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The effect of bottom sediment supplement on heavy metals content in plants (*Zea mays*) and soil

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Abstract. Important aspect of bottom sediments is the problem of their management or disposal after their extraction from the bottom of rivers, dam reservoirs, ports, channels or ponds. The research aimed at an assessment of potential environmental management of bottom sediment used as an admixture to light soil basing on its effect on contents of heavy metals in plants and soil. The research was conducted on light soil with granulometric structure of weakly loamy sand. The bottom sediment was added to light soil in the amount of 0 (control) 5, 10, 30 i 50%. The test plant was maize (*Zea mays*), "Bora" c.v. The sediment applied in the presented research revealed high share of silt and clay fractions, alkaline pH and low contents of heavy metals, therefore it may be used as an admixture to the above mentioned soils to improve their productivity. The applied bottom sediment to the soil affected a decreased in Zn, Cd and Pb content in maize in comparison with the treatment without the deposit whereas increased content of Cu, Cr and Ni. No exceeded permissible content of heavy metals concerning plant assessment in view of their forage usability were registered in maize biomass.

Key words: bottom sediment, heavy metals, maize, utilization of bottom sediments

Introduction

A majority of heavy metals reaching waters as a result of human economic activities is trapped in bottom sediments. Bottom deposits which accumulate these substances are therefore an important source of information about the degree of water environment anthropopressure. Another crucial aspect of bottom sediments is the problem of their management or disposal after their extraction from the bottom of rivers, dam reservoirs, ports, channels or ponds (Fonseca et al. 1998, 2003). Many authors emphasize that utilization of bottom sediments free from chemical or biological pollution in agriculture may be of considerable environmental and ecological importance and prove the most rational way of their management (Baran et al. 2010, Jasiewicz et al. 2010). The research aimed at an assessment of potential environmental management of bottom sediment used as an admixture to light soil basing on its effect on contents of metals in plants and soil.

Materials and Methods

A two-year pot experiment (2009-2010) was conducted on light soil with granulometric composition of weakly loamy sand. The investigated material originated from the bottom of the Besko Reservoir situated on the Wisłok river in the Podkarpackie Voivodeship (Poland). The material was classified to clay deposit group, revealed alkaline reaction and natural content of heavy metals (Baran et al. 2011). The research was conducted on light soil with granulometric structure of weakly loamy sand. The experimental design comprised 4 treatments in 4 replications. The bottom sediment was added to light soil in the amount of 0 (control) 5, 10, 30 i 50%. Bottom sediment was added to the soil in the first year of the investigations. The test plant was maize (*Zea mays*), "Bora" c.v. After the harvest the plant material was dried at 65^{o}C in a dryer with forced air flow and the amount of dry mass yield was determined (the shoots and roots). Subsequently the plant material was crushed in a laboratory mill and subjected to chemical analysis. The heavy metals (Zn, Cu, Ni, Cd, Pb, Cr) contents in the plant material were assessed after dry mineralization and ash dissolving in HNO_3 (1:3) using ICP-AES method (JY 238 ULTRACE, Jobin Yvon). The obtained results were

Table 1. Content of heavy metals in maize [mg · kg^{-1} d.m.]

Treatment	Part of plant	Cr	Zn	Pb	Cu	Cd	Ni
Soil without sediment (control)	Shoots	0.50	35.67	0.49	1.51	0.32	0.27
	Roots	5.29	60.33	6.76	3.87	2.43	3.75
Soil+ 5% sediment	Shoots	0.96	25.57	0.43	1.90	0.20	0.51
	Roots	3.96	38.87	4.39	4.22	1.90	3.89
Soil +10% sediment	Shoots	0.59	29.57	0.42	2.15	0.26	0.34
	Roots	5.37	37.73	4.78	5.84	1.41	5.03
Soil +30% sediment	Shoots	0.49	26.87	0.41	2.50	0.20	0.74
	Roots	5.54	33.80	3.09	12.43	1.06	8.19
Soil +50% sediment	Shoots	0.77	26.27	0.38	3.31	0.21	0.46
	Roots	6.21	36.67	4.02	8.93	1.40	7.67

verified statistically using one-way ANOVA at significance level α=0.05, by means of Statistica 9.0 programme.

Results

Presented investigations revealed that maize roots accumulated more all heavy metals than the aboveground parts. Zinc content in maize was relatively high in comparison with the other metals, which results from plant considerable activity in this element uptake (Tab. 1). The highest Zn concentrations both in the aboveground parts and roots noted among the experimental treatments were in the control plants. The least quantities of zinc were assessed in the plants from treatments with a 30% and 50% supplement of the sediment to the soil. The highest concentrations of Cu were found in maize aerial parts on the treatment with a 50% supplement of bottom deposit, whereas in roots on the treatment with a 30% share of bottom sediment in the soil. The lowest copper content in the aboveground biomass and roots was assessed on the control treatment. In the maize biomass the highest nickel concentrations were registered on the variant with a 30% admixture of bottom deposit to the soil whereas the lowest on the variant with the control treatment (soil without sediment) (Tab. 1). The highest Pb concentrations were revealed on the control treatment. In comparison with the other elements, cadmium content in maize yields was the lowest. As for zinc and lead, the applied bottom sediment affected a decrease in cadmium content in maize in comparison with the treatment without the deposit, and the least amounts of cadmium were assessed in the plants on treatments with a 30% sediment supplement to the soil. The highest Cr concentrations in the plant of parts were assessed on the treatment with a 50% admixture of bottom sediment to the soil.

Discussion

In many countries extracted sediments are a waste material, which depending on its chemical composition may be environmentally used without limitations or with some restrictions, but if excessively polluted, it must be deposited on a landfill site. If the extracted sediments reveal a neutral or alkaline pH, have a high content of silt and clay fractions and low heavy metal concentrations, they may be utilized for improving the properties of light and acid soils. The sediment applied in the presented research revealed high share of silt and clay fractions, alkaline pH and low contents of heavy metals, therefore it may be used as an admixture to the above mentioned soils to improve their productivity. Environmentally justified method of dredged sediment management is also their use as structure and soil forming material for soiless systems and wastelands investigated potential management of dredged bottom sediments. In the presented experiments the assessment of heavy metal content in maize was based on potential use of produced biomass for animal feeds, using limit contents of heavy metals in plants stated by the Regulation of the Minister of Agriculture and Rural Development on the permissible quantities of undesired substances in feeds. The assessment of the obtained maize biomass using this criterion revealed that it meets the requirements for good quality fodder with respect to the contents of all metals.

Conclusions

1. A not uniform effect of bottom sediment admixture on heavy metal concentrations in maize was determined. The applied bottom sediment to the soil affected a decreased in Zn, Cd and Pb content in maize in comparison with the treatment without the deposit whereas increased content of Cu, Cr and Ni.
2. No exceeded permissible content of heavy metals concerning plant assessment in view of their forage usability were registered in maize biomass.

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