The effect of chopping raw material on composting result with the biopore infiltration hole method

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Abstract. This research aims to analyze the effect of chopping raw material on compost quality and quantity that was made with the biopore infiltration hole method. The composting was done in duplo on the backyard with clay soil type, and the water infiltration rate was 0.3 cm/hour. The holes were made with 10 cm of diameter, 100 cm of depth, and the distance between holes were 50 cm. There were four composition variations on this research i.e 50% yard waste and 50% food waste with and without chopping, 70% food waste and 30% yard waste with and without chopping. The chopping was using an organic waste chopping machine so that the waste size became 0.3 - 1.5 cm, while the size waste without chopping was ≥ 3 cm. The compost analysis was done toward maturity, compost quality (physical elements and macro elements), and compost quantity. The composting process took 65-80 days to get riped. The best variation was chosen by the scoring method. The result showed that compost with 50% yard waste and 50% food waste was the best variation because the compost quality has met the standard for physical elements and macro elements, it produced more compost quantity. The chopping process could speed up the composting time until 15 days.

1. Background
Organic waste consists of food waste, paper, carton, plastic, and yard waste [1]. Organic waste has the most significant percentage of whole waste production in Indonesia. Based on data from the Ministry of Environment, 57% of total waste is organic waste[2]. The amount of organic waste that can be processed is only 14%, and 66% ends up in the landfill, while the rest are in the environment and cannot be handled. The most widely used, biodegradable organic waste processing is composting. Composting is a natural process of decomposition of organic materials or decomposition by microorganisms on biodegradable organic materials. Composting converts biodegradable organic materials into biological materials that contain humus substances [1].

One of the composting methods is the biopore infiltration hole method. Biopore infiltration hole has a vital function in assisting waste processing. It has many advantages to the environment, such as improving the soil ecosystem, absorbing water, preventing flood, increasing groundwater reserves, facilitating waste handling, maintaining cleanliness, and turning waste into compost [3]. The biopore infiltration hole method is different from the other ground composting method. It uses soil as a medium to convert waste into compost. In this method, waste is put into a hole with a diameter 10-30 cm and 50-100 cm depth, made in the house yard or garden. After that, the waste in the hole is eaten by biota in the ground. That biota could process the waste by decreasing its size and mixing it with a microbe to speed up the composting process naturally [4].

From the various benefits of this method above, many efforts have been made by the Indonesian Government to promote biopore infiltration hole method as a filler for groundwater reserves and as a compost maker to reduce the amount of domestic organic waste. However, in its implementation, people commonly put the waste directly into the hole without any treatment or addition like activator or starter addition, so that the result was not optimal and required a longer composting time. Some factors could affect the process, such as the C/N ratio, the size, and composition of waste, humidity, temperature, and microorganisms [3]. In this research, the wastes were chopped first before being
composted. So, the waste size became smaller and even. The optimal size waste for composting are 2.5-7.5 cm [1]. This research's expected result is that there is a recommendation for waste treatment before the composting process. The quality and quantity of compost can be improved, and the composting time can be shortened.

2. **Material and methods**

2.1 **Preparation Stage**

The preparation for this research were:

1. Choosing the composting location
   The composting process was located in the yard/garden, and soil type and water infiltration rate were tested to support the data analysis.
2. Preparation of compost raw materials
   The waste used in this research was domestic organic waste, which was food waste, and yard waste. The food waste used was biodegradable food leftovers such as rice, meats, fruits, and vegetables, and the yard waste that was used consists of leaves. This study's percentage of food waste refers to Eryuningsih's research [5] (look table 1). This composition was used for the food waste that was put into the biopore hole. In this research, half of the waste were chopped, and the other half were not chopped.

| Waste Component | Composition Percentage (% weight) |
|-----------------|-----------------------------------|
| Vegetable       | 54.40                             |
| Fruits          | 28.55                             |
| Rice            | 11.77                             |
| Meats           | 5.27                              |

*Source:* [5]

3. Determination of research variations

This research was to analyze the effect of chopping raw material on compost that made used biopore infiltration hole method. So, the variations of this research were with and without chopping. The chopping process used an organic waste chopping machine so that the waste is 0.3-1.5 cm in size. Meanwhile, waste without chopping was >3 cm in size. The composting was done in two composition variations: 50% of food waste with 50% yard waste and 70% food waste with 30% yard waste. These two variations were chosen based on research about the composition of domestic waste, and the ministry of environment [2] said that the percentage of food composition was about 50-70%. In contrast, the percentage of yard waste was about 30-50% [6]. Each variation was done in duplo. Variation for this research showed in table 2.

4. The biopore hole digging

Eight biopore holes were made because there were four variations, and all of that was done in duplo. The holes were made using biopore hole drill. It was made with 10 cm of diameter, 100 cm of depth, and the distance between holes are 50cm [7]. The design of the biopore infiltration hole is shown in figure 1.

| Table 2. Research Variation. |
|-------------------------------|
| Variation | Chopping | Raw material |
|-----------|-----------|--------------|
| 1         | Unchopped | 50% FW<sup>a</sup>: 50%YW<sup>b</sup> |
| 2         | Chopped   | 50% FW<sup>a</sup>: 50%YW<sup>b</sup> |
| 3         | Unchopped | 70% FW<sup>a</sup>: 30%YW<sup>b</sup> |
| 4         | Chopped   | 70% FW<sup>a</sup>:30%YW<sup>b</sup> |
5. Water infiltration rate and soil type test
Testing the water infiltration rate was done by inserting water until it was full into the biopore hole and leaving it for 24 hours, then the measurements were taken with a ruler so that the water infiltration rate was 0.3 cm/hour. The soil types were obtained from research by Liliwarti and Satwarnirat which conducted soil types testing at the Faculty of Engineering, Andalas University. From the result of the analysis, the type of soil is clayey loam[8].

2.2 Research Stage
The steps for the main research were:

1. Waste analysis
Before the composting process, some analysis was done, including temperature analysis, pH, water content, and the C/N ratio. This step was done to determine if the waste has met the standard for composting or not. The water content for waste before composting is between 50-60%, and the optimum C/N ratio is between 25-50 [9]. The other parameters, like temperature and pH based on Sudaryono said that the optimum temperature for waste before composting is between 25-28°C and pH, are between 6-7[10]. If the waste has met the standard so it could be the compost material.

2. Inserting compost into the biopore hole
The next step was putting the waste into the biopore hole according to each variation. Afterwards, the holes were closed with PVC to strengthen the holes so as not to slide and prevent animals or unwanted objects from entering the holes.

3. Compost maturity test
The observation of compost maturity was done every day for temperature, pH, compost volume reduction rate, humidity, color, texture, and odor, according to SNI 19-7030-2004[11]. The observation was also done for composting time.

4. Compost removal

YW = Yard Waste
FW = Food Waste
When the compost was ripe, the compost is removed from the hole. Afterwards, compost was dried in the shade or a place that was not exposed to direct sunlight.

5. Compost quality test
Compost quality was tested based on SNI 19-7030-2004[11] about compost and domestic organic waste. Parameters that were tested are physical elements (water content, temperature, pH, color, and odor) and macro elements (carbon (C), nitrogen (N), C/N ratio, phosphor, and kalium).

6. Compost quantity test
The compost quality test was done with weighing the solid compost produced from each variation.

2.3 Data Processing and Analysis

1. Analysis of compost maturity, quality, and quantity
Analysis of compost maturity, quality, and quantity was done by comparing the data with the standard. Raw material data were comparing with Tchobanoglous [9] standard, quality, and maturity compost data were comparing with SNI 19-7030-2004[11], and for the quantity were analyzed by the weight percentage of compost.

2. Determining the optimal composting variation
Determining the optimal composting variation was done by a scoring method. The scoring system includes three criteria. Those criteria are:

a. Criterion 1: Score 1 was given to the variation that satisfies the standard [11]. This score was for quality and maturity parameter;
b. Criterion 2: Score 0 was given the variation that does not satisfy the standard [11]. This score was for quality and maturity parameter;
c. Criterion 3: This was for the parameter which has no standard. The maximum score (4) was given the best variation, and the minimum score (1) was given the variation not right. This score was for composting time and compost quantity parameter.

The best variation was the variation that has the highest score.

3. Results and discussion

3.1 Environmental Conditions
The environmental conditions could affect the composting process. Hence, before starting the composting, it was important to check and analyze the composting place condition. The soil analysis result showed that the soil type is clay, and the water infiltration rate was 0.3 cm/hour, which was a slow category. Soil texture has an important role in efforts to infiltrate rainwater. Based on Brata dan Nelistya, a free soil texture has more pore than the clay texture[7]. Therefore, the sandy soil texture will absorb water faster than the clay texture. Based on Environment Ministry Rules No. 12, 2009 about Rainwater Utilization said that the soil texture for biopore infiltration hole should have the water infiltration rate $\geq 2.0$ cm/hour. For details about the relationship between soil texture with water infiltration rate shown by table 3

| 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: [7]
Soil texture and water infiltration rate could affect the composting process in biopore infiltration hole. The rain intensity could also affect biopore infiltration hole because of the infiltration hole made on open land, which was directly exposed to rainwater. High rain intensity will make the holes filled by water, and the humidity will increase, then it could affect the composting process. This research was done in the transition season from the rainy season to the dry season. So that in this research, all the conditions and rain duration that happened during the composting process were noted. The result was there are 38 rainy days from 60-80 days of composting. Based on data from the Meteorology and Geophysics Agency of Padang City, the rain that happened were classified as light rain until medium rain.

3.2 Raw Material Analysis
The raw material analysis was done to know if the raw material has qualified as compost material depends on the standard. The parameter that was analyzed includes temperature, pH, humidity, and the C/N ratio. The result of the raw material analysis is shown in Table 4. The result showed that all parameters has met the standard so that the raw material can use for compost. Food waste has a lower temperature, pH, and C/N ratio than yard waste, but it has higher water content. The more water content in raw material causes the temperature became lower. It caused by food waste has more water content than yard waste, which consists of dry leaves. Based on Tchobanoglous [9], food waste contains 58% water content and yard waste contains 51%. The more water content in raw material caused the initial temperature for raw material close to the water temperature. The pH of raw materials at the beginning of composting was generally acidic to neutral (pH 6-7). This result inline with Kurnia's research, where food waste has a pH of 3 to 6, while yard waste has a pH of 6 to 7[12].

C/N ratio is the critical parameter in the composting process. If the C/N ratio in raw material were high, the microorganisms would lack of N for protein synthesis. The decomposition process became slow, while if the ratio C/N was too low because of too much nitrogen, so the nitrogen would be released to the atmosphere and caused a foul odor [13].

| Parameter     | Raw Material | Standard (*) | Information |
|---------------|--------------|--------------|-------------|
|               | Yard Waste   | Food Waste   |             |
| Temperature   | 28°C         | 26°C         | 25-28°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: *[11]

3.3 Maturity Analysis
During the composting process, the maturity observation was done every day until the compost was ripe. The parameters that measured were temperature, pH, reduction rate, humidity, texture and color, odor, and composting time. Because the research was done in duplo, the analysis results were averaged for each variation in the study. The compost maturity result showed that the compost temperature was in the range 27-28°C and neutral pH (7-7.4). The compost volume reduction was in the range of 32-54%. Texture, color, and odor have resembled soil. Thus, all the composting variation has met the maturity standard based on SNI 19-7030-2004[11]. The temperature less than 30°C or same with soil water temperature, neutral pH, compost reduction in 20-40%, and the texture, color, and odor has resembled soil.

The composting process took time about 65-80 days. The composting time for chopped raw material (variation 2 and 4) faster than unchopped raw material (variation 1 and 3). Composting time for chopped raw material is 65 days, and the unchopped material is 80 days. Chopping the material can speed up the composting process for 15 days. Chopping made the size of raw material smaller and
even, making it easier for the decomposition process. Based on Damanhuri and Padmi, the smaller the material's diameter, the larger the surface area, and it made the contact between bacteria and organic matter became better[1]. The smaller the raw material size, so the decay process became faster. The composition of the raw material also affected the maturity of the compost. The results of the analysis of composting maturity is shown in table 5.

### Table 5. Maturity Analysis.

| Variation | Temperature (°C) | pH | Compost Reduction (%) | Humidity | Texture and Color | Odor | Composting Time (Day) |
|-----------|-----------------|----|------------------------|----------|------------------|------|-----------------------|
| 1         | 27              | 7.2| 32                     | Less humid | Soil and black | Soil  | 80                    |
| 2         | 28              | 7.2| 41                     | Less humid | Soil and black | Soil  | 65                    |
| 3         | 27              | 7.3| 35                     | Less humid | Soil and black | Soil  | 80                    |
| 4         | 28              | 7.0| 41                     | Less humid | Soil and black | Soil  | 65                    |

Composting with biopore infiltration hole method took time a little longer than the other composting method like Rotary Kiln and Takakura method. This condition was caused by biopore infiltration composting was done on the outdoor, so it was affected by weather conditions. This research was done in the transition season from rainy season to dry season, and 38 rainy days happened during the composting process. It was affected by humidity and composting time. Weather conditions in indoor composting (Rotary Kiln and Takakura) can be minimized so that the composting time can be faster to 15-30 days. Biopore infiltration composting can be done in the dry season to avoid the holes fulled by water because of rain [14].

### 3.4 Quality Analysis

The compost quality tested after the compost was ripe and after it was dried and sifted. The parameter for this quality analysis was physical elements and macro elements. The result of physical elements analysis showed that solid compost water content was in the range 39.03 - 45.67%, the temperature in 27-28°C, pH in the neutral range (7.0-7.3) soil texture, the color was black, and the odor had resembled soil. The result for macro elements showed that C-organic was in the range 10-10.02%, N-total in 0.51-0.64%, C/N ratio in 15.59-19.58%, Phosphor in 0.15-0.32%, and Kalium in 6.7-9.6%. All the variation has met the standard according to SNI 19-7030-2004[11]. There was no significant effect between the chopped waste with the unchopped waste in the final result. The chopped waste was more affected by composting time. The chopped waste ripen faster than the unchopped waste. The result of the quality analysis is shown in table 6 and table 7.

### Table 6. Physical Element Analysis of Compost Quality.

| Variation | Water Content (%) | Temperature (°C) | pH | Color | Odor | Information |
|-----------|------------------|-----------------|----|-------|------|-------------|
| 1         | 40.28            | 27              | 7.2| Black | Soil | Qualified   |
| 2         | 39.03            | 28              | 7.2| Black | Soil | Qualified   |
| 3         | 45.67            | 27              | 7.3| Black | Soil | Qualified   |
| 4         | 41.43            | 28              | 7.0| Black | Soil | Qualified   |
| Standard[10]| <50%            | <30°C           | 6.8-7.49| Black | Soil |

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Table 7. Macro Element Analysis of Compost Quality.

| Variation | C-Organic | N Total | C/N Ratio | Phosphor | Kalium |
|-----------|-----------|---------|-----------|----------|--------|
| 1         | 10.2      | 0.55    | 18.74     | 0.16     | 7.3    |
| 2         | 10.0      | 0.51    | 19.58     | 0.15     | 6.7    |
| 3         | 10.1      | 0.64    | 15.59     | 0.32     | 9.6    |
| 4         | 10.2      | 0.59    | 17.24     | 0.22     | 7.1    |

Standard [10] 9.8-32% >0.4% 10-20 >0.1% >0.2%

3.5 Quantity Analysis
The quantity compost that produces from biopore infiltration hole composting is shown in table 8. The solid compost produced was about 1.10-1.40 kg, with a percentage between 75% to 81.4%. The compost quantity was affected by the type and composition of raw material. Variation 2 with 50% food waste and 50% yard waste and chopped raw material has the highest quantity than the others.

Table 8. Quantity Analysis.

| Variation | Raw Material (Kg) | Solid Compost (Kg) | Quantity Percentage (%) |
|-----------|-------------------|-------------------|------------------------|
| 1         | 1.4               | 1.10              | 78.6                   |
| 2         | 1.4               | 1.14              | 81.4                   |
| 3         | 1.8               | 1.35              | 75.0                   |
| 4         | 1.8               | 1.40              | 77.5                   |

3.6 Selection of the Best Variation
The selection of the best compost variation was done by scoring method. It was included the maturity analysis, quantity, and quality analysis. Based on the scoring criteria that explained in the methodology, the variation with the highest score was variation 2, with 50% chopped food waste and 50% chopped yard waste. Quality and quantity on variation 2 has met the standard [11]. The percentage quantity of compost is 81.4%. It was more than the other variation. Afterwards, the composting time shorter than the other variation with 60 days of composting. The result of the composting score is shown in table 9.

Table 9. Scoring for the Best Variation Selection.

| Variation | Compost Maturity | Compost Quality | Compost Quantity | Total Score |
|-----------|------------------|-----------------|------------------|-------------|
| 1         | 7                | 5               | 3                | 15          |
| 2         | 8                | 5               | 4                | 17          |
| 3         | 7                | 5               | 1                | 13          |
| 4         | 8                | 5               | 2                | 15          |

3.7 Recommendation
The result of this research shown that the biopore infiltration composting needs 65-80 days of composting. It was caused by the rain that happened during the composting process. The soil type (clay) and the slow water infiltration rate (0.3 cm/hour) were the other reasons the composting process being slow. It took time a little longer to infiltrate the rainwater, increasing the humidity, and the decomposition process became slower.
The purpose of biopore infiltration hole method were to increase groundwater reverse, increase water infiltration rate, increase soil fertility, and produce compost. Therefore, this research was also analyzing the water infiltration rate after composting. The result showed that the water infiltration rate increase to 0.8 cm/hour from 0.3 cm/hour. It showed that the other purpose of this method to increase the water infiltration rate has succeeded. So it could recommend that, if wanted a faster-composting process, so the composting could do in the dry season. In the dry season, rain intensity lower than the rainy season, so the hole was not often waterlogged, and the compost will ripe faster.

4. Conclusion
The conclusion of this research were:

1. The result of compost maturity and quality for all variations has met the standard according to SNI-19-7030-2004 about compost specification from domestic organic waste. The composting time was 65-80 days, and the compost reduction is 32-41%, and the percentage is 75-81.4%. But, the rainy weather that happened for 38 days caused the compost always full of water, and the decomposition became slow;
2. Chopping on raw material affected composting time and compost quantity. It can speed up the composting time until 15 days and increase the solid compost quantity about 2.5-2.8%;
3. The scoring result for maturity, quality, and compost quantity, showed that the optimum variation for composting is 50% chopped food waste and 50% chopped yard waste.

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