CHEMICAL STABILIZATION OF HEAVY METALS ON CONTAMINATED SOILS BY LIGNITE

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Abstract:
Lignite is a potential chemical stabilising agent for a chemical stabilization remediation technology. We studied effects of lignite on immobilization of toxic metals under laboratory conditions. A soil incubation experiment was carried out in a complex experimental system with Cr, Pb, Zn salts with respect to the normalized matrix-plan. After incubation there were assayed the metal fractions with different mobility: nitrohydrochloric acid soluble ("total") metal concentration, and distilled water, acetate buffer, Lakanen-Erviö buffer soluble metal concentration for mobile fractions. The strongest stabilisation effect of lignite can be seen in case of Cr while the weakest in case of Zn. It is confirmed that the lignite is a suitable additive for chemical stabilisation during combined chemical- and phytostabilisation of contaminated soils.

Keywords: heavy metal, lignite, chemical stabilisation

Introduction

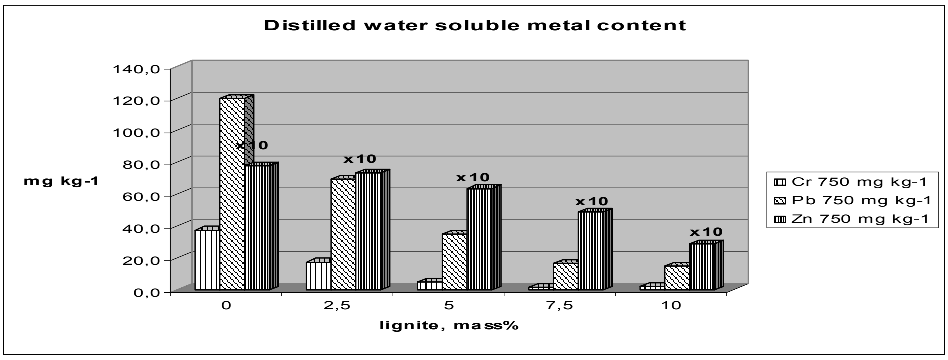
Pollution of the Biosphere with toxic metals and other chemicals may pose remarkable environmental and human health risk (Várallyay, 2006). Usually the most efficient in situ technology for cleaning the toxic metal contaminated soil is combined physico-chemical and phytoremediation technologies (Bíro, 2007, Feigl et *al.,* 2006). There are many inorganic and organic stabilising amendments (Carmona et *al.* 2005; Maurice and Kumpiene 2005, Terzano et *al*., 2005, Gaast et *al.,* 2003, Weigand et *al.,* 2003) but only a few are tested under laboratory conditions. Lignite is a potential chemical stabilising agent for a chemical stabilization remediation technology. We studied effects of lignite on immobilization of toxic metals under laboratory conditions.

Materials and methods

A soil incubation experiment was carried out in a complex experimental system. DISITOBI model assures information about experimental object characterized by multidimensional response-function (Biczók et *al.* 1994, Anton et *al.* 1994). There were 4 treatments (lignite, Pb, Cr, Zn as $Pb(NO_3)_2$; $Cr(NO_3)_3.9H_2O$; $ZnSO_4.7H_2O$.) in 3 replications. 5-5 levels of the 4 studied factors were combined in an orthogonal way by means of the program with respect to the normalized matrix-plan. Temperature and soil moisture were constant during the incubation period (4 weeks). The parameters of the model acidic sandy soil are: $pH(H_2O)$ 4,9; OM 0,9%; $CaCO_3$ 0%; salt <0,02%; total N,P,K (mg/kg): 610, 329, 1770, respectively. After incubation there were assayed the metal fractions with different mobility: nitrohydrochloric acid soluble ("total") metal concentration, and distilled water, acetate buffer, Lakanen-Erviö buffer soluble metal concentration for mobile fractions.
Form of the DISITOBI model in the present experiment:
$y=B_0+B_1*L+B_2*Pb+B_3*Zn+B_4*Cr+B_5*L*Pb+B_6*L*Zn+B_7*Zn*Pb+B_8*Cr*L+B_9*Cr*Pb+B_{10}*Cr*Zn+B_{11}*L^2+B_{12}*Pb^2+B_{13}*Cr^2$ where:
y=dependent variable, B_0-B_{13}=parameters of the model, L=lignite volume %, Pb, Zn, Cr=toxic metal concentration in mg kg^{-1}

Results and discussion

The distilled water and acetate buffer extracts are modeling the migration-infiltration risk of pollutants, while concentrations in Lakanen Erviö buffer gives information about of possibility of plant uptake. According to the experimental model (Table 1.), lignite had a significant negative effect on mobility of Cr and Zn in each extracts and of Pb in distilled water and acetate buffer extracts. The strongest stabilisation effect of lignite can be seen in case of Cr while the weakest in case of Zn. The Cr concentration of mobile fractions were reduced by 96%; 92%; 77% in distilled water, acetate buffer and Lakanen Erviö extracts respectively under the effect of 10 mass % lignite. The 10 mass % lignite concentration reduced the Zn mobility by more than 61% in distilled water and by 56 % and 38 % in acetate buffer and Lakanen Erviö extract (Figure 1-3.).



LSD 5%(Cr)=1,62; LSD 5%(Pb)=4,45; LSD 5%(Zn)= 37,45

Figure 1.

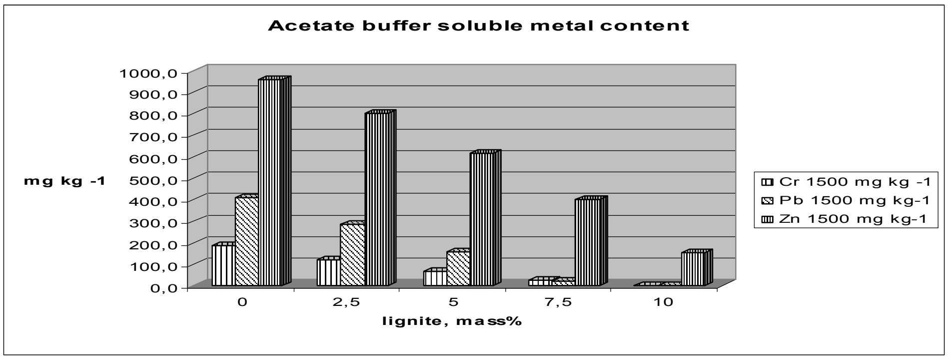
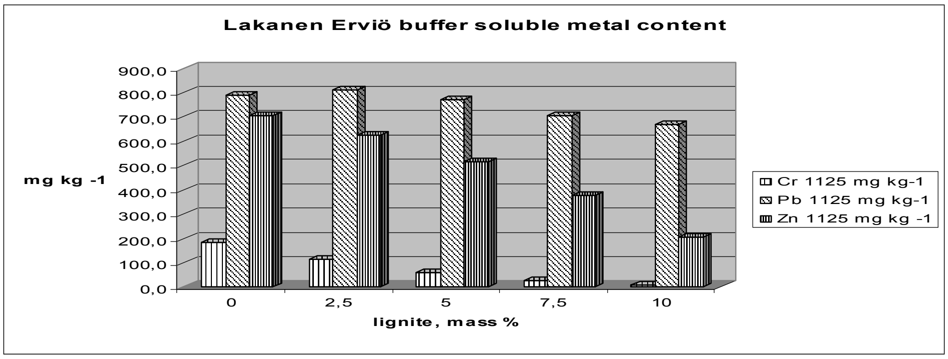


Figure 2.

LSD 5%(Cr)=1,79; LSD 5%(Pb)=19,58; LSD 5%(Zn)= 26,71



LSD 5%(Cr)=5,36; LSD 5%(Pb)=51,03; LSD 5%(Zn)= 41,36

Figure 3.

Table 1. Probability levels of the model parameters and determination coefficients (R^2)

	Nitrohydrochloric acid soluble			Distilled water soluble			Acetate buffer soluble			Lakanen Erviö buffer soluble		
Factors	Cr	Pb	Zn	Cr	Pb	Zn	Cr	Pb	Zn	Cr	Pb	Zn
B0	+XXX	+XXX	+XXX	+XXX	+XX	+XXX	+XXX	+XXX	+XXX	+XXX	+XXX	+XXX
L				-XXX	-XXX	-XX	-XXX	-XXX	-XX	-XXX		-X
Pb		+XXX			+XX			+XXX			+XXX	
Zn			+XXX		-X	+XXX			+XXX			+XXX
Cr	+XXX			+XXX	+XXX	+XXX	+XXX	+XXX	+X	+XXX		
LxPb					+XX							
LxZn												
LxCr				-XXX	-XXX					-XXX		
ZnxPb												
CrxPb					+X		+XXX					
CrxZn					-XX							
L^2				+XX			+X			+X		
Pb^2												
Zn^2												
Cr^2				+XX								
R^2	98,1	97,6	93,7	98,1	87,0	97,7	98,9	98,4	97,9	95,7	98,4	98,1

XXX = P < 0,01; XX = P < 0,05; X = P < 0,1; + =positive effect;- = negative effect

Conclusions

The evaluated lignite additive decreased the mobility of the Cr , Pb and Zn heavy metal contaminants in all three investigated extracts. It is confirmed that the lignite is a suitable additive for chemical stabilisation during combined chemical- and phytostabilisation of contaminated soils.

According to the above presented results the DISITOBI model is a good initial basis for developing experimental methodology.

For further studies of laboratory and field scale, must be determined the heavy metal uptake of pilot plants and technological doses of lignite.

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