Design of Organic Waste Processing System at The 3R Waste Disposal Site in The Grogol Selatan Area with Biological Conversion

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Abstract. Waste management is a growing concern in many urban areas, especially in developing countries like Indonesia. Jakarta, as one of the world's largest cities, grapples with substantial organic waste production, accounting for over half of its total waste. Bantar Gebang landfill, a major recipient of Jakarta's waste, faces increasing challenges. This study focuses on TPST 3R Grogol Selatan, an Integrated Waste Management Site in Jakarta. While it employs composting to manage organic waste, issues like leachate formation and odors persist, affecting the local community's environment and quality of life. To address these challenges, the study proposes a solution incorporating biological treatments such as black soldier flies, vermicomposting, and windrow composting. The selection of the design is determined using the Analytical Hierarchy Process (AHP), aiming to enhance organic waste management sustainably while mitigating environmental and health risks.

Keywords: Organic waste, Black soldier fly, Composting, Biological treatment, Analytic hierarchy process

1 Introduction

Waste management is a significant challenge for many cities, particularly in developing countries. The growing population and urbanization have led to an increase in waste generation, which often exceeds the capacity of local authorities to manage it effectively. This can lead to a range of environmental, health, and social problems.

When waste is not managed properly, it can accumulate in public spaces, pollute the air and water, and create health hazards for residents. For example, uncollected waste can spread infections and cause respiratory problems. Improper disposal of hazardous waste can also contaminate soil and groundwater, leading to long-term health risks for communities.

Food waste is a significant challenge in Indonesia. According to the data from The Economist Intelligence, Indonesia generates 23-48 tons annually from 2000 to 2019 [1]. This food waste is

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generated throughout the food supply chain, including production, processing, distribution, and consumption.

As the capital city of Indonesia and one of the largest cities in the world, Jakarta is one of the largest producers of organic waste in Indonesia. According to the DKI Jakarta Provincial Government, organic waste accounts for approximately 53.75% of the total waste generated in Jakarta [2].

Bantar Gebang, a landfill located in Bekasi, West Java, is a major destination for waste from Jakarta and its surrounding areas, currently contains 39 million tons of waste and estimated around 40 meters high [3].

Based on the above problem, to divert organic waste at Bantar Gebang, it is important to implement waste treatment facilities particularly in local market.

Located nearby to the traditional market, TPST 3R Grogol Selatan, one of the Integrated Waste Management Site in Jakarta, has implemented an organic waste processing system using composting. Despite its ability to reduce certain volume of waste by composting, some lacks in such technology have been reported. The formation of leachate is found and has serious environmental and health consequences for the local community. The odor from improperly composted waste can be a nuisance to nearby residents, which in turn can affect their quality of life.

In addition to composting, black soldier flies (BSF) are emerging alternative to reduce organic waste. It is known for their ability to rapidly consume large amounts of organic waste, such as food waste, animal manure, and agricultural residues. The larvae of black soldier flies are reportedly able to consume up to twice their body weight in organic waste per day.

Therefore, this study aims to design the organic waste treatment at TPST 3R Grogol Selatan using biological treatment such as black soldier fly, vermicomposting and windrow composting. Analytical Hierarchy Process (AHP) was performed to derive the selected design.

2 Methods

2.1 Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) is a decision-making method developed by mathematician and operations researcher Thomas Saaty [4]. It is used to evaluate and prioritize a set of options or alternatives based on a set of criteria and their relative importance.

2.2 Alternatives

Three alternatives were selected for the organic waste treatment including black soldier fly, vermicomposting and windrow composting.

2.3 Criteria

Product Valuation

This table outlines the products obtained from three distinct waste treatment methods: Black Soldier Fly (BSF), Vermi-composting, and Windrow Composting. Each of these methods yields valuable products that can have various applications.

Table 1. Product Valuation of Three Different Waste Treatment Alternatives

Treatment method	Products
Black Soldier Fly (BSF)	- Dry Larvae - Fresh Larvae
Vermi – composting	- Fertilizers
Windrow Composting	- Fertilizers

Area

In Table 2, the land area requirements for implementing three distinct waste treatment methods: Black Soldier Fly (BSF), Vermi-composting, and Windrow Composting were compared. The area needed for each method is a critical consideration, as it can impact the feasibility and practicality of waste management.

Table 2. Area comparison of three different alternatives.

Treatment Method	Area	Sources
Black Soldier Fly (BSF)	75 m^2	[5]
Vermi – composting	50 m^2	[6]
Windrow Composting	400 m^2	[7]

Investment cost

Table 3 provides an overview of the total investment costs associated with three distinct waste treatment methods: Black Soldier Fly (BSF), Vermi-composting, and Windrow Composting. The financial aspects of waste management is essential in making informed decisions regarding resource allocation and long-term sustainability.

Table 3. Investment costs comparison of three different alternatives

Treatment	Total Investment Cost
BSF	Rp14.242.350,00
Vermicomposting	Rp5.557.800,00
Windrow composting	Rp9.769.000,00

Treatment duration

Table 4 presents a comparison of the treatment durations associated with three distinct waste treatment methods: Black Soldier Fly (BSF), Vermi-composting, and Windrow Composting. Understanding the time required for waste processing is crucial for planning and operational efficiency in waste management systems.

Table 4. Treatment duration comparison of three different alternatives

Treatment	Treatment duration	Reference
Black Soldier Fly (BSF)	19 day	[8]
Vermi composting	28 day	[9]
Widrow composting	7 day	[10]

2.4 Variable Measurements

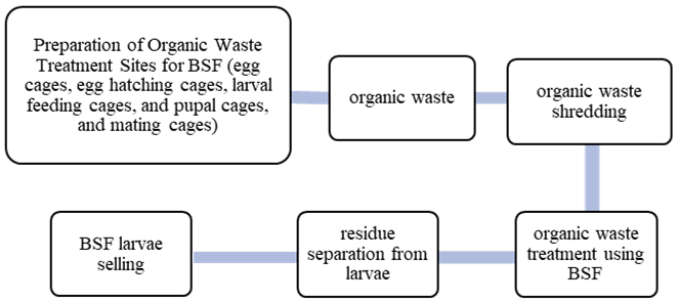
The variable measurements were performed by converting the respondents' perceptions into numerical form with the help of a predetermined qualitative comparison scale as below:

Table 5. Scale and degree of preference for comparison

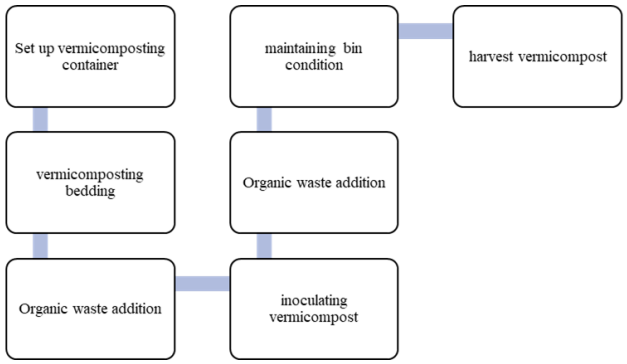
Scale	Degree of preference
1	Equal importance
3	Moderate importance of one factor over another
5	Strong or essential importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Values for inverse comparison

3 Result and Discussion

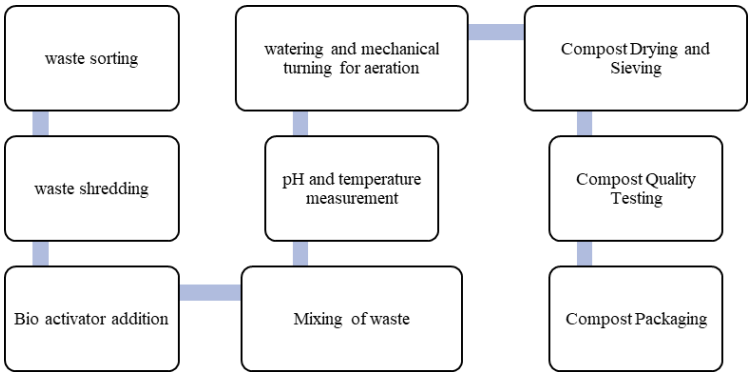
Three alternatives were selected for the organic waste treatment including black soldier fly, vermicomposting and windrow composting. Processing flow of each alternative is given below.



(a)



(b)



(c)

Fig. 1. Three alternatives were selected for the organic waste treatment: (a) black soldier fly, (b) vermicomposting and (c) windrow composting.

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3.1 Overall selected alternative

Overall selected alternative for organic treatment are as follows

Table 6. Table of Selected Alternative.

Method	Weight	Rank
BSF	0,654	1
Vermicomposting	0.420	2
Windrow composting	0.281	3

Based on the above table, it can be concluded that the best biological treatments are BSF with a weight of 0.654 and followed by vermicomposting and windrow composting.

3.2 Design

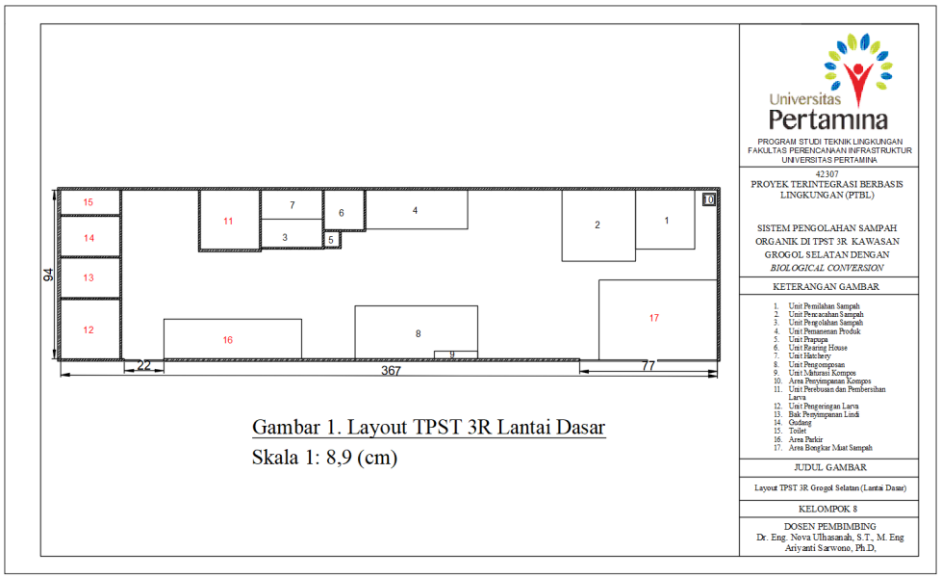
The design of this organic waste processing facilities will be carried out at TPST 3R Grogol Selatan, located at Jalan Kramat Patal Senayan RT.02 RW.02 Grogol Selatan Village, Kebayoran Lama, South Jakarta. The total land area of TPST 3R is 285 m2 (Heripto, 2020). Located nearby to the South Grogol Market, TPST 3R Grogol Selatan receives organic waste up tp 120.15 kg/week vegetable, fruit, and other organic waste.

Some criteria design for TPST 3R Grogol Selatan include minimum area of TPST 3R is 200 m2. According to PerMenPU No. 3 Tahun 2013 [11], unit area dan area percentage of TPST 3R are as follows:

Table 7. Unit Area and Area Percentage.

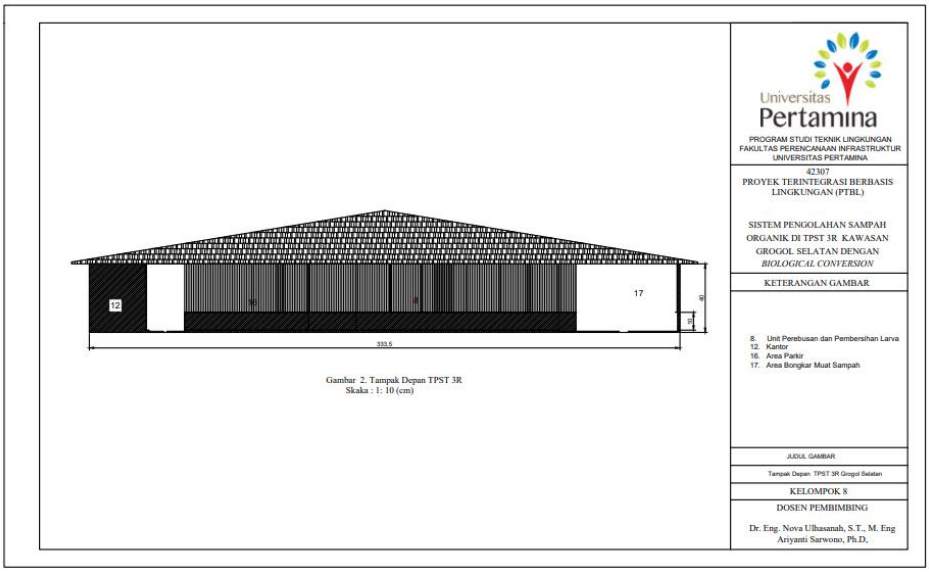
No.	Unit Area	Area Percentage (%)
1	Sorting area	10
2	Organic waste processing area	50
3	Storage area	5
4	Packaging Area	10
5	Office	5

In addition to the above criteria, BSF based organic waste processing unit have the criteria such as breeding unit, waste storage area, waste treatment unit, and harvesting unit. The design of TPST 3R was depicted in the figure below.



Gambar 1. Layout TPST 3R Lantai Dasar
Skala 1: 8,9 (cm)

(a)



Gambar 2. Tampak Depan TPST 3R
Skala : 1: 10 (cm)

(b)

Fig. 2. Design TPST 3R Grogol Selatan: (a) Layout TPST 3R Grogol Selatan (scale 1:8.9 cm), (b) front view of TPST 3R Grogol Selatan (scale 1:10 cm)

Conclusion

Biological treatment such as black soldier fly, vermicomposting and windrow composting were selected to treat organic waste at TPST 3R Grogol Selatan, Jakarta. AHP was performed to evaluate the alternatives. Black soldier fly was chosen as the best method in comparison to the vermicomposting and windrow composting. The design was presented to accommodate organic waste in TPST 3R Grogol Selatan of 120,15 kg/week.

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