Biodegradable Chelator-Assisted Washing and Post-Treatment of Arsenic Contaminated Soil

Shafiqur Rahman[1*], Naoyuki Jii[1], Atsuhiko Tanimoto[1], Yasuhiro Harada[1], Asami S. Mashio[1], Zinnat A. Begum[1], Ismail M. M. Rahman[2*], Hiroshi Hasegawa[1*]

1: Kanazawa University, Kakuma, Kanazawa 920-1192, Japan

2: Fukushima University, 1 Kanayagawa, Fukushima City, Fukushima 960-1296, Japan

*corresponding author(s): rahman.shafiqur@stu.kanazawa-u.ac.jp (SR); immrahman@ipc.fukushima-u.ac.jp (IMMR); hhiroshi@se.kanazawa-u.ac.jp (HH)

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INTRODUCTION

Excavated soils contaminated with geogenic arsenic (As) are increasing concerns in Japan due to after disposal impact on the ecosystem and human health (Katsumi, 2015; Li, Kosugi et al., 2017; Tabelin, Basri et al., 2012). The removal of As from contaminated excavated soil is thus a must but challenging task. One of the widely evaluated approaches for the remediation of contaminated soil is washing with aminopolycarboxylate chelators, such as ethylenediaminetetraacetic acid (EDTA). However, the consumption and subsequent toxicity of EDTA and its homologs evoke eco-concerns due to their prolonged persistence and low biodegradability (Bagherifam, Brown et al., 2019; Hettick, Canas-Carrell et al., 2015). Herein, the efficiency of ethylenediamine N,N'-disuccinic acid (EDDS) and 3-hydroxy-2, 2'-imino disuccinic acid (HIDS) has been evaluated to treat As-contaminated excavated soil as potential EDTA alternatives. Besides, post-treatment options to suppress subsequent As-leaching from the chelator-washed soils was assessed.

MATERIALS AND METHODS

The soil sample was mixed with chelator in solution and treated in a thermostatic shaker for different durations. The suspension was then centrifuged, and the supernatant was collected via filtration for inductively coupled plasma optical emission spectrometry (ICP-OES) analysis. After the chelator-assisted washing of soil sample, the separated supernatant was treated using a combination of organic coagulant, CHP408 plus polymer flocculant, AP410C with Fe^{III} and Ca^{II} salts. The soil residues were mixed with different cement-based binders plus CHP408 and AP410C to suppress the re-elution of As. The resulted mixture was filtered, and the filtrate was analyzed in ICP-OES for As-content.

RESULTS AND DISCUSSION

The efficiency of chelators on the extraction of As was correlated with the washing variables, e.g., chelator types, washing duration, solution pH, and chelator concentrations. As-extraction rates with the chelators increased rapidly until 1 h, followed by a gradual increment up to the equilibrium at 12 h. The extracted content of As increased significantly with the increase of chelator concentration. The efficiency order of chelators was as follows: HIDS > EDTA > EDDS > Control (pH 11) (Figure 1). Biodegradable chelator, EDDS followed by HIDS also showed excellent efficiency in extracting other potentially-toxic-elements (PTEs: Pb, Cd, Cr, Cu, Ni, and Zn). EDTA causes the highest dissolution of interfering soil minerals, e.g., Ca, which might have interrupted EDTA's removal efficiency towards As and other PTEs compared to the biodegradable chelators.

The eluted-As in chelator-washed suspension was better immobilized with combined Fe^{III} and Ca^{II} salt application blended with organic coagulant and polymer flocculant. All the cement amendments except the ordinary Portland cement, Tuff-rock ace, and GS225 showed superior As-stabilization capability without the Fe^{III}-additives.

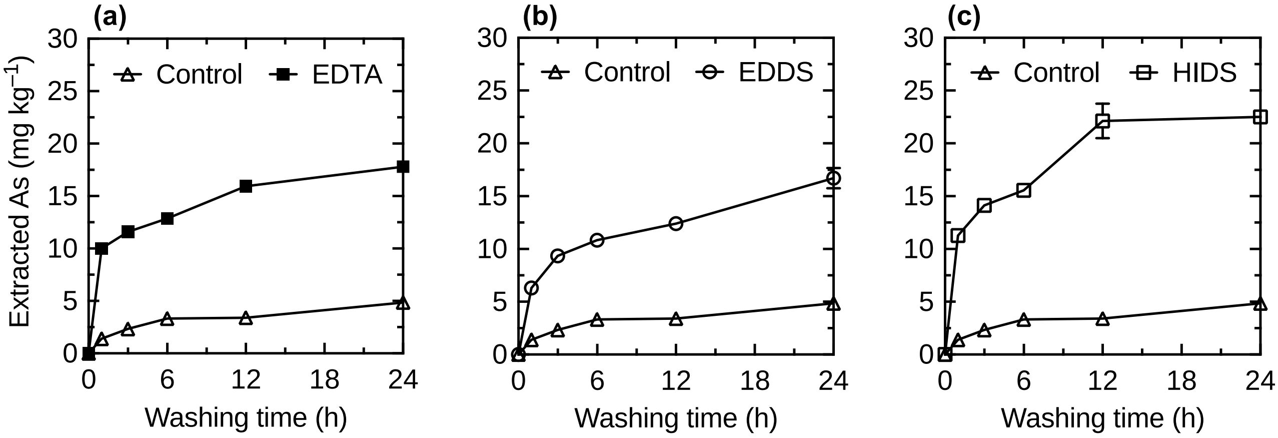

Figure 1 Comparative As-extraction with different chelators: (a) EDTA, (b) EDDS, and (c) HIDS at varying washing time (0 to 24 h). Chelator concentration, 10 mmol L^{-1}; solution pH, 11.

CONCLUSION

In this study, a remediation pathway to treat As-contaminated excavated soil was developed combining washing with biodegradable chelators and fixation of residual As in chelator-washed soil. The proposed remediation approach is free from post-treatment contamination. Hence, it could be a practical green solution for recycling surplus excavated soils from construction activities for geotechnical applications.

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