Bioenergetic use of heavy metal polluted soils – a non-phytoremediation approach

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Pollution of the biosphere with harmful elements has accelerated dramatically since the beginning of the Industrial Revolution. Many areas are polluted on a large scale: industrialized areas, mining areas, river meadows in flood plains, and peri-urban areas with waste water irrigation etc. In Germany up to 10.4 % of the arable land is potentially contaminated, mostly by several elements. Polluted areas should not be used for food and feedstuff production but they can be utilized by harvesting plants for energy production or for technical purposes. Remediation to remove appreciable amounts of toxic elements from soils is normally not effective. Traditional remediation with chemical technologies is not reasonable because of missing suitable methods, ecologic reasons, extremely high costs, and it is not applicable to large amounts of contaminated soil. Remediation by plants (phytoremediation) needs a very long time (thousands of years) even if hyper-accumulating plants are used. This can easily be shown by simple balance calculation for cadmium, which belongs to the most toxic, most mobile and plant available heavy metal.

These reasons should be sufficient to abandon any conventional remediation approach. A much better measure is to leave the toxic elements in the soil and to produce plants like crops or short rotation trees with low uptake rates of harmful elements. As an example low-accumulating crops may be used in reactors for biogas production without impairing the fermentation process by toxic elements. After biogas production the residues can be returned to the soils from where the plants were harvested, without exceeding the maximum permissible values of heavy metal in fertilizers. Low-accumulating plants from contaminated sites can also be used as primary material for the production of paper, textiles, building materials, bioplastics etc. without creating contaminated wastes.

Soil-plant transfer factors (concentration of an element in the plant divided by the concentration in the soil) for different crops are systematically determined for a wide range of elements in different polluted soils with different pH-values, to find plants with low transfer factors. The soil and plant samples were digested completely with a mixture of concentrated HF-$HClO_3$-HNO_3 in closed PTFE vessels and analysed by ICP-OES and -MS. Examples of high yield crop plants with low transfer factors of toxic elements are maize Padrino and Amadeo, Rye Vitallo, and Barley Christelle. In contrast Amaranth spec., Sunflower Salut, Phacelia Amerigo and Sorghum Maja should not be cultivated on contaminated soils because of their high uptake of cadmium and of other heavy metals.

Conclusion: By harvesting plants with high yield and low transfer factors and their use for the production of renewable energy or for technical products, contaminated sites can be utilized wisely without competing with food production.

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