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Phytoextraction of heavy metals from contaminated soil: expectations and limitations

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Heavy metal (HM) contamination of soils has become a serious problem in areas of intense industry and agriculture. Soils polluted with HMs pose a health hazard to humans as well as plants and animals, often requiring soil remediation practices. Conventional remediation methods usually involve excavation and removal of contaminated soil layer, physical stabilization or washing of contaminated soils with strong acids or HM chelators (Berti et al., 1998; Steele and Pichtel 1998). Wide-spread low to medium level pollution of agricultural land represents a specific problem. The remediation of large areas of agricultural land by conventional technologies used for small areas of heavily contaminated sites is not economically feasible. However, if no remediation action is undertaken, the availability of arable land for cultivation will decrease, because of stricter environmental laws limiting food production on contaminated lands.

Heavy metal phytoextraction has emerged as a promising, cost-effective alternative to the conventional engineering-based remediation methods (Salt et al, 1995). Early phytoextraction research focused on hyperaccumulating plants which have the ability to concentrate high amounts of HMs in their plant tissues. However, hyperaccumulators often accumulate only a specific element, and are as a rule slow growing, low biomass producing plants with little known agronomic characteristics (Cunningham et al., 1995). This constrains their practical use for phytoremediation, since the total metal extraction is the product of plant biomass and HM tissue concentration. Some HMs has limited solubility in soil solution and bioavailability due to complexation with organic and inorganic soil colloids, sorption on oxides and clays and precipitation as carbonates, hydroxides and phosphates (Ruby et al., 1999). Therefore, a successful phytoremediation must include mobilisation of HMs into the soil solution that is in direct contact with plant roots. In most soils capable of supporting plant growth, the phytoavailable levels of HM and particularly of Pb are low and do not allow substantial plant uptake if chelates are not applied. Chemical amendments, such as synthetic organic chelates, can enhance phytoextraction by increasing HMs bioavailability in soil thus enhancing plant uptake, and translocation of HMs from the roots to the green parts of tested plants (Huang et al., 1997, Epstein et al., 1999). Of the chelates tested, ethylene diamine tetraacetic acid (EDTA) was often found to be the most effective. Restrictions apply, however, to the use of EDTA and other chelating agents. EDTA and EDTA-HM complexes are toxic (Dirilgen, 1998) and poorly photo-, chemo- and biodegradable in soil (Nörtemann, 1999). *In situ* application of chelating agents can cause groundwater pollution by uncontrolled metal dissolution and leaching (Grcman et al., 2001) Therefore, the potential risks of use of EDTA or other chelators for phytoextraction should be thoroughly evaluated before steps towards further development and commercialization of this remediation technology are attempted. In resent researches humic acids (Evangelou et al., 2004) and new biodegradable chelates (Grcman et al., 2003) were tested. EDDS was reported by Jones and Williams (2001) as biodegradable, strong transition metals and radionuclides chelate. Even the highest concentrations of HMs in harvestable plant tissues achieved in different studies are still far from the concentrations required for efficient phytoextraction procedures. Plant HMs concentrations of more than 1% in dry biomass are required for efficient phytoextraction technology. Beside new biodegradable chelates, new techniques of chelate application to safely increase bioavailability of HMs in soils and transgenic plants with high biomass yield and improved Pb accumulation potential in the harvestable plant parts need to be developed.

In this paper some soil column and pot experiments to evaluate the effects of different amounts and modes of EDTA and EDDS application in soil on Pb, Zn and Cd uptake by different test plants will be presented. Also influences of chelators on HMs leaching through the soil profile and on phytotoxicity and toxicity to arbuscular mycorrhiza and other soil microorganisms will be discussed.

References:

Berti R., Cunningham S.C., Cooper E.M. 1998. Case studies in the field-in-place inactivation and phytorestoration of Pb-contaminated sites. V: metal-contaminated soils: in situ inactivation and phytorestoration. Berti W.R., Cunningham S.C., Copper E.M. (eds.). Austin, Landes bioscience: 235-248.

Cunningham S.C., Berti W.R., Huang J.W. 1995. Remediation of contaminated soils and sludges by green plants. V : Bioremediation of inorganics. Hinchee E., Means J.L., and Burris D. (eds.). Columbus-Richland, Batelle Press: 33-54.

Dirilgen N. 1998. Effects of pH and chelator EDTA on Cr toxicity and accumulation in *Lemma minor*. Chemosphere, 37: 771-783.

Epstein A.L., Gussman C.D., Blaylock M.J., Yermiyahu U., Huang J.W., Kapulnik Y., Orser C.S. 1999. EDTA and Pb-EDTA accumulation in Brassica juncea grown in Pb-amended soil. Plant and soil, 208: 87-94.

Evangelou M.W.H., Daghan H., Schaeffer A. 2004. The influence of humic acids on the phytoextraction of cadmium from soil . Chemosphere, 57: 207-213.

Grcman H., Velikonja-Bolta S., Vodnik D., Kos B., Lestan D., 2001. EDTA enhanced heavy metal phytoextraction: metal accumulation, leaching and toxicity. Plant Soil, 235: 105–114.

Grcman H., Vodnik D., Velikonja Bolta Š., Lestan D. 2003 Ethylenediaminedissuccinate as a new chelate for environmentally safe enhanced lead phytoextraction. J. environ. qual., 32: 500-506.

Huang J.W., Chen J., Berti W.R., Cunningham S.D. 1997. Phytoremediation of lead contaminated soils: role of synthetic chelates in lead phytoextraction. Environmental science & technology, 3: 800-805.

Jones P.W., Williams D.R. 2001. Chemical speciation used to assess [S,S’]-ethylenediaminedissuccinic acid (EDDS) as a readily-biodegradable replacement for EDTA in radiochemical decontamination formulations. Applied radiation and isotopes, 54: 587-593.

Nörtemann B. 1999. Biodegradation of EDTA. Applied microbiology biotechnology, 51: 751-759.

Ruby M.V., Schoof R., Brattin W., Goldade M., Post G., Harnois M., Mosby D.E., Casteel S.W., Berti W., Carpenter M., Edwards D., Cragin D., Chappell W. 1999. Advances in evaluating the oral bioavailability of inorganics in soil for use in human health risk assessment. Environmental science and technology, 32: 3697-3705.

Salt D.E., Blaylock M., Kumar P.B.A.N., Dushenkov V., Ensley B.D., Chet I. and Raskin I. 1995. Phytoremediation: a novel strategy for the removal of toxic metals from the environment using plants. Biotechnology, 13: 468-474.

Steele M.C., Pichtel J. 1998. Ex-situ remediation of metal contaminated superfund soil using selective extractants. Journal environmental engeneering, 124: 639-645.

Wenzel W.W., Unterbrunner R., Sommer P., Sacco P. 2003. Chelate-assisted phytoextraction using canola (Brassica napus L.) in outdoors pot and lysimeter experiments. Plant and Soil, 249: 83-96.