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SOME HEAVY METALS ACCUMULATION AND DISTRIBUTION IN *TYPHA LATIFOLIA* L. FROM LAKE WIELKIE IN POLAND

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COMMUNICATION

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Abstract: The contents of Cd, Pb, Cu, Mn, Zn, Ni and Fe in different organs of *Typha latifolia* L., coming from six sites selected within Jezioro Wielkie (Leszczyńskie Lakeland in western Poland), were determined. Three groups of metals, each with a different accumulation pattern within the plant were distinguished in this study. Pb, Zn and Cu were found to be the least mobile and shown the following accumulation scheme: roots > rhizomes > lower leave part > top leave part. By contrast, Mn, a metal which is both easily transported in plants and accumulated in green plant organs, exhibited the following accumulation scheme: roots> top leave part > lower leave part > rhizomes. Ni, Cd and Fe were accumulated by the cattail as follows: roots > rhizomes > top leaf part > lower leaf part. The fact that *Typha latifolia* L. had the highest proportion of all the metals studied in its roots can suggest that some kind of protection barrier exists which prevents toxic compounds permeating from that part of this plant to its rhizomes and its aerial parts. The confirmation of this thesis requires some further research.

INTRODUCTION

Macrophytes, as primary producers, playing a vital role in elemental circulation, make up some of the essential elements of shallow water ecosystems [15]. Aquatic plants accumulate heavy metals effectively. Nonetheless, there are differences in respect of the capacity of the roots of various macrophyte species to accumulate heavy metals. Additionally, there are differences in metal translocation levels from roots to other plant parts [1]. Cattail is a macrophyte which accumulates heavy metals efficiently and thus may serve in metal bioindication [18]. This species is expansive, and is widespread in lowland shallow waters and in lower mountain regions. Cattail colonies expand rapidly by growth of the rhizomes. These colonies fill water bodies at a high rate, causing overgrowth, and contribute to turning them into dry land. The plant is characterized by extensive biomass growth and high decomposition rate [16]. The aim of the study herein was to show varied heavy metal accumulation capacities in different organs of *Typha latifolia* L.

METHOD AND MATERIALS

The investigation was carried out in six study sites, selected in littoral of eutrophic Lake Wielkie, a shallow lake located near Boszkowo village, 60 km southwest from Poznań, in western Poland. The area of this region, Leszczyńskie Lakeland, was partly moulded by the influence of an ice cover during the last glaciations [3, 20]. The surface and average depth of Lake Wielkie are 51.2 ha and 1.3 m, respectively [4], but the bottom of this re-servoir is clayey-peaty [8]. The lake examined is surrounded by a narrow belt of emergent vegetation, dominated by *Typha latifolia* L. and *Phragmites australis* (Cav.) Trin. ex Steud. Submerged macrophytes were represented exclusively by the *Ceratophyllum demersum* L., which forms extensive underwater meadows. However, the shore region was overgrown by patches of *Nymphaea alba* L. and *Nuphar lutea* (L.) Sibith. & Sm.

Three samples of *Typha latifolia* L. were collected from each of the study sites during the full growing season (July). Next they were cut up in the following parts: the tip of the leaf (20 cm long), the lower part of the leaf (20 cm long), the rhizome as well as the roots, and analyzed separately. Prior to the analyses, plant material was washed thoroughly in distilled water, then dried and pulverized. Plant material (0.5 g) was subsequently digested in an open system with concentrated nitric acid and hydrogen peroxide (30%). The concentrations of Fe, Mn, Zn, Pb and Cu were determined by atomic absorption spectrometry with flame atomization, whereas Cd and Ni was with electrothermal atomization (AVANTA PM by GBC Scientific Equipment). All elements were measured against SIGMA standards. The concentrations of Cd and Ni in some of the studied plant samples were found to be below the detection limit, such as $3 \cdot 10^{-6}$ and 10^{-4} $mg \cdot kg^{-1}$, respectively.

The precision of the measurements was determined by comparing the results of heavy metal content in the solutions made from three separately weighted portions of each sample, having being analyzed using identical methods. The reproducibility of the methods used was compared to the results of an inter-laboratory study through digesting, and also by analyzing reference material GBW 07604 Poplar Leaves (Institute of Geophysical and Geochemical Exploration Lanfang China). Values were found to be 98 ± 3% (percent ± standard deviation).

Differences between particular organs of *Typha latifolia* L. with respect to mean concentrations of elements were evaluated by analysis of variance with the F Snedecor test. The least significant difference was calculated. Student t test was applied to compare the concentration of elements in the lower part of the cattail leaves and in its concentration in the rhizomes [14]. All statistical calculations were carried out using the CSS-Statistica Statsoft© [17].

RESULTS AND DISCUSSION

The analysis with LSD test indicated that levels of heavy metals in various organs of *Typha latifolia* L. were statistically diversified (Tab. 1). The mean concentrations of heavy metals in the studied organs of *Typha latifolia* L. (Tab. 1) were found to be relatively low, and within the ranges of geochemical background values given by Manny *et al.* [11] and by Kabata-Pedias and Pendias [9]. However, the root content of Mn, Cd and Fe was found to be greater than that in the ranges given in the above-mentioned studies.

The concentrations of Pb, Cu and Zn noted in *Typha latifolia* L. parts from highest levels to the lowest were as follows; roots, rhizomes, lower parts of leaves, and lastly, with the least concentration, top leaf parts. These findings were in agreement with results cited by Kabata-Pendias and Pendias [9], Hozhina *et al.* [7] and Aksoy *et al.* [1, 2] who reported on relatively low mobility of Pb and Cu which tended to accumulate mainly in macrophyte roots. The high concentrations of Pb in underground plant parts as compared to aerial parts was also demonstrated by Panich-Pat *et al.* [13], Vardanyan and Ingole [19], Letachowicz *et al.* [10]. The lowest concentration of Pb in top aerial parts of the cattail studied here is likely to be brought about by low mobility of Pb affecting its transport rate within the aerial plant organs. The Pb content ratios of the lower leaf parts to roots, and that of the top leaf parts to roots of *Typha latifolia* L. were 52.4 ± 27.5 and 39.8 ± 11.7% respectively. The high content of Zn found in the roots and rhizomes of the cattail as compared to its aerial organs follows the findings of Demirezen and Aksoy [5], who reported twice as much zinc in *Typha angustifolia* L. underground organs than in its aerial parts.

According to Kabata-Pendias and Pendias [9] Mn easily moves within plants, and accumulates mainly in the aboveground green plant organs. The results for *Typha latifolia* L. studied herein also show high Mn concentration in the top leaf section of the plant while the highest content of manganese was found in the plant roots. Although no significant statistical difference has been noticed between the content of Mn in the lower part of the cattail leaves and in its concentration in the rhizomes ($t_{tab} = 2.07$, $t_{est} = 0.27$), the level

Table 1. Ranges of mean concentrations of heavy metals [mg·kg^{-1} DM] in leaves, rhizomes and roots of *Typha latifolia* L. and results of Snedecor test ($n = 54$, $F_{tab.} = 2.82$, $p < 0.05$)

Organs of *Typha latifolia* L.		Mn	Zn	Cu	Cd	Pb	Ni	Fe
Top leaf part	min	103	11.4	3.19	0.001	1.94	1.87	79.1
	max	570	23.2	5.78	0.016	3.40	2.47	131
	mean	212	18.3	4.50	0.008	2.54	2.17	101
	SD	169	4.44	0.76	0.006	0.46	0.17	16.4
Lower leaf part	min	69.5	14.1	3.12	ND	1.85	ND	56.4
	max	135	27.4	6.20	ND	4.49	ND	85.7
	mean	92.7	22.7	4.72		3.22		67.8
	SD	17.3	4.44	1.12		0.91		8.27
Rhizomes	min	63.3	28.5	3.17	0.017	3.06	2.14	141
	max	213	156	8.59	0.06	6.52	2.67	213
	mean	97.1	79.9	6.05	0.033	5.14	2.45	184
	SD	52.7	47.1	1.51	0.02	0.96	0.13	25.3
Roots	min	368	54.0	14.3	0.12	3.49	3.05	1367
	max	520	90.8	22.1	4.75	10.8	44.8	2534
	mean	442	73.3	17.3	1.77	6.83	19.2	1832
	SD	55.6	13.6	2.64	1.71	2.17	14.8	429
Fest.[a]		37.0	20.8	163	12.6	27.2	18.0	191
LSD[b]		76.6	20.3	1.37	0.70	1.06	6.11	177

ND – no detection level
a – F estimated
b – least significant difference

of Mn in the lower parts of leaves exceeded that of the rhizomes. Similar distribution of Mn was noticed by Page and Feller [12] for monocotyledonae plants as well as by Demirezen and Aksoy [6] for certain species of aquatic plants.

The analysis also revealed that Ni, Cd and Fe accumulated predominantly in cattail roots, and the metal content decreased according to the following pattern: rhizomes, upper leave part, and lower leave part. Kabata-Pendias and Pendias [9] found Cd and Fe to move slowly within the plant, and tend to accumulate in underground plant organs. Also, the studies of Aksoy *et al.* [2] and Demirezen and Aksoy [6] show the highest accumulation of Cd and Fe in the underground parts of *Phragmites australis* (Cav.) Trin. ex Steud. and *Typha angustifolia* L.

The fact that *Typha latifolia* L. had the highest proportion of all the metals studied in this paper in its roots can suggest that some kind of protection barrier exists which prevents toxic compounds permeating from that part of this plant to its rhizomes and its aerial parts. The confirmation of this thesis requires some further research.

REFERENCES

[1] Aksoy A., D. Demirezen, F. Duman: *Bioaccumulation, Detection and Analyses of Heavy Metal Pollution in Sultan Marsh and its Environment*, Water, Air, and Soil Pollution, **164**, 241–255 (2005).

[2] Aksoy A., F. Duman, G. Sezen: *Heavy Metal Accumulation and Distribution in Narrow-Leaved Cattail (Typha angustifolia) and Common Reed (Phragmites australis)*, J. Freshwater Ecol., **20**(4), 783–785 (2005).

[3] Anders P.: *Pojezierze Leszczyńskie*, Wydawnictwo PTTK „Kraj", Warszawa 1985.

[4] Choiński A.: *Katalog jezior Polski, cz. III, Pojezierze Wielkopolsko-Kujawskie*, Wydawnictwo Naukowe UAM, Poznań 1995.

[5] Demirezen D., A. Aksoy: *Accumulation of heavy metals in Typha angustifolia (L.) and Potamogeton pectinatus (L.) living in Sultan Marsh (Kayseri, Turkey)*, Chemosphere, **56**, 685–696 (2004).

[6] Demirezen D., A. Aksoy: *Common hydrophytes as bioindicators of iron and manganese pollutions*, Ecological Indicators, **6**, 388–393 (2006).

[7] Hozhina E.I., A.A. Khramov, P.A. Gerasimov, A.A. Kumarkov: *Uptake of heavy metals, arsenic, and antymony by aquatic plants In the vicinity of ore mining and processing industries*, Journal of Geochemical Exploration, **74**, 153–162 (2001).

[8] Joachimiak B.: *Jeziora województwa leszczyńskiego*, Leszczyńska Oficyna Wydawnicza, Leszno 1995.

[9] Kabata-Pendias A., H. Pendias: *Biogeochemia pierwiastków śladowych*, PWN, Warszawa 1993.

[10] Letachowicz B., J. Krawczyk, A. Klink: *Accumulation of Heavy Metals in Organs of Typha latifolia L.*, Polish Journal of Environmental Studies, **15**(2a), 407–409 (2006).

[11] Manny B.A., S.J. Nichols, D.W. Schloesser: *Heavy metals in aquatic macrophytes drifting in a large river*, Hydrobiologia, **219**, 333–344 (1991).

[12] Page V., U. Feller: *Selective Transport of Zinc, Manganese, Nickel, Cobalt and Cadmium in the Root System and Transfer to the Leaves in Young Wheat Plants*, Annals of Botany, **96**, 425–434 (2005).

[13] Panich-Pat T., P. Pokethitiyook, M. Kruatrauchue, E.S. Upatham, P. Srinives, G.R. Lanza: *Removal of lead from contaminated soils by Typha angustifolia*, Water, Air, and Soil Pollution, **155**, 159–165 (2004).

[14] Parker R.E.: *Introductory Statistics for Biology*, Edward Arnold Publishers Ltd., London 1983.

[15] Pip E.: *Cadmium, copper and lead in aquatic macrophytes in Shoal Lake (Manitoba-Ontario)*, Hydrobiologia, **208**, 253–260 (1990).

[16] Podbielkowski Z., H. Tomaszewicz.: *Zarys hydrobotaniki*, PWN, Warszawa 1982.

[17] StatSoft Inc.: *STATISTICA for Windows* (data analysis software system), version 7.1, www.statsoft.com (2008).

[18] Szymanowska A., A. Samecka-Cymerman, A.J. Kempers: *Heavy Metals in Three Lakes in West Poland*, Ecotoxicology and Environmental Safety, **43**, 21–29 (1999).

[19] Vardanyan L.G., B.S. Ingole: *Studies on heavy metal accumulation in aquatic macrophytes from Sevan (Armenia) and Carambolim (India) lake systems*, Environment International, **32**, 208–218 (2006).

[20] Zgodziński B.: *Województwo leszczyńskie*, Krajowa Agencja Wydawnicza, Poznań 1981.

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AKUMULACJA I ROZMIESZCZENIE WYBRANYCH METALI CIĘŻKICH W *TYPHA LATIFOLIA* L. Z JEZIORA WIELKIEGO W POLSCE

Oznaczono zawartość Cd, Pb, Cu, Mn, Zn, Ni i Fe w różnych organach *Typha latifolia* L., zebranych w lipcu z sześciu stanowisk Jeziora Wielkiego (Pojezierze Leszczyńskie w zachodniej Polsce). Wyznaczono trzy grupy metali w zależności od miejsca ich akumulacji. Pierwszą grupę stanowią pierwiastki mało mobilne w roślinie: Pb, Zn i Cu, które reprezentują następujący schemat kumulacji: korzenie > kłącza > dolna część liścia > górna część liścia. Do drugiej grupy metali należy Mn, który jest pierwiastkiem łatwo transportowanym i jest akumulowany głównie w zielonych częściach roślin: korzenie > górna część liścia > dolna część liścia > kłącza. Z kolei Ni, Cd i Fe akumulowane są zgodnie ze schematem: korzenie > kłącza > górna część liścia > dolna część liścia. Akumulacja najwyższych zawartości wszystkich badanych metali ciężkich w korzeniach badanych roślin może sugerować istnienie u pałki szerokolistnej barier ochronnych zapobiegających wnikaniu związków toksycznych do kłączy i części nadziemnych tej rośliny. Stwierdzenie tego wymaga jednak dalszych badań.