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USE OF STRAW AND WATER EXTRACT FROM FARMYARD MANURE FOR REMEDIATION OF HEAVY METALS POLLUTED SOILS

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INTRODUCTION

Heavy metals deriving from the anthropogenic activity are common pollutants of the environment. Once they enter the soil they persist in soils for thousands years and it is very difficult to eliminate their effects on the soil-plant system. Smelters and mines are of the greatest and often the oldest industrial sources of soil heavy metal contamination.

Phytoremediation in its broadest sense means using plants to restore the environment. It is a technology at an early stage of development, unless one includes the long-practised use of plants for re-vegetation of disturbed areas or waste heaps.

Two types of soil phytoremediation - immobilisation and mobilisation of heavy metals in soil were studied. Immobilisation makes heavy metals unavailable for plants. A common technique is to apply dolomitic lime, phosphates, or organic matter residues (Impens et al., 1991). Different types of zeolites were very effective in reducing Pb and Cd uptake by plants (Gworek, 1992; Czupyrna et al., 1989).)Mobilisation increases heavy metals availability and improves heavy metals uptake by plants used in for remediation.

MATERIALS AND METHODS

The site of studies is situated in vicinity of a Kremikovtsi smelter near Sofia, Bulgaria. The smelter was built in 1960. Main pollution came from iron-ore processing works. Surface of polluted area is about 10 000 ha.

For preliminary studies 7 arable soils with different level of heavy metal pollution were sampled. Sampling points were distributed around the smelter. The soil layer 0-20 cm were sampled from all sampling areas. After the manual removal of plant debris soils were dried and sieved at 4 mm and stored till the beginning of experiments. Most polluted Kremikovtsi soil was studied in pot experiments. Some soil chemical characteristics: C org - 2.06%; pH (in H_20) - 7.4; Cu - 85 $mg.kg^{-1}$; Zn - 1320 $mg.kg^{-1}$; P - 1300 $mg.kg^{-1}$; Cd - 5.5 $mg.kg^{-1}$.

Three different crops typical for this area were used in our study: Triticale, Cabbage and Lettuce. Every species was studied in conditions of 6 treatments:

Control - Kremikovtsi soil - characterized as very highly polluted soil. The content of lead, zinc and cadmium is extremely high.
Farmyard manure extract - Water extract of farmyard manure (in w/w proportion 3:2=water:manure) was applied in rate corresponding to 60 ton farmyard manure per hectare) 30 $ml.kg^{-1}$
Straw - Well ground straw 10 $g.kg^{-1}$ + NPK - 200 - 100 - 300 $mg.kg^{-1}$

Heavy metals content was determined by AAS after wet digestion. Statistical analyses were done on Statgraphics statistical package.

In pot experiment we study two types of soil remediation - immobilisation and mobilisation of heavy metals in soil. Immobilisation makes heavy metals unavailable for plants. Mobilisation increases heavy metals availability and improves heavy metals uptake by plants used in for remediation. The effect depends on the plant species. That is why in our study we used three different plants species typical for studied area - triticale, cabbage and lettuce (well know as an accumulator of cadmium- according to Basta et Gradwohl, 2000).

RESULTS AND DISCUSSION

Studied treatments affected crops yield as depend of nitrogen application. The treatment with straw application increased yield due to higher inorganic nitrogen content in soil. Straw carbon bound applied inorganic N partly and remaining nitrogen was sufficient for optimal yield (Table 1).

Table 1. Dry matter yield from pot experiment g per pot (2 kg soil)

Treatments	Triticale	Lettuce	Cabbage
Control	9,4	3,5	3,3
FM extract	9,2	3,8	3,3
Straw	17,7	5,6	11,0
$LSD_{0.05}$	4.1	3.2	2.0

Heavy metals content in crops depends on the plant, treatment and species of heavy metal (Fig. 1, 2, 3). Higher content of Zn and Cu is observed in Straw treatment for triticale, lettuce an cabbage, with exception for Farmyard extract for cabbage. Lead content varied as depend of studied crop. For triticale higher lead content was observed in Straw treatment. For lettuce higher Pb content was in Control treatment. In this case FM extract treatment decreased strongly Pb content in lettuce plants (about 3 times). Cabbage plants extracted more heavy metals (Cu, Pb, Cd) in FM extract treatment. Straw treatment was optimal fro extraction of Zn by cabbage. Cadmium extraction level was very low and that is why treatments and crop type influence on Cd content is not very clear.

Heavy metals uptake by studied plants is correlated with crop yields (fig. 4, 5 and 6). Higher yields correlate with higher uptakes. Lead uptakes have 2 exceptions - a relatively high uptake in Control treatment for lettuce, and highest uptake for lead in farmyard manure extract treatment for cabbage. Uptake range for different metals of all studied crops is Zn, Pb, Cu and Cd.

CONCLUSIONS

The analyses of green house experimental data give us reason to conclude that treatment with straw application is more suitable than treatment with farmyard manure extract.

We received information about the impact of plant species on the accumulation of heavy metals in upper, green parts. Accumulation of heavy metals in upper part of studied plants depends as well to plant species

The range of average heavy metal content in plants is as follows: for Cu - lettuce, triticale and cabbage; for Zn - lettuce, triticale and cabbage, for Pb - cabbage, lettuce and triticale and for Cd - lettuce, cabbage and triticale.

The range of average heavy metal uptake by plants is as follows: for Cu - triticale, lettuce and cabbage; for Zn - triticale, lettuce and cabbage, for Pb - triticale, cabbage and lettuce and for Cd - triticale, cabbage and lettuce.

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Fig. 1. Heavy metals content in triticale

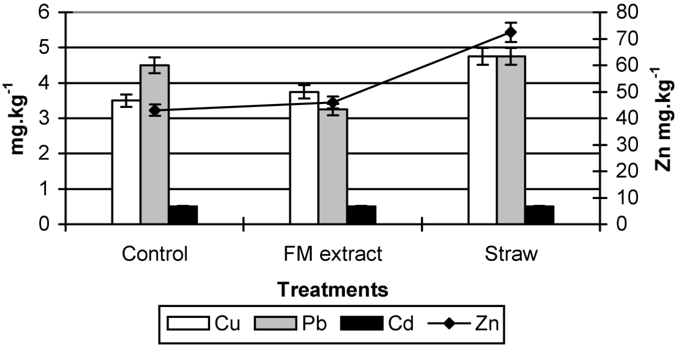

Fig. 2. Heavy metals content in lettuce

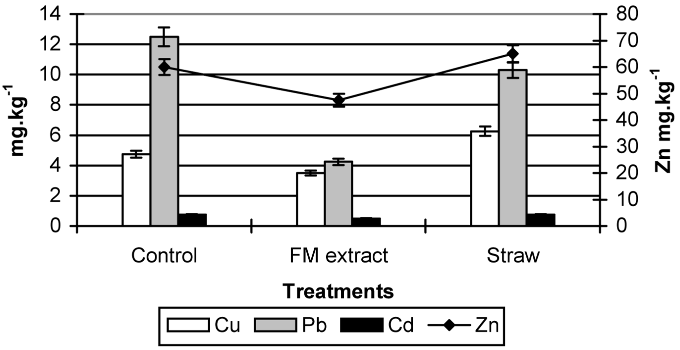

Fig. 3. Heavy metals content in cabbage

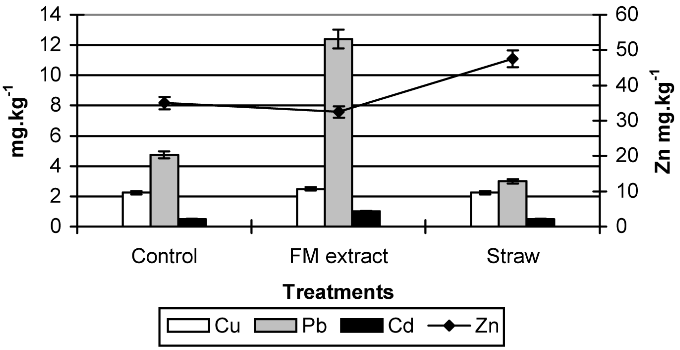

Fig. 4. Heavy metals uptake by triticale

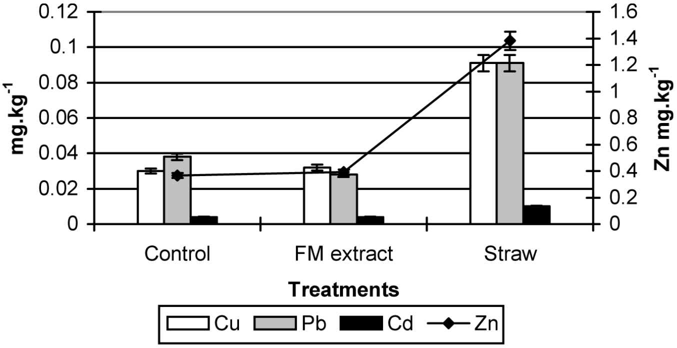

Fig. 5. Heavy metals uptake by lettuce

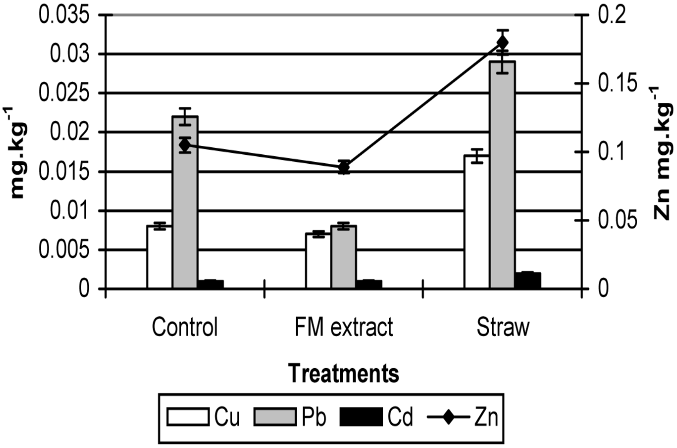

Fig. 6. Heavy metals uptake by cabbage