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In situ remediation of Cd, Cu and Zn contaminated topsoils by different amendments

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Trace metal contamination of soils in the vicinity of metal mines and industrial sites is very common in industrial countries. Due to the extent of these contaminations polluted most soils cannot be cleaned through conventional remediation techniques (e.g. dig and dump). Thus the most appropriate option to minimize the hazard of transferring metals into the food chain is an in situ immobilization of these elements by amendments. In situ immobilization does not mean a reduction of the total metal content, but rather enhancement of the natural attenuation mechanisms concerning metal mobility and bioavailability or the formation of new inorganic or organic phases. It decreases exposure by one or a combination of different processes such as sorption, redox reaction, precipitation, ion exchange, complexation, excesses of competing elements and humification

Within the framework of a research project between the Justus Liebig University of Giessen and the Ivane Javakhishvili University Tbilisi State University, research has been conducted on in situ immobilization of Cd, Cu and Zn in the A-horizon of Kastanozems contaminated from non-ferrous metal mining, in Southeast Georgia. These soils are characterized by high contents of clay, Fe- and Mn-oxides, organic matter and also a neutral pH, resulting in a high cation exchange capacity. In spite of that, the examined soil show high contents of mobile metals exceeding action and trigger values due to the German Federal Soil Protection and Contaminated Sites Ordinance.

Aim of the study was the reduction of the mobile fractions of Cd, Cu and Zn along with the reduction of plant uptake. Four different amendments were tested in order to achieve these goals: elementary Fe, a natural Georgian zeolith, Divergan® (a synthetic polymer) and a Biochar product. The amendments were mixed in different concentration levels to 4 kg of the soil and incubated in a climate chamber. After five weeks a significant decrease in the NH_4NO_3 extractable metals were measured in comparison to the control. The Divergan® amendment lowered the Cd content even below the detection limit. The other amendments reduce the Cd content significantly but not below the action value. The Cu content was significantly reduced with the Fe amendment (minus 19%) and the Divergan® amendment (minus 77%). The Zn content was significantly reduced by all amendments.

Furthermore, *Spinacia oleracea* L., *Brassica napus* L. and *Triticum aestivum* L. were grown in succession in the pots. The control pots showed severe toxic chlorotic symptoms on leaves and growth depression for *S.olercea* and *B.napus* but not for *T.aestivum*. The amendment pots all showed more or less severe chlorotic symptoms up to none symptoms, but growth increased in all treatments. The dry weight increased within the amendment pots (up to $>$20 fold in case of *B.napus*) and metal concentrations in plant tissue decreased in comparison to the control pots (minus 85% in case of Cd and *B.napus*). In conclusion Divergan® worked best in reducing the mobile fraction as well as plant uptake of Cd, Cu and Zn in the contaminated Kastanozem.