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Regional Case Study

Biodegradability Potential Measurement of Organic Waste to Enhance Compost Quality at the University of Mataram

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Abstract

This study aims to analyze the volume, weight, composition of organic waste, the characteristics of C/N, moisture content, and biodegradability fraction as a reference for biodegradability potential. Using the load count analysis method—based on modifications of SNI 19-3964-1994 and the UN-Habitat Wise Waste Cities Tools (2010)—researchers measured the daily waste generation, which amounted to approximately 11,967±2,528 liters in volume and 1.91±0.4 tons in weight. The organic waste primarily consisted of dry leaves (53%), household waste (25%), green manure and grass (17%), and vegetable waste (5%). Laboratory tests revealed the waste had a carbon-to-nitrogen (C/N) ratio of 62.07%, a moisture content of 66.76%, and a biodegradability fraction of 7.6%. These values do not align with raw material composting standards, indicating the need for waste treatment before composting. To enhance the composting process, the study recommends separating green (nitrogen-rich) and brown (carbon-rich) materials, prioritizing the green portion as the main composting input, and drying the material initially to reduce moisture to 40–45%. Composting is highlighted as a simple, eco-friendly solution for managing organic waste, contributing to soil fertility, structure improvement, and supporting sustainable agricultural practices.

Keywords: Compost raw materials; compost quality; decomposition; organic waste ; valorization; universities

1. Introduction

Solid waste in the education area is included in the non-domestic sector, which is a component of municipal waste. The University of Mataram is one of the largest universities in West Nusa Tenggara that focuses on environmental sustainability. The University of Mataram produces anorganic waste from educational activities and organic waste from food waste and green open spaces. Waste generation sources can be categorized based on several activities, including education and research, and the commercial, residential, and administrative sectors (Adeniran et al., 2017a). Waste management at the University of Mataram still adopts the old paradigm of collect-transport-disposal, so that all waste generation ends up at the Kebon Kongo Landfill. Unmanaged solid waste causes negative impacts, including air pollution, water pollution, land degradation, leachate, and CH_4 emissions. These impacts impose environmental costs to restore public health and other social costs (Abubakar et al., 2022). Waste management in higher education is complex and multidisciplinary, requiring the involvement of many experienced stakeholders (Fagnani and Guimarães, 2017).

Based on observations of waste transportation by vehicle, waste generation at the University of Mataram is dominated by organic waste in the form of fresh grass and dry leaves. In this study, organic waste generation was the source of the material studied by considering the quantity of dominant waste generation and the negative impacts caused. Organic waste that decomposes naturally produces large amounts of methane gas (CH_4) and ammonia (NH_3), which can contribute significantly to global climate change (Chen et al., 2020; Dede et al., 2023). The current problem is that valid and accurate data on organic waste generation and composition remain unknown. The inventory of organic waste generation and composition data is very important in formulating waste reduction strategies and policies, as well as formulating the maximum potential for recycling and waste processing in developing sustainable organic waste management programs (Smyth et al., 2010). The processing of organic waste at the University of Mataram was initiated using the composting method. Effective composting can be achieved by providing optimal initial conditions for decomposers, including a proper balance of nutrients, moisture content, and aeration (Azim et al. 2017). Biodegradability potential describes the percentage of organic waste that can be decomposed naturally using microorganisms as raw materials to optimize the composting process. Factors that affect the success of composting include the texture of the raw material, temperature of the composting process, humidity, PH, C/N ratio (Ayilara et al., 2020), and lignin content (Wang et al., 2022).

The application of the composting method has many advantages, such as increasing agricultural productivity and soil organic matter content (Luo et al., 2017), and spurring plant growth due to the presence of sufficient elements in the composted material (Pane et al., 2014). Besides being a fertilizer, compost is very useful for bioremediation (Ventorino et al., 2019), pest and plant disease control (Pane et al., 2019), weed control (Coelho et al., 2019), pollution prevention (Uyizeye et al., 2019), erosion prevention, and landscape and wetland restoration. Composting can increase the biodiversity of soil biota and reduce the risk of environmental damage caused by synthetic fertilizers (Pose-Juan et al., 2017). Composting is an environmentally friendly method with low cost (Waqas et al., 2018). Composting is an appropriate method for processing easily biodegradable organic wastes (Abdel-Shafy and Mansour, 2018).

Several studies have been conducted on waste management in universities that include organic waste. Adeniran et al. (2017) measured the waste generation and composition at the University of Lagos. The results of this study showed waste generation, composition, and recycling potential, which stated that the volume and distribution of plastic bags on campus had a positive correlation with the distribution of commercial and academic areas; therefore, optimization of waste generation reduction was needed (Adeniran et al., 2017a). Bahcelioglu et al. (2020) measured waste generation and composition in the Metu Turkey Campus, which has implications for calculating recycling potential, developing strategies to reduce waste generation, increasing the percentage of recyclable material collection, and starting composting (Bahçelioğlu et al., 2020). Research by Torrijos et al. 2021 related to the integration of food waste processing and garden waste with the composting method. This study resulted in a reduction in waste generation and an increase in composting practices for organic waste management on campus (Torrijos et al., 2021). Research measuring waste generation and composition in higher education by Guerreiro et al. (2024) resulted in recommendations such as collection of organic waste at the source, separation of wet waste as a very important management basis, awareness and participation of the academic community, and conducting PDCA (Plan, Do, Check, and Act) cycles in waste management in higher education (Rodríguez-Guerreiro et al., 2024). El Halwagy's 2024 research on waste management strategies in higher education by applying checkpoints in the form of workflow in the development of waste management in CIC-New Cairo. The existence of a waste management workflow is very important for stakeholders to develop a waste management plan in accordance with college activities (El-Halwagy, 2024). This research bridges the gap in previous studies on organic waste management by using the composting method to maximize the effectiveness of the composting process. The effectiveness of composting is represented by parameters such as the C/N ratio, moisture content, and biodegradability fraction to ensure the quality of raw materials for composting. This study aimed to identify the generation and composition of organic waste while evaluating the potential for biodegradability in enhancing the quality of compost raw materials.

2. Methods

2.1 Location and Time

This research was conducted at the University of Mataram, Mataram City, West Nusa Tenggara Province for 8 days from May 28 to 6 June 2024 as sampling time for waste generation and composition analysis according to SNI 19-3964-1994.

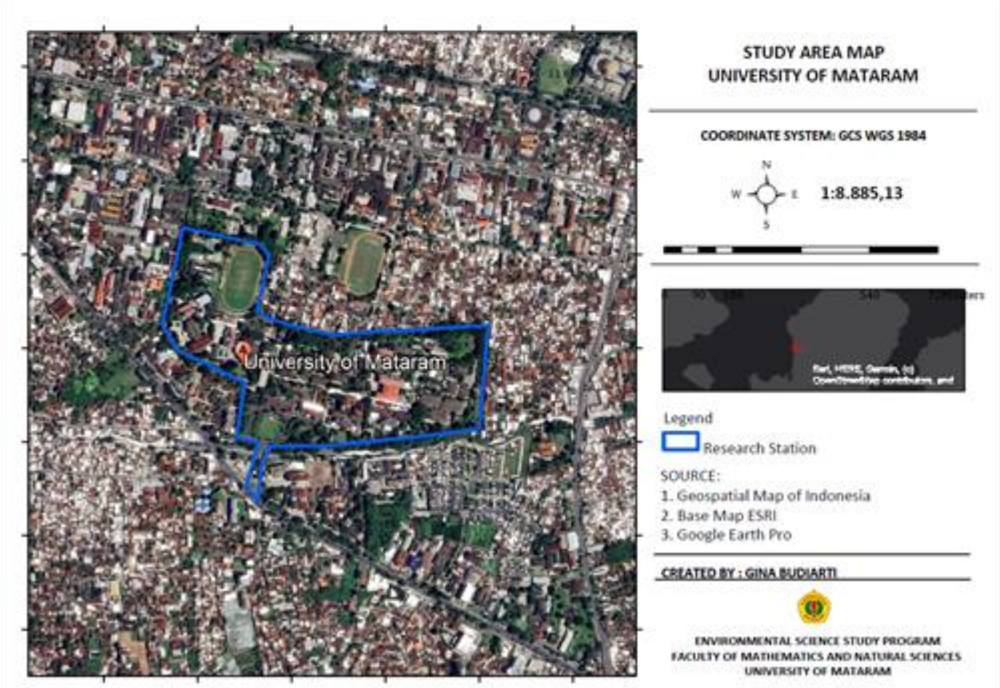

Figure 1. Research Location

2.2 Research Instrument

The instruments used in this study included a camera, compacting box 60 L, worksheet, meter measurement, name tag sticker, plastic clip 7 cm, PPE (hat, mask, hand gloves, hand sanitizer), set of equipment for moisture content analysis (porcelain cup, desiccator, oven), set of equipment for analysis of lignin content (stirring rod, porcelain cup, glass funnel, desiccator, hotplate, filter paper, Erlenmeyer flask, oven, drop pipette, analytical balance), digital hanging scale, and vehicle. The materials needed are organic waste, distilled water, and 72% sulfuric acid (H_2SO_4).

2.3 Research Procedure

2.3.1 Organic Waste Volume and Weight Generation.

Organic waste sampling was conducted using the Load Count Analysis Method based on the volume of organic waste transported by vehicle. The University of Mataram operates two transportation vehicles consisting of dump trucks, providing one transportation service per day. This study is limited by the fact that direct measurements were conducted on a single dump truck, operating under the assumption that the other dump truck is of identical size and that the volume of waste transported is consistently full, similar to other truck. The organic waste volume generation is formulated as follows:

$$Vg = \frac{((OWV\ V1\ x\ Tr)+(OWV\ V2\ x\ Tr)1+\cdots+(OWV\ V1\ x\ Tr)+(OWV\ V2\ x\ Tr)n))}{Tsd} \quad (1)$$

Description:

Vg : volume generation (liter/day)

OWV V1 : organic waste volume in vehicle 1 (liter) at day 1 until day 8
OWV V2 : organic waste volume in vehicle 2 (liter) at day 1 until day 8
Tr : total ritation quantity day 1 until day 8
Tsd : total sampling day

The calculation of waste weight was obtained by converting the organic waste volume (liters) using the average density obtained by direct sampling. The weight of the waste is formulated as follows:

$$wg = \frac{(ADOw \; x \; Vg1) + \cdots + (ADOw \; x \; Vg8)}{Tsd} \quad (2)$$

Description
Wg : waste generation (kg/day)
ADOw : average density organic waste (kg/liter)
Vg : volume generation (liter) day 1 until day 8
Tsd : total sampling day

2.3.2 Composition of Organic Waste

The organic waste composition was calculated using ASTM D5231-92. These data were obtained by sampling approximately 11 kg/day based on ASTM D5231-92 standards related to the research sample used between 91 kg and 136 kg for 8 days. The amount of waste composition that must be sorted to be sampled is obtained for as many as 19 samples through the following equation (3):

$$n = \left(\frac{t.s}{e.\bar{x}}\right)^2 \quad (3)$$

The value of t is the desired confidence level of 90% with the number of organic waste samples ∞ such that the value of t is 1,645, s is the estimated standard deviation for organic waste with a value of 0.0725, e is the desired precision level of 10%, and x is the estimated average value of 0.0625 (D34 Committee, n.d.). The grouping of organic waste at the University of Mataram is based on the research of Yulipriyanto et al. (2001), which includes vegetable waste, green manure and grass, dry leaves, and household waste (Yulipriyanto, n.d.). Organic waste that has been separated into as many as 19 samples was grouped based on the results of Yuliprianto et al. (2001) and then weighed based on each category. The composition of the organic waste is formulated as follows:

$$Composition \; of \; organic \; waste \; (\%) = \frac{wet \; weight \; spesific \; type \; of \; organic \; waste}{wet \; weight \; total \; organic \; waste} \; x \; 100\% \quad (4)$$

2.3.3 Organic Waste Characteristics

The biodegradability potential of organic waste in the University of Mataram was obtained by measuring the C/N parameters, moisture content, and biodegradability fraction obtained from the lignin content test. In measuring the potential biodegradability parameters, organic waste samples were taken in an amount of ±10 grams for each parameter sample. The preparation of organic waste samples involved compositing all types of waste compositions to ensure homogeneous mixing. The C/N content, moisture content, and lignin content of organic waste were obtained through laboratory tests using the characteristic measurement analysis method in (Table 1).

Table 1. Analysis methode of parameter in laboratory

Parameter	Analysis Method	Reference Standard
Carbon	UV-Vis Spectrophotometry	Walkley & Black
Nitrogen	Kjeldahl Methode	SNI 2803:2010
Moisture content (%)	Gravimetry	SNI 1971:2011
Lignin content (%)	Klason Method	SNI 0492:2008

The parameters of C/N, moisture content, and biodegradability fraction that were analyzed in the laboratory were compared with the ideal parameters required as compost raw materials. Based on previous research, effective composting requires the right raw material with a C/N ratio of 1:30, a moisture content of approximately 40–60% (Ameen et al., 2016), and a biodegradability fraction of ≥50% (Ruslinda and Hayati, 2013) . The biodegradable fraction is closely related to the lignin content. The lignin content affects the biodegradability fraction; a higher lignin content corresponds to a lower biodegradability fraction. (Dewilda et al., 2022). Based on the calculation of the kinetic constant of the reaction, organic waste containing high lignocellulosic material will decompose longer, resulting in a small biodegradability fraction (Gutiérrez et al., 2017). The measurement of the biodegradable fraction is influenced by the combustion of volatile solids at 550 °C (Ruslinda and Hayati, 2013). The biodegradable fraction can be analyzed using the following formula:

$$BF = 0.83 - 0.028\,LC \quad (5)$$

Description

BF : biodegradability fraction expressed in volatile solid basis

LC : lignin content in volatile solid expressed in % by weight

0.83 and 0.028 : empirical constant

$$Recyling\ potential\ (\%) = \frac{wOw\ std}{T\ wOw}\ x\ 100\% \quad (6)$$

Description

wOw std : organic waste generation that meets compost raw material standards

T wOw : total organic waste generation

3. Result and Discussion

3.1 The Organic Waste Generation in University of Mataram

The measurement of the volume and weight of organic waste generation at the University of Mataram began with the sorting of organic waste (Figure 2) into the categories of vegetable waste, green manure and grass, dry leaves, and household waste. Waste sorting directly in the vehicle is carried out starting at 08.00 WITA because, at that time, it is a daily routine transportation schedule by the operator before being transported to the Kebon Kongo landfill.

Figure 2. Organic waste sorting process in the vehicle

The average volume of organic waste generated in the University of Mataram is 11,967 ± 2,528 L/day with a weight of 1.91 ± 0.4 tons / day (Figure 3). The number of academicians at University of Mataram based on PD-Dikti data in 2023 was 34,790 people with individual organic waste generation of 0.06 kg/person/day and 0.40 L/person/day. The factors that influence waste generation in higher education are the attitudes of the academic community, gender, number of study programs, type of university, and operational costs (Pan et al., 2022). Waste management in higher education presents several challenges, including a wide variety of waste types, diverse campus activities, inadequate waste segregation, and improper waste disposal (El-Halwagy 2024). The results of this study are in line with waste generation at Andalas University 2.19 tons / day with a total academic community of 37,099 people with individual organic waste generation of 0.05 kg / person / day (Yenni Ruslinda et al., 2023). Another study on waste generation and composition at Lagos University found that the organic waste generation was 4.83 tons/day with a total academic community of 57,467 people with individual organic waste generation of 0.08 kg/person/day (Adeniran et al., 2017a).

The implications of the waste weight data are to determine the recycling potential and economic potential of various types of waste. Utilization of waste generation will generate positive economic impacts, such as providing income to the community (Allevi et al., 2021). The implication of waste volume generation is to determine waste handling such as containerization (volume of containers and container materials), waste collection (waste collection patterns and waste collection infrastructure), and waste transportation (waste transportation patterns and transportation equipment). The generation and composition of organic waste are very important in determining the proper handling and processing of organic waste, including converting waste into energy sources and predicting greenhouse gas emissions arising from waste generation and management (Abdel-Shafy and Mansour, 2018). Comprehensive organic waste generation and composition data can generate waste management development strategies (with social, structural, and managerial approaches) to reduce organic waste generation, increase the collection of recycled materials, and initiate organic waste processing using composting methods (Bahçelioğlu et al., 2020). One alternative to organic waste management is to add added value to organic waste for compost and biochar. Based on research by Adhikari et al. (2024), the right organic waste processing technology can be selected by measuring greenhouse gas emissions at each stage of the process with the Life Cycle Assessment (LCA) method. The results showed that processing organic waste into biochar is more environmentally friendly than composting (Adhikari et al., 2024). Universities can build waste processing facilities such as waste banks that distribute inorganic waste consisting of paper and plastic for sale, and organic waste is processed into compost, increasing the circular economy potential for the academic community (Widiyanti and Hadi, 2022). The implications of waste management are not only focused on recycling but also include recommendations such as waste segregation at the source, optimization of landfill practices, thermal treatment measures, strategies to enhance waste value as a relevant solution aligned with local realities, increasing community participation, and promoting recycling initiatives (Zhang et al., 2024).

The volume and weight of waste generation showed a fluctuating trend during the eight days of measurement. The volume and weight of waste on the first day tended to increase because there was hoarding of volume and weight of organic waste at the beginning of the week. Vehicles on weekends or holidays are not carried out, so waste from Fridays to Sundays accumulates. This is in line with the research of Parizeau et al. (2006), which explains that people have a habit of collecting and storing waste during the weekend, so there is hoarding when there is no transportation (Parizeau et al., 2006). The volume and weight of waste on the second and third days tend to decrease because routine transportation activities are carried out every weekday. The volume and weight of waste on the fourth day on Thursday and Friday increased due to green open space maintenance activities in the form of trimming branches and leaves and cutting green grass. The volume and weight of waste on the fifth and sixth days on Monday and Tuesday increased because there was hoarding of waste on Saturday and Sunday without routine transportation on that day.

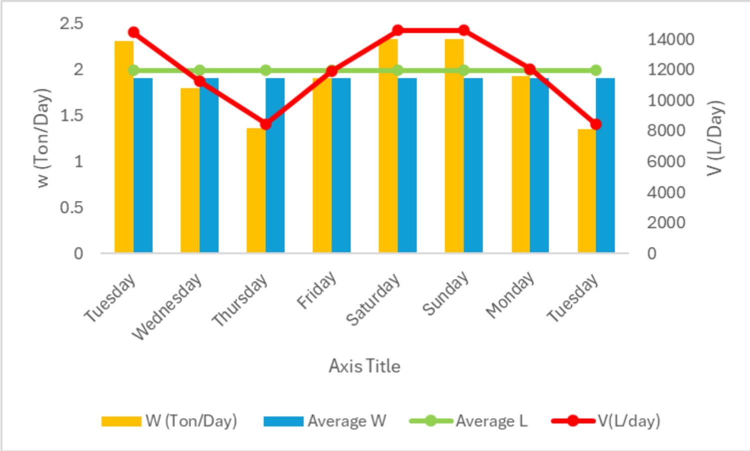

Figure 3. The organic waste generation in University of Mataram

3.2 The Composition of Organic Waste

The composition of organic waste in the University of Mataram was carried out by sorting waste based on the composition of waste types consisting of vegetable waste, green manure and grass, dry leaves, and household waste. The composition of organic waste types in the University of Mataram is dry leaves 53%, household waste 25%, green manure and grass 17%, and vegetable waste 5% (Figure 4). The composition of organic waste types in the University of Andalas is similar to the results of the study, which is dominated by green waste from roads and parks 22.4% and food waste (31.5 %) (Yenni Ruslinda et al., 2023). Research at the University of Lagos showed the highest percentage of food waste (10%) and waste from green open spaces (5%) (Adeniran et al., 2017a). The high percentage of organic waste with dry leaves is due to the large amount of green open space owned by the University of Mataram, which is 17.58 hectares or equivalent to 43.74% of the total area of the University of Mataram (Fitriani et al., n.d.). This green open space includes parks, fields, and other green areas planted with various types of plants and trees. The amount of dry leaves produced was very significant. These leaves fall naturally and add to the volume of organic waste that must be managed. The lowest organic waste type composition is 5% vegetable waste because the canteen at the University of Mataram offers a menu that does not use many vegetables.

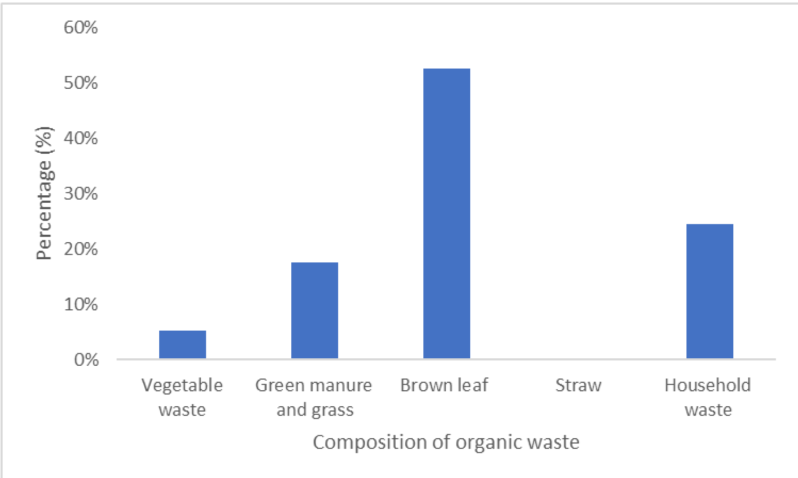

Figure 4. The composition of Organic Waste

The calculation of waste generation and composition can be used to determine the recycling potential, including compostable, recyclable, and non-recyclable (Moqbel, 2018). The composition of the highest type of organic waste was 53% dry leaves. The high percentage of organic waste in the form of dry leaves is attributed to the extensive green open spaces at Universitas Mataram, which cover an area of

17.58 hectares or equivalent to 43.74% of the total area of Universitas Mataram (Fitriani et al., n.d.). These green open spaces encompass various parks, fields, and other green areas planted with diverse types of plants and trees. The quantity of dry leaves produced is significantly high. These leaves fall naturally, contributing to the volume of organic waste that needs to be managed. Several studies have examined waste composition on university campuses, highlighting its implications for waste reduction efforts through segregation and recycling potential. In the segregation process, waste composition is categorized into paper, plastic and metal, glass, and non-recyclable within faculty buildings. When setting up sorting facilities are placed in faculty buildings, individual waste bins in offices and classrooms are removed, and waste segregation is conducted in a centralized manner. Following the segregation efforts, the composition of sorted waste was found to be 25% glass, 27% paper, 24% metal/plastic, and 23% non-recyclable waste (a reduction from the initial 100% to 24% after segregation efforts) (Gursoy Haksevenler et al., 2022). The study by Adeniran et al. (2017) analyzed the waste composition at the University of Lagos, which consisted of 24% polyethylene plastic, 15% paper, 15% organic waste, 9% plastic, 8% inert material, 7% sanitary waste, 7% textiles, 6% other waste, 4% leather, 3% metal, 2% glass, and 0% electronic waste. The volume and distribution of polyethylene bags were found to correlate with commercial and academic activities on campus. Understanding waste composition is highly beneficial for selecting appropriate waste management technologies, particularly in optimizing reuse, recycling, and waste reduction efforts (Adeniran et al., 2017b).

Based on the characteristics of nutrient content and lignocellulose, the recycling process of garden waste should be separated into the green part (grass and leaves) and brown part (branches) as an effective approach. From an environmental and economic perspective, the brown part is more suitable for energy conversion, whereas composting for nutrient recovery is more appropriate for the green part. The right combination of recycling technologies will transform garden waste into a valuable resource to support the circular economy and address future sustainability challenges (Liu, 2023). The processing of dry leaf waste can be utilized to produce dry leaf briquettes as an environmentally friendly alternative energy source, a source of livelihood, and a positive contribution to waste management in a given area. To ensure the quality of dry leaf briquette products, proximate and ultimate analyses were conducted following the Indonesian National Standard (SNI) No. 01-6235-2000. The test results indicated a moisture content of 4.35%, an ash content of 5.65%, a fixed carbon content of 78.68%, a calorific value of 6115 cal/g, and a combustion rate of 1.5 g/min (Sihotang et al., 2024). The composition of the food waste reached 25%. This is because the canteen at the University of Mataram offers various foods with minimal vegetable content. The valorization potential of food waste can be used as soil conditioner products with anaerobic digestion technology, compost products with aerobic composting technology, soluble organic waste material products with chemical hydraulic technology, and biochar products with pyrolysis technology (Ansari et al., 2024).

3.3 Characteristics of Organic Waste

Based on research by Azim et al. (2017), composting parameters consist of start-up, monitoring, and quality parameters. The results of laboratory tests show that the organic waste at the University of Mataram has the following characteristics (Table 2).

Table 2. Laboratory test results

***Start-up Parameter* Characteristic**	**Raw Material Standard Value**	**Reference**	**Laboratory Test Results**	**Description**
C/N Ratio	1:30	Gonawala et al 2017	62,07	Not meet standard
Moisture content	40 - 60%	Ameen et al 2016	66,76 %	Not meet standard

Start-up Parameter Characteristic	Raw Material Standard Value	Reference	Laboratory Test Results	Description
Biodegradability fraction	≥ 50 %	Fauzi et al 2022	7,6 %	Not meet standard

The results showed that The C/N ratio of the organic waste was 62.07. When compared to the standard value of compost raw materials 1:30, the C/N ratio value did not meet the standard. The biodegradable fraction of organic waste was 7.6%, which is below the standard for raw materials. This is because the composition of the highest type of organic waste in the University of Mataram is in the form of dry leaves at as much as 53%. Garden waste is divided into two parts: the green part (leaves and grass) and the brown part (branches, roots, and stems) (Vandecasteele et al., 2016). The nutrient content of the green part was three times higher than that of the brown part. The total content of N, P, and K in the green parts reaches 3.3% and the C/N ratio is only about 36, while the brown parts have a total content of N, P, and K of 1% and a C/N ratio of 177. The brown part has a lignocellulose content of nearly 90% with higher lignin content, which can resist biodegradation and slow down the decomposition of hemicellulose and cellulose (Karnchanawong et al., 2017). When composting materials have a low C/N ratio, air cannot enter the waste pile, causing anaerobic conditions that result in odor and nitrogen loss in the form of ammonia gas. If the C/N ratio is too high, the activity of organisms will be reduced, and the rate of decomposition will be slow (Manea et al., 2024). The first process that must be done is to understand the characteristics of the composition of organic waste by separating the green and brown parts so that it can help in choosing the right technology to increase the effectiveness of recycling. When viewed from the aspect of waste type composition, the potential biodegradability of organic waste based on the composition of the green part of organic waste is 22%, which consists of green manure, grass, and vegetable waste. The study conducted by Rahman et al. (2021) examined the processing of garden waste, including dry leaves, fresh leaves, and grass clippings, using the composting method at a pilot-scale level. To optimize the initial C/N ratio, raw materials were mixed with livestock manure and other waste, resulting in C/N ratios of 25:1 and 42:1 in the analysis. The C/N ratio for mature compost was found to range between 10:1 and 15:1, yielding compost at 50% to 70% of its wet weight. An economic analysis was conducted, revealing a benefit-to-cost ratio (BCR) greater than 1, indicating that composting garden waste is a viable process that can support agricultural needs (Abdul Rahman et al., 2020).

The results showed a moisture content of 66.76%, which did not meet the standard of composting raw materials moisture content of 40–60%. The high water content is because all types of waste undergo composting. High moisture content can result from the moisture content of wet waste, such as household waste, green manure, and vegetable waste. The presence of water content can come from metabolic water produced by microorganism activity. Excess moisture content can lead to reduced oxygen diffusion, which will inhibit the activity of microorganisms. The microbial activity is highly dependent on the presence of moisture and inhibits the mineralization of organic matter (Chennaoui et al., 2018) (Antoszewski et al., 2022). Excess moisture content causes anaerobic conditions that result in unpleasant odors, while too little moisture content can inhibit microbial growth and activity (Zhao et al., 2022). Torijos et al 2021 conducted a study on the integration of the composting process of garden waste and food waste which resulted in a fairly high moisture content value of 67.3 ± 3.6 during the irrigation practice which aims to keep the moisture content high until the final process in supplying earthworm activity for the next process. In this study, it was not recommended that the moisture content be lowered before application to the soil, as the compost was taken directly from the compost maturation site to the use site without transitional storage (Torrijos et al., 2021). However, a significant impact of excess moisture content in the range of 60–70% can be CH_4 and N_2O emissions. The composting decomposition process will be optimized with a moisture content of 40–50% by allowing the compost raw material to dry for the first few days to a moisture content of 40–45% (Ermolaev et al., 2019). The moisture content decreases due to a combination of rising temperature and forced ventilation, leading to water loss in the form of vapor. Additionally, the optimal moisture content varies and primarily depends on the physical structure and changes in particle size during the composting process (Gigliotti et al., 2012). The optimal moisture content for composting materials is not universally defined, as it is inherently dependent on the distinct physical, chemical, and biological properties of each material. These characteristics influence the complex interactions between moisture and key associated factors, including water retention capacity, particle size distribution, porosity, and permeability (Makan et al., 2013).

The management of organic waste in various higher education institutions has been implemented through the provision of composting facilities. The primary objective of these composting areas is to produce organic fertilizer from dry leaves and food waste. Waste segregation is conducted based on its composition, categorizing it into biodegradable, non-biodegradable, and recyclable materials (Geronimo, 2018). A study by Smyth et al. (2010) on waste characterization at the University of Northern British Columbia found that the institution generated between 1.2 and 2.2 metric tons of waste per week, with 70% of this waste being potentially reducible through waste minimization, recycling, and composting activities. Paper and paper-based products, disposable beverage containers, and compostable organic materials were identified as the three primary material types targeted for waste reduction and recycling efforts (Smyth et al., 2010). El Hawagy et al. (2024) conducted a study on waste management at the Department of Architecture, CIC Cairo, which highlighted that educational institutions could serve as role models for best practices in resource efficiency, ultimately yielding positive ecological and economic impacts. Effective waste management in educational institutions requires a holistic approach, encompassing the development of waste reduction plans, the promotion of recycling and composting programs, and the integration of waste management initiatives into the curriculum. To ensure the sustainability of these programs, active collaboration and engagement from all stakeholders within the institution are essential. Several strategies can be employed to enhance academic community participation in waste management, including upcycling workshops, community clean-up activities, composting initiatives, recycled material art projects, plastic-free campaigns, electronic waste recycling programs, waste audits, food waste reduction challenges, the creation of sustainable products, low-waste events, green infrastructure projects, and waste reduction education campaigns (El-Halwagy, 2024).

The composting process is a long-established technology; however, various limitations hinder its efficiency and widespread adoption. Some of these challenges include pathogen detection, low nutrient content, prolonged composting duration, slow mineralization processes, and the generation of unpleasant odors. Several strategies can be employed to enhance composting effectiveness. One approach is the extraction of single nutrients (mono-nutrients) from compost, as soil analyses conducted before planting often reveal deficiencies in specific nutrients. The extraction of single-nutrient fertilizers is beneficial in preventing excessive nutrient application to crops. The addition of microorganisms capable of decomposing complex and recalcitrant organic materials can accelerate the composting process. Furthermore, integrating odor control mechanisms during composting can mitigate air pollution issues. To enhance compost's ability to improve soil structure and nutrient availability, it is essential to supplement it with essential nutrients such as nitrogen, which plays a key role in promoting plant growth. Effective compost production can also be achieved by incorporating plant-derived anti-nematode, viricidal, bactericidal, and fungicidal compounds. This approach supports the full implementation of organic farming, reducing reliance on chemical inputs (Ayilara et al., 2020). Improving the quality and homogeneity of organic waste raw material is crucial for optimizing composting efficiency and the final compost quality. To achieve this, modern technologies for organic waste sorting and pre-treatment should be developed, with a particular focus on minimizing operational and environmental costs. The implementation of artificial intelligence (AI) and machine learning (ML) in organic waste sorting systems can significantly enhance sorting accuracy and efficiency. The efficiency of the composting process and the quality of the final compost are strongly influenced by key operational parameters such as aeration, moisture, and temperature. The advancement of sensor technology and the Internet of Things (IoT) can facilitate real-time monitoring and control of these parameters. Future research should focus on the development of intelligent composting systems capable of automatically adjusting aeration and temperature to optimize microbial activity and accelerate composting (Manea et al., 2024).

4. Conclusion

The volume generation of organic waste generated at the University of Mataram is 11,967 ± 2,528 L/day, the weight generation of organic waste is 1.91 ± 0.4 kg / day, and the composition of organic waste types includes dry leaves 53%, household waste 25%, green manure and grass 17%, and vegetable waste (5%). The C/N ratio, moisture content, and lignin content of organic waste from Mataram University are 62.07%, 66.76%, and 7.6%, respectively, which are below the standard for raw materials. The biodegradability potential of organic waste based on the composition of the green part of organic waste is 22%, which consists of green manure, grass, and vegetable waste. The generation and composition of organic waste are very important in determining the recycling potential and economic potential of various types of waste, the proper handling and processing of organic waste, including converting waste into energy sources and predicting greenhouse gas emissions arising from waste generation and management. To optimize certain parameters that do not meet the standard requirements of compost raw material, several strategies can be implemented. These include separating the green and brown fractions of organic waste, allowing initial drying of the compost raw material for a few days, and introducing microbial inoculants to accelerate the composting process. The segregation of organic waste into green (readily compostable) and brown (hard to compostable) fractions is essential to ensure a more homogeneous raw material that meets the initial parameter standards for the composting process.

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