# Heavy metal removal from municipal sewage sludges by phytoextraction

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## Abstract

In European Union countries up to 80% of sewage sludge is used in agriculture and forestry, whereas in Poland only 11% is used as fertilizer. The principal environmental concern is the inevitable presence of heavy metals when using sewage sludge as fertilizer. The main objective of this study is to assess the effectiveness of the phytoextraction process in removing heavy metals from sludges. A method of whole plant (with roots) harvesting was developed since plants initially accumulate heavy metals in roots. EDTA (ethylenediaminetetraacetic acid) was used as a chelating agent in the experiment. Results of the control treatment (without EDTA) showed that the concentration of heavy metals (Pb, Cd and Zn) in corn and white mustard roots was 2–6 fold higher than in shoots. In treatments with EDTA this effect was not observed. The method of whole plant harvesting was most effective in removing Cd from sewage sludge in experiments with corn and with EDTA; however, this effect was not detected with white mustard. It was shown that the new harvesting method could be effective in removing heavy metals from municipal sewage sludge.

## Introduction

Sewage sludge from municipal wastewater treatment plants contains high quantities of nutrients and organic matter needed for plant growth, but also contains high heavy metal concentrations. Heavy metals can accumulate in soil and in plants when sludge is applied as fertilizer and eventually can produce harmful effects in animals and humans. Therefore, the study of effective methods for heavy metal removal from sludge is very important in order to minimize prospective health risk during application. (Lasheen at al., 2000)

Currently, remediation methods for heavy metal removal from soil and sludges are expensive and disruptive. Recently, efforts have been directed toward finding remediation strategies that are less expensive and less damaging to soil properties than current approaches. One such method is phytoextraction in which plants uptake heavy metals from the soil or sludge, followed by harvesting the aboveground biomass. Harvested material then is disposed of in a landfill or treated to recover metals (Cooper at al., 1999).

Accumulation of metals is higher in roots than in shoots since heavy metal transport from roots to shoots is often restricted. Thus the main objectives of this study were: (1) to work out a method of whole plant harvesting, and (2) to assess effects of whole plant harvesting in phytoextraction of heavy metals from sludge.

## Materials and Methods

A stabilized sludge sample was obtained from a municipal wastewater treatment plant located in Katowice-Panewniki, southern Poland. Total heavy metal content (extraction with 10 % $HNO_3$) of the sample was the following: Pb 156.2, Cd 4.38, Zn 704.7 (mg/kg dry solid). The sample pH was 6.03.

Sludge was introduced into shallow plastic containers. A biodegradable mesh was laid down on the sludge surface to enable plant (shoots and roots) removal. Corn seeds *(Zea mays* cv. Prosna) or white mustard seeds (*Sinapis alba* cv. Nakielska) were planted on the mesh surface. After germination, plant roots grew out of the mesh and into the sludge. Sludge was treated with EDTA three weeks after planting. 5 mmol EDTA/kg was used for corn while 2.5 mmol EDTA/kg was used for white mustard. Controls were not treated with EDTA. One week after EDTA application the mesh was removed along with aboveground plant parts and the majority of root systems. Plant samples were analyzed for Pb, Cd and Zn.

## Results and Discussion

Accumulation of Pb, Cd and Zn was higher in roots than shoots irrespective of plant species in the control experiment (Table 1). Xian (1989) observed the same effect with cabbage. Application of EDTA to the sludge resulted in higher heavy metal concentrations in plant tissue. Cd and Zn concentrations were higher in white mustard shoots in comparison with roots in treatments with EDTA. Blaylock at al. (1997) found similar results using Indian mustard for Pb.

Table 1. Effect of EDTA on heavy metal concentration in plants

| Plant species | amendment | plant part | content of (mg/kg) | | |
|---|---|---|---|---|---|
| | | | Pb | Cd | Zn |
| white mustard | Control | shoot | 3.6 | 1.26 | 497.0 |
| | | root | 21.0 | 3.75 | 835.0 |
| | 2.5 mmol EDTA | shoot | 53.1 | 17.01 | 1222.0 |
| | | root | 108.5 | 6.22 | 565.2 |
| corn | Control | shoot | 3.44 | 0.74 | 118.5 |
| | | root | 5.9 | 1.19 | 398.0 |
| | 5 mmol EDTA | shoot | 12.4 | 4.98 | 622.7 |
| | | root | 6.05 | 59.0 | 626.1 |

It is necessary to multiply plant dry weight and metal concentrations in plant tissue to assess phytoextraction effectiveness. Pb and Zn concentrations in shoots were so high following EDTA treatments that root harvesting had little influence on phytoextraction effectiveness. For example, corn shoots contained 6.40 mg $Pb/m^2$, whereas roots contained 0.18 mg $Pb/m^2$. However, phytoextraction effectiveness of Cd was high when shoots were removed with roots (Table 2) after treatment with EDTA.

Tabel 2. Phytoextraction effectiveness of Cd from sludge (mg Cd/$m^2$)

| Plant species | Plant part | Control | EDTA |
|---|---|---|---|
| corn | shoot | 0.321 | 2.570 |
| | root | 0.073 | 1.770 |
| | **total** | **0.394** | **4.340** |
| white mustard | shoot | 0.167 | 3.215 |
| | root | 0.011 | 0.037 |
| | **total** | **0.178** | **3.252** |

## Conclusions

Results of this study indicate that whole plant removal could enhance phytoextraction effectiveness of Pb, Cd and Zn when chelating agents are not used. This mesh method of harvesting can result in highly effective phytoextraction when chelating agents cannot be used. The mesh method of harvesting should be effective in Cd removal from sludge when chelating agents are used.

## References


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