Kinetic evaluation of carbon to nitrogen ratio in relation to different POME-PPF mixture during vermicomposting process

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Abstract

Malaysia is the largest producer of palm oil (*Elaeis guineensis*). Malaysia and Indonesia contributes about 87 % of world palm oil production. Oil palm processing generates a large quantity of by-products including Palm oil mill effluent (POME) and palm press fibre (PPF). Decomposition of these by-products under natural conditions is a time-consuming taking process. Vermicomposting technology could be an alternative and suitable method for the management of POME. In this study, vermicomposting of three POME:PPF ratios (50:50, 60:40 and 70:30, known as 50%, 60% and 70% mixture of POME-PPF) was assessed over 45 d, under laboratory condition. The results showed a higher decomposition rate in 50% mixture of POME-PPF (k= 0.0498 d^{-1}) as compared to other mixtures. This study confirms that 50% mixture of POME-PPF serves as an optimal mixture for vermicomposting process.

Keywords: Oil palm, POME, PPF, Kinetics, Vermicomposting technology

Introduction

The oil palm industry has been recognized for its contribution towards economic growth and rapid development, it has also contributed to environmental pollution due to the production of huge quantities of by-products from the oil extraction process. Malaysia is the largest producer of palm oil (*Elaeis guineensis*). Malaysia and Indonesia contributes about 85 % of world palm oil production (Figure 1). Decomposition of by-products generated from the oil palm process such as palm oil mill effluent (POME) and palm pressed fibre (PPF) under natural conditions is a time-consuming process. The organic fraction of the wastes can be

converted into valuable products through the vermicomposting process. The important role of earthworms in the biological processes includes breaking down the solid organic matter (Atiyeh et al. 2000) and releasing a portion of the organic matter into earthworm biomass and respiration products (Dominguez et al. 2001) rendering the nutrients available for the plants (Sun 2003). Decomposition of the organic matter are slow, the consideration of the kinetics are important (Trinsoutrot et al. 2000).

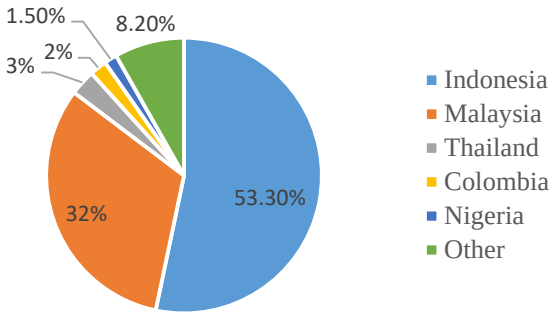

Figure 1: Global Palm oil production 2015(MPOB 2015)

Materials and Methods

The kinetic analysis of three POME-PPF mixtures namely 50 %, 60 % and 70 % POME were analyzed during the vermicomposting process using epigiec earthworm (*Eudrilus eugeniae*). Determination of a rate law, describing a rate of a reaction during the decomposition process, was conducted. The decomposition model in this study shows a linear trend based on different POME-PPF mixtures. The model follows the first-order kinetics by Levenspiel (1999) in which the rate of decomposition depends on the concentration of a single reactant to the first power. The first-order kinetics model has been used to quantify the change of a lumped parameter, i.e. carbon-to-nitrogen (C:N) ratio, as shown in Eq. (1).

$$\ln([C:N_t]/[C:N_0]) = -k_t \quad (1)$$

$C:N_0$ and $C:N_t$ refers to the C:N ratio at the initial of the reaction and at any time t; with the first order rate constant k_t (d^{-1}).

Results and Discussion

Among all the elements released during the vermicomposting process, carbon-and-nitrogen (C:N) ratio serves as the key parameter for the microbial degradation process. Nitrogen is needed by the microbes to grow quickly during composting. Nitrogen is the essential element to promote plant growth, notably the leaf and forage crops. Suthar (2006)) reported that the earthworms enhanced the nitrogen levels in the vermicompost by adding their excretory products (mucus, body fluid, enzymes) and even through the decaying tissues of dead worms during vermicomposting. The decomposition rate of the POME-PPF mixtures (50 %, 60 % and 70 %) was measured in terms of ln ($C:N_t/C:N_0$) with respect to time as shown in Fig. 2. The rate constant obtained from the 50 % POME-PPF mixture is higher ($k_{50\%} = 0.05\ d^{-1}$) as compared to the 60 and 70 % POME-PPF mixture, as shown in Table 1. The higher value of the k indicates the higher level of decomposition rate of C: N ratio in the 50 % mixture of POME-PPF and becomes the most favorable mixture. The 50 % POME-PPF showed a rapid decrease of C:N ratio over 30 d indicating a high degree of organic matter stabilization and agronomic potentiality. This result conformed to the co-composting of POME and PPF by Lim et al. (2009). Although 70 % mixture of POME-PPF showed the highest R^2 value, a higher R^2 value does not necessarily indicates the most suitable model.

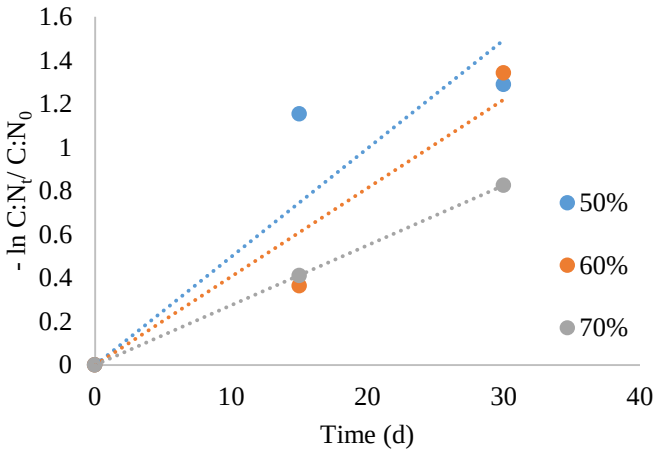

Figure 2: Decomposition rate of C:N in 50 %, 60 % and 70 % mixture of POME-PPF during vermicomposting.

Table 1 First-order reaction models for 50 %, 60 % and 70 % POME-PPF mixtures during vermicomposting.

POME-PPF mixture	First-order reaction model	R^2
50 %	y = 0.050x	0.792
60 %	y = 0.041x	0.921
70 %	y = 0.028x	1.0

Conclusion

The kinetics study for the degradation of C:N on various mixtures of POME-PPF was carried out during the vermicomposting process. The decomposition rate of 50 % mixture of POME-PPF, evaluated through the first-order kinetic model, has shown the highest rate ($k_{50\%}$ = 0.05 d^{-1}) as compared to the 60 and 70 % POME-PPF mixtures. This study recommends vermicomposting as a viable waste valorization method to degrade the wastes from the palm oil industry in a more efficient manner.

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