Geochemical and anthropogenic soil loads by potentially risky elements

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ABSTRACT

The differentiation between anthropogenic and geogenic loads of the soils by potentially risky elements was observed. The collection of soil horizon samples from 21 localities with different anthropogenic loads (imission fall-outs, floods, historical mining) and geogenic loads (lithogenic, chalcogenic) was composed. The soil characteristics (pH, C_{ox}), total content of 13 potentially risky elements, content of potentially risky elements in the extract of 2M HNO_3, 1M NH_4NO_3 (mobile forms) and 0.025M EDTA (potentially mobilizable forms) were detected. The solubility as the ratio of total content and the content of risky elements in the other extracts was calculated. The differences between the solubility for each risky element and for each type of the load were determined. It was concluded that the highest solubility was determined in the fluvisols contaminated by the floods and in the soils contaminated by imission fall-outs. Significantly lower solubility of potentially risky elements was determined in the soils with geogenic loads. The efficiency of the used extracts for the differentiation of the soil load was assessed (2M HNO_3, 0.025M EDTA). The types of geogenic loads were characterised in the extent of used soil collection. Geochemically anomalous parent materials and soil types developed on these parent materials were described.

Keywords: potentially risky elements; geogenic and anthropogenic soil loads; solubility of risky elements

The anthropogenic and geogenic soil load by potentially risky elements is the topic of the paper. The theme was observed in the framework of the proposal of the limit values of hazardous elements in the soils in previous works (Podlešáková et al. 1996). The proposal, which contains the problems of geochemical anomalies in necessary extent, was based on the results of the pot trials, terrain researches and the finding of other authors (Hindel and Fleige 1991).

Three main soil groups with increased values of potentially risky elements influenced by the geochemistry of the substrate were delimited in our conditions (Němeček et al. 1996):

– the soils (especially Cambisols) from basic and ultrabasic rocks with increased values of Ni, Cr, Co and V especially (basalt, diabas, amfibolite, syenite, serpentine etc.)
– the soils (especially Cambisols) from acid magmatic and metamorphic rocks influenced by the existence of metallogenic zones with increased values of As, Cu, Zn and Pb especially
– the soils from the products of some limestone weathering with increased values of Cd especially, furthermore of Cr, Ni, Zn etc.

We respected that the natural geogenic background is formed by the soil substrates with diffuse contents of some potentially risky elements (lithogenic type) or by the existence of metallogenic zones (chalcogenic type). The potentially risky elements are bound in many chemically well known minerals (Remy 1962, Slavík et al. 1974, Bouška et al. 1980, Bernard et al. 1981, 1992).

In previous article, we predominantly focused our attention on the North and Northwest Bohemian region of the Czech Republic (Němeček et al. 1996). The simply defined zones with mafic rocks (basalt area in České středohoří, Doupovské hory, amphibolite of Mariánsko-lázeňský complex) and the zones influenced by the existence of metallogenic processes in hydrothermal association *as-coni* in Krušné hory (Bernard et al. 1981) were detected. The existence of localities with historical mining (for example Měděnec, Cínovec) confirms the use of the minerals in the past not only in this area but also in the other localities of the Czech Republic (for example Kubova Huť in Šumava, Kutná Hora, Příbram etc.). The description of the soil loads by potentially risky elements is complicated by heavy imission influence in North and Northwest Bohemian region (Podlešáková et al. 1999). The localities with increased values of potentially risky elements of geogenic origin are found on the whole area of the Czech Republic.

The soils developed on the products of the limestone weathering with increased values of geogenic Cd were localised in the area of the Czech karst. Analogous research has not yet been done in the area of Moravian karst. The source of Cd in the soils of Karpathyan flysh in the North Moravian imission region (Podlešáková et al. 1999) was difficult to differentiate.

The risks resulting from the increased values of potentially risky elements of geogenic origin are represented as lower risk within comparison with anthropogenic soil contamination. The reduction of element mobility is considered as the main factor (Bezvodová 1997). However, the research of risk element mobility (Podlešáková and Němeček 2001) confirmed increased transfer of some risk elements from the soils with geochemical anomalies into the plants in many cases. The total content of the elements (Cr, Ni) was statistically determined as the first factor influencing the transfer coefficients in the case of mafic rocks predominantly. The potentially risky elements (Mn, Zn, Pb) in metallogenic zones of acid parent materials showed strong dependency of the mobility on the soil acidity during the testing. The overcoming of critical values of the potentially risky elements in fodder plants (MZe ČR 1996) was detected in some cases in acid soils.

The determining of geogenic and anthropogenic origin of potentially risky elements could be complicated in the soils influenced by geochemical anomalies of the parent material and anthropogenic loads (Borůvka et al. 1996). The study of mobile and potentially mobilizable forms of risk elements in the soils (Podlešáková et al. 2001) could help to explain this question.

The author's team deals with the problem of the further difference between geogenic and anthropogenic soil loads by potentially risky elements. The collection of 21 soil profile samples from the area of the Czech Republic was used for the comparison of both types of the loads by potentially risky elements.

MATERIAL AND METHODS

The profile soil samples were used for the comparison of anthropogenic and geogenic soil loads by potentially risky elements. The samples were taken from the following horizons:

A – humic horizon, the horizon of topsoil of arable land or the grassland, the sample depending on the depth of the horizon

B – the horizon under the topsoil, the sample depending on the soil type

C – the horizon of parent material

The samples were taken from 21 localities. The selected soil types included the soils with different geogenic and anthropogenic loads. The selections of the soil types followed the account of the presence and categorisation of the parent materials in the Czech Republic. The selected geogenic soil loads followed the main types of the geochemically anomalous parent materials in our conditions. The imission load (imission fall-outs) and fluvial load (fluvisols in flood areas of the industrial rivers) represented the anthropogenic soil loads by potentially risky elements. The soils with the combination of geogenic and anthropogenic loads were also tested. The

Table 1. The characterisation of the localities

Number	Locality	Soil type	Parent material	Horizon A (cm)	Horizon B (cm)	Horizon C (cm)
1709	Krupka – grassland	KAd	gneiss	20	50	80
1710	Krupka – forest	KAd	gneiss	10	20–30	50
1711	Mikulov – grassland	KAd	gneiss	15	50	80
1712	Mikulov – forest	KAd	gneiss	8	30	90
1926	Příbram – Kovohutě	KAm	slates and greywackes	10	30	80
1927	Mokrsko	KAm	acid intrusive rocks	10	50	100
1928	Brná n. L.	KAe	basalt	< 10	30–40	70–80
1929	Beroun Koněprusy	RZm	limestones	< 10	25	40–50
1930	Mladá Boleslav	FLm	alluvial deposits	10	30–40	70–80
1931	Kaňk	HNm	loesses	0–20	40–50	70–80
1932	Píšťany n. L.	FLm	alluvial deposits	20	40–50	80–90
1933	Moldava	KAd	gneiss	0–10	25	50
1934	Počerady	CEm	loesses	0 –30	50	90
1936	Horní Lomná	KAm	flysh slates	0–15	25–40	60–80
2234	Tichá	KAe	basic effusive rocks	0–10	20–30	50–60
2235	Vendryně	PGm	polygenetic loams	0–10	30–40	70–80
2236	Paskov	LUm	loesslike deposits	0–20	40–50	90–100
2237	Starý Kolín	KAr	terrace gravels	0–10	20	40–60
2283	Ředice	KAm	acid intrusive rocks	0–20	30–40	60–70
2284	Horní Hanychov	KAm	phyllites	0–10	25–35	70
2285	Sobákov	KAr	non carbonaceous sandstones	0–20	30	85
2286	Klínovčík	KAd	gneiss	0–10	25–35	60–70
2287	Boletice	FLm	alluvial deposits	10	35	80–90
2288	Lesná	KAe	basalt	10	30	90–100
2289	Arnoltice	LUg	non carbonaceous sandstones	20	30–40	80–90

KAd – dystric Cambisol, KAe – eutric Cambisol, KAm – typic Cambisol, KAr – arenic Cambisol, CEm – typic Chernozem, FLm – typic Fluvisol, HNm – haplic Luvisol, LUm – Albeluvisol, PGm – typic Stagnosol, RZm – rendzic Leptosol characterisation of the localities is presented in Table 1. Following characteristics in the soil samples were determined:

– pH value (0.2 M KCl)
– C_{ox} content (Tjurin method)
– the total content of As, Be, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, V and Zn ($HClO_4$ + HF + HNO_3)
– the content of As, Be, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, V and Zn in the extracts of 2M HNO_3, 1M NH_4NO_3 and 0.025M EDTA (Podlešáková et al. 2001)
– the content of Hg by AMA method

The localities with geogenic loads were confronted with geological map (1:200 000).

The collection of the results was compartmentalised and statistically interpreted. The determining of the extractability of potentially risky elements as the ratio of total content of the elements and their mobile (extract of 1M NH_4NO_3) and potentially mobilizable content (0.025M EDTA) was calculated.

RESULTS AND DISCUSSION

The comparison between the concentrations of the risk elements in soil samples and background risk elements concentrations (MŽP ČR 1994) was undertaken. Total contents of risk elements and the values of the solubility (percent ratio between mobile or mobilizable content and total content × 100) are presented. The kind of assumed prevailing load is designated, An means anthropogenic load, G means geogenic load. The values of risk element's concentrations in three soil horizons A, B, C are described. These characteristics are illustrated for As only in the article (Table 2). The prevailing geogenic load resulting from the risk element distribution in the soil profile was calculated in the soils of the localities Mokrsko, Klínovčík and Horní Hanychov. Strong influence of imission fall-outs in the soils of localities Příbram, Moldava and Starý Kolín is obvious. The fluvisol from the locality Píšťany nad Labem was polluted by the floods of the Labe river, the soil

Table 2. Increased content of As in the soils (* solubility %)

No.	Locality		Soil type	Parent material	Load A	Load G	pH	C_{ox} (%)	As_{tot} (mg.kg^{-1})	HNO_3 × 100*	NH_4NO_3 × 100*	EDTA (total)
1927	Mokrsko	A	KAm	Granodiorite (amphibol. biotit.)		+	4.45	0.85	477.50	20.8	0.0	1.5
		B					4.35	0.20	224.10	6.3	0.0	0.3
		C					4.55	0.08	1045.00	48.1	0.0	3.6
2286	Klínovčík	A	KAd	Gneiss (muscovitic)		+	3.47	3.60	49.02	65.9	0.6	71.2
		B					3.28	1.70	85.80	36.4	0.1	28.6
		C					3.88	0.85	100.40	54.6	0.0	39.8
2283	Ředice	Ah	KAm	Granite (amphibol. biotit.)		+	6.21	1.25	31.88	9.0	0.1	3.6
		B					6.13	0.32	30.84	5.9	0.0	2.2
		C					5.82	0.04	32.24	9.3	0.0	2.7
2284	Horní Hanychov	A	KAd	Phyllite		+	3.71	2.95	55.60	13.5	0.0	4.5
		B					3.87	1.05	38.40	5.3	0.0	1.0
		C					4.19	0.28	59.48	10.2	0.0	0.7
1926	Příbram	A	KAm	Slates, Greywackes	+		4.45	1.94	75.64	45.9	0.0	10.5
		B					4.35	0.44	27.00	22.7	0.1	7.1
		C					4.15	0.08	23.18	7.7	0.0	1.8
1933	Moldava	A	KAd	Gneiss (biotit.)	+		4.80	4.36	44.22	44.3	0.0	1.5
		B					4.90	3.39	21.70	23.7	0.0	0.8
		C					4.35	0.20	12.47	10.5	0.0	1.0
2237	Starý Kolín	A	KAr	Terrace gravels	+		3.98	3.23	25.52	32.2	0.1	18.3
		B1					3.99	0.36	12.29	45.9	0.1	12.2
		B2					4.24	0.08	6.02	34.9	0.2	14.1
		C					3.99	0.20	8.09	28.8	0.1	26.3
1931	Kaňk	A	HMm	Loesses	+		6.70	1.54	191.140	43.1	0.4	52.9
		B					7.05	0.61	245.90	26.8	0.3	38.8
		C					7.20	0.40	1151.00	70.8	0.1	16.6
1932	Píšťany	A	FLm	non-carbonaceous alluvial deposits	+		6.60	5.47	37.03	53.0	0.1	34.6
		B					6.60	2.93	46.13	64.2	0.0	25.5
		C					6.65	1.05	18.40	33.3	0.0	21.7

A – anthropogenic load, G – geogenic load

Table 3. Parent materials and soils with geogenic loads (acid-neutral metamorphic rocks)

Parent material	Soil type	Extract	Horizon	Element As (mg.kg^{-1})
Gneiss (muscovitic, migmatic) (R)	typic, dystric Cambisol	total	A	477.50
Phyllite (F)	KAm, KAd		B	224.0
Solifluction deposits			C	1045.0
of acid-neutral		HNO_3	A	0.18
metamorphic rocks (D11B)			B	0.06
			C	0.11
		NH_4NO_3	A	0.086
			B	0.022
			C	0.043
		EDTA	A	0.23
			B	0.03
			C	0.08

from the locality Kaňk was polluted by historical mining activity.

After the comparison of As solubility in the following extracts, we concluded, that increased As solubility in 2M HNO_3 and EDTA in the soil of Klínovčík locality is the consequence of the coincidence of geogenic load and airborne anthropogenic load. Increased As solubility in 2M HNO_3 was detected in the soils with anthropogenic load, especially in the fluvisols. Increased As solubility in A horizon is characteristic for the load by imission fallouts. Increased As solubility in 2M HNO_3 and 0.025M EDTA in horizon C was observed in the soil contaminated by historical mining (locality Kaňk). The use of the 1M NH_4NO_3 extract does not seem to be suitable for As, because of a very low As yield in the extract.

On the base of the known results it was concluded, that the source of the load is significant for the risk element mobility in the soil. The finding that the presence of the mobile forms of Be, Cd, Mn, Zn, and to a lesser extent of Pb and As, is influenced by soil acidity in the soils with anthropogenic and geogenic loads was confirmed by previous results (Podlešáková et al. 2001). The use of 1M NH_4NO_3 extract seems to be more appropriate for the estimate of the risk of increased element mobility than for the identification of the load sources.

The complex approach for the identification of the type of the load is required. The profile distribution of risk elements in the soil was observed as the most important description in the first step. The different level of the distortion related to the migration of mobile risk elements in the soil profile or with the coincidence of geogenic and anthropogenic influence could be achieved in this step. The next entries could be obtained by the use of the assessment of risk element solubility. The use of the ratio between the contents of risk elements in the extract and their total content seems to be suitable. Different extracts showed different efficiency for individual potentially risky elements and for the identification of the soil loads. The presented values of the risk element solubility were calculated from the evaluation of the collection of only

Table 4. Parent materials and soils with geogenic loads (acid-neutral magmatic rocks)

Parent material	Soil type	Extract	Horizon	Elements (mg.kg^{-1})		
				As	Be	Pb
Granite (amphibol. biotit.)	typic, dystric Cambisol	total	A	477.50	4.90	48.1
Granodiorite (Z,GD)	KAm, KAd		B	224.1	4.99	38.1
Solifluction deposits			C	1045.0	4.48	67.0
of acid-neutral		HNO_3	A	99.50	0.49	15.6
magmatic rocks (D11A)			B	65.60	0.50	10.3
			C	107.80	0.69	19.4
		NH_4NO_3	A	0.093	0.003	0.4
			B	0.029	0.002	0.4
			C	0.068	0.005	0.45
		EDTA	A	7.18	0.043	0.4
			B	2.77	0.062	0.4
			C	8.0	0.096	0.45

Table 5. Parent materials and soils with geogenic loads (carbonaceous rock weathering)

Parent material	Soil type	Extract	Horizon	Elements ($mg.kg^{-1}$)					
				Cd	Co	Cr	Ni	V	Zn
Solifluction deposits	Rendzina RE	total	A	4.23	31.69	198.2	161.6	213.6	232.7
of residual products			B	4.45	32.94	200.6	164.7	226.4	233.9
from the carbonaceous rocks			C	5.74	31.10	194.9	146.2	269.0	221.1
weathering (D14)		HNO_3	A	3.02	16.43	3.63	27.5	37.3	43.3
Solifluction deposits			B	2.95	16.98	3.88	26.9	30.5	45.2
of solid rocks (D16)			C	5.46	15.73	3.51	24.2	32.4	38.3
		NH_4NO_3	A	0.021	0.010	0.002	0.29	0.15	0.10
			B	0.021	0.008	0.003	0.31	0.16	0.10
			C	0.029	0.008	0.004	0.25	0.12	0.10
		EDTA	A	2.15	14.28	11.75	14.00	5.11	4.54
			B	2.45	10.65	0.07	12.70	4.61	4.65
			C	2.55	9.02	0.06	10.00	3.38	3.54

21 soil profiles, the common validity of the numbers is not considered.

As – sufficient effect for the identification of the load was reached by the use of 2M HNO_3 extract. The values of As solubility in the A horizon of the soil collection were for geogenic load (*G*) 13%, imission load (*I*) 40% and fluvial load (*F*) 42%. The use of the 0.025M EDTA extract also showed good results. The values of the As solubility were for *G* 3.5%, for *I* 9.3% and for *F* 25.5%.

Be – the comparison of Be solubility in the extracts was complicated not only trough low Be concentrations in the used soils. The solubility in 2M HNO_3 was markedly increased in the soils with geogenic load developed on basic substrates. The values for *G* were about 80% in the soils developed on the limestone and about 50% in the soils developed on the basic effusive rocks. The values for *G* 10–15% were calculated in the soils developed on acid substrates. The values for *I* depended on the soil type and ranged from 20 to 50%. Calculated values for *F* ranged from 30 to 90%. Sufficient efficiency for the soil load identification was not reached by the use of 0.025M EDTA, either.

Cd – the element with generally increased solubility reached the values in the 2M HNO_3 extract for *G* 71%, *I* 87% and *F* 95%. The values of Cd solubility in 0.025M EDTA extract were 51% for *G* and 72% for *I*, but high level of the heterogeneity of the values was detected. The value for *F* 95% was calculated.

Cr – from the comparison of the Cr solubility in 2M HNO_3 extracts, the differences between *G* and *I* were not determinate. Only low total Cr concentrations were detected in the soil collection. The values of Cr solubility moved to 10% for *G* and *I*. Marked increase (48–67%) was calculated for *F*. The use of 0.025M EDTA extract reduced the differences between Cr solubility for *G*, *I* and *F*.

Cu – the distinguishing efficiency between the loads was reached by the use of 2M HNO_3 extract in spite of low total Cu concentrations in the soils. The values were

Table 6. Parent materials and soils with geogenic loads (basic effusive rocks)

Parent material	Soil type	Extract	Horizon	Elements ($mg.kg^{-1}$)				
				Co	Cr	Mn	Ni	V
Basic effusive	typic, eutric Cambisol	total	A	36.80	144.5	2067	60.8	305.0
rocks D11A (b, u), l	KAm, KAe		B	35.93	145.5	2165	71.0	300.0
			C	31.76	97.0	3755	55.3	305.0
		HNO_3	A	11.10	9.09	671	30.1	70.3
			B	10.24	10.37	635	28.5	69.4
			C	7.74	10.20	537	20.8	63.1
		NH_4NO_3	A	0.021	0.002	14.47	0.94	0.25
			B	0.035	0.004	7.52	0.56	0.25
			C	0.042	0.001	12.13	0.85	0.25
		EDTA	A	5.21	0.02	355	10.60	5.56
			B	4.92	0.02	436	5.21	4.00
			C	10.62	0.02	1695	5.07	8.94

Table 7. Parent materials and soils with geogenic loads (serpentine)

Parent material	Soil type	Extract	Horizon	Elements (mg.kg^{-1})					
				As	Co	Cr	Mn	Ni	V
Serpentine (HD)	eutric Cambisol	total	A	39.00	94.70	1230.00	1112.00	1500.00	160.00
Solifluction deposits	KAe	HNO_3	A	0.96	59.90	87.50	698.00	705.00	15.00
of metamorphic rocks		NH_4NO_3	A	0.020	0.019	0.010	3.020	1.400	0.240
D11B (b)		EDTA	A	0.96	12.30	1.17	578.00	150.00	2.68

for *G* 30%, *I* 44% and *F* 72%. The use of the extract 0.025M EDTA showed similar trend (*G* 18%, *I* 28% and *F* 41%).

Mn – high distinguishing efficiency was reached by the use of 2M HNO_3 extract, the values were for *G* 33%, *I* 55% and *F* 78%. The use of 0.025M EDTA extract showed differences between the loads, the values were for *G* 17%, *I* 28% and *F* 57%.

Ni – considering low total Ni concentrations in the soils, no significant differences were calculated between *G* and *I*. Marked increase of the solubility in the 2M HNO_3 extract and 0.025M EDTA was observed in the case of *F*.

Pb – significant distinguishing efficiency was reached after the use of 2M HNO_3 extract. Calculated values were for *G* 32%, *I* 57% and *F* 83%. The same effect was observed after the use of the extract 0.025M EDTA.

Zn – The values calculated after the use of the extract 2M HNO_3 were for *G* 20%, *I* 50% and *F* 70%. Wide range of *G* and *I* values complicated the evaluation. Lower distinguishing efficiency was reached after the use of the extract 0. 025M EDTA, mainly between *G* and *I*. Only the increase of *F* value was calculated.

The soils with geogenic load were separated on the base of parent material and the type of geogenic load. The soil types developed on the parent materials and maximum concentrations of the potentially risky elements are presented. The parent materials were integrated into main classes of the parent materials according to current Czech Taxonomic Soil Classification System (Němeček et al. 2001). The types of the geogenic loads in the extent of observed soil collection are summarised in Tables 3–7.

The geogenic loads (chalcogenic type) by As in typic and dystric Cambisols developed on acid and neutral metamorphic rocks are presented in Table 3. The geogenic loads by As, Pb and Be in Cambisols are presented in Table 4. The geogenic load (lithogenic type) by Cd, Co, Cr, Ni, V and Zn is presented in Table 5. Eutric Cambisol developed on the serpentine (locality Mohelno) is presented in Table 7, the increased concentrations of As, Co, Cr, Mn, Ni and V are only presented in horizon A.

On the base of the experiment, it was concluded that geogenic loads of chalcogenic and lithogenic type could be localised in the soils of the Czech Republic. Increased concentrations of potentially risky elements in the soils with geogenic load could overcome legislative limits of their concentrations in agriculturally used soils (MŽP ČR 1994).

Geogenic load of chalcogenic type was determined in the case of As (Bezvodová 1977) and partly of Pb in the Cambisols developed on intrusive and metamorphic acid rocks of the matallogenic zones.

Geogenic load of lithogenic type was found in the case of Be in the soils from the granites and in the case of Cd, Co, Cr, Ni, V and Zn in the soils from the products of limestone weathering and in the case of Co, Cr, Mn, Ni and V in the soils developed on the basic effusive or metamorphic rocks (Němeček et al. 1996). The increased concentrations of As in the soils from basic metamorphic rocks were detected.

The soils with geochemical anomalies of chalcogenic type were found in the local presence of metallogenic zones. The localities in Krušné Hory (Bernardt et al. 1981) and Příbram were detected in the extent of observed soil collection. The occurrences of the soils with geochemical anomalies of lithogenic type are associated with basic effusive and metamorphic rocks. The wide areas in North, West and Central Czech region were determined. The other local zones could be found in the whole area of the Czech Republic.

The increased concentrations of some potentially risky elements (Cd predominantly) were detected in the soils developed on the products of limestone weathering (Slavík et al. 1974) in the area of Czech karst. The anthropogenic inputs of Cd into the soils of Karpathian flysh related with imission fall-outs (Sáňka et al. 1998) were confirmed.

The comparisons of the total contents of potentially risky elements in three depths of the soil profile and the solubility of potentially risky elements in the extracts of 2M HNO_3 and 0.025 M EDTA were successfully used for the differentiation of prevailing soil load.

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ABSTRAKT

Geochemické a antropogenní zátěže půd potenciálně rizikovými prvky

Příspěvek se zabývá rozlišením antropogenní a geogenní zátěže půd potenciálně rizikovými prvky. V souboru profilových vzorků z 21 lokalit, odebíraných ze tří hloubek půdního horizontu, byly sledovány základní pedologické charakteristiky (pH, C_{ox}), celkový obsah 13 rizikových prvků, obsahy v extraktu 2M HNO_3, jejich mobilní obsahy (extrakt 1M NH_4NO_3) a potenciálně mobilní obsahy (obsah 0.025M EDTA). Soubor zahrnoval lokality s různou antropogenní zátěží (imisní spady, fluviální zátěž, historická důlní činnost) a s různou geogenní zátěží (litogenní, chalkogenní), závisející na půdotvorném substrátu. Byly vypočteny procentuální hodnoty rozpustnosti rizikových prvků jako poměr obsahů mobilních a potenciálně mobilních a obsahů celkových. Pro jednotlivé rizikové prvky byly zjištěny rozdíly v jejich rozpustnosti v závislosti na typu zátěže. Nejvyšší rozpustnost rizikových prvků byla zjištěna ve fluvizemích kontaminovaných vodou řek, následují půdy s imisní zátěží. Geochemická zátěž byla charakterizována v daném souboru půd výrazně nižšími hodnotami rozpustnosti rizikových prvků. Byla ověřena vhodnost použitých extrakčních činidel pro rozlišení antropogenní a geogenní zátěže půd potenciálně rizikovými prvky (2M HNO_3, 0.025M EDTA). V rozsahu sledovaného souboru byly popsány základní typy geogenní zátěže a vyčleněny geochemicky anomální půdotvorné substráty a půdní typy na nich vyvinuté.

Klíčová slova: potenciálně rizikové prvky; geogenní a antropogenní zátěž půdy; rozpustnost rizikových prvků

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