Title: Simultaneous Immobilization Strategy of Anionic Metalloids and Cationic Metals in Agricultural Systems: A Review

Presenting author name: Khadeza Yasmin

Affiliation details of Presenting author (PhD student, Department of Science and Environmental Studies, The Education University of Hong Kong, Tai Po, Hong Kong Special Administrative Region, 999077 and Assistant Professor, Department of Soil Science, Sylhet Agricultural University, Sylhet, 3100, Bangladesh.

Co-authors' details: Md. Shahadat Hossain and Wai Chin Li

Affiliation details of Co-authors (**Md. Shahadat Hossain:** Professor, Department of Soil Science, Sylhet Agricultural University, Sylhet, 3100, Bangladesh, and Wai Chin Li: Associate Professor, Department of Science and Environmental Studies, The Education University of Hong Kong, Tai Po, Hong Kong Special Administrative Region, 999077.

Abstract:

Concurrent heavy metals remediation in natural environments poses significant challenges due to factors like metal speciation and interactions with soil moisture. This review focuses on strategies for immobilizing both anionic and cationic metals simultaneously in soil-crop systems. Key approaches include water management, biochar utilization, stabilizing agents, nanotechnology, fertilization, and bioremediation. Sprinkler or intermittent irrigation combined with soil amendments/biochar effectively immobilizes As/Cd/Pb simultaneously. This immobilization occurs through continuous adsorption-desorption, oxidation-reduction, and precipitation mechanisms influenced by soil pH, redox reactions, and Fe-oxides. Biochar from sources like wine lees, sewage sludge, spent coffee, and Fe-nanoparticles can immobilize As/Cd/Pb/Cr/Co/Cu/Zn together via precipitation. In addition, biochar from rice, wheat, corn straw, rice husk, sawdust, and wood chips, modified with chemicals or nanoparticles, simultaneously immobilizes As and Cd, containing higher Fe_3O_4, Fe-oxide, and OH groups. Ligand exchange immobilizes As, while ion exchange immobilizes Cd. Furthermore, combining biochar especially with iron, hydroxyapatite, magnetite, goethite, silicon, graphene, alginate, compost, and microbes—can achieve simultaneous immobilization. Other effective amendments are selenium fertilizer, Ge-nanocomposites, Fe–Si materials, ash, hormone, and sterilization. Notably, combining nano-biochar with microbes and/or fertilizers with Fe-containing higher adsorption sites, metal-binding cores, and maintaining a neutral pH could stimulate simultaneous immobilization. The amendments have a positive impact on soil physio-chemical improvement and crop development. Crops enhance production of growth metabolites, hormones, and xylem tissue thickening, forming a protective barrier by root Fe-plaque containing higher Fe-oxide, restricting upward metal movement. Therefore, a holistic immobilization mechanism reduces plant oxidative damage, improves soil and crop quality, and reduces food contamination.

Biography

Khadeza Yasmin is a full-time PhD student in the Department of Science and Environmental Studies at the Education University of Hong Kong, Hong Kong SAR, China. Prior to her doctoral studies, she served as an Assistant Professor in the Department of Soil Science at

Sylhet Agricultural University, Bangladesh, with six published research articles and one forthcoming book chapter.