EFFECTS OF BIOCHAR ON METAL ION RELEASE AND PHYTOTOXICITY REDUCTION IN HEAVY METAL CONTAMINATED SOILS IN SRI LANKA

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Serpentine soil derived from Ultramafic rocks may release elevated concentrations of toxic heavy metals such as Ni, Cr ,Mn, etc. and tannery waste polluted soil (TWS) may directly contribute to the release of Cr into surrounding areas. Hence, the presence and bioaccumulation of excessive amounts of such hazardous metals in surrounding areas may have serious consequences for groundwater, agricultural productivity and human health. The objectives of the present study were to investigate the potential of woody biochar, a waste byproduct of Dendro power industry in Sri Lanka, as a soil amendment to immobilize bioavailable toxic metals including Ni, Cr and Mn and reduce their phytotoxicity. Biochar (BC) was obtained from a Dendro power industry at Thirappane, Sri Lanka. The BC was characterized by proximate and ultimate analyses. Metal release experiments were carried out with distilled water to investigate the release kinetics and mechanisms of Ni and Mn in BC amended/unamended serpentine soil. A pot experiment was conducted using tomato plants (*Lycopersicon esculentum L.)* to evaluate the effects of biochar on reducing phytotoxicity in both serpentine and TWS. Three BC applications, 1.0, 2.5 and 5.0 % (w/w) were used in both metal release and pot experiments. The bioavailability of Ni, Cr and Mn was assessed by 0.01 M $CaCl_2$ single extraction procedure. Sequential extractions were utilized to evaluate solid phase metal fraction in soils.

Time dependent data of metal release experiments revealed that both Ni and Mn from BC amended as well as unamended serpentine soil leach rapidly during first 60 min, followed by a steady state increase beyond 60 min and the equilibrium reached after 120 min. The 5.0 % BC amendment decreased in released amounts of Ni and Mn by 52 % and 36 % respectively, compared to the BC unamended serpentine soil. Hence, the released percentages of Ni and Mn in BC unamended soil implied that the released amounts of both Ni and Mn are significantly decreased with increasing BC application. The release of both Ni and Mn from serpentine soil was better described by the simple Elovich model suggesting a heterogeneous diffusion of metals under chemisorption mechanisms.

The least biomass production displayed in tomato plants grown on BC unamended serpentine and TWS and which was about 40- fold and 2-fold lesser than the average dry weight of plants on 5.0 % BC amended serpentine and TWS respectively. There was a marked effect of BC amendments on the bioaccumulation of these metals in tomato plant tissues and the bioaccumulation reduced significantly with increasing the concentrations of BC amendment. All BC applications reduced the bioaccumulation of Cr, Ni and Mn by 80-93 % in serpentine soil and Cr by 87- 97 % in TWS compared to the BC unamended soils.

The $CaCl_2$ extractability of Cr, Ni and Mn significantly decreased after addition of BC to both serpentine and TWS. The reduction in bioavailable concentrations of Cr, Ni and Mn in BC amended serpentine soil reached 88, 92 and 83 % respectively; while Cr in BC amended TWS reached 55 % in the presence of 5.0 % BC amendment. Hence, it was concluded that the bioavailability of these metals decreases with increasing BC concentrations. In both BC amended and unamended serpentine soil, Ni showed the highest $CaCl_2$ extractability and hence, the bioavailability of Cr, Ni and Mn was in the order of Ni > Mn > Cr.

In 5.0 % BC amended TWS, Cr was bound dominantly in the residual fraction that was 4-fold higher than BC unamended soil and hence, it was attributed to decrease the exchangeable fraction of Cr by 99 % compared to the residual fraction. The reduced amounts of all these metals in the exchangeable fraction of both serpentine and TWS implied that the reduction is mainly due to the immobilization of Cr, Ni and Mn depending on the concentrations of BC amendment and thereby reducing their bioavailability from soil to tomato plants in great extent. Overall, our results supported that the use of BC as a soil amendment could be an alternative and economically viable strategy to immobilize and reduce the phytotoxicity of bioavailable toxic metals such as Cr, Ni and Mn in serpentine and tannery waste polluted soils in Sri Lanka.