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PHYTOMANAGEMENT OF POLYELEMENT CONTAMINATED SOILS USING PHYTOEXTRACTION STRATEGIES AND BIOMASS PRODUCTION

A multidisciplinary approach is warranted to make phytoextraction a feasible commercial technology to remediate Me-contaminated soils [1, 2]. Options for the appraisal of phytoextraction depend on several initial settings, some being related to legislation. These are: (1) the initial concentrations of matrix contaminants, the magnitude of their labile pools that interact with biota and risks these pose for relevant pollutant linkages, (2) remediation objectives based on proposed end use and (3) site management constraints.

Based on our results and other researches carried out on BIOGECO and BRSU platform, a management plan is suggested in the purpose of full cycle phytoremediation of Me-contaminated sites using sustainable aided phytoextraction strategy tandem with high biomass production, including the following steps:

1. Evaluation of the initial level of pollution and environmental risks. First, the site's suitability for phytoextraction should be evaluated by field observations and laboratory studies. Soil samples should be analyzed to determine not only the magnitude of metal contamination, but also other physico-chemical parameters influencing the behavior of metal in the soil and soil solution, chemical forms in which metals are present for determining whether decreasing metal concentrations to target cleanup criteria by means of phytoextraction can be a realistic option [3]. Bioassays using phyto- or zooindicators can be applied to determine the bioavailable fraction of contaminant. The biocenotic research of plant and animal communities living in the contaminated area is necessary to carry out for a subsequent long-term monitoring. It is also recommended to study the genetic structure of populations.

2. Selection of plant / microorganisms / amendments candidates and suitable options. The site-specific capacities of various plant species / cultivars / mutants / clones to survive, accumulate, and tolerate metals should likewise be tested under laboratory conditions using bioassay and/or fading technique. Next, most indicative plant parameters must be measured: biochemical, chemical, morphological and physiological traits. The defined limits of plant tolerance allow us to determine the range of contamination, where phytoextraction can be

most effective and to model the TE transfer from soils and roots to harvestable parts. With the help of amendments we can regulate bioavailable fraction in soil (increase or decrease depending on objectives). In parallel, the improving role of endophytic bacteria and mycorhizae can be tested [4]. Based on the gathered information, as well as on the local climatic conditions, a suitable plant/microorganisms/amendments combination may then be selected.

3. Implementation of the selected remediation strategy in the field condition (pilot). Before starting the implementation of phytoremediation option, a planning is needed, because many operations have to start much earlier than the planting (e.g. amendment addition, seed inoculation, seedling cultivation, etc). The plant mortality and productivity of various parts (vegetative, generative) influence plant density. In view of allelopathic and pathogenic relations, intercropping and/or crop rotation can be successfully used. During the field experience, the plant status must be constantly monitored, and if necessary, fertilization, irrigation (especially in the first stages of development) and other agricultural practices must be adapted [5]. It is necessary to apply mechanical means for plot isolation and protection (fencing, netting) against wild animals (with both objectives to protect animal to toxic feed resources and to preserve the plant harvest). Time and type of harvest and separation of the collected parts depend on the pollutant content and type of subsequent valorization. If in the future the green parts of plants are used, the harvest of non-senescent biomass is recommended to avoid reincorporation of contaminated plant parts (especially leaves) into the soil. It is also recommended to cultivate intermediate crops after harvest – so-called winter crop cover in temperate climate.

4. Biomass valorisation and developing the remediation strategy and implementation in the large scale. The choice of conversion process for plant material depends on its type and contaminant content. If it is oil-based substrate with low metal contents, the most cost-effective manner is the production of biodiesel (sunflower, tobacco), bioethanol (tobacco) or essential oils (vetiver). Sugary seeds and shoot (sorghum) can be used to produce bioethanol. The seeds with negligible Me content were recommended also for animal feed. The main part of the green mass of plants may be susceptible to various conversion processes, depending on the level of contamination and local conversion chains:

1) composting to fertilise TE-deficient soil (low Me-level);
2) vacuum and oxidative pyrolysis;
3) liquid extraction;
4) synthesis of hydrogen fuel, biofuel, bioplastic;
5) biogas and activated carbons;
6) hydrothermal oxidation [6];
7) gasification.

Heavily contaminated material is sometime subjected to incineration or ashing with subsequent use of thermal energy. The resulting post-combustion ash can be used in the production of nutrient additives for the plants or buried in special landfills. Financial returns and other economical aspects are needed to be revised at this stage.

The monitoring of soil and biota, during (once in 3–5 years) and after the application of aided phytoextraction, is recommended for assessing the status of ecosystems and clarifying the real duration of phytoremediation. To date, commercial phytoextraction has been constrained by the expectation that site remediation should be achieved in a time comparable to other clean-up technologies. After a pilot testing, this low-cost technology should be used for the in situ remediation of large areas of contaminated (or marginal) land.

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