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FULL PAPER

The effect of paddy husk biochar towards zinc availability in contaminated soil

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Abstract

Soils polluted with heavy metals have become common across the plantation sector. There is a reduction in plant growth as well as the yield of the plants that have been planted on heavy metal-contaminated soil. Uses of fertilizers and other soil amendments also add small amounts of heavy metals to the soil, which can develop over time with repeated applications. This study was conducted to identify the appropriate rate of paddy husk biochar applied to soil in order to reduce the presence of heavy metals. The main focus was to determine the availability of heavy metals in soil such as zinc. Next, is to know the best possible measure of biochar towards the contaminated soil to decrease the metal availability. The treatment of this experiment is different rates of biochar which are 0 g, 15 g, 20 g, 30 g and 40 g. This research measured the available Zn in the soil before and after applying PHB, which takes 3 weeks to let them interact. The biochar significantly influenced the Zn availability in soil. This study has shown that the application of PHB to soil has the potential to reduce the availability of Zn.

1. Introduction

Soils polluted with heavy metals have become common across the plantation sector. There is a reduction in plant growth as well as the yield of the plants that have been planted on heavy metal-contaminated soil. Agricultural soils normally contain low background levels of heavy metals. Namgay *et al*. (2010) reported that contamination from industrial activities or byproducts can give a side effect or increase the natural levels of heavy metals in soil, creating a health hazard to people, livestock and plants. Uses of fertilizers and other soil amendments also add small amounts of heavy metals to the soil, which can develop over time with repeated applications.

Despite the fact that plants require a certain amount of heavy metals for their growth and upkeep, excessive amounts of these metals can become distinctly harmful to plants. As metals cannot be broken down, when concentrations within the plant exceed ideal levels, they adversely influence the plant both directly and indirectly. Plants growing on heavy metal-polluted soils show a reduction in growth, performance, and yield. Excessive amounts of metals also can become harmful to organisms. Other heavy metals such as lead, cadmium, mercury, and arsenic do not have any beneficial impact on organisms and are consequently viewed as the main threats since they are extremely destructive to both plants and creatures. The capability of paddy husk biochar apparently overcomes this issue. Biochar may reduce soil compaction and enhance nutrient uptake from the soil. In this experiment, the main objective was to determine available Zn in contaminated soil and determine the potential of PHB as a good absorbent of Zn.

2. Materials and methods

2.1 Preparation of zinc artificial contamination and rice husk biochar

Soil samples were taken from the Universiti Teknologi MARA Melaka in Jasin share farm at 0-15 cm depth. The samples were air-dried, passed through a 2-mm sieve and kept in a dry room. A solution of 400 ppm Zn in zinc sulfate ($ZnSO_4$) was prepared prior to artificial contamination. The solution was mixed with soil and left incubated for three weeks. Rice husk was

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taken from a rice mill in Tanjung Karang, Selangor. The rice husk was subjected to a continuous slow pyrolysis process at a temperature of >500°C as per the making of biochar.

2.2 Treatment of zinc-contaminated soil using rice husk biochar

Rice husk biochar (RHB) was applied to Zn-contaminated soil at rates of 0, 15, 20, 30 and 40 g/kg soil which represents five treatments of T0, T1, T2, T3 and T4, respectively. Each treatment was repeated four times. The experimental units were arranged in a Completely Randomized Design (CRD) and left incubated in the laboratory for three weeks.

2.3 Soil pH and zinc availability analysis

Soil samples before and after treatment application were analyzed for pH using 1:2.5 (w/v) in distilled water and the pH was read using Mettler Toledo desktop pH meter. Zinc availability in soil was determined by Mehlich No. 1 method. The extracted Zn was analyzed by Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES).

3. Results

3.1 Treatment effect on soil pH

The pH of the contaminated soil was 8.7 and the cation exchange capacity (CEC) was 12.42 mol/kg after the application of RHB. The soil pH before applying the treatment was 4.32, which is acidic. There was an increment of pH observed after RHB treatment of, which 4.40, 4.82, 4.95, 4.98 and 5.10 for T0, T1, T2, T3 and T4 respectively.

3.2 Zinc availability in soil

Figure 1 shows the soil Zn availability in artificially contaminated soil treated with RHB. The highest Zn concentration before applying RHB was in T2 of which 239.1 ppm which exceeds the limit concentration of Zn standard in soil. Overall, the Zn concentration decreased except for T0 (control). After three weeks, the amount of Zn increased from 64.6 to 138 ppm. For T2, there was a reduction of Zn which was 165.3 to 42.88 ppm. While T3 decreased from 221.2 to 137.1 ppm and T4 also reduced from 167.9 to 76.4 ppm.

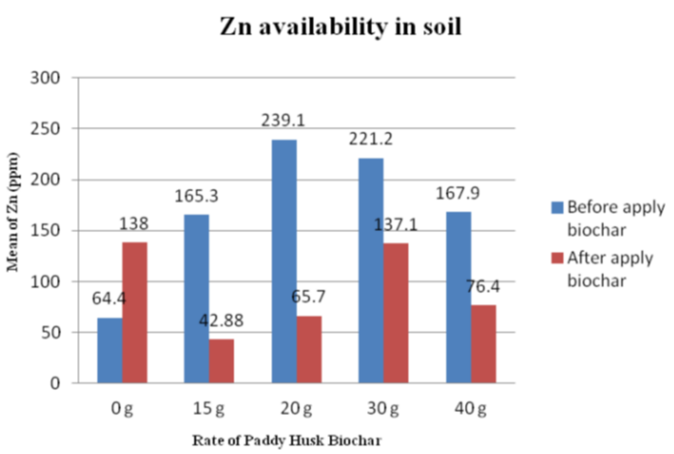

Figure 1. Mean of Zn availability before and after applying PHB.

4. Discussion

The result of this study shows soil pH increases with the amount of RHB applied. According to Masulili and Utomo (2010), biochar could be utilized as a substitution for lime material to enhance the pH of acidic soils. This is in agreement with Kamara *et al*. (2015). Some biochar has been shown to have a high pH, consequently, can be used as a liming agent when applied to acidic soil (Beesly and Marmirolli, 2011). As reported by Lu *et al*. (2014), pH functioned to neutralize soil acidity, which also is a factor in metal mobility. Higher soil pH would promote metal adsorption, subsequently can lessen the bioavailability (Zhang *et al*., 2013).

Figure 1 shows that there was a fluctuation of Zn concentration in the contaminated soil from T0 to T4. This could be due to the soil-RHB mixture dynamic sorbent actions on applied Zn. However, a reduction of Zn content was positively observed in T2, T3 and T4. It proves that the application of RHB was able to immobilize Zn thus reducing its availability. The physicochemical properties of biochar, such as porous structure, and hydroxyl and carbonyl groups, could contribute to the degradation of heavy-metal pollutants such as Zn (Zhu *et al*., 2015). In addition, Yang and Sheng (2003) reported that biochar is a strong sorbent than other forms of organic matter.

5. Conclusion

The RHB application of up to 40 g/kg soil significantly reduced Zn availability and increase soil pH in Zn artificially contaminated soil. This study has shown that the application of RHB to soil has a strong potential to reduce the availability of Zn below its toxic level as well as soil acidity.

Conflict of interest

The authors declare no conflict of interest.

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FULL PAPER

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