NOVEL EDTA-BASED METHOD OF WASHING Pb CONTAMINATED SOILS: HAZARD MITIGATION AND SUSTAINABLE SOIL USE

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Introduction

The potential of aminopolycarboxylic chelants for soil Pb removal and bioaccessibility stripping is well known. The most frequently used is ethylenediamine tetraacetate (EDTA) because of low toxicity, high efficiency for toxic metal removal and relatively low price. Soil washing (extraction, leaching, flushing) where EDTA and toxic metals forms water-soluble complexes (chelates) and used washing solution is separated from the solid phase is straightforward operation. However, chelates which partly remained in washed soil are compounds with high degree of stability and must be further removed by extensive soil rinsing. What makes remediation difficult is treatment of large volumes of generated effluents, preferably to recycle both EDTA and process waters. We are presenting the development of a new, effective and emission-free soil washing technology and our research on the treated soils' overall health, functioning and potential use after remediation.

Methods

Metals were measured using AAS and XRF. A spectrophotometric method based on ferroin formation using sodium sulfite as reducer was used for EDTA determination. Soil properties were assessed by pedological analysis, fractionation and leachability of toxic metals by sequential extraction and metal bioaccessibility by UBM tests. Soil respiration and enzyme activities were measured as indicators of soil functioning. Plant fitness was assessed by chlorophyll fluorescence and gas exchange measurements.

Results

Calcareous soil from Meza Valley, Slovenia and acidic soils from Arnoldstein, Austria and Pribram, Czech Republic (with 1028, 862 and 926 mg Pb kg^{-1}, respectively) were washed with 60-100 mmol kg^{-1} EDTA in series of 30 batches (50 kg $batch^{-1}$). Technology features novel reaction of alkaline substitution, precipitation and adsorption of toxic metals on polysaccharides and chelant acidic precipitation for in average 83% EDTA and complete process waters recycle (no wastewater was generated). The pH gradient was imposed by $Ca(OH)_2$ and H_2SO_4; the reagents' excess was removed with remediated soil as an inert $CaSO_4$, thus to prevent saltification of recycled process waters (Figure 1). Remediation removed 60, 78 and 71% of Pb from Meza, Arnoldstein and Pribram soils, respectively, and reduced Pb bioaccessibility into simulated human gastro-intestinal phase (assessed using UBM) by 5.0-, 7.7- and 8.1-times, respectively. Residual emissions (EDTA, toxic metals) were prevented by soil ageing and deposition of remediated soil on reactive permeable barrier. The solid wastes from process amounted to 10.8 kg t^{-1} of soil and the material /energy cost of remediation up to 20.6 € t^{-1}.

Sustainable soil use after remediation was investigated for Meza soils. The effect of remediation on soil physical and chemical properties and soil functions were minor and reparable (Jelusic et al., 2013; Zupanc et al., 2015). Revitalization measures for restoration of soil fertility and plant fitness included fertilization with Mn and hydrogel amendment to improve soil water holding capacity (Jelusic et al., 2014b). Sequential extractions did not reveal long-term reversal of reduced bioaccessibility of toxic metals (Jelusic et al., 2014a). Safe vegetable production has been demonstrated after soil washing of originally medium contaminated soil (Jelusic et al., 2014c). Use of remediated soil as a substrate for ornamental plants and grasses was studied and proposed for originally highly contaminated soils, unsuitable for food production (Jelusic et al., 2015). Significant spatial reduction of toxic metals (Pb, Zn and Cd) contamination and reduction of Pb blood levels in children before and after soil remediation and have been modeled and predicted for Meza Valley (Finzgar et al., 2014; Jez et al., 2015).

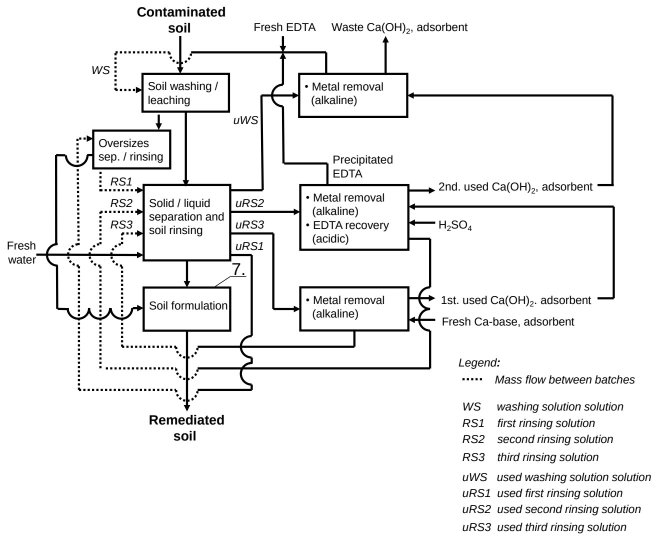

Figure 1. Flowchart of the novel soil washing technology.

Conclusion

Reactions and processes used in novel technology were able to absorb and neutralize fluctuations of measured parameters without operator intervention throughout the series of remediation batches, demonstrating the adjustability and resilience of the novel technology for different soils and chelant inputs. Remediated soil retained quality and provided ecosystem services, including safe food production. A demonstrational remediation plant using scale-up of the novel technology is under construction in the Meza Valley, Slovenia (ENVIT Ltd, EU Life+ project ReSoil, http://liferesoil.envit.si).

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