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Comparison of Composting Results Using the Batu Terawang Method and Open Windrow Method

Ilham Nurfadly[1*], Sri Sumiyati[1], Sudarno[1]

[1] Master of Environmental Engineering, Universitas Diponegoro, Semarang, Indonesia.

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Corresponding Author:
Ilham Nurfadly
ilhamnurfadly929@gmail.com

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Abstract: Composting is a waste management process that converts organic material into humus that can be reused. Composting can be applied using several methods such as the open windrow method, this method is a way of making compost that will get sufficient aeration so that it will help the compost maturity process more quickly. The aim of this research is to compare the results of composting using the open brick method and open windrow based on chemical parameters. During the composting process, a different bioactivator was added to each compost, using two bioactivators, namely MoL and M-Bio, and periodic checks were carried out every three days during the six weeks of composting. Based on the comparison results, the C, P content and C/N ratio in the two methods produced content values that were not significantly different, however, in the overlay brick method, the control compost was superior in terms of P content and C/N ratio. Meanwhile, the open windrow method has a consistent increase in C, P content and C/N ratio.

Keywords: Brick method; Comparison; Composting

Introduction

Composting is a waste management process that converts organic material into humus which can be used as soil fertility (Sayara et al., 2020; Ayilara et al., 2020). Apart from that it can also reduce the volume of waste, produce products that can be sold, increase soil fertility, increase the water absorption capacity of the soil, and reducing air pollution due to waste burning (Kassa et al., 2024; Siddiqua et al., 2022; Kibria et al., 2023). The compost process resulting from weathering (decomposition) of biologically remaining organic material into a humusized part will contain high levels of nutrients and its ability to easily absorb and release phosphorus, potassium and other nutrients is believed to be able to suppress soil-borne diseases in plants (Chen et al., 2023; Santoro et al., 2024; Solomon et al., 2023). Good quality compost must pass physical, chemical and biological parameter tests. Physical parameters in compost consist of temperature, pH, soil moisture, color and odor, while chemical parameters consist of water content, carbon, nitrogen, phosphorus, potassium and C/N ratio, and biological parameters by testing the microorganisms in it.

The compost parameters examined in this research used SNI 19-7030-2004 concerning Compost Specifications from Domestic Organic Waste. This research will discuss compost maturity seen through chemical parameters, namely carbon, phosphorus, and C/N ratio. Compost maturity based on these three ingredients can be characterized by the organic material used being decomposed over time until it turns into humic substances, the rise and fall of carbon content is influenced by the condition of microorganisms during the composting process and has an inverse relationship with the content water (Ahmed et al., 2023; Palaniveloo et al., 2020).

The carbon content value can be said to be mature if it reaches a value of 9.80% - 32%. Furthermore, the increase and decrease in phosphorus content is influenced by nitrogen content according to Razaq et al. (2017), Cummings et al. (2023) and Zhou et al. (2024)

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because the higher the nitrogen content, the more microorganisms are able to break down phosphorus, which will increase the phosphorus content as well, this applies vice versa. The content value can be said to be mature if it reaches a minimum content value of 0.10%. While the C/N ratio content is influenced by the carbon and nitrogen content during the composting process, the C/N ratio can be said to be mature with a content value of 10 – 20. Composting can be applied using several methods such as the open windrow method, this method is a way of making compost that will get sufficient aeration so that it will help the compost maturity process more quickly (Giagnoni et al., 2020). This composting is widely used on a large scale because the process is short, efficient, simple and low cost but has the disadvantage of having to stir the compost manually to ensure aeration, proper mixing, and remove moisture (Kong et al., 2018; Zhu-Barker et al., 2017).

Apart from that, there is also the takakura method, takakura is a practical composting method because it does not require a large space but this composting method is only on a household compost scale or smallscale compost (Dewilda et al., 2021). Next, there is composting using the overlay brick method, this method is a method of composting organic waste using a stacked brick system arranged with a certain distance between the bricks so as to produce holes that can facilitate the aeration process (Afifah et al., 2021). Composting using Bata Terawang technology has not been well socialized, so the level of community participation in processing organic waste with Bata Terawang is still very minimal.

Apart from that, the composter can make more organic waste processed (Hettiarachchi et al., 2020).According to Hasna et al. (2020), the advantages of using a Bata Terawang composter to process organic waste include being able to accommodate a lot of waste, harvesting the compost is very easy, no need for special care, the compost results are quite good, can minimize rainwater entering the pile compost, all types of organic waste can be processed with the Bata Terawang composter, and the decomposition process is faster, because oxygen occurs well. Based on the results of the discussion above, this research will aim to compare the results of the chemical parameter content of compost using two different composting methods, namely open windrow and open windrow. Many studies using this method may have been carried out, but not many have been carried out simultaneously to compare chemical parameters, including C, P and C/N contents. Based on the basic ingredients for composting being taken from market waste, the most suitable composting methods for large scale are open windrow and open windrow.

Next, the comparison of the compost content was added with the bioactivators Mol and M-bio within 6 weeks of composting. After that, chemical content identification; will be carried out through the Environmental Engineering laboratory at Diponegoro University.

Method

The composting process in this research was carried out for 6 weeks by carrying out routine checks every 3 days with the aim of seeing the development and changes in the 5 existing composts. Composting is carried out using two methods, the first method is using an open windrow and the second method is using overlay bricks. The two methods used both use organic waste as basic materials and are carried out with the same treatment (Zheng et al., 2013). The composting process using the open windrow method uses composting bag media, while the open windrow composting process uses bricks arranged in stacks. In both composting processes, bioactivators are added to speed up the composting process, namely MOL and M-BIO bioactivators with different doses in each compost as explained in table 1.

The use of the MOL bioactivator added to the composting process was produced by the author himself by mixing organic materials such as fruit, vegetables and egg shells mixed with brown sugar and water and then left to ferment for 2 weeks. Meanwhile, the use of the M-BIO bioactivator is a factory-produced bioactivator. This aims to compare compost maturity using two different bioactivators. There were 5 composts studied, namely control compost with 0 ml of bioactivator added, M1 with the addition of 125 ml of MoL bioactivator, M2 with the addition of 150 ml of MoL, P1 with the addition of 125 ml of M-Bio bioactivator, and P2 with the addition of 150 ml of M-Bio bioactivator. The composting process is carried out for 6 weeks with regular checking every 3 days. After that, the compost was tested for chemical parameters such as C, P, and C/N ratio in the Environmental Engineering laboratory, Diponegoro University.

Table 1 explains the addition of bioactivators used during the composting process and Figure 1 explains the tools used during the composting process.

Table 1. Addition of Compost Bioactivator

Compost	Volume (ml)
Control	0
M1	125
M2	150
P1	125
P2	150

Result and Discussion

Beginning of Composting

In the first 2 weeks of the composting process, the compost is only physically and biologically checked. Checking the compost chemically or carried out with laboratory tests after week 2, week 3, week 4, and week 5 which will be explained in the table below week 2 means week 1 in the chemical parameter test. Chemical parameter testing is carried out in the second week of composting because physically the compost has met or can be said to be mature. This ripening is indicated by the color turning black, no smell, and the appearance of maggots and worms. The appearance of these animals can also be useful in helping the rate of decomposition of the organic material used, so that nutrients and soil fertility will increase (Novita et al., 2021).

Carbon or C

C in composting is an important part, because in the composting process it functions as an energy source for microbial cells by freeing CO_2 and other materials which will evaporate (Wang et al., 2024). Carbon is formed from the decomposition stage of organic matter and the carbon content is influenced by external factors, namely rainfall, soil type, temperature, soil management, organic matter and CO_2 content (Gerke, 2022; Leifeld et al., 2020). The composting results show that the carbon content in this study is in accordance with the compost criteria of SNI 19-7030-2004 concerning Compost Specifications from Domestic Organic Waste. The control compost results from the bata terawang method showed that the C content had a higher value compared to the open windrow method every week, besides that, the average content produced in the bata terwang composting method during the testing period had a higher content than the open windrow method. namely 18.17% while the open windrow is 13.26%. This is influenced by the fact that the compost using the overlaid brick method has a higher content every week, even though both methods had a decrease in the compost content in one of the processes.

The C content in M1 compost using the open windrow method produces a consistent increase every week, this is different from the open windrow method which experienced a decrease in week 2. However, even though the compost using the open windrow method experienced a decrease on average in the content test it had higher content, namely 18.06%. This average content is not monitored too far because the open windrow method has an average content of 17.08%. A consistent increase in C content every week was also experienced by the M2, P1 and P2 compost using the open windrow method. This could possibly be caused by the open windrow method using a more closed media (composting bag) while the open windrow method uses a brick layered media that has large cavities, because according to Destiasari et al. (2024), wind, rain and temperature can affect the quality of the compost. Undetermined environmental conditions mean that Terawang brick compost does not have a stable value. In addition, because the open windrow method has a consistent increase in C content, this method has a higher average than the open brick method, namely M2 compost 21.04% and P2 19.91%.

Table 2. Carbon Value Results

Batu Terawang											Open Windrow
Week	Control	M1	M2	P1	P2	Week	Control	M1	M2	P1	P2
1	15.08	19.03	19.22	16.13	15.08	1	12.55	14.31	18.91	13.09	17.32
2	19.38	15.17	18.12	19.87	14.27	2	13.14	15.49	18.97	16	20.53
3	20.47	18.81	15.61	18.54	13.95	3	12.14	17.96	21.87	17.34	20.26
4	17.76	19.24	20.12	17.73	13.75	4	15.21	20.56	24.43	17.30	21.57

Meanwhile, in contrast to P1 compost, compost using the overlaid brick method has a higher average of 18.06%, while in the open width method the P1 compost content is 15.93%. This is because the compost content in the overlaid brick method has a greater value each week, although the increase in value only occurs in the 2nd week of the composting process. Then the periodic decrease in P2 compost could be caused because during the composting process the author did not chop up the organic material consistently. The decrease in C content could be caused by organic material continuing to experience degradation (Malinverno & Martinez, 2015; Harju et al., 2021; Guliyev et al., 2023). During the degradation process, some of the carbon is converted into more stable humic substances by microorganisms and most of the others are released as gases, such as carbon dioxide (CO2) methane (CH4) (Yang et al., 2020). Therefore, to anticipate this, there is a need for enumeration so that during the composting process it can easily decompose (Jalalipour et al., 2020). Table 2 below shows the results of a comparison of C content in composting using the open windrow method and the open windrow method.

Phosphorus or P

P is one of the nutrients needed for plant development and growth, however phosphorus is a non-renewable resource which is relatively abundant in animal remains and other organic remains (Devlin et al., 2017; Zhan et al., 2021). P in plants functions to increase plant resistance to pest attacks, root growth and flower growth. The composting results show that the phosphorus content in this study is in accordance with the compost criteria of SNI 19-7030-2004 concerning Compost Specifications from Domestic Organic Waste. The control compost content based on laboratory results shows that the compost using the open windrow method has a higher content than the open windrow method, even the control compost using the open windrow method has the highest average content compared to M1, M2, and P2 compost using the open windrow method.

This is different from the open windrow compost method, where the control compost has the lowest content compared to compost with the addition of bioactivators. According to the author, this condition is caused by the unequal distribution of organic material in each compost sample, because a greater organic content will produce a higher phosphorus content (Mabagala & Mng'ong'o, 2022), apart from that, composting is made from organic waste according to Rehman et al. (2020) is able to provide high phosphorus content. It can be seen in Table 3 that the difference in P content in M1, M2, P1, and P2 compost from the brick overlay method and the open windrow method only has a difference of 0.02 – 0.1%, this means that each compost has a higher P content. almost the same in both methods.

The rise and fall of P content in the composting process is influenced by nitrogen content (Trivana & Pradhana, 2017) because the higher the nitrogen content, the more microorganisms capable of breaking down phosphorus will increase. The nitrogen content in the composting process continues to increase in this research due to the addition of bioactivators, according to Kaswinarni et al. (2020) and Zaman et al. (2020), bioactivators contain a lot of nitrogen. However, in this study, the only consistent increase in compost content was in the open windrow method, whereas in the open windrow method, the control and M2 compost experienced increases and decreases. Table 3 below shows the results of a comparison of P content in composting using the open windrow method and the open windrow method.

Table 3. Phosphorus Value Results

Batu Terawang											Open Windrow
Week	Control	M1	M2	P1	P2	Week	Control	M1	M2	P1	P2
1	0.35	0.24	0.21	0.38	0.28	1	0.23	0.20	0.26	0.20	0.24
2	0.39	0.26	0.30	0.34	0.31	2	0.26	0.28	0.33	0.27	0.30
3	0.34	0.33	0.28	0.30	0.35	3	0.27	0.36	0.41	0.33	0.40
4	0.33	0.37	0.39	0.40	0.40	4	0.29	0.39	0.42	0.35	0.40

C/N ratio

During the composting process, C/N is very important because it plays a role in microbial growth. So, an optimal C/N ratio balance is very important to formulate an efficient compost mixture. The C/N ratio will project the rate of organic degradation which is regulated by the amount of carbon converted into CO2 (Rastogi et al., 2020). Composting results show that the average C/N content ratio in this study is in accordance with the compost criteria of SNI 19-7030-2004 concerning Compost Specifications from Domestic Organic Waste, however the 3rd week P2 compost using the overlay brick method does not meet SNI standards because has a content of 8.77%. Research (Rochaeni et al., 2024) states that a C/N ratio of 8.11% - 11.50% is still considered good for compost.

The increase and decrease in the C/N ratio content in composting is of course influenced by several factors. The increase in content can be influenced by NH3 to be converted into NH4. As a result, NH3 is volatilized into N2 into the air and causes the nitrogen content to increase while the decrease can be caused by the activity of compost microbes. The addition of bioactivators can help the microbes to work actively with the aim of provides initial energy to microbes as provisions for reproduction, but the more active the microbes are, the more they will affect the decomposition process. The average value of compost in the overlay brick method is control compost (15.45%), M1 (12.38%), M2 (14.91%), P1 (14.31), and P2 (10.47%) while in the open windrow method the control compost was (12.88%), M1 (17.07%), M2 (17.38%), P1 (16.57%), and P2 (16.78%).

Based on these values, it shows that the overall average weekly C/N ratio content of compost using the open windrow method has a greater content value than that of the open windrow method. Table 4 below shows the results of a comparison of the C/N ratio content in composting using the open windrow method and the open windrow method.

Table 4. Results of C/N Ratio Values

Batu Terawang											Open Windrow
Week	Control	M1	M2	P1	P2	Week	Control	M1	M2	P1	P2
1	19.58	12.86	17.80	12.13	10.93	1	10.79	14.96	15.57	14.64	15.05
2	13.01	11.94	17.76	14.72	11.60	2	12.43	17.91	17.95	16.44	16.64
3	18.44	14.04	10.01	14.71	8.77	3	13.71	17.25	17.10	17.13	17.14
4	10.76	10.69	14.07	15.69	10.58	4	14.58	18.17	18.90	18.07	18.30

Comparison

The comparison results of the compost content that has been tested 4x with a composting period of 6 weeks show that the C content of the two methods, if the average content value in 6 composts for 6 weeks is averaged, both have the same average content, namely the overlaid brick method. 17.36% and the open windrow method 17.44%. Based on these average results, it can be concluded that the two methods have a C content that is not too far apart in each compost, but if we look in detail at the weekly content values, the compost using the overlaid brick method has a higher content value in the control compost, M1 compost, and P1 compost. Then, the P content in each compost using the open windrow method experienced a consistent increase, this is different from the compost using the open windrow method which had an increasing and decreasing P content in the control compost and M2. Apart from that, in the compost using the overlay brick method, the P content in the control compost has a higher value than the compost with the addition of bioactivators (M1, M2, and P2) but if the average content value in 6 composts for 6 weeks is averaged between the two has an average content that is not much different, namely the open brick method 0.32% and the open windrow method 0.31%.

Furthermore, the C/N ratio content produced in this composting produces the same results as the P content, namely the average control compost content is greater than compost with the addition of bioactivators (M1, M2, P1, and P2) using the overlay brick method, p. This is inversely proportional to the open windrow method where the content of the control compost is lower than the compost with the addition of bioactivators. Apart from that, the P2 compost content value in the third week did not meet SNI standards, namely 8.77%.

Conclusion

The results of the C, P content and C/N ratio in the composting process have values that are not too different each week. It can be concluded that the addition of different bioactivators does not have a big influence on the composting results. Apart from that, if the content values are averaged over 4 laboratory tests, the average C and P content produces values that are not much different, while the C/N ratio produces the highest content value using the open windrow method. The open windrow method also has a consistent increase every week. Meanwhile, in the overlay brick method, the P and C/N content of the control compost had higher values than the compost added with bioactivator and one of the composts had a C/N ratio that did not meet SNI standards. However, the overlaid brick method also has a good average consistency of P content.

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Author Contributions

Conceptualization; I. N.; methodology.; S. S; validation; S.; formal analysis; I. N.; investigation.; S. S.; resources; S.; data curation: I. N; writing—original draft preparation. S. S.; writing—review and editing: S.; visualization: I. N. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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