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Ball-Milled Biochar and Its Effect on Remediation of Soil from Industrial Area

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Extended Abstract

The increasing soil pollution with heavy metals requires new and sustainable remediation solutions. Biochar, an environmentally friendly carbon material derived from various biomasses, has recently been used as a soil amendment to immobilize heavy metals in polluted soils. Despite the recognized benefits of biochar, its adsorption and immobilization efficiency still needs to be improved. Recently, ball milling has been considered as an environmentally friendly technology for biochar modification. Mechanical grinding of biochar into fine micro- and nano-sized particles can improve the physical and chemical properties of biochar in terms of metal adsorption [1, 2]. Therefore, testing of ball-milled biochar for metal immobilization in polluted soils is crucial for the development of nanoremediation. The objective of this work was to compare selected properties of pristine and ball-milled biochars and their effect on selected soil properties and leachability of metals from soil polluted by the smelting industry.

Biochar obtained by pyrolysis at 650 °C from roadside deciduous trees (Fluid SA, Sędziszów, Poland) was fractionated into: macrosized biochar (MBC) with a particle size of 1 mm and ball-milled biochar (BBC) with an average particle size of 52 μm. Ball milling was performed in a planetary ball mill (S100; Retsch Corporation) with agate balls of 2.4 and 10 mm for 1.6 h at 575 rpm [3]. Immobilization of Cu (1298 mg/kg), Pb (268 mg/kg), and Zn (60 mg/kg) in soil from an industrial area (Legnica, Poland) was performed for the following treatments: 1) control of polluted soil, 2) soil + 5% MBC (w/w); 3) soil + 5% BBC (w/w). The soil was incubated in acrylic columns (25 cm length, 2.5 cm inner diameter) for 75 days. A volume of distilled water (determined based on pore volume) was added to each column every ten days and leachates were collected from all columns after 48 hours and characterized.

BBC exhibited higher cation exchange capacity and more acidic surface functional groups (carboxyl, phenolic, and lactone groups) than MBC. Although BBC contained higher total metal contents than MBC, their water solubility was low, which minimized the risk of possible metal leaching from the BBC in soil. Soil amendments with MBC and BBC mainly affected soil pH and soil organic matter content. BBC was more beneficial than MBC in improving these soil properties. Due to the acidic pH (4.26) of the soil, the mobility of Cu was very high (62.8%, with 26.8% of Cu being bioavailable). Pb and Zn occurred at lower concentrations and showed intermediate mobility (23.9% and 29.7%, respectively). BBC proved to be more effective than MBC in immobilizing of Cu and Pb. In contrast, MBC increased the leachability of Cu, Pb, and Zn compared to the control soil. Ball-milled biochar from roadside deciduous trees could be a promising remediation option to reduce the leachability of mobile Cu and Pb in acidified soils affected by the smelting industry.

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