BORNEO JOURNAL OF SCIENCES AND TECHNOLOGY (BJoST)
VOL. : 04, ISSUE: 02 , 53-59
DOI: http://doi.org/10.35370/bjost.2022.4.2-07
e-ISSN: 2672-7439 © 2018, UTS Publisher.

University of Technology Sarawak

ORIGINAL ARTICLE

Effect of Temperature with Different Composting Ages of Sawdust

*1,2Nasihah Mokhtar, 2Mohammad Hafsanjani Salleh, 2Alvin Ann Anhu, 1,2Sofiyah Mohd Razali, 1,2Mohamad Saiful Sulaiman, 1Razak Wahab and 1,2Taharah Edin

1Centre of Excellence in Wood Engineered Products, University of Technology Sarawak, 96000 Sibu, Sarawak, Malaysia

2School of Engineering and Technology, University of Technology Sarawak, 96000 Sibu, Sarawak, Malaysia

ABSTRACT - A lot of residues have been generated every year. It is estimated that the total number of energies generated from waste in 2012 is 0.720, 0.381, and 1.657 Mtoe (One Million Toe) in Malaysia. The waste needs to manage properly to avoid the generation of huge waste in the future. The objective of this study is to test the effect of three different compost ages on compost temperature and to determine the active phase of the compost. In this study, there are 6 different composts to be monitored for temperature. There are three different ages of compost such as 7 days, 30 days and 90 days composts. The compost is made of wood waste and paddy husk (control). Vegetable waste and E.M. (Effective Microorganism) solution were also added to each type of compost. These wood wastes were derived from the mixture of fast-growing timber species at the sawmill. The use of wood waste compost is an efficient strategy for re-using material refuse, which would be cheaper and safe for the environment. This study proves that there is no effect of compost age on temperature for the compost of 90 days age as it is not significantly ($P>0.05$) different. In addition, the active phase for the sawdust compost is from day 42 to 56. These findings will provide useful information about the temperature of the compost that influences determining compost maturity in the future.

ARTICLE HISTORY
Received: 30 Dec 2021
Revised: 4 April 2022
Accepted: 15 May 2022

KEYWORDS
Compost age
Temperature
Wood waste
Waste management

INTRODUCTION

Wood waste can be turned into valuable products. The waste from timber or engineered wood products can contribute to the horticulture industry for media, especially compost production. Waste could be described as any material used and is no longer wanted because the valuable or useful part has been removed. Wastes in the wood industry could be in solid form, while others are soluble or solvent. Waste is the leftover materials generated during the manufacturing process that are considered unusable and useful again and thus discarded. Wood wastes consist of wood pieces and particles generated from the industrial or small-scale processing of wood, construction and demolition activities and broken-down wood products. Common wood wastes include bark, scrap lumber, sawdust, construction and demolition, offcuts, ash from burning wood wastes, and broken furniture [1];[2]. Wood waste or wood chips are great materials for many purposes [3]. Wood is a natural and renewable resource that is biodegradable and has exceptional mechanical and thermal properties [4];[5].

Composting is one of the crucial and economical methods of recycling organic waste. Composting is one of the low-cost biological decomposition processes [6]. Composting has become a preferred method for municipalities and industries to recycle various organic byproducts, transforming them into useful soil conditioners and amendments [7]. Composting process involves several microbes, thus circuited by microbial activity. The physical-chemical parameter affected by this process includes temperature,

*Corresponding Author: Nasihah Mokhtar. University of Technology Sarawak (UTS), email: nasihah@uts.edu.my

aeration, moisture content, Carbon and Nitrogen ratio (C:N ratio) and pH [8]. Composting has several benefits: it improves manure handling, possible saleable product, land application, weed seed and pathogen destruction by high temperature in the compost pile, minimum risk of pollution problems, and perfect soil conditioner [9]. Composting is a process in which the biological breakdown of organic waste under different controlled conditions occurs [10]. Wood chips are a good bulking agent when handling animal wastes with a high moisture content during composting. The wood wastes increase microbial activity by supplying oxygen to the composting pile. An active composting pile containing wood chips generates considerable heat, and a large amount of vapour is released into the air. Therefore, composting reduces the volume and mass of the raw materials within a short period. Aerobic composting does not generate evil-smelling gasses as anaerobic tend to do [11].

According to the EPA [12], particle size, moisture content, oxygen flow, and temperature are only some things that need to be "managed" while composting. Composting or controlled decomposition is required for particle size to achieve an appropriate ratio of "green" and "brown" organic materials as feedstock and nutrients. Green organic matter contains huge nitrogen levels, such as grass clippings, food leftovers, and manure. Carbon-rich "brown" organic elements include dried leaves, wood chips, and branches low in nitrogen. Experimentation and perseverance are required to get the right nutritional balance. Composting is a science and an art. They increase the surface area for microbes to feed on by grinding, chipping, and shredding materials. More uniform compost mixtures can also be produced by using smaller particles, increasing the insulation of compost piles. However, if the particles are too fine, they may impede air movement.

Besides, the moisture content is also essential for the survival of microorganisms in a compost pile. The microorganisms may reach the nutrients in organic material because water helps transfer the chemicals throughout the compost pile. Moisture is present in organic material at variable degrees, but it can also be introduced through rainfall or purposeful irrigation. To manage oxygen flow while composting, adding bulking agents like wood chips and shredded newspaper or turning the pile can help circulate oxygen. Decomposition proceeds more quickly under aerobic settings than under anaerobic ones. However, care must be taken not to over-oxygenate the pile since this might hinder the composting process and dry it out. As a result, the temperature factor necessitates a specific temperature range for microorganisms.

Composting can be accelerated, and pathogens and weed seeds are eliminated at certain temperatures to manage temperature while composting. Due to microbial activity, the pile's core can reach at least 140° F. As temperatures drop, anaerobic conditions (such as rotting) take hold. The right temperature can be achieved by controlling the preceding four parameters. Thus, this study hypothesises that compost age is significant to temperature. This study aims to test the effect of three different compost ages on compost temperature and determine the compost's active phase.

MATERIALS AND METHODOLOGY

Materials

The composting materials were prepared using wood waste, paddy husks as control, vegetable wastes, E.M. (Effective Microorganism), molasses and rainwater. The wood waste or sawdust is supplied from Sawmill Company in Sibu, Sarawak, Malaysia. Six composts were prepared at 7 days, 30 days, and 90 days, respectively (Table 1). Out of 3, 6 composts were made from the sawdust, and the rest were paddy husk (control). The composts produced by co-composting vegetable wastes had good agronomic potential in nitrogen and potassium [13]. The ratio of wood waste, vegetable waste and E.M. solution is mentioned in table 1.

Table 1. Types of Composts

Type of Compost	Age (Days)
Wood waste + vegetable waste + E.M. solution with molasses and rainwater (10: 1: 14)	7 days 30 days 90 days
Paddy husk + vegetable waste + E.M. solution with molasses and rainwater (10: 1: 14)	7 days 30 days 90 days

Compost Preparation

Sawdust of 20 kg was mixed with vegetable waste and a solution of E.M solution and molasse (Figure 1). This step was repeated with 350 g paddy husk to replace sawdust. The weight of sawdust and paddy husk was different because the supply of paddy husk was limited. The paddy husk acts as a control for this study. Composting paddy husk is one of the best methods to solve waste management problems because composting enables the conversion of paddy husk into a stabilised organic amendment. This end product can improve nitrogen (N) availability [14];[15].

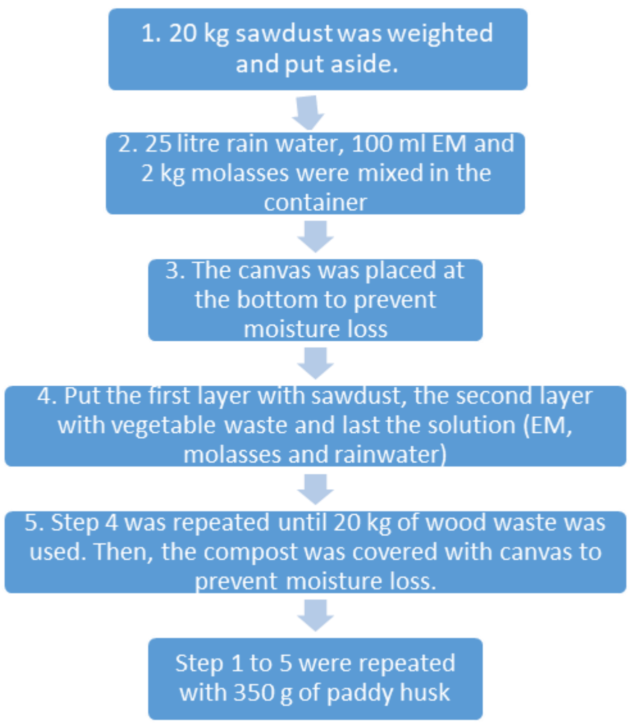

Figure 1. Process of Compost Making

Measurement of Compost Temperature

The temperature of composts was measured once in three days using a thermometer compost. The physical characteristics of the composts were also recorded.

Statistical Analysis

The temperatures of sawdust and paddy husks were recorded and compared at 7, 30 and 90 days. A statistical t-test or Mann-Whitney test was used to determine whether the mean temperature between both groups of sawdust and paddy husk were significantly different or not. The Statistical Package for the Social Sciences (IBM SPSS version 25.0) was used for the statistical analysis.

RESULTS AND DISCUSSION

The sawdust and paddy husk's temperature were collected until day 90, and the result was compared, as illustrated in Figure 2. For the 20 days, there were no significant temperature differences between both composts. According to Latifah et al. [15], a day after the composting commenced, the temperature of the compost entered the mesophilic phase (< 50 °C). The mesophilic phase lasted for 19 days. The thermophilic phase (55 °C) started on day 20 of the composting process. On day 20 of composting, the thermophilic phase ensued due to the energy released during the catabolism of microorganisms. High temperature is necessary for the chemical incorporation of N into a stable form within the compost [16]. However, significant temperature differences were observed between both composts, notably on days 25 to 35 and 42 to 56. The cooling phase of the co-composting process started on day 35, after which the temperature of the compost gradually decreased to equal ambient temperature. Good aeration is vital to maintaining the high temperature at the thermophilic stage. The compost temperature decreased on day 35 when the microbes were depleting nutrients and energy from composting substrates. The mesophilic microbes dominated the decomposition process after day 35 until all readily available energy sources were utilised. The mesophilic phase observed in this study suggests that the population of the mesophilic microbes was established. According to Sundberg and Jonsson [17], mesophilic microbes (grow at a temperature between 40 and 45 °C) are dominant throughout composting mass in the process's early stage. These microorganisms use oxygen to transform C from the composting feedstock to obtain energy and release carbon dioxide and water [18]. Thus, the active phase for paddy husk compost (control) is from 25 to 35 days. In contrast, the active phase for the sawdust compost is from day 42 to 56. In the last 30 days, starting from day 60 to 90, the temperature pattern of both compost is almost unchanged, with paddy husk slightly higher than sawdust.

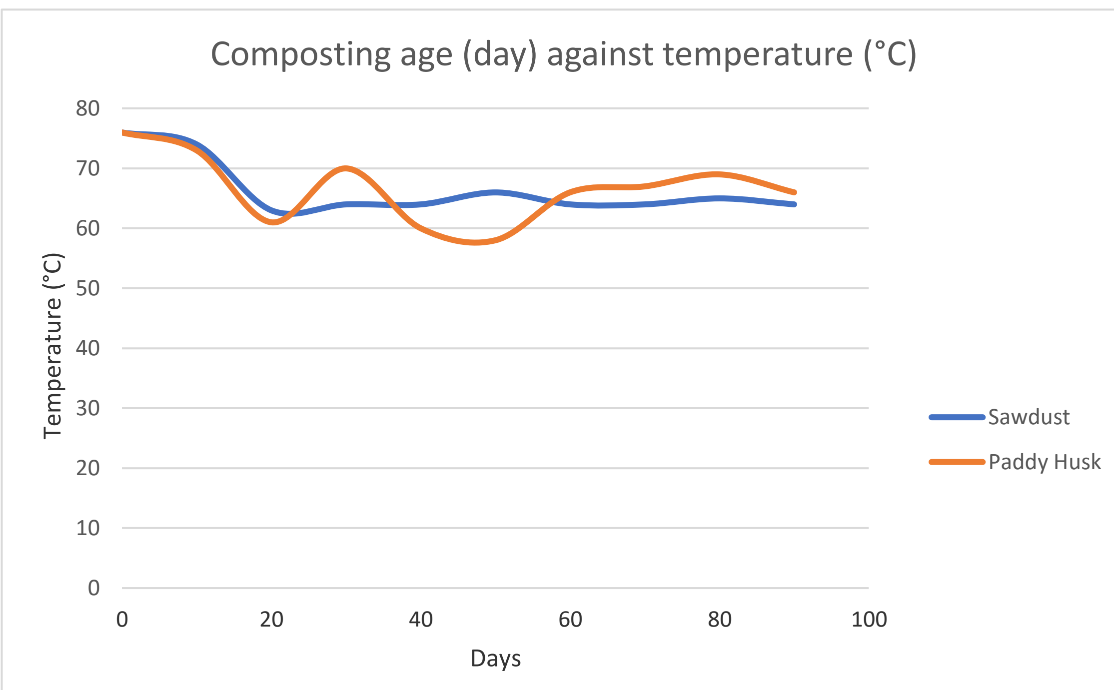

Figure 2. Temperature Profile during Composting Process

Table 2. Statistical Analysis of Compost Age and Temperature Correlation for Different Group.

Compost Age	Compost Type	The p-value of the Statistical Test (t-test or Mann-Whitney)
7 days	Sawdust Paddy husks	0.003
30 days	Sawdust Paddy husks	0.002
90 days	Sawdust Paddy husks	0.230

*p-value <0.05 - The group is significantly different from each other

From Table 2, the results show a significant mean variation of temperature between both composts for the first 7 days as the p-value from the statistical test is less than 0.05 ($p=0.003$). The same trend also was observed for the compost of age 30 days, with a p-value of 0.002. However, the statistical result for compost age of 90 days shows that the p-value is greater than 0.05 ($p=0.230$). This finding suggests no significant differences or variation in temperature changes between sawdust and the paddy husks group for 90 days. A significant difference in 7 and 30 days results is probably due to the composting media's temperature development depending on the compost composition and aeration [19];[20]. Thus, the results indicated that temperature significantly affects the composting process and quality.

Physical Characteristics of Sawdust Composts

So many immature organisms can be seen for 90 days of compost (Figure 3). The colour of this compost looks brownish-black. In addition, an unpleasant smell can be detected from this compost. The microorganisms are mainly responsible for further breaking down part of the humus into carbon dioxide, water and nutrients for the plants. This process is called mineralisation: nutrients are released and can be taken directly by plant roots [21].

Figure 3. 90 days of compost

Some immature organisms were visible during the 30 days of compost (Figure 4). The colour of this compost looks less brownish-black. While for the 7 days of compost, any immature organisms cannot be seen by the naked eye (Figure 5). The colour of this compost looks only brownish. The compost colour should vary between medium and dark brown. Darkness also depends on moisture content. Black compost often indicates too high temperatures during composting, leading to combustion [22]. Colour changes in the compost need further understanding and their relationship to compost quality. Colour is one of the maturity assessments for compost quality [23].

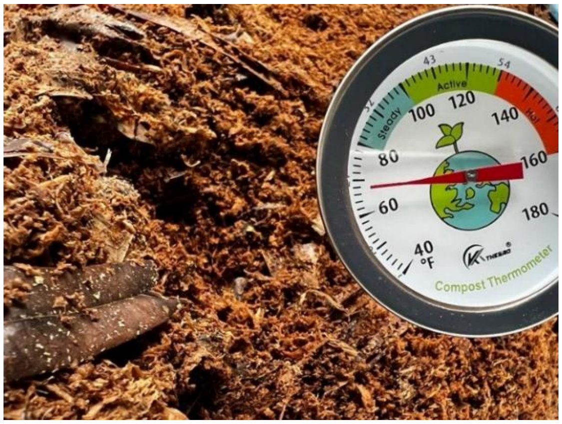

Figure 4. 30 days of compost

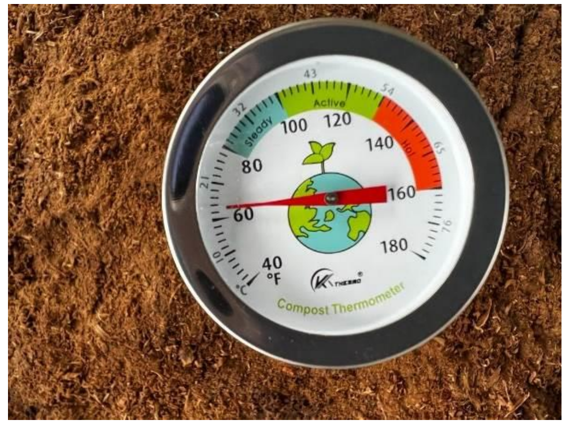

Figure 5. 7 days of compost

CONCLUSION

This study has shown that composting generally involves the action of heat and microorganisms on organic materials. There is the effect of compost age on temperature as the compost age 7 days and 30 days had a significant ($P<0.05$) difference in temperature. In contrast, there is no effect of compost age on temperature for the compost of 90 days age as there is no significant ($P>0.05$) difference. In addition, the active phase for the sawdust compost is from day 42 to 56. These findings are crucial to making an effective compost in the future, especially from wood waste, by providing helpful information about the temperature that influences determining compost maturity in Malaysia.

ACKNOWLEDGMENT

The authors would like to thank the University of Technology Sarawak for funding this project through the research grant (UCTS/RESEARCH/2/2018/04 (01)).

REFERENCES

[1] Owoyemi, J. M., Zakariya, H. O., Elegbede, I. O. Sustainable wood waste management in Nigeria. Environmental & Socio-economic Studies, 4(3), 1-9. 2016

[2] Keene S., Smyth C. End-of-Life Options for Construction and Demolition of Timber Waste: A Christchurch Case Study. Univ. Canterbury, New Zealand. 2009

[3] Ivanova, O. V., Ivanov, E. A., Tereschenko, V. A., Efimova, L. V., Zaznobina, T. V., Frolova, O. A. Wood waste of forest industry of Siberia for feeding cows. In IOP Conference Series: Earth and Environmental Science (Vol. 341, No. 1, p. 012095). IOP Publishing. 2019

[4] Mokhtar N, Razali SM, Sulaiman MS, Edin T, Wahab R. Converting wood-related waste materials into other value-added products: A short review. In IOP Conference Series: Earth and Environmental Science 2022 Jun 1 (Vol. 1053, No. 1, p. 012030). IOP Publishing. 2022

[5] Besserer A, Troilo S, Girods P, Rogaume Y, Brosse N. Cascading recycling of wood waste: A review. Polymers 13(11) 1752. 2021

[6] Kadir, A. A., Azhari, N. W., Jamaludin, S. N. An overview of organic waste in composting. In MATEC Web of Conferences (Vol. 47, p. 05025). EDP Sciences. 2016

[7] Butler, T. A., Sikora, L. J., Steinhilber, P. M., Douglass, L. W. Compost age and sample storage effects on maturity indicators of biosolids compost. Journal of environmental quality, 30(6), 2141-2148. 2011

[8] Fathi, H., Zangane, A., Fathi, H., Moradi, H., Lahiji, A. A. Municipal solid waste characterisation and it is assessment for potential compost production: A case study in Zanjan city, Iran. American Journal of Agriculture and Forestry, 2(2), 39-44. 2014

[9] Raza, S., Ahmad, J. Composting process: a review. International Journal of Biological Research, 4(2), 102.2016

[10] Chen, L., de Haro Marti, M., Moore, A., Falen, C. The composting process. Dairy Manure Compost Production and Use in Idaho, 2, 513-532. 2011

[11] Food and Fertilizer Technology Center. Composting Wood Chips. [Online]. [Accessed: 02-Feb-2022]. Available: https://www.fftc.org.tw/en/publications/main/507. 2021

[12] EPA. Types of composting and understanding the process. [Online]. [Accessed: 12-Jan-2022]. Available: https://www.epa.gov/sustainable-management-food/types-composting-and-understanding-process. 2016

[13] Musa, A. M., Ishak, C. F., Karam, D. S., Md Jaafar, N. Effects of fruit and vegetable wastes and biodegradable municipal wastes co-mixed composts on nitrogen dynamics in an Oxisol. Agronomy, 10(10), 1609. 2020

[14] Latifah, O., Ahmed, O. H., Abdul Majid, N. M. Enhancing nitrogen availability, ammonium adsorption-desorption, and soil pH buffering capacity using composted paddy husk. Eurasian soil science, 50(12), 1483-1493. 2017

[15] Latifah, O., Ahmed, O. H., Susilawati, K., Majid, N. M. Compost maturity and nitrogen availability by co-composting of paddy husk and chicken manure amended with clinoptilolite zeolite. Waste Management & Research, 33(4), 322-331. 2015

[16] Saludes RB, Iwabuchi K, Miyatake F. Characterisation of dairy cattle manure/wallboard paper compost mixture. Bioresource Technology 99: 7285–7290. 2008

[17] Sundberg C, Jonsson H. Higher pH and faster decomposition in biowaste composting by increased aeration. Waste Management 28: 518–526. 2007

[18] Chang JI, Tsai JJ, Wu KH. Composting of vegetable waste. Waste Management Research 4: 354–362. 2006

[19] Verma, R., Maurya, B. R., Meena, V. S., Regar, K. L., KUMAR, L., JAT, M. M., Deewan, P. Studies on Temperature Fluctuation and Moisture Changes in Different Methods of Composting. Trends in Biosciences. 2014

[20] Aydn, G.A., Kocasoy, G. Investigation of appropriate initial composition and aeration method for co-composting of yard waste and market wastes. J. Environ. Sci. and Health, 38(2): 221-231. 2003

[21] Inckel, M., de Smet, P., Tersmette, T., Veldkamp, T. The preparation and use of compost (Vol. 27). Agromisa. 2005.

[22] Amery, F., Vandaele, E., Körner, I. Loades, K., Viaene, J. Vandecasteele, B., Willekens, K. Compost quality indicators. Interreg North Sea Region. [Online]. [Accessed: 06-Jan-2022]. Available: https://northsearegion.eu/media/15220/soilcom-report-1-compost-quality-indicators.pdf. 2020.

[23] Kiyasudeen, K., Ibrahim, M. H., Quaik, S., Ismail, S. A. Prospects of organic waste management and the significance of earthworms. Springer. 2015.