Combined chemical and phytostabilisation of an acidic mine waste – Long-term field experiment

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The area of the former lead and zinc sulphide ore mine is heavily polluted with toxic metals, such as Zn, Cd, Pb, Cu and As. As part of a complex environmental management concept the diffusely polluted area is planned to be remediated with an *in situ* technology, the combination of chemical stabilisation with phytostabilisation (CCP). To find the best stabilizer-plant combination microcosm, field-lysimeter and field experiments were done. For the stabilization of the highly acidic, heavily weathered sulphidic metal ore mine waste originated form one of the biggest waste depositions in the mining area, various types of fly ashes and their combination with lime and steel shots were applied. As phytostabilizing plants grass mixture and two *Sorghum* species (*Sorghum sudanense* and *Sorghum vulgare*) were applied at fully controlled constructed field plots. The demonstration of the CCP technology was followed for three seasons by integrated monitoring and evaluation method.

For the monitoring of the experiments we applied both physico-chemical analytical methods (extraction with extractants of increasing strength for the examination of metal mobility: distilled water, acetic acid and Aqua Regia) and biological-ecotoxicological methods (Microbial activity – living cell concentration, *Vibrios fisheri* luminescence inhibition test, *Sinapis alba* root and shoot growth inhibition test, *Tetrahymena pyriformis* reproduction inhibition test and *Sinapis alba* rapid bioaccumulation test), and their results were evaluated together based on a score-system developed by us. The score system allows us to compare the efficiency of the tested stabilizers and to find the best remediation option.

The field lysimeter and plot experiments proved the efficiency of CCP, especially of the combination of fly ash, lime and steel shots together with grasses. CCP was successful in decreasing metal mobility and as a result the risk of toxic metals in the treated waste, in controlling leaching, erosion and plant uptake. The amount of Cd, Cu and Zn in the collected drainage water decreased with more than 99% due to the fly ash, lime and steel shot treatment, so that the final concentration was lower, than the Maximum Effect Base Quality Criteria set by Gruiz et al. (2006) for groundwater in the area. Pb decreased with 91%, ensuring an acceptable risk level, but As became more mobile due to increased alkalinity. The toxicity of both the mine waste and the drain-water decreased and healthy vegetation was established on the treated plots with low metal contents, fulfilling animal/human food quality criteria.