Study of Land Productivity in Composting Process of Tea Solid Waste at PT Gunung Slamat

Antika Tafrijiyah*, Bayu Widiyanto, Nia Elfiana
Department of Natural Science Education, Faculty of Teacher Education and Educational Sciences
Universitas Pancasakti Tegal, Jl. Halmahera Km.1 Kota Tegal 52121, Indonesia.
Email: antikatafrijiyah48@gmail.com*

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Abstract

PT. Gunung Slamat, as a company operating in the tea processing industry, was founded by the Sosrodjojo family. This scientific article aims to analyze land productivity in composting solid tea waste at PT. Gunung Slamat by considering land area, waste processing capacity, and providing recommendations for solutions that can significantly increase the productivity of solid tea waste processing land. The research adopts a phenomenological approach to obtain the required data. Phenomenology is defined as a type of research that seeks to analyze descriptively and introspectively various forms of human consciousness and experience. Data obtained from quantitative observations will cover various aspects such as the amount of compost produced, the time required to process waste into compost, which will then be collected and analyzed. The compost produced from waste processing at PT. Gunung Slamat is used as fertilizer within the company's environment and distributed to local farmers, benefiting both the environment and the local community. This compost product is not sold because PT. Gunung Slamat focuses more on selling tea products. In waste processing, several issues have been identified, including a lack of suitable technology for utilizing tea waste. The research findings indicate that land productivity in composting solid tea waste fluctuates during the study period, with changes associated with various factors such as waste quantity, weather, and management practices. Further evaluation of the factors influencing land productivity, along with the implementation of more advanced technology, can enhance efficiency and have a positive impact on the environment.

Keywords: *Productivity*, *Tea Waste Compost, Waste.*

1. INTRODUCTION

Indonesia, with its favorable climate and soil conditions for tea plant growth, has gained a reputation as one of the world's largest tea producers (Zakariyah, Anindita and Baladina, 2014). Despite the significant economic benefits of this achievement, massive tea production also results in a considerable amount of solid waste. Tea solid waste consists of remnants of tea leaves and other parts of the tea plant that are not utilized in the production process.

PT. Gunung Slamat, a company in the tea processing industry, was founded by the Sosrodjojo family in 1953 after previously producing jasmine tea in 1940. In addition to jasmine tea, PT. Gunung Slamat produces black and green tea in various forms, both loose-leaf and packaged, under brands such as Teh Cap Botol, Teh Celup Sosro, Teh Cap Poci, and others (PT. Gunung Slamat, 2019). While the high productivity of tea can be observed through the production of products by PT. Gunung Slamat, it also leads to an increase in post-production waste. Based on field observations over approximately four months, it can be concluded that PT. Gunung Slamat in Slawi, Central Java, generates no less than 2.7 tons of tea waste every month.

Solid waste arising from the tea beverage industry, particularly at PT. Gunung Slamat, generally consists of unused tea leaves in the production process, leftover raw materials, and by-products of the production process. The solid tea waste in this company is derived from the oxidation/firing process, primarily related to the tea shoots changing color to red due to delayed leaf turning during shoot oxidation (Muningsih, 2019). From an economic value perspective, waste can be categorized as economically valuable or non-economic. Non-economic waste refers to material

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that does not provide added value even after undergoing processing, and processing is done solely for ease of disposal (Sulaeman, Arifin and Sadat, 2017). Unfortunately, most of the solid tea waste is currently considered economically valueless and is disposed of without further processing. Inefficient management of solid tea waste can have serious environmental impacts, including soil and water pollution, negatively affecting overall environmental quality.

1.1. Tea Waste

Solid waste is one of the types of waste generated from the tea processing industry. It consists of tea leaves that are not used in the tea production process. Solid tea waste has a composition rich in fibers, proteins, fats, and carbohydrates. If not properly processed, this waste can create environmental problems such as water and soil pollution and reduce land productivity. Accumulated tea waste not only poses a threat to the environment but also requires significant space and labor for disposal. Steps to address this issue need to be explored. Although some approaches, such as using it as livestock feedstock, converting it into fertilizer, and other methods, have been proposed, only a few are viable for meeting the needs of large-scale tea processing industries, and efficient methods have sparked great interest and hope among scientists (Yang, Liang, Wang, Sun, Tao, Xu, Zhang, Zhang, C. Ho, et al., 2016).

1.2. Compost

Indonesia faces recurring waste problems, including in remote villages, largely due to a lack of awareness about waste's environmental impact. Various methods are available to address this issue, but they are often not consistently applied in daily life and are neglected. As a result, waste accumulates, leading to environmental pollution. The waste generated is hazardous to health, and addressing this issue requires community empowerment and appropriate guidance. One effective method is converting waste into compost through an increasingly popular recycling process. Compost is made through the decomposition process of organic waste, such as leaves. Compost is known as a natural fertilizer that can nourish plants without the use of chemicals. By using compost, plants can grow well because it is a natural substance that does not harm the soil environment. Recycling waste into compost has a dual advantage: first, it efficiently processes waste, and second, it increases its commercial value by selling high-value compost (Sylvia, Anwar and Khairani, 2019).

Composting requires the assistance of microorganisms to break down materials and accelerate the process. One factor used in this process is Effective Microorganism 4 (EM4). EM4 functions to expedite the decomposition of organic material, reduce odors during the process, suppress the growth of harmful microorganisms, and enhance the activity of beneficial microorganisms (Anugrah Natalia, Anif Sholikhuddin and Muhammadi, 2021).

The aerobic composting process consists of three stages marked by changes in compost temperature: the mesophilic stage, the thermophilic stage, and the cooling stage. In the initial mesophilic stage, the temperature increases to around 40°C due to the activity of fungi and acid-forming bacteria. Subsequently, the temperature continues to rise into the thermophilic stage, ranging from 40 to 60°C, where the degradation and stabilization of materials occur maximally. In the cooling stage, microbial activity decreases and is replaced by mesophilic bacteria and fungi (Worotitjan, Pakasi and Kumolontang, 2022).

During the cooling stage, the process of water evaporation from the composted material continues, as well as the stabilization of pH and the refinement of humic acid formation. The final product is stable and serves as a source of organic fertilizer. However, the decomposition process of organic material in immature compost (C:N ratio > 25) still occurs, creating anaerobic conditions in the root zone due to oxygen consumption by microbes and immobilization of nutrients, especially nitrogen, leading to nutrient competition between microorganisms and plants (Saraswati and Pratapna, 2017).

Factors influencing compost production include the Carbon-to-Nitrogen (C:N) ratio, moisture content, oxygen content, temperature, pH, and other factors of the raw materials to be processed into compost. The ideal C:N ratio is between 20 to 40:1 or 30 to 1, considered the best ratio. Municipal waste has a relatively optimal C:N ratio of 30 to 40:1, supporting the composting process well (Sahwan, 2010).

1.3. Compost Processing

Based on the manufacturing process, there are two types of compost tea: aerated compost tea (ACT), which receives oxygen through stirring during its production process, and non-aerated compost tea (NCT), which has limited oxygen supply, resulting in restricted stirring (Berek, 2017). Composting can be done aerobically (with oxygen) or anaerobically (without oxygen). Aerobic composting produces CO_2, H_2O, nutrients, and some humus, while anaerobic composting produces CH_4, CO_2, and intermediate compounds that often produce a foul odor due to H_2S and sulfur organic compounds like mercaptan. Aerobic composting is more energy-efficient, producing more energy (484 - 674 kcal/mol glucose) compared to anaerobic composting (26 kcal/mol glucose), and it occurs more quickly (Saraswati and Pratapna, 2017). Composting technology has developed significantly, from open systems to closed systems with air injection. Various types of reactors are used in the composting process, such as vertical and horizontal tower reactors, but the basic process remains the same. According to a study by BPPT, an open system or variations of an open system are the most suitable options for Indonesia based on climate, economic, and socio-cultural conditions (Sahwan, 2010).

1.4. Ideal Composting Facilities

Composting facilities are used to transform organic waste into compost. The composting process takes place in well-managed composting facilities. Composting facilities can be used by individuals, families, or communities to manage the organic waste they generate. An ideal composting facility must meet several criteria to ensure an efficient and effective composting process. Some factors to consider when designing an ideal composting facility include:

1. Size: The composting facility should be large enough to accommodate the amount of organic waste generated by a family or community. An ideal composting facility should have a minimum volume of 10 m³.
2. Ventilation: The composting facility should have a good ventilation system to maintain air quality inside the facility and ensure the composting process runs smoothly. Ventilation can be achieved by creating holes in the walls or roof of the composting facility.
3. Drainage: The composting facility should have good drainage to dispose of water produced during the composting process. Drainage can be provided by installing drainage channels or placing the composting facility on sufficiently elevated ground.
4. Cover: The composting facility should be equipped with a cover to maintain moisture levels inside the facility, prevent rainwater and animals from entering. The cover can be made of waterproof or heat-resistant materials.
5. Accessibility: The composting facility should be easily accessible to facilitate management and maintenance.
6. Stability: The composting facility should be built on stable ground capable of bearing heavy loads.
7. Design: The composting facility should be well-designed and aesthetic, harmonizing with the surrounding environment

(Kementerian Lingkungan Hidup dan Kehutanan, 2021).

Research on land productivity through composting solid tea waste at PT. Gunung Slamat has some connections with previous research conducted in relevant fields. These connections include the nutrient content aspect of solid waste processed into compost(Muningsih, 2019) and (Mukarramah, Sari and Lusyiani, 2023) discussing leaf litter waste productivity. This research contributes positively to waste management efficiency by converting solid tea waste into compost. By reducing the volume of waste ending up in landfills, this research supports sustainable waste management practices. It also provides scientific evidence of increased land productivity in agriculture using compost from solid tea waste. This information can be beneficial for local farmers and the agricultural industry to improve crop yields and soil health. In this context, a critical assessment of the environmental impact generated by tea production, especially in terms of solid waste management, needs to be undertaken. Sustainable and innovative steps need to be taken to reduce its negative impact, considering the application of modern waste management technology and environmentally-based strategies. Awareness of these issues at the industry level can help achieve a balance between high productivity and environmental sustainability.

It is not yet known to what extent the amount of tea waste generated at PT. Gunung Slamat can be balanced with the products obtained through the composting process. Factors such as land limitations, possibly ineffective composting methods, and technological mismatch may contribute to this imbalance. Therefore, an analysis of land productivity in the composting process of solid tea waste at PT. Gunung Slamat is crucial to evaluate waste management land productivity in this company and provide appropriate solutions to significantly improve land productivity in solid tea waste processing. This research aims to analyze land productivity in the composting process of solid tea waste at PT. Gunung Slamat by considering land area, waste processing capacity, and providing recommendations for solutions that can significantly improve land productivity in solid tea waste processing.

2. METHODS

This study employs a phenomenological approach to explore the necessary data. Phenomenology is defined as a research type that seeks to analyze descriptively and introspectively various forms of human consciousness and experience, encompassing sensory, conceptual, moral, aesthetic, and religious aspects (Helaluddin, 2019).

In collecting existing data, there are three stages for obtaining understanding. 1) Epoche is the stage where the researcher suspends prejudices, assumptions, judgments, and interpretations to fully realize the reality faced. 2) Phenomenological reduction is the stage where the researcher looks at the phenomenon as a whole, including physical characteristics and experiences that emerge in the researcher's consciousness when observing the phenomenon. Through phenomenological reduction, the researcher identifies constituents of the experience related to the experienced phenomenon. 3) Imaginative variation is the stage where the researcher attempts to access structural components of the phenomenon with the goal of identifying related conditions. These conditions may involve factors such as time, space, or social relationships that influence the emergence of the phenomenon from Willing (In Yusuf, Nurwanah and Sari, 2022).

Data collection is conducted through observation and direct interviews with respondents who are employees responsible for compost production at PT. Gunung Slamat. Data obtained from quantitative observations will cover various aspects such as the amount of compost produced, the time required to process waste into compost, which will then be collected and analyzed to determine land productivity in waste processing into compost.

Figure 1. Composting Location

The research is conducted at PT. Gunung Slamat, a tea processing company located in Tegal Regency, Central Java. PT. Gunung Slamat was chosen as the research location because it is where solid tea waste is generated and can be used as raw material for compost production. The location of solid tea waste processing into compost, as depicted in Fig 1, is located at the back of the main production facility. The processing is carried out regularly during working hours, with solid tea waste entering every day. Daily data on incoming waste and compost results during the research period provide an overview that the average waste produced per day reaches 111 kg. Managing solid tea waste is the main focus at this location, and the process is designed to minimize environmental impact.

Productivity refers to the relationship between the outcomes produced and the resources utilized. Increasing productivity can have a positive impact on economic growth. It is important to emphasize that productivity is not identical to production. Instead, productivity encompasses a combination of effectiveness and efficiency in resource utilization. Productivity in agriculture is defined as the ability of an input (land area) to produce an output (production yield) per unit of land area (Reza and Effendi, 2022). To determine land productivity in composting, it is obtained by dividing the production yield (in tons) by the land area (in hectares) over a specific period. This can be systematically expressed as follows:

$$Land\ Productivity = \frac{Production\ Yield\ (tons)}{Land\ Area\ (ha)} \quad (1)$$

Source: Sudarmo (Reza and Efendi, 2022)

This research aims to analyze land productivity in the context of solid tea waste management into compost at PT. Gunung Slamat. The main focus of the research includes sustainability aspects, compost results, and environmental impact. This is a qualitative research with a phenomenological approach. Land productivity in composting is the phenomenon to be understood and analyzed.

3. RESULTS AND DISCUSSION

The investigation into land productivity through composting of solid tea waste at PT. Gunung Slamat is closely related to previous research conducted in the relevant field. This connection includes

the nutritional composition of solid waste transformed into compost, as explored by (Muningsih, 2019) and (Mukarramah, Sari and Lusyiani, 2023), focusing on the productivity of tea leaf waste. This research contributes positively to effective waste management by transforming solid tea waste into compost. By reducing the volume of waste reaching landfills, this study supports sustainable waste management practices. Additionally, it offers scientific evidence of increased land productivity in agriculture through the application of compost derived from solid tea waste. This provides valuable insights for local farmers and the agricultural industry to enhance crop yields and soil health.

The objective of this research is to analyze land productivity in the composting of solid tea waste at PT. Gunung Slamat by calculating the area and capacity for waste processing and providing solutions to improve land productivity in processing solid tea waste into compost. The collected data indicates that land productivity fluctuated during the research period. The data in Table 1 presents the results of observations conducted at PT. Gunung Slamat to determine the quantity of waste and compost produced. The tea leaves utilized by PT. Gunung Slamat are in a dried form imported from West Java (Nurbaity and Saring, 2017). Consequently, PT. Gunung Slamat does not engage in the harvesting of tea leaves used for production. The total land area of the composting site is 630 m^2, with 324 m^2, used for processing solid tea waste, while the remaining 306 m^2, is designated for rest areas and access roads. The amount of solid tea waste generated from the processing, conducted regularly during working hours, enters the system every day. Daily data on incoming waste and compost results during the research period provide an overview that the average waste produced per day in a month reaches 120 kg.

Table 1. Observation Data of Tea Waste at PT. Gunung Slamat

Month	Working Days	Compost Production Results	Averange Incoming Waste
September 2022	26 Days	2.885 Kg	110,9 Kg/ Day
October 2022	25 Days	2.781 Kg	111,2 Kg/ Day
November 2022	26 Days	2.418 Kg	93 Kg/ Day
December 2022	20 Days	3.314 Kg	165,7 Kg/ Day

The calculation using formula (1) yields data presented in Table 2. Based on the land productivity data obtained from September to December, it can be observed that land productivity varies over time. In September, land productivity reached 89,04 tons/ha, indicating good compost production. However, in October, land productivity significantly decreased to 85,83 tons/ha, marking the lowest compost production. This decline may be attributed to factors such as a decrease in the amount of waste processed during composting. In November, land productivity increased again to 74,62 tons/ha, indicating high efficiency in waste processing. In December, land productivity decreased once more to 102,28 tons/ha. Despite December producing a higher amount of waste than the previous month, land productivity remains relatively low, suggesting potential improvements in process efficiency. This aligns with the research conducted by (Siseraf Pamusu, Nur Alam and Sulaeman, 2013), which found that land area significantly influences the local red onion production in Olobuju Village.

Table 2. Land Productivity in Composting Solid Tea Waste at PT. Gunung Slamat

Month	Land Area (ha)	Compost Production Results (ton)	Land Productivity (ton/ha)
September 2022	324 m^2 = 0,0324 ha	2,885 tons	89,04 ton/ha
October 2022	324 m^2 = 0,0324 ha	2,781 tons	85,83 ton/ha
November 2022	324 m^2 = 0,0324 ha	2,418 tons	74,62 ton/ha
December 2022	324 m^2 = 0,0324 ha	3,314 tons	102.28 ton/ha

The research results in Table 2 show fluctuations in land productivity each month during the research period. The inconsistency in land productivity is attributed to various factors, including differences in the input of solid tea waste processed into compost, the number of effective working days, composting duration, and the final compost yield. In a previous study, the land productivity of tea compost production in the research conducted by Azurianti et al., (2022) ranged from 10.2 to 15.9 tons/ha. Meanwhile, in Bria (2016) research, the average land productivity of tea compost in Indonesia was 12.5 tons/ha.

In the waste processing at PT Gunung Slamat, a simple composting method is employed using EM4, which serves to expedite the decomposition of organic materials, eliminate odors during the decomposition process, and enhance the activity of beneficial microorganisms believed to increase productivity and process efficiency (Syafrudin and Zaman, 2007). Solid tea waste produced by PT Gunung Slamat is collected at the composting site and then shredded in the field to reduce its size for easier processing. EM4 is added in specific doses and mixed with water to achieve a moisture content of around 60-70%. After adding EM4, maintenance is performed to control moisture levels, and periodic mixing is done to optimize processing. Once the solid tea waste reaches a color similar to soil or dark brown, the compost is ready for harvesting or use. The time needed to harvest compost from solid tea waste is 1 to 2 weeks, indicating efficient waste processing in a relatively short period.

The costs incurred for processing solid tea waste at PT Gunung Slamat are quite low, especially by using water and EM4, and utilizing existing equipment at the facility. This indicates that the company can process waste effectively. The compost produced from waste processing at PT Gunung Slamat is used as fertilizer within the company's environment and distributed to local farmers, benefiting both the environment and the local community. This compost is not sold because PT Gunung Slamat focuses more on selling tea products than waste products. In waste processing at PT Gunung Slamat, some issues have been identified, including a lack of suitable technology for tea waste utilization, limited awareness of the importance of waste management, and land limitations. However, the company has taken steps to address these issues, such as developing appropriate technology and collaborating with external parties to expand land areas.

4. CONCLUSIONS

Based on the analysis of composting land productivity data, it can be concluded that the investigation into solid tea waste management into compost at PT. Gunung Slamat has yielded several significant findings. Productivity refers to the relationship between the outcomes produced and the resources utilized. Increasing productivity can have a positive impact on economic growth. It is important to emphasize that productivity is not identical to production. Instead, productivity encompasses a combination of effectiveness and efficiency in resource utilization. The research results indicate that land productivity in solid tea waste composting fluctuates during the research period, with changes that can be associated with various factors such as the quantity of waste, weather conditions, and management practices. Further evaluation of the factors influencing land productivity, along with the implementation of more advanced technology, can enhance efficiency

and have a positive impact on the environment. Therefore, this study contributes to the understanding of solid tea waste management in the tea industry, with a focus on land productivity, sustainability, and waste processing efficiency. Continuous evaluation is necessary to ensure the implementation of best practices in the management of the tea industry waste.

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