TENYEARSOFMONITORINGTHEATMOSPHERIC INPUTS AT THE ČERNOKOSTELECKO REGION, CENTRAL BOHEMIA*

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Concentration and fluxes of As, Be, Cd, Cu, Mn, Pb and Zn in bulk atmospheric precipitation and in three kinds of throughfall were studied in the Černokostelecko region, central Bohemia throughout the time period 1990–1999. Fluxes (in $mg.m^{-2}.yr^{-1}$) were calculated from more than 2600 elemental analyses of samples collected monthly. Fluxes of the elements in bulk atmospheric precipitation on an open place are generally lower than the median values for the Czech Republic. Since 1995 they have shown markedly decreasing tendency except for Mn, which here partly originates in the metabolites of the forest vegetation. The fluxes of As and Cu have been reduced by more than 70%, of Pb and Zn by more than 65% and 50%, respectively, Similar characteristics were observed in the mixed forest-, beech- and spruce throughfall. Higher fluxes of the elements in throughfall originate in the tree metabolism and/or in the scavenging of the near- surface atmospheric aerosol. It was proved that Cu and Zn mainly come from the latter source. The paper also discusses differences between the two applied sampling procedures of throughfall and the advantages of the new collectors equipped with glass impactor cones, which protect samples against contamination by solid debris.

monitoring; trace elements; As, Be, Cd, Cu, Mn, Pb, Zn; deposition; atmospheric precipitation; trends; central Bohemia; anthropogenic contamination

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INTRODUCTION

Atmospheric inputs of chemical compounds into the terrestrial ecosystems represent significant and often problematic flux of matter which has been severely affected by various human activities (Nriagu, Pacyna, 1988). The deposition of solid, liquid and gaseous chemical substances, above all the toxic trace elements and strong inorganic acids, seriously affects the natural biogeochemical cycling of matter in the environment (Nriagu, 1989). In the Czech Republic, as well as in other Central-European countries, emissions from power plants burning low quality coal, from heavy industry and road traffic have posed serious threat for the environment, as well as for the human population, throughout the second half of the 20th century (Bencko et al., 1995; Moldan, Schnoor, 1992). These hazards resulted in growing concern for the quality of environment and they invoked various programs focused on study and monitoring the contamination extent of its individual components and matter fluxes (Fottova, 1989; Anonymous, 1998).

The broader Cernokostelecko region and especially the area of the State Nature Reserve "Voděradské bučiny" forest was selected in late 80's as a typical model landscape for the biogeochemical study of cycling of selected major, minor and trace elements and for the evaluation of their natural and anthropogenic sources in the environment (Minařík et al., 1998, 1999; Skřivan, Artner, 1989; Skfivan, Vach, 1993; Skřivan etal., 1995, 1996, 1997, 1999). Study of atmospheric inputs of elements (bulk atmospheric precipitation in an open place) started in 1989 and it was gradually supplemented by sampling of the precipitation below the tree canopy (the mixed forest-, beech- and spruce stand throughfall).

The up to now time span of monitoring thus covers three important processes which have profound positive effect on the quality of atmospheric immissions: the deep national economy restructurisation including the reduction of heavy industry output, gradual and complete desulphurisation of large power plants burning low quality brown coal, and remarkable decrease in consumption of leaded gasoline.

MATERIAL AND METHODS

Methods of sampling and sample processing

Sampling of the bulk atmospheric precipitation in an open place has been in operation monthly since May 1989 at the experimental station Truba and since May 1996 at Arboretum into a set of four and three collectors, respectively. Both sites arc facilities of the Faculty of Forestry, the Czech University of Agriculture (see Fig. 1). Samples of the mixed forest throughfall were collected into a set of 9 VOSS collectors (see lower) evenly distributed on a 20 m x 20 m square plot from May 1993 until October 1996 at the locality Truba near the locality of the bulk precipitation sampling. The sampling plot involved beech (*Fagus sylvatica* L.), oak (*Quercus robur* L.), birch (*Betula pendula* L.), lime (*Tilia platyphyllos* L.), larch (*Larix deciduous* L.), spruce (*Picea abies* L. Karst), and pine (*Pinus sylvestris* L., *Pinus nigra* *I..).* *To* obtain more precise information on the throughfall chemistry compatible with the published data, 4 VOSS + 4 GCTC (see lower) samplers were installed in the beech (+ hornbeam) growth. Another 9 VOSS + 4 GCTC samplers were placed in coniferous growth of spruce, which arc the typical tree species of the Voděradské bučiny National State Reserve. Sampling of the beech throughfall has been in progress since April 1994, and of spruce throughfall since December 1996 at the northern tip of the "Lesní potok" catchment (see Fig. I).

Procedures of the hulk precipitation- and throughfall sampling were described elsewhere (Skřivan, Vach, 1993: Skřivan et al., 1999). The collectors of bulk precipitation determined for the study of trace elements content consist of a IL polyethylene bottle equipped with glass funnel 12 cm in diameter inserted into the cap of the bottle. The funnel is protected from hirds hy a casing made from another 5L polyethylene bottle turned upside down, with walls cut in a sawtooth pattern.The mouth of the glass funnel is protected from falling organic dehris and insects by a small glass bubble. Samples of throughfall were originally collected in polyethylene (PE) VOSS collectors developed in the Czech Geological Survey, Prague. The collectors consist of a polyethylene (PE) funnel (1 1.X cm in diameter) whose upper rim is arranged in a sawtooth pattern to protect samples from contamination by birds. The lower mouth of the funnel is equipped with a nylon sieve and it is screwed up with the double PE screw to IL PE sampling bottle The collectors possess several disadvantages that were discussed by Skřivan and Burian (1996). Since 1996 the samples of throughfall have been collected simultaneously in new GCTC (Glass Cone Throughfall Collector) devices described in detail by Skřivan et al. (1999). Glass conical bulb, serving as an impact target of the throughfall drops, represents the main innovative element of the collector. The bulb is placed onto a cylindrical PE holder where it is carried by eight small PE hooks turned down into the cylinder. Drops of throughfall caught on the conical part of the bulb flow down on its surface and enter the inner space of the bolder through a narrow gap between the rim of the cylinder and the bulb. The liquid then flows down into the collecting IL vessel through the double PE screw cap equipped with small glass funnel. The pipe of the funnel is sealed with a hollow glass ball, which automatically opens when liquid starts pouring in. Construction of these new collectors, contrary to the VOSS collectors, prevents the contamination of liquid samples by leaching of retained organic material (fallen leaves, needles and organic debris) and allows better collection of solid atmospheric aerosol. More than three years of experience with the GCTC collectors proved their suitability for the throughfall sampling.

All the 1 L PE sampling bottles are carefully washed (hot distilled water, 0.5% HNO_3, distilled and redistilled water). For the bulk precipitation sampling, 2.5 ml of diluted (22% v/v) HNO_3 (Merck, Suprapur) were inserted in each sampling bottle to prevent the adsorption of dissolved forms of elements onto the walls of the sampling bottle. It is necessary to point out that the acid also dissolves part of the elements bound to the solid particles. The analyzed liquid part of samples obtained after their membrane filtration in a laboratory, represents the sum of dissolved elements in the precipitation together with the forms of the elements weakly bound to the solid particles of the deposition. Bulk precipitation samples for determination of the conductivity, laboratory pH measurements and bulk chemical composition were collected separately.

The bottles were transported in sealed PE bags to the laboratory and weighed to determine the volume of the liquid. The samples were then filtered using a 0.45 pm membrane filter. The filtrate was stored at +4 °C in a cooler until the analysis. In the case of throughfall, aliquots of samples prepared for the trace element determination were acidified (after the bulking of the average throughfall samples by volume), and after 1 day they were filtered through the membrane filters.

Analyses of bulk atmospheric precipitation and throughfall were performed at the laboratory of the Geological Institute, Academy of Sciences of the Czech Republic. Concentration of studied minor and trace elements was determined (in case of Be after sample preconcentration by evaporation) using the atomic absorption spectrometry (AAS, VARIAN SpectrAA 300), by flame- or graphite furnace technique. Content of arsenic was determined by the hydride-generation technique, using the same AA Spectrometer.

RESULTS AND DISCUSSION

The monitoring results of atmospheric input of seven trace- and minor elements are summarized in Tables I to VII. The selection covers a set of the typical elements, which enter the atmosphere as a result of human activities. As, Be, Cd, Cu, and Zn are present mainly in the emissions from coal combustion and smelting processes. Emissions from the road traffic burning the

I. Input of the elements through bulk atmospheric precipitation, locality Truba (PT) (in $\mu g.m^{-2}.yr^{-1}$)

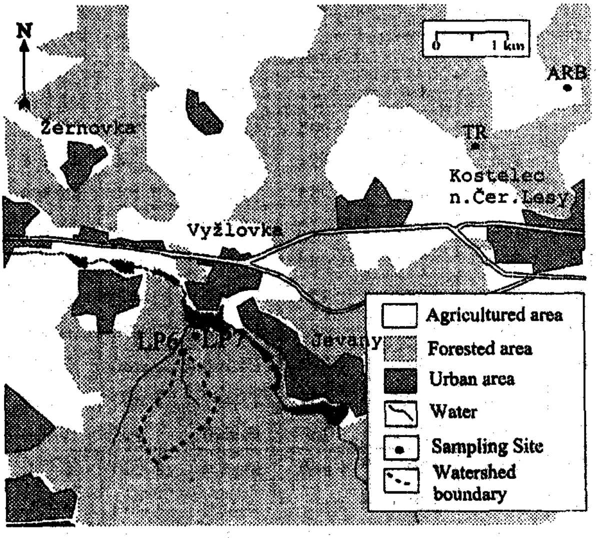
Source	Hydrol. year	Element						
		As	Be	Cd	Cu	Mn	Pb	Zn
1	1990	n.d.	n.d.	n.d.	668	11 900	2 430	56 400
1	1991	n.d.	n.d.	n.d.	891	8 520	2 080	47 400
1	1992	n.d.	n.d.	n.d.	955	10 800	2 290	16 700
1	1993	452	n.d.	n.d.	1 130	14 900	3 240	7 100
1	1994	1 360	33.4	78.8	1 230	14 000	3 410	8 900
1	1995	1 720	39.9	103.0	1 250	13 100	2 460	10 700
1	1996	925	20.0	105.0	922	12400	2 830	6 640
1	1997	563	15.8	30.8	377	12 100	2 280	5 270
1	1998	331	14.0	37.4	351	23 400	1600	5 010
1	1999	272	4.08	25.1	260	10 800	812	4 790
2	1990-1992	4 200	90.0	470	4 800	15 000	11 000	41 200
3	1998	n.d.	n.d.	120.0	n.d.	9 040	1 560	23 200
4	1995-1997	n.d.	n.d.	130	3 500	n.d.	3 300	14 000
5	1990	460	57.0	106	1 180	2 360	3000	6 780

For Tabs. I and II:
1 – own results
2 – mean values for the Czech Republic in 1990-1992 (Beneš, 1994)
3 – median values for the Czech Republic (CHMI, 1998)
4 – rural areas in England and Wales (Mott et al., 1998)
5 – mean values in rural areas of Norway, 1990 (Berg et al., 1994)

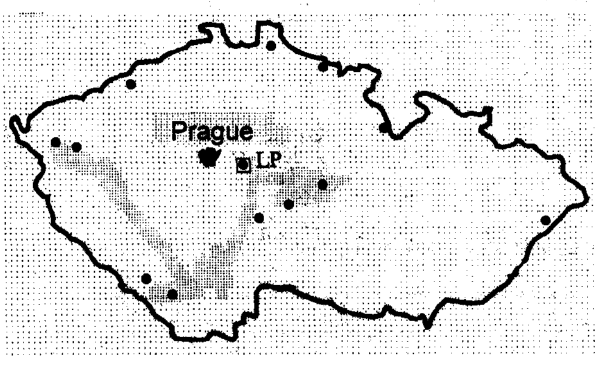
II. Input of the elements through bulk atmospheric precipitation, locality Arboretum (PA) (in $\mu g.m^{-2}.yr^{-1}$)

Source	Hydrol. year	Element						
		As	Be	Cd	Cu	Mn	Pb	Zn
1	1996*	387	18.3	70.3	651	9 125	1 860	5 020
1	1997	418	12.5	30.2	659	8 870	1 600	5 840
1	1998	263	13.1	36.2	362	14 000	1 100	4 310
1	1999	154	3.49	20.0	158	6 250	507	2 970
2	1990-1992	4 200	90.0	470	4 800	15 000	11 000	41 200
3	1998	n.d.	n.d.	120.0	n.d.	9 040	1 560	23 200
4	1995-1997	n.d.	n.d.	130	3 500	n.d.	3 300	14 000
5	1990	460	57.0	106	1 180	3 2 360	0 0	6 780

* measured since May, recounted for the whole year



1. Sampling localities at the Cernokostelecko region



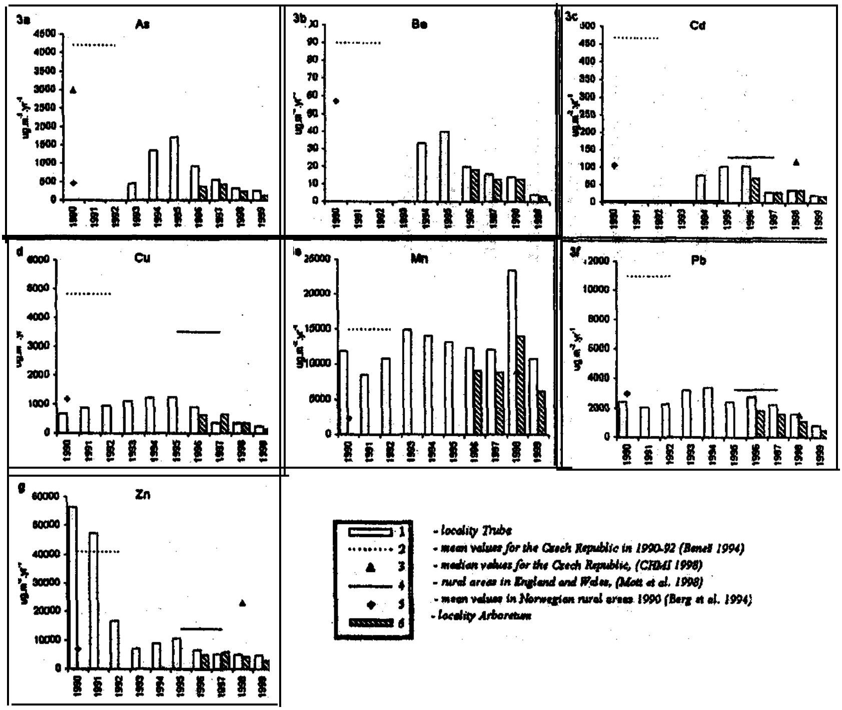
2. Network of the bulk precipitation- and through-fall monitoring in the Czech Republic, managed by the Czech Geol. Survey, Prague

full dots: sampling sites of the CGS
squared dot (LP): area of sampling localities at Cernokostelecko

leaded gasoline represent the main source of Pb (Nriagu, Pacyna, 1988). Manganese belongs to the group of elements, which are essential in the metabolic processes of the living organisms. It is thus strongly cycled by the forest trees.

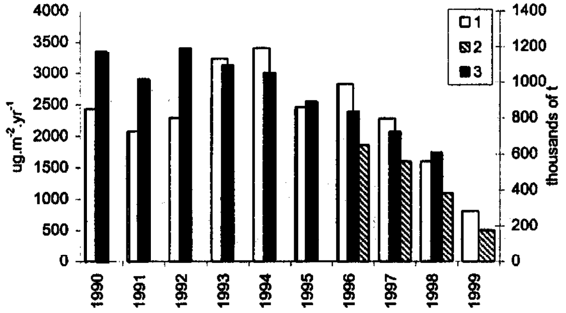
Bulk atmospheric precipitation

Tables I and II present annual (hydrological years) fluxes of the elements in bulk atmospheric precipitation studied at sampling localities Truba and



3a–g. Fluxes of the elements in bulk precipitation compared with other data

Arboretum of the Czech Agricultural University near Kostelec n. Č. lesy (see Fig. 1). For comparison both tables contain mean values of the fluxes in the Czech Republic during **1990–1992**, presented by B en e š (1994). Tables also include median values obtained in the Czech Geological Survey (**Český** Geologicky **Ústav**) network of sampling stations in 1998 (Czech **Hydrome**teorological Institute 1998, see also Fig. 2). Last two rows of the tables contain data from the low-contaminated areas in Europe (rural areas in Great Britain /England, Wales/ and in Norway, respectively). Our numbers for **1995–1999** generally show progressively decreasing tendency in all elements except for the manganese. The trends are shown in Figs. 3a to 3g. They correspond to the declared emission trends of the major solid air pollutants in the Czech Republic (CR), which decreased between the years 1987 and 1997 by 89.85% (Anonymous, 1999). Decrease of the Pb deposition flux, observed and discussed already in 1993 (**S** k ř i v a n , V a c h , **1993**), **corre-**



4. Deposition fluxes of Pb at Truba and Arboretum compared with the sales of leaded gasoline in the Czech Republic
1 – Sampling site Truba ($\mu g\ Pb.m^{-2}.yr^{-1}$)
2 – Sampling site Arboretum ($\mu g\ Pb.m^{-2}.yr^{-1}$)
3 – Sales of leaded gasoline in CR (thousands of t)

lates with the trend of leaded motor gasoline sales in the CR, which is shown in Fig. 4 (Anonymous, 1999). Comparison with the data of others shows that fluxes of Zn in the Cernokostelecko region corresponded to the mean of the Czech Republic in 1990-1992, whether our fluxes of Cu and Pb were much lower in those years. On the other hand, our fluxes of Cd and Zn monitored in both the localities in 1998 are much lower than the median values for the CR, fluxes of Pb being similar. Monitored fluxes of the essential element Mn in the Cernokostelecko region are high and they are evidently affected by the character of surrounding landscape. Sampling devices are located in forest clearings, so that the samples may have been spoiled by small droplets of througfall during the precipitation events occurring during the windy weather. This effect was discussed and presented previously (S k ř i v a n et al., 1995). The monthly Mn-concentrations at Truba in two cases (in 6/91 and 2/98) more than 15times exceeded the mean of the remaining annual values. This was probably caused by the contamination of samples by organic debris eluates. The two erratic primary values were therefore eliminated. In spite of this, flux of Mn in 1998 at both sites is the highest. Nevertheless, with respect to anthropogenic contamination, the localities Truba and Arboretum should be characterized as relatively clear. Considerable drop in the deposition of all technogenic elements (As, Be, Cd, Cu, Pb and Zn) in the last five years, caused by the restructurisation of Czech industry, desulphurisation of large power plants and the decrease in consumption of leaded gasoline, makes our last four data comparable with those of the Norwegian rural areas in 1990 (B erg et al., 1994).

Precipitation below the tree canopy (the throughfall)

This elemental flux is resulting from the chemical composition of bulk precipitation and its interaction with the tree canopy. The above-ground part of trees, with its large surface area, scavenges fine particles of the wet and dry near-ground atmospheric aerosol. The reactive atmospheric gases (SO_2, NO_x etc.) are also adsorbed by the tree canopies. Beside this, the assimilation organs of trees (leaves and needles) exclude part of the metabolized elements, entering the tree tissues through the root uptake. Part of all these substances is washed out of the tree canopy during the precipitation events, and the wet deposition becomes thickened by the evapotranspiration. Resulting throughfall is consequently enriched in a number of chemical elements in comparison with those present in the corresponding wet precipitation. On the other hand, part of several trace elements (mostly of anthropogenic origin) is present inside the fine particles of poorly soluble solid aerosol, which remains in the tree canopies, attached to the assimilation organs and the elements enter the ground only with the litterfall.

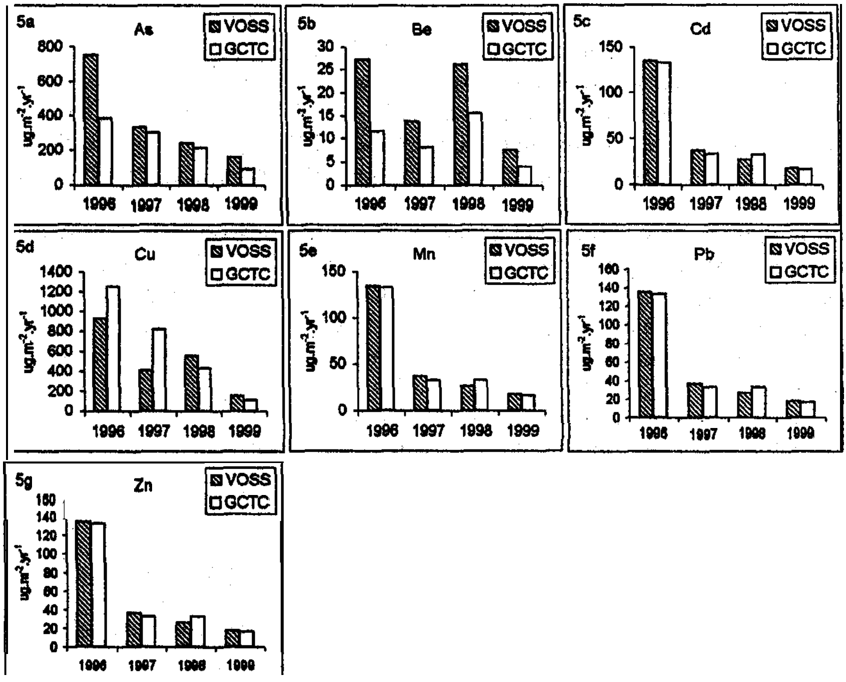
Tables III to VII summarize the values of atmospheric fluxes caused by the individual kinds of throughfall, which were collected by two types of collectors with differing characteristics. The tables contain values of the elemental fluxes in throughfall and their ratios to the corresponding values of the bulk precipitation collected at site Truba, which covers the whole time - span of the monitoring. Values of the ratios may be interpreted as the enrichment factors for the individual elements in throughfall.

The mixed forest througfall (Table III) was collected into the VOSS collectors close to the sampling site of the bulk precipitation, locality Truba. More than three years of monitoring clearly show the enormous, probably metabolic (Heinrichs, Meyer, 1980) flux of Mn (with values of the enrichment factor higher than 40). It has also revealed the moderate enhance-

III. Input of the elements through the mixed-forest throughfall (ThM) locality Truba (VOSS samplers) (in $\mu g.m^{-2}.yr^{-1}$)

Hydrol. year	Element						
	As	Be	Cd	Cu	Mn	Pb	Zn
1993*	n.d.	174	n.d.	4 600	973 000	942	107 000
1994	567	32.2	143	1 820	570 000	871	19 300
ThM/PT	0.42	0.96	1.81	1.48	40.7	0.26	2.17
1995	1 750	27.2	176	1 940	589 000	914	18 200
ThM/PT	1.02	0.68	1.71	1.55	45.0	0.37	1.70
1996	832	27.2	159	1 450	615 000	600	19 600
ThM/PT	0.90	1.36	1.51	1.57	49.6	0.21	2.95

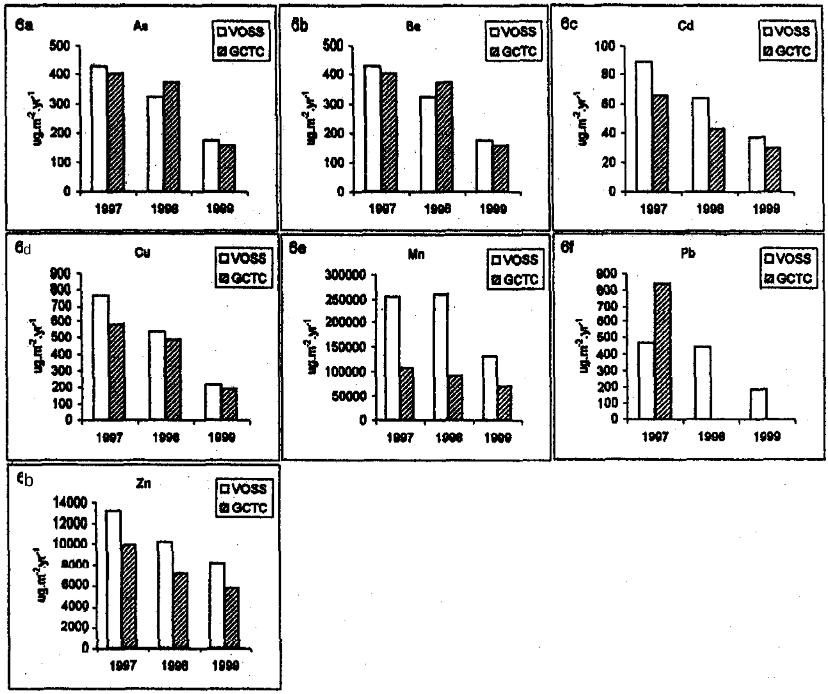
* measured since May, recounted for the whole year



5a–g. Fluxes of the elements in beech throughfall, locality LP6, sampled by the VOSS and GCTC collectors

ment of Cu and Zn, which are the two other essential and/or anthropogenic elements in throughfall. Enhanced flux of Cd, which is a toxic trace element with chemical characteristics similar to Zn, is also remarkable. On the other hand, the toxic trace element Pb (and to a lesser extent possibly As) is (are) partly retained in the form of poorly soluble solids in the tree canopies.

Values of the annual element fluxes in the beech throughfall collected at the "Lesní potok" catchment into both the VOSS and GCTC collectors are presented in Tables IV and V and their magnitudes are compared in Figs. 5a to 5g. Main characteristics of fluxes of the individual elements are similar to those of the mixed forest throughfall, but the enhancement in fluxes of Mn, Cu and Zn is lower, as it corresponds to lower density of the tree crowns at the sampling locality. This is evident above all for Mn. It must be noted that the evaluated fluxes and enrichment factors of Be and Cd in beech throughfall (as well as in bulk precipitation) are affected by the fact, that part of the



6a–g. Fluxes of the elements in spruce throughfall, locality LP7, sampled by the VOSS and GCTC collectors

primary (concentration) data of these elements was below the detection limit of the analytical determination. The retention of As and Pb in the tree crowns is verified here. Comparison of the amount of fluxes of the strongly metabolized Mn unambiguously denotes the positive error of the determination in samples obtained by the VOSS collectors. The error is caused by additional leaching of organic material, caught in the funnels of the collectors.

The observed characteristics of the individual element fluxes, as well as of the sampling techniques, are more evident in comparison of Tables VI and VII, showing the results of monitoring the spruce throughfall at the "Lesni potok" catchment. Fluxes evaluated from samples collected both by the VOSS and GCTC devices are again compared in Figs. 6a to 6g. The denser canopies of the spruce growth ensure thorough contact of the raindrops of wet precipitation with the tree surface, which results in higher intensity of the phenomena described above. The VOSS collectors always provide higher

IV. Input of elements through beech throughfall **(ThBV)** at Lesni **potok** locality LP6 (VOSS samplers) (in $\mu g.m^{-2}.yr^{-1}$)

Hydrol. year	Element						
	As	Be	Cd	Cu	Mn	Pb	Zn
1994*	333	32.8	66	1 470	101 000	1 490	11 200
1995	1 540	31.9	87.9	1 530	111 000	1 210	10 600
ThBV/PT	0.895	0.799	0.853	1.22	8.47	0.492	0.991
1996	752	27.3	135	928	108 000	844	13 400
ThBV/PT	0.813	1.37	1.29	1.01	8.71	0.298	2.02
1997	334	13.7	37	414	63 500	314	6 040
ThBV/PT	0.593	0.867	1.20	1.10	5.25	0.138	1.15
1998	240	26.1	26.9	554	106 000	179	4 740
ThBV/PT	0.725	1.86	0.719	1.58	4.53	0.112	0.946
1999	156	7.51	18.0	151	41 600	167	4 140
ThBV/PT	0.572	1.84	0.717	0.582	3.85	0.206	0.864

* measured since March, recounted for the whole year

V. Input of elements through beech throughfall **(ThBG)** at **Lesní potok,** locality LP6 (GCTC samplers) (in $\mu g.m^{-2}.yr^{-1}$)

Hydrol. year	Element						
	As	Be	Cd	Cu	Mn	Pb	Zn
1996*	384	11.5	133	1 250	80 300	963	6 940
1997	300	8.06	33.0	822	44 300	885	7 420
ThBG/PT	0.53	0.51	1.07	2.18	3.66	0.39	1.41
1998	213	15.5	32.8	431	68 100	599	5 190
ThBG/PT	0.64	1.11	0.88	1.23	2.91	0.37	1.04
1999	92.1	3.92	18.4	110	32 900	229	3 860
ThBG/PT	0.34	0.96	0.73	0.42	3.05	0.28	0.81

* measured since April, recounted for the whole year

fluxes of the trace elements, which could have been either of anthropogenic or metabolic origin. Comparison of the corresponding values concerning As is ambiguous, and in Pb it was not possible because the GCTC collectors were contaminated by this element in December 1997 by shooting.

The question of Cu and Zn origin, which were mostly found in higher amounts in throughfall is complicated due to the fact, that they are both metabolized and cycled by the vegetation. They also enter the atmosphere as

VI. Input of elements through spruce throughfall (ThSV) at Lesní potok locality LP7 (VOSS samplers) (in $\mu g.m^{-2}.yr^{-1}$)

Hydrol. year	Element						
	As	Be	Cd	Cu	Mn	Pb	Zn
1997	432	25.5	89.6	768	255 000	468	13 200
ThSV/PT	0.77	1.61	2.91	2.04	21.07	0.21	2.50
1998	322	22.2	63.7	534	260 000	439	10 200
ThSV/PT	0.97	1.59	1.70	1.52	11.11	0.27	2.04
1999	175	10.6	37.3	217	130 000	183	8 120
ThSV/PT	0.64	2.60	1.49	0.84	12.04	0.23	1.70

VII. Input of elements through spruce throughfall (ThSG) at Lesni potok locality LP7 (GCTC samplers) (in $\mu g.m^{-2}.yr^{-1}$)

Hydrol. year	Element						
	As	Be	Cd	Cu	Mn	Pb	Zn
1997	404	13.3	65.7	582	107 000	842	9 910
ThSG/PT	0.718	0.842	2.13	1.54	8.84	0.369	1.88
1998	374	11.7	43.2	489	91 400	n.d.*	7 190
ThSG/PT	1.13	0.836	1.16	1.39	3.91		1.44
1999	158	8.28	29.8	193	70 600	n.d.*	5 790
ThSG/PT	0.581	2.03	1.19	0.744	6.54		1.21

* not evaluated, contaminated by shooting

a result of anthropogenic activities. Observed marked decrease of their deposition fluxes in past 4 years must be caused by reduction of their inputs into the atmosphere. If there exists significant metabolic flux of the elements in throughfall, then the decrease should have been more pronounced in the bulk precipitation fluxes, as the contribution of the metabolites in throughfall in the individual years should remain constant. It varies only in the course of the individual growing seasons. The ratios of fluxes by throughfall to bulk precipitation then should gradually increase. This tendency was not observed and the flux ratios of Cu and Zn in both beech- and spruce throughfall actually decrease. This fact leads to the conclusion, that majority of these two elements in throughfall come from the scavenged above-ground atmospheric aerosol.

The direct statistical comparison of the validity of results obtained by two (VOSS and GCTC) sampling procedures of throughfall is not possible with respect to numerous factors, which affect the composition of samples and the evaluation of the elemental fluxes. Nevertheless, the new GCTC collector prevents spoiling of samples by the fallen organic material leaching and also it does not sample solid forms of the precipitation (hail and snow) which do not interact with the tree surface. These two advantages of the GCTC collectors guarantee, that they provide us more realistic information about the chemistry of the throughfall.

CONCLUSIONS

The study of As, Be, Cd, Cu, Mn, Pb and Zn inputs through the bulk atmospheric precipitation and throughfall has yielded the following results:
- Fluxes of elements in bulk precipitation are lower than their median values of the Czech Republic.
- Flux of Mn in bulk precipitation is affected by the throughfall from surrounding forest vegetation.
- Since 1995 the fluxes of As and Cu in bulk precipitation have been reduced by more than 70%, of Pb and Zn by more than 65% and SO%, respectively.
- Fluxes of the elements in throughfall are generally higher and they reflect the density and character of the corresponding tree crowns.
- Enhanced fluxes of the elements in throughfall result from the scavenged near-surface atmospheric aerosol and/or from the metabolites of trees washed out of their assimilation organs.
- Main Cu and Zn source in studied kinds of throughfall is the solid atmospheric aerosol.
- The comparison of the two used throughfall collectors (VOSS and GCTC) has shown two main advantages of the latter:
  - i. The VOSS type generally yields higher fluxes, in spite of the fact that it collects also the solid state - wet precipitation, which does not interact with the tree surface. Higher fluxes of elements result from the leaching of solids entrapped in the collecting funnels.
  - ii. The construction of the new GCTC collectors ensures that they do not sample the solid precipitation, which is not the true throughfall.

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SKŘIVAN, P. - NAVRÁTIL, T. - BURIAN, M. (Geologický bstav, Akademie věd České republiky, Praha, Česká republika):

Deset let monitorování atmosférických srážek na Cernokostelecku ve středních Čechách.

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Práce pojednává o látkových tocich As, Be, Cd, Cu, Mn, Pb a Zn v celkové atmosférické depozici a ve třech typech srážek pod korunami stromů (throughfallu), které byly studovhy v letech 1990-1999 na Černokostelecku ve středních Čechách. Toky, vyjádřené v $\mu g.m^{-2}.r^{-1}$, byly vypočítány na základě vice než 2 600 analytických stanoveni prvků ve vzorcich shromažďovaných v jednoměsíčních intervalech. Vstup prvkh depozici na volné ploše je obecně nižší než medián odpovidajicich hodnot pro Českou republiku. Od roku 1995 vykazuji toky výrazně sestupnou tendenci s výjimkou Mn, který zde dilem pochází z metabolitů lesnich stromů. Tak látkové toky As a Cu se snížily o vice než 70 %, Pb o vice než 65 % a Zn o vice než 50 %. Podobné charakteristiky byly zjištěny take v podkorunových vzorcich srážek získaných ve smíšeném lese a pod korunami buku a smrku. Vyšší toky prvků v podkorunových srážkách dílem pocházejí z metabolic lesnich stromů, dilem jsou výsledkern záchytu tuhého aerosolu z přízemních vrstev atmosféry. By10 prokázáno, že hlavnim zdrojem Cu a Zn je atmosférický aerosol. V práci jsou dále diskutovány rozdily mezi dvěma paralelně použitými metodikami shromažďování srážek pod korunami stromh (throughfallu) a zdůrazněny přednosti nových kolektorů opatřených skleněným impaktnim kuželem, zamezujicim kontaminaci vzorků.

monitorování; stopov6 prvky; As, Be, Cd, Cu, Mn, Pb, Zn; atmosférická depozice; srážky; trendy; střední Čechy; antropogenni kontaminace

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