EFFECT OF RICE STRAW AND ITS DECOMPOSED MATERIAL ON IMMOBILIZATION OF CADMIUM IN RED SOIL BY BIOCHAR

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ABSTRACT

To effectively utilize agricultural wastes for soil cadmium immobilization has become hot topic of environmental science. This study examined the effect of rice straw (RS), its decomposed product (DRS) and rice straw biochar (BC) on immobilization of Cadmium (Cd). Results showed that, all treatments at the 3% application rate of biochar with increasing the RS and DRS application rate from 0% to 15%, the soil pH and soil organic matter (SOM) level significantly increased. RS and DRS combined with BC in different rate made toxicity characteristics leaching procedure test (TCLP) cadmium levels in soil reduced by the percentage of 6.2-25.1 and 6.2-31.7, respectively. For European Community Bureau of Reference (BCR) sequential extraction procedure, the exchangeable-Cd and reducible-Cd fractions were transferred to oxidisable and residual-Cd fractions in both RS and DRS treatments when their combination with BC in various ratios. Overall, different rates of RS and DRS can promote biochar effect of cadmium immobilization in red soil. The most effective treatment for immobilization of cadmium by biochar is 3% for raw rice straw and 0.6% for decomposed rice straw.

Keywords: *biochar, rice straw, cadmium, immobilization.*

1. INTRODUCTION

Cadmium is one of the most toxic metals. Cadmium in soil, mainly coming from human activities, is easily uptaken by crops and threat to human health through the food chain (Hédiji et al., 2015; Wang et al., 2011; Xiong et al., 2016). Cadmium in soil is difficult to be degraded by microorganisms or chemical activity (Bolan et al., 2013). To reduce its soluble and exchangeable fraction in soil, chemical immobilization remediation is a potential method, which can satisfy the cultivated land resource utilization and ensure the demand for food supply (Hu et al., 2017).

Global annual output of agricultural waste is about 500 million tones (Duku et al, 2011), and its returning to the farmland soil directly is one of the most economical and realistic methods for improving soil fertility (Zhu et al., 2010). In addition, few studies reported that crop straw may decrease the available concentrations of heavy metals in soil through adsorption. Soil incorporation with 1% rice straw could significantly reduce available Cd, while addition 1% wheat straw clearly decreased Pb level in soil (Xu et al., 2016). In a similar line, Cui et al. (2008) reported that free Cd^{2+} concentration in soil decreased when adding rice straw at the rate of 6%. However, decomposition process of crop straw in soil may cause the change to immobilization effect on heavy metal. The concentration of $CaCl_2$-extractable Cd from soils amended with rice straw decreased on day 4 of incubation, while clearly higher on day 7 or 21, but became comparable to the control on day 81 (Tang et al., 2017).

Crop straw biochar as immobilization material has been proven that effectively enhanced the adsorption of heavy metal and significantly reduced their mobility and phytoavailability (Park et al., 2011; Puga et al., 2015), it is also advantages in greenhouse gas emission reduction (Awad et al., 2018). Short-term pot experiment result showed that concentration of Cd in red soil decreased in toxicity characteristics leaching test (TCLP) by 42.9 and 36.7% for rice straw biochar and maize stover derived biochar, respectively at 3% application rate (Saqib et al., 2018). Similarly, the result for two years experiment revealed a substantial reduction in the exchangeable fraction of Pb and Cu by 57.56% and 54.18% respectively when adding 5% of rice straw biochar to co-contaminated soil, meaning soluble form of heavy metals transformed into insoluble forms (Abdus et al., 2019). However, the amount of biochar should be controlled below 5% to avoid the negative impact on soil properties (Matovic, 2011).

The aim of this study was to investigate the effect of rice straw and its decomposed product combined with rice straw biochar in various ratios on Cd immobilization, providing the theoretical

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