

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Key words: water quality, cyanide and heavy metal pollution, bioindicator Trichoptera

Abstract. In February–March 2000 cyanide and heavy metal spills entered the River Tisza. In the period of the pollution and after the discharge drifted down, measurements were continuously taken to analyse the water quality state. In the period of the pollution the maximum cyanide concentration was 28.5 times higher than the limit value of the 5th class water quality and maximum heavy metal concentrations were: 440 µg/l Zn, 230 µg/l Pb, and 210 µg/l Cu. The results obtained after the period of the contamination indicated that the water in the Middle Tisza was of first and second class. The Trichoptera as indicators, however, showed that the water quality ranged from the first to the third class as 11% of the species were oligosaprobic, 54.5 % of them beta-mesosaprobic, and 33.5 % of them alpha-mesosaprobic.

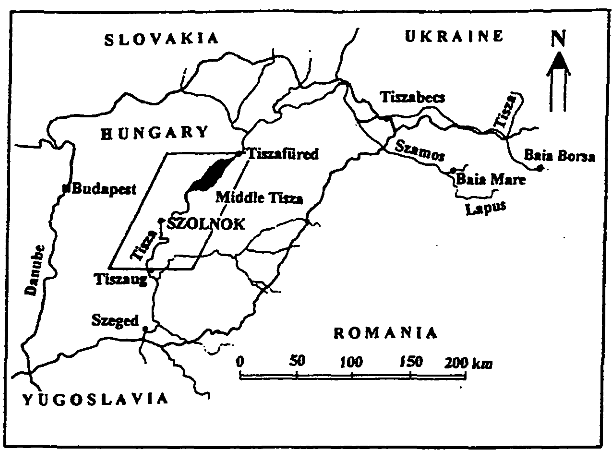

Fig. 1. Map of study area

Introduction

The aim of this paper is to present a documentation of the cyanide and heavy metal pollution and its effects as well as to justify the use of Trichoptera as water quality indicators.

Prior to the pollution, in 1999, the water quality of the Middle Tisza Region (between 433.5 and 267.6 rkm of the Tisza, Fig.1) from Tiszafüred to Szolnok was of second and third class in accordance with the Hungarian standard (MSZ 12749:1993). It was also stated that the water of the river from Szolnok to Tiszaug was more polluted according to certain water quality parameters (ZSUGA et al., 2000). In February-March 2000 cyanide and heavy metal pollution swept along the Tisza River, which, through the trend in the water quality, affected the ecosystem of the river. Nearly 100 thousand m^3 waste water of high cyanide concentration was discharged from the storage pond of the waste waters of the company AURUL (Romania) into the brooks Zazar and Lápos, which belong to the catchment area of the River Szamos. This incident had catastrophic transboundary impacts in Hungary in the Szamos and Tisza rivers. Regarding concentrations the maximum cyanide concentration was in the range of 20-30 mg/l in the Hungarian part of the River Szamos and of 10-15 mg/l in the River Tisza, downstream of the confluence with the River Szamos. Further downstream in the River Tisza the concentration became gradually lower. The maximum cyanide concentration of the Tisza water, when leaving Hungary, was 1.49 mg/l.

In March the dam of the Novac sedimentation pond (Baia Borsa) was broken. About 25,000 tonnes of heavy-metal contaminated sludge/sediment was discharged into Creek Vaser, then to the River Viseu, which is a tributary of the River Tisza.

Methods

Measurements of the concentrations of contaminants were continuous at the time of pollution, other parameters were measured fortnightly by the Middle Tisza Region Environmental Protection Inspectorate. Measurements of the chemical parameters were taken in compliance with the Hungarian and international standards, the evaluations were done in accordance with MSZ 12749:1993 standard.

Total cyanide content was determined in compliance with Hungarian Standard No. MSZ 260-30 (colorimetric measurement upon distillation). This method is essentially the same as that of the international standard ISO 6703.

Regarding the heavy metals, which were associated with the cyanide pollution in various complex forms, the determination of dissolved metal content was made with the atomic-absorption method, mainly for copper, zinc and lead, in compliance with the Hungarian standard MSZ 1484-3. This standard also complies with the relevant international standards.

There is no reference in the specialized literature to the aquatic insects of the Middle Tisza Region as a means of water qualification. Following the cyanide and heavy metal pollution a light trap was set up on the Tisza Dam 20 m from the open water surface near Szolnok and continuously operated from 15 May to 1 October 2000, and from among the indicator organisms the Trichoptera were studied as indicators of the water quality state. It is to be noted that the light trap was two kilometers away from the mouth of the Zagyva River flowing into the Tisza, which may have influenced the number of species and individuals of the captured Trichoptera, as they can live several months and fly considerable distances. Theoretically Trichoptera from the polluted stretch of the Zagyva River could only accentuate the prevalent trend in the water quality of the Tisza River, whereas from the unaffected stretch, they could unaccentuate it. These are only hypotheses, which cannot be justified as they were not investigated. The imagines were identified using MALICKY (1983), for the classification of the trichopteran species into saprobien categories, MOOG (1991, 1995) was used.

Results and Discussion

Chemical analysis

The poisonous tide drifted along the Hungarian stretch of the Tisza between 1 and 12 February 2000. The effect of this cyanide pollution was detectable at Szolnok (340.0 rkm) from 6 p.m. on February 8, and from 8 p.m, the same day, the cyanide concentration sharply increased. A maximum of 2.85 mg/l total cyanide concentration was measured at 4 a.m. on February 9, which was many times higher than the limit value (> 0.1 mg/l) of the 5th class water quality of MSZ 12749:1993 standard.

The cyanide spill took about 70 hours to flow along the Middle Tisza and by 4 p.m. on February 11 the cyanide concentration decreased to under 0.01 mg/l, which was previously characteristic of the Tisza (Fig. 2). The continuous after-analyses showed that the cyanide concentration of the river continued to be under the first class water quality limit value (0.01 mg/l).

In the period of the heavy metal pollution in March, the maximum heavy metal concentrations in the Middle Tisza region were the following: total zinc 440 µg/l, total lead 230 µg/l, and total copper 210 µg/l (Fig. 3). These values compared to those in the stretch of the Upper Tisza were lower by about an order. The dissolved fractions in the Middle Tisza did not reach the characteristic values of the Tisza either. According to the continuous after-analyses the quality of the river considering heavy metal is of first class.

At the time of the heavy metal pollution and after the flood we did metal analyses at several sites in the flood sediment of the river. In the region of Szolnok (340.19 rkm; 336.73 rkm), and below Szolnok, at Tiszavárkony (320.0 rkm) the concentrations measured after the flood, changed in different degrees. The degree of the deposition was likely to be influenced mainly by the local bed and flow conditions, and the big flood in April, which almost totally rinsed through the river.

According to the data of the fortnightly water quality analyses based on other components (pH, conductivity, dissolved oxygen, chemical oxygen demand, ammonium, nitrate, phosphate concentration, and chlorophyll-*a* content), first and second class water quality was characteristic of the river from January-August

2000 (Fig. 4). Sometimes in winter, water quality of third class also evolved.

Trichoptera as indicators of water quality

From among the aquatic insects used as water quality indicators, caddisflies (Trichoptera) render information about the varied water habitats due to their large number of species in the waters of Hungary. The data of the earlier scrap collections (STEINMANN, 1970, UJHELYI, 1971, 1982) and the previous studies (NÓGRÁDI and UHERKOVICH, 1999, UHERKOVICH and NÓGRÁDI, 1997) include a total of 50 caddisfly species for the Hungarian Tisza (KISS, 2000).

According to earlier data, the Trichoptera in the Middle Tisza are represented by the families of Hydropsychidae, Psychomyidae, Ecnomidae, Limnephilidae, Glossosomatidae, Phryganeidae, and Brachicentridae. Species in the families Philopotamidae, Lepidostomatidae, Goeridae, Sericostomatidae and Beraeidae are lacking as they prefer the habitats in springs, streams, rills, and pools with through flowing water in the mountains of medium height.

The sum of the frequency values of the five categories within the saprobien system is 10. From among the 31 species collected, 20 species have been listed in saprobien categories. 16 of these species have high indicator weight (G=3 or 4) and three of them have low indicator weight (G=2). Because of insufficient knowledge due to the scarcity of data, 9 species cannot be listed in any of the saprobien categories (Table 1). 54.5 % of the species are beta-mesosaprobic with *Hydropsyche bulgaromanorum*, *Neureclipsis bimaculata*, *Limnephilus affinis*, *Atripsodes albifrons*, *Ceraclea alboguttata* among them. 33.5 % of the species are alpha-mesosaprobic, e.g.: *Ecnomus tenellus*, *Agraylea sexmaculata*, *Hydroptila sparsa*, *Hydropsyche contubernalis*. 11 % of the species are oligosaprobic, e.g.: *Ithytrichia lamellaris*, *Halesus digitatus*, *Limnephilus lunatus*. 1 % of the species *(Ithytrichia lamellaris)* can also live in xenosaprobic waters and may have come from outside the Tisza River. *Ecnomus tenellus* seems to tolerate polysaprobic waters (Fig. 5). The saprobien indices of the different species are shown in Table 1. Accepting the saprobien system described by MOOG (1991, 1995), we state that the water quality ranged from the first to the third class, i.e. from oligosaprobic through beta-mesosaprobic to alpha-mesosaprobic.

The dominant species of the light trap material were: *Hydropsyche bulgaromanorum* (3127 individuals, with a flight period of May to late September), *Neureclipsis bimaculata* (353 individuals), *Ecnomus tenellus* (187 individuals) and *Oecetis ochracea* (95 individuals). The species left occurred in small or larger numbers (1-10 or 10-100, resp.). It is to be noted that *Hydroptila cornuta*, *Hydroptila sparsa* and *Ithytrichia lamellaris* were collected along the Tisza River for the first time, captured at Szolnok. These species can be considered colouring elements. *Hydroptila cornuta* is new to the trichopteran fauna of Hungary. It can be found in England, Scandinavia, in the north of Germany, Poland, and Italy.

Conclusions

The results of the chemical analyses after the pollution indicated that the water quality of the Tisza River was of first and second class, the biological effect measures, however, showed that 11 % of the species were oligosaprobic, 54.5 % of them beta-mesosaprobic, and 33.5 % of them alpha-mesosaprobic, i.e. the biological water quality ranged from the first to the third class. The above percentages may have been influenced by the number of species and individuals of Trichoptera from the Zagyva River, a tributary of the Tisza River in this region. The 31 species of the captured Trichoptera represent 62 % of the total number of species listed for the total length of the Tisza River in Hungary, which indicates that these aquatic insects have a high chance of survival.

Several measures have been taken to minimize the problems in environmental protection. Simultaneously with the continuous monitoring of the water quality of the Tisza River, a detailed study of its fauna seems indispensable. The Hungarian government also makes important contributions to the systematic implementation of the National Environmental Protection Programme.

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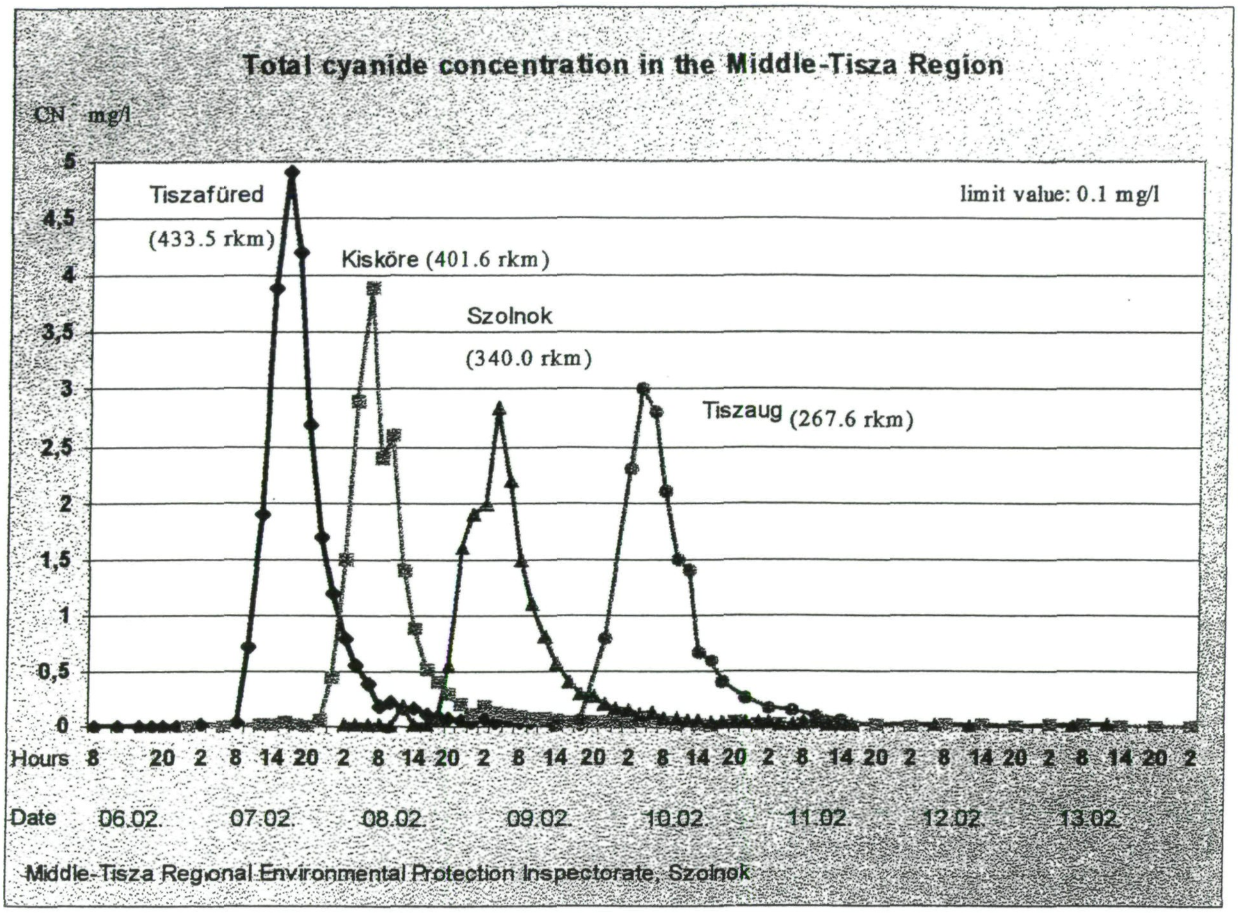
Table 1. Classification of the trichopteran species of the Middle Tisza at Szolnok into saprobien categories described by Moog. += occurrence, -= insufficient knowledge, X= xenosaprobic, O= oligosaprobic, β= beta-mesosaprobic, α= alpha-mesosaprobic, p= polysaprobic, G= indicator weight, SI= saprobien index

	Species captured in a light trap	X	O	β	α	p	G	SI
	HYDROPTILIDAE							
1.	*Agraylea sexmaculata (C., 1834)*	-	-	5	5	-	3	2.5
2.	*Hydroptila cornuta M., 1922*	-	-	-	-	-	-	-
3.	*Hydroptila forcipata (E., 1873)*	-	1	6	3	-	3	2.2
4.	*Hydroptila lotensis M., 1930*	-	-	-	-	-	-	-
5.	*Hydroptila sparsa (C., 1834)*	-	-	6	4	-	3	2.4
6.	*Ithytrichia lamellaris (E., 1873)*	2	6	2	-	-	3	1.0
7.	*Orthotrichia costalis (C., 1834)*	-	2	6	2	-	3	2.0
8.	*Oxyethira tristella K., 1895*	-	-	-	-	-	-	-
	HYDROPSYCHIDAE							
9.	*Hydropsyche bulgaromanorum M., 1977*	-	-	8	2	-	4	2.2
10.	*Hydropsyche contubernalis McL., 1865*	-	-	2	8	-	4	2.8
	POLYCENTROPODIDAE							
11.	*Neureclipsis bimaculata (L., 1758)*	-	1	7	2	-	3	2.1
12.	*Cyrnus crenaticornis (K., 1859)*	-	-	-	-	-	-	-
13.	*Holocentropus picicornis (S., 1836)*	-	-	5	5	-	3	2.5
	PSYCHOMYIIDAE							
14.	*Psychomyia pusilla (F., 1781)*	-	2	5	3	-	2	2.1
	ECNOMIDAE							
15.	*Ecnomus tenellus (R., 1842)*	-	-	3	7	+	4	2.7
	LIMNEPHILIDAE							
16.	*Glyphotaelius pellucidus (R., 1783)*	-	2	4	4	-	2	2.2
17.	*Halesus digitatus (S., 1781)*	-	5	4	1	-	2	1.6
18.	*Limnephilus affinis (C., 1834)*	-	-	-	-	-	-	-
19.	*Limnephilus auricula (C., 1834)*	-	-	-	-	-	-	-
20.	*Limnephilus flavicornis (F., 1787)*	-	-	-	-	-	-	-
21.	*Limnephilus lunatus (C., 1834)*	-	+	+	+	-	-	-
22.	*Limnephilus vittatus (F., 1798)*	-	-	-	-	-	-	-
	LEPTOCERIDAE							
23.	*Ceraclea alboguttata (H., 1860)*	-	1	7	2	-	3	2.1
24.	*Ceraclea dissimilis (S., 1836)*	-	1	7	2	-	3	2.1
25.	*Oecetis notata (R., 1842)*	-	+	+	+	-	-	-
26.	*Oecetis ochracea (C., 1825)*	-	+	6	4	-	-	-
27.	*Setodes punctatus (F., 1793)*	-	-	-	-	-	-	-
28.	*Athripsodes albifrons (L., 1758)*	-	-	8	2	-	4	2.2
29.	*Athripsodes cinereus (C., 1834)*	-	1	7	2	-	3	2.1
30.	*Mystacides longicornis (L., 1758)*	-	-	6	4	-	3	2.4
31.	*Leptocerus tineiformis (C., 1834)*	-	-	5	5	-	3	2.5



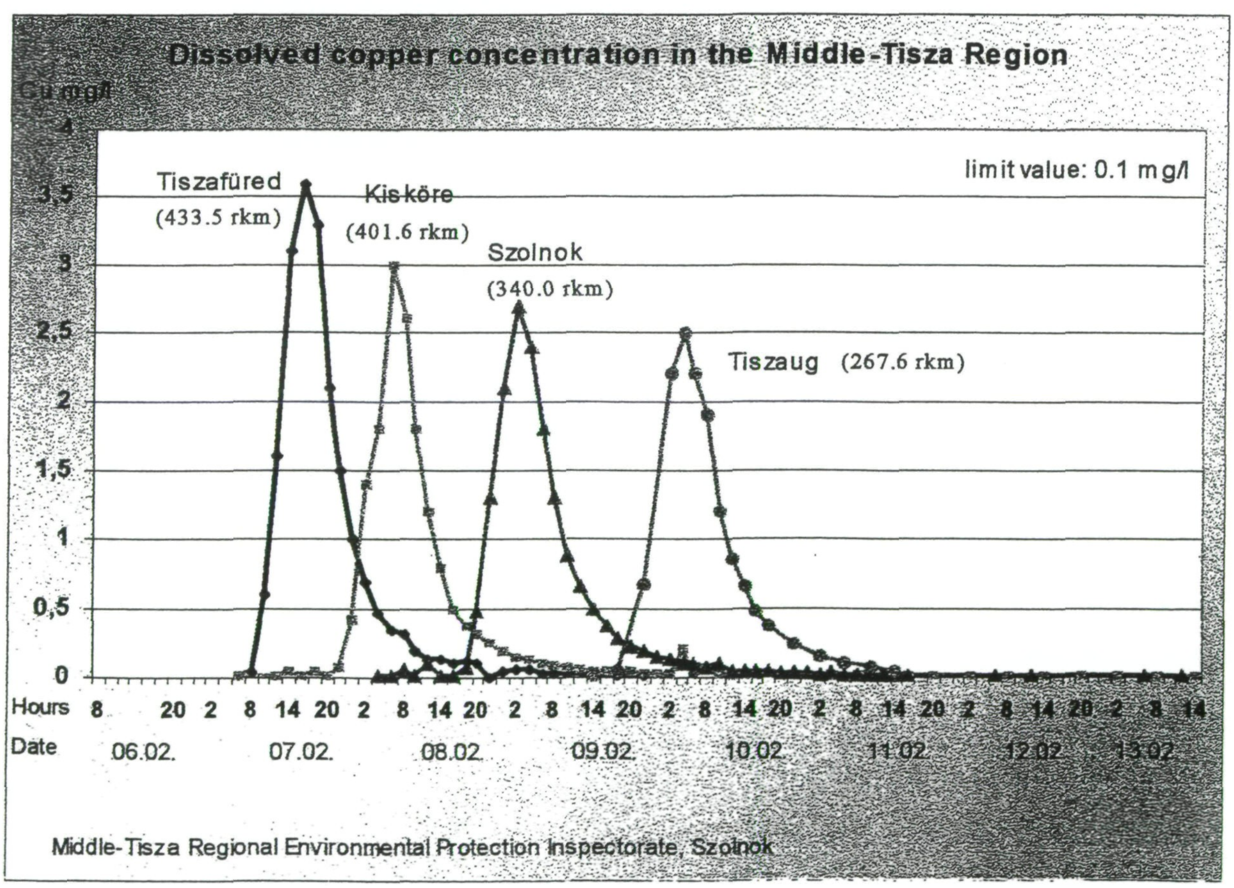


Fig. 2. Water quality in the Middle Tisza at the time of the cyanide pollution

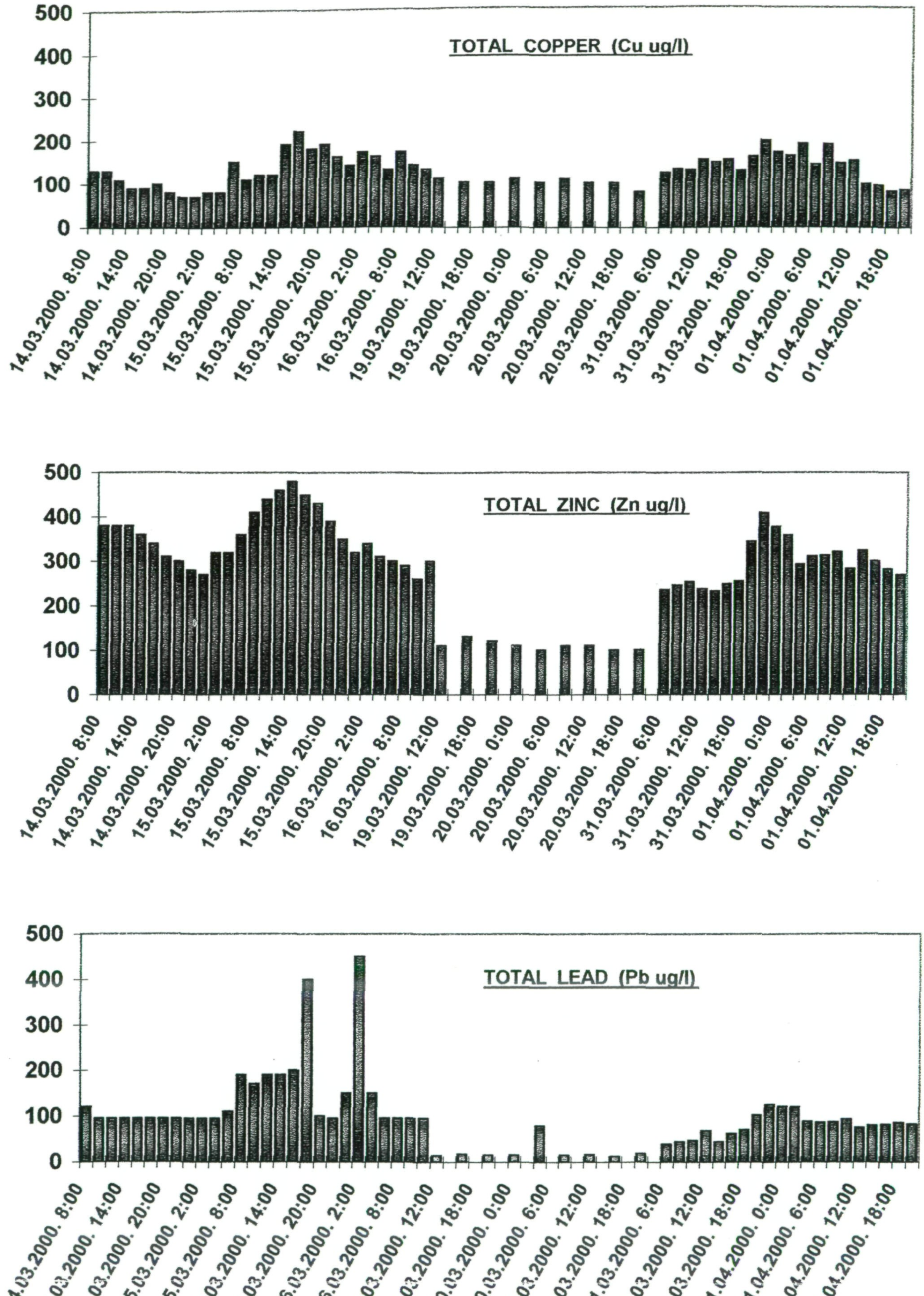


Fig. 3. Concentration of heavy metals at the Middle-Tisza region at 03. 2000.

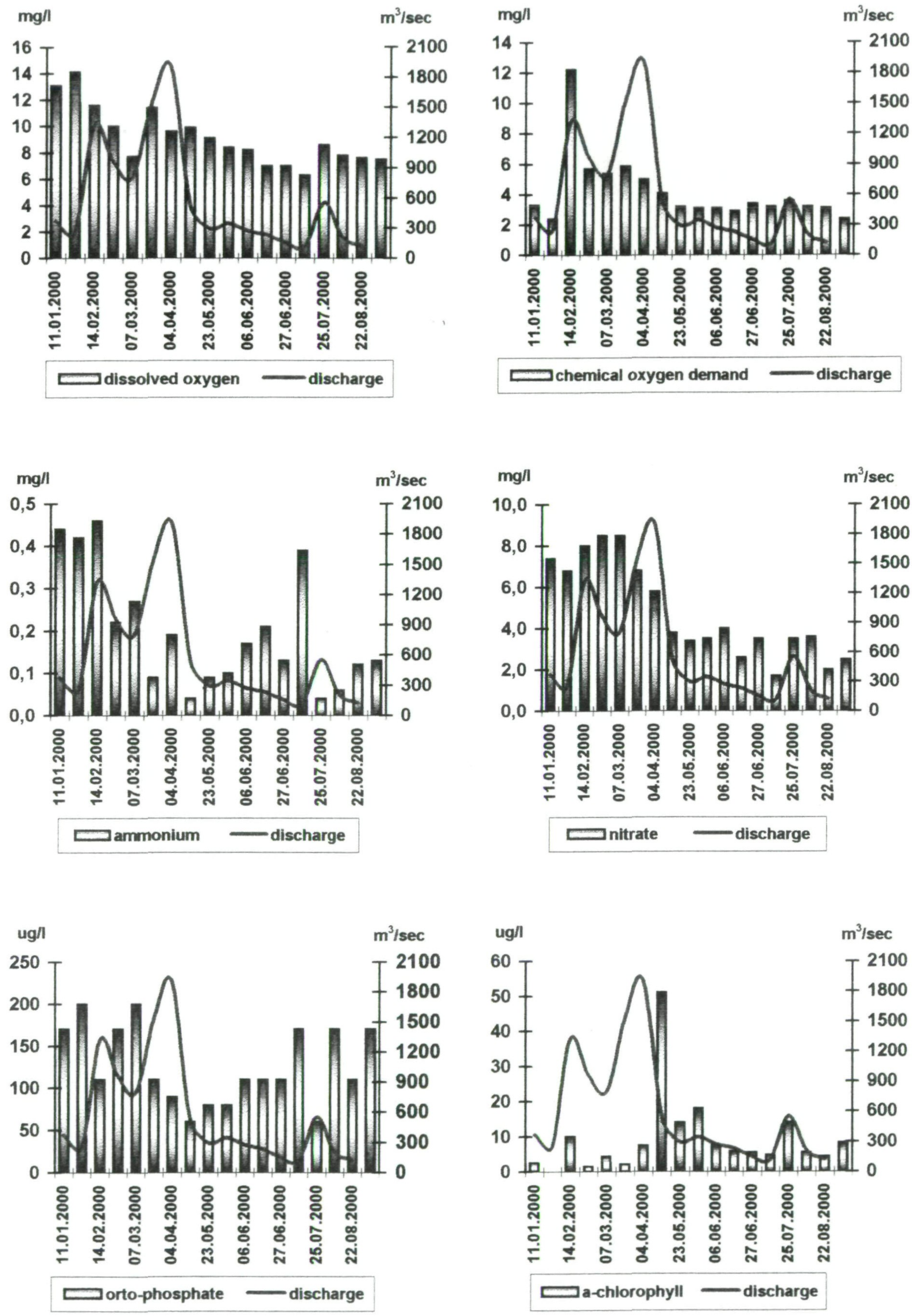


Fig. 4. Trend of some water chemical components in the Middle Tisza at Szolnok

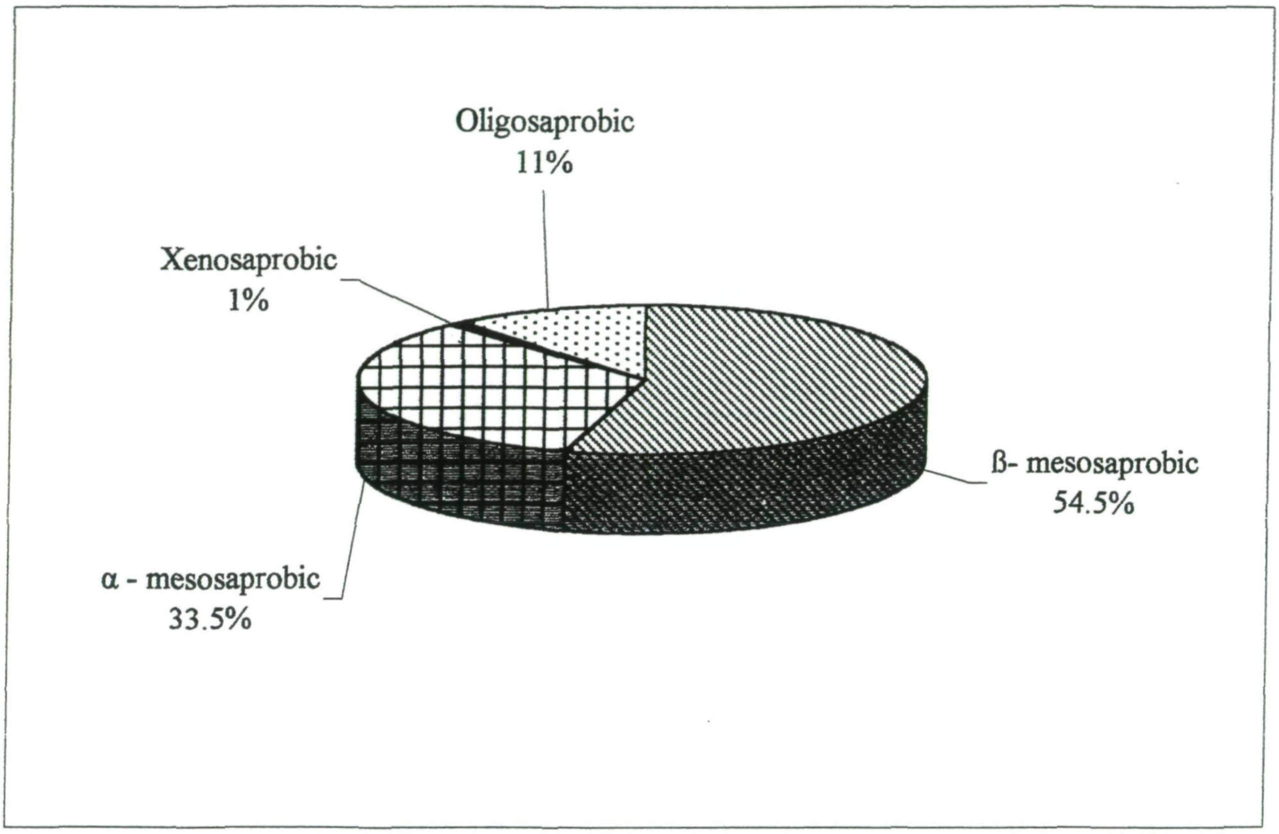


Fig. 5. Distribution of the trichopteran species in the Middle Tisza at Szolnok in accordance with their saprobien values