World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:12, No:04, 2018

Phytoremediation of Arsenic-Contaminated Soil and Recovery of Valuable Arsenic Products

Authors : Valentine C. Eze, Adam P. Harvey

Abstract : Contamination of groundwater and soil by heavy metals and metalloids through anthropogenic activities and natural occurrence poses serious environmental challenges globally. A possible solution to this problem is through phytoremediation of the contaminants using hyper-accumulating plants. Conventional phytoremediation treats the contaminated hyper-accumulator biomass as a waste stream which adds no value to the heavy metal(loid)s decontamination process. This study investigates strategies for remediation of soil contaminated with arsenic and the extractive chemical routes for recovery of arsenic and phosphorus from the hyper-accumulator biomass. Pteris cretica ferns species were investigated for their uptake of arsenic from soil containing 200 ± 3ppm of arsenic. The Pteris cretica ferns were shown to be capable of hyper-accumulation of arsenic, with maximum accumulations of about 4427 ± 79mg to 4875 ± 96mg of As per kg of the dry ferns. The arsenic in the Pteris cretica fronds was extracted into various solvents, with extraction efficiencies of 94.3 ± 2.1% for ethanol-water (1:1 v/v), 81.5 ± 3.2% for 1:1(v/v) methanol-water, and 70.8 ± 2.9% for water alone. The recovery efficiency of arsenic from the molybdic acid complex process 90.8 ± 5.3%. Phosphorus was also recovered from the molybdic acid complex process at 95.1 ± 4.6% efficiency. Quantitative precipitation of $Mg_3(AsO_4)_2$ and $Mg_3(PO_4)_2$ occurred in the treatment of the aqueous solutions of arsenic and phosphorus after stripping at pH of 8 – 10. The amounts of $Mg_3(AsO_4)_2$ and $Mg_3(PO_4)_2$ obtained were 96 ± 7.2% for arsenic and 94 ± 3.4% for phosphorus. The arsenic nanoparticles produced from the $Mg_3(AsO_4)_2$ recovered from the biomass have the average particles diameter of 45.5 ± 11.3nm. A two-stage reduction process – a first step pre-reduction of As(V) to As(III) with L-cysteine, followed by $NaBH_4$ reduction of the As(III) to As(0), was required to produced arsenic nanoparticles from the $Mg_3(AsO_4)_2$. The arsenic nanoparticles obtained are potentially valuable for medical applications, while the $Mg_3(AsO_4)_2$ could be used as an insecticide. The phosphorus contents of the Pteris cretica biomass was recovered as phosphomolybdic acid complex and converted to $Mg_3(PO_4)_2$, which could be useful in productions of fertilizer. Recovery of these valuable products from phytoremediation biomass would incentivize and drive commercial industries' participation in remediation of contaminated lands.

Keywords : phytoremediation, Pteris cretica, hyper-accumulator, solvent extraction, molybdic acid process, arsenic nanoparticles
Conference Title : ICPPPD 2018 : International Conference on Phytoremediation, Phytotechnologies and Project Development
Conference Location : London, United Kingdom
Conference Dates : April 24-25, 2018