



Arsenic compounds occurring in ruderal plant communities growing in arsenic contaminated soils



Jana Tremlová^{a,*}, Ilona Vašíčková^a, Jiřina Száková^a, Walter Goessler^b, Oliver Steiner^b,
Jana Najmanová^a, Tereza Horáková^c, Pavel Tlustoš^a

^a Department of Agroenvironmental Chemistry and Plant Nutrition, Czech University of Life Sciences, CZ-165 21 Praha 6, Czech Republic

^b Institute of Chemistry, Analytical Chemistry, Karl-Franzens-University of Graz, A-8010 Graz, Austria

^c Department of Systems Engineering, Czech University of Life Sciences, CZ-165 21 Praha 6, Czech Republic

ARTICLE INFO

Article history:

Received 29 June 2015

Received in revised form 27 November 2015

Accepted 29 November 2015

Available online 1 December 2015

Keywords:

Speciation

Terrestrial plant

Hyphenated technique

HPLC

ICPMS

Arsenobetaine

Arsenocholine

TETRA

TMAO

ABSTRACT

Wild growing phytocenosis from three different areas near former gold or silver mines—Kutná Hora, Roudný and Nalžovské Hory (Czech Republic) were investigated for total arsenic and arsenic species concentrations. The most abundant plant families that occurred were *Fabaceae*, *Lamiaceae*, *Asteraceae*, *Poaceae* and *Plantaginaceae*. Several plant species such as *Achillea millefolium* L. (*Asteraceae*), *Anthoxanthum odoratum* L. (*Poaceae*), *Plantago lanceolata* L. (*Plantaginaceae*) are widespread and could be found in all of the investigated areas. Total As concentrations in aboveground biomass of plants growing on those three sites were determined by an inductively coupled plasma mass spectrometry (ICPMS) and ranged from 0.02* mg As kg⁻¹ (*Stellaria* spp.) to 39.30 ± 6.32 mg As kg⁻¹ (*Daucus carota* L.). The concentrations seem to be dependent on both plant species and physico-chemical soil properties. For the arsenic speciation a high performance liquid chromatography (HPLC) online connected with the ICPMS was used. Results have shown that arsenite and arsenate are the prevalent arsenic compounds. Methylarsonic acid (MA), dimethylarsinic acid (DMA), arsenobetaine (AB), arsenocholine (AC), tetramethylarsonium ion (TETRA), and trimethylarsine oxide (TMAO) were identified as minor species. Arsenobetaine was found at significant concentrations in *Carex praecox* Schreb. (28% of the extractable As amount) and *P. lanceolata* L. (1.2% of the extractable As amount).

© 2015 Elsevier B.V. All rights reserved.

1. Introduction

Several areas in the Czech Republic are characterized by elevated levels of As in soils mostly connected with gold and silver deposits. The most important ones are located in the central Bohemia. Locations such as Kutná Hora, Mokrsko, Roudný, etc. are well known examples with former mining activities on which high As content in soil occurs (Filippi et al., 2004).

The toxic effects of arsenic on plants are described by several authors (Bencko et al., 1995; Kabata-Pendias and Pendias, 2001; Rahman et al., 2008). Dembitsky and Rezanka (2003) summarized that methylated As species show generally lower toxicity than inorganic ones. For toxicity evaluations not only the total content is important, but the abundance of individual arsenic compounds

(speciation). Arsenobetaine (AB) and arsenocholine (AC) are considered as non-toxic or harmless compounds to man (Kuehnelt and Goessler, 2003).

Although As is an element with limited plant availability (Pickering et al., 2000), its content in plants in contaminated areas of the Czech Republic exceeds the maximum content in forage and thus may pose a health risk for wild or outside keeping and grazing herbivores and might follow-up the food chain (Tremlová et al., 2011). Among the identified arsenic compounds in terrestrial plants predominantly As(III) and As(V) can be found. Methylarsonic acid (MA), dimethylarsonic acid (DMA), arsenobetaine (AB), arsenocholine (AC), tetramethylarsonium ion (TETRA), trimethylarsine oxide (TMAO) and some arsenosugar analogs have been observed as well (Ruiz-Chancho et al., 2008). A study of Tlustoš et al. (2002) showed that in roots of radish (*Raphanus sativus* L.) the dominant As compound was As(III), whereas As(V) was more represented in leaves. High proportions of DMA in plants (about 17% of total As content in the roots and 18% in leaves) compared to

* Corresponding author.

E-mail address: tremlova@af.czu.cz (J. Tremlová).

Table 1

List of individual plant species occurring on investigated locations and sites and total As content in their aboveground biomass.

No.	Latin name	Family	Total As content (mg kg ⁻¹)				
1	<i>Aegopodium podagraria</i> L. ^P	Apiaceae	0.87 ± 0.09 (NH 2)	0.93 ± 0.03 (NH 3)	0.73 ± 0.12 (NH 4)	0.50 ± 0.05 (NH 5)	
2	<i>Agrostis stolonifera</i> L. ^P	Poaceae	2.15 ± 0.15 (KH 1)	1.09 ± 0.08 (KH 3)	1.13 ± 0.06 (KH 5)		
3	<i>Achillea millefolium</i> L. ^P	Asteraceae	1.51* (KH 3)	14.4 ± 1.7 (R 1)	5.23 ± 0.62 (R 2)	1.67 ± 0.08 (R 4)	0.51 ± 0.03 (NH 1)
			0.08 ± 0.01 (NH 3)	0.88 ± 0.20 (NH 4)			
4	<i>Alchemilla vulgaris</i> L. ^P	Rosaceae	0.21* (NH 2)				
5	<i>Alopecurus pratensis</i> L. ^P	Poaceae	1.02 ± 0.40 (KH 3)	0.58 ± 0.08 (KH 4)			
6	<i>Anthoxanthum odoratum</i> L. ^P	Poaceae	0.68* (KH 3)	3.83 ± 1.00 (R 1)	0.49 ± 0.07 (NH 2)		
7	<i>Arrhenatherum elatius</i> (L.) Presl ^P	Poaceae	0.76* (KH 1)	0.66 ± 0.03 (KH 2)	1.24* (KH 3)	0.89 ± 0.08 (KH 4)	0.94* (KH 5)
			1.00 ± 0.05 (NH 1)	0.54 ± 0.03 (NH 2)			
8	<i>Artemisia vulgaris</i> L. ^P	Asteraceae	0.711 ± 0.04 (NH 3)	0.71 ± 0.04 (NH 4)			
9	<i>Ballota nigra</i> L. ^P	Lamiaceae	0.42 ± 0.05 (NH 3)				
10	<i>Brachypodium pinnatum</i> Beauv. ^P	Poaceae	0.60 ± 0.05 (KH 1)	0.69 ± 0.14 (KH 2)	0.59 ± 0.04 (KH 3)	0.45 ± 0.07 (KH 4)	
11	<i>Briza media</i> L. ^P	Poaceae	1.68 ± 0.55 (KH 4)				
12	<i>Calamagrostis epigejos</i> L. ^P	Poaceae	3.09 ± 0.21 (R 1)	1.54 ± 0.08 (R 2)	5.02 ± 0.51 (R 5)		
13	<i>Campanula rapunculoides</i> L. ^P	Campanulaceae	0.86 ± 0.12 (NH 3)				
14	<i>Campanula</i> spp. ^P	Campanulaceae	7.48* (NH 5)				
15	<i>Carex nigra</i> L. ^P	Poaceae	0.58 ± 0.05 (NH 2)				
16	<i>Carex praecox</i> Schreb. ^P	Poaceae	0.68 ± 0.07 (KH 2)	1.16 ± 0.21 (KH 4)			
17	<i>Centaura jacea</i> L. ^P	Asteraceae	2.38 ± 0.41 (R 1)	1.09 ± 0.05 (R 4)			
18	<i>Cerastium holosteoides</i> Fr. ^{a/p}	Caryophyllaceae	0.85* (NH 2)				
19	<i>Cirsium arvense</i> (L.) Scop. ^P	Asteraceae	0.44 ± 0.10 (KH 5)	6.93 ± 0.87 (R 4)			
20	<i>Convallaria majalis</i> L. ^P	Liliaceae	0.53 ± 0.03 (NH 5)				
21	<i>Convolvulus arvensis</i> L. ^P	Convolvulaceae	1.84* (KH 2)	0.18 ± 0.03 (NH 3)			
22	<i>Crepis biennis</i> L. ^{a/p}	Asteraceae	1.10* (NH 5)				
23	<i>Cynosurus cristatus</i> L. ^P	Poaceae	0.73* (NH 2)	0.11* (NH 3)			
24	<i>Cytisus scoparius</i> L. ^P	Fabaceae	0.89 ± 0.11 (NH 1)				
25	<i>Dactylis glomerata</i> L. ^P	Poaceae	0.76 ± 0.23 (NH 2)	0.70 ± 0.03 (NH 3)	0.58 ± 0.06 (NH 4)	0.53 ± 0.05 (NH 5)	
26	<i>Daucus carota</i> L. ^P	Apiaceae	39.30 ± 6.32 (R1)	0.73 ± 0.08 (NH 3)			
27	<i>Deschampsia caespitosa</i> L. ^P	Poaceae	5.49 ± 0.29 (R 1)	2.00 ± 0.10 (R 3)	1.14 ± 0.12 (R 5)	0.82 ± 0.04 (NH 2)	0.84 ± 0.03 (NH 4)
28	<i>Dianthus</i> spp. ^{a/b/p}	Caryophyllaceae	0.49 ± 0.03 (NH 4)				
29	<i>Dryopteris filix-mas</i> L. ^P	Dryopteridaceae	0.46 ± 0.13 (NH 5)				
30	<i>Echium vulgare</i> L. ^{b/p}	Boraginaceae	0.92 ± 0.05 (NH 1)				
31	<i>Elytrigia repens</i> (L.) Desv. ^P	Poaceae	1.33 ± 0.07 (KH 1)				
32	<i>Epilobium montanum</i> Huds. ^P	Onagraceae	0.44 ± 0.12 (NH 5)				
33	<i>Epilobium</i> spp. ^{a/p}	Onagraceae	0.60* (NH 2)				
34	<i>Epipactis helleborine</i> L. ^P	Orchidaceae	5.45 ± 0.27 (R 1)				
35	<i>Equisetum arvense</i> L. ^P	Equisetaceae	34.75 ± 4.88 (R 1)	29.40 ± 2.74 (R 2)	14.90 ± 0.80 (R 3)		
36	<i>Erodium neuradifolium</i> L. ^{a/b}	Geraniaceae	0.95* (NH 5)				
37	<i>Festuca pallens</i> Host ^P	Poaceae	1.16 ± 0.19 (KH 1)	0.22 ± 0.01 (KH 2)	1.08 ± 0.40 (KH 3)	0.38 ± 0.03 (KH 4)	1.95* (KH 5)
38	<i>Fragaria vesca</i> L. ^P	Rosaceae	1.77 ± 0.34 (R 2)	1.08 ± 0.38 (R 5)			
39	<i>Galium mollugo</i> L. ^P	Rubiaceae	2.32 ± 0.24 (R 4)	0.72 ± 0.13 (NH 2)	0.52 ± 0.15 (NH 4)		
40	<i>Galium verum</i> L. ^P	Rubiaceae	2.79 ± 0.21 (KH 1)	0.86 ± 0.07 (KH 2)	1.25 ± 0.08 (KH 4)	0.74 ± 0.04 (KH 5)	
41	<i>Geum urbanum</i> L. ^P	Rosaceae	0.90* (NH 4)	0.18 ± 0.01 (NH 5)			
42	<i>Hieracium pilosella</i> L. ^P	Asteraceae	9.96 ± 1.15 (R 1)	6.57 ± 0.34 (R 2)	1.38 ± 0.28 (NH 1)		
43	<i>Hypericum perforatum</i> L. ^P	Hypericaceae	1.40 ± 0.07 (KH 4)	1.76* (KH 5)	0.30 ± 0.01 (NH 2)	0.83 ± 0.09 (NH 3)	0.78* (NH 4)
			0.27* (NH 5)				
44	<i>Chaerophyllum aromaticum</i> L. ^P	Apiaceae	8.45 ± 0.42 (R 4)				
45	<i>Chenopodium album</i> L. ^a	Apiaceae	0.46 ± 0.02 (NH 5)				
46	<i>Impatiens parviflora</i> L. ^a	Balsaminaceae	5.69* (R 5)				
47	<i>Impatiens</i> spp. ^a	Balsaminaceae	0.49 ± 0.02 (NH 5)				
48	<i>Lactuca serriola</i> L. ^{a/b}	Asteraceae	6.04 ± 1.50 (R 5)				
49	<i>Lactuca</i> spp. ^{a/b}	Asteraceae	0.79* (NH 3)				
50	<i>Lamium</i> spp. ^{a/p}	Lamiaceae	0.51 ± 0.06 (NH 5)				
51	<i>Lolium</i> spp. ^{a/b/p}	Fabaceae	0.20 ± 0.01 (NH3)	0.25 ± 0.04 (NH 4)	0.90 ± 0.12 (NH 5)		
52	<i>Lotus corniculatus</i> L. ^P	Fabaceae	4.97 ± 0.78 (R 1)	2.36 ± 0.42 (R 2)	1.69 ± 0.08 (R 3)	1.05 ± 0.05 (NH 1)	0.47 ± 0.02 (NH 3)
			0.11 ± 0.01 (NH 4)				
53	<i>Lysimachia vulgaris</i> L. ^P	Primulaceae	2.29 ± 0.25 (NH 5)				
54	<i>Medicago lupulina</i> L. ^{a/p}	Fabaceae	0.48* (NH 1)	0.16 ± 0.01 (NH 2)	1.02 ± 0.04 (NH 3)		
55	<i>Medicago</i> spp. ^{a/p}	Fabaceae	0.78 ± 0.02 (NH 5)				
56	<i>Melandrium album</i> L. ^{a/b}	Caryophyllaceae	0.61 ± 0.02 (NH 3)				
57	<i>Pastinaca sativa</i> L. ^P	Apiaceae	0.63 ± 0.11 (NH 2)				
58	<i>Phleum pratense</i> L. ^P	Poaceae	0.72 ± 0.04 (R 4)	0.42 ± 0.04 (NH 3)			
59	<i>Phragmites communis</i> L. ^P	Poaceae	1.08 ± 0.08 (R 2)	1.09 ± 0.06 (R 3)			
60	<i>Pimpinella major</i> L. ^P	Apiaceae	2.31* (NH 4)	2.31* (NH 4)			
61	<i>Pimpinella saxifraga</i> L. ^P	Apiaceae	5.96* (KH 4)				
62	<i>Pimpinella</i> spp. ^P	Apiaceae	0.80 ± 0.04 (NH 1)				
63	<i>Plantago lanceolata</i> L. ^P	Plantaginaceae	1.33 ± 0.98 (KH 3)	13.50 ± 0.88 (R 1)	3.23 ± 0.57 (R 4)	0.56 ± 0.03 (NH 1)	0.47 ± 0.05 (NH 2)
			0.77 ± 0.04 (NH 3)	1.75 ± 0.09 (NH 4)	0.83 ± 0.08 (NH 5)		
64	<i>Plantago major</i> L. ^P	Plantaginaceae	3.28 ± 1.04 (R 4)	0.81 ± 0.02 (NH 5)			
65	<i>Poa pratensis</i> L. ^P	Poaceae	0.56 ± 0.03 (NH 2)	0.36 ± 0.02 (NH 3)	1.19* (NH 5)		
66	<i>Polygala vulgaris</i> L. ^P	Polygalaceae	8.49* (R 1)				
67	<i>Potentilla anserina</i> L. ^P	Rosaceae	17.64* (R 1)	6.62 ± 0.33 (R 4)			
68	<i>Potentilla heptaphylla</i> L. ^P	Rosaceae	0.46 ± 0.06 (KH 4)				
69	<i>Prunella vulgaris</i> L. ^P	Lamiaceae	1.07 ± 0.04 (NH 3)				
70	<i>Ranunculus acris</i> L. ^P	Ranunculaceae	1.39* (KH 4)	0.31 ± 0.30 (NH 2)			
71	<i>Ranunculus repens</i> L. ^P	Ranunculaceae	1.25 ± 0.13 (R 4)				

Download English Version:

<https://daneshyari.com/en/article/4554140>

Download Persian Version:

<https://daneshyari.com/article/4554140>

[Daneshyari.com](https://daneshyari.com)