Growth Kinetics of Microorganisms On Fiber Solid Waste Composting Of Palm Oil Plant

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ABSTRACT

Solid waste of palm oil has increased along palm oil industry development in Indonesia. Solid waste palm oil mill is organic pollutants. One of it is fiber waste, if it not managed properly will pollute the environment. The purpose of this study was to examine the effect of mixed cultures on process of aerobic composting of palm fiber with windrow method. This research is treating three windrows with size 6 x 1 x 0.5 m^3 each one without the addition of a starter, with the addition of starter and addition of starter and POME. The C/N ratio result of the research showed that 19,91 on composting without starter at days 34, 19,73 on composting with starter addition at days 32, and 16,93 at days 30 on composting with addition of starter and POME. Optimum composting is windrow with additing starter and POME. At this composting kinetic parameters are maximum growth rate (μ_{maks}), máximum substrat consumption constanta (Ks), and yield coeficient (Y), continuously 0,73 day^{-1}, 49,1 g/L, and 0,030.

***Key words**: palm fiber, aerobic, composting, C/N ratio, starter, kinetic*

1. INTRODUCTION

Palm oil industry in Indonesia has developed, it can be seen from the increasing amount of palm oil production every years. Based on Directorate General of Plantation (2012) data, in 2011 the amount of palm oil production is about 23 million tons, and increased at 20122 to 26 million tonnes. As a result of the development of the palm oil industry, the amount of solid waste such as empty fruit bunches, fibers and shell, increaseing too. Along the time, solid waste, especially fiber is used as a source of potential energy as boiler fuel. However, not all palm fruit fiber utilized so as just piling up in the factory area. Therefore, the oil palm fruit fiber is used for other purposes, which is used for making fertilizer (Mailinda et al, 2012).
The composting process can be quickly depending on the growth of microorganisms involved in the composting. In this research, it will be determined the growth of microorganisms in the composting of solid waste oil on kinetics

data, where the kinetics of the growth of these microorganisms can be used as a basis for the design of the composting process or the design of bioreactors.

2. EXPERIMENT

In this research, solid waste composting process is done by using fibers of palm oil as a raw material because it has organic elements needed by plants. In addition, the mixed cultures of septic tanks is also used as a raw material source of microorganisms. which is can speed up the composting process.
Composting palm fiber made with the combining optimum conditions of fiber composting has been done by previous researchers with solid waste is the same, namely the concentration of starter (microorganisms) optimum 20% (Shahila, 2012) and with the addition POME (Palm Oil Mill Effluent) 1: 3 (Baharuddin et al, 2009) and without additing of starter.

Windrow system used in this study shown in Figure 1.

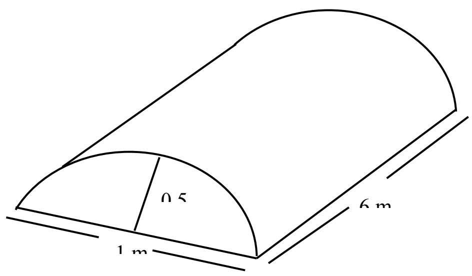

Figure 1 The Size of Windrow Composting

Research steps to be conducted in this study can be seen in Figure 2.

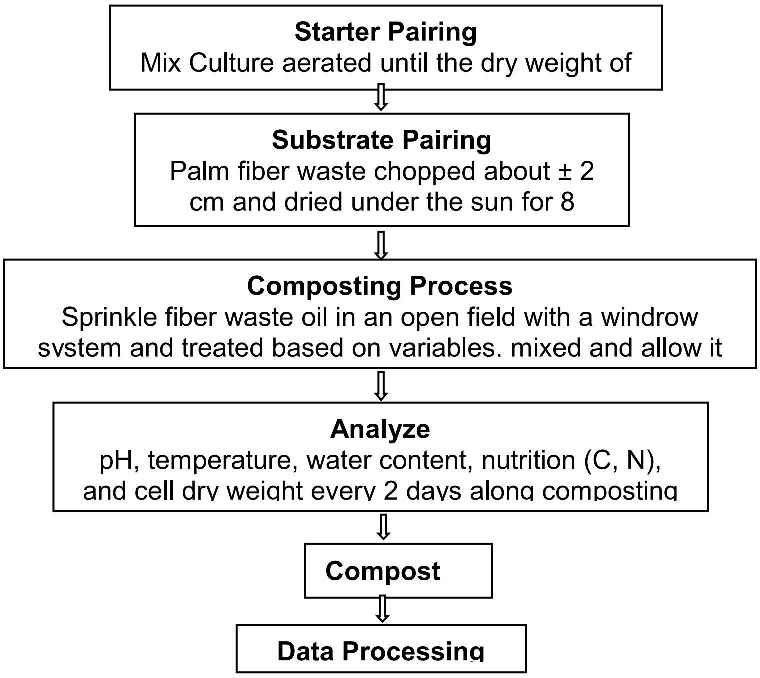

Figure 2. Flow Diagram Of Research Methods

Microorganism growth kinetics data was studied during the exponential phase of the batch system. In the model of Monod, kinetic parameters regarding the growth of microorganisms and nutrients relation to the environment demonstrated by three factors: μ_{maks}, Ks and Yield (Haryuwibawa et al, 2014).

- Specific Growth Rate (μ)

Exponential growth occurs when all the requirements for growth are met, this can be expressed by:

$$\Delta x = \mu x \, \Delta t \quad (1)$$

By dividing both sides of Equation 1 by Δt, then the derivative limit Δt -> 0, is obtained:

$$\left(\frac{dx}{dt}\right) = \mu x \quad (2)$$

Where :
dx / dt = rate of growth of the biomass (mass / (volume.time))
μ = specific growth rate
x = concentration of biomass

- Yield (Y)

Y growth results defined mathematically as:
Accretion amount of biomass as a result of use of the substrate.

$$Y = \frac{\Delta x}{\Delta S} \quad (3)$$

$$\frac{x - x_o}{S - S_o} = Y \quad (4)$$

Where :
xo = initial biomass concentration
So = initial substrate concentration
Y = the result of growth

- Saturation Constant (Ks) and Maximum Growth Rate (μ_{maks})

This parameter is determined by using the Monod equation (Fahria et al, 2013):

$$\mu = \mu_{maks} \frac{S}{K_S + S} \quad (5)$$

Where :
Ks = saturation constants (g/l)

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μ_{maks} = maximum growth rate (days^{-1})
S = concentration substrate (g/l)

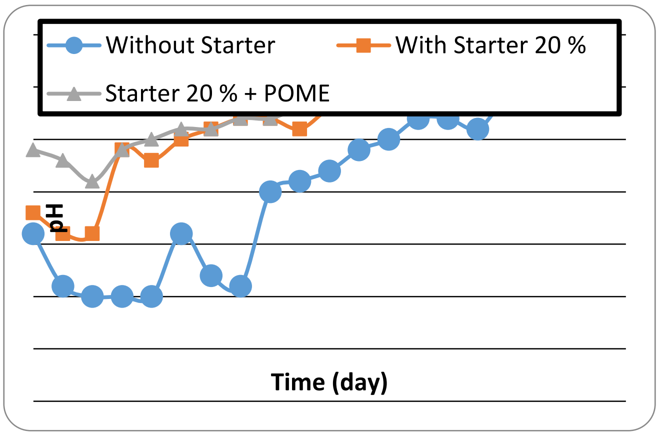
By dividing both sides by μ, the equation to be obtained are:

$$\frac{1}{\mu} = \frac{K_S}{\mu_{maks}} \frac{1}{S} + \frac{1}{\mu_{maks}} \quad (6)$$

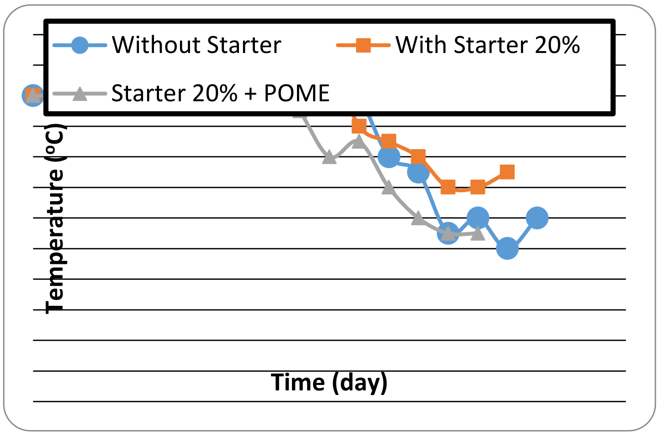
Plot with pulled-value 1/μ and 1/s in the linear regression of the obtained straight line formed where the slope is the value Ks/μ_{maks} and intercept is $1/\mu_{maks}$, so the value of Ks and μ_{maks} can be known.

3. RESULTS AND DISCUSSION

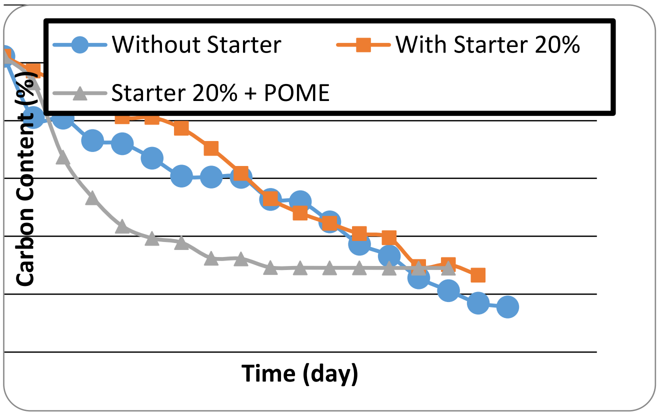
During the composting measurement of pH, temperature, and the water content. The result of measurement shown by Figure 3 (a),(b) and (c).



(a)



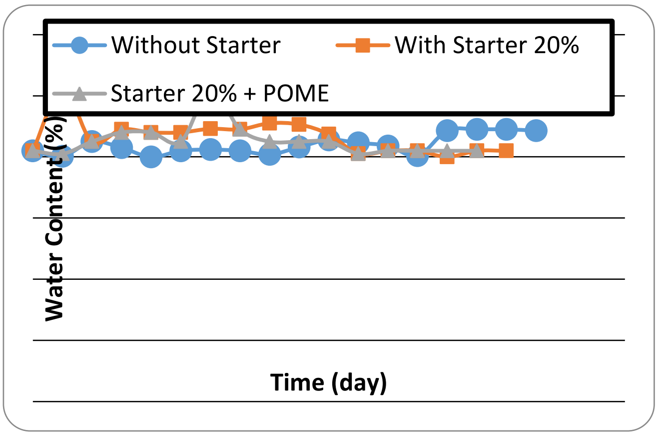
(b)



c)

Figure 3. (a) Profil pH during Composting, (b) Profil Temperature during Composting, (c) Profil Water Content during Composting

Results of measurements for pH, temperature and moisture content are shown in Figure 3 (a), (b) and (c) show that on the whole windrow microorganisms living within the range of pH, temperature and moisture content are sufficient and appropriate to the activity of microorganisms. in addition, the changes of carbon and nitrogen content in the entire windrow during the composting was analizing. From the analysis of carbon and nitrogen levels will be obtained C/N ratio of each Windrow. This can be shown by Figure 4 (a), (b) and (c).



(a)

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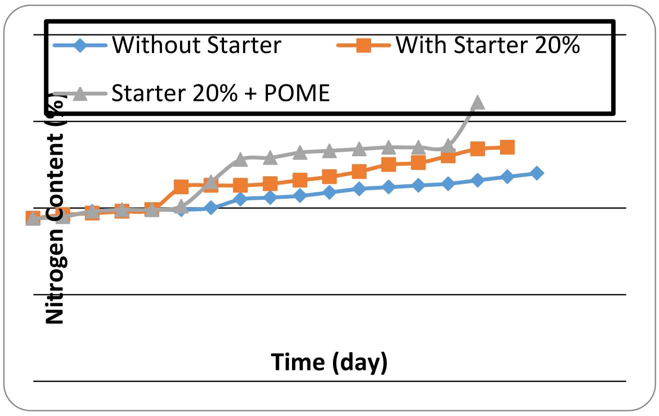
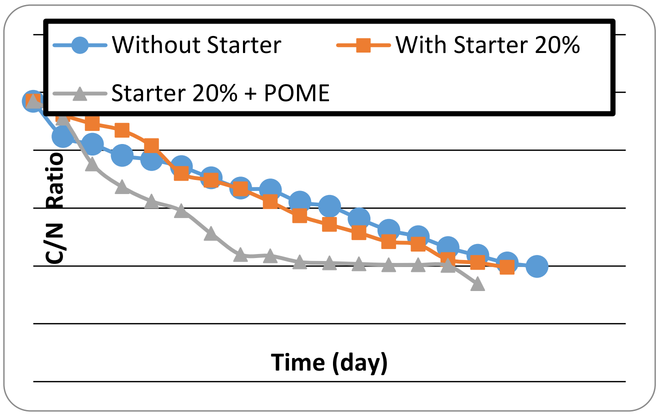


(b)



(c)

Figure 4. (a) The changes of Carbon Contents, (b) The changes of Nitrogen Contents, (c) C/N Ratio during Composting

Figure 4 (a) shows that carbon content during the composting process has down trendline. On composting without the addition of starter, carbon levels dropped from 45,55% to 23,89%. For the composting process by adding a starter 20%, carbon content dropped from 45,55% to 26,64%, while composting with the addition of a starter mix of 20% and carbon content POME down from 45,55% to

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27,25%. Decreased levels of carbon is caused by the carbon element in the organic matter breaks down into CO_2 and H_2O. The compound of CO_2 then evaporates during the composting process so that carbon levels decreased (Ilham, 2013). Carbon contained in the carbohydrates in organic compounds is decomposed with the following reaction:

$$C_6H_{10}O_5 + 6O_2 \rightarrow 6CO_2 + 5H_2O$$

Figure 4 (b) shows that the conditions for composting nitrogen levels increased in all treatments. This is because the activity of microorganisms that convert urea into nitrate form which can increase the nitrogen in compost (Mailinda, 2013). Nitrification of ammonia to nitrate takes place with the following reaction:

$$NH_4^+ + 1{,}5\ O_2 \rightarrow NO_2^- + 2H^+ + H_2O$$
$$NO_2^- + 0{,}5O_2 \rightarrow NO_3^-$$

Levels of nitrogen during composting is fluctuate because of the loss of nitrogen in the form of highly volatile ammonia into the air so that the concentration of nitrogen decreased. It can be seen from the smell of ammonia arising during composting (Tarigan, 2001).

Figure 4 (c) shows the change in C/N ratio at each windrow during composting. C/N ratio declines fluctuate. This is because the levels of nitrogen fluctuate. Composting without the addition of starter has a C/N ratio 19,91 achieved on days 34. Composting with variable addition of starter 20% reaching C/N ratio 19,73 on days 32, and with the addition of 20% mixed starter with POME has C/N ratio 16,93 on days 30. This indicates that the addition of POME effect on C/N ratio is generated. Organic content contained in POME useful as nutrients in the growth of microorganisms, so that the microorganisms involved in composting has a maximum and good activity.

Before determine microorganism growth kinetics data, the growth of microorganism (biomass) as VSS will be analized. The concentration of biomass shown by Figure 5. The Figure 5 shows the growth phase of microorganisms during composting. The biomass on the windrow without the addition of starter in the range of 0,57 – 0,75 g/l for 32 days. The growth of microorganisms on the windrow with the addition of a starter and the addition of starter and POME, has a range of 0,57 – 5,50 gr/l and 0,57 to 5,98 g/l. This suggests that the growth rate of biomass in composting with the addition of starter and POME higher than the growth of biomass on two other windrow. This condition can be caused by more nutrients available for growth of microorganisms (Romli et al, 2013).

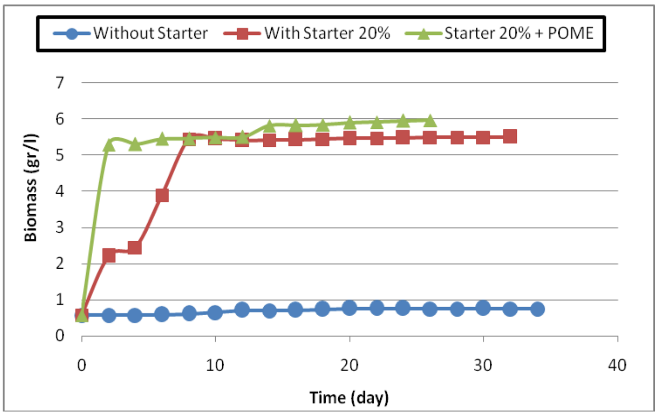

Figure 5. The growth of Microorganism

From C/N ratio and microorganism growth, the composting with addition starter 20% and POME has best condition. So growth kinetics of microorganisms that will count is the window with the addition of a starter 20% and POME.

- Saturation Constant (Ks) and Maximum Growth Rate (μ_{maks})

1/μ and 1/s graph as shown in Figure 6, will form a linear where the slope formed is Ks/ μ_{maks} and intercept 1/μ_{maks}, thus the value of Ks and μ_{maks} was determined.

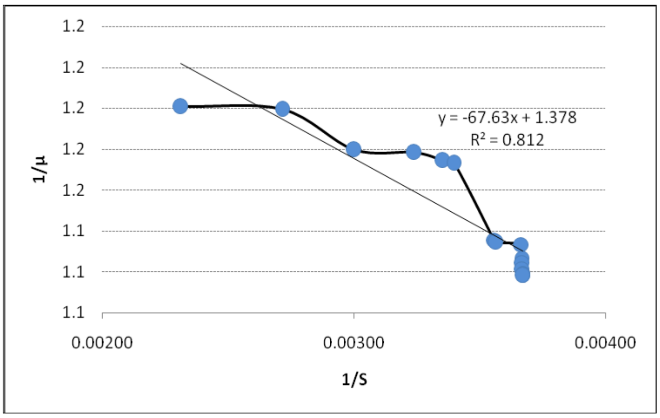

Figure 6. The relation of 1/ μ and 1/μ_{maks}

ISBN : 978-602-73367-0-4

Figure 6 show that :
y = -67,634 x + 1,3782
(7)
In this case, $1/\mu_{maks}$ = 1,3782 and Ks/μ_{maks}= 67,634, and then results of this equation are μ_{maks} = 0,73 day^{-1} and Ks = 49,1 gr/l.

Ks value of the microorganisms in the composting of palm fiber with the addition of starter 20% and POME is 49,1 g/l. This means that the substrate concentration of 49,1 g/l, the microorganism is able to grow with the specific growth rate amounting to half of the maximum growth rate (μ_{maks}). If substrate concentration below 49.1 g/l, the growth rate will decline or grow at a low rate.

- Yield (Y)

  From equation (4) : $$Yield\ (Y) = \frac{5{,}98-0{,}57}{455{,}50-272{,}50}$$
  $$Yield\ (Y) = 0{,}030$$

Yield of 0,030 indicates the number of cells of microorganisms (biomass) formed 0,030 per gram substrate (carbon) consumed by microorganism. Result calculation of kinetic parameter values in Table 1.

Table 1. Microorganism growth kinetics on on fibre composting with addition starter and POME

No	Parameter	Value
1	$\mu_{maks}(hari^{-1})$	0,73
2	Ks (g/l)	49,1
3	Y	0,030

4. CONCLUSIONS

From the study it can be concluded that POME (Palm Oil Mill Effluent) effect on the composting process. The addition of POME can be a source of nutrients for microorganisms so that the C/N ratio of compost produced in accordance with the ratio of C/N soil is reached within the time quickly. The C/N ratio on composting with the addition of starter and POME obtained amounted to 16,93 on days 30. Microorganism growth kinetics parameter values obtained from the experiments is the value of the maximum growth rate (μ_{maks}), constant maximum substrate utilization (Ks), yield (Y), which is respectively 0,73 day^{-1}, 49,1 g/l, and 0,030.

ISBN : 978-602-73367-0-4

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