REDUCTION OF ABIOTIC STRESS IN A METAL POLLUTED AGRICULTURAL AREA BY COMBINED CHEMICAL AND PHYTOSTABILISATION

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INTRODUCTION TO THE PROBLEM

The agricultural area south to the village of Gyöngyösoroszi, Hungary is heavily polluted with toxic metals of mining origin. The hobby gardens are regularly flooded by the Toka-creek, which carries metal polluted sediment from the abandoned mining area north to the village (Figure 1 and 2). Due to the anthropogenic stress the vegetables and crops produced in the area contain high amount of toxic metals, such as Zn, Cd, Pb and As, which represents unacceptable risk for humans and other members of the food chain. The metal content of plants was found to be above the limit value for food and fodder. The activity of the soil microflora was lower than in the unpolluted area and the soil was toxic for bacteria, plants and animals, according to ecotoxicological test-results. To reduce the stress posed on soil living organisms and plants, the area is planned to be treated by combined chemical and phytostabilisation. The technology is able to reduce metal transport by all possible pathways: transport by runoff and seepage water, erosion, deflation and plant uptake. Plant uptake is reduced both by chemical treatment restricting metal mobility and by the selection of non-accumulative plant species.

Fig. 1: The catchment area of the Toka-creek (former mining site)

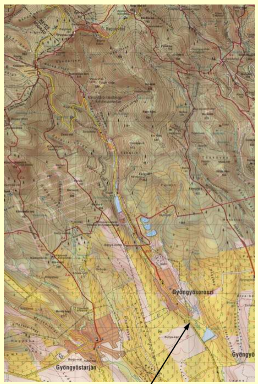

Fig.2: A regularly flooded hobby garden Increasing metal content and toxicity towards the creek (at the right side)

FIELD EXPERIMENT AND MONITORING

Field plot size: 20 m × 60 m
Chemical stabiliser: 5 w/w% (75 t/ha) fly ash (half of the area treated), best stabiliser chosen based on microcosm experiments (Feigl et al., 2007).
Plants used for phytostabilisation: *Zea mays*, *Sorgum vulgare technicum, Sorgum vulgare sudanense* and natural vegetation (invasive weed) as plant control.

Monitoring:
integrated methodology
Combination of chemical-analytical methods with biological methods and toxicity testing.

Metal content of soil:
- Extractable by distilled water,
- Extractable by ammonium-acetate (pH=4.5),
- Total by aqua regia digestion,
Analysis by ICP-AES.

Toxicity of the soil:
- *Vibrio fischeri* luminescence inhibition test,
- *Sinapis alba* root and shoot growth inhibition test.
Test applied to whole soil (direct contact).
Soil activity:
- Aerob living cell number.

Metal content of plants:
- Digestion with nitric acid and hydrogen peroxide
Analysis by ICP-AES.
Biomass: Dry weights determined at the end of the growing season.
Sampling: Monthly during the growing season, average sample from 20 spots.

SOLUTION TO THE PROBLEM - RESULTS

The concentration of metals in the hobby garden soil is the highest close to the Toka-creek due to regular floodings and decreases with the distance. The most mobile metals in the soil are Zn and Cd, while Pb and As are less available. Due to the treatment with fly ash the extractable (mobile) metal contents decreased with 80–92% (Figure 3 and Table 1). The biological activity of the soil microflora increased and the toxicity of the soil decreased by 15–32% according to bacterial and plant biotests (Table 2). The fly ash treatment also decreased the metal accumulation of plants by 30–80% thus getting below the limit value for food and fodder (Cd: 1 mg/kg, Pb: 10 mg/kg, Zn: 100 mg/kg). The increase of metal content measured in the invasive weed mixture underline the importance of the proper selection and control of plants applied for phytostabilisation (Figures 4–7).

Fig. 3: Acetate extractable metal content of fly ash treated and non-treated soil in function of distance form the creek

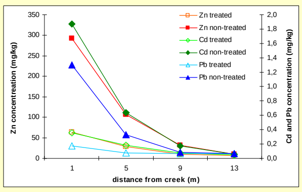

Table 1: Metal content of fly ash treated and non-treated soil (total, acetate and water extractable amounts; DL: detection limit)

	Zn			Cd			Pb		
	total	acetate	water	total	acetate	water	total	acetate	water
Non-treated (mg/kg)	1102	237.4	4.106	5.23	1.540	0.051	352	1.314	<DL
Treated (mg/kg)		47.7	0.315		0.275	<0.004		0.260	<DL
Decrease (%)		79.9	92.3		82.2	>92.1		80.2	

Table 2: Change in soil activity and toxicity due to fly ash treatment

Test method	Treated soil
Aerob living cell number	1.5 times increase
Vibrio fischeri test	15% decrease in toxicity
Sinapis alba test	32% increase in plant growth

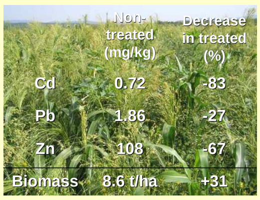

Fig. 4 Metal content and biomass of *Sorgum vulgare technicum*
(results given for dry weight and shoots)

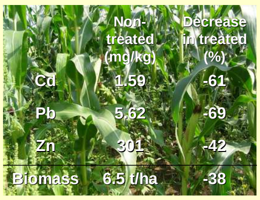

Fig. 5 Metal content and biomass of *Zea mays*

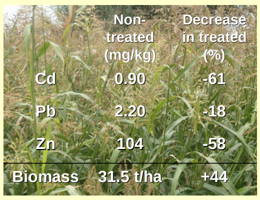

Fig. 6 Metal content and biomass of *Sorgum vulgare sudanense*

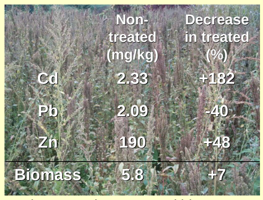

Fig. 7 Metal content and biomass of weeds

CONCLUSIONS

The fly ash addition decreased the mobility of the Zn, Cd and Pb in toxic metal contaminated agricultural soil at a former mining site. According to our field experiments' results fly ash is an efficient chemical stabilising agent and combined with suitable phytostabilising plants is a promising environmentally- and cost efficient remediation technology able to reduce environmental risk to an acceptable value.

ACKNOWLEDGEMENTS

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