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Enhancing composition and heavy metals combined with humic substances by adding black tourmaline during composting

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ABSTRACT

Humic substances (HSs) extracted from compost play an important role in remediating heavy metals pollution of soil. Adding mineral additive is widely considered as a practical way to enhance the synthesis of HSs and immobilize heavy metals during composting process. Meanwhile, it is a prosperous field to search more mineral additive related to local conditions. Therefore, three dosages of Black Tourmaline (TM) were applied into initial feedstocks to investigate its effect on the composition of HSs and heavy metals combined with HSs. Results demonstrated that TM shortened the maturity period and promoted the transformation from degradable organic substances to stable structures. The variation of spectral parameters such as $SUVA_{254}$, $SUVA_{280}$, A_4/A_1, Pi, n and specific values of FTIR provided evidences for the degradation of aliphatic carbon and the formation of aromatic carbon. Meanwhile, adding TM increased the HA-Cu and HA-Zn, and thus decreased the bioavailability of heavy metals. Therefore, TM is beneficial for improving composition of HSs and reducing toxicity of compost, and 10% is suggested in this research. To further, more specific additive amounts of TM should be investigated to get more details about the application of TM in composting technology.

1. Introduction

Cu and Zn are applied into poultry farms to defense diseases and improve animal growth as feed additives [1]. However, less microelements are absorbed by animals, which leads to the higher concentration of HMs in PM. The long - term application of PM into farmland without improper pretreatment could cause soil contamination and thus caused risks to human health [2,3]. Furthermore, the HMs imported into soil could not be decomposed by microbes. Hence, it is essential to immobilize HMs for the sake of recycling PM safely [4].

Aerobic composting is generally regarded as a feasible method to manage PM and generate organic fertilizers [5]. It was confirmed that HMs bioavailability can be reduced though composting, dominantly in the maturity stage [6–8]. In this process, the formation of stable HSs featured with functional groups is main contributor to the HMs immobilization [9–12]. While during the composting process, the improper conditions of compost piles including C/N value, moisture content, temperature, pH, O_2 concentration and particle size affect the microbial activities, and thus have a negative effect on composition of HSs [10]. The lower HA contents of compost fixed less HMs, and the application of it into farmlands inhibited the seed germination and the growth of plant roots due to the toxicity [13]. Therefore, it is urgent to improve transformation of HSs and its binding ability with HMs in a sustainable way.

To date, adding mineral additives has been widely used to optimize the composting conditions, and then improves humification ascribed to the great specific surface area, porosity, high availability and wide distribution [14]. Jindo et al. [9] demonstrated that adding 10% biochar into compost improved aromatic-C and carboxylic-C of FA contents. Wang et al. [15] revealed that zeolite combined with biochar

Abbreviations: A_4/A_1, Ration of the area at 435-480nm and at 300-345nm; TM, Black Tourmaline; Cu, Copper; EEM, Excitation - emission matrix; EM, Emission; EX, Excitation; FA-Cu, The concentration of copper combined with fulvic acid; FA-Zn, The concentration of zinc combined with fulvic acid; FRI, Fluorescence regional integration; FTIR, Fourier transform infrared; FA, Fulvic acid; GI, Germination index; HA-Cu, The concentration of copper combined with humic acid; HA-Zn, The concentration of zinc combined with humic acid; HMs, Heavy metals; HA, Humic acid; HSs, Humic substances; Pi, n, Percentage fluorescence response; PM, Pig manure; SD, Sawdust; $SUVA_{254}$, The specific UV absorbance at 254 nm; $SUVA_{280}$, The specific UV absorbance at 280 nm; TKN, Total kjeldhal nitrogen; TOC, Total organic carbon; Zn, Zinc

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