The effectiveness of composter at the integrated waste treatment plant in the campus of engineering faculty Hasanuddin University

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Abstract. The weight of domestic solid waste generation at the Faculty of Engineering of Hasanuddin University is 62.60 kg day⁻¹. The percentage of organic waste generation is 28%, so the weight of organic waste generation on this campus is 17.66 kg. One way to utilize organic waste is by composting. There are three methods for composting, including (1) aerobic methods, (2) anaerobic methods, and (3) combining aerobic and anaerobic methods. The method used in measuring waste generation is the measurement of waste generation in ten buildings located on this campus for eight consecutive days, according to the procedures in the Indonesian National Standard. The data used in this study include primary and secondary data. Primary data in this study are the results of measurements of weight, volume, and composition of waste. Whereas, secondary data in this study is the number of the campus population of the Faculty of Engineering. From the primary and secondary data, composter space requirements, effectiveness, and investment evaluation through the Benefit-Cost Ratio of the three composting methods can be calculated. From the calculation results, the space requirements for aerobic composter are 16.08 m², 16.08 m² for the anaerobic composter, and 25.61 m² for combination aerobic and anaerobic composter. The effectiveness values for each composter method were 98.7%, 98.47%, and 98.9% for aerobic, anaerobic composters, and the combination of the two, respectively. Furthermore, the value of the Benefit-Cost Ratio for each composter method is 1.20, 1.38, and 1.85 for aerobic, anaerobic composters, and the combination of the two, respectively.

1. Introduction
The Faculty of Engineering, Hasanuddin University, located in Bontomaranuu District, Gowa Regency, South Sulawesi, is one of the educational institutions that produce domestic waste every day, one of which is organic waste. This faculty has ten buildings that operate actively during weekdays and remain open during weekends. Furthermore, with the number of students who are always increasing, it can be imagined how the faculty produce much amount of waste every year. Waste is goods that are considered to be unused and are discarded by the previous owner/user, but for some people, these items can still be used if managed with the correct procedures [1].

Waste generation occurring at the faculty is not disposed of at the landfill site, because the integrated waste treatment plant of the Engineering Faculty is still under construction. One way to
reduce the volume of waste in this faculty is usually done by burning. However, this method can cause environmental and health problems. Waste burning smoke contains several pollutants, for example, dioxin, furan, arsenic, mercury, mercury, carbon dioxide, carbon monoxide, nitrogen oxide, sulfur oxide, and hydrochloric acid. Some of these pollutants can also end up in ash left behind from open burning. This pollutant also increases the number of contaminants in the air. Moreover, dioxin and furan pollutants may cause certain types of cancer, liver problems, disorders of the immune system, endocrine system, and reproductive function, as well as adverse effects on the developing nervous system and other developmental events. And also, waste can release methane gas, which can explode and can cause respiratory problems. Previous research [2,3,4,5,6] has shown that methane emissions and concentrations at TPA Tamangapa in Makassar vary widely, 2.44 - 18 Gg/year of methane emissions, and 12 - 425 ppm of methane concentrations.

One of the facilities that are expected to reduce waste problems is to build an Integrated Waste Treatment Plant (IWTP) or abbreviated as TPST in Indonesian, on the campus of the Faculty of Engineering, Hasanuddin University. This facility is currently under construction. According to Law No. 18 of 2008, IWTP is a place for collection, sorting, reuse, recycling, and final waste processing. IWTP is expected to change the waste management system to become decentralized, the management system in the upstream area [7]. Waste should not be treated as disgusting goods but should be treated as goods that can still be used. To reduce the volume of existing waste and not endanger the environment, it must be able to be used as raw or other useful material. Organic waste, which generally dominates domestic waste, can be processed into compost by using a composter, a tool used to help the work of bacteria that decompose various organic materials in the waste into compost. The aims of this research are: (1) to find out the generation and composition of waste in the Faculty of Engineering (FE) campus/Gowa Campus, (2) to determine the composting that is suitable for use in IWTP of Gowa campus, (3) to analyse the effectiveness of the use of composter in IWTP of Gowa campus, and (4) to evaluate the feasibility of composter investment using the Benefit-Cost Ratio (BCR) method.

According to Crawford, J. H (-) in [8], compost is the result of partial/incomplete decomposition of a mixture of organic materials that can be artificially accelerated by populations of various microbes in conditions of a warm, humid and aerobic environment or anaerobic. Compost is the final substance in a fermentation process of piles of garbage/litter of plants and sometimes also includes animal carcasses. Compost is fertilizer derived from plant residues and animal dung, or combination between manure, green leaf fertilizer, and compost. Compost can be in the form of liquid or solid, which can improve the physical properties and structure of the soil, increase the resistance of soil water, soil chemistry, and soil biology [9].

The composting or composting process is a biological process because during the process, several living bodies called microbes, such as bacteria and fungi, play an active role [10]. Composting is a process of decomposition and stabilization of organic matter by microorganisms in controlled environmental conditions (controlled) with the final result in the form of humus and compost [11]. The composting method is one way to process organic waste into fertilizer. And the use of organic waste in the form of compost can be one of the solutions/our efforts as members of the community in tackling and reducing landfill waste, which ultimately has an impact on reducing soil pollution [12].

1.1. Composter

Based on the IWTP Technical Directive, 2017 [13], the composter is a tool to process organic waste into compost. Some composting technologies that are commonly applied in the field are:

1.1.1. Bamboo aerator system. The bamboo aerator is made by hoarding organic waste on the construction of a bamboo triangle with a length of slats attached to the two sides of the triangle, so that air flows between the cavities. Thus the oxygen demand for composting is fulfilled. Regional-scale composting using the open windrow method is a composting process that is proven to be the most efficiently carried out and controlled. The open windrows method that has been developed by the Agency for the Assessment and Application of Technology (BPPT) and the Recycling and Composting Unit (UDPK) does not even use mechanical counting and does not use activators.
Examples of bamboo aerators can be seen in Figure 1, and the bamboo aerator processing workflow can be seen in Figure 2.

**Figure 1.** Bamboo aerator [13].

**Figure 2.** The workflow of composting in bamboo aerator [13].

**Figure 3.** Aerobic drum composter [13].
1.1.2. *Drum composter.* Drum composter is composting, which is done in a closed manner to get compost and liquid fertilizer that comes from compost leachate. The following are the methods for using drum composter: (1) chop organic waste to small sizes of 1 to 2 cm, (2) then spray the Bio-activator liquid BOISCA, or EM4 in the chopped waste while stirring to mix evenly, (3) put chopped organic waste into the drum composter, (4) this composter can be refilled at any time and repeatedly in a day, and (5) cover the composter tightly. Aerobic and anaerobic drum composter images can be seen in Figures 3 and 4.

1.2. Effectivity
Effectiveness refers to the success or achievement of goals. Effectiveness is one of the dimensions of productivity (results), which leads to the achievement of targets related to quality, quantity, and time. Moreover, effectiveness is a measure that states how far the objective (quality, quantity, and time) has been achieved, where the more significant the percentage of goals achieved, the higher the effectiveness [14].

1.3. Investment evaluation
An investment is a long-term investment activity, where in addition to the investment, it is necessary to realize from the start that the investment will be followed by several other expenses that need to be prepared periodically. These expenses consist of operational costs, maintenance costs, and other costs that cannot be avoided. Besides expenses, the investment will generate a certain amount of profit or benefit, possibly in the form of sales of products or goods or services or lessees of facilities. There are various methods in evaluating the feasibility of investments that are commonly used, one of which is the Benefit-Cost Ratio (BCR) method. This method emphasizes the comparison value between benefits that will be obtained with the aspects of costs and losses that will be borne by the investment [15].

2. Methods
This research was conducted at the Gowa Campus, the Campus of the Faculty of Engineering - Hasanuddin University in Gowa. The data were collected for eight days according to Indonesian National Standard No. 19-3964-1994 [16] in ten buildings on this campus; Center of Technology (COT), Center of Student Activity (CSA), Classroom (CR), Student Dormitory, Architecture, Mechanical, Electrical, Civil, Geology, and Naval Building.

The tools used in collecting waste samples in each campus building in Gowa Campus are: (1) waste bags used to collect waste from all buildings on the Gowa campus, (2) measuring box to measure the volume of waste, (3) meters to measure the height of waste in a measuring box, (4) scales to measure the weight of waste, (5) stationery to record data on the measurement of waste generation, (6) gloves to protect the skin from direct contact with waste, and (7) masks to protect yourself from the unpleasant smell of waste.
Primary data required in this study include observation of existing conditions, measurement of waste generation, composition, characteristics, and volume of waste. Measurement steps taken to collect primary data mentioned above are in accordance with Indonesian National Standard No. 19-3964-1994. The data that has been collected will then be calculated to determine the composter requirements and its space requirements at the IWTP of the Gowa Campus. There are two kinds of the composter, and each of which has its calculation: (1) bamboo aerator composter and (2) aerobic and anaerobic drum composter.

The calculation for bamboo aerator composter based on IWTP Technical Directive, 2017: (1) $V_{ow} = \%$ of organic waste $\times V_w$ / day, (2) organic waste generation $= \rho_{ow} \times V_{ow}$, (3) $V_{twc} = (composting\ time \times有机\ waste\ generation) \div \rho_{ow}$, (4) $V_{bac} = (length \times width \times height) \div 2$, (5) transverse area of trapezium $= ((The\ width\ of\ the\ compost\ pile + The\ width\ of\ the\ upper\ area) \times height\ of\ trapezium)) \div 2$, (6) $V_{cp}$ (without aerator) $= V_{trapezium} - V_{bac}$, (7) $\Sigma_{ur} = V_{twc} / V_{cp}$, (8) $A_{bac} = (the\ width\ of\ trapezium + area\ in\ right\ space + area\ in\ left\ space) \times (the\ length\ of\ trapezium + area\ in\ right\ space + area\ in\ left\ space)$, and (9) composting area $= \Sigma_{ur} \times A_{bac}$. Where, $V_{ow} = organic\ waste\ volume$, $V_w = total\ waste\ volume$, $\rho_{ow} = density\ of\ the\ organic\ waste$, $V_{twc} = the\ total\ volume\ of\ waste\ that\ will\ be\ composted\ in\ 30\ days$, $V_{bac} = volume\ of\ bamboo\ aerator\ composter$, $V_{cp} = volume\ of\ the\ compost\ pile$, $\Sigma_{ur} = the\ number\ of\ units\ required$, and $A_{bac} = the\ planned\ area\ of\ the\ bamboo\ aerator\ composter$. Generally, the composter drum calculation is the same as a bamboo aerator composter. The difference is the composter dimensions. The calculation for aerobic and anaerobic drum composter based on IWTP Technical Directive, 2017: $V_{drum} = \pi \times r^2 \times t$, $V_{cp} = V_{drum}$, $\Sigma_{ur} = V_{twc} / V_{cp}$, $W_{dc} = the\ width\ of\ drum\ rotary + space\ between\ ends$, $A_{dc} = length \times width$, Total space requirements $= \Sigma_{ur} \times A_{dc}$. Where, $V_{drum} = the\ volume\ of\ a\ drum$, $W_{dc} = the\ width\ of\ per\ unit\ drum$, and $A_{dc} = Area\ or\ space\ for\ one\ unit\ drum$. The effectiveness of the use of composters is the percentage of tangible results divided by the target of the composted waste volume. Where the greater the percentage of the ratio achieved, the higher the effectiveness. Moreover, one of the various methods in evaluating the feasibility of investing, namely the Benefit-Cost Ratio (BCR) method. This method emphasizes the comparison value between the benefits that will be obtained with the aspects of costs and losses that will be borne (cost) with this investment, $BCR = Benefit / Cost$. The decision criteria to determine whether an investment plan is economically feasible or not after going through this method are: if the $BCR \geq 1$, then the investment is feasible; on the other hand, if $BCR < 1$, the investment is unfeasible.

3. Results and discussions
Waste generation per individual unit in Gowa Campus is 0.013 kg/person/day and 0.25 liter/person/day [6]. Furthermore, from the whole building and the total population of the Gowa
Campus, the waste generation is 62.60 kg/day or 1206.5 L/day. The waste composition in Gowa Campus could be seen in Figure 6, where organic waste is the highest percentage with 28%. Organic waste is a component of waste that is quickly degraded or decomposed due to the activity of microorganisms, especially waste that comes from food scraps. Thus, management requires speed, both in the collection, processing, and transportation. The composition of 28% of organic waste in the Gowa Campus is divided into 18% (64%) of food waste (meat, fish, rice), 5% (18%) of vegetables, 3% (11%) of rinds, and 2% (7%) of leaves. In Figure 7, it can be seen that the composition of organic waste is dominated by food waste.

![Figure 6. Percentage of waste composition in gowa campus.](image)

![Figure 7. Percentage of waste organic composition in gowa campus.](image)

Based on the composition of organic waste, the aerobic composter is suitable for composting vegetable waste, fruit peels/rinds, and leaves. As for food waste, especially those containing protein,
the anaerobic composter is preferable. For the drum composter, two methods can be used, namely anaerobic and aerobic, the difference is that in the aerobic drum composter, there is a porous pipe that functions as air circulation. In this study, three composter scenarios that will be used in the IWTP of Gowa Campus, namely (1) the combination of a bamboo aerator and anaerobic drum composter, where the bamboo aerator composter will compost 10% of organic waste in the form of vegetable waste, rinds, and leaves, while anaerobic drum composter will compost 18% of organic waste in the form of food waste, (2) aerobic drum composter, which will compost 28% or all of the organic waste, and (3) anaerobic drum composter which will compost 28% or all of the organic waste on the Gowa campus. The results of the calculation of the three composter scenarios that will be used at the IWTP of Gowa Campus can be seen in Table 1.

![Table 1. The three composter scenarios.](image)

From the calculation of space requirements, the use of a combination of the two types of a composter requires more space compared to one type (aerobic or anaerobic) composter. For the IWTP of Gowa Campus is recommended using only one type of composter, namely anaerobic drum composter. Despite the cost, the investment is more expensive, but the land area required is not the area required by a combination of two types of the composter. Furthermore, anaerobic composter does not produce odors. Based on the calculation of the effectiveness ratio, the results are 98.9%, 98.7%, and 98.7% for (1) the bamboo aerator (aerobic) and drum composter (anaerobic), (2) aerobic drum composter, and (3) anaerobic drum composter, respectively. It can be concluded that the three composter scenarios have a high effectiveness value. Moreover, the value of the Benefit-Cost Ratio (BCR) from each scenario is 1.85, 1.20, and 1.38 for (1) the bamboo aerator (aerobic) and drum composter (anaerobic), (2) aerobic drum composter, and (3) anaerobic drum composter, respectively. From the calculation, it is known that the composter procurement investment is in the feasible category because the BCR value is more than one (> 1). Especially when viewed from an environment-economic point of view.

4. Conclusions
The conclusions obtained in this study are:
- Waste generation in Gowa Campus is 0.013 kg/person/day and 0.25 liters/person/day. Total waste generation is 62.60 kg/day and 1206.5 liters/day. The composition of waste on this campus consists of 28% of organic, 21% of PET plastic, 17% of Non-PET plastic, 11% of paper, 11% of cardboard, 8% of tissue, 3% of styrofoam, and 1% of metal. Furthermore, 28% of organic is divided into 18% of food waste, 5% of vegetables, 3% of rinds, and 2% of leaves.
- Appropriate composter to use at the IWTP of Gowa Campus TPST is anaerobic drum composter because (1) it is effective, which is shown by its effectiveness value, which exceeds 98%, (2) does not require a large space, and (3) does not cause unpleasant odors.
- The effectiveness ratio of the three composter scenarios shows a high effectiveness value, 98.9%, 98.7%, and 98.7% for (1) the bamboo aerator (aerobic) and drum composter (anaerobic), (2) aerobic drum composter, and (3) anaerobic drum composter, respectively. This value indicates that the use of composter, either one type or a combination of two types of the composter, is very effective in reducing organic waste on the Gowa campus.
The composting procurement investment is in the feasible category because the Benefit-Cost Ratio (BCR) value of the three composter scenarios is more than one (> 1). Especially when viewed from an environment-economic point of view.

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