

TRACE ELEMENTS IN STREAM SEDIMENTS OF TWO SMALL FORESTED CATCHMENTS

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ABSTRACT

Content and forms of Fe, Mn, Be, Cd, Co, Cr, Cu, Ni, Pb, and Zn in the sediments of two small streams from forested areas in the Central Bohemia were studied to evaluate the influence of underlying rocks, the anthropogenic impact of atmospheric emissions and the mobility of these elements.

EXPERIMENTAL

Characteristics of the studied areas are given in the table 1.

Table 1.

catchment	Lesní potok	Mlynářův Luh
location	30 km SE from Prague	40 km WSW from Prague, 60 km SE from major coal-fired power plants in NW Bohemia
area (km ²)	0,7	2,1
elevation (m a.s.l.)	495 - 400	546 - 400
mean annual discharge (l.s ⁻¹)	3,2	4.9
annual precipitations (mm)	635	515
underlying rocks	biotitic granite (Říčany and Jevany type)	porphyric and fluidal palaeorhyolites

Table 2 compares the content of the above mentioned elements in rocks and corresponding stream sediments, fractions $-0,063$ mm (Skřivan 1988, Vejnar 1974, Černý 1989). The only input of matter into the studied forested catchments besides the weathering of rocks is the atmospheric deposition. The magnitude of this input can be estimated from the annual precipitation and the total amount of these elements in the wet and dry deposition, which is shown in the table 3. (Selected data for the nearest locality to Lesní potok - Sojovice - according to Škoda 1988, data from the station Truba, valid also for the catchment Lesní potok, represent the soluble portion of the elements only. Data for Mlynářův Luh

ording to Dvořáková 1989).

Table 2.

catchment element	Lesní potok		Mlynářův Luh	
	average content of studied element in ppm = g.t ⁻¹			
	rock	sediment	rock	sediment
Fe	18.10 ³	10-22.10 ³		
Mn	0,8.10 ²	4-10.10 ²		
Be	12-13	10-15		
Cd		0,3-2,0		
Co	< 5	10-33		
Cr	30	80-100		
Cu	4-5	15-23		
Ni	<10	35-50		
Pb	40-84	90-150		
Zn	25-33	100		

Table 3.

catchment station of sampling	Lesní potok		Mlynářův Luh
	Sojovice	Truba	Mlynářův Luh
	content in $\mu\text{g.l}^{-1}$ = ppb		
Be	0,01	<0,2	0,06
Cd		<5	0,16
Cu	13,4	13,0	1,23
Pb	21,0	12,0	7,07
Zn	110,0	80,0	24,0

The fate of the elements held in stream sediments, especially their ability to remobilize, depends on their speciation, i.e. on the forms in which they are bound in this environment. The basic information gives us the sequential extraction technique - SET - (Tessier 1979, Letovská 1989, Skřivan 1988), which enables us to distinguish 5 basic forms of elements: A- loosely bound to the solid matter, B- bound in carbonates, C- bound in the oxhydroxides of Mn and Fe, D- bound in organic matter, and E- strongly bound or incorporated in the structures of remaining rock-forming minerals and accessories. The results of the SET of sediment samples originating from the two catchments, are summarized in the

table 4 (Skřivan 1988, Letovská 1989).

Table 4.

catchment		Lesní potok					Mlýnářův Luh				
element	ratio of each form of element from its total content (%)										
	form	A	B	C	D	E	A	B	C	D	E
Fe		0	0,4	37,5	4,2	57,9	0	0	11,9	2,8	85,3
Mn		12,4	7,6	70,3	4,7	5,0	3,1	7,1	62,1	6,3	21,4
Be		4,7	18,0	37,3	6,7	33,3	0	7,2	34,6	13,9	44,3
Cd		40,3	7,5	9,8	0	42,4	10,5	6,8	12,6	4,1	66,0
Co		5,7	3,5	26,3	8,3	56,2	1,2	1,6	22,4	14,8	60,0
Cr		0	1,1	3,3	6,6	89,0	0	0,2	0,3	6,8	92,7
Cu		0,4	0,9	1,7	18,7	78,3	0,4	0,8	1,1	18,7	79,0
Ni		12,2	4,3	11,6	7,9	64,0	2,7	3,0	18,6	13,7	62,0
Pb		2,6	4,7	18,2	3,8	70,7	2,6	3,5	4,0	11,9	78,0
Zn		6,9	3,4	26,4	12,3	51,0	1,7	6,1	27,4	8,3	56,5

The forms A, B, C, and D are apt to remobilize under changing conditions - ~~through the increase in ionic strength of the corresponding water~~, through the change in its pH and redox conditions. The total amount of these four forms is thus very important especially in case of the physiologically toxic trace elements such as Be, Cd, Cr, Cu, and Pb. From this point of view, in our case, the amount of extractable Be, which is present mainly in the form bound to the oxohydroxides of Fe and Mn is important. The comparison of the concentration of Fe and Mn with that of Be (and also of Cd, Co, Ni, and Zn) shows strong correlation of the content of Mn with the mentioned trace elements. The remobilization of these metals thus occurs under reducing conditions (low redox potential) in the sediment, caused mainly by the decomposition of organic matter. The remobilization is also supported by the low pH due to the acid precipitations. This can be seen in the next table 5, showing the content of dissolved forms of selected elements in surface water of catchments Lesní potok and Mlýnářův Luh in comparison with that of Jevanský brook, adjoining to the first mentioned catchment and flowing from prevailingly an agricultural region.

It remains to answer the question of the origin of the studied trace metals and to evaluate the share of atmospheric deposition, influenced by the anthropogenic emissions. From the tab. 1 and

It is possible to estimate the yearly input of the elements into the catchments through the atmospheric deposition, and from the tab. 1 and 5. the output through the surface waters (in soluble forms). The corresponding numbers are presented in the table 6.

surface water	Lesní brook		Jevanský brook	Mlynářův Luh brook
pH of water	5,03	4,95	7,84	7,49
element	content of the dissolved forms in $\mu\text{g.l}^{-1} = \text{ppb}$			
Be	6	6	< 0,2	$\leq 0,3$
Cd	< 5	< 5	< 5	0,01-0,09
Cu	18	4	< 2	0,4 - 3,1
Pb	< 2	< 2	< 2	0,21-1,25
Zn	20	10	10	6 - 44
Mn	100	110	110	5 - 134
Fe	40	60	30	2 - 31

catchment	Lesní potok		Mlynářův Luh	
element	yearly input (output) in g.yr^{-1} per catchment area			
	input (deposition)	output (surface water)	input (deposition)	output (surface w.)
Be	4,5	610	65	≤ 46
Cu	$6,0 \cdot 10^3$	$0,4-1,8 \cdot 10^3$	$1,3 \cdot 10^3$	$0,1-0,5 \cdot 10^3$
Pb	$5,3-9,3 \cdot 10^3$	$< 0,2 \cdot 10^3$	$7,6 \cdot 10^3$	$< 0,1-0,2 \cdot 10^3$
Zn	$3,6-4,9 \cdot 10^4$	$0,1-0,2 \cdot 10^4$	$2,6 \cdot 10^4$	$0,1-0,7 \cdot 10^4$

CONCLUSIONS

From the above mentioned data it is possible to state the following conclusions:

1. The content of Mn, Zn, (Cu, Ni, Co) in sediment is higher than that of the corresponding rock.
2. There is a strong correlation of the content of Be, Co, Ni, Zn, (Cd) in sediment with that of Mn.
3. The elements Cr, Cu, Pb, Ni, Co, and Zn in sediments are predominantly strongly bound in the debris of rock-forming minerals and in accessories.

4. The prevailing extractable form of Zn, Ni, Co, Be (Fe and Mn) is that bound to oxohydroxides, Cu and Cr are connected with organic matter.
5. The output of Be through surface water of the catchment Lesní potok (even only in the dissolved forms) strongly exceeds its atmospheric input, which leads to the conclusion that this element is probably not anthropogenically accumulated in the studied sediments, its main source in the surface water being the weathering of the lithosphere. The results also indicate that this is not the case of Cu, Zn, and especially Pb.

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