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The Composting Time Effect of the Activated Sludge from Bioethanol Solid Waste by Orgadec Bio-activator to the Compost Characteristics

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ABSTRAK

Suatu industri bioetanol menghasilkan limbah dalam proses produksinya, salah satunya adalah limbah padat berupa activated sludge. Keberadaan dari limbah padat ini semakin lama semakin menumpuk sehingga perlu dilakukan pengolahan menjadi sesuatu yang lebih berguna. Salah satu pemanfaatan yang dapat dilakukan untuk mengolah limbah padat adalah dengan membuat pupuk kompos.Tujuan dari penelitian ini adalah mengetahui waktu pengomposan pada pembuatan pupuk kompos dari activated slude hasil samping produksi bioetanol, terhadap kandungan pupuk kompos yang dihasilkan. Bioaktivator yang digunakan adalah Orgadec. Waktu pengomposan yang digunakan adalah minggu ke-0, minggu ke-1, minggu ke-2, minggu ke-3, minggu ke-4. Analisis kandungan pupuk yang dilakukan adalah karakteristik fisik pupuk kompos, suhu, pH, Kelembaban, C organik, N total, P total, K total, serta rasio C/N sesuai dengan SNI 19-7030-2004. Dari analisis yang dilakukan, pupuk kompos dari activated sludge dengan bioaktivator orgadec menghasikan kompos yang memiliki karakteristik sesuai dengan SNI 19-7030-2004

***Kata kunci*:** Activated sludge, orgadec, kompos, bioaktivator

ABSTRACT

A bioethanol industry produces waste, one of which is activated sludge. The number of this solid waste is constantly increasing; therefore, it is necessary to process it into something useful. One way to achieve this is by turning it into compost. This study aimed to determine the composting time of activated sludge on the content of compost produced. The bio activator used was Orgadec. The composting time used as samples is on week 0, week 1, week 2, week 3, and week 4. The fertilizer content analysis includes the physical characteristics of compost, temperature, pH, humidity, organic C, total N, total P, total K, and the C/N ratio matches SNI 19-7030-2004. According to the conducted analysis, the compost made using activated sludge with orgadec as the biovactor created a compost that has characteristics that meet the standards of SNI 19-7030-2004.

***Keyword*:** Activated sludge, orgadec, compost, bio-activator

1. INTRODUCTION

Waste is the residue from industry or activity, which contains hazardous toxic materials due to their properties, concentration, or amount that can endanger the environment, health, and humans or other living creatures, both directly and indirectly [1]. Sludge from an anaerobic process of WWTP unit in the bioethanol industry contains nitrogen, carbon, phosphor, and kalium, increasing soil fertility for the plantation process. However, some say that sludge has lignocellulose and poor nutritional quality, making undesirable direct absorption in the soil [2]. That is why further processing is needed, one of which is by composting the activated sludge. In 2003 Supriatni [3] used a fast neutron activator application to determine the content of N, P, and K elements in the sludge from WWTP to determine the possibility of its utilization as

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compost. However, treatment is still needed to increase the concentration of macro elements.

Composting aims to activate the microbial to accelerate the decomposition process of organic matter within the sludge. Not only that. This process can reduce the C/N ratio of organic material so that it can be equivalent to the C/N ratio of the soil and facilitate its absorption into plants. C/N ratio is the ratio between carbohydrates and nitrogen contained in a material. The higher the C/N ratio of organic matter, the longer the composting or decaying process will take. The C/N ratio of the soil should be 10-12 [4]. The nutrients in the sludge itself are still low, and therefore it is necessary to add straw waste to maximize the produced compost. Organic materials used as sources of organic fertilizers may come from agricultural and non-agricultural waste/products, from agricultural products in the form of crop residues (straw), agricultural residues (rice husks, peanut shells, bagasse, and sugar cane remnants), manure (cow, buffalo, chicken, duck, and horse dung), and green fertilizer [4]. The nutritional content in straws is pretty high, and it has not been used properly [5]. According to Arafah [6], the use of organic fertilizer produced using straws shows the growth and the yield of plants using organic fertilizers are higher than those not using organic fertilizers. Rice-made straw is an organic material with a relatively high C/N ratio and can change the soil's physical properties.

Whether composted or fresh, organic fertilizers have an important role in improving the chemical, physical and biological properties of the soil and as a source of plant nutrients. However, organic fertilizer that has been composted can provide nutrients faster than in its fresh form. There has been a decomposition process carried out by several kinds of microbes during the composting process, both under aerobic and anaerobic conditions [7].

Organic fertilizers contain many microorganisms (fungi, actinomycetes, bacteria, and algae). By adding organic fertilizers into the soil, the microorganisms in the soil will be stimulated to develop. The activities of various microorganisms in organic fertilizers produce growth hormones such as auxins, gibberellins, and cytokinins that stimulate the growth and development of plant roots, so the area of absorption for a nutrient is wider [8].

A bio activator is a substance that contains microbes that will help the composting process to go faster and in big quantities/volumes. Orgadec bio activators contain microbes such as Trichoderma pseudokoningii and Cytophaga sp. These microbes have a great ability to produce enzymes that can decompose lignin and cellulose, and the end products of the decomposition process are water and carbon dioxide. Orgadec bio activator is expected to shorten the composting time [8].

This study follows the effect of composting time in making compost from activated sludge from bioethanol industrial waste using the Orgadec bio activator to the resulting compost. There are 2 types of composters used, non-aeration and aeration.

The resulting compost is odorless and has an earthy smell. According to Setyorini et al. [4], mature compost smells like soil. Composting time that is too long or under anaerobic conditions can cause the compost to smell bad.

2. RESEARCH METHODS

The composting process in this study uses Orgadec bio activator, while the types of composter used are non-aeration and aeration. Aeration and non-aeration composter sketches are shown in the figure 1. The material used in this study is activated sludge, a by-product of the anaerobic biodigester in the bioethanol production process. The activatedsludge came from the bioethanol industrial wastewater treatment plant in East Java.

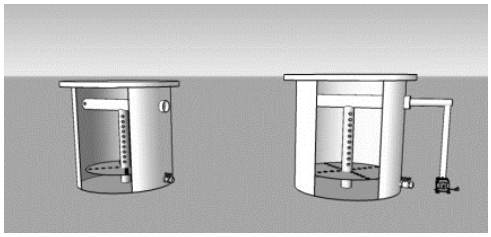

Figure 1. The composter design of aeration and non-aeration process.

1 kg of each Anaerobic sludge and chopped straw were put into the composter. 100 mL of Orgadec bio activator was diluted with water until there was 1 L in total, then it was added to the composter and stirred evenly. There are two types of composters: non-aeration and aeration composters. The composter was closed for 28 days to get a good compost maturity level. Physical analysis was carried out for each time variable, namely blank, week 1, week 2, week 3, and week 4, to determine the physical appearance, color, and smell. Compost is said to be ripe if it is dark brown, does not smell, and when it is pressed in hand, it does not feel hot and has a crumbly texture. Furthermore, quantitative tests were carried out in the form of pH testing using a pH meter, temperature analysis using a digital thermometer, water content analysis using the Gravimetric method, humidity analysis using a digital hygrometer, analysis of organic C and P elements using a UV-Vis spectrophotometer, N analysis using the Kjeldahl method, K analysis using Inductively Coupled Plasma (ICP), and determining the C/N ratio. The compost fertilizer parameters were compared to the compost fertilizer standard of SNI 19-7030-2004.

3. RESULTS AND DISCUSSION

3.1. PHYSICAL ANALYSIS

Before composting, performing size reduction towards the straw is necessary to expand its surface area to facilitate the activity of microorganisms. The compost's maturity can be identified from its physical analysis, such as the texture, color, and smell. The results of the analysis are as shown in table 1. Enzymatically, the size forming process of the organic matter determines the composting process. Microorganisms will break down the cells in said material by producing cellulase enzymes that degrade the plant's cellulose. Cellulose links shall break and become simplified until it forms a smooth texture [9]. Degraded compost does not resemble its original form because of the natural decomposition by microorganisms during the composting process [10].

Table 1. Physical analysis of compost

Physical Parameter	Composter	
	Aeration	Non Aeration
Texture	Crumbly	Crumbly
Color	Brown	Brown
Smell	Earthy	Earthy

According to Ubaidillah [10], a good compost has brownish-black color, and the compost has an earthy smell instead of a rotten one. The decomposition process within the materials may cause a rotten smell under anaerobic conditions or extended composting time [4]. The conducted research results with compost with brownish black color, crumbly texture, and earthy smell. The standard of SNI 19-7030-2004 also supports this.

3.2. WEIGHT LOSS ANALYSIS

According to Manurung [11], Orgadec bio activator contains Trichoderma pseudokoningii and Cytophaga sp microorganisms. During the composting process, many microorganisms act as decomposers which causes a higher weight loss rate in compost. This is caused by a lot of organic material decomposing and reducing the weight of the compost. Significant weight loss means that the decomposing microbes are effective and fast. Changes to the organic matter's structure shall occur during the composting process because of the microorganisms within the compost. The changes include decomposing cellulose, hemicellulose, fat, linen, carbon dioxide (CO_2), and water. Therefore the final

weight of mature compost would ideally be between 55-75% of the original [12].

Table 2. Percentage of the mass loss of the compos.

Composter type	Initial Weight (kg)	Final weight (kg)	% Weight Loss
Non-aeration	3.05	2,35	22,95
Aeration	3.05	2.33	23,61

The study results (Table 2) show that the weight loss percentage during the 4-week composting period isn't too significant; 22.95% in non-aeration composters and 23.61% in aeration composters don't meet the ideal percentage of weight loss in composting process.

3.3. EFFECT OF TIME ON TEMPERATURE

The increase in temperature during the fermentation process indicates microorganisms that decompose organic matter to ensure the composting process goes smoothly [9]. In the early stages of the composting process, the increase in temperature is called the mesophilic phase, where microorganisms begin to decompose organic matter. These mesocolic microorganisms live at a temperature of 10-45 ^{0}C and will reduce the particle size of organic matter, which increases the surface area and accelerates the composting process [13]. The cooling stage signifies a decrease in microbial activity and the replacement of thermophilic microorganisms with mesophilic bacteria and fungi. This phase occurs from the 14th day to the 28th. The decrease in composting temperature marks this activity until it is equal to the surrounding temperature [12].

From Figure 2, it is shown that an increase in temperature occurs in the first week and peaks in week 3. After passing week 3, the temperature decreased. The final temperature measurement of the composting process (on week 4) was 40.2 (non-aeration) and 39 (aeration). The standard temperature of compost according to SNI 19-7030-2004 is 30-35 ^{0}C, which is lower than the results from the study. This was possible because the composting process in week 4 had not been completed. There are still working microorganisms that made the temperature still high.

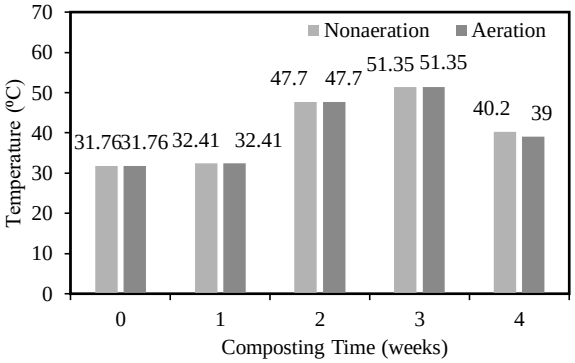

Figure 2. Results of temperature analysis on composting time

3.4. THE EFFECT OF TIME ON ACIDITY (pH)

Low pH acidity can cause some microorganisms to die, and therefore it is not good for the composting process. If the pH is too high, it can cause microorganisms to require too much oxygen and may cause the nitrogen element to turn into ammonia.

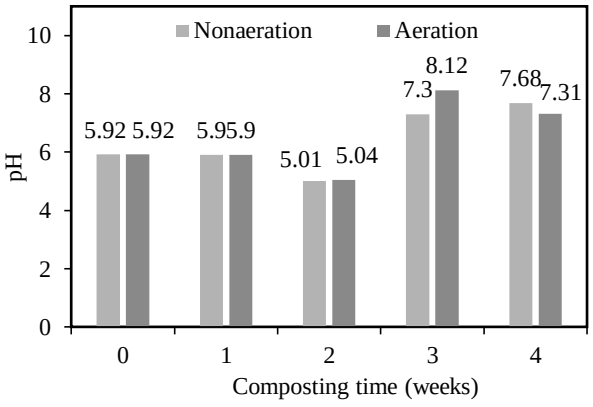

Figure 3. Results of pH analysis on composting time

From Figure 3, it is show that there was a significant increase in pH in the 3rd week. The increase was due to the nitrogen

dissolving process emitted into ammonia that reoccurs due to the activity of microorganisms. In the 4th week, the pH of the compost went down, which was caused by microorganisms that converted organic matter into high organic acids. The microbes in the composting process work at a 5.5-8 pH range, and the pH in this particular composting process are still in good condition. The highest pH was on the 3rd week of the composting process using an aeration composter, 8.12.

3.5. THE EFFECT OF TIME ON HUMIDITY AND WATER CONTENT

Moisture is directly related to the activity of bacteria in the composting process. Microorganism activity peaks at high humidity. On the other hand, low humidity can cause mold to grow.

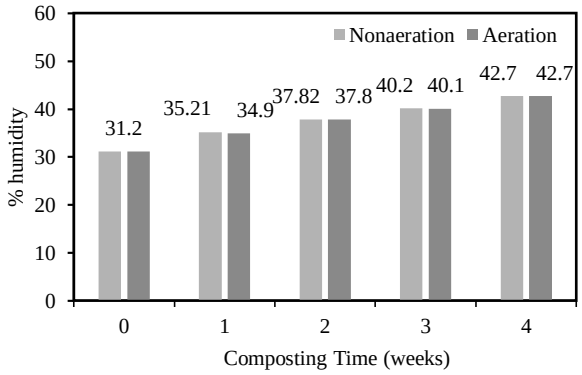

Figure 4. Results of moisture analysis on composting time.

According to Supriatna [14], humidity plays an important role in the metabolism of microorganisms. Humidity should be maintained at 40-60%. If the humidity is low, then some spraying is necessary. If the humidity is too high, it is important to repeat the composting process. If the humidity is below 40%, microbial activity will decrease and further decrease at 15% humidity. If the humidity is higher than 60%, the nutrients will be washed off, and the air volume will decrease. It will decrease microbial activity and cause anaerobic fermentation, which causes a bad odor [15]. From the analysis results (Figure 4), the humidity before the composting process was 31.2%. Over time the water content continued to increase, and in week 4, the highest water content peaks at 42.7% for the aeration and non-aeration processes. The water content will significantly accelerate the changes and decomposition of organic materials used to make compost [16].

Table 3. Analysis of water content

Water content		
SNI 19-7030-2004	Non-aeration	Aeration
40-50%	40.07	42.22

The analysis of the water content (Table 3) at the end of the composting period (week 4) showed that the non-aeration and aeration composters match the water content in SNI 19-7030-2004. If the water content is below 40% or dry, it can cause the decomposition process to slow down or even halt, but if the water content is above 60%, it can cause an anaerobic process and cause odor [17].

3.6. EFFECT OF TIME ON ORGANIC C, N (NITROGEN), P (PHOSPHORUS), AND K (POTASSIUM)

Microorganisms use carbon (C) as a source of nutrients to form new cells for their growth [10]. The decomposition rate of organic matter is related to the organic C content. The more microorganisms, the faster the organic matter is decomposed, and the more organic C is decreased. The increase in organic C in the material will reduce the decomposition rate.

The analysis results at Figure 5 show that organic C was decreased from week 0 to week 4, indicating that the number of microorganisms that decompose organic matter increased. There was a significant decrease in the type of non-aeration composter in week 4, indicating that the decomposition process occurred spontaneously. Organic C at the end of

composting was at 14.41 (non-aeration) and 24.41 (aeration). This indicates that organic C has met the requirements of ripe compost based on SNI 19-7030-2004, which is 9.8-32%.

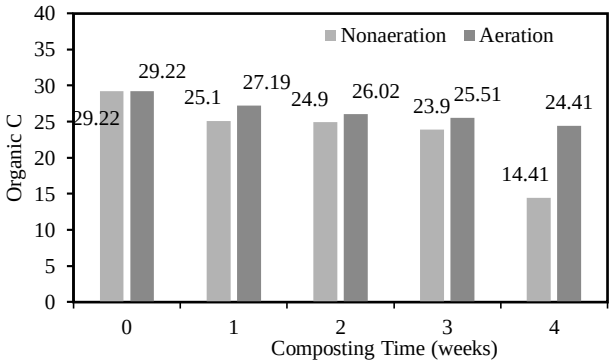

Figure 5. Results of organic C analysis on composting time

3.7. THE EFFECT OF TIME ON TOTAL NITROGEN

In the composting process, the total N will increase. The increase in total N results from the protein being decomposed by microorganisms into amino acids, and amino acids will become ammonium and oxidized into nitrate [17]. In the composting process with non-aeration and aeration types of the composter (Figure 6 & 7), the total N increased from week 0 to week 3. In week 4, there was a slight decrease, and it increased again in week 4.

The increase in total P occurs due to the microbial activity that decomposes organic matter. From the results of the analysis of the type of non-aeration composter (Figure 6), it was seen that the P from weeks 0 to 2 has decreased. This was due to the less effective decomposition process of materials by microorganisms contained in the bio activator. Then in week 3 and week 4, there was a significant increase, indicating that the microbial activity in those weeks increased, which is the opposite of the analysis obtained from the aeration composter type (Figure 7). The total P-value tends to show an increase every week, except in week 3, where it slightly decreased and resurged in week 4.

The increase in total K during the composting process is caused by microbial activity that decomposes organic matter. From week 0 to week 2 (figure 6), the total K amount did not show any change. This was similar to the total P-value because, at weeks 0 and 2, there was no significant activity carried out by microorganisms. Then in week 3 and week 4, it began to show an increase, which means that the activity of microorganisms thrives in those weeks. In the aeration composter (Figure 7), the total K value decreased in week 1 and resurged in weeks 2 and 3. It decreased in week 4. The decrease in the value of K can be caused by the nature of the element potassium, which is easy to dissolve and drift.

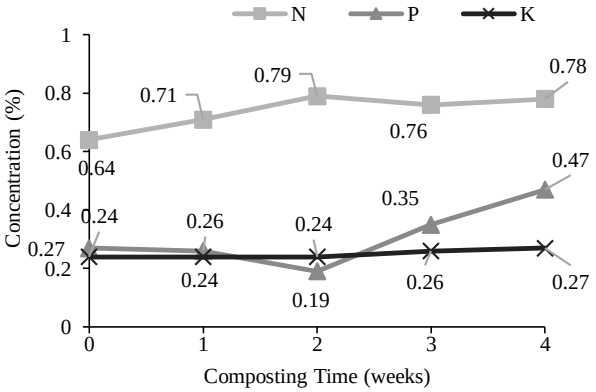

Figure 6. The analysis result of N, P, and K total value on composting time in the non-aeration composter.

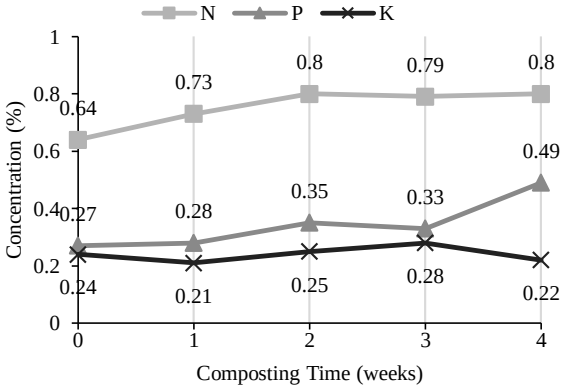

Figure 7. The analysis results of total N, P, and K values for the time of composting in aeration type composter.

From the final results of the composting process, it was apparent that composting in non-aeration and aeration types of composter had results that meet the standard of compost of SNI 19-7030-2004 (Table 4).

Table 4. Results of analysis of the amount of N, P, and K in aeration and non-aeration composters.

Parameters	Before composting	SNI	Composter	
			non-aeration	aeration
N (%)	0.64	> 0.4	0.78	0.8
P (%)	0.27	> 0.1	0.47	0.49
K (%)	0.24	> 0.2	0.27	0.22

3.8. EFFECT OF COMPOSING TIME TOWARD C/N RATIO

The C/N ratio is the ratio of carbon (C) and nitrogen (N). The C/N ratio ranges from 10- to 12. A good and receptable C/N ratio for soil is one whose value is close to or equal to it. Raw organic matter usually has a fairly high C/N ratio; therefore, composting is necessary to reduce the C/N value. Microbes that decompose organic matter require nitrogen and carbon in the composting process. Carbon acts as a source of energy, and nitrogen forms the proteins. Microorganisms require 30 parts C for 1 part N. The C/N ratio of 30 is the ratio required in an efficient composting process [4].

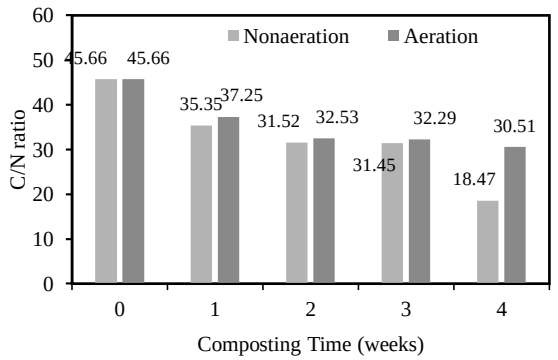

Figure 8. Results of the C/N ratio analysis on composting time

From the results of the analysis of the C/N ratio at Figure 8, the end of the composting process, non-aeration composter meets the requirements for ripe compost based on SNI 19-7030-2004, which is 10-20%. Meanwhile, in the aeration composter, the ratio of C/N is still quite high, which was 30.51.

3.9. LEACHATE GENERATED FROM THE COMPOSTING PROCESS

Leachate is a liquid that seeps down from the compost, which forms due to the dissolution and rinsing of dissolved matter and decaying by microbial activity.

Table 5. Results of analysis of leachate generated from the composting process

Type of Composter	Leachate (mL)	pH
Non-aeration	29,3	6,9
Aeration	29,5	6,8

Table 5 show that the amount of leachate produced from non-aeration and aeration composters has no significant difference, nor in the pH value. The pH of the leachate meets the compost standard of SNI 19-7030-2004, which is 6-9.

4. CONCLUSION

From the research results, conclusions were obtained that met the research objectives of testing compost production using the Orgadec as bio activator and using aeration and non-aeration type composters. The resulting compost has parameters close to SNI from the analysis: the crumbly/fine texture, brownish-black color, and earthy smell. Longer composting time gives better results. Nutrient analysis showed N values of 0.78 (non-aeration) and 0.8 (aeration); P values of 0.47 (non-aeration) and 0.49 (aeration); K values are 0.27 (non-aeration) and 0.22 (aeration). The C/N ratio of the composting process shows decreasing value from week 0 to week 4 until it came close to C/N, which was 18.47 for non-aeration composters. While the aeration composter still has a fairly high C/N ratio of 30.51.

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