CHAPTER 8

FACTORS LIMITING EFFICIENCY OF PHYTOEXTRACTION AT MULTI-METAL CONTAMINATED SITES

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Abstract

The paper is based mostly on results from 3 field experiments and pot experiments with additional references to the literature. The three field experiments of reference will be first presented. Then the site characteristics (including the local climatic and edaphic conditions as well as the nature and extent of the contamination), the plant characteristics and the aspects related to the legislative background will be presented successively. It should be remembered that all these aspects may interact and thus are not truly independent parameters.

1. INTRODUCTION

Phytoextraction has been proposed as a suitable alternative to destructive techniques used so far to clean up soils contaminated with heavy metals. Indeed, the use of plants to remove metals from soils is environmental friendly and its cost is low compared to engineering-based techniques such as soil capping, soil washing, vitrification, landfiling etc. Additionally, it is an in situ and solar generated technique that could help to rehabilitate large areas of agricultural soils contaminated mostly in the upper layer, maintaining or even restoring soil fertility. It also produces less waste because the biomass may be recycled for both energy and metals. Unlike phytostabilisation - its counterpart among the phytoremediation techniques - phytoextraction potentially resolves most of the legislative requirements that ask for metal removal down to a given threshold.

The general drawbacks of phytoextraction are well known (e.g. Vangronsveld and Cunningham, 1998 ) and its optimisation still requires a lot of research: phytoextraction is a slow process in comparison to the above mentioned techniques (10 years is the goal on which most people agree on to
recognize phytoextraction as economically acceptable). Its application is limited because of the lack of established methods and successful completed remediation case studies, the lack of recognised economic performance and the risk of food chain contamination. Additionally it may not be able to remove 100% of the contaminants and its efficiency has been proved for some contaminants only. Alternatively, the plants might not be able to withstand highly toxic concentrations of the contaminants.

However, it is not the aim of this paper to review these drawbacks in detail: a preliminary comparison with the other available techniques should determine whether these negative aspects are limiting or not for choosing phytoextraction for a given site. Once it has been decided to use phytoextraction as a clean up technique, many pitfalls may appear that will limit its efficiency; that is, its ability to reach the goal set in a reasonable time and with limited negative side effects. They may be due to the specificities of the site, soil, plants and contamination characteristics but also to external constraints like legislation. Highlighting these factors will help to define the boundaries conditions for the use of phytoextraction and thus our ability to offer an efficient technique to landowners or local authorities either as main remediation tool or as part of a “remediation package”.

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2. SITE CHARACTERISTICS

2.1. Experimental Sites in Switzerland

Site characteristics include the climatic conditions, the nature of the soil that is contaminated, the extent of the soil volume concerned (surface and depth), the nature and the extent of the contamination, the metals to be removed, their concentrations, their availability to plants, their toxicity, the presence of other contaminants (both inorganic or organic), and the degree of heterogeneity of the contamination.

The three sites chosen to illustrate these different aspects and their impact on the final efficiency of phytoextraction are presented in Table 1. Two are agricultural soils and the third is a landfill that has been closed and revegetated with trees. They are moderately contaminated with metals,