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## The influence of humic acids on the metal bioavailability and phytoextraction efficiency in long-term sludge applied soil

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Heavy metal pollution of soils causes many environmental and human health problems. Phytoextraction of heavy metals from contaminated soils has the prospect of being an effective and economic in situ technique.

Long-term sludge treated soil enriched with heavy metals (Zn, Cu, Ni, Pb and Cd) was used in the experiment. The influence of exogenous humic acid (HA) on the bioavailability of Zn, Cu, Ni, Pb and Cd from sludge applied soil and heavy metal uptake of tobacco plant was examined in greenhouse experiment.

HA were applied to long-term sewage sludge polluted soil at 1 % and 2 %, and the uptake of Zn, Cu, Ni, Pb and Cd into tobacco plant was determined. Soil samples were collected after harvest and total and DTPA-extractable Zn, Cu, Ni, Pb and Cd contents of soil were determined.

Table 1. Effects of humic acid applications on the total and DTPA extractable concentrations of heavy metals in the polluted greenhouse soil after harvesting

Heavy metal concentration in soil (mg kg <sup>-1</sup> )		Humic acid treatment rates (%)		
		0 (control)	1	2
Zn	Total	238	237	237
	DTPA	43 c	66 b	77 a
Cu	Total	86	85	85
	DTPA	12 b	16 a	16 a
Ni	Total	44	44	44
	DTPA	1.8	2.0	2.0
Pb	Total	105	105	104
	DTPA	15 c	28 b	33 a
Cd	Total	1.2	1.2	1.2
	DTPA	0.22	0.25	0.23

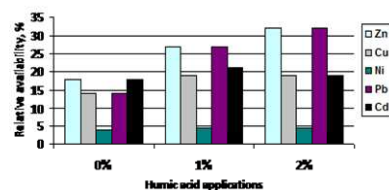


Fig. 1. Effect of humic acid applications to soil on relative availability of heavy metals

Table 2. Effect of humic acid application to polluted greenhouse soil on the dry matter yield and heavy metal concentration in the shoots of tobacco plant

	Humic acid treatment dosage (%)		
	0 (control)	1	2
Dry matter yield (g)	86 a	77 b	72 b
Zn (mg kg <sup>-1</sup> )	37 c	52 b	77 a
Cu (mg kg <sup>-1</sup> )	16 c	23 b	33 a
Ni (mg kg <sup>-1</sup> )	2.4	2.5	2.6
Pb (mg kg <sup>-1</sup> )	3.1 b	5.5 a	5.6 a
Cd (mg kg <sup>-1</sup> )	0.7 c	1.34 b	1.44 a

Diethylenetriaminepentaacetic acid (DTPA)-extractable Zn, Cu, Ni and Pb concentrations and plant uptake of metals increased significantly by HA applications. While HA treatment at 2 % rate to soil increased the heavy metal concentration in the shoot tissue, plant growth was diminished.

The results suggest that soil amendments with HA can be considered as an alternative approach to reduce the availability and mobility of heavy metals and to increase phytoextraction efficiency of heavy metal polluted soils.