Physico-Chemical Properties In Degradation Of Oil Palm Solid Waste By Microbial Inoculant And Palm Oil Mill Effluent

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Abstract. Composting fiber ex-fibercyclone and oil palm midrib are the alternative method in waste management and the yielded organic residues that have potential to enhance soil and to assists plant growth. The aim of this study was to evaluate the physico-chemical properties of oil palm midrib and fiber composted by palm oil mill effluent (POME) and microbial inoculant provided commercially. This study was arranged in randomized block design (RBD) and the design was divided into 2 groups based on the type of solid waste samples used. Within each group the solid waste (SW) was tested as follows: P1 = SW was inoculated by activator A (Control); P2 = SW was mixed with cow manure and inoculated by activator B; P3 = SW was mixed with cow manure and inoculated by POME; P4 = SW inoculated by activator B; and P5 = SW inoculated by POME. Physico-chemical status were periodically tested along the experiment. The results of this research showed that composting process had formed mesophilic temperature with the highest at 39.25°C; with a range of pH 6.02 – 8.29 and conductivity 0.35 – 1.84 mS/cm at week 16. The C/N ratio of compost product at the end of composting was 7.05 – 12.41. Results revealed that the final of compost C:N ratio <20 and the macronutrient content fulfilled the requirement of Indonesian Standard Quality of Compost which potentially used as an alternative growing media for plant.

Keywords: activator, fiber, fibercyclone, oil palm midrib, recycling waste

1. Introduction
Oil palm (Elaeis guineensis Jacq.) is a very important vegetable oil-producing plant besides nuts, corn, sunflower and others. Indonesia is the largest producer and exporter of palm oils in the world. In [1] stated that the production of palm oil in year 2000 amounted to 7 million tons and in 2011 increased to 22.51 million tons. In the last three decades, the level of global consumption of palm oil (CPO) has increased tenfold, as stated in [2] that in 2000 global consumption of palm oil reached 24.6 million tons and in 2010 reached 54 million tons.

Palm oil field and processing activities produce various types of waste. Waste generated from oil palm field and processing activities are oil palm trunk, oil palm midrib, empty fruit bunches, ex-
fibercyclone fiber (Palm fruit mesocarp fibers), palm kernel shells, low grade fibre press cake materials and liquid waste disposal in the form of palm oil mill effluent (POME). Oil palm midrib as a waste is generated from pruning and replanting activities. In [3] estimated that 7.14 million tons of palm oil midrib waste per year will be produced by 2020. In [4] mentioned that the waste of mesocarp fiber equal to 30% of fresh fruit bunches processed. Furthermore, Palm oil mill effluent wastewater contain high concentration of nitrogenous compounds and minerals that can be converted into valuable material using microbial processes. Furthermore, [5] in their review states that palm oil mill effluent is considered as a rich nutrient resources of organic waste and it will be able to recycling into other application. Therefore, Palm oil midrib and fiber ex-fibercyclone are organic material waste that has the potential as a basic material for composting and the POME potentially used as an activator.

Compost is often used as an organic fertilizer to increase the useful nutrients and to assist plant growth and used as a soil enhancer. In [3] states that the main purpose of composting is to produce stable compost products containing sufficient nutrients for plant growth and also increase soil fertility. Further research of [3] showed that the addition of palm oil liquid waste can mature the compost by lowering the C/N ratio and decomposer microorganisms in the process is dominated by Pseudomonas sp. In the composting process is often done addition of microorganisms with the aim to increase the nutrient compost, which usually called the addition of bioactivator or activator agent. Activator is a liquid containing microorganisms that help the process of decomposition of organic matter. [6] stated that a variety of organic compounds produced by microbes in the process of decomposition in nature play a role in spurring growth, accelerating the process of flowering, improving the process of biosynthesis of biochemical compounds, inhibiting pathogens, and even increasing the production of secondary metabolites as raw material for medicine, pesticide and so on.

The addition of the right consortium of microorganisms and palm oil mill effluent can contribute to the composting process. Therefore, the aim of this study is to find out whether commercial consortium of microorganisms and palm oil mill effluents can be used as an activator for composting oil palm solid waste which resulting the compost value that close to good compost quality standards.

2. Materials and Methods

The experiment was conducted at the Experimental Station I of the Oil Palm Cultivation study programme in Citra Widya Edukasi Palm Oil Polytechnic Institute, Bekasi City, Indonesia.

2.1 Materials

Oil palm midribs were collected from the Experimental Station III of Citra Widya Edukasi Palm Oil Polytechnic Institute in Subang, West Java. Mesocarp fiber (ex-fibercyclone) and Palm Oil Mill Effluent (POME) were collected from PT. Perkebunan Nusantrara VIII, Kertajaya, Malingping, Banten, West Java. In the present study, the commercial activators used in this experiment were EM-4 (activator A) and Agrisimba (Activator B). EM-4 was manufactured and marketed by PT Songgolangit Persada, Jakarta. The Agrisimba was obtained from PT Rekayasa Hayati, Bandung Institute of Technology.

2.2 Methods

2.2.1 Preparation of Compost. The oil palm midribs (OPM) were cut into small pieces and then dried. The dried samples were then chopped to get a smaller size. Fiber (MF) were cut as well to get smaller sizes. After that, those dried samples were weighed (3 kg for each treatment) and placed on a plastic container measuring 32 x 28 x 24 cm and composted by Takakura method.

In this study the method used was a Randomized Block Design (RBD) one factorial which was divided into 2 groups, and each group consists of 5 treatments. Each treatment consisted of 2 replicates and 2 samples. The raw material for this experiment were (a), oil palm midrib (OPM) and (b). fiber (MF). This experiment consisted of two groups and five treatments of each group, namely: (1). First group are P1 (50% OPM : 50% cow manure + activator A); P2 (50% OPM : 50% cow manure + activator B); P3 (50% OPM : 50% cow manure + POME); P4 (100% OPM + activator B); P5 (100%
OPM + POME); (2). Second group are M1 (50% MF : 50% cow manure + activator A); M2 (50% MF : 50% cow manure + activator B); M3 (50% MF : 50% cow manure + POME); M4 (100% MF + activator B); M5 (100% MF + POME). The microbial decomposer and POME were added to each of the pile once every week for 4 months.

2.2.2 Determination of Physicochemical Properties. The temperature was measure weekly throughout the composting period at three different points in the middle layer of the compost pile by using thermometer. The thermometer dipped into the pile for about five minutes before taking the reading. Compost samples (10 g) were collected from the interior of the compost pile weekly. The finely-ground samples were suspended in distilled water (100 ml) and the filtrate were used to measure the pH and conductivity. pH and conductivity were measured using electrical pH meter dan electrical conductivity respectively.

2.2.3 Chemical and Biological Analysis. The chemical properties of the soil were analyzed in Test Lab in Agronomy and Horticulture Department, Institut Pertanian Bogor. Chemical of composts which were analyzed at the beginning and end of the experiment to determine levels of C/N ratio, C-organic, Total Nitrogen, Phosphate content, Pottassium content and CEC (Cation Exchange Capacity). The microbial properties that measured were cellulolytic bacteria and cellulolytic fungi and were analyzed in Soil Research Institute, Bogor, Indonesia.

Cellulose and hemicellulose content of composts were measured in Chemical Laboratory, Citra Widya Edukasi Palm Oil Polytechnic Institute using the Chesson Method, Datta 1981 [7]. One gram of dry sample (A) was added by 150 ml distilled water dan refluxed at 100°C for 1 hour. The result was filtered and the residues were washed with 300 ml of hot water. The residues were dried until the weight was constant and then it was weighed (B). The residues were added 150 ml of H_2SO_4 1 N and refluxed in the heating mantle for 1 hour at 100°C. After that, it was filtered and washed by 300 ml distilled water dan the residues were dried until the weight was constant (C). The dried residues were added 100 ml of H_2SO_4 72% and it was soaked at the room temperature to 4 hours. After that it was filtered and the residues were added of 150 ml of H_2SO_4 1 N and refluxed at 100°C in the heating mantle for 1 hour. The residues were filtered and washed with 400 ml of distilled water. The residues were dried at 105°C until the weight was constant and weighed (D). The content of hemicellulose and cellulose were calculated using the formula: water content (% weight) = ((mass of A – mass of B) / mass of A) x 100%; Hemicellulose content (% weight) = ((mass of B – mass of C) / mass A x 100%); cellulose content (% weight) = ((mass of C – mass of D) / mass of A x 100%).

2.2.4 Statistical Analysis. Analysis of variance was performed on all to test the treatment effect on different chemical and physical parameters measured using a STAR analytical package of 2.0.1 version.

3. Result and Discussion

3.1 Changes in composting temperature

In this research, the temperature fluctuation range in the midrib compost is 26.05 - 36.31 °C, whereas in the fiber compost the temperature range is 19.59 - 39.25°C. Temperature is one important indicator in composting. Temperature changes that occurred due to microbial activity in degradation of organic material. At the beginning of composting, the temperature increased and further the temperature decreased near the soil temperature after maturity. The addition of activator significantly affected the compost temperature fluctuation (Table 1 and 2). In the observation, the compost temperature up and down along the period of composting. The activity of bacterial metabolism caused the temperature of the compost to rise and this was caused by microbial respiration [8]. Conversely, when the temperature drops indicates that the activity of microbial metabolism decreased. The compost pile affects the decomposition process. The shallow pile will result in compost heat dissipating, and low heat indicates low microorganism activity.
Table 1. Changes in temperature during oil palm midrib composting processes

| Treatment | Weeks of composting | 1  | 4  | 8  | 12 | 16 |
|-----------|---------------------|----|----|----|----|----|
|           |                     |    |    |    |    |    |
| Activator A | OPM + CM            | 36.31±13.48 | 27.90±0.16 bc | 28.40±0.27 | 26.87±0.20 a | 28.06±0.02 ab |
| Activator B | OPM + CM            | 35.59±9.32  | 28.56±0.29 a  | 28.05±0.49  | 26.06±0.13 c | 27.68±0.11 bc |
|            | OPM                 | 27.67±1.57  | 28.12±0.38 ab | 27.93±0.25  | 26.32±0.18 bc| 27.77±0.01 bc |
| POME       | OPM + CM            | 28.84±0.29  | 28.19±0.27 ab | 28.22±0.46  | 26.60±0.03 ab| 28.27±0.14 a |
|            | OPM                 | 27.87±0.34  | 27.43±0.08 c  | 27.75±0.13  | 26.05±0.15 c | 27.57±0.35 c |

Note. Means with the same letter within a column are not significantly different using LSD at p < 0.05; OPM = oil palm midrib; CM = cow manure

Table 2. Changes in temperature during fiber ex-fibercyclone composting processes

| Compost Treatment | Weeks |    |    |    |    |
|-------------------|-------|----|----|----|----|
|                   |       |    |    |    |    |
| Activator A       | MF + CM | 30.96±0.15 | 29.96±0.03 a | 28.98±0.01 ab | 20.95±0.06 a | 28.73±0.17 a |
| Activator B       | MF + CM | 31.79±0.18 | 29.70±0.40 ab | 28.10±0.17 bc | 20.05±0.03 bc | 27.89±0.09 b |
|                   | MF     | 39.25±12.10 | 28.50±0.11 c  | 27.45±0.37 c  | 19.59±0.09 c  | 27.90±0.32 b |
| POME              | MF + CM | 38.96±11.00 | 29.06±0.42 bc | 29.80±0.90 a  | 20.86±0.43 a  | 28.46±0.00 a |
|                   | MF     | 30.20±0.55  | 29.10±0.29 bc | 27.92±0.09 bc | 20.29±0.09 b  | 28.62±0.29 a |

Note. Means with the same letter within a column are not significantly different using LSD at p < 0.05; MF = Oil palm Fiber; CM = cow manure.

At week 1 on the compost material appeared high temperature. This is in line with the research of [9], that the increase in temperature in the first week is an indication of the high activity of microorganisms in self-duplication and in decomposing complex organic matter into simpler compounds. Whereas the lowest compost temperature was found at week 12 on compost material with POME and fiber compost material by giving activator B.

In [10] stated that composting of patchouli leaf pulp with the aid of activators A and B shows the observation of compost temperature which is relatively the same, that is 37.88°C (activator A) and 37.89°C (activator B). Generally, at week 12 the compost temperature decreases compared to the fourth and eighth week temperatures. The rise and decrease of temperature occurred during the composting process indicates the existence of microorganism which works in the process of
decomposition of organic matter [11]. At the end of composting, compost temperatures were stable and did not show any significant change. These stable temperature indicates that the activity of microorganisms in the decomposition process has begun to decrease because the amount of organic material was not sufficient to be consumed by bacteria decomposers.

3.2 Changes in pH compost
pH value of compost during the composting process of midrib was in the range of 5.35 - 9.16, whereas in composting fiber the pH range was 6.02 - 9.05. In the composting process the pH changes always occur. The addition of activator on composting of oil palm midrib and fruit palm fiber has an effect on the acidity (pH) of fiber compost (Table 3 and 4). The pH of the midrib compost from week 1 to week 16 decreased. Based on Tables 3 and 4, at 12 weeks composting pH fluctuations begin to stabilize until the end of composting.

Table 3. Changes of pH during oil palm midrib composting processes

| Compost Treatment | Weeks |
|-------------------|-------|
|                   | 1     | 4     | 8     | 12    | 16    |
| Activator A       |       |       |       |       |       |
| OPM + CM          | 9.00±0.43 a | 8.72±0.02 | 8.64±0.04 a | 8.62±0.84 a | 8.23±0.11 a |
| Activator B       |       |       |       |       |       |
| OPM + CM          | 8.07±0.08 b | 6.76±0.43 | 6.21±0.04 c | 5.35±0.05 b | 6.02±0.30 b |
| OPM               | 7.80±0.03 bc | 7.37±0.24 | 6.62±0.33 c | 5.50±0.67 b | 5.14±0.11 c |
| POME              |       |       |       |       |       |
| OPM + CM          | 8.69±0.13 a | 9.16±0.22 | 8.82±0.21 a | 9.12±0.08 a | 7.96±0.40 a |
| OPM               | 7.70±0.04 c | 6.67±2.31 | 7.75±0.57 b | 7.88±0.30 a | 7.70±0.36 a |

Note. Means with the same letter within a column are not significantly different using LSD at p < 0.05.
OPM = oil palm midrib; CM = cow manure.

Table 4. Changes of pH during fiber ex-fibercyclone composting processes

| Compost Treatment | Weeks |
|-------------------|-------|
|                   | 1     | 4     | 8     | 12    | 16    |
| Activator A       |       |       |       |       |       |
| MF + CM           | 8.08±0.33 | 8.28±0.08 a | 9.05±0.12 a | 8.39±0.17 a | 7.99±0.10 a |
| Activator B       |       |       |       |       |       |
| MF + CM           | 7.89±0.18 | 7.83±0.11 b | 6.12±0.32 c | 6.87±0.79 cd | 6.10±0.30 c |
| MF                | 7.63±0.05 | 7.93±0.03 b | 6.90±0.09 b | 6.02±0.23 d | 6.25±0.02 c |
| POME              |       |       |       |       |       |
| MF + CM           | 8.04±0.52 | 8.13±0.05 a | 9.04±0.22 a | 8.05±0.05 ab | 8.29±0.31 a |
| MF                | 7.44±0.27 | 7.80±0.02 b | 7.37±0.08 b | 7.43±0.08 bc | 6.93±0.08 b |

Note. Means with the same letter within a column are not significantly different using LSD at p < 0.05.
MF = oil palm fiber; CM = cow manure.
Changes in pH showed that there were the activity of microorganisms. At the beginning of the composting process, pH was generally somewhat acidic due to the activity of bacteria that produce acid [12]. In this experiment, the pH of the applied activator solution was acidic with a pH of 5-5.5, making the pH of the compost changed to decrease compared to pH at the beginning of composting. In activator B, the acid pH was obtained from the addition of urea at the time of activation of the activator solution. During the composting process, the increasing of pH was caused by the activity of microorganisms that no longer decompose organic matter of carbon compound into organic acid. At weeks 12, the pH value decreases. Decreasing of pH value occurred because there was a reduction process that binds oxygen to increase the activity of microorganisms and the activity of these microorganisms produce organic acids [13].

3.3 Electrical Conductivity of composts
In all compost treatments, the value of the conductivity of the midrib and fiber compost increased every week. The range of conductivity value of midrib compost during composting process was 0.26 - 1.54 mS.cm⁻¹, whereas the conductivity value of fiber compost during composting process was 0.38 - 1.88 mS.cm⁻¹ (Tables 5 and 6). These showed that the addition of activator in the composting process significantly affect the increasing of compost conductivity value.

Table 5. Changes of conductivity during oil palm midrib composting processes

| Compost Treatment | Weeks |
|-------------------|-------|
|                   | 1     | 4     | 8     | 12    | 16    |
|                   | mS.cm⁻¹ |       |       |       |       |
| Activator A OPM + CM | 0.69±0.17 | 0.42±0.02 bc | 0.56±0.10 bc | 0.73±0.40 | 0.67±0.03 b |
| Activator B OPM + CM | 0.88±0.06 | 1.23±0.23 a | 1.06±0.18 a | 1.13±0.06 | 1.34±0.09 a |
| OPM               | 0.43±0.15 | 0.40±0.01 bc | 0.98±0.25 a | 1.54±0.04 | 0.63±0.35 bc |
| POME OPM + CM     | 0.51±0.09 | 0.60±0.06 b | 0.94±0.06 ab | 1.16±0.74 | 0.87±0.02 b |
| OPM               | 0.43±0.10 | 0.30±0.02 c | 0.51±0.09 c | 0.26±0.02 | 0.35±0.13 c |

Note. Means with the same letter within a column are not significantly different using LSD at p < 0.05.
OPM = oil palm midrib; CM = cow manure
Table 6. Changes of conductivity during fiber ex-fibercyclone composting processes

| Compost Treatment | Weeks     |
|-------------------|-----------|
|                   | 1         | 4         | 8         | 12        | 16        |
|                   | mS.cm⁻¹    |           |           |           |           |
| Activator A       | MF + CM   | 1.13±0.59 | 1.18±0.10 a | 0.89±0.13 bc | 1.24±0.01 a | 1.36±0.09 bc |
|                   | MF        | 0.85±0.78 | 0.37±0.12 b | 1.16±0.23 b | 1.40±0.17 a | 1.52±0.11 a |
| Activator B       | MF + CM   | 1.28±0.48 | 1.04±0.11 a | 1.88±0.04 a | 1.35±0.14 a | 1.84±0.14 a |
|                   | MF        | 0.38±0.06 | 0.46±0.09 b | 0.38±0.00 d | 0.63±0.34 b | 0.42±0.09 d |
| POME              | MF + CM   | 1.28±0.41 | 1.07±0.14 a | 0.77±0.12 c | 1.25±0.04 a | 1.14±0.12 c |
|                   | MF        | 0.38±0.06 | 0.46±0.09 b | 0.38±0.00 d | 0.63±0.34 b | 0.42±0.09 d |

Note. Means with the same letter within a column are not significantly different using LSD at p < 0.05.

MF = oil palm fiber; CM = cow manure

The electrical conductivity is the value where the salinity in the compost can be observed. The increase in conductivity values during the composting process also occurred in a study conducted by [14], which further stated that the rise in conductivity values can occur due to decomposition activity of organic matter which then releases exchangeable minerals such as Ca, Mg, K and P in the available form, which is in the form of cations. [15] describes his research that the EC values of the final compost was in the range of 1.6 – 2.4 mS.cm⁻¹, that indicates high salinity levels based on the ideal growing media.

The greater the value of conductivity, the macronutrient content in the compost will be greater. In [16] stated that testing of Electrical Conductivity (EC) value or conductivity value was done to know the suitability and correctness of nutrient content of a material so that it can be utilized as nutrient source in cultivation. In research conducted by [16], that solutions with high conductivity values are directly proportional to vegetative plant growth. The highest conductivity value describes the compost composition that has large amounts [16] of macronutrients, because it is the basic material of ion formation, and is a description of the amount of nutrients contained in the compost.

3.4 Chemical Composition of Compost

3.4.1 C/N ratio, CEC content and Macronutrient. The results of the C/N ratio test of the composting results at week 16 showed the values between 7.05 and 12.41, as shown in Table 7. These results indicate that composting of palm oil midrib and fiber with the addition of the bioactivator and POME can reach the maturity, since C/N end ratio was generated according to C/N mature compost ratio according to Indonesian Quality Standards ie <20. The C/N ratio is a factor to be considered in composting. The final value of the C/N compost ratio should correspond to the range of C/N soil ratio [17].

Non-mature composts may result in the accumulation of toxic substances as a result of anaerobic decomposition processes, such as methane and acetic acid. In the research of [18] suggested that immature compost can lead to the immobilization of nitrogen that can interfere with plant growth. According to [19] and [20] compost that has been mature enough and can be utilized by plants has a C/N ratio <20. Furthermore, the lower the C/N ratio of compost, the more nutrients available for plants to meet their daily needs [21].
Table 7. Chemical Composition of Organic Waste Compost at Week 16

| Compost Treatment | C-Organik (%) | N Total (%) | P$_2$O$_5$ (%) | C/N Ratio | K$_2$O (%) | CEC (cmol (+)/kg) |
|-------------------|---------------|-------------|----------------|------------|------------|------------------|
| Activator A       |               |             |                |            |            |                  |
| OPM + CM          | 12.12         | 1.72        | 0.66           | 7.05       | 1.11       | 44.75            |
| MF + CM           | 30.68         | 3.41        | 1.64           | 9.00       | 3.25       | 67.90            |
| Activator B       |               |             |                |            |            |                  |
| OPM + CM          | 30.76         | 3.14        | 1.03           | 9.80       | 1.70       | 77.62            |
| MF + CM           | 28.21         | 4.18        | 0.83           | 6.75       | 1.54       | 63.74            |
| OPM               | 34.70         | 3.41        | 0.40           | 10.16      | 0.53       | 84.97            |
| MF                | 32.86         | 3.71        | 0.33           | 8.86       | 0.54       | 44.69            |
| POME              |               |             |                |            |            |                  |
| OPM + CM          | 33.59         | 3.30        | 1.58           | 10.18      | 3.56       | 70.22            |
| MF + CM           | 26.87         | 2.92        | 0.83           | 9.20       | 2.10       | 38.73            |
| OPM               | 37.97         | 3.06        | 1.05           | 12.41      | 1.78       | 74.05            |
| MF                | 28.79         | 2.55        | 0.66           | 11.29      | 1.06       | 64.87            |

Note. OPM = oil palm midrib; MF = oil palm fibre; CM = cow manure.

The value of CEC compost at week 16 observation was in the range 38.37 - 84.97 cmol (+). Kg⁻¹ (Table 7). CEC has a relationship to macronutrients and micronutrients to compost. According to [22] that the greater the CEC value, the greater the macronutrient content and the micronutrients at the compost. This is due to organic acids able to increase the value of CEC, and greater 3 to 10 times of clay mineral.

The macronutrient content of nitrogen, phosphate and potassium at week 16 observations was consecutively in the range of 1.72 - 4.18% (Nitrogen), 0.33 - 1.66% (P$_2$O$_5$) and 0.53 - 3.56 (K$_2$O). The content of all macronutrients of oil palm midrib and fiber compost is shown in table 7. Nitrogen (N total), phosphor (P$_2$O$_5$), and potassium (K$_2$O) content of the compost in this research have been fulfilled with the standard of compost quality according to [23] respectively, i.e. 0.10% (N), 0.1 (P$_2$O$_5$), and 0.2 (K$_2$O). For additional information, the physical condition of the compost produced, both oil palm midrib and fiber, although in both there were still fibrous, but in color and texture looks brownish blackish, weak and smell like soil.

3.5 Microbial count, Hemicellulose and Cellulose Analysis

In Table 8 showed the microbial count at the end of the composting processes of midrib and fiber compost. Composted fiber treated with activator B showed the highest cellulolytic bacterial count (3.18 x 10$^6$ cfu/g) compare to other compost treatments. While the composted midrib treated with activator B showed the highest cellulolytic fungi count (1.484 x 10$^6$ propagul/g) as compared to other compost treatments.

The highest temperature during the composting process was only around 36.31 - 39.25°C. Thus, the bacteria that work on the decomposition process was a mesophilic bacteria that can degrade cellulose and hemicellulose contained in the compost material. This is also happened in the research conducted by [24] which composes fiber with temperature fluctuations of 29-32°C and there was only mesophilic stage in the composting process. The thermophilic phase was not achieved is due to the loss of heat in the compost pile due to the lack of compost piles [24] and it impact further to the unavailability of foodstuffs for thermophilic microorganisms [11].
Table 8. Cellulolytic Bacteria and Cellulolytic Fungi population at the end of the composting processes

| Treatment        | Cellulolytic Bacteria | Cellulolytic Fungi |
|------------------|-----------------------|--------------------|
|                  | (cfu/g)               | (Propagul/g)       |
| Activator A      |                       |                    |
| OPM + CM         | 2.04 x 10^6           | nd                 |
| MF + CM          | 8.20 x 10^4           | nd                 |
| Activator B      |                       |                    |
| OPM              | 1.75 x 10^6           | 1.48 x 10^6        |
| MF               | 3.18 x 10^6           | 7.14 x 10^3        |
| POME             |                       |                    |
| OPM              | 2.03 x 10^6           | nd                 |
| MF               | 2.62 x 10^8           | nd                 |
| OPM + CM         | 1.77 x 10^6           | nd                 |
| MF + CM          | 1.33 x 10^6           | 5.34 x 10^4        |

Note. OPM = oil palm midrib; MF = oil palm fibre CM = cow manure

Table 9. Hemicellulose and cellulose content

| Material         | Hemicellulose | Cellulose |
|------------------|---------------|-----------|
|                  | (%)           |           |
| MF               | 21.72         | 23.26     |
| OPM              | 26.52         | 20.60     |
| MF Compost       | 11.23         | 6.85      |
| OPM Compost      | 18.76         | 8.37      |

Note. OPM = oil palm midrib; MF = oil palm fibre

Results in Table 9 showed that the hemicellulose and cellulose content of the fibers were 21.72% and 23.26%, respectively, while the hemicellulose and cellulose content of the oil palm midrib were 26.52% and 20.60%, respectively. These proved that in this research, the process of degradation of organic compounds in raw materials into carbon dioxide, heat and humus as the final product caused by the activity of microorganisms [25].

In [26] states that in the composting process involves synergistic actions of various microorganisms (consisting of bacteria, including actinobacteria and fungi) are required to recycle lignocellulosic materials. Polymers such as hemicellulose and cellulose will only be degraded after simple compounds (easily degraded) have been consumed by the microorganisms. Hemicellulose acts as crosslinker between cellulose, therefore the removal of hemicellulose will tend to cellulose to loose [27]. After that the lignocellulosic material is partially transformed into humus. This is in accordance with microbiological analysis (Table 8) which shows that cellulolytic bacteria and fungi were found in both composting systems.

This present study of physco-chemical of oil palm midrib and fiber compost revealed that the application of bioactivator and POME are essential element in the composting processes. The bioactivator and palm oil mill effluent delivered high reduction of C:N ratio in decomposing the solid waste palm oil organic matter. The macronutrient content provided at the end of the composting process has fulfilled the requirement of Indonesian Standar Quality of Compost. Assessment of the ecotoxicological risk associated with the use of compost as soilless planting media and soil amendment are needed.
Acknowledgements
The study is part of the research funded through the Ministry of Research, Technology and Higher Education of Republik Indonesia under the PDP Grant Scheme 2017/18. The author acknowledges Citra Widya Education Oil Palm Polytechnic Institute for providing research facilities. Great appreciation also is known to Christine Sembiring, A.Md, Habiburahman, A.Md, Eldo Destama, A.Md, for providing the assets and fine informed data needed in the field.

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