Growth Kinetics of Microorganisms In Composting Processof Empty Fruit Bunch

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ABSTRACT

CPO production increased resulting in the amount of waste also increased, such as solid waste Empty Fruit Bunch (EFB). The composting process is one alternative method for reducing environmental pollution caused by waste EFB. However, the composting process takes a long time. Therefore, it is important to do a breakthrough to speed up the processing time. In this research, EFB composting process is done by adding a mixed culture that is useful as a starter and POME as a nutrition source. The purpose of this research was to determine the kinetic parameters of growth of microorganisms in the composting process Empty Fruit Bunch (EFB) as information on the scale-up bioreactor. Aerobic composting process takes place with variations in source of microorganisms, they are without the addition of mixed cultures; the addition of mixed cultures with a concentration of 60%; and the addition of mixed cultures 60% + POME. Stages of this researchare the preparation of a starter, substrate preparation, preparation windrow, and the composting process. operating conditions of the composting process are a moisture content of 40-60%, 30-50 ^{0}C temperature, and pH 6 to 8.5. The results showed that the reduction in C/N ratio in the composting process of EFB by adding POME faster in the amount of 19,77 on day 32 with a value of kinetic parameters are μ_{max} 0.63 day^{-1}, the value of yield 0,014, and K_s amounted to 32,32 g / L.

Key Words: *CompostingProcess, Empty Fruit Bunch, Microorganisms, Palm Oil Mill Effluent (POME), Windrow*

1. INTRODUCTION

The increasing of palm oil commodities in the world trade of vegetable oils has encouraged the Indonesian government to expand oil palm plantations. CPO production in 2010 amounted to 21.8 million tons (USDA, 2011) and will be 30-32 million tons in 2014. CPO production increased resulting in the amount of waste also increased, such as Empty Fruit Bunch (EFB). Empty Fruit Bunch (EFB) is a major waste of the oil industry which amount to 20-25% of the weight of fresh fruit bunches (Baharuddin et al, 2009). TKS has cellulose, hemicellulose, lignin in large and small amounts of the compound N, P, K and micro nutrients, so it has the potential to be processed into compost. The composting process is one alternative method for reducing environmental pollution caused by waste EFB. However, the composting process takes a long time and a wide area. Therefor, it needs to be done the next research related to the composting process. One of the advanced research is to determine the kinetic parameters of microorganisms growth in the composting process to determine the properties of the microorganisms growth (Maulana, 2013). The growth of microorganisms is related with composting process because microorganisms are a bio-activator that makes the composting process faster. The purpose of this study was to determine the effect of the microorganisms source on the growth of microorganisms and the quality of the product. Moreover, the purpose of the study is to determine the kinetic parameters of the microorganisms growth in the composting process of EFB as an additional information in the development of the composting process.

The principle of composting is mixing organic material and microorganisms as bio-activator. Microorganisms use to maintain the balance of carbon (C) and nitrogen (N), which is a important factor of composting (Indriani, 2010). The composting process is shown in Figure 1.

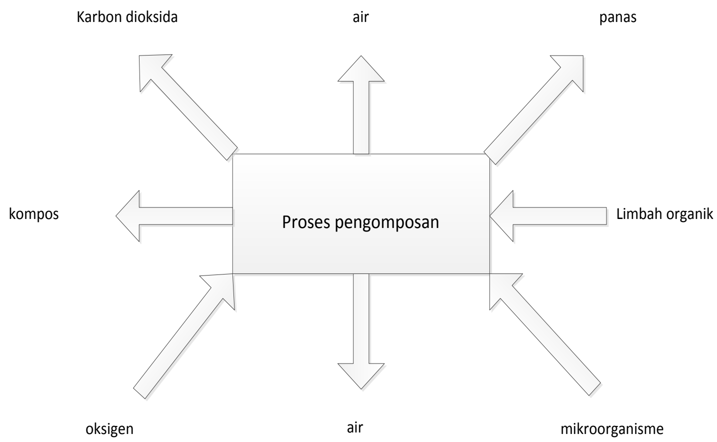

Figure 1. ***Input*** **and** ***Output*** **of Composting Precess (Ahmad** ***et al, 2007)***

Good composting process will produce products with good quality (Unus, 2002). The success of a compost product is influenced by some factors, they are :

a. The size of material
   The small size of the material will enlarge the surface area of materials with microorganisms.
b. Nutrient
   C / N ratio is always used as an indicator to determine the maturity of the compost. C / N ratio for the initial condition that is equal to 30: 1 (Suhaimi

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et al, 2001). Microorganisms use carbon as an energy source and use nitrogen for protein synthesis.

c. The water content (humidity).
   In general, microorganisms can work effectively at 40-60% moisture. The conditions of water content should be maintained so that the microorganisms can work optimally (Tobing, 2009).
d. Temperatures
   The optimum temperature around 30-50 ^{0}C. If the temperature is too high microorganisms in the death phase. Whereas, if a relatively low temperature microorganisms can not operate optimally (Tobing, 2009).
e. PH levels and the heap
   The higher of pH levels in the compost pile, the faster decomposition of material occurs.

2. EXPERIMENT

Focus of this research based on kinetics process of microorganisms growth. Kinetic process is the procedure that describes the development of the process. Microbial growth in batch culture system is done without the addition of a new medium into the culture (Maulana, 2013). Microorganisms in closed systems undergo four phases of growth, namely:

a. Lag phase
   Lag phase occurs when inoculum cells derived from cultures that have stopped growing or they are in the stationary phase due to the limitations of the substrate or product inhibition. Metabolic activity will increase the number of cells at the end of the adaptation phase (Maulana, 2013).
b. Exponential phase
   Lag phase followed by an increased rate of cell growth to achieve maximum growth in logarithmic or exponential phase (Maulana, 2013). In the exponential phase, microorganisms have cleavage highest and constant in a short generation time.

In addition, the cell biomass can be determined through a constant specific growth rate (μ) (Maulana, 2013), namely:

$$\frac{dX}{dt} = \mu X \qquad \ldots (1)$$

Where:

dX : change in biomass over time dt
dt : change in time
X : cell biomass
M : constant growth rate

Monod found that when a fresh medium containing glucose as the carbon source and as a source of energy, the growth cycle occured. The correlation of specific growth rate (μ) and substrate concentration (S) is described with a curve similar to a model enzyme kinetics Michaelis-Menten (Maulana, 2013). Monod equation can be made with the reversal of the straight line equation as follows:

$$\frac{1}{\mu} = \frac{K_s}{\mu max}\frac{1}{S} + \frac{1}{\mu max} \quad \ldots (2)$$

3.1 Raw Materials

Empty Fruit Bunch (EFB), mixed cultures, and Palm Oil Mill Effluent (POME) are raw materials used in this study.

3.2 Variables of research

The research variables include:

a. Without addition of mixed cultures (0%)
b. With the addition of mixed cultures 60%
c. With the addition of mixed cultures 60% + POME

The series of tools windrow composting method illustrated in Figure 1.

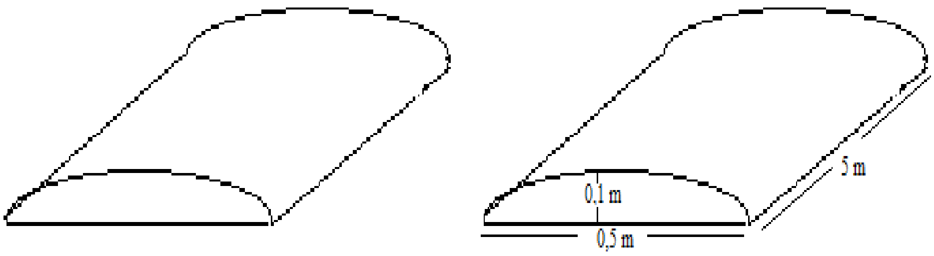

Figure 1. Tools windrow composting method

3.2 Procedure of composting

Empty Fruit Bunch (EFB) which has been chopped and sprinkled in the open field with a windrow system, then added starter with a variations are 0%, 60%, and 60% mixed cultures + POME. EFB and starter mixture then stirred. During the composting process takes place, measurement of pH, temperature, and water content in each bioreactor are done every two days. Analysis nutrients C, N, and the number of cells in each pile are done every two days during the composting process.

3. RESULTS AND DISCUSSION

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3.1 The temperature profile During Composting Process

Temperature is one factor of microorganisms activity during the composting process. The temperature profile during the composting process of Empty Fruit Bunch (EFB) is shown in Figure 2.

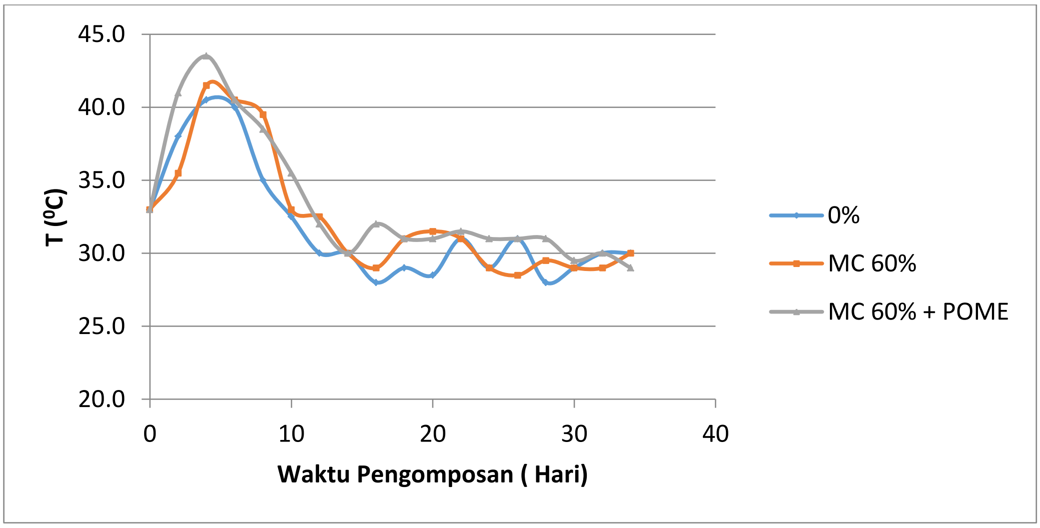

Figure 2. Temperature profile during the composting process

In Figure 2 it can be seen at the beginning of composting up to the 5th day of temperature rise. Increased temperatures indicate that the activity of microorganisms begin to decompose organic materials contained in the substrate, due to the process of decomposition by the reaction of microorganisms to produce heat which causes the temperature to rise (Nugroho, 2006). The windrow of mixed culture substrate with the addition of 60% + POME have a greater number of microorganisms and nutrients compared to other variables of mixed cultures. This causes the heat energy generated increases. Microorganisms decomposition during the composting process releases heat energy (Isroi, 2008).

3.2 PH profile During Composting Process

Decomposition process of organic materials will be generated compounds that can affect the pH during the composting process. PH profile during EFB composting process is shown in Figure 3.

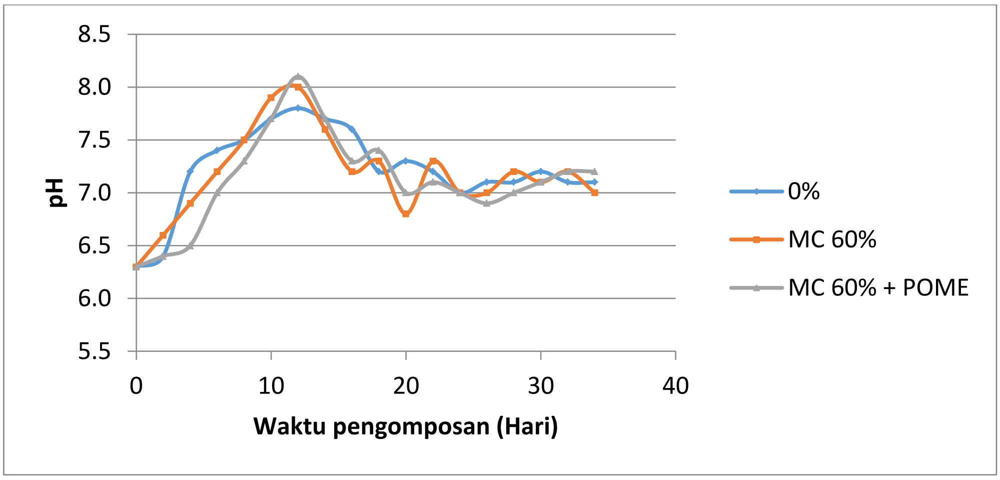

Figure 3. pH Profile during EFB Composting Process

In Figure , it can be seen that at the beginning of the composting until the twelfth day of substrate pH increased which indicates that microorganisms begin to consume the organic materials in the substrate. This condition occurs in each of the various sources of microorganisms. Acidic conditions in the beginning of the composting process caused by the activity of microorganisms in the substrate produces simple organic acids (Murbandono, 2010). In addition, the increase of pH is also due to an increase in the levels of ammonia in the presence of biochemical reactions of nitrogen contained in the substrate (Baharuddin et al, 2009).

3.3 Moisture Profile During Composting Process

The water content is one of the factors that affect the composting process. Profile of moisture content during the composting process for each variable are shown in Figure 4.

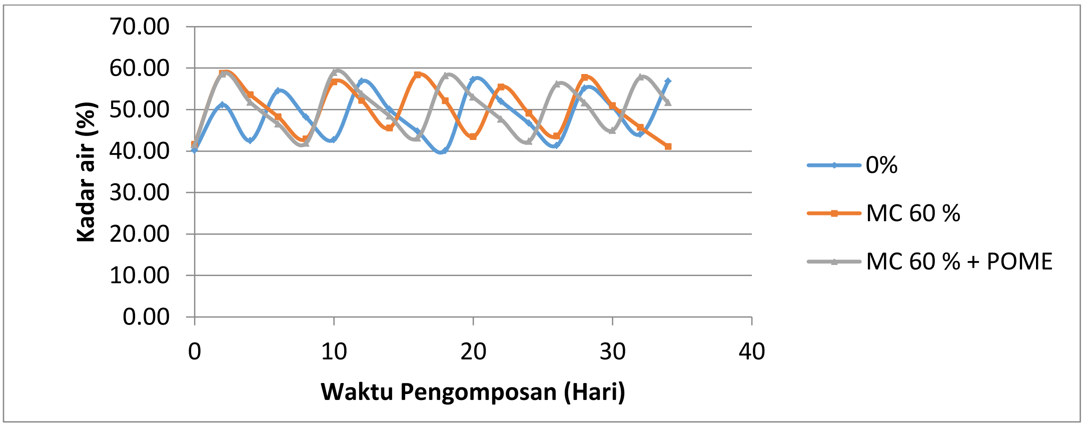

Figure 4. Moisture Profile During Composting Process

In Figure 4 it can be seen that during the composting process the water content is in a stable state that is 40-60%. In general, microorganisms can work at 40-60% humidity (Tobing, 2009). Low water content (<40%) would lead to dryness of the windrow and will affect to activity and growth of microorganisms. If the compost moisture content > 60%, will result in reduced supply of oxygen needed by microorganisms to grow (Hartutik *et al*, 2008).

3.4 Effect of Microorganisms Source to C / N ratio

The principle of composting is to lower C / N ratio in organic matter (Hartutik *et al,* 2008). Data of reduction in C / N ratio during the composting process can be seen in Figure 5.

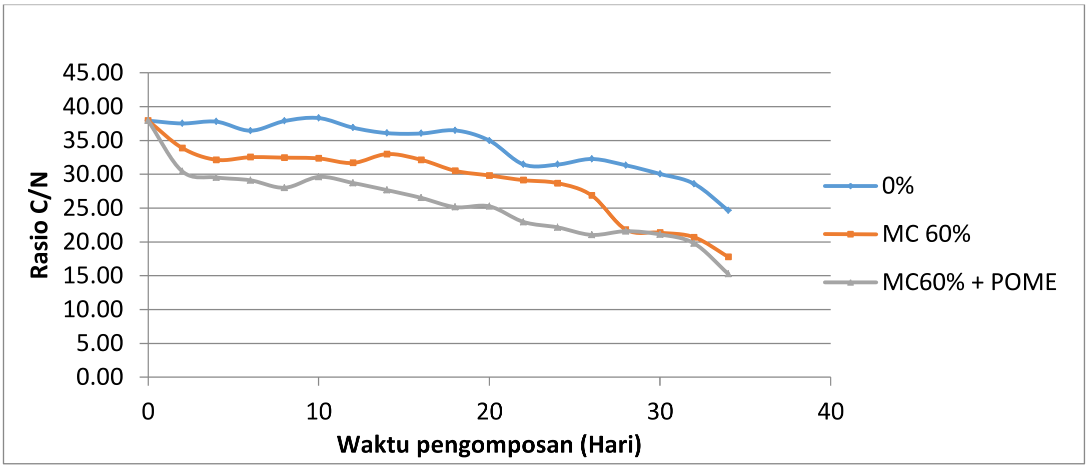

Figure 5. Rasio C/N Profile During Composting Process

In figure 5, it can be seen that C / N ratio is obtained at the optimum windrow with the addition of mixed cultures (60%) + POME is equal to 19.77 on day 32. This condition occured because there are much microorganisms and nutritions in windrow with addition mixed culture 60% + POME, so that the composting process faster than other windrow.

3.5 Determination of kinetic parameters values

The intersection between 1 / μ and 1 / S generates a straight line and the equation as shown in figure 6.

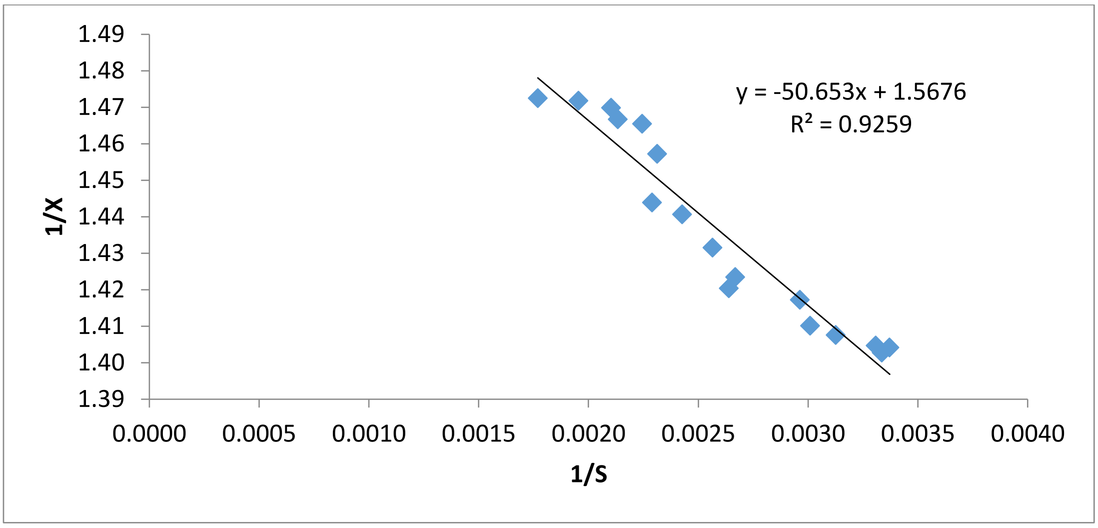

Figure 6. Intersection of 1 / μ and 1 / S

Figure 6 given a linier equation, the equation is :

$y = -50{,}65\,x + 1{,}567$ ... (3)

By using the Monod equation in equation 2, it through a graph of 1 / μ vs 1 / S shown in Figure 6, the value of μ_{max} for variation source with the addition of mixed cultures of microorganisms 60% + POME is 0.63 day^{-1} and K_s value is 32.32 g / L. Meanwhile, using data analysis results obtained substrate and biomass yield coefficient (Y) is 0,014.

4. CONCLUSIONS

The conclusion from this study are:

1. The optimum conditions obtained in source variation mixed cultures of microorganisms with the addition of 60% + POME, the carbon content is 29.66%, the nitrogen content is 1.50%, and the C / N ratio is 19.77.
2. The kinetic parameters for variation source with the addition of mixed cultures of microorganisms 60% + POME are μ_{max} is 0.63 day^{-1}, K_s amounted to 32.32 g / L and the yield amounted to 0,014.

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