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THE EFFECT OF RAW MATERIAL COMPOSITIONON COMPOSTING RESULT WITH THE BIOPORE INFILTRATION HOLE (BIH) METHOD

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ABSTRACT

Besides functioning as water infiltration, biopore infiltration holes (BIH) also work as composting of organic waste. This study aims to analyze the effect of raw material composition on the quality and quantity of compost using the BIH method. Composting was done in duplicate in the yard area with clay soil type and water infiltration rate was 0.3 cm/hour. The holes were made with10 cm of diameter, 100 cm of depth and the distance between the holes are 50 cm. There were 4 composting variations i.e., 100%-yard waste, 100% food waste, 50%-yard waste and 50% food waste, and 70% food waste and 30%-yard waste. The analysis was done toward compost maturity, compost quality (physical and macro elements) and compost quantity. The results showed that all variations of compost raw materials had met the standard of maturity and quality of physical and macro-compost elements according to SNI 19-7030-2004 regarding compost specifications from domestic organic waste, with composting time ranging from 65-75 days. Composts that consist of food waste and yard waste can accelerate the composting time by 5 days, compared to compost without mixture. The best variation in terms of maturity, quality and quantity is a variety of raw materials consisting of 50%-yard waste and 50% food waste.

Keywords: compost, maturity, quality, quantity, biopore infiltration hole (BIH).

INTRODUCTION

Biodegradable waste is organic waste that easily processed by microorganisms. The examples of organic biodegradable waste are food waste, fruits, vegetables, and leaves [3, 5]. Based on data from [10], as much as 57% of the total waste is organic waste with only 14% of organic waste that processed and 66% of the waste ends up in landfill while the rest is in the environment and could not be handled. Biodegradable waste can be processed by composting techniques. Composting is a controlled decomposition, a natural process of decomposing organic materials by microorganisms. Composting transforms organic material into biologically stable materials containing humus substances [6].

There are several composting methods that have been developed, one of which is the Biopore Infiltration Hole (BIH) composting method. BIH is basically widely recognized by the public as a technology to absorb water into the ground. Besides that, BIH also has an important role in helping waste processing. Other benefits of BIH are improving soil ecosystems, absorb water, prevent flood, increase groundwater reserves, facilitate waste handling and maintain cleanliness and turn waste into compost [4]. The BIH composting method is different from other types of ground composting. BIH uses the soil as a medium for compost formation. BIH technology is a man-made, cylindrical hole made vertically into the ground with 10-30 cm diameter and 50-100 cm depth that is made in a house or garden yard. The waste that enters the BIH then becomes a food source for various soil fauna. Soil fauna can process the waste by reducing its size and mixing it with soil microbes which can synergistically accelerate the natural composting process [13].

Some of the factors that influence composting are the C/N ratio of raw materials, composition of raw materials, humidity, temperature and microorganisms [15]. Composting performance improvement can be done by examining the parameters that affect BIH composting and related to the quality and quantity of compost. Several studies have been conducted to improve composting performance, including research [12] on the comparison of types of organic waste to composting time in BIH, where it was found that the composting time for BIH was 30 days for fish wastes, 42 days for fruit skins and 40 days for the remaining vegetables. Meanwhile, research [18] showed that BIH filled with leaves took 1 month to begin to rot, while BIH filled with kitchen waste or food scraps took shorter time to start rotting, about 7 days. From these two studies, it was found that the type of waste that was put into the BIH affected the composting time [12, 17]. However, in these previous studies, analysis of the composition of organic waste as raw material for BIH composting had not been analyzed. For this reason, this study aims to analyze the composition of compost raw materials on the performance of BIH composting in terms of maturity, quality, quantity and duration of composting.

METHODOLOGY

In the beginning, research preparation was carried out consisting of selecting the composting location, preparing the compost raw materials and preparing the equipment for BIH composting. From the results of field survey, location of the yard to build BIH was chosen, with a distance of 2 m from the building. Location of the BIH is in the middle of the yard, so that it is in direct contact with the outside air, both during rainy and hot sun. To see the initial soil condition before composting, the soil type and water infiltration rate are tested.

The raw materials used in BIH composting are yard waste (YW) and food waste (FW), which are easily

biodegradable waste commonly found in domestic sources. The yard waste used consists of leaves, while food waste consists of leftover rice, leftover side dishes, leftover fruits, and leftover vegetables suitable for compost. The percentage of food waste used in this study refers to research [6] regarding the composition of household food waste consisting of 54% vegetable waste, 29% fruit leftover, 12% leftover rice and 5% leftover side dishes. To standardize the size, the compost raw material is chopped using an organic waste shredder type MPO 500 HD electric, so that it has a size of 0.3-1 cm. The variation in the composition of the compost raw material used in this study can be seen in Table-1. The equipment used in this study can be seen in Table-2. The equipment consists of BIH making tools and tools to measure the maturity of the quality and quantity of compost.

Table-1. Variation of compost raw material composition.

Variation	Raw Material
1	100% YW
2	100% FW
3	50% FW: 50%YW
4	70% FW: 30%YW

Note:
YW = Yard Waste; FW = Food Waste

. **Table-2.** Research equipments.

Item	Function
BIH drill	Make BIH
Pipe and PVC cover	Cover the BIH
Organic-waste shredder	Shred raw material
pH meter	Measure the compost pH
Thermometer	Measure the compost temperature
Sieve (diameter 3 cm)	Sieve compost
Scale	Weigh solid compost
Spectrophotometer	MeasureC-Organic and Phosphor
Atomic Absorption Spectrophotometer (AAS)	Measure Kalium level

Furthermore, the BIH was made using a BIH drill. Eight holes were made because the research was done in duplicate. Holes diameter is 10 cm with 100 cm depth and the distance between holes was 50 cm [4]. The mouth of the hole is supported using PVC pipe and the hole is covered using PVC cover that has been perforated to prevent unwanted animals or objects from entering the BIH. The cross section of the BIH can be seen in Figure-1.

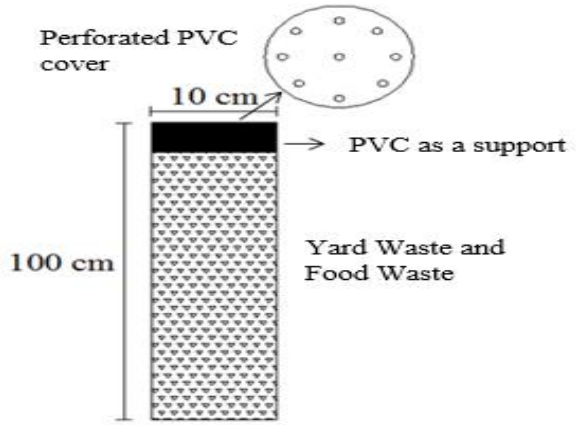

Figure-1. BIH cross section.

The research began with the analysis of compost raw materials including temperature, pH, moisture content, and C/N ratio. This analysis aims to determine whether the compost raw material used fulfilled the requirements as compost raw material based on literature. If raw material had met the standard, compost is carried out by entering the raw material into the BIH according to the composting variation, as shown in Table-1. During composting, compost maturity test was done every day. Monitoring for maturity includes temperature, pH, reduction level, humidity, color, texture and odor. Measurement of temperature and pH were done using a thermometer and pH meter. The compost reduction was done by measuring the percentage of waste reduction in the BIH. Moisture, color and texture were visually observed. If monitoring showed that the compost had matured according to the standard, the compost was removed from the hole. The compost is ripe when it reached soil temperature, which is ≤ 30°C, pH reached neutral pH, reduction level of 20-40%, less moisture, texture and color resembles soil and smells of soil [13]. Then the compost was dried in the shade or not exposed to direct sunlight. The compost sieved with a compost sieving machine to obtain a uniform compost size. After composting, the water infiltration rate test was conducted again, to find out the differences that occurred after composting.

The measurement of ripe compost quality includes physical elements and macro elements [2]. Measurement of macro elements was done using the spectrophotometric method. The measurement results are compared with the quality standard of domestic waste compost based on SNI 19-70-30-2004. Besides quality, the quantity of solid compost was also measured by weighing the compost by each variation.

Next, the selection of BIH composting variations was done by scoring the maturity, duration of composting, quality and quantity of compost. The scoring criteria are: (a) for parameters that have a quality standard, a value of 1 is given if the variation met the SNI 19-7030-2004 quality standard, while those that did not met the SNI 19-7030-2004 quality standard are given a value of 0. (b) For parameters that did not have a quality standard, the score was given according to the ranking, the highest score was

given with a score of 4 and the lowest score is given a score of 1. Criterion (a) are used for the analysis of compost maturity and quality parameters, while criterion (b) is used for composting time parameters and compost quantity. The selected optimal composting variation was the variation with the highest score.

RESULTS AND DISCUSSIONS

Environmental Conditions

The first step on doing BIH composting research was knowing the soil conditions. Soil conditions include the rate of water infiltration in the soil and soil types. From the test results, the water infiltration rate was 0.3 cm/hour which is in the slow category [4] with clay type of soil.

Rainfall can also affect composting time. If the intensity of rain occurs in the composting area was high, then composting will be slow due to the high moisture content of the compost [14]. This research was conducted in the transition from the rainy season to the dry season. The rain occurs during the composting process was recorded. Then, the rain data was classified into moderate rain and light rain by referring to data Padang City [1]

Raw Material Analysis

Analysis of compost raw materials was done to determine the condition of raw materials before the composting process. Analysis of compost raw materials includes raw material temperature, pH, humidity, and C/N ratio. From the measurement results, the raw material for food compost has a lower temperature, about 26°C compared to yard waste, which is 28°C. This was because the water content in food waste was higher than in yard waste. Based on the water content test of compost raw materials, the water content of food waste was 58% and water content of yard waste was51%. The higher water content in the compost raw material, the lower the temperature will be [14].

The pH of raw materials at the beginning of composting is generally acidic to neutral (pH 6-7) [17]. The initial pH of food waste is 6.5, while the pH of yard waste is 6.6. Food waste has more acidic starting pH than yard waste. According to [11], food waste has a pH of 3 to 6, while yard waste has a pH of 6 to 7.

The C/N ratio is an important parameter in the composting process. If the C/N ratio of raw materials was high, microorganisms will lack N for protein synthesis and the decomposition process became slow, whereas if the C/N ratio is too low due to too much nitrogen, nitrogen will be released to the atmosphere in the form of ammonia gas which can cause bad smell [8]. Analysis of compost raw materials in this study can be seen in Table-3, while the C/N ratio of the various compost raw materials can be seen in Table-4.

Table-3. Compost raw material analysis.

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

* Tchobanoglous, 2002

Table-4. C/N ratio of compost raw material.

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

*****Tchobanoglous, 2002

Compost Maturity Analysis

During the composting process, compost maturity was monitored every day until the compost is ripe. The parameters measured were temperature, pH, reduction level, humidity, texture and color, odor, and composting time. Based on the results of compost maturity monitoring, all composting variations had met the maturity standard based on SNI 19-7030-2004, the temperatures less than 30°C or the same as groundwater temperatures, neutral pH, reduction levels of 20% -40%, as well as texture, color, and the smell of compost that resembles soil. The temperature for mature compost for all variations ranges from 27°C to 28°C. The pH of ripe compost for all variations were in the neutral range, from 7 to 7.4. The reduction rate was in the range of 32% to 54% and the texture, color and smell of ripe compost resemble soil.

The composting time for the certain type of raw material (variations 1 and 2) was 70 and 75 days, while the composting time for a mixture of food waste and yard waste (variations 3 and 4) took 65 days. Composting with the BIH method required a longer composting time than other composting methods such as takakura and *Rotary*

Kiln. This was because BIH composting was done in an open area so it was influenced by the weather. If the BIH is exposed to rain, it will take longer composting time because the water enters the BIH will interfere with the decomposition process of organic matters. In this study, during the composting process there were 38 rainy days classified as light to moderate rain. In addition, the slow rate of infiltration of water causes rainwater enters the BIH to take longer to infiltrate so that the humidity of the compost was high and the decomposition process was slow. The results of compost maturity analysis can be seen in Table-5.

Compost Quality Analysis

Compost quality testing was done after the compost was ripe, after a process of drying and sieving. Compost quality analysis was done on physical and macro elements based on SNI 19-7030-2004. Physical elements include water content, temperature, pH, color, and smell, while macro elements include C-Organic, Nitrogen, C/N Ratio, Phosphor (P_2O_5), and Kalium (K_2O).

Based on the compost quality test, it was found that all variations of compost raw materials in this study had met the quality standards of compost based on SNI 19-7030-2004 for both physical and macro elements. The water content of the compost ranges from 33.42% to 48.39%, the temperature was at 28°C, the pH was in the neutral range of 7.0-7.4 with a blackish color and smells like soil. For macro element parameters, C-Organic was in the range 9.9% to 11.4%, N-Total was in the range 0.51% to 0.81%, the C/N ratio was in the range 14.11 to 19.58, Phosphor was in the range 0.15% up to 0.29% and Kalium was in the range 6.7% to 9.2%. Analysis of compost quality for physical and macro elements of all variations of compost raw materials can be seen in Table-6 and Table-7.

Compost Quantity Analysis

Analysis of the quantity of compost for all variations of compost raw materials is shown in Table-8. Based on the measurement of the quantity, it was found that the percentage of compost quantity ranged from 57.5% to 78.6% of the initial quantity of compost raw material that was put into BIH. The composting variation that produces the most compost is variation 3 which consists of 50% food waste and 50%-yard waste. The quantity of solid compost was influenced by the type and composition of the compost raw material. Compost which consists of a mixture of food waste and yard waste decomposes faster, compared to similar compost raw materials.

Selection of BIH Composting Variation

The selection of the best BIH composting variations was done by scoring. The results of the scoring of each BIH composting variation can be seen in Table-9. The composting variation with the highest score was variation 3, namely the composition of raw materials consisting of 50%-yard waste and 50% food waste. This is influenced by the shorter composting time and the quantity of solid compost produced is more than the other composting variations. Raw material composition affects composting time and compost quantity. Compost consisting of a mixture of food and yard waste will decompose faster [9].

Table-5. Compost maturity analysis.

Variation	Temperature (ºC)	pH	Reduction Level	Humidity	Texture and Colour	Odor	Composting Duration (days)
1	28	7.3	25	Less humid	Soil and black	Soil	75
2	28	7.4	54	Less humid	Soil and black	Soil	70
3	28	7.2	41	Less humid	Soil and black	Soil	65
4	28	7.0	41	Less humid	Soil and black	Soil	65

Table-6. Physical elements analysis.

Variation	Water Content (%)	Temperature (ºC)	pH	Colour	Odor	Remarks
1	33.42	28	7.3	Black	Soil	Accepted
2	48.39	28	7.4	Black	Soil	Accepted
3	39.03	28	7.2	Black	Soil	Accepted
4	41.43	28	7.0	Black	Soil	Accepted
Standard	<50%	<30°C	6.8-7.49	Black	Soil	

Table-7. Macro elements analysis.

Variation	C-Organic	N Total	Ratio C/N	Phosphor	Kalium
1	9.9	0.57	17.30	0.29	7.1
2	11.4	0.81	14.11	0.24	9.2
3	10.0	0.51	19.58	0.15	6.7
4	10.2	0.59	17.24	0.22	7.1
Standard	9.8-32%	>0.4%	10-20	>0.1%	>0.2%

Table-8. Compost quantity analysis.

Variation	Raw Material (kg)	Solid Compost (kg)	Quantity Percentage (%)
1	0.8	0.54	73.8
2	2	1.03	58.8
3	1.4	1.14	81.4
4	1.8	1.40	77.5

Table-9. Scoring.

Variation	Compost maturity	Compost quality	Compost quantity	Total score
1	9	10	2	21
2	10	10	1	21
3	11	10	4	25
4	11	10	3	24

RECOMMENDATION

The main purpose of the BIH composting method is to increase groundwater reserves, increase the rate of water infiltration, increase soil fertility, and produce compost. In this study, the water infiltration rate was tested after BIH was applied so that the water infiltration rate was increased to 0.8 cm/hour from 0.3 cm/hour. These results indicate that the goal of BIH in increasing the rate of water infiltration has been fulfilled. Likewise, with the aim of producing compost, from this research the compost produced has met SNI 19-7030-2004 regarding the quality standard of domestic waste compost.

However, in BIH composting, it took longer time to reach compost maturity. This was influenced by weather conditions, because composting was done in an open area. To overcome this, the recommendation that can be given is to compost BIH during the dry season. In the dry season, the rain intensity tends to be lower so that the BIH is not easily flooded and the compost will ripen faster [16], [19].

CONCLUSIONS

The results showed that the composition of the raw materials affected the maturity process and the duration of BIH composting as well as the quality and quantity of compost. Compost raw materials consisting of a mixture of yard waste and food waste can speed up the composting time of 5 days and increase the quantity of compost by 21% compared to similar raw materials. The composition of the most optimal compost raw material for BIH composting consists of a mixture of 50% food waste and 50%-yard waste. From the results of the compost maturity and quality test, this variation has met the SNI 19-7030-2004 standards regarding the specifications for compost from domestic organic waste. The composting time for this variation is 65 days and the percentage of quantity of solid compost produced was 81.4%.

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REFERENCES

[1] Meteorology, Climatology and Geophysics Agency. 2019. [Online].http://www.bmkg.go.id. [Accessed date 10 September 2019].

[2] National Standarization Agency.SNI 19-7030-2004 about Compost Spesification from Organic Domestic Waste, 2004.

[3] Baya S.N., Azura Irnis. Naraiti Tengku. 2014. Mini Review: Environmental Benefits of Composting Organic Solid Waste by Organic Additives in Malaysia. Bulletin of Environmental Science and Management. 2(1): 1-17.

[4] Brata Kamir R. and A. Nelistya. 2008. Biopore Infiltration Hole, Penebar Swadaya, Jakarta.

[5] Chatterjee R., Gajjela S., Thirumdasu R. K. 2017. Recycling of Organic Waste for Sustainable Soil Health and Crop Growth. International Journal of Waste Resources. 7: 1-8, 2017. ISSN 2252-5211.

[6] Damanhuri E. & Padmi T. 2016. Integrated Waste Management. Bandung. Environmental Engineering Bandung Technology Institute (ITB).

[7] Eryuningsih W., Slamet R. & Ruslinda. Y. 2017. Design and Performance Testing of Communal Composter for Processing Domestic Waste. Final Project. Padang: Environmental Engineering Andalas University.

[8] Ismayana A., Nastiti S. I. & Suprihatin. 2012. Initial C/N Ratio Factor and Aeration Rate in Bagasse and Blotong Co-Composting Process. Journal of Agricultural Industry Technology. 22(3): 173-179.

[9] Jalaluddin., ZA, Nurul., Syafrina., Rizki. 2016. Processing of Fruit Organic Waste into Fertilizer Using Effective Microorganisms. Journal of Chemical Technology Unimal. 5(1): 17-29.

[10] Ministry of Environment and Forestry, National Waste Management Information System, 2018. [Online]. http://www.sipsn.menlhk.go.id/. [Accessed: 11 August 2019]

[11] Kurnia V. C., Sri S. & Ganjar S. 2017. The Effect of Moisture Content on the Results of Composting Organic Waste Using the Open Windrow Method. Journal of Mechanical Engineering. 6(2): 119-123, 2017.ISSN 2549 -2888.

[12] Mawaddah. 2018. Comparison of the Types of Organic Waste to the Length of Composting Time in the Biopore Infiltration Hole as a Reference for Ecology and Environmental Problems Subjects. Thesis. Banda Aceh: Ar-raniry State Islamic University.

[13] Nugroho S & Hadi W. 2019. Application of Biopore Infiltration Hole as an Urban Runoff Management IPTEK Journal of Procedings Series. (5): 324-332.

[14] Ratna, Dian Asri Puspaand Samudro, Ganjarand Sumiyati Sri. 217. Effect of Water Content on the Process of Composting Organic Waste with the Takakura Method. Environmental Engineering Journal. 06(2): 124-128.

[15] Rezagama, Arya dan Samudro Ganjar. 2015. Takakura Optimization Study and Addition of Husk and Bran. Presipitation Journal. 12(2): 66-70.

[16] Ruslinda Y., Aziz R., Arum L. S., Sari N. 2021. The Effect of Activator Addition to the Compost with Biopore Infiltration Hole (BIH Method). Jurnal Ilmu Lingkungan. 19(1): 53-59, doi:10.14710/jil.19.1.53-59.

[17] Tchobanoglous. 2002. Integrated Solid Waste Management-Engineering Principles and Management Issues. New York: McGraw-Hill.

[18] Widyastuti Sri. 2013. Comparison of Types of Waste to the Length of Composting Time in the Biopore Infiltration Hole. Time Engineering Journal. 11(07): 5-14.

[19] Y. Ruslinda, R. Aziz, N. Sariand L. S. Arum. 2021. The effect of chopping raw material on composting result withthe biopore infiltration hole method. IOP Conf. Series: Materials Science and Engineering, doi:10.1088/1757-899X/1041/1/012033.