Physical Parameters of Compost Made from Cattle Farming Waste Using Vermicomposting Method

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Abstract. Cattle Farm should not only be focusing on increasing productivity and maximizing profit but also on the environmental issue that happens around it. Recycling the waste and turning it into fertilizer is an excellent method of waste management. Effective and efficient organic waste management also provides great benefits for humans. One method that can be used is by using the vermicomposting method using *Lumbricus rubellus* earthworm inside a bamboo reactor. In this research there are two bamboo reactors used, Reactor A contains a mixture of cow dung and rice straw, and Reactor B containing cow manure only. Physical parameters that were observed are moisture content, pH, temperature, color, and odor. The data were taken around weeks 0, 2, 4, and 6. It shows that the composts have water content values over 50%, pH values between 6-9, temperatures of <30 °C, blackish in color, and an odor that resembles the smell of soil. From the four parameters examined, only the water content did not fulfill the SNI 19-7030-2004 requirement about the standard of compost quality, however water content can be controlled by drying.

1. Introduction

Nowadays, cattle farming in Indonesia only focuses on increasing livestock productivity and not considering the impact of the industries on the environment [1]. According to Melse and Timmerman [2], sustainable livestock not only taking attention to livestock livelihood and its production but also the handling of waste that can potentially pollute the environment around it.

The utilization agricultural and livestock waste as compost is a good alternative in managing the wastes was produced. Vermicomposting is one of wastes managing method that is also suitable for climatic conditions in Indonesia. The resulting vermicompost contains better nutritional content when compared to conventional compost [3, 4, 5]. Vermicompost is a mixture of earthworm feces with the remaining media or feed used in the earthworm cultivation. Several studies have shown that earthworms able to decompose various organic wastes, such as animal feces, sludge from sewerage, crop residues, and agricultural waste. Several species of earthworms that are known for their usage in vermicomposting include *Lumbricus rubellus*, *Pheretima hupiensis*, *Eudrilus eugeniae*, *Eisenia Foetida*, *Lampito mauriti*, *Lumbricus terrestris* [6].

To find out the effectiveness and the efficiency of Yogyakarta farmers' latest innovation in using bamboo reactors in the vermicomposting process, several physical parameters are needed to be tested, such as physical color, odor, temperature, pH, particle size, and moisture content. According to Widarti
et al. [7], if the water content is over 60%, the air content will decrease, resulted in reduced microbial activity and fermentation will occur, causing an unpleasant odor, however, if the water content is less than 50% the composting process will slow down. According to Edward et al. [8], the ideal pH for vermicomposting is between 7 and 8 while for regular compost is around 6 and 8. If the pH is too high then ammonia gas will be produced, and oxygen consumption will be higher and cause negative impacts on the environment and if the pH is too low, it will kill the microorganisms involved in the composting process.

A larger surface area will increase the contact between microbes and the material, increasing the decomposition rate. The particle size also determines the amount of space between the materials [7]. Other physical parameters, such as temperature will affect the worms’ growth. According to Mellawati et al. [9], compost with a temperature slightly higher than 25°C is still good for the growth of earthworms. According to SNI 19-7030-2004 regarding compost specifications, the reference temperature is around the temperature of groundwater, which does not exceed 30°C. Color and odor are used in determining compost maturity. Proper or ripe compost has a blackish color and smells like soil. If the compost has an unpleasant odor, it could indicate a fermentation process and possibly contain compounds that are harmful to plants.

2. Materials and Methods
The research was conducted at the Faculty of Civil Engineering and Planning, Universitas Islam Indonesia and the physical parameters were analyzed at the Environmental Laboratory of FTSP UII. The livestock and agricultural waste were collected from the agricultural and livestock industry around the Universitas Islam Indonesia. The composting method used is the vermicomposting method/using worms as decomposers method. The worm species used is *Lumbricus rubellus*. A tubular reactor made from woven bamboo with a diameter of 22 cm, a height of 114 cm, and a volume of 0.043 m$^3$ will be used. Inside the reactor is where the earthworm will be cultivated and the decomposing process will occur.

![Figure 1. Bamboo reactor.](image)

The vermicomposting process uses two reactors, reactor A which contains dried cow dung and rice straw, and reactor B that contains cow dung only. On August 1, 2017, the composting process started with the inclusion of cow dung and straw into the reactor along with 1.5 kg of *Lumbricus rubellus* worms, and then physical parameters such as moisture content, pH, temperature, color and odor, and particle size of compost were observed at weeks 0, 2, 4, and 6.

The resulting vermicompost is then analyzed for its moisture content using an oven drying process. The water content then calculated using the formula:
Water Content = \( \frac{a-b}{a} \times 100\% \)  \( \text{(1)} \)

where (a) is the weight of wet compost and (b) is the weight of dried compost.

pH measurements were taken using pH indicator paper with the ratio of vermicompost and distilled water of 1:5. The temperature was measured by using a mercury thermometer, while color and odor were manually measured by direct observation of the resulting compost and particle size was measured by the rate of vermicompost reduction in reactor A and reactor B using a measuring meter.

3. Results and Discussion

The vermicomposting method in this study uses a bamboo reactor to decompose cow manure and rice straw waste into vermicompost. The bamboo reactor is the latest technological innovation in vermicomposting, the first in Indonesia. The advantage of this technology is that it can make it easier to breed earthworms and process organic waste without stirring and reversing the media for earthworms and heaps of organic waste [10]. The bamboo reactor has small cavities formed from the gap of the bamboo, it serves as ventilations make it easy for air to get inside the reactor.

3.1. Water content

Moisture content or moisture plays an important role in the composting rate speed. From the research and the observations taken, the percentage of vermicomposting moisture content analysis results are presented in Figure 3.

![Figure 2. Cavities in the bamboo reactor.](image)

![Figure 3. Change in water content.](image)
From Figure 3, it can be seen that the water content at week 0, 2, 4 in reactor A is 67.2%, 70.68%, and 72.37%, while in reactor B is 66.62%, 74.43%, and 73.16%. The two graphs show that both of the reactors have a water content of around 70%, but there is a difference in water content at week 2 between reactors A and B of 3.75%, this could be due to differences in the materials used. Rice straw in reactor A requires more water to decompose rice straw compared to pure cow dung in reactor B, causing differences in water content in the second week, while at week six the water content in the two reactors begins to decrease.

The percentage of water content in the two reactors is above the limit of the number stated in SNI 19-7030-2004, making the decomposing process go slower. According to Dahono [11], if the humidity is greater than 60%, the nutrients will be washed and the air volume decreases, as a result, the microbial activity will decrease and anaerobic fermentation will occur which causes an unpleasant odor. However, when using a bamboo reactor even though both reactors contain high moisture content, it does not have a foul odor, this is because the water in the reactor does not settle at the bottom of the surface of the vermicompost material and the cavities around the reactor allow for better air circulation.

Several factors could affect the composting process, such as materials used, the weather, and the environment around where the composting process occurs. The dry rice straw added to reactor A affects water content which in turn affects the composting rate, to speed up the composting process, it is necessary to add water to the reactor periodically to maintain moisture and water content. Also to avoid exposing the reactor to rainwater, both reactors were put in closed space.

3.2. pH (degree of acidity)

The life of earthworms is also determined by pH. Fender [12], stated that the acidity of the media greatly affects the population and activity of earthworms so that it becomes a limiting factor for the spread and species, generally, earthworms grow well at an optimum pH of around 6 - 7.2. Observation data from reactor A and reactor B is shown in Figure 4.

![Figure 4. Changes in pH vermicomposting.](image)

In Figure 4. The pH in the vermicomposting process changes from alkaline to neutral. By using pH paper, samples at weeks 0, 2, and 4 show a decrease in both reactors. In reactor A which contains a mixture of cow dung and rice straw, the pH decreases relatively slow compared to reactor B which contains 100% cow dung, this is due to the breaking down of organic materials in rice straw such as
cellulose, carbohydrates, protein, and lignin into organic acids. In the sixth week, pH has stabilized which indicates that the vermicompost is mature.

At week 0, the pH in the vermicomposting medium was high, causing the death of several earthworms in the reactor. Edward et al. [8] who states that earthworms are very sensitive to pH in soil, which is a limiting factor in determining the number of species that can live in certain soils. The vertical and horizontal distribution of earthworms is greatly influenced by soil pH. The pH in reactor A and reactor B fulfilled the SNI 19-7030-2004 standard.

3.3. Temperature
Observations show that during the composting period the temperature of the mixture of cow dung and rice straw in reactor A was not much different from cow dung in reactor B. The data are presented as follows:

![Figure 5. Changes in vermicompost temperature.](image)

The temperature conditions from weeks 0, 2, 4, and 6 are fairly good for the growth of earthworms with a temperature of around 25°C. Worms cannot break down organic materials from agricultural or livestock wastes in their raw state unless the organic materials have been broken down by decomposing bacteria to a certain extent. The bacteria that grow at 25-27 oC are bacteria of the genus Micrococcus and genus Bacillus, which are included in mesophilic and thermophilic bacteria [13]. If the temperature exceeds 30°C, it will hinder the worms’ activities and eventually making decomposing process stop. The temperature shown by the graph is in the range of SNI 19-7030-2004 standards.

3.4. Particles size, color, and odor
3.4.1. Particles size
To accelerate the composting process by macroorganisms, the size of the raw materials used, in this case, rice straw, needs to be reduced. First, the rice straw is cut into 5-8 cm size and then mixed with cow dung which has a particle size of approximately 1-4 cm. The decreasing rate of vermicomposting in reactor A and reactor B can be seen in Figure 6.
Figure 6. The rate of decrease graph.

The graph shows that the decomposition process in the reactor is happening at a quick rate, this is due to the small size of the material and the large water content in the reactor, thus accelerating the composting process. The average reduction rate that occurred in reactor A and B was 20 cm/week in 4 weeks periods. The average reduction rate is needed to predict how much raw material needs to be added. This is one of the advantages of vermicomposting with a reactor. At week six, the reduction rate slows down, indicating that the vermicompost is mature.

According to Dalzell [14], to break down organic matter, microbes need water, oxygen from the air, and nutrients from organic matter as an energy source. In the process, it will release CO2, water, and heat, and cause the raw material to decrease. Vermicompost volume shrinks as the compost ripens. At first, the reduction or shrinking rate is fast, but when the compost ripen the rate will be slower. The rate also depends on the characteristics of the raw material used.

3.4.2. Color and odor
Mature compost has blackish-brown color and also smells like soil. If the compost smells bad, it means anaerobic fermentation has occurred and if the compost still smells like the raw material used, it means the compost is not yet mature. The data obtained from the observations are presented in Table 1.

Table 1. Color and odor parameters on vermicompost.

| Weeks - Reactor | Parameter | Color | Odor     |
|-----------------|-----------|-------|----------|
| Week-0          | Reactor A | Reddish black | Cow manures’ smell |
| (Cow Manure and Rice Straw) |          |       |          |
| Week  | Reactor | Color   | Description                                      |
|-------|---------|---------|--------------------------------------------------|
| 2     | B       | Reddish black | Cow manures’ smell                              |
|       | A       | Brownish black | Already smell like soil, but still have the smells of manure |
|       | B       | Blackish    | The smell resembles the soil                    |
| 4     | A       | Blackish    | The smell resembles the soil                    |
Reactor B (Cow Manure) Blackish The smell resembles the soil

Reactor A (Cow Manure and Rice Straw) Blackish The smell resembles the soil

From Table 1. It can be seen that there is a change in the color of the vermicomposting material from week 0 to week 4, from reddish black to black, resembling soil. In reactor A, the rice straw used in the vermicompost mixture has decomposed into smaller sizes. The results are within the standard set by SNI 19-7030-2004 [15].

4. Conclusion
From the research and the observations, the vermicompost exhibit physical parameters as follow, the water content of over 50%, pH value between 6-9, the temperature below 30°C, the average reduction rate of 10cm/week, and blackish in color with an odor resembling soil. Several physical parameters, such as temperature, pH, color, and smell of compost, are in the acceptable range that has been set in SNI 19-7030-2004 regarding compost quality standards. The only parameter that outside the acceptable range is the water content, with over 50.
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