SOYBEAN VARIETIES AS EFFECTIVE TOOL FOR PHYTOREMEDIATION OF CADMIUM POLLUTED SOIL

Ljupcho Mihajlov[1], Biljana Balabanova[1], Vesna Zajkova Panova[1], Shuhe Wei[2]

[1]Faculty of Agriculture, University"Goce Delčev", Krste Misirkov No. 10-A, 2000 Stip, Republic of Macedonia
[2]Key Laboratory of Terrestrial Ecological Process, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110016, China

INTRODUCTION

Cadmium (Cd) is an important toxic heavy metal and the warning of health risks from Cd pollution were issued initially in the '70s. Increased concentrations of Cd in agricultural soils are known to come from human activities, such as the application of phosphate fertilizer, sewage sludge, wastewater, pesticides, mining and smelting of metalliferous ores with high Cd content, and traffic. Although there are many reports on Cd contamination in agricultural soils, most of the investigations are concentrated in the vicinity of the mine sites. But concerning point is certainly dealing with the problem of cadmium soil pollution. Remediation has been improved as most effective for soil pollution. Recently phytoremediation has been improved as one of the most convenient techniques for remediation of heavy metals from contaminated soils.

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

METHODOLOGY

➢Soybean varieties with long vegetation (***Balkan, Ilindenka* and *Pavlikeni***) and soybean varieties with short vegetation (***Pella, Avigea* and *OW***) were used in association with rhyzobacterium *Bradyrhizobium japonicum*.

➢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/DATA SUMARY

Soil analysis

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

Sequence of mobility -soil

Zletovo: Cd>Pb>Mn>Zn>Mo>Cu>Ni>Tl>Co>Fe>As

Bucim: Mn>Pb>Cd>Co>Mo>Ni>Zn>Cu>As>Tl>Fe

Lumbryhumus: Tl>As>Mo>Mn>Cd>Cu>Zn>Co>Pb,Ni>Fe

Amzibegovo: Mn>Cd>As>Pb>Ni>Ni>Tl>Co>Mo>Zn>Cu

Table 1. Total content of Cd in soybean varieties with short vegetation in different parts of plants (values given in mg/kg)

	Soils from location Zletovska Reka															
	Avigea- A					**OW**					**Pela**					
	Root	Shoot	Leaf	Seed	Pods	Root	Shoot	Leaf	Seed	Pods	Root	Shoot	Leaf	Seed	Pods	
Min	0.15	0.37	1.2	0.27	0.36	0.75	0.96	6.02	0.77	1.7	0.57	1.09	4.6	0.49	0.88	
Max	0.33	0.55	1.43	0.39	0.91	3.34	6.29	13.45	0.95	3.35	0.63	0.65	1.72	0.45	0.7	
Med	0.26	0.13	0.84	0.08	0.1	1.27	1.31	2.42	0.61	0.79	4.52	4.72	13.5	**1.29**	**3.52**	
	Soils from Amzibegovo contaminated with $Cd(NO_3)_2$ solution in concentration 1, 2, 3, 5, 10 mg kg^{-1}															
	Root	Shoot	Leaf	Seed	Pods	Root	Shoot	Leaf	Seed	Pods	Root	Shoot	Leaf	Seed	Pods	
A1	1.94	2.30	3.97	1.26	2.47	2.61	4.15	6.63	1.04	1.42	2.08	1.28	4.25	0.41	0.78	
A2	6.99	2.71	6.03	1.74	1.94	3.31	2.24	7.23	2.29	2.98	3.00	2.03	4.50	**1.19**	1.60	
A3	16.41	**4.99**	7.66	**3.22**	**5.07**	**14.28**	2.06	11.56	2.29	2.04	5.41	2.14	5.91	0.90	1.32	
A5	22.57	2.69	13.94	1.75	2.39	**14.45**	2.60	11.20	1.95	2.42	**11.98**	**2.52**	5.54	0.96	**1.71**	
A10	**44.5**	3.50	**15.2**	2.90	3.30	6.58	2.01	**29.2**	1.88	1.96	13.23	2.24	**14.94**	0.82	1.40	
	Lubrihumus contaminated with solution of $Cd(NO_3)_2$ in concentration 1, 2, 3, 5, 10 mg kg^{-1}															
	Root	Shoot	Leaf	Seed	Pods	Root	Shoot	Leaf	Seed	Pods	Root	Shoot	Leaf	Seed	Pods	
LH1	0.57	0.81	1.26	0.63	0.82	0.22	0.24	42.84	0.15	0.17	0.5	0.31	0.4	0.22	0.39	
LH2	1.19	1.41	2.29	1.16	1.5	0.5	0.31	0.55	0.22	0.39	1.1	0.56	2.05	0.29	0.71	
LH3	1.44	1.37	1.98	0.98	0.86	1.48	1.07	0.16	0.63	1.01	0.51	0.56	1.72	0.25	0.58	
LH5	1.99	1.33	5.15	1.23	0.9	1.81	1.2	0.09	0.5	1.03	/	/	/	/	/	
LH10	2.51	1.01	4.66	1.23	0.9	/	/	/	/	/	/	/	/	/	/	

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

	Soils from location Zletovska Reka															
	Balkan-B					**Ilindenka**					**Pavlikeni**					
	Root	Shoot	Leaf	Seed	Pods	Root	Shoot	Leaf	Seed	Pods	Root	Shoot	Leaf	Seed	Pods	
Min	0.41	0.19	0.24	0.13	0.16	0.62	0.32	0.42	0.16	0.22	0.2	0.21	0.47	0.12	0.19	
Max	0.6	0.83	1.74	0.33	0.6	0.59	0.23	0.33	0.13	0.18	0.36	0.26	0.4	0.16	0.21	
Med	0.77	0.14	0.32	0.11	0.09	0.83	0.14	0.22	0.14	0.18	0.41	0.11	0.35		0.11	
	Soils from Amzibegovo contaminated with $Cd(NO_3)_2$ soluton in concentration 1, 2, 3, 5, 10 mg kg^{-1}															
	Root	Shoot	Leaf	Seed	Pods	Root	Shoot	Leaf	Seed	Pods	Root	Shoot	Leaf	Seed	Pods	
A1	2.73	2.94	3.41	2.53	3.73	0.92	0.85	1.5	0.69	0.77	10.9	7.07	15.05	7.37	11.2	
A2	14.6	2.49	4.79	2.83	2.15	4.63	2.17	3.09	0.9	1.5	14.1	5.82	10.92	4.98	5.79	
A3	10.3	4.5	7.29	3.53	5.6	4.82	1.88	2.92	1.48	1.87	15.5	2.04	4.42	4.04	2.59	
A5	9.63	4.41	43.8	3.33	5.34	3.53	2.06	4.17	0.81	1.61	5.55	0.73	2.11	1.44	0.92	
A10	15.7	2.47	38.4	2.46	2.94	8.03	1.68	4.32	0.99	1.65	8.73	2.24	7.72	1.5	2.01	
	Lubrihumus contaminated with soluton of $Cd(NO_3)_2$ in concentration 1, 2, 3, 5, 10 mg kg^{-1}															
	Root	Shoot	Leaf	Seed	Pods	Root	Shoot	Leaf	Seed	Pods	Root	Shoot	Leaf	Seed	Pods	
LH1	1.68	0.57	0.54	0.19	0.24	0.7	0.38	2.34	0.41	0.55	0.12	0.12	0.08	0.14	0.11	
LH2	1.03	0.41	/	/	/	4.57	0.72	1.29	0.66	0.68	1.22	0.85	1.94	0.46	0.52	
LH3	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	
LH5	/	/	/	/	/	/	/	/	/	/	1.99	1.33	5.01	1.23	0.90	
LH10	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	

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.
- OW and Pella are potentially useful for remedying Cd-contaminated soil and can be introduced as a good potential Cd-hyper accumulator plants.