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PHYSICO-CHEMICAL PROPERTIES OF LOW-MOOR PEATS VS THEIR BINDING CAPACITY FOR HEAVY METALS

INTRODUCTION

The ability of peat to bond contaminants has been known for many years (Bunzl et al. 1976, Brown et al. 2000), nevertheless both mechanism of heavy metal binding onto this material and the relations between their properties and sorption capacity have not yet thoroughly elucidated.

The presented studies were aimed to evaluate the sorption properties, mechanism and binding strength for selected heavy metal ions of low-moor peats of defined type/kind and botanical origin, as a function of their physico-chemical properties.

MATERIAL AND METHODS

Studies on sorption and mechanism of heavy metal binding were carried out on 5 samples of different low-moor peat taken from the Wizna peat-bog localized in the catchment areas of the Narew and Biebrza Rivers. The samples were characterized with respect to their decomposition rate, moisture content, porosity, ash content, pH (in H₂O) and ion exchange properties, which comprised the actual (CEC_a) and total (CEC_t) cation exchange capacity and its base saturation ratio, as well as functional groups content that showed prevalence of carboxalate (-COOH) and phenolic hydroxide (-OH) groups (Kyzioł, 2002).

To assess the sorption capacity of the studied peats, a series of equilibrium isotherm batch experiments for Cr³⁺, Cu²⁺, Cd²⁺ and Zn²⁺ binding on peat from chloride solutions with the initial metal concentration range 1 - 6000 mg Me/dm³ and pH 4.0 were conducted. The binding strength of metal ions sorbed onto studied peats from the input solution at initial concentration 5000 mg Me/dm³ was evaluated with use of 6-step sequential chemical fractionation (Kersten and Förstner, 1988).

RESULTS AND DISCUSSION

Studied matter that represented 4 types of low-moor peats (Polish Standard PN-85/G-02500) displayed different decomposition rate (DR, %). The most decomposed matter appeared to be Alder Peat Humus (DR = 55-70%), while Hypnum Moss Peat was the least decomposed one (DR = 18%). The extent of decomposition was

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dependent upon the conditions of the peat exposure to air, and declined in parallel with the increase of moisture content in the ambient environment. The increase of decomposition rate resulted in the increase of ash content and decrease of porosity; pH value in water suspension ranged from pH 5.6 (for Hypnum Moss Peat) to pH 6.45 (for Alder Peat Humus), depending on the contents in the sorption complex of peat of Ca^{2+} ions that originated from water inflow to the peat-bog (Table 1).

Table 1. Physical and physicochemical properties of studied peats

Peat		Decomposition rate (%)	Natural moisture content (%)	Porosity (%)	Ash content (%)	pH (H_2O)
Type	Kind					
Peat Humus	Alder	70	73.60	80.73	12.55	6.45
Peat Humus	Brushwood	55	79.67	81.88	10.40	6.32
Rush Peat	Reed	55	75.11	85.54	9.50	6.21
Sedgeous Peat	Sedge	30	78.45	87.11	9.10	5.81
Hypnum Moss Peat	Moss	18	92.80	89.94	7.20	5.76

Due to low ash content in the studied peat, sorption capacity was controlled predominantly by the sorption complex formed of negatively charged organic colloids. Carboxylic ($-\text{COOH}$) and phenolic hydroxide ($-\text{OH}$) groups, from which H^+ ions are partially displaced by other cations, are responsible for the negatively charged surfaces. In this respect, the effect of humic substance is similar to that of silicate clay minerals; though, its negative surface charge is more pH-dependent than the respective charges of clay minerals.

High CEC_t of Alder Peat Humus and Rush Peat (that is comparable to the CEC_t value of clay minerals of the smectite group) and dominance of Ca^{2+} ions in their sorption complex results in higher metal binding capacity than that of Reed and Moss Peats (Table 2, Fig.1). Comparison of CEC with functional group contents suggests that the complex involved in metal ion binding was the carboxylic group.

Table 2. Ion exchange properties of studied peats

Peat		CEC_a	CEC_t	$\text{Ca}_{\text{ex}}^{2+*}$	V^{**} (%)	Functional groups (cmol(+)/kg)	
Type	Kind					(cmol(+)/kg)	
Peat Humus	Alder	121.3	125	112.6	97.0	138	176
Peat Humus	Brushwood	119.5	130	110.2	91.9	135	142
Rush Peat	Reed	110.5	123	102.2	89.8	117	143
Sedgeous Peat	Sedge	60.3	85	53.2	70.9	110	128
Hypnum Moss Peat	Moss	49.5	78	44.6	63.5	106	122

* $\text{Ca}_{\text{ex}}^{2+}$ – exchangeable Ca^{2+} ion; ** V - base saturation ratio of CEC_t ;

Of the metal ions, in the highest amounts were bound Cr^{3+} (210.88 – 298.24 cmol(+)/kg) and Cu^{2+} (118.65 - 155.18 cmol(+)/kg), while binding capacity of Cd^{2+} (38.96-68.81 cmol(+)/kg) appeared to be the lowest, which is consistent with the order developed by Wieder (1990).

The experiments displayed different mobility and consequently also different susceptibility of sorbed metal ions to release, depending both on a metal nature and on the physico-chemical properties and botanical origin of the peats. The prevalence of

weak bonds, mainly in exchangeable fraction, showed Cd^{2+} and Zn^{2+} ions, while Cr^{3+} was predominantly stably bound in organometallic complexes. In general, the more readily metal ion was bound onto the sorption complex, the higher was its binding strength and the more difficult was its removal.

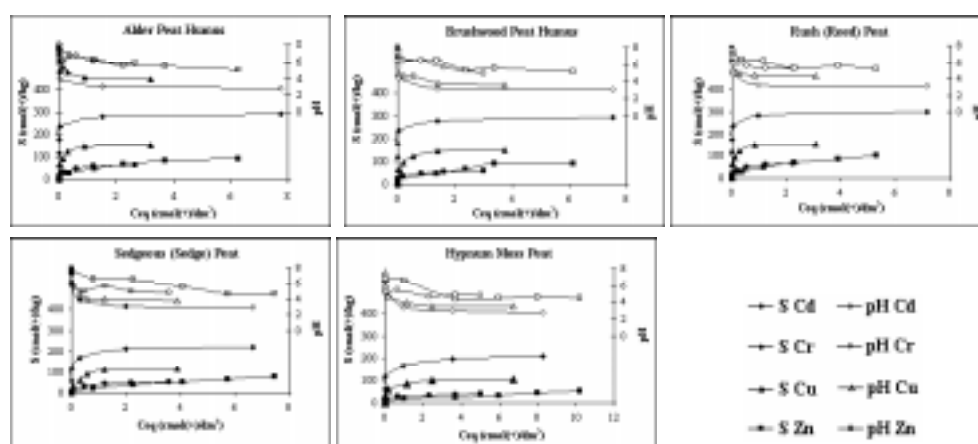


Fig.1 Sorption of Cd^{2+} , Cr^{3+} , Cu^{2+} and Zn^{2+} onto low-moor peats

CONCLUSION

The elucidation of mechanisms of sorption and release of heavy metal ions from peat should significantly contribute to the knowledge of metal binding on the natural and anthropogenic matter with predominant organic fraction that commonly occurs in the unsaturated zone, including humus layer of soils.

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