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The Effect of Activator Addition to the Compost with Biopore Infiltration Hole (BIH) Method

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ABSTRACT

The composition of organic waste reaches 59% of the total municipal solid waste in Indonesia. One way to process organic waste is composting by utilizing microorganisms to break down waste into compost. Naturally, the composting process took a long time but can be accelerated by adding microorganisms to the activator. This study analyzes the quality and quantity of compost using the Biopore Infiltration Hole (BIH) method with activator addition. Composting was duplicated in the yard area with clay soil type and water infiltration rate of 0,3 cm/hour. The BIH was made in a 10 cm diameter, a 100 cm depth, and the distance between the holes was 50 cm. Composting variations consist of variations in the composition of the raw materials and the activators' uses. Variations in the raw material composition consisted of 100% yard waste, 100% food waste, 50% yard waste and 50% food waste, and 70% food waste and 30% yard waste. In contrast, the activator variations consisted of no activator, EM4 activator, and Stardec activator. Compost analysis consists of maturity, quality of physical and macro elements, and quantity of compost. The results showed that all variations of composting had met the standard of maturity and quality of physical and macro elements according to SNI 19-7030-2004. The addition of activator affected composting time and compost quantity. The composting time in BIH with activator ranges from 41-60 days. In BIH without activator ranges from 65-75 days, there was a reduction in composting time by 15-25 days with the activator addition. However, the activator addition caused reducing the compost quantity by 10-20%. The selection of compost variations by scoring results in compost with a composition of 50% yard waste and 50% food waste and the addition of Stardec activators was the best variation in terms of compost maturity, quality, and quantity.

Keywords: Activator, Biopore Infiltration Hole (BIH), Compost, Quality, Quantity

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1. Introduction

Waste is one of the problems that are closely related to human activities. Law of The Republic Indonesia Number 18 of 2008 about Waste Management stated that waste is the residue of daily human actions and solid natural processes. The increasing population growth and a consumptive lifestyle will be in line with increasing waste production. This condition is proven by data obtained from the Ministry of Environment and Forestry (2017) that Indonesia's waste production increased by an average of 1 million tons per year. Data from the Ministry of Environment and Forestry in 2018 stated that Indonesia's total organic waste is 59% consisting of 44% of food waste and 15% of yard waste. However, only 7% of the total waste was recycled, and 69% of the waste ended up in landfills, while the rest is in the environment and cannot be handled. Therefore, proper processing is needed for the organic waste problem in Indonesia.

One of the ways to process organic waste is by composting technique. Composting is a natural process of decomposing organic materials conducted by microorganisms such as bacteria, actinomycetes, and fungi (Chatterjee, 2017). Domestic waste and yard waste were the categories of organic waste that could be composted. Fruits waste, vegetable waste, potato skins, eggshells, and tea pulp are examples of organic waste that could be easily composted at home (Baya, 2014). There are several composting methods, one of which is by composting Biopore Infiltration Hole (BIH). BIH is a water infiltration method and composting on a domestic scale with 10 cm cylindrical hole made in soil and putting organic material in it as food for the organisms so that the biopore formed. Naturally, the composting process took a long time but can be accelerated by adding microorganisms contained in the activator (Damanhuri, 2016).

Research about the effect of activators' addition on the quality and duration of composting has been conducted for several composting techniques. Rahman (2016) mentioned that composting using Rotary Kilns produced compost in good quality and a shorter time when using Stardec activators than using EM4 activators. Octavia conducted another research (2012) using Takakura composting. The three activators used are EM4, Stardec, and Superfarm. EM4 and Stardec activators produce better quality

compost. The research also showed that the addition of activators could accelerate the composting process two weeks early.

Research to tested the effectiveness of leaf waste composting process using three different activators showed that leaf compost with EM4 activator showed a percentage depreciation and decreased C/N ratio faster than using activators made from orange peel waste and vegetable waste (Widianingrum and Lisdiana, 2015). Similar results were obtained from Marlinda's research (2015) on EM4 and Promi bio activators' effect in the organic liquid fertilizers production from domestic organic waste. The results showed that EM4 bio activators produce liquid fertilizer with higher organic C compared to Promi. However, the effect of adding activators to the quantity and quality of composting using the BIH method is not yet known. Therefore, this research aimed to examine the impact of activators' addition to composting using the BIH method and choose the most optimal type of activator to be used to improve the performance of composting results using the BIH method in the future.

2. Methodology

The steps of this research consist of research preparation, primary research, data processing, and analysis.

2.1. Research Preparation

Preparation of this research includes choosing the composting location, preparing compost waw materials and types of activators, and making the BIH.

In this research, BIH composting was conducted in a yard area directly exposed to the outside air. The BIH location's environmental conditions are determined by soil texture and water infiltration rate and the weather conditions during composting by recording rainy days.

This research's Compost raw materials are Yard Waste (YW) and Food Waste (FW). Yard waste consists of leaves, while food waste consists of rice waste, side dishes waste, fruit waste, and vegetable waste. Compostable waste composition refers to Eryuningsih's research (2017) for domestic waste composed of 55% vegetable waste, 30% fruit waste, 10% rice waste, and 5% side dishes waste. In this research, there are four variations of compost raw material composition, as shown in Table 1. Before putting the compost raw materials into the BIH, it was chopped with an organic waste chopper machine type MPO 500 HD so that it became a size of 10-15 mm. The activators used were EM4 and Stardec because frequently used in composting and easily obtained in the market. The amount of activator used is adjusted as the provisions on each activator packaging, Stardec is 2,5% of the weight of waste to be composted. At the same time, EM4 was mixed with sugar and water first with a ratio of 1:1:50. The composting variation is shown in Table 1, and each composting variation created a duplo.

The number of 24 holes provided according to the duplo composting variations with a diameter of 10 cm, a depth of 100 cm, and a distance between the holes was 50 cm. At the mouth of the hole, a cantilever and a cover were using perforated PVC pipe. The cross-section of the BIH shows in Figure 1.

Table 1. Variation of Raw Materials and The Use of BIH Activators

Variations	Raw Materials	Activators
1A	100% YW	Without activator
1B	100% YW	EM4
1C	100% YW	Stardec
2A	100% FW	Without activator
2B	100% FW	EM4
2C	100% FW	Stardec
3A	50% FW: 50%YW	Without activator
3B	50% FW: 50%YW	EM4
3C	50% FW: 50%YW	Stardec
4A	70% FW: 30%YW	Without activator
4B	70% FW: 30%YW	EM4
4C	70% FW: 30%YW	Stardec

Notes:
YW = Yard Waste; FW = Food Waste

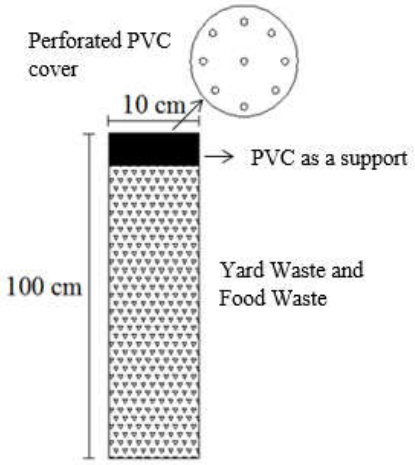

Figure 1. Cross Section of BIH

2.2. Main Research

The steps in the primary research were:

1. Analysis of compost raw materials. Parameters in analyzing raw materials include temperature, pH, water content, and C/N ratio. This analysis was to determine whether the raw materials are meeting the requirements as a compost raw material.
2. Composting. In this research, there were 12 composting variations, as seen in Table 1. The composition variation of raw materials consists of 4 variations, while there were three variations of activator that are without activator, with EM4 activator, and with Stardec activator. Composting began with putting compost raw materials and activators into the BIH. After 3/4 is fulfilled, the BIH is closed using a perforated PVC cover to avoid animals or unwanted objects getting into the BIH. During composting, the BIH weather conditions are recorded, such as the length of rainfall to complete the BIH composting analysis data.
3. Observation of compost maturity. The observed parameters for compost maturity were

temperature, pH, reduction rate, humidity, color, texture and odor, and the composting duration. Observations do every day—temperature observation using a thermometer and pH observation with a pH meter. Observe humidity by putting a wooden stick into the BIH. If the soil is humid, additives such as sawdust were added into the BIH to absorb water, whereas if the soil was dry, water was sprinkled into the BIH. Color, texture, and odor parameters were visually observed. The composting duration starts from the beginning of composting until the compost was ripe according to the standards.

4. Compost quality analysis. Compost quality test conducted after the compost was ripe and has been through drying and sifting. The physical elements analysis includes water content, temperature, pH, color, texture, and odor. In contrast, macroelements consist of C, N, C/N ratio, P, and K. Water content was measured by measuring the fresh weight and dry weight after heated at 105°C, temperature and pH measurement using thermometer pH meter. In contrast, visual measure uses for the parameter of color, texture, and odor. The measurement of the macro element using spectrophotometry method. The measurement result compares to the quality standard of domestic waste compost (SNI 19-7030-2004).
5. Compost quantity analysis. Measurement of compost quantity by weighing the solid compost produced for each composting variation.

2.3. Data Processing and Analysis

1. Analysis of raw materials, mature, quality, and quantity of compost
   Compost raw materials analysis is conducted by comparing the measurement results of Tchobanoglous and Keith (2002) while analyzing maturity and compost quality by comparing with the quality standard of domestic waste compost (SNI 19-7030-2004). Quantity analysis calculates the percentage of solid compost weight produced by dividing the weight of solid compost produced by compost raw materials' initial weight.
2. Selection of the activator type
   To choose the most optimal type of activator for the composting result, it assessed by scoring to 12 variations of the research. Scoring assesses the maturity analysis, composting duration, compost quality, and quantity analysis. The scoring criteria are as follows:
   a. Criteria 1: value "1" for the variation met the quality standard (SNI 19-7030-2004);
   b. Criteria 2: value "0" was given to variations that did not meet the quality standard (SNI 19-7030-2004);
   c. Criteria 3: for parameters that did not have a quality standard, the assessment was assessed by a ranking system. The highest score exceeds "12," and the lowest score is "1". Criteria 3 uses for the duration of composting and compost quantity parameter. The optimal composting variation was the variation that had the highest score.

3. Result and Discussion

3.1. Environment Conditions

In this research, environmental conditions data, including soil conditions around BIH and weather during composting recorded. The required soil condition data is soil texture and water infiltration rate, which is necessary to know before doing the BIH composting. The measurement results showed that the soil texture in Andalas University campus's yard area was clay loam with a water infiltration rate of 0.3 cm/hour, categorized as slow. The relation between soil texture and rainwater infiltration rate showed in Table 2.

Table 2. Relation of Soil Texture and RainWater Infiltration Rate

Soil Texture	Water Infiltration Rate (cm/hour)	Category
Sandy Clay	>3,3	Faster
Clay	2,5-3,3	Fast
Dusty Clay	1,5-2,5	Medium
Clay Loam	0,25-1,5	Slow

Source: Brata and Nelistya, 2008

Rainfall can also affect the duration of composting. If the intensity of rain in the composting area was high, then composting will be slow because of the compost's high water content. The research conducts during the transition season from the rainy season to the dry season. The duration of the rain during the composting process was recorded. During the composting process, rain occurred for 30 days with about 1-3 hours. According to the Meteorological, Climatology and Geophysics Agency (MCGA) of Padang City, the rain was categorized as light to moderate rain.

3.2. Compost Raw Materials Analysis

The raw materials used in this research were food waste and yard waste. It was analyzed to determine whether the raw materials used for composting met the standards of compost raw materials. The parameters measured were temperature, pH, humidity, and C/N ratio. The temperature of food waste was 26°C, and the yard waste was 28°C. It was because the water content in food waste was more than yard waste. Based on the water content test in the compost raw materials, the water content of food waste was 58%. The water content of yard waste was 51%—the more water content in compost raw materials, the lower the temperature (Ratna, 2017).

The initial pH of food waste compost raw materials was 6,5, while the pH of yard waste was 6.6. Food waste had a more acidic initial pH compared to yard waste. According to Kurnia (2017), food waste had a pH of 3 to 6, while yard waste had a pH of 6 to 7. At the beginning of composting, the pH of raw materials was commonly acidic to neutral (pH 6-7) (Tchobanoglous and Keith, 2002).

Table 3. Compost Raw Materials Analysis

Parameter	Raw Materials		Standards*	Information
	Yard Waste	Food Waste		
Temperature	28°C	26°C	25°C -28°C	Qualified
pH	6,6	6,5	6-7	Qualified
Water Content	51%	58%	50%-60%	Qualified
C/N Ratio	40	34,8	25-50	Qualified

*Source: *Tchobanoglous and Keith, 2002*

Table 4. C/N Ratio of Compost Raw Materials

Variations	C/N Ratio	Standards*	Information
1 (100% YW)	40	25-50	Qualified
2 (100% FW)	34,8	25-50	Qualified
3 (50% FW : 50% YW)	37,4	25-50	Qualified
4 (70% FW : 30% YW)	36,4	25-50	Qualified

*Source: *Tchobanoglous and Keith, 2002*

The result of the analysis of the C/N ratio of compost raw materials showed C/N rate of food waste was 34.8%, and yard waste was 40%. It has met the standard C/N ratio of 25-50% (Tchobanoglous and Keith, 2002). If the C/N ratio of compost raw materials was high, it caused microorganisms to lack nitrogen to synthesize proteins so that the decomposition process ran slowly. However, if the C/N ratio were too low would causing too much nitrogen, so the nitrogen will disappear into the atmosphere in the form of ammonia gas that causing an unpleasant odor (Ismayana, 2012). The compost raw material analysis results in this research show in Table 3 and Table 4. All variations of raw materials have met the standards of compost raw materials obtained from the analysis results to be used for composting.

3.3. Compost Maturity Analysis

Compost maturity analysis is conducted daily on temperature parameters, pH, reduction rate, humidity, texture and color, odor, and composting duration. Based on the results of compost maturity monitoring, all composting variations have met the standard of maturity according to SNI 19-7030-2004, which is the temperature less than 30°C or equal to groundwater temperature, neutral pH, the reduction rate of 20%-40%, also texture, color, and odor that resembled soil.

Composting duration was about 41-75 days. Composting was faster on variations with the addition of activators (variations B and C) than variations without the addition of activators (variation A). Composting duration of variations with activators' addition was about 41-65 days, while variations without activators' addition were about 65-75 days. The addition of activators could accelerate the composting of the BIH for 10-15 days. Composting duration was faster in variation with the addition of Stardec activator (C variation) than the addition of EM4 activator (variation B). Composting duration with the addition of Stardec activators was about 41-59 days, while the addition of EM4 activator was about 42-60 days. It was caused by the composition of microorganisms contained in each activator. It was also found in research with composting using Rotary kiln composter. Composting with the addition of Stardec activator took time faster than composting using EM4 activator and without activators (Rahman, et al. 2016).

Table 5. BIH Compost Maturity Analysis

Variations	Temperature (°C)	pH	Reduction Rate (%)	Humidity	Texture and Color	Odor	Composting Duration (day)
1A	28	7,2	25	less humid	soil and black	soil	75
1B	28	7,3	25	less humid	soil and black	soil	60
1C	27	7,2	29	less humid	soil and black	soil	59
2A	28	7,1	54	less humid	soil and black	soil	70
2B	28	7,2	48	less humid	soil and black	soil	55
2C	28	7,1	46	less humid	soil and black	soil	53
3A	28	7,2	41	less humid	soil and black	soil	65
3B	28	7,3	36	less humid	soil and black	soil	45
3C	28	7,4	38	less humid	soil and black	soil	43
4A	28	7,0	41	less humid	soil and black	soil	65
4B	27	7,3	38	less humid	soil and black	soil	42
4C	28	7,3	39	less humid	soil and black	soil	41

Besides the type of activator, the maturity of BIH composting was also affected by compost raw materials' composition. Composting was riped faster on mixed raw materials between food waste and yard waste (variations 3 and 4), which took 41-65 days, compared to variations without mixing raw materials (variations 1 and 2) that took 53-75 days. Composting with a mixture of compost raw materials that consist of food waste and yard waste also accelerates the maturity of composting using Rotary Kiln composter (Ramadhano, 2016). However, compared to other composting methods such as Takakura and Rotary Kiln, BIH composting took a longer composting time. BIH composting was conducted at the opened area so that it was affected by the weather. If it were rain, composting would run slowly due to the high soil humidity in the BIH to interfere with the organic material process decomposition. The final result of compost maturity analysis for each research variations showed in Table 5.

3.4. Compost Quality Analysis

Compost quality analysis conducts after it was riped, dried, and sifted. The quality analysis assesses the physical elements and macro elements. Physical elements include water content, temperature, pH,

color, and odor, while macro elements include C-Organic, Nitrogen, C/N ratio, Phosphor (P_2O_5), and Kalium (K_2O). The test results showed that compost produced from all research variations had met the domestic waste compost quality standards according to SNI 19-7030-2004. The water content of riped compost was in the range of 31,45% to 49,40%, the temperature in the range of 28-29 °C, pH in the neutral range of 7,1-7,4 with black color and an odor resembling soil. Results of macroelements show that the C-Organic was in the range of 9,90 to 14,20%. The N-Total was in between 0,51-0,82%. The C/N ratio was in between 14,11 to 19,93. Phosphor content was in between 0,15-0,34%. And Kalium was in between 6,7-11,29%. Comparison of compost quality analysis results and quality standards showed in Table 6 and Table 7. The variations in the composition of compost raw materials and variations in the type of activators show that the quality of compost produced has met the compost quality standards according to SNI 19-7030-2004, so consumers can apply it widely.

Table 6. Physical Element of Compost Quality Analysis

Variations	Water Content (%)	Temperature (°C)	pH	Color	Odor	Information
1A	33,42	28	7,3	black	soil	qualified
1B	32,96	29	7,3	black	soil	qualified
1C	31,45	28	7,2	black	soil	qualified
2A	43,59	28	7,2	black	soil	qualified
2B	49,40	28	7,1	black	soil	qualified
2C	49,21	28	7,2	black	soil	qualified
3A	39,03	28	7,3	black	soil	qualified
3B	38,60	29	7,2	black	soil	qualified
3C	36,53	29	7,4	black	soil	qualified
4A	41,43	28	7,1	black	soil	qualified
4B	47,70	28	7,2	black	soil	qualified
4C	48,92	29	7,3	black	soil	qualified
Standard	<50%	<30°C	6,8-7,49	Black	Soil	

Table 7. Macro Element of Compost Quality Analysis

Variations	C-Organic (%)	N Total (%)	C/N Ratio	Phosphor (%)	Kalium (%)
1A	9,90	0,57	17,30	0,34	7,1
1B	10,11	0,61	16,44	0,15	6,87
1C	10,10	0,59	17,13	0,16	7,11
2A	10,40	0,74	14,11	0,21	8,4
2B	11,66	0,59	19,93	0,27	9,30
2C	13,09	0,75	17,46	0,31	11,29
3A	10,00	0,51	19,58	0,16	6,7
3B	10,42	0,61	17,09	0,25	8,51
3C	10,71	0,60	17,86	0,19	8,74
4A	10,20	0,59	17,24	0,22	7,1
4B	14,20	0,82	17,21	0,22	9,86
4C	12,19	0,79	15,52	0,29	9,54
Standard	9,8-32%	>0,4%	10-20	>0,1%	>0,2%

The addition of EM4 and Stardec activator to the composting using Rotary Kiln also showed similar results with this research. The results showed that the riped compost's water content was in the range of 38,71% to 43,81%, the temperature between 29-30 °C, neutral pH was 7 with black color and odor resembling soil. For macro element parameters, C-Organic was between 15,32-19,68%, N-Total was in the range of 0,55% to 1,04%, C/N ratio was between 18,91 to 27,66, Phosphor was 5,71%, and Kalium was between 0,75-0,86%. The quality of compost obtained also met the compost quality standards according to SNI 19-7030-2004 (Rahman, 2016).

3.5. Compost Quantity Analysis

Varies of raw materials weight was put into the BIH due to the different types of raw materials. The raw materials were containing more food waste than yard waste. Therefore, quantity analysis is conducted based on the percentage of solid compost weight produced, which is obtained from comparing the solid compost weight with the compost raw materials' initial weight put into the BIH.

Based on quantity measurement, the variation with activators' addition produced less compost than those that did not use activators. The percentage of compost quantity with the addition of activators (variations B and C) ranges from 33,50% - 70%, while variations without activators (variation A) range from 51,25% - 81,43%. The same result was also obtained in the research using Takakura composting, which mentioned that composting with activators' addition has more reduction rate compared to variations that did not use activators. Composting with the addition of activators has more microorganisms to decompose organic materials so that it is well decomposed and more reducted than composting without activators.

In this research, 2C variation with 100% composition of food waste and Stardec activator produced the least compost quantity. The texture of food waste is softer and more comfortable to decompose coupled with Stardec activator

microorganisms, causing more reduction of the compost. Table 8 showed the results of compost quality analysis of all research variations.

Table 8. BIH Compost Quantity Analysis

Variations	Raw Materials (Kg)	Solid Compost (Kg)	Quantity Percentage (%)
1A	0,8	0,54	66,88
1B	0,8	0,56	70,00
1C	0,8	0,57	70,63
2A	2	1,03	51,25
2B	2	0,75	37,50
2C	2	0,67	33,50
3A	1,4	1,14	81,43
3B	1,4	0,89	63,57
3C	1,4	1,01	72,14
4A	1,8	1,40	77,50
4B	1,8	0,92	51,11
4C	1,8	0,79	43,89

3.6. Selection of The Composting Variations

The optimal composting selected based on the type of activator and the composition of the raw materials by scoring the analysis results of compost maturity, composting duration, quality, and compost quantity.

From the results of the maturity analysis test with six parameters tested that are temperature, pH, reduction rate, humidity, texture and color, and also odor (Table 5), all variations have met the quality standard so that they were given a value of "6" for each variation. The compost quality test results are drawn in Table 6 and Table 7. The results show that all variations have met the quality standard; thus, they reach the highest value of "10" for all variations.

The result of criteria 3 shows that both variations; the fastest composting duration and the most solid compost quantity, was given the highest value of "12". The result of scoring the selection of raw materials composition and activator type shows in Table 9.

The variation with the highest score is the 3C variation, which is composting with the composition of raw materials consisting of 50% yard waste and 50% food waste with the addition of Stardec activator.

Table 9. Scoring The Composting Variations Selection

Variations	Composting Time	Compost Maturity	Compost Quality	Compost Quantity	Total Score
1A	1	6	10	7	24
1B	4	6	10	8	28
1C	5	6	10	9	30
2A	2	6	10	5	23
2B	6	6	10	2	24
2C	7	6	10	1	24
3A	3	6	10	12	31
3B	8	6	10	6	30
3C	9	6	10	10	35
4A	3	6	10	11	30
4B	10	6	10	4	30
4C	11	6	10	3	30

3.7. Recommendaion

The results of this research showed that the BIH method took the composting time up to 75 days. The long composting time was affected by soil conditions and rainfall. The texture of clay loam with a slow category water infiltration rate of 0,3 cm/h was one of the causes of slow-processing composting. The slow rate of water infiltration caused the infiltration of rainwater entering the BIH to take time a little longer. The compost humidity was high, and the decomposition was slowly processed. Therefore, composting was recommended in the dry season for a faster-composting process. In the dry season, the intensity of rain was lower so that BIH was not easily inundated, and the compost would ripen faster. The BIH method's purpose was to increase groundwater reverse, increase water infiltration rate, increase soil fertility, and produce compost. In this research, the water infiltration rate follows after the BIH composting. The test results obtained an increase in water infiltration rate from 0,3 cm/hour before the composting began to 0,8 cm/hour after composting. This result showed that it had fulfilled the BIH's purposes, besides increasing groundwater reserve and producing compost.

4. Conclusion

This research found that all variations of composting have met the quality standards of domestic organic compost according to SNI 19-7030-2004. The addition of activators and the use of a mixture of yard waste and food waste as the raw materials affected the compost maturity duration and the compost quantity produced. Variation with the raw materials' composition was 50% of yard waste and 50% of food waste. The addition of the Stardec activator was the best variation on composting using the BIH method.

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