Geophysical Research Abstracts
Vol. 12, EGU2010-2311-2, 2010
EGU General Assembly 2010

In-situ-Remediation of Soils contaminated by Heavy Metals in the Region of Bolnisi, Georgia

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Background, aim and scope

The top soils of the Mashavera valley in S-E Georgia are highly contaminated by Cu, Zn and Cd. Due to the fact that the soils are intensively used for agriculture, a high risk potential within the food chain exists. As the top soils can not be cleaned, an in-situ immobilization of the heavy metals by Fe-oxides seems to be the adequate remediation for the study area. Based on earlier researches of the Institute of Soil Science and Soil Conservation a field experiment was conducted in 2008 to proof this technique for the study area. An heavily contaminated experimental field was treated with zerovalent Fe in March 2008. Mobile fractions of Cu, Zn and Cd, increase of amorphous Fe-oxides, changes of soil pH and plant available, inorganic P were determined in March, June and October.

Materials and methods

An arable field close to the town Bolnisi was chosen and separated in 16 plots. Half of them were chosen for the remediation. 1% (w/w) zerovalent Fe was spread homogeneously and mixed in the top soils (0-20 cm) of the plots chosen for treatment. Irrigation and cropping was done identically in treated and control variants. Composite samples of all plots were taken directly after application in March as well as in June and October. The samples were dried at 40˚C, sieved for 2 mm, partially finely grounded and stored by room temperature. Mobile fractions of Cu, Zn and Cd were extracted by 1 M $NH_4NO_3$and pseudo-total content was determined in aqua regia. Amorphous Fe-oxides were extracted with oxalate. All metal concentrations in extracts were determined with atomic absorption spectrometer (AAS). Inorganic P was measured photometrical and soil pH was determined in 0.01 $CaCl_2$.

Results

Only marginal fluctuations of soil pH were measured in control as well as in treated plots. The mobile fractions of Cu and Cd decreased significantly by 71.8 and 53.4%, while in control plots Cd even increased by 4.75%. Significantly higher contents of amorphous Fe-oxides were measured for treated compared to control variants and significant higher P contents were measured in control plots.

Discussion

The marginal fluctuations of the pH, appearing in treated as well as control variants, are caused by typical uncertainties of pH-measurements. Due to this no influence of the zerovalent Fe application on soil pH can be measured. A clear and significant decrease of mobile heavy metals can be measured for treated in contrast to the control variants. The significant higher contents of amorphous Fe-oxides in treated variants can be traced back to the application of zerovalent Fe. Based on the fact that no increase was measured over the entire term, the formation of fresh-formed amorphous Fe-oxides can be assumed for the first weeks after application. Significant lower contents of plant available P in the treated plots could be induced by P-fixation on fresh-formed amorphous Fe-oxides. Nevertheless P supply is still high and no further steps for stabilization are necessary.

Conclusions

The efficiency to reduce mobile Cu, Zn and Cd by application of zerovalent Fe decreases in the sequence Cu > Cd > Zn. Soil pH was not and plant available P was only marginal affected by the application of zerovalent

Recommendations and perspectives

The application of zerovalent Fe is suitable for in-situ fixation of Cu, Zn and Cd in topsoils of the study area. Nevertheless better homogenizing and partially higher application rates might be necessary. An evaluation of the remediation technique to reduce bioavailability of Cu, Zn and Cd is in progress. Additionally changes in heavy metal fractions have to be monitored for the next years in order to investigate long term effects.