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Plum Stones Biochar – Efficient Resource for Phosphate Recovery and Alternative Fertilizer

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Abstract

The global food demand has drastically increased in the last decade, raising the application of chemical fertilizers to support it. In the same time, high growing fruits/vegetables processing industries (FVPI) are generating significant amounts of organic waste, whose landfilling represents unsustainable practice with significant environmental hazards. Lignocellulosic waste (LCW), generated by FVPI, represents valuable renewable resource with many beneficial properties, that can be mechanically, chemically or thermochemically converted into the materials with significant benefits which might reduce environment pollution and support circular economy principles. In this paper we have thermochemically transformed waste plum stones (PmS) from the local FVPI company, into the biochar (BC) – stable, porous, carbon rich matrix, plain with surface functional groups, that can be further tailored for various purposes. The characterization of obtained PmS-BC resulted in the following elemental organic analysis: C(66.8 wt%), N(1.62 wt%), H(2.7 wt%) and O(28.9 wt%); chemical analysis revealed significant amounts of nutritional components such as P(1.1 wt%), K(0.3 wt%), Mg(1.7 wt%) and Ca(0.25 wt%), while toxic metals were not present. Low O/C ratio (0.3) indicated high stability of PmS-BC in soil, with the half-life from 100 - 1000 years (Spokas, 2014). The raw PmS-B was used for the sorption of eutrophication agent, phosphate ions (PO_4^{3-}), but instead of binding, release of phosphorous from the PmS-B structure occurred: PO_4^{3-} concentration raised from initial 135.2 to 147.4 mg/L. Similar results were obtained by He et al. (2020) who confirmed that the native tobacco stalk biochar releases phosphorus, explaining that without the chemical modification, BC surface has a high negative zeta potential, which electrostatically repulse phosphate ions and, due to the acidity of the phosphorus solution, release already contained phosphorous. In order to improve BCs ability to bind phosphate ions, Mg, Al, Fe, and other metals are often loaded onto the biochar surface (Wan et al., 2017). Having this in mind, PmS-B was modified according to the procedure adopted from Ronghua et al. (2017). Modified biochar (PmS-B-M) showed excellence sorption capacity toward phosphates (calculated by Sips isotherm) of 181.46 mg/g, much higher than others found

in literatures (Lopičić et al., 2023). The post-sorption characterizations by SEM-EDX, XRD, and FTIR suggested that colloidal and nano-sized MgO, in the form of periclase particles deposited on the surface of PmS-B-M, were the main sites for the phosphate sorption. Results of this investigation show that PmS-B-M can be effectively used as efficient phosphate remediation technology, where the exhausted, P-loaded biochar can be directly applied to the soil as fertilizer to improve soil fertility, regulate pH, raise water-holding capacity, and support microbial activities. Fertilizers made of LCW biomass available in abundant amounts, might promote global food production, enhance CO2 capture, reduce waste generation/environment pollution, and improve soil quality.

Keywords: waste biomass, pyrolysis, sorption, phosphate, soil enrichment

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