Optimal Selection of Biochars for Remediating Metals Contaminated Mine Soils

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Approximately 500,000 abandoned mines across the U.S. pose a considerable, pervasive risk to human health and the environment due to possible exposure to the residuals of heavy metal extraction. Historically, a variety of chemical and biological methods have been used to reduce the bioavailability of the metals at mine sites. Biochar with its potential to complex and immobilize heavy metals, is an emerging alternative for reducing bioavailability. Furthermore, biochar has been reported to improve soil conditions for plant growth and can be used for promoting the establishment of a soil-stabilizing native plant community to reduce offsite movement of metal-laden waste materials. Because biochar properties depend upon feedstock selection, pyrolysis production conditions, and activation procedures used, they can be designed to meet specific remediation needs. As a result biochar with specific properties can be produced to correspond to specific soil remediation situations. However, techniques are needed to optimally match biochar characteristics with metals contaminated soils to effectively reduce metal bioavailability. Here we present experimental results used to develop a generalized method for evaluating the ability of biochar to reduce metals in mine spoil soil from an abandoned Cu and Zn mine. Thirty-eight biochars were produced from approximately 20 different feedstocks and produced via slow pyrolysis or gasification, and were allowed to react with a filtered standardized extract of the mine spoil soil. The biochar was removed from the solutions by filtration and the resulting solutions analyzed for metals. Extract solutions without biochar served as the controls for initial mine soil extract solution metal concentrations. Five metals (Zn, Cu, Cd, Mn and Ni) were most abundant in the mine soil extract. Fifteen of the 38 biochars tested removed more than 99% of these 5 metals from solution, and 20 biochars removed more metal than Granulated Activated Charcoal (GAC). In general, high temperature (HTT ≥ 500 °C and gasification) biochars were more effective at metal removal than those made at lower temperature. The high performing biochars were produced from feedstocks derived from grass straw, anaerobically digested plant fiber, dairy manure and bioenergy crops. Interestingly, biochars made from softwoods, hardwoods, and nut shells produced via slow pyrolysis removed less metal than GAC. This presentation will examine relationships among feedstock selection, pyrolysis temperature, and biochar properties for their ability to remove these five metals from solution. The implications of employing the designer biochar concept, and methods for matching biochar properties to specific soil impairments, including metal toxicity, will be discussed.