Bioacumulation of certain heavy metals by unionidae molluscs in Criş/Körös[1] rivers

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Abstract

The authors examined the bioaccumulation of heavy metals (Cu,Zn and Mn) of the unionid shells in Criş/Körös rivers. Altough the unionids are present in abundant populations in these rivers, it was established that their survival is endangered by the high content of xenobiotics.

Keywords: river, Unionidae, heavy metals.

Introduction

The heavy metal content of the natural waters and of the sediments reflects the geochemical particularities of the examined place, their quantities usually do not exceed the tolerable values for the organisms. Due to the human influences the concentration of the heavy metals may increase in the water as well as in the sediment. The aquatic organisms accumulate these elements along the trophic chain. Molluscs are particularly well known as the bioaccumulators of some of these metals (Fuller, 1974; Burky, 1983; Lakatos et all. 1990), taking them either directly from the environment, or indirectly through the food they take up. The metals are reserved in the soft parts of the body as well as in the valves. It is known that the unionida molluscs are great plankton consumers, it was experimentally demonstrated that algae are able to retain the 78 - 98 % of the heavy metal content (in positive relation with the concentration) from culture media during 14 days (Nagy-Tóth and Barna, 1982). Due to these qualities of the unionid molluscs many author suggest their use as bioindicators in this sense and recommend in a particular way the use of gills as indicator organs for the heavy metal bioaccumulation (Salánki et all. 1991).

1 The first name is Romanian, and the second Hungarian.

Fig. 1. Copper content in water, sediment and Unionidae mussels along the Crişul Alb River Valley

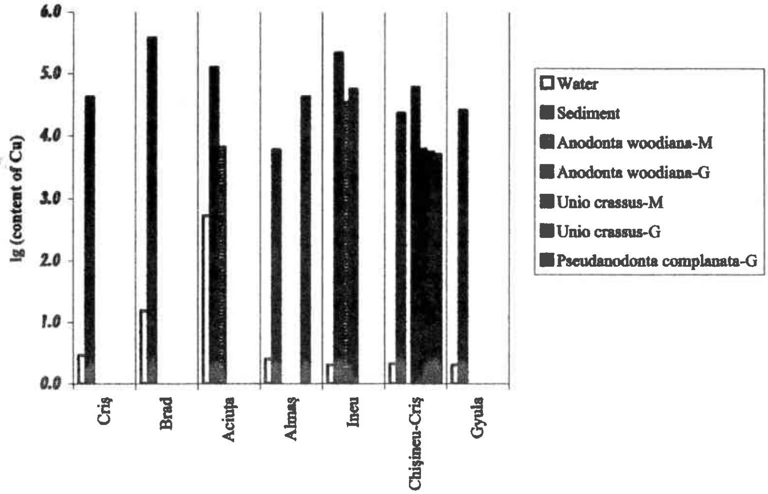
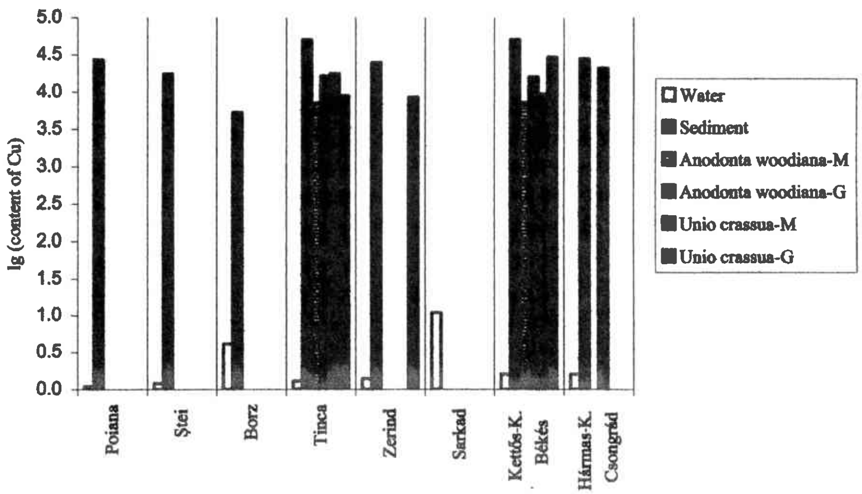


Fig. 2. Copper content in water, sediment and Unionidae mussels along the Crişul Negru, Kettős- and Hármas Körös River"s Vallies



Many studies demonstrate the sub-lethal and lethal toxic effects of these xenobiontics in different organisms, the modification of their metabolism (Nagy-Tóth, 1981) as well as the appearance of certain malformations (Szító, 1994) or other modifications in the cells of different organs, or even the modifications of the nervous system (Serfőző, 1993).

Dévai and his collab. (1993) precise the fact that living organisms are the most adequate and valuable indicators for the presence of heavy metals. At the same time they call attention to the fact that organisms accumulate in different quantity and in a selective way the heavy metals according to their taxonomic affiliation and their habitude, fixing with a great importance the taxonomic groups in bioindication. The above mentioned author exhausts the problem accepting the theory of Juhász-Nagy (1986), exhausting two principal aspects: the inner particularities of the organisms (the inner complex) and the environmental particularities (the exterior complex). The first determines the relation of the organism towards the adequate element or substance, namely the possibilities of the organism to metabolise and to accumulate, as well as the quantities that can be accumulated. These qualities are specific for different species. At the same time the attitude of organisms is specific for different elements and substances. In this context the exterior complex contains geochemical particularities of the environment and the environmental pollution.

The indicator value of the aquatic organisms is more obvious in the case of the temporary and pollution, in which neither the water nor the sediments contain an excessive quantity of pollutant, but the organisms still bear the sign of modifications produced by them (Moore - Ramamoorthy 1984, ap. Dévai, 1993).

Because the disappearance of the unionid shells from the lower reach of the Mureş river, along a 420 km section (Sárkány-Kiss, 1992) was caused exactly by the high concentration of the heavy metals. We consider an adequate proposal that the loading degree of the aquatic organisms with xenobiontics should be introduced as a parameter of danger degree for the aquatic communities, even if they are still numerous and in apparently undamaged populations. Dévai and his collab. (1993) suggest for this parameter the term "perniciousness". These considerations led us in our preceding paper (in this volume) to consider the unionide mollusc populations "vulnerable" in the Criş/Körös rivers.

Materials and Methods

At the same time with studying the unionid mollusc associations on the rivers Crişul Alb/Fehér-Körös and Crişul Negru/Fekete-Körös, in June 1994 a material was also collected for the determination of the heavy metal content at those collecting stations where the abundancy of these organisms permitted it. Taking into consideration the different

Fig. 3 .Zink content in water, sediment and Unionidae mussels along the Crişul Alb River Valley

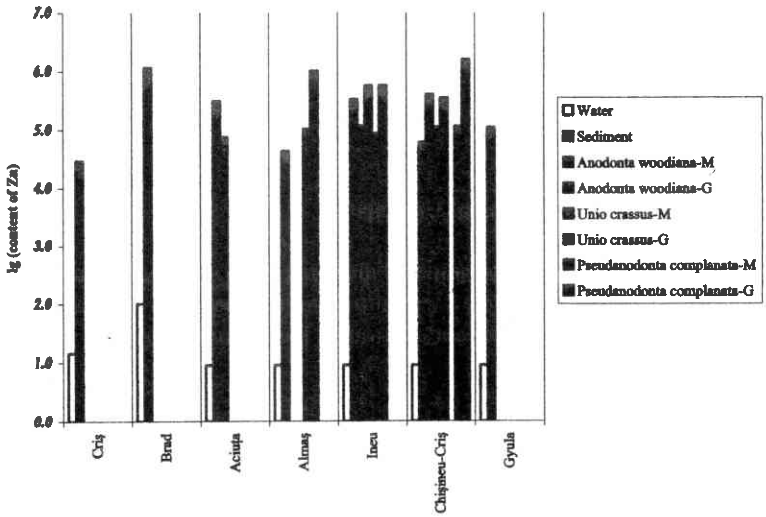
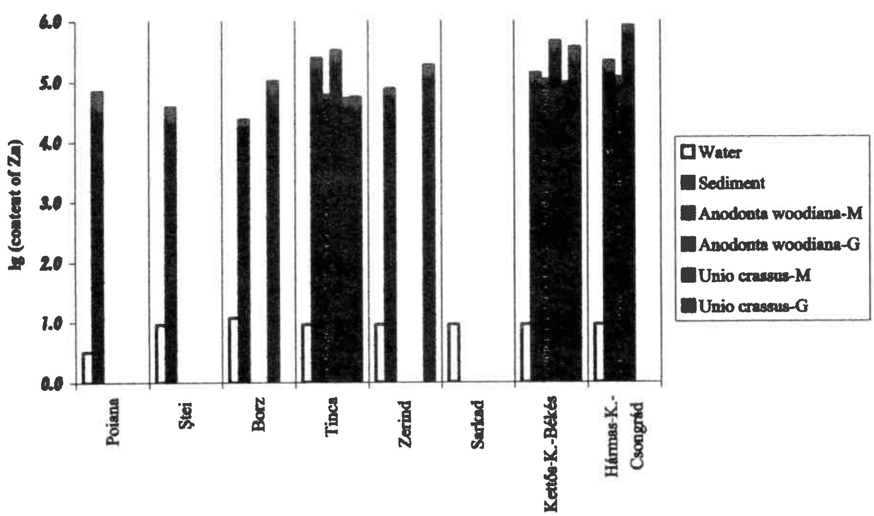


Fig. 4. Zink content in water, sediments and Unionidae mussels along the Crişul Negru, Kettős- and Hármas Körös Rivers Vallies



accumulation of the metals in different organs (Wachs, 1985), after determining the species we separately collected the branchiae and the muscles. The collected and analysed samples were approximately at the same age. The prepared material was dried in a disinfector (10 - 105 °C) in the camp. So our results are related to the dry material of the organs.

The determination of the heavy metals were performed in the analytical labs of the Chemistry Faculty at the "Babeş-Bolyai" University using atomic absorbtion spectrophotometers.

Results and Discussions

Analysing the copper content of the water, the sediments and of the unionid shells in the rivers Crişul Alb, Crişul Negru, Kettős-Körös and Hármas-Körös, the Crişul Alb is primarily remarkable with its far higher metal concentrations in every studied reaches. Otherwise the copper is considered one of the most toxic elements and at the same time is easily accumulated by the majority of the organisms (Wachs, 1985). Observing the results from the Table 1. and 2. and the diagrams from the Fig. 1. and 2. we notice as well the great differences between the copper content of the water and of the sediment. In general the copper content of the unionides is less than the copper content of the sediment. Only one exception was made at the collecting station Aciuţa where the branchiae of the Anodonta woodiana species contain an approx. 3 times higher quantity than it exists in the sediment. We especially observe the great differences between the concentration of the water and the different unionide species that contain from 13 to 600 times more copper than the water does. The values are generally higher in the branchiae, but in some cases the copper content of the muscles exceeds the content of the branchiae. The concentrations are lightly higher in the case of the A. woodiana species and with a little bit lower in the case of Unio crassus and Pseudanodonta complanata species.

Taking into consideration the zinc concentration (Table 3., 4., Fig. 3., 4.) in the water and the sediment, we also found higher values in the case of the Crişul Alb than the Crişul Negru. The unionidae species zinc bioaccumulation is more accentuated than that of the copper, this result confirms the data of the bibliography (Wachs, 1985). In all cases the zinc content in these organisms exceeds the concentrations of the sediment. At the same time we observe more higher concentrations in the branciae than in the muscles. The greatest capacity of bioaccumulation was noticed at the Pseudanodonta complanata species at the station Chişinău-Criş (9 μg/l in the water; 59 800 μg/kg in the sediment; 113 130 μg/kg in the muscles and 1 563 510 μg/kg in the gills). The decreasing order of the species concerning the bioaccumulation is: A. woodiana and U. crassus.

The manganese has no noxious effects, on the contrary is an element of vital importance, but we found a very great bioaccumulation in our samples (Tab. 5., 6., Fig. 5.,

Fig. 5. Mangan content in water, sediments and Unionidae mussels along the Crişul Alb River Valley

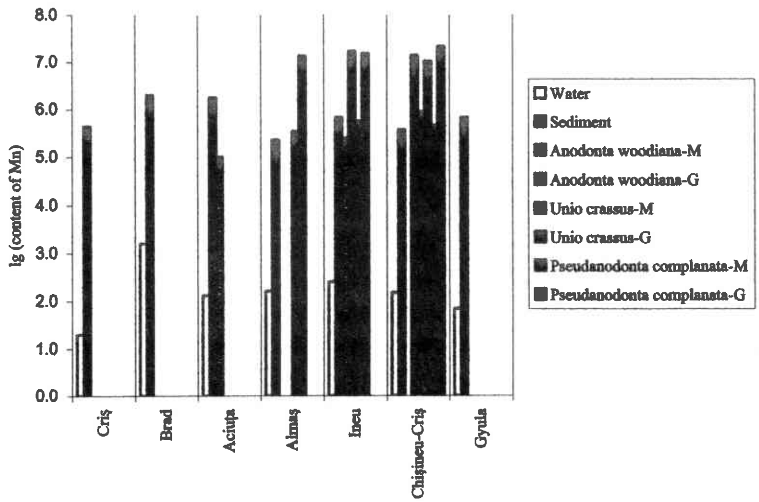
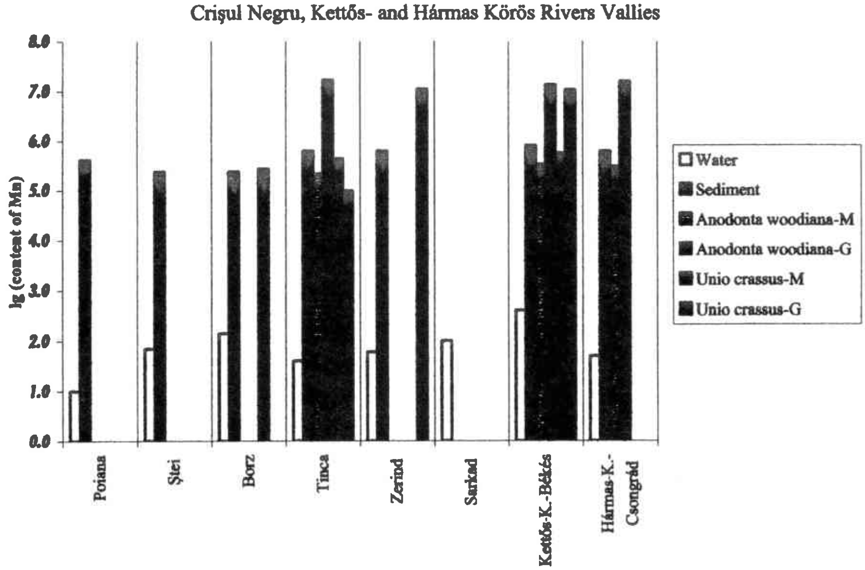


Fig. 6. Mangan content in water, sediments and Unionidae mussels along the Crişul Negru, Kettős- and Hármas Körös Rivers Vallies



6.). In the rivers Crişul Alb and Crişul Negru the manganese exists in great quantities in the water and in the sediments, but the concentrations at the unionids, especially in the gills, may exceed from 20 to 60 times the concentrations in the sediments. Serfőző (1995) maintains the fact that the manganese might function like an antistressor against the toxic effect of the heavy metals. Since it is not known the biochemical mechanism of such a process we indicate only our registered values without any other interpretations.

In the years 1994 and 1995, in autumn, at the collecting station Ineu on the Crişul Alb we noticed 10 % and respectively 20 % of mortality without observing other sign of pollution. We consider that these populations at Ineu are at their lethal limits due to the heavy metal accumulation. Taking into consideration the fact that also a very low heavy metal concentration, only 1 µg/l, can impede the 90 - 100 % of the respiration and of the metabolic processes (shellfishes close their suctorial organ and interrupt the filtration) the danger represented by the water concentrations is very obvious and this effect is more accentuated for the young entities in the rivers Criş/Körös (Sîrbu and Sárkány-Kiss, unpublished data).

Conclusions

In the rivers Crişul Alb, Crişul Negru, Kettős-Körös and Hármas-Körös the unionid populations by their high Cu and Zn contents may be considered to be endangered by disappearance.

In the case that protection measures will not be taken these highly valuable elements of the fauna in natural clearing of the waters will disappear without a trace likewise in the case marked by us on the lower reach of the river Mureş/Maros.

Table 1.

Cu	Criş	Brad	Aciuţa	Almaş	Ineu	Chişineu-Criş	Gyula
Water (μg/l)	2.9	15.3	536	2.5	2	2.1	2
Sediment (μg/kg)	42100	377900	126200	6000	217200	23400	26000
Anodonta woodiana-M (μg/kg weight)			6620		34450		
Anodonta woodiana-G (μg/kg weight)					56680	60990	
Unio crassus-M (μg/kg weight)						6070	
Unio crassus-G (μg/kg weight)				42600		5530	
Pseudanodonta complanata-G (μg/kg weight)						5040	

Table 2.

Cu	Poiana	Ştei	Borz	Tinca	Zerind	Sarkad	Kettős K.-Békés	Hármas K.-Csongrád
Water (μg/l)	1.1	1.2	4.1	1.3	1.4	10.9	1.6	1.6
Sediment (μg/kg)	27000	17500	5300	50300	24600		50900	27900
Anodonta woodiana-M (μg/kg weight)				7070			7250	
Anodonta woodiana-G (μg/kg weight)				16300			15990	21090
Unio crassua-M (μg/kg weight)				17520			9380	
Unio crassua-G (μg/kg weight)				8890	8470		29110	

Table 3.

Zn	Criş	Brad	Aciuţa	Almaş	Ineu	Chişineu-Criş	Gyula
Water (µg/l)	14.5	100	9	9	9	9	9
Sediment (µg/kg)	29300	1139200	307000	42400	328100	59800	107200
Anodonta woodiana-M (µg/kg weight)			73780		115580	396610	
Anodonta woodiana-G (µg/kg weight)					557720	109320	
Unio crassus-M (µg/kg weight)				101910	85800	343790	
Unio crassus-G (µg/kg weight)				997570	559840		
Pseudanodonta complanata-M (µg/kg weight)						113130	
Pseudanodonta complanata-G (µg/kg weight)						1563510	

Table 4.

Zn	Poiana	Ştei	Borz	Tinca	Zerind	Sarkad	Kettős K.-Békés	Hármas K.-Csongrád
Water (µg/l)	3.2	9	11.7	9	9	9	9	9
Sediment (µg/kg)	69800	37800	23400	242600	75800		137000	216400
Anodonta woodiana-M (µg/kg weight)				59400			106240	115990
Anodonta woodiana-G (µg/kg weight)				322830			453190	804580
Unio crassus-M (µg/kg weight)			101620	52520			95010	
Unio crassus-G (µg/kg weight)				55100	185950		363470	

Table 5.

Mn	Criş	Brad	Aciuţa	Almaş	Ineu	Chişineu-Criş	Gyula
Water (µg/l)	20	1590	130	160	250	150	70
Sediment (µg/kg)	439050	1995400	1765500	224600	678200	367200	675300
Anodonta woodiana-M (µg/kg weight)			100240		243940		
Anodonta woodiana-G (µg/kg weight)					16949150	13755870	
Unio crassus-M (µg/kg weight)				338760	561830	894430	
Unio crassus-G (µg/kg weight)				13332420	15001110	10321170	
Pseudanodonta complanata-M (µg/kg weight)						456400	
Pseudanodonta complanata-G (µg/kg weight)						21304270	

Table 6.

Mn	Poiana	Ştei	Borz	Tinca	Zerind	Sarkad	Kettős K.-Békés	Hármas K.-Csongrád
Water (µg/l)	10	70	140	40	60	100	400	50
Sediment (µg/kg)	411400	235700	236200	619200	614100		802800	619100
Anodonta woodiana-M (µg/kg weight)				211840			332830	301330
Anodonta woodiana-G (µg/kg weight)				16802820			13458960	15797040
Unio crassus-M (µg/kg weight)			269080	434170			556800	
Unio crassus-G (µg/kg weight)				96560	10990150		10597160	

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