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Effect of Fermentation Time and Sugar Concentration on the Quality Characteristic of Organic Fertilizer from Cattle and Rabbit Manure Using Vinnase Media

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Abstract

Vinasse waste is liquid waste from distillation products in bioethanol.Vinasse processes. The rest is organic matter which can be used to fertilize the soil. Therefore, alcohol waste must be treated with the addition of complementary organic materials in order to obtain it used as a plant media for probiotic bacteria which are very good for soil and plants.The production of probiotic bacteria culture media used the basic ingredients of vinasse waste mixed with rice bran and shrimp paste, which can work effectively to ferment organic matter. Bacteria will be cultured by adding vinasse waste and shrimp paste boiled for 5 minutes and cooled to room temperature 25°C, let stand for 3 weeks (21 days). Cow manure and rabbit urine are potential ingredients for making organic fertilizers. Furthermore, making fertilizer from cow manure and rabbit urine using EM-4 bacteria cultured with vinasse using variationsin fermentation time of 7, 14, 21 days and sugar content of 0,25; 0,5; 0,625 (% w/v). Then the finished fertilizer sample is tested for analysis of the levels of Nitrogen, Phosphor, And Potassium, and C. Organic. Test nitrogen levels with the Kjeldahl method, analysis of phosphorus content (P_2O_5) and K (K_2O) levels with HNO_3 and $HClO_4$ extraction and C.Organic analysis using the Walkley & Black method. The results of the analysis test for the optimum levels of Nitrogen (N) obtained fermentation time of 21 days with a level of 1,14%. The percentage of phosphorus (P_2O_5) and and potassium (K_2O) obtained the best fermentation time of 14 days with levels of 0,51% and 0,74% respectively. The optimum conditions for Nitrogen (N) and potassium (K_2O) are in a 0,5% sugar concentration except for the optimum Phosphorus (P_2O_5) in a sugar concentration of 0,625%. The results of the analysis of fertilizers that meet the parameters of Indonesian National Standard 19-7030-2004 are the variation of fermentation time on the 21st day with an N content of 1,14%; P 1,43%; K 0,42%; C. Organic 20,26; and the C / N ratio of 17,81.

Keywords: *Waste vinasse; EM-4; Cow manure; Rabbit urine, Fertilizer, Fermentation, Sugar concentration*

1. Introduction

The need for ethanol in the world is increasing, this has triggered the development of the bioethanol industry. The function of ethanol itself, apart from being an organic solvent, is a raw material for the chemical industry, as well as a material for the cosmetic and pharmaceutical industries [7]. Bioethanol is produced from various agricultural products, such as ingredients containing sugar derivatives such as molasses (molasses). The bioethanol industry from molasses produces a dangerous liquid waste known as vinasse. Vinasse is the liquid that comes from distillation products in the bioethanol manufacturing process [10]. Vinasse waste can be processed by processing it into a bacterial fermentation medium. From previous researchers regarding the content of vinasse waste, it was not found any content that was harmful to the environment except for high acidity (4,5). The rest is organic matter that can be used to fertilize the soil. One alternative solution that can be done for vinasse is by processing it into a medium for fermenting bacteria [3]. Vinasse waste contains elements of Nitrogen, Phosphor, and Potassium, S, Fe, Mg, Ca, and Na which are very useful for increasing soil fertility [15]. Making probiotic bacteria culture media using vinasse as a basic ingredient mixed with rice bran and shrimp paste. Fermentation makes nutrients easier for plants to absorb. Thus, vinasse waste can be an alternative to growing media for fermentation bacteria [3]. Bacteria will be cultured by adding vinasse, bran and shrimp paste and boiled for 5 minutes and cooled to room temperature 25ºC, let stand for 3 weeks (21 days). Effective Microorganism 4 (EM-4) is a mixture of beneficial microorganisms. The number of fermenting microorganisms in EM4 is very large, these microorganisms are selected which can work effectively in fermenting organic matter [6]. The EM-4 bacteria will later be cultured with vinasse, bran and shrimp paste to become a decomposer for organic fertilizers. One of the organic fertilizers that can be used and easily obtained is by using manure. Manure is urine and animal feces that have gone through a fermentation process so that it contains enzymes, hormones, and nutrients that are good for soil and plants. Cow manure is one of the potential ingredients for making organic fertilizer [4]. One cow per day produces manure ranging from 8-10 kg per day or 2.6-3.6 tonnes per year or the equivalent of 1.5-2 tonnes of organic fertilizer so that it will reduce the use of inorganic fertilizers and speed up the process of land improvement. The resulting livestock waste is no longer a burden on business costs but is a byproduct that has high economic value and if possible is equivalent to the economic value of the main product (meat). The nutrient content of Nitrogen, Phosphor, And Potassium from cow dung is 0.4%; 0.2%; 0.1% [1]. Rabbits are pets that can produce urine every day. Urine is waste from animals, so if it is not used it can pollute the environment. Based on the results of research, rabbit urine has higher levels of Nitrogen, Phosphor, and Potassium (2.72%, 1.1%, and 0.5%). compared to the manure and urine of other livestock such as horses, buffalo, cows, sheep, pigs and chickens [11]. Based on the above background, the purpose of this study was to determine the process of utilizing cow manure and rabbit urine into organic fertilizer which was given EM-4 decomposer that had been cultured with vinasse waste to study the effect of fertilizer fermentation time and variations in the levels of sugar solution added as a source of energy for bacteria. The culturing research on EM4 by utilizing vinasse waste is a novelty in this study compared to Trivana's research (2017) which only uses EM4 directly without being cultured first [16].The finished fertilizer will be tested for levels of Nitrogen, Phosphor, and Potassium, C. Organic and C / N ratio and analyzed with levels of Indonesian National Standard 19-7030-2004.

2. Experimental

2.1. Materials

Vinasse was obtained from the alcohol industry in the Bekonang area of Sukoharjo. EM-4 bacteria were cultured by adding vinasse, bran and shrimp paste boiled for 5 minutes and cooled to room temperature 25ºC left alone for 3 weeks (21 days). Cow manure and rabbit urine are taken directly to the farmer in the Mojolaban area. Make cow dung

and rabbit urine using EM-4 that has been cultured. With the composition of 500 grams of cow dung, 8 ml of rabbit urine, 1 ml of EM-4, variations of Javanese sugar with variations of 0.25%, 0.5% and 0.625%. Then the fertilizer mixture is fermented by varying the fermentation time, namely 7 days, 14 days and 21 days. Each time variation, the sample is directly tested for analysis at the Faculty of Agriculture, Sebelas Maret University. Test nitrogen levels with the Kjeldahl method, analysis of phosphorus content (P_2O_5) and K (K_2O) levels with HNO_3 and $HClO_4$ extraction and C.Organic analysis using the Walkley & Black method.

2.2. Bacterial Culture and Making Organic Fertilizer

Bacterial culture, starting from taking bioethanol waste, is carried out using jerry cans to culture bacteria. The process of culturing bacteria is carried out with the basic material of 20 L of bioethanol waste which is put in a boiling tank / container with a capacity of 100 liters. Smooth it out and add 750 grams of shrimp paste which is useful as an additive to protect microbial cultures. Puree 250 grams of ginger, 250 grams of lightnes, 250 grams of ginger, 250 grams of turmeric, 250 grams of laos using a blender is useful so that the vinasse smell is not too strong. Enter the results from blending into the boiling tank. Then add 1 kg of bran because it contains nutrients that are very good for microorganisms. Then add water to a capacity of 100 liters. The mixture is then boiled for 5 minutes and cooled to room temperature 25^{o}C. After that all the ingredients are put in a container can with a size of 25 liters and let stand / cool for 2-3 days. After chilling all the ingredients are given an EM-4 bioefactor with a ratio of 1 cap EM-4 (10 ml): 5 liters of potion. Then let stand for 3 weeks (21 days) for the development of bacteria. Cow manure and rabbit urine are taken directly to the farmer in the Mojolaban area. Then the cow dung is dried for 7 days to reduce the moisture content. Furthermore, cow dung and rabbit urine are fermented using EM-4 that has been cultured. Where the composition of each fertilizer sample is 500 grams of cow dung, 8 ml of rabbit urine, and 1 ml of EM-4 which has been cultured, then adding a mixture of Javanese sugar with variations of 0.25%, 0.5% and 0.625%. Then the fertilizer mixture is fermented by varying the fermentation time, namely 7 days, 14 days and 21 days. Each time variation, the sample is directly tested for analysis at the Faculty of Agriculture, Sebelas Maret University. The yield of the fertilizer is blackish brown like soil and smells of soil.

2.3. Nitrogen, Phosphor, and Potassium, C. Organic Levels Test

Test nitrogen levels with the Kjeldahl method with three stages, namely digestion, distillation and titration. Analyze the levels of phosphorus (P_2O_5) and potassium (K_2O) by extracting HNO_3 and $HClO_4$ and C.Organic analysis using the Walkley & Black method.

2.3.1. Kjeldahl method

The principle of the determination of nitrogen levels by the Kjeldahl method is that there are three stages, namely destruction, distillation and titration. The formula for calculating the total nitrogen content is :

$$(\%)=\frac{(V1-V2) \times N \times 14{,}008 \times p \times 100 \times fk}{W}$$

Where % is total nitrogen content; V1 is sample volume; V2 is blank volume; N is normality of the titration; 14.008 is an atomic weight N; p is dilution factor; Fk is water content correction factor; and W is a sample weight.

2.3.2. Extracting HNO_3 and $HClO_4$

The formula for calculating phosphorus levels as P_2O_5 (%) is

$$\%b/b = (\text{mg/L phosphorus} \times \frac{\text{Sample volume}}{\text{Sample mass}} \text{ mL/g} \times \frac{1}{1000} \text{ L/mL} \times \frac{1}{1000} \text{ g/mg}) \, 100\%$$

The formula for calculating potassium levels as K_2O (%) is:

$$\%b/b = (\text{mg/L potassium} \times \frac{\text{Sample volume}}{\text{Sample mass}} \text{ mL/g} \times \frac{1}{1000} \text{ L/mL} \times \frac{1}{1000} \text{ g/mg}) \, 100\% \times 1{,}2$$

Where 1,2 is conversion from K to K_2O

2.3.3. Walkley & Black method

The formula for calculating organic C levels is :

$$C\ (\%) = \frac{\text{ppm curve} \times (\text{ml extract}/1000) \times 100}{\text{dry weight } 105^0\text{C} \times 1000}$$

3. Results and discussion

3.1. The effect of the length of fermentation time with levels of Nitrogen, Phosphor, And Potassium

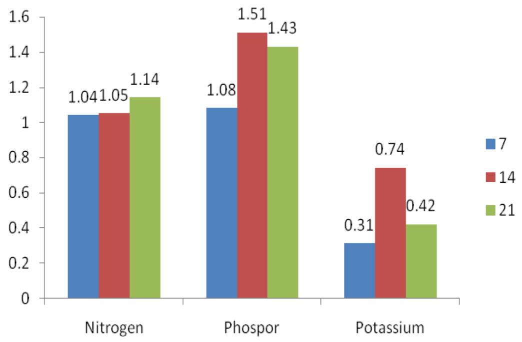

Figure 1: Effect of length of fermentation time with levels of Nitrogen, Phosphor, And Potassium

Based on **figure 1**, N levels have increased from the 7^{th} day to the 21^{st} day. The increase in N (nitrogen) levels of fertilizer occurs due to the decomposition process carried out by microorganisms that produce ammonia and nitrogen. Nitrogen reacts with water to form NO_3^- and H^+. NO_3^- compounds are very water-soluble, and cannot be handled by soil colloids and there will be loss of N in the form of gases, where NO_3^-reacts to N_2 and N_2O. This loss of N is overcome by reversing the manure pile so that the water content is reduced, sufficient oxygen supply for microorganisms to break down protein into ammonia ($NH4^+$), and a good aeration process [5]. In Figure 1, the percentage of nitrogen (N) to the fermentation time is in the best condition with a fermentation time of 21 days. In this best condition, nitrogen is obtained at 1.14%. The phosphorus content is also influenced by the high nitrogen content, the higher the nitrogen contained, the multiplication of microorganisms that break down the phosphorus will increase so that there will be an increase in the phosphorus content in manure. Based on the results of the analysis of the variance of total phosphorus content, it was found that the fermentation time had an insignificant influence on the total phosphorus content or there was no significant difference. The treatment of fermentation time from 7 to 14 days experienced an increase in phosphorus levels. The long treatment of fermentation from day 14 to day 21 showed a decrease in phosphorus levels, although not too much. Possible factors that have differences in the content of phosphorus are due to microbial activity that can overhaul the phosphorus so that it affects the increase in total P content [17]. The role of microbes in the fermentation process is mutually sustainable. According to [17], the fermentation process plays a role in accelerating the breakdown of organic matter and destroying organic matter. The

total P content in the 7-day fermentation was the amount at which these microorganisms began to adapt. In this adaptation phase, microorganisms make adjustments to their environment. After adapting to new conditions, the cells then use the sugar solution as an energy source and multiply. Decomposition is getting better as indicated by the increasing levels of phosphorus on the 14th day because the cells will grow rapidly to the maximum number. At 14 days of fermentation, the total P content became 1.51%. On the 21st day, the P content decreased to 1.43%. This is because the microorganisms reach a balance, namely, the number of microorganisms produced is the same as the number of dead microbes. At this time the microbial activity will decrease. This is due to a lack of carbon-containing foods or nutrients. In addition, the results of metabolism that cause toxins or can inhibit microbial growth. In this phase, the population number still slightly increases, because the number of cells that grow is still more than the number of cells that die. This can be seen in the graph which shows that the phosphorus content at the 21st day fermentation time was still higher than the phosphorus content at the 7-day fermentation time. Besides, it is also caused by the phosphorus-decomposing bacteria (P_2O_5) that have reached their maximum growth condition before the specified time variable [9]. Potassium is used by microorganisms in the substrate as a catalyst, with the presence of bacteria and their activity will greatly affect the increase in potassium content. Potassium can be bound and stored in cells by bacteria and fungi [8]. In Figure 1, the percentage of potassium (K_2O) against the fermentation time is in the best condition with a fermentation time of 14 days. In this best condition, potassium is obtained by 0.74%. In the graph, it can be seen that it has decreased during the fermentation time of 21 days. This is because the bacterial food reserves that are sourced from potassium (K_2O) have been used up. It can be said that the bacteria have reached a stationary phase and will experience a death phase [2]. From Figure 1 above, the best conditions can be obtained to obtain the percentage of Nitrogen (N) levels obtained by fermentation time of 21 days with a level of 1.14%. The percentage of phosphorus (P_2O_5) and potassium (K_2O) obtained the best fermentation time of 14 days with levels of 0.51% and 0.74%, respectively.

3.2. Effect of length of fermentation time on levels of C. organic

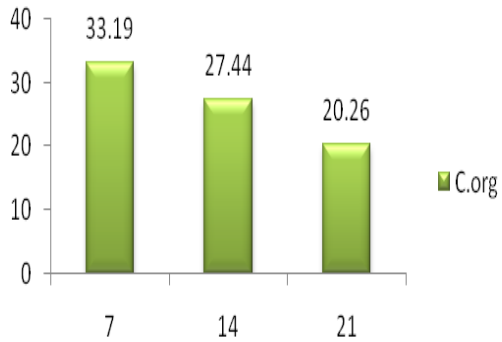

Figure 2. Effect of fermentation time on C. organic levels

Based on the results of the C-organic analysis on the 7th day, it has not fulfilled Indonesian National Standard 19-7030-2004, namely 9.8-32%. The C-organic in fertilizers is influenced by the quality of organic matter and the activity of microorganisms involved in the breakdown [14]. From Figure 2 above, the yield of C. organic from day 7 to day 21 decreases. The longer the fermentation time, the carbon content in the fertilizer decreases. This is caused by microbes that use carbon to reproduce. Microbes take energy for the breakdown of organic matter from the calories produced in biochemical reactions, such as changing carbohydrates into CO_2 and H_2O gases continuously so that the carbon content in manure drops lower [12].

3.3. Effect of length of fermentation time with C / N levels

The value of the C/N ratio of organic matter is an important factor that needs to be considered as fertilizers. From Figure 4.3 above, it can be seen that the C. organic content from day 7 to day 21 has decreased. This is because in the fermentation process there has been a reaction of C to CO_2 and CH_4 in the form of gas. In addition, the C-organic in organic matter is also used by microorganisms as a food source so that the amount is reduced. Meanwhile, the total N value in the organic matter has increased due to the decomposition of the compost material by microorganisms that produce ammonia and nitrogen, so that the total N content of compost increases. By decreasing the C-organic content and increasing the total N content, the C/N ratio decreased. Organic material has become compost/fertilizer and can be used for plants if the C/N ratio is <20. The minimum and maximum C/N ratio requirements in Indonesian National Standard 2803: 2004 Solid NPK Fertilizer are 10-20.

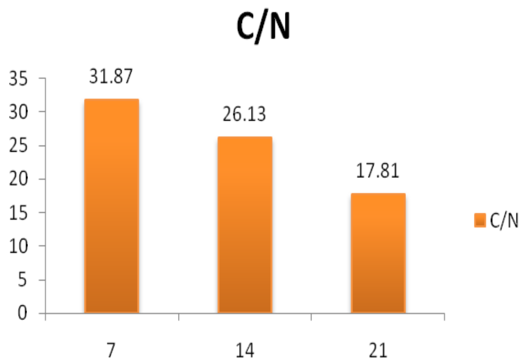

Figure 3 Effect of length of fermentation time with C/N levels

Table 1. Results of Fertilizer Analysis and Indonesian National Standard 19-7030-2004

Measured	Indonesian National Standard 19-7030-2004			day sample		
	unit	Min	Max	7	14	21
Nitrogen	%	0,40		1,04	1,05	1,14
Phosfor	%	0,10		1,08	1,51	1,43
Potassium	%	0,20		0,31	0,74	0,42
C-Organic	%	9,80	32	33,19*	27,44	20,26
C/N		10	20	31,87*	26,13*	17,81

According to table 1, the results of nitrogen, phosphorus and potassium have met the minimum standards set by Indonesian National Standard 19-7030-2004. At the time of fermentation, the 7th day organic matter had a C/N ratio of 31.87, C-organic 33.19, levels of Nitrogen, Phosphor, and Potassium were 1.04%, 1.08%, and 0 respectively 31%. The initial C/N ratio meets the criteria for the initial C/N value for compost, which ranges from 30-50. The high C-organic content indicates that the organic material is sufficient for microorganisms to obtain energy during the decomposition process. Microorganisms use nitrogen for the maintenance and formation of body cells. The more nitrogen content, the faster the organic matter will break down. Microorganisme use only a small portion of phosphate and potassium elements for their metabolic activities. Generally, phosphate solubilizing bacteria can also dissolve elemental potassium in organic matter. The results of the 21st day manure analysis met the Indonesian National Standard 19-

7030-2004 parameters, while the 7th and 14th day manure was obtained with a C/N ratio that did not meet Indonesian National Standard 19-7030-2004. The longer the composting process is carried out, the smaller the C/N ratio [13]. This is because the C content in the compost material has decreased a lot because it is used by microorganisms as a food / energy source, while the nitrogen content has increased due to the decomposition of compost materials by microorganisms that produce ammonia and nitrogen so that the C/N ratio decreases.

3.4 Effect of levels of sugar solution on levels of Nitrogen, Phosphor, And Potassium

Based on Figure 4, the levels of Nitrogen, Phosphor, and Potassium fertilizer have increased from 0.25% sugar solution to 0.5% sugar solution. The increase in N (nitrogen) levels of fertilizer occurs due to the decomposition process carried out by microorganisms. In the sugar solution 0.625% the levels of N and K decreased although only slightly, the phosphorus increased from 1.40% -1.43%. The increase in levels of Nitrogen, Phosphor, and Potassium is relatively increasing and is likely to continue to increase until optimum conditions are reached. The optimum conditions for nitrogen and potassium are in a 0.5% sugar solution except for the optimum Phosphorus in a sugar solution of 0.625%.

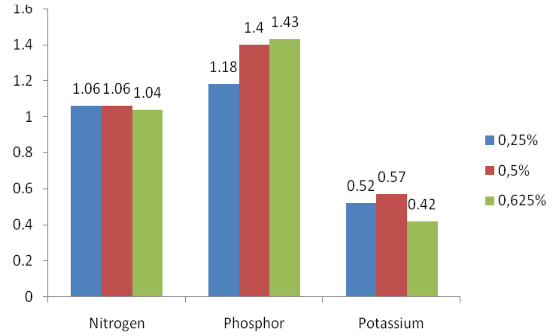

Figure 4. Effect of levels of sugar solution with levels of Nitrogen, Phosphor, And Potassium

3.5 Effect of Sugar Solution Levels on C. Organic

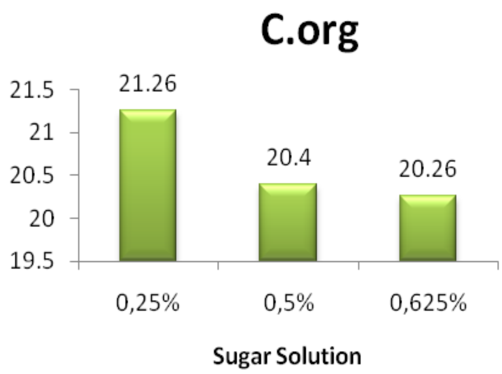

Figure 5. Effect of levels of sugar solution on levels of C. organic

Based on the results of the C-organic analysis, it meets Indonesian National Standard 19-7030-2004, namely 9.8-32%. Total C-organic in fertilizers is influenced by the quality of organic matter and the activity of microorganisms involved in decomposition [14]. Based on Figure 5, it can be seen that the most optimum organic C. is found in the sample with the addition of 0.25% sugar solution. The greater the amount of sugar solution given, the greater the organic C. This is due to the increasing number of nutrients supplied to microbes. However, with the addition of too much sugar solution, the microbes that decompose the fertilizer will die [2].

3.6 Effect of Sugar Solution Levels on C/N

Based on the C/N value of compost ratio according to Indonesian National Standard 19-7030-2004, namely (10-20). The C/N ratio contained in the compost describes the level of maturity of the compost, the higher the C/N it means the compost has not broken down completely or in other words, it is not yet ripe and not ready to be used as fertilizer. If the C / N ratio is high, the nutrient content is small for plants, if the C / N ratio is low, the nutrient availability is high for plants [14]. Based on Figure 6, it can be seen that the C/N ratio of the variation in the added levels of sugar solution as bacterial nutrition has met the Indonesian National Standard 19-7030-2004 standards, namely between 10-20. This means that the variation of the sugar solution does not affect the maturity level of the fertilizer because the C/N value of the variation meets Indonesian National Standard.

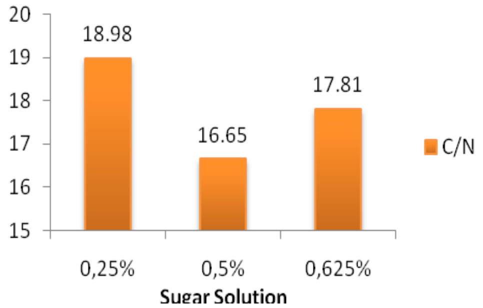

Figure 6. Effect of levels of sugar solution with levels of C/N

4. Conclusion

The EM-4 bacteria were successfully cultured by adding vinasse, bran, and shrimp paste. Fermentation time affects levels of Nitrogen, Phosphor, and Potassium in organic fertilizers. Nitrogen (N) levels were obtained during the fermentation time of 21 days with a level of 1.14%. The percentage of phosphorus (P_2O_5) and and potassium (K_2O) obtained the best fermentation time of 14 days with levels of 0.51% , and 0.74%, respectively. The fermentation time affects the C. organic content, and the C/N ratio in fertilizers. The content of C. organic from day 7 to day 21 decreased. The longer the fermentation time, the lower the carbon content in the fertilizer. This is caused by microbes that use carbon to reproduce. The addition of various sugar solutions also affects the levels of Nitrogen, Phosphor, And Potassium in fertilizers. Nitrogen, Phosphor, and Potassium levels of fertilizer increased from 0.25% sugar solution to 0.5% sugar solution. Increased levels of N (nitrogen) fertilizers occur due to the decomposition process carried out by microorganisms. The optimum conditions for nitrogen and potassium are in a 0.5% sugar solution except for the optimum Phosphorus in a sugar solution of 0.625%. The addition of various sugar solutions also affected the C. organic content, and the C/N ratio in fertilizers. The greater the amount of sugar solution given, the greater the organic C. This is due to the increasing number of nutrients supplied to microbes. However, with the addition of too much sugar solution, the microbes that decompose the fertilizer will die. The results of the analysis of fertilizers that meet the parameters of Indonesian National Standard 19-7030-2004 are fermentation time on the 21st day with nitrogen content of 1.14%, Phospor 1.43%, potassium 0.42%, C. Organic 20.26 and C/N ratio 17.81. Manure on days 7 and 14 obtained fertilizer samples with a C / N ratio that did not meet Indonesian National Standard 19-7030-2004 (Table 1).

Acknowledgments

All participants who contributed to the research carried out are listed in this section.

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