A „mesocosm“ model in use of phytoremediation decision support investigations

N. DINEV, V. KOUTEV, D. DIMITROV and L. DIMOVA

Summary

Phytoremediation is a relatively new and gentle technique to rehabilitate polluted and chemical degraded soils as whole. A number of approaches are used to understand the behavior of contaminant in soil, their effect on the plant and transfer in food chain. One of the most important questions is to find primary effect on the plant growth and especially on the plant root system. The problem in front of scientists is to use a model system, which must create conditions close to both the field and the pot experiments. To decide this problem we apply a "mesocosmos"- lysimeter mode pots for PhytoDec project.

The used mesocosmos essentially are containers filled on-side with slightly homogenized soil and at the bottom filled with a layer of clean zeolite. The pots are with volume about 60 L. and 65 kg soil from the selected field was placed into. Soil is delluvial, and the degradation parameters are due to a copper- smelter production. Soil pH is 4 (measured in soil/water), and Cu content is 1300 ppm. The experiment is realized according to preliminary discussed scheme- the concentrations of macro- and microelements have to measured by artificial roots put in 15 and 30 cm (from the top) depth as well as the leached solution. Soil solution is obtained by vacuum application on the soil samples ("artificial roots").

Mixed grasses were seeing in the Spring 2003.

Every month a selection of leachates has been done. Results from one of these solutions received in September 2003 was discussed in the present paper.

Different amendments are used to remediate soil. One of them is the classical one (lime) and the reason to use it was to increase soil pH and to decrease Cu-mobility. Other amendments are natural materials- zeolite and modified zeolite (enriched with macroelements- trade mark "perlit") produced in Bulgaria. Third group is consisted of organic amendments- natural peat (neutral pH) and coal powder. In addition, a ferry-hydroxide was applied in some of variants.

The application of lime is most effective and relatively fast effect on the soil properties and plant growth. Increasing of lime dose leads to strongly decreasing of heavy metal concentrations in all three solutions depth. The most effective results are received at dose of 150g/pot. The difference between control (not treated) variant and variants with added lime material is about 19 times (15 cm depth), 28 times (30 cm depth) and 81 times (in plastic tube, 70 cm depth). Using of other amendments shows that more of them in combination improve soil properties. The negative effects are detected at variants with peat (alone), added in two doses; with peat and ferric hydroxide in combinations. The worst was the result with application of zeolites and perlite added alone.

Our results showed that for the remediation of sample soil a correction of pH by lime has to be done as first step obligatory. The changes in soil solution at three depths by modeling experiment are indicative for the distribution of pollutants in soil profile. Using a series of measurements we could create an adequate model useful for the phytoremediation decision support system.

Introduction

Phytoremediation is a relatively new and gentle technique to rehabilitate polluted and chemical degraded soils as whole. A number of approaches are used to understand the behavior of contaminant in soil, their effect on the plant and transfer in food chain. One of the most important questions is to find primary effect on the plant growth and especially on the plant root system. The problem in front of scientists is to use a model system, which must create conditions close to both the field and the pot experiments. To decide this problem we apply a "mesocosm"- lysimeter mode pots for PhytoDec project.

The common use of lysimeter is oriented to investigation of leaching of different elements and ions in soil profile. The leaching of nitrate (PARENTE et al., 2003; RYAN, 2003), nitrate and ammonium ions (JUNEDI et al., 2003) in purpose of monitoring is reported recently.

The type of lisimeter used by us is a filled up type. The advantage of this type lysimeter is the creation of similar for drainage in all replications.

The goal of the present investigation was to assess the implication of lysimeter type "mesocosm" pots for phytoremediation capacity of plants in heavy metal polluted strongly acid soil.

Material and methods

Soil is collected from the area of Zlatitza (Central Bulgaria). Since forty years there is a still working copper plant. The soil is delluvial- alluvial and is enriched in trace elements (especially copper). The soil acidity varies from 4 to 6.5 and the acidity increases close the smelter. In selected area the concentration of Cu is about 1750 ppm. In the some parts, the area is practically desertificated.

A pot experiment (so called mesocosm) is carried out.

The used mesocosm essentially are containers filled on-side with slightly homogenized soil and at the bottom filled with a layer of clean zeolite. The pots are with volume about 60 L. and 65 kg soil from the selected field was placed into. Soil

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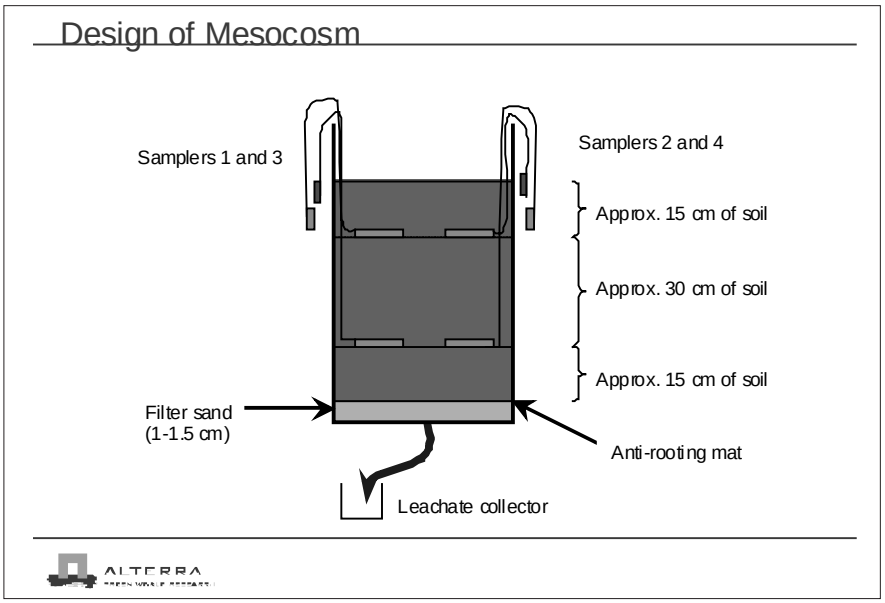

is delluvial, and the degradation parameters are due to a copper- smelter production. Soil pH is 4 (measured in soil/water), and Cu content is 1300 ppm. The experiment is realized according to preliminary discussed scheme- the concentrations of macro- and microelements have to measured by artificial roots put in 15 and 30 cm (from the top) depth as well as the leached solution. Soil solution is obtained by vacuum application on the soil samples ("artificial roots").

Variants

The used mesocosmos essentially are containers filled on-side with slightly homogenized soil and at the bottom filled with a layer of clean zeolite. The pots are with volume about 60 L. and 65 kg soil from the selected field was placed into. Soil is delluvial, and the degradation parameters are due to a copper- smelter production. Soil pH is 4 (measured in soil/water), and Cu content is 1300 ppm. The experiment is realized according to preliminary discussed scheme- the concentrations of macro- and microelements have to measured by artificial roots put in 15 and 30 cm (from the top) depth as well as the leached solution. Soil solution is obtained by vacuum application on the soil samples ("artificial roots").

Mixed grasses were sowed in the Spring 2003.

Every month a selection of leachates has been done. Results from one of these solutions received in September 2003 were discussed in the present paper.

Table 1: **Type and concentration of amendments applied in experiment Plant- grass mixture.**

	g/65 pot (kg soil)				
	CaO	peat	Fe_2O_3	zeolite	coal
Control	0	0	0	0	0
2	75	0	0	0	0
3	150	0	0	0	0
4	225	0	0	0	0
5	150	0	0	0	500
6	150	0	0	0	1000
7	150	0	0	0	1500
8	150	500	0	0	0
9	150	1000	0	0	0
10	150	1500	0	0	0
11	0	1000	0	0	0
12	0	500	0	0	0
13	0	1500	0	0	0
14	150	0	400	0	1000
15	150	1000	400	0	0
16	150	1000	400	0	0
17	0	0	0	400	0
18	150	1000	0	400	0
19	150	0	0	400	0
20	0	0	400	400	0

Different amendments are used to remediate soil (*Table 1*). One of them is the classical one (lime) and the reason to use it was to increase soil pH and to decrease Cu- mobility. Other amendments is a natural materials- zeolite is originated from Bulgaria. Third group is consisted of organic amendments- natural peat (neutral pH) and coal powder. In addition, a ferry-hydroxide was applied in some of variants.

Results and discussion

The investigation of different lechates is very indicative for monitoring of root nutrition. The concentrations of copper and zinc at different depths showed the trend to changes of pollutant concentrations after application of several amendments.

The behavior of Cu at 15 and 30 cm laid artificial roots is the identical (*Figures 1* and *2*). After increasing of the lime material the concentration of Cu strongly decrease. Negative (i.e. increasing of Cu in the lechates) effects showed the variants 11 and 12 with peat added in doses of 500 and 1000 mg/ pot as well the variants 17 and 20, treated with ferric oxide and zeolites added alone and combined.

The changes in zinc concentrations in lysimeter expressed the same tendency like copper- increasing of concentrations at variants 11, 12, 17 and 20. The slight difference is that concentration of Zn at 15 cm depth is higher than at 30 cm.

The concentration of Cu is significantly higher in lysimeter water leached down the pots (*Figure 3*). The Cu content increased till 47 mg/ L in variant 20. Zinc concentration is lower and the changes

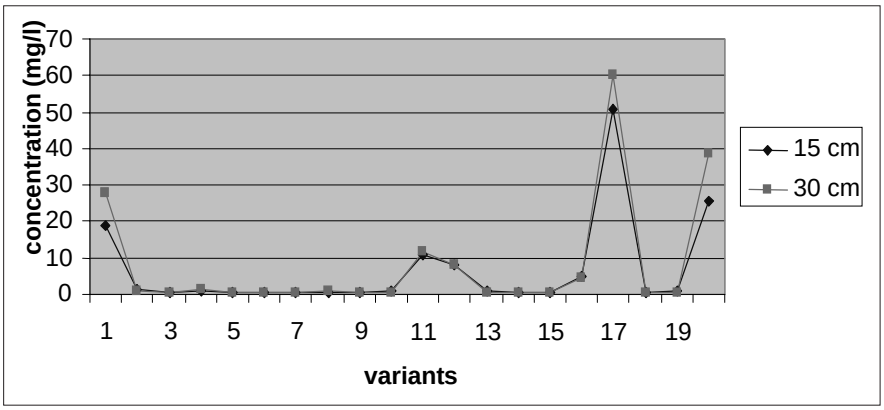

Figure 1: **Lechates_Cu**

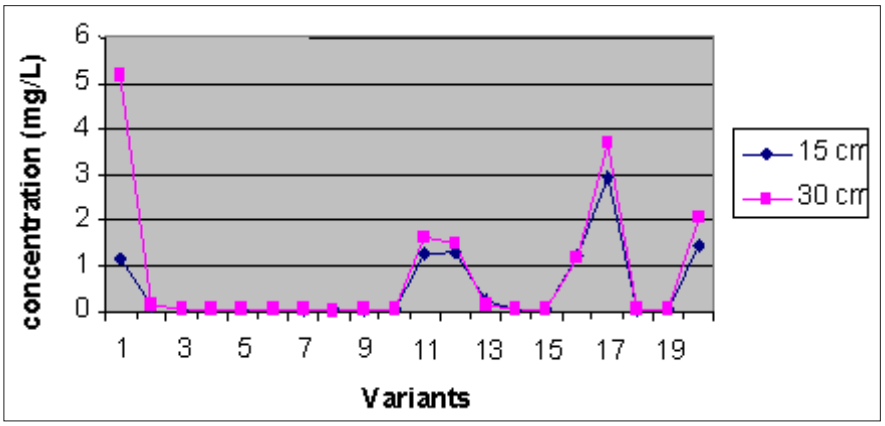

Figure 2: **Lechates_Zn**

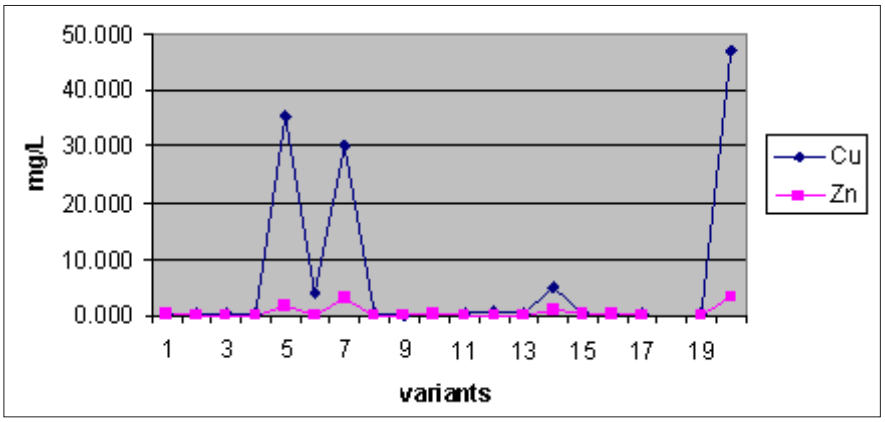

Figure 3: **Concentration of Cu and Zn in lysimeter water**

were close to measured in artificial root extracts.

The concentration of Cu is very high in variants 5 and 7 with application of coal powder. This didn't correlated with all other measurement. Our explanation about received data is that very low penetration of the water compared with other variants leads to enrichment of lysimeter water with copper.

Conclusions

The application of lime is most effective and relatively fast effect on the soil properties and plant growth. Increasing of lime dose leads to strongly decreasing of heavy metal concentrations in all three solutions depth. The most effective results are received at dose of 150g/pot.

Using of other amendments shows that more of them in combination improve soil properties. The negative effects are detected at variants with peat (alone), added in two doses; with peat and ferric hydroxide in combinations. The worst was the result with application of zeolites added alone.

Our results showed that for the remediation of sample soil a correction of pH by lime has to be done at the first step obligatory. The changes in soil solution at three depths by modeling experiment are indicative for the distribution of pollutants in soil profile. Using a series of measurements we could create an adequate model useful for the phytoremediation decision support system.

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