

SEASONAL VARIATIONS OF HEAVY METAL CONTENT IN WATER IN A POLLUTED MIRE FROM SOUTHERN POLAND

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SUMMARY

Trace metal concentrations (Fe, Ca, Mg, Al, Zn, Pb, Cd, Ba, Tl and As) in pore water has been studied seasonally in the extensively drained mire Bagno Bruch.

All the elements reveal higher concentrations in the pore water from upper layer. The maxima were observed in autumn when the mire was rewetted after a dry summer season. At that time the acidity dropped to the pH value of 3.0. The highest increase was detected for Ca, Mg, Zn, Cd, Ba and Tl. The concentration of Al was relatively stable during the study.

KEY WORDS: metals, peat, pore water, toxicity

INTRODUCTION

Many European peatlands contain elevated concentrations of potentially toxic metals in their subsurface layers; a fact directly related with high efficiency of peat to retain metals from increased atmospheric pollution in the last 100-160 years. Peat drainage and droughts cause lowering of water table and subsequent water acidification (Tipping *et al.*, 2003). This may favour an alteration of peatlands from net sinks to net sources of trace metals.

The Bagno Bruch, located close to the Upper Silesia industrial agglomeration, is extensively drained, highly acidic and contains high concentrations of heavy metals, particularly Zn, Pb and Cd. Investigations done by Fiałkiewicz *et al.* (2008) indicate that the upper part of peatland is highly contaminated by various heavy metals. Lead, zinc and cadmium reach their maximum concentration of 238-401 mg kg⁻¹, 165-770 mg kg⁻¹, 7-31 mg kg⁻¹, respectively, within the investigated depth range of 0 -34 cm in three profiles. The values decreased downwards to non-toxic concentrations in deeper layers (Smieja-Król *et al.*, 2011).

The aim of the study was to investigate the response of metals accumulated in peat to variations in the water table level.

MATERIALS AND METHODS

Bagno Bruch (BB) mire (N: 50° 31', E: 19° 2', 300m asl) covers about 39 ha. The detailed characteristic of surface formation as well as the soil and habitat conditions of BB mire is

given by Ekonomiuk *et al.* (2004). BB has been extensively drained by a system of ditches more than 60 years ago. A characteristic feature is a presence of several meters wide strips, resulting probably from peat extraction. The ditches and strips are nowadays covered by thick floating vegetation mats (*Oxycocco-Sphagnetea* community). The investigated site has a vegetation cover of *Vaccinio uliginosi-Pinetum* community. It is covered by *Andromeda polifolia*, *Eriophorum vaginatum*, *Ledum palustre*, *Oxycoccus palustris*, *Pinus sylvestris* and different *Sphagnum* species.

In each of three sites two pipes were installed: a 0.5m long, perforated within the depth range of 0-40cm and a 1m long with a perforation between 60 and 100cm below peat surface. Water was sampled seasonally during 2009 – 2011. The pH, electrical conductivity (EC) and water table level was measured directly on the field.

The water samples were filtered using 0.45 membrane filters and acidified. Concentrations of Ca, Mg, Fe, Al and Zn were determined by atomic absorption spectroscopy (Solaar 969, ThermoOptek). Concentrations of Ba, Pb, Cd, As and Tl were determined by Perkin Elmer ICP-MS spectrometer Elan 6100 DRC-e. Rhodium was used as an internal spike during ICP-MS analysis.

RESULTS AND DISCUSSION

The drained peat is very sensitive for seasonally variable precipitation. BB is usually filled with water during winter and spring, while in autumn and summer water table falls significantly. The fluctuations of water table level are followed by changes in pH and EC in the 0 – 40 cm peat layer (Fig. 1). The acidity in the upper layer was in the range of pH 3.0 - 4.5 (mean 3.7).

In 2010 the mean EC value was $89 \mu\text{S cm}^{-1}$. The low position of the water table level recorded in the summer and autumn of 2009 increased the EC up to $580 \mu\text{S cm}^{-1}$, with the mean value for the autumn measurements levelled at $197 \mu\text{S cm}^{-1}$.

The pH and EC values show lesser variations in the lower peat layer (60 – 100cm). The acidity in the deeper layer was between 3.2 and 4.0 pH, with a mean pH value of 3.5. The electrical conductivity was between 39 and $147 \mu\text{S cm}^{-1}$ (mean $113 \mu\text{S cm}^{-1}$).

The mean element concentrations measured in the two depth layers are given in Tab. 1. All the analysed elements reveal higher concentrations in the upper part. The highest concentrations were measured in autumn 2009 when the mire was rewetted after dry summer season, corresponding to the high EC values recorded at that time. The differences in concentrations measured seasonally for Ca and Zn in the upper and lower layer are shown in Fig. 2. After the rewetting, the highest increase was noted for Ca, Mg, Zn, Cd, Ba and Tl. Much lower increase was observed for Fe, As and Pb, while the concentration of Al was relatively stable during the study.

The concentrations of metals in mire pore water recorded in autumn 2009 are several times higher than the metals concentrations in precipitation (Tab. 2).

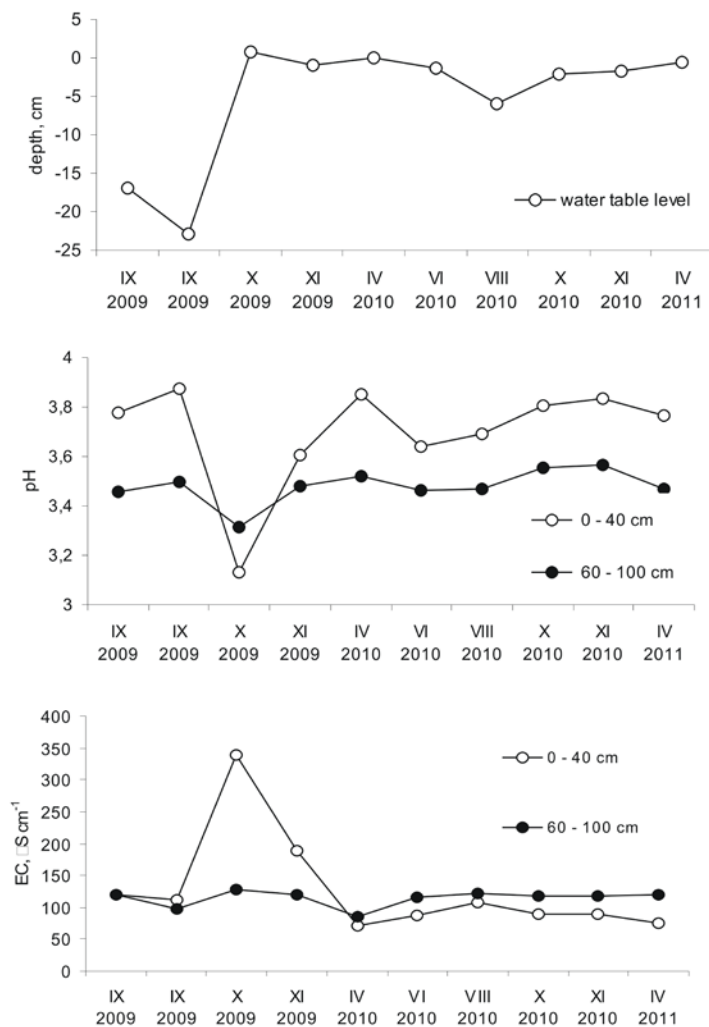


Fig.1. Seasonal variations in water table level, pH and EC in one of the pipes (no 1).

Table 1. Mean element concentrations together with the standard deviations values for pore water measured in three pipes (20 measurements) in two depth intervals

	0 - 40 cm		60 - 100 cm	
	mean value	s.d	mean value	s.d.
mg l ⁻¹				
Fe	6.52	4.38	2.21	0.81
Ca	8.56	9.18	2.13	1.43
Mg	1.89	1.66	1.20	0.25
Mn	0.14	0.16	0.03	0.03
Zn	0.91	1.18	0.15	0.10
Al	1.57	0.73	0.64	0.16
µg l ⁻¹				
As	13.85	9.79	9.25	1.91
Cd	4.89	8.52	0.56	0.25
Pb	36.96	30.07	6.81	5.70
Ba	662.93	596.40	57.73	38.21
Tl	1.17	1.97	0.29	0.32
Cu	12.07	6.98	13.19	8.79

Table 2. Chemical composition of monthly averaged samples of atmospheric precipitation collected in Katowice meteorological station located ~40 km south from the BB mire in 2010 (Szymańska-Kubicka *et al.*, 2011)

mg l ⁻¹	range
Ca, mg l ⁻¹	0.55 - 4.20
Mg, mg l ⁻¹	0.06 - 0.52
Na, mg l ⁻¹	0.13 - 2.20
K, mg l ⁻¹	0.17 - 0.85
Fe, mg l ⁻¹	0.023 - 0.110
Zn, mg l ⁻¹	0.060 - 0.990
Cr, µg l ⁻¹	0.3 - 0.0016
Cd, µg l ⁻¹	0.15 - 0.00650
Mn, mg l ⁻¹	0.0010 - 0.0350
Cu, µg l ⁻¹	4.3 - 0.0450
Ni, µg l ⁻¹	1.0 - 0.0041
Pb, µg l ⁻¹	2.4 - 0.0190

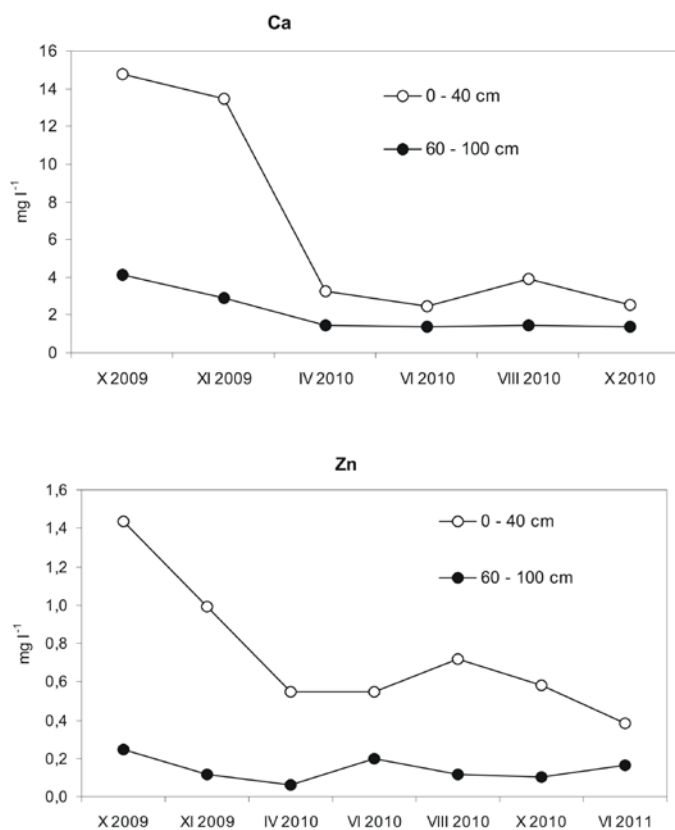


Fig.2. Seasonal variations in Ca and Zn concentration in pipe no 1 in two depth intervals.

CONCLUSION

In conclusion, fluctuations in water table level promote the release of stored trace metal into pore water, significantly exceeding the metal concentrations derived from atmospheric fall.

ACKNOWLEDGEMENT

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REFERENCES

- Ekonomiuk A, Rycharski M, Malawska M, Wilkomirski B. The raised bog “Bagno Bruch” – soil and habitat conditions. Proceedings of 12th International Peat Congress: Wise Use of Peatlands 2004:853–6.
- Fialkiewicz B., B. Smieja-Król, J. Sikorski, B. Palowski. 2008. The minerotrophic peat bog “Bagno Bruch” as a potential archive of past changes in heavy metal concentrations. Proceedings of the 13th International Peat Congress. After Wise Use – The Future of Peatlands, Ed. Catherine Farrell and John Feehan, Vol.2, 13-16.
- Smieja-Król B., Fialkiewicz-Kozieł B., Sikorski J., Palowski B. 2010 - Heavy metal behaviour in peat – mineralogical perspective. The Science of The Total Environment 408(23): 5924-31.
- Szymańska-Kubicka L., Pillich-Konieczny A., Straszak K., Zbrojkiewicz R, Caban P., Kluba J. Rasała J., 2011: Powietrze. In: Stan Środowiska w Województwie Śląskim w 2010 roku. (Eds Szczygieł A. et al.) 17-65.
- Tipping E, Smith EJ, Lawlor AJ, Hughes S, Stevens PA. Predicting the release of metals from ombrotrophic peat due to drought-induced acidification. Environ Pollut 2003;123:239–53.