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Does heavy metal deposition affect nutrient uptake by moss *Pleurozium schreberi*?

P. Kapusta[1] and B. Godzik[1]

[1] W. Szafer Institute of Botany, Polish Academy of Sciences, Lubicz 46, 31-512 Kraków, Poland, p.kapusta@botany.pl, b.godzik@botany.pl

Abstract. Heavy metals may influence chemical composition of plants, and thus shape elemental stoichiometry of plant communities. That is because some physiological processes aiming at neutralization of contaminant toxicity require increased acquisition of some nutrients (e.g. N, S, P or Ca). The aim of the study was to evaluate the heavy metal deposition in Poland using moss *Pleurozium schreberi* as a bioindicator, and check whether C/N, C/S, C/P and Ca/Mg ratios in mosses correspond with the accumulation of heavy metals. Heavy metal concentrations in mosses were highly variable across the study area – southern parts of the country, industrialized and densely populated, were the most contaminated. There were significant correlations between nutrient ratios and metal accumulation in mosses. Mosses seem to take 1) more N, P and S under Cu contamination, and 2) more Ca under Zn contamination. This increased acquisition of nutrients, mainly N and Ca, may be a response to higher toxicity of heavy metals. Further studies are required to exclude other causes for observed relationships.

Keywords: Heavy metals, element stoichiometry, nutrient uptake, moss monitoring

Introduction

Harmful effects of heavy metals on living organisms have been described repeatedly. Studies mainly have focused on heavily contaminated ecosystems where adverse changes are evident (biodiversity loss, disturbances of essential physiological processes like photosynthesis and respiration, etc.). However, heavy metals may exert important effects on biological systems also when they are deposited in smaller amounts. For example, they may influence chemical composition of plants, and thus shape elemental stoichiometry of plant communities. That is because contaminants can initiate various physiological processes in plant cells aiming at neutralization of contaminant toxicity. Some of these processes involve the synthesis of sulfur-, nitrogen- or phosphorus-rich substances (e.g. phytochelatins; Zenk, 1996), while others are associated with an active acquisition of calcium ions.

The aim of the study was to 1) evaluate the heavy metal deposition in Poland using moss *Pleurozium schreberi* as a bioindicator, and 2) check whether C/N, C/S, C/P and Ca/Mg ratios in mosses correspond with the accumulation of heavy metals.

Materials and Methods

The research was a part of the 2010 European moss survey. A common moss species *Pleurozium schreberi* (Willd. ex Brid.) Mitt. was used to evaluate heavy metals deposition in Poland. In 2010, green parts of mosses were collected from nearly 300 sites evenly distributed across the country. Concentrations of heavy metals (Cd, Cu, Fe, Ni, Pb, Zn) and nutrients (C, N, P, S, Ca and Mg) were determined. Metal contents were measured by atomic absorption spectrometry (Varian 220 FS) after digestion in the mixture of HNO_3 and $HClO_3$ (4:1). Total N was measured using Kjeldahl method (Tecator 2300), total C and S using LECO SC144, and total P using colorimetric method (Hach Lange DR3800).

Simple correlation analysis was performed to detect relationships between C/N, C/P, C/S, Ca/Mg ratios and contents of heavy metals in mosses. Prior to analysis, data were transformed with logarithmic or exponential functions to obtain normal or at least symmetric distributions and scaled between 0 and 1.

Results and Discussion

In 2010, average concentrations of Cd, Cu, Ni and Pb in mosses were 0.38, 6.4, 8.0 and 5.9 mg kg^{-1}, respectively.

Tab.1 Coefficients of correlations between nutrient ratios and accumulation of heavy metals in mosses (calculated for transformed variables); highly significant correlations (P<0.0001) are in bold

	Cd	Cu	Fe	Ni	Pb	Zn
C/N	0.10	**-0.40**	-0.10	0.04	-0.05	0.16
C/P	-0.02	**-0.20**	-0.16	0.15	**-0.22**	0.03
C/S	0.04	**-0.23**	-0.16	0.03	-0.10	0.08
Ca/Mg	**0.29**	-0.06	0.03	0.03	0.10	**0.69**

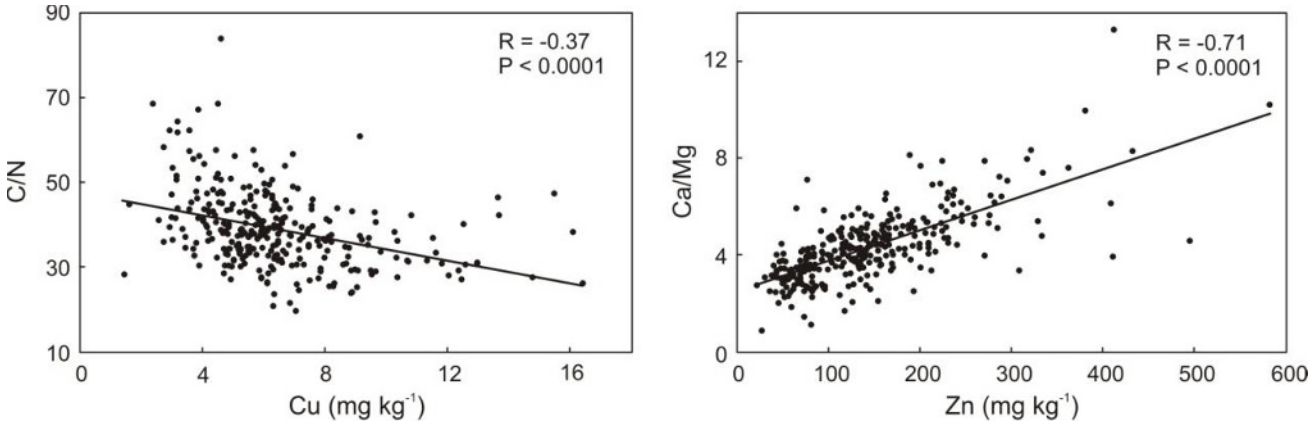

Fig.1 The strongest relationships between heavy metal accumulation and nutrient ratios in mosses

They were found significantly lower as compared to the values obtained in the past (in 1995; data not shown). Average concentrations of other metals – Fe and Zn – were 391 and 145 mg kg^{-1}; they did not alter in time. Spatial patterns of the accumulation of most heavy metals in mosses were dominated by a large-scale trend – southern parts of Poland, industrialized and densely populated, were contaminated more than the rest of the country. A small-scale variability was also an important component of investigated spatial patterns.

There were significant (after Bonferroni correction) correlations between moss C/N, C/S, C/P ratios and heavy metal accumulation (Tab 1). The results suggest that mosses take more N, P and S when they are exposed to high deposition of Cu (Fig. 1). Similar phenomena have been described in the literature. For example, algae under heavy metal contamination stress produced thiol peptides – derivatives of gluthatione – rich in N and S (e.g. Pawlik-Skowrońska, 2002). Their concentration in cells reflected the level of metal toxicity.

Highly significant correlation was found between Ca/Mg ratio and Zn accumulation in mosses (Fig. 1). Increased acquisition of Ca by plants under heavy metal contamination has been documented several times. According to some authors (e.g. Antosiewicz, 1995), Ca can help in neutralization of metal toxicity in cells.

Observed relationships can be explained in other way. Increased uptake of N and Ca may reflect higher availability of these nutrients in the area of elevated atmospheric deposition of heavy metals. To check this, new data on emissions from agriculture (fertilization), industry (e.g. cement plants) from transport should be taken into account in further studies.

Conclusions

Heavy metal deposition in Poland is characterized by high spatial variability. This may cause a considerable variation in some nutrients uptake by mosses. Increased acquisition of N and Ca may be a response to higher toxicity of heavy metals such as Cu and Zn. Further studies are required to support this hypothesis.

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