HIGH CARBON WOOD ASH BIOCHAR FOR MINE TAILINGS REMEDIATION: A FIELD ASSESSMENT OF PLANTED TREE PERFORMANCE AND METALS UPTAKE

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Unique properties of biochar render it appealing for revegetating and decontaminating historic, barren, and chemically complex mine tailings; however, the scale and remote location of many mining sites make widespread implementation unrealistic. Bottom ash from bioenergy facilities can contain high levels of charcoal residue, and thus qualify as a type of biochar; the availability of this material at low cost makes it of particular interest in the context of tailings remediation. Nevertheless, bottom ash is variable and often contains residual toxic metals/metalloids that could potentially be phytoabsorbed into plant tissues. Very few field trials exist testing in situ applications of high carbon wood ash biochar (HCWAB), whether trace metals in ash are absorbed and stored within plant tissues, and if so, how this may affect plant growth and survival or possibly the wider food chain. A large-scale, multi-year replicated field trial was implemented on historic contaminated metal mine tailings in Northern Ontario (Canada) over a range of wood ash amendment dosages (0-30 t/ha); responses examined included substrate properties, success of planted *Pinus banksiana* Lamb. saplings, and tree tissue element concentrations. Sapling survivorship and biomass growth were inventoried annually, while substrate chemical parameters were measured in part using acid-digestion and ICP-MS, as well as innovative field tools such as Plant Root Simulator (PRS) probes. To assess elemental composition in sapling tissue, we propose and test a novel application of electron probe x-ray microanalysis combined with Laser-ablation inductively coupled mass spectrometry (LA-ICP-MS) to intact needle and branch samples across the range of dosages applied. Results were interpreted through analysis of variance and fitted to both linear and higher order log-logistic dose response models. Peak survival and growth of saplings were observed at mid-range biochar dosages of 3-6 t/ha. Similarly, substrate ion availability of P, K, Fe, Zn, and Pb were stable at these lower dosages, but increased above 6 t/ha, while substrate supply of NO^-_3 was significantly reduced at the high dosages. The trace amounts of toxic metals/metalloids of concern measured in wood ash (namely As, Cd, Cu, and Pb) did not lead to significantly increased sapling tissue concentrations at low to moderate dosages, but in some cases tissue contaminant levels increased at the highest dosage considered (30 t/ha). In the case of select important plant elements such as Molybdenum, concentration in HCWAB amended tailings was significantly linked to ultimate tree tissue storage. Our findings highlight the potential for high carbon wood ash biochar to be used for metal mine restoration at low to moderate dosages.

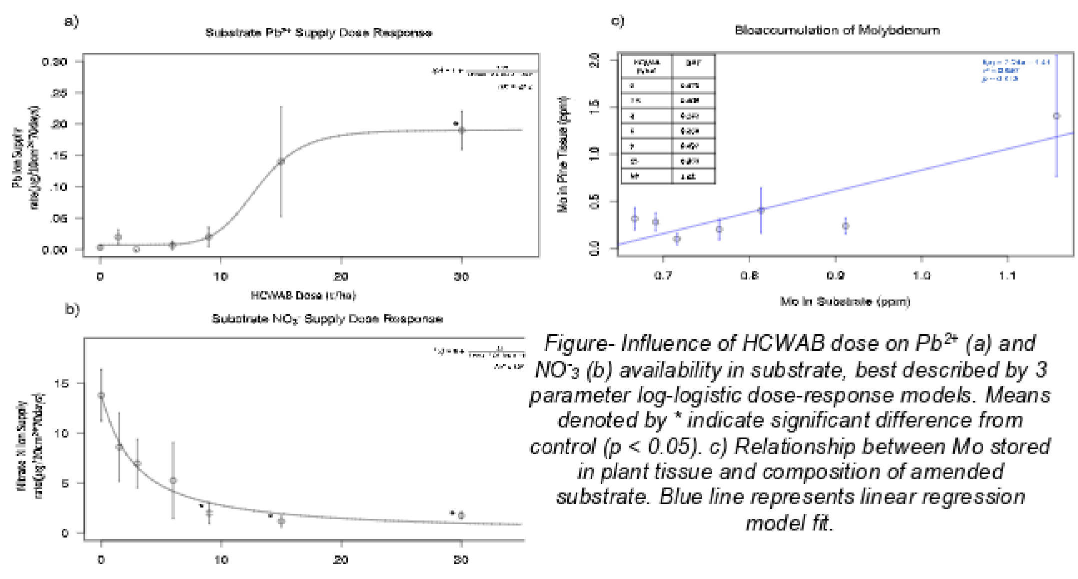

*Figure- Influence of HCWAB dose on Pb^{2+} (a) and NO^-_3 (b) availability in substrate, best described by 3 parameter log-logistic dose-response models. Means denoted by * indicate significant difference from control ($p < 0.05$). c) Relationship between Mo stored in plant tissue and composition of amended substrate. Blue line represents linear regression model fit.*