PHYTOREMEDIATION OF CADMIUM POLLUTED SOILS USING SOYBEAN VARIETIES

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INTRODUCTION

"PHYTOREMEDIATION basically refers to the use of plants and associated soil microbes to reduce the concentrations or toxic effects of contaminants in the environments". It can be used for removal of heavy metals as well as for organic pollutants. Phytoremediation also enjoys popularity with the general public as a "GREEN CLEAN". This method is not hazardous to human health, environment friendly and from economic point of view is very cost effective. There are different types of phytoremediation: phytoextraction, phytovolatilization, phytostabilization and rhizofiltration. THE MOST SUITABLE METHOD FOR CD EXTRACTION OF SOIL IS PHYTOEXTRACTION. This method is based on excluding cadmium from soil by plant through water received from the root system, sorption or through some other mechanism. A great number of plant species have been studied in their ability to remediation of Cd from soil, including several varieties of soybean.

The main purpose of this study is to evaluate the efficiency of three SOYBEAN VARIETIES with short vegetation in incorporation with rhyzobacterium *BRADYRHIZOBIUM JAPONICUM* for cadmium phytoextraction/phytostabilization.

METHODOLOGY

The experiment was set up in an open field conditions with selected soybean varieties with short vegetation (**PELLA**, **AVIGEA** and **OW**). The experiment was performed in appropriate pots for growing soybeans set according to the method of randomized block system, with duration from June to October, 2011. The soil, where the soybean seeds were planted, was collected from the surface layer (0-15 cm) downstream from the potentially polluted area from Zletovska river. Five locations were selected, wherefrom the soil was collected (**Z1, Z2, Z3, Z4** and **Z5**). This is an area where the Pb-Zn mine "Zletovo" is operating for more than 20 years. Four seeds of each variety were sown in each container and reduced into two plants after growing. Before the sowing, seeds were treated with a suspension of rhyzobacterium *Bradyrhizobium japonicum.*

RESULTS

Table 1. Chemical/mechanical soil composition from Zletovska River region (n=5/5)

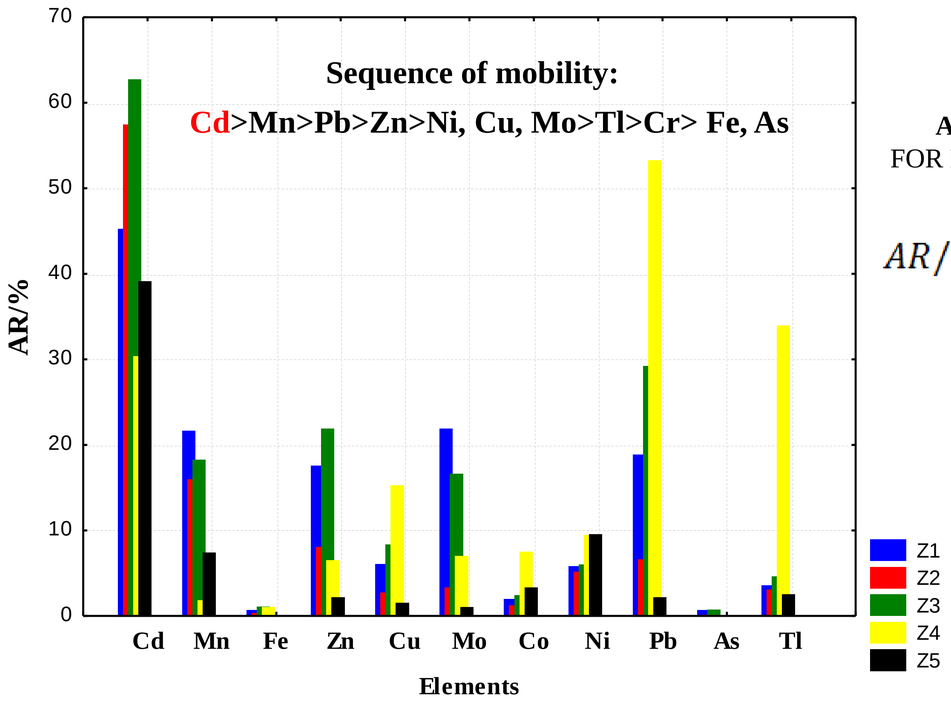
Soil parameters	Determined Range	Median
Cation exchange capacity, CEC (cm/mol)	0.3-9.8	5.7
Electrical conductivity, EC (msS/cm)	0.22-12.1	1.72
pH/KCl	3.2-6.9	3.2
Organic matter, OM (%)	0.92-5.24	1.47
K_2O (mg/100g)	1.4-15.3	4.9
P_2O_5 (mg/100g)	1.4-12	3.4
Total Cd (mg/kg)	0.97-17.6	2.3
Available Cd (mg/kg)	0.32-3.9	1.1
Loam (%)	0.01-10.2	1.9
Sand (60-2000 μm)	69.5-97.2	78.7

Elements TOTAL content (mg/kg)

Locality	Cd	Mn (%)	Fe (%)	Zn	Cu	Mo	Co	Ni	Pb	As	Tl
Z1	2.3	0.31	4.21	608	44	1.3	14	13	437	39	1.9
Z2	4.2	0.64	5.5	1267	86	2.4	14	11	1116	97	3.1
Z3	1.32	0.23	3.72	369	27	1.0	10	11	306	25	1.5
Z4	17.6	3.28	9.33	8551	138	6.3	13	7.6	3987	240	5.2
Z5	0.97	0.49	7.25	1420	74	3.2	2.2	4.7	1701	265	4.9

AVAILABLE content in soil (given in mg/kg)

Location	Cd	Mn	Fe	Zn	Cu	Mo	Co	Ni	Pb	As	Tl
Z1	1.1	690	291	105	2.7	0.28	0.28	0.79	83	0.26	0.06
Z2	2.3	1030	181	91	2.2	0.08	0.17	0.57	67	0.10	0.09
Z3	0.84	430	412	82	2.2	0.17	0.23	0.69	89	0.19	0.07
Z4	3.9	200	932	461	18	0.44	0.95	0.73	2123	0.079	1.3
Z5	0.32	365	24	31	1.1	0.02	0.08	0.40	35	0.062	0.11



ACTIVITY RATIO
FOR ELEMENTS IN SOILS

$$AR/\% = \frac{[E]_{AV}}{[E]_t} * 100$$

Table 2. Total content of Cd in soybean varieties with short vegetation in different parts of plants (values given in mg/kg)

	Avigea					*OW*					*Pella*				
	Root	**Stem**	**Leaf**	**Seed**	**Pod**	**Root**	**Stem**	**Leaf**	**Seed**	**Pod**	**Root**	**Stem**	**Leaf**	**Seed**	**Pod**
Z1	0.15	0.37	1.20	0.27	0.36	0.75	0.96	6.02	0.77	1.70	0.57	1.09	4.60	0.49	0.88
Z2	0.33	0.55	1.43	0.39	0.91	3.34	6.29	13.4	0.95	3.35	0.63	0.65	1.72	0.45	0.70
Z3	0.26	0.13	0.84	0.08	0.10	1.27	1.31	2.42	0.61	0.79	4.52	4.72	13.5	1.29	3.52
Z5	0.42	1.45	3.10	0.36	0.93	5.72	7.73	7.60	2.57	5.41	4.92	2.55	7.87	0.94	1.85

TRANSLOCATION FACTOR (TF), **BIOLOGICAL ACCUMULATION COEFFICIENT** (BAC) and **BIOLOGICAL CONCENTRATION FACTOR** (BCF) values were used to evaluate the potential of plant species for phytoextraction and phytostabilization of the soybean varieties with short vegetation

Table 3. Biological Accumulation Coefficient (BAC) and Biological Concentration Factor (BCF) in soybean varieties / **Significant values >1**

	Avigea					*OW*					*Pella*				
	Root	**Stem**	**Leaf**	**Seed**	**Pod**	**Root**	**Stem**	**Leaf**	**Seed**	**Pod**	**Root**	**Stem**	**Leaf**	**Seed**	**Pod**
Z1	0.14	0.34	1.10	0.25	0.33	0.68	0.88	5.51	0.70	1.56	0.52	1.00	4.22	0.45	0.80
Z2	0.15	0.24	0.63	0.17	0.40	1.48	2.78	5.94	0.42	1.48	0.28	0.29	0.76	0.20	0.31
Z3	0.31	0.15	1.00	0.10	0.12	1.52	1.56	2.89	0.73	0.94	5.39	5.63	16.1	1.53	4.20
Z5	1.31	4.51	9.65	1.11	2.88	17.8	24.1	23.7	8.01	16.9	15.3	7.95	24.5	2.94	5.76

Table 4. Translocation Factor (TF) in soybean variety (*Avigea, OW and Pella)*

	Stem	**Leaf**	**Seed**	**Pod**
Min	0.49	1.33	0.19	0.38
Max	3.44	8.05	1.81	2.72
Median	1.28	3.22	0.48	1.00

CONCLUSIONS

- *The present investigation revealed that soybean varieties with short vegetation, OW and Pella could be efficient plants for phytoextraction of Cd from contaminated soil.*
- *Highest efficiency of Cd phytoextraction occurred when soil was contaminated. The soybean variety Avigea showed lower ability for phytostabilization and phytoextraction.*
- *Both, BAC and TF values higher than 1 indicated that OW and Pella are potentially useful for remedying Cd-contaminated soil and can be introduced as a good potential Cd-hyper accumulator plants.*

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