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UNDERGRADUATE THESIS

OPTIMAL SITE PLANNING OF BIODIGESTER-BASED AT 3R WASTE PROCESSING SITE THROUGH ANALYTICAL HIERARCHY PROCESS (AHP) AND GEOGRAPHIC INFORMATION SYSTEM (GIS) ANALYSIS IN SEMARANG REGENCY

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Telah berhasil dipertahankan di hadapan Tim Penguji dan diterima sebagai bagian persyaratan yang diperlukan untuk memperoleh gelar Sarjana pada Departemen Teknik Lingkungan, Fakultas Teknik, Universitas Diponegoro.

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ABSTRACT

Rapid population growth in Semarang Regency has increased waste generation, while new landfill development is often rejected due to high costs and land needs. Waste management remains suboptimal, with most waste directly disposed of at landfills. The Blondo landfill reached 52.23% capacity in 2022 and 51.97% in 2023. Waste reduction efforts through waste banks only target inorganic waste, despite 73.14% of total waste being organic. Implementing 3R waste processing facilities (3R WPS) with biodigester technology offers a strategic solution to reduce waste and generate renewable energy. Biodigesters are chosen for their ability to convert organic waste into energy. The placement of biodigester facilities considers technical, social, and environmental aspects using the Analytical Hierarchy Process (AHP) and Geographic Information System (GIS) methods. Data collection is carried out based on SNI 3964:2025 and the gravimetric method to measure volatile content, in order to determine the potential of organic waste and the number of facilities needed. Organic waste in Semarang Regency accounts for 56.1% of total waste generation. Based on the analysis results, the volatile solid content reached 96.26% and the total solid content was 34.65%, making it suitable for use as raw material for biodigesters. The GIS analysis results showed that 20 biodigester facilities were needed, with a potential electricity production of 724 kWh per day for large-scale 3R waste management sites and 379 kWh per day for small-scale 3R waste management sites. The total cost of constructing a 3R WPS with a biodigester facility is estimated at IDR 4,836,980,790.65 for a large scale and IDR 3,681,719,032.98 for a small scale. Based on a financial feasibility analysis using the Net Present Value (NPV), Economic Internal Rate of Return (EIRR), Benefit Cost Ratio (BCR), and Payback Period methods, the WPS 3R project, designed to operate for 20 years, is deemed feasible for implementation.

Keywords: Analytical Hierarchy Process; Geographic Information System; Biodigester; Renewable Energy; Organic Waste

CHAPTER I
INTRODUCTION

1.1 Background

Rapid population growth along with increased landfill in Semarang Regency that was rejected due to high costs and large land requirements (Simamora, Zebua, & Handayani, 2022), emphasize the need for a better management strategy. Waste management in Semarang Regency in 2022 amounted to 38.85% and in 2023 decreased to 37.70%. Thus, the total waste managed economic and social activities trigger urban problems such as increased waste generation (Hidayat, 2020). Based on data from the National Waste Management Information System (SIPSN), waste generation in 2024 was recorded at 34,214,607.36 tons/year and Central Java was recorded as the province with the third largest amount of waste generation in Indonesia. Waste generation in Central Java Province is 10.32% of the total waste generation in Indonesia. Out of 29 regencies and 6 cities, Semarang Regency is the 8th largest waste producer in Central Java with 0.6% of the total waste in Indonesia.

Waste management in Semarang Regency is still not optimal (Hardyanti, Juliani, Puspita, & Octaviani, 2023). Most of the waste is disposed of directly in landfills. The full capacity of the Blondo landfill, as well as a plan to build a new in 2022 amounted to 52.23% and in 2023 amounted to 51.97% of the total waste generation in Semarang Regency. Waste reduction efforts in Semarang Regency are only through 49 waste bank units managed by the community. Then, the only waste handling is transported to the Blondo landfill. Therefore, efforts to reduce waste and extend the life of existing landfills are needed.

Efforts that can be made are by reducing waste directly at the source and reducing waste at the Reduce, Reuse, and Recycle Waste Processing Station (WPS 3R). Waste reduction at the source is still difficult to do so it needs an integrated effort to be well managed through 3R waste processing site. Waste reduction efforts through WPS 3R are effective in reducing waste generation, especially organic waste (Halimah, Purwaningrum, & Siami, 2022; Shofi, Auvaria, Nengse, & Karami,

2023). Currently, reduction efforts in Semarang Regency through waste banks only manage inorganic waste to be recycled. Based on this, the implementation of 3R WPS will help reduce waste generation because 73.14% of waste in Semarang Regency is organic waste.

Organic waste management to reduce waste generation in Semarang Regency with 3R waste processing site can be done using biodigester management technology. The selection of Biodigester processing technology is due to its potential to convert waste into renewable energy sources. The energy source is in the form of fuel that can be converted into heat energy and electrical energy. In addition, the sediment from the biodigester can be used as compost for additional nutrients for plants. Therefore, this technology was chosen as an effort to reduce waste generation in Semarang Regency.

1.2 Problem Identification

Based on the background above, the following problems can be identified:

1. The increasing population is followed by an increase in the amount of waste generation.
2. 3R waste processing site in Semarang Regency has not been able to optimize waste management.
3. The high waste generation and lack of waste management have resulted in the full capacity of Blondo Landfill.

1.3 Problem Statement

Based on the identification of the problem, the following problems can be formulated:

1. How is the existing condition of organic waste generation in Semarang Regency?
2. How to plan the optimal location and design of 3R waste processing site with organic waste biodigester facilities in Semarang Regency?
3. How to calculate the amount of biogas and electricity generated from the organic waste biodigester facility process in Semarang Regency?

4. What are the costs required for planning the placement of 3R waste processing site with organic waste biodigester facilities in Semarang Regency?

1.4 Research Objectives

The objectives of the placement of biodigester facilities in Semarang Regency in this study can be formulated as follows:

1. Identify the existing condition of organic waste generation in Semarang Regency.
2. Planning the optimal location for the placement and design of 3R waste processing site with organic waste biodigester facilities in Semarang Regency.
3. Calculating the amount of biogas and electrical power generated from the processing of organic waste with organic waste biodigester in Semarang Regency.
4. Determine the Budget Plan (RAB) required for the planning of 3R waste processing site with organic waste biodigester facilities in Semarang Regency.

1.5 Problem Limitation

Regional restrictions on the planning of the placement of biodigester facilities are in Semarang Regency. Restrictions on the planning and feasibility study of the placement of organic waste biodigester facilities in Semarang Regency include:

1. Study of the general condition of the planning area which includes population, analysis of waste generation and composition, and existing conditions of organic waste management.
2. Study of the placement point plan for 3R waste processing site biodigester, which is a Geographic Information System study integrated with data, industrial area data, urban growth according to the RTRW, and electricity networks.

3. Study of organic waste management design with biodigesters at 3R waste processing site according to the DLH WPS 3R Technical Guidelines 2023.
4. Cost Budget Plan (RAB) starting from the construction, operation, and maintenance of 3R waste processing site with biodigester in Semarang Regency.

1.6 Benefits Conceptualization

The expected benefits of planning and feasibility study of the placement of organic waste biodigester facilities in Semarang Regency include:

1. For Planners / Writers

   As a means of applying the knowledge and theories obtained during lectures and deepening knowledge about biodigester planning and as a requirement for graduation from the Environmental Engineering Study Program.
2. For the Community

   Provides information and alternatives in organic waste management and reduces organic waste generation and develops new renewable energy sources.
3. For the Government

   As a reference material for the Semarang Regency Government in alternative organic waste management by planning the placement of biodigester facilities at 3R waste processing site so that the problem of organic waste can be handled while reducing global warming.

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