BIOCHAR AND ASH AMENDMENT EFFECTS ON MINE RECLAMATION IN THE BOREAL FOREST

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Natural re-vegetation of gold mine tailings, the main waste products of ore processing for gold extraction consisting of crushed rock, is difficult due to their high bioavailability of heavy metals, low nutrient status and limited organic carbon [1-3]. Charcoal produced from the burning of organic matter through controlled pyrolysis, hereafter referred to as 'biochar', has been utilized extensively in agriculture as a climate-friendly option to remediate nutrient-poor and contaminated soils [4,5]. Biochar produced from wood is highly recalcitrant, has a large surface area due to its porous structure and can bind nutrients and water, improving soil fertility [5-7]. Biochar can also bind undesirable compounds within the soil such as heavy metals, limiting their bioavailability to plants. Ash has a liming effect on acidic soils and can contribute large quantities of valuable nutrients to the soil following wildfire disturbance. We hypothesized that tailings amendment with biochar and ash would promote plant growth by inhibiting toxicity effects of heavy metal contamination and improving substrate fertility through increases in soil water and nutrient availability. To test this hypothesis field trials were implemented at the Goldcorp Inc. Musselwhite Gold Mine located in Northern Ontario, Canada. Growth responses of two native grass (*Poa palustris* and *Andropogon gerardii*) and one native tree species (*Pinus banksiana*) grown on a mixed sand and tailings substrate with high-ash biochar amendment were measured. Amendment with two types of biochar were investigated: i) woodash, a 38% biochar waste product from a northern Ontario wood-fired co-generation power plant and ii) natural charcoal harvested from a local wildfire. The trials were implemented in October 2015 and partial harvest was completed in September 2016. Statistical analyses indicate a significant increase in plant growth in amended sites compared to controls for both grass species. A large number of the planted tree seedlings were removed by local wildlife; however, the remaining seedlings observed indicate increased growth and survivorship though not statistically significant. Soil temperature gauges were installed in September 2016 in order to examine the effects of soil amendment on soil temperature. Laboratory analysis of plant biomass, soil and biochar characterization was also completed. In addition, during harvest the presence of a highly invasive non-native plant, *Melilotus* (both *M. alba* and *M. officinalis*), was observed to be the dominant taxon colonizing exposed tailings and sand substrates in the area of our trials. A greenhouse study was implemented examining the capacity of the high ash biochars utilized as treatments in this study to bind the allopathic compounds released by *Melilotus* in order to further understand the mechanisms driving the observed increases in growth of plants in amended plots. Statistical analysis indicated that biochar positively affected seed germination and early seedling growth indicating sorption of the allelopathic compounds. The close proximity of the vast majority of Canadian mine sites to the boreal forest and associated timber mills provides a logistical and economic incentive for the investigation of this potential resource. This study is the first of its kind in a Northern boreal ecosystem and the initial results are extremely promising for future applications of biochar in both mine reclamation and invasive species management.

1. Tordoff GM, Baker AJM, Willis AJ. Current approaches to the revegetation and reclamation of metaliferous mine wastes. *Chemosphere*. 2000;41:219-228.
2. Shu WS, Ye SZH, Zhang ZQ, Lan CY, Wong MH. Natural colonization of plants on five lead/zinc mine tailings in southern china. *Restoration Ecology*. 2005;13:49-60.
3. Winterhalder K. Environmental degradation and rehabilitation of the landscape around sudbury, a major mining and smelting area. *Environmental Reviews NRC Research Press*. 1996;4:93-102.
4. Beesley L, Moreno-Jimenez E, Gomez-Eyles JL, Harris E, Robinson B, Sizmur T. A review of biochars' potential role in the remediation, revegetation and restoration of contaminated soils. *Environmental Pollution*. 2011;159:3269-3282.
5. Jeffrey S, Verheijen FGA, van der Velde M, Bastos AC. A quantitative review of the effects of biochar application to soils on crop productivity using meta-analysis. *Agriculture, Ecosystems & Environment*. 2011;144(1):175-187.
6. Uchimaya M, Lima IM, Klasson KT, Wartelle LH. Contaminant immobilization and nutrient release by biochar soil amendment: Roles of natural organic matter. *Chemosphere*. 2010;80:935-940.
7. Zhang X, Wang H, He L, et al. Using biochar for remediation of soils contaminated with heavy metals and organic pollutants. *Environmental Science and Pollution Research*. 2013;20:8472-8483.