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Urban Soil Enzyme Activity Restoration with Burger Dirt †

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Abstract: Soil enzyme activity is a good indicator of soil quality. Urban soil has been known to have poor quality on plant growth. In the meanwhile, food waste is a huge issue around the world. Burger dirt with the use of food waste has potential to improve soil quality. The objective of this study was to determine the effect of Burger dirt on soil enzyme activity. It was conducted at 1:1 and 1:2 soil to Burger dirt ratio for 2, 4, 6 and 8 weeks. Then, the soil enzyme activity, pH and moisture content was determined. The finding shows that soil pH was stabilized to 7 significantly at 6 and 8 weeks of restoration period at the 1:2 ratio. The 1:2 soil to Burger dirt ratio significantly increased soil moisture content from 12.00 ± 0.286 to 14.3 ± 2.11%. Soil urease activity was enhanced from 1.330 ± 0.0407 to 10.5 ± 0.315 mg NH_3-H at 8 weeks of restoration period and vice versa in catalase activity (0.525 ± 0.0104 to 0.0839 ± 0.00535 mL 0.02 mol/L $KMnO_4$/g dry soil). An 8-week soil restoration period with 1:2 ratio of soil to Burger dirt is recommended to improve the soil enzyme activity and pH.

Keywords: urban soil; Bokashi; kitchen waste; soil stabilizing; soil amendment

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1. Introduction

Soil enzyme activity is one of the best indicators for soil quality [1]. Soil enzyme is a stable protein with catalyst function. They mainly come from plant root residue and animal and microbes excretion which turn organic compound to an inorganic compound [2]. Soil enzyme activity plays an important role in the nutrient cycle. For instance, proteases, amidases, urease, and deaminases are involved in the N cycle. However, the nutrient cycling is interrupted, and soil organism activity is modified in urban soil. With the help of vegetation and ecology restoration, it improved soil nutrient and enzyme activity such as catalase and dehydrogenase enzyme [3,4].

Soil enzymes are sensitive to the condition at which they work, which includes pollution and aeration. Among the pollutants contained in urban soil is heavy metal (e.g., Zn, Pb and Cd) [5]. Thus, urbanization is gradually making us prone to food insecurity and increases our carbon footprint throughout food transportation. Generally, Malaysia has acidic soil which is known to be less fertile, hence causing it to have lower agronomic potential. This is common to the soil in the equatorial region. Being a hot and humid country, the rate of nutrient loss is high in Malaysia. Acid soil and anthropogenic activity are often related to the low microbial biomass and enzyme activity [1]. Hence, it may not contribute to alleviate the demand of nutritious food for our basic needs.

On the other hand, food is fundamental to human development. About 30–35% of total food production (~1.3 billion tonnes food and USD 1 trillion) is wasted (non-recyclable) annually [6]. Food waste is a global issue; however, it is a novel problem in Malaysia as the amount of food waste has only increased recently. Looking at the bright side, food waste can possibly be the nutrient for our next meal. Food recycling by composting and fermentation is required to solve the downstream issues of food waste and thus contributed to SDG 12: Responsible consumption and production and SDG 13: Climate action.

Burger dirt is commonly known as Bokashi. It is a highly versatile method to digest the organic materials such as food waste, anaerobically. Thus, it is environment friendly as it produces low amounts of greenhouse gases emission [7]. Burger dirt is also known to have a positive effect on soil properties [8] However, no previous study has been carried out on the urban soil enzyme activity restoration. Previous studies focused on the vermicompost or utilizing other compost as soil restoration measures. There is a lack of finding regarding the effect of Burger dirt on soil enzyme restoration. The objective of this study is to determine the effect of soil enzyme activity change with assorted Burger dirt ratio and restoration period.

2. Materials and Methods

2.1. Site Study, Experimental Design and Treatment

The experiment was carried out in a greenhouse located in Faculty of Agriculture, University Putra Malaysia (UPM) with the coordinate of latitude 2°59′31.4″ N and longitude 101°42′52.1″ E. The studied soil was clay. The experiment was conducted at completely random design (CRD) with 4 replications of Burger dirt treatments in different soil restoration periods (2, 4, 6, and 8 weeks) and the ratio of soil to Burger dirt (1:1 and 1:2). The experiment was conducted as destructive sampling with 32 sampling units, in total.

2.2. Burger Dirt Soil Restoration Treatment

Burger dirt preparation method was modified based on a method by [9,10]. The 20 cm depth of urban soil was collected from the Field 10, UPM. The fresh soil was sieved at 2 mm and mixed well with Burger dirt in the ratio of 1:1 and 1:2 (in weight basis). The mixed of urban soil was filled with a weight of 1.3 kg per polybag in a 10 × 10 cm polybag, covered with 0.7 kg urban soil and covered with a plastic gunny bag. No irrigation was provided along the restoration period. The Burger dirt consists of 1.722 ± 0.2560 % of total N (digested with wet digestion and determined by distillation and titration).

2.3. Soil Analysis

The air-dried soil samples were crushed by using mortar and pestle. The soil was then sieved with a 2 mm sieve. Soil texture was determined according to [11]. Soil pH was determined using a 1:2.5 soil to water ratio [12]. Soil moisture content was measured gravimetrically using 20g of fresh soil that had been oven-dried at 105 °C until a constant weight is achieved. [12]. Catalase activity was measured by back-titrating residual H_2O_2 with $KMnO_4$ [2,13,14]. Urease activity was determined spectrophotometrically [2,15].

2.4. Statistical Analysis

Recorded data were subjected to analysis with two-way analysis of variance (ANOVA) with 4 replication using R statistic software. When F was significant at the $p <$ 0.05 level, treatment means were compared and separated using DMRT.

3. Results and Discussions

Soil urease activity has significant negative correlation with soil moisture content. Soil urease activity and pH were positively correlated. Soil moisture content and catalase activity were positively corelated. Urease activity was negatively correlated with pH and catalase activity. Soil pH was also negatively correlated with soil moisture content and catalase activity.

3.1. Soil pH

The ratio of soil to Burger dirt and soil restoration period had no significant interaction (p = 0.58058) with pH. Soil pH was significantly different along the soil restoration period ($p = 1.555e^{-9}$). Soil pH significantly increased from 4 to 6 weeks of the soil restoration period (Figure 1A). The ratio of the Burger dirt in soil showed the pH stabilization has significant differences (p = 0.009463) in both ratio which are 1:1 (7.09 ± 0.11) and 1:2 (7.27 ± 0.098). A 1:2 ratio of Burger dirt significantly improved pH in the soil. Initially, Burger dirt was produced in anaerobic condition with the acidic EM addition, and then exposed to aerobic condition with soil for soil restoration. Therefore, the pH rose with the aerobic soil restoration [17]. Another possible explanation was that the drought condition increased the soil pH over time [18]. A remarkable result was that the initial urban soil pH increased to the optimum level in 2 (pH 6.78 ± 0.068) and 4 (pH 6.83 ± 0.079) weeks of soil restoration period and thus, made the essential nutrient available for plant.

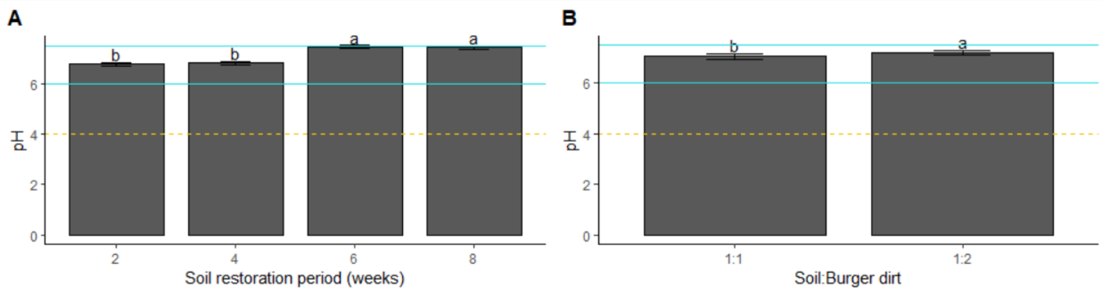

Figure 1. Effect of (**A**) soil restoration period and (**B**) soil: Burger dirt ratio on pH. Means ± standard error with different letters is significantly different at $p < 0.05$ using DMRT. " – ": recommended pH range (pH 6.0-7.5) [16]; " - - -": pre-treated soil pH (4.00 ± 0.0473).

3.2. Soil Moisture Content

No significant interaction (p = 0.869497) was found between the ratio of soil and Burger dirt and restoration period in soil moisture content, the amount of soil water available. Soil moisture content was significantly different with the restoration period (p = 0.004833) and ratio of soil and Burger dirt ($p = 8.576e^{-10}$) (Figure 2). Soil moisture content significantly declined after 2 weeks of the soil restoration period. Nonetheless, the soil moisture content is maintained from week 4 to week 8 of the soil restoration period. A 1:2 ratio of soil to Burger dirt significantly improved soil moisture content. Soil moisture content is the key for soil enzyme activity where it affects the microbial biomass and respiration [2,19]. Soil moisture content and organic matter had significant correlation with soil enzyme activity such as arylsulfatase [20,21]. Based on previous findings, a high soil moisture content significantly enhanced soil enzyme activity such as saccharase, urease, protease, β-glucosidase and acid-phosphatase activity [2]. Catalase activity was also increased with soil moisture content in arable humus and beech forest soil [22,23]. A 20% of soil moisture content was significantly higher catalase, urease, alkaline phosphatase, acid phosphatase, β-glucosidase, arylsulfatase and dehydrogenase activity than 40, 60% of soil moisture content [23]. On the contrary, any decline in soil moisture content indicated that the actual transpiration rate decreased [24].

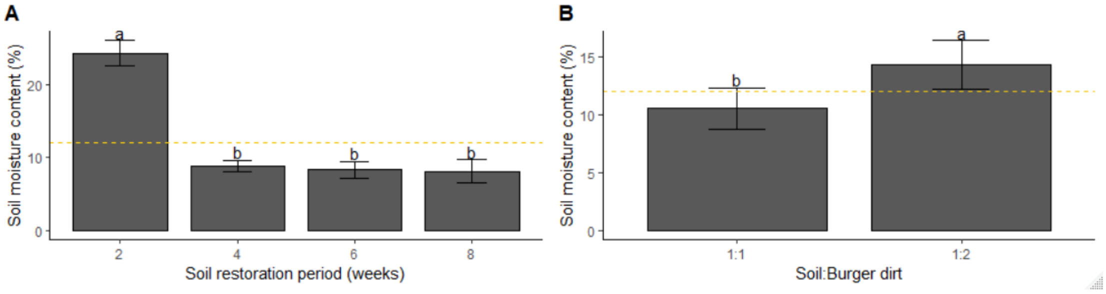

Figure 2. Effect of (**A**) soil restoration period and (**B**) soil: Burger dirt ratio on soil moisture content. Means ± standard error with different letters is significantly different at $p < 0.05$ using DMRT. " - - - ": pre-treated soil moisture content (12.00 ± 0.286%).

3.3. Soil Catalase Activity

Soil catalase activity significantly increased with the soil to Burger dirt ratio of 1:1 and 1:2 (Figure 3B). However, it significantly decreased with the soil restoration period of 2, 4, 6 and 8 weeks (Figure 3A). Soil catalase activity has declined 18.22% after applying Burger dirt. Soil moisture content and catalase activity were closely correlated (0.58). The pre-treated soil was low in organic matter compared to treated ones. However, catalase activity of Burger dirt treated soil was significantly reduced. Low catalase activity indicated low biological activity in the soil [25]. This is due to the fact that soil moisture content has decreased along the drought soil restoration period as they were positively correlated (Figure 3A). Soil air and water percentage played a vital role in catalase activity. Soil catalase increased under well aerated soil [26]. Soil pore size distribution and soil water-filled pore space may indirectly affect the soil enzyme activity as it significantly affected the bacterial and fungal biomass [27]. The pre-treated soil was probably high in soil pore size of catalase activity.

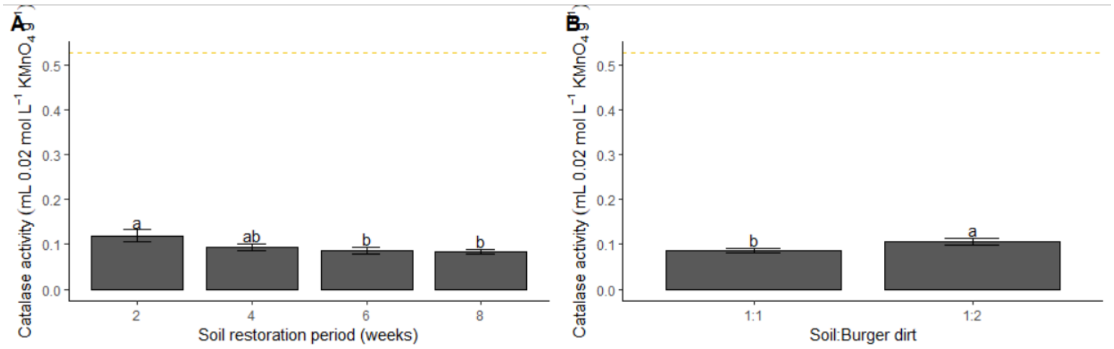

Figure 3. Effect of (**A**) ratio of soil to Burger dirt (1:1 and 1:2) and (**B**) soil restoration period (weeks) on soil catalase activity (mL 0.02 mol L^{-1} $KMnO_4$ g^{-1}). Means ± standard error with different letters is significantly different at $p < 0.05$ using DMRT. " - - - ": pre-treated soil catalase activity (0.525 ± 0.0104 mL 0.02 mol L^{-1} $KMnO_4$ $^{-1}$).

3.4. Soil Urease Activity

Urease activity significantly increased with a long soil restoration period (Figure 4). Moreover, urease activity and pH were closely correlated (0.67). Soil catalase activity has increased 683.11% after applying Burger dirt. Urease is a specified enzyme for ammonification. The substrates for ammonification are urea, uric acid, and organic nitrogen [28]. In other words, high ammonium is referred to as high urease. Low ammonium is released in soil as the soil moisture content decreases (Figure 2) and pH increases (Figure 1) [28]. Therefore, ammonium concentration may be increased as urease activity increases along the soil restoration period. In dry season, urease activity was significantly higher compared to rainy season [29].

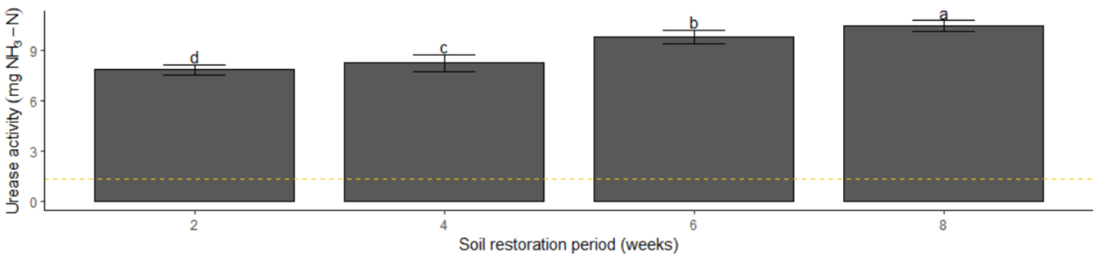

Figure 4. Interaction effect of soil restoration period (weeks) on soil urease activity (mg NH_3-N). Means ± standard error with different letters is significantly different at $p < 0.05$ using DMRT. “ - - - ”: pre-treated soil urease activity (1.330 ± 0.0407 mg NH_3-N).

5. Conclusions

Amendment of Burger dirt has changed the soil enzyme activity significantly. Two weeks of soil restoration period with 1:2 soil to Burger dirt ratio is recommended to improve soil urease activity. A 1:2 ratio significantly increased soil moisture content. Nonetheless, soil moisture content and catalase activity decreased simultaneously. Soil urease activity also enhanced significantly at an 8 weeks of soil restoration period as soil pH increased. The optimum soil pH 6.0-7.5 was achieved. All in all, the Burger dirt is also a good alternative to food waste management.

Supplementary Materials: The following supporting information can be downloaded at: www.mdpi.com/xxx/s1, Figure S1: title; Table S1: title; Video S1: title.

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