Number: 014 A/UN7.F3.6.8.TL/DL/IX/2025
015 A/UN7.F3.6.8.TL/DL/IX/2025
016 A/UN7.F3.6.8.TL/DL/IX/2025

# UNDERGRADUATED THESIS

## OPTIMIZING ORGANIC WASTE TREATMENT THROUGH ENVIRONMENTAL IMPACT ASSESSMENT IN GROBOGAN REGENCY



**Arranged By:**

| | |
|---|---|
| **ADORA SALSA BIGITA** | **21080122140098** |
| **ALVINA DAMAYANTI** | **21080122140131** |
| **APRIANTO TYAS DWI NUGROHO** | **21080122130054** |

**DEPARTEMENT OF ENVIRONMENTAL ENGINEERING**

**FACULTY OF ENGINEERING**

**UNIVERSITAS DIPONEGORO**

**2025**

# HALAMAN PENGESAHAN

Skripsi ini diajukan oleh :
NAMA                   : Adora Salsa Bigita
NIM                     : 21080122140098
Jurusan/Departemen   : Teknik Lingkungan Fakultas Teknik Undip
Judul Skripsi           : Optimizing Organic Waste Treatment through Environmental Impact Assessment in Grobogan Regency

**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.**

Pembimbing I:
Dr.Eng. Ir. Bimastyaji Surya Ramadan, S.T., M.T.
199203242019031016

Pembimbing II:
Dr. Ling., Ir. Sri Sumiyati, S.T., M.Si., IPM., ASEAN Eng.
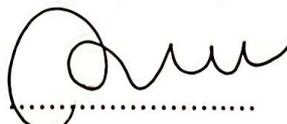197103301998022001

Ketua Penguji:
Dr. Ir. Budi Prasetyo Samadikun, S.T., M.Si., IPM., ASEAN Eng.
197805142005011001

Anggota Penguji:
Prof. Ir. Mochamad Arief Budihardjo, S.T., M.Eng.Sc, Env.Eng, Ph.D., IPM., ASEAN Eng.
197409302001121002

Semarang, 28 Oktober 2025
Program Studi Teknik Lingkungan
Fakultas Teknik Undip
Ketua

Prof. Dr. Ir. Badrus Zaman, S.T., M.T., IPM., ASEAN Eng.
NIP. 197208302000031001

# HALAMAN PENGESAHAN

Skripsi ini diajukan oleh  :

NAMA : Alvina Damayanti

NIM : 21080122140131

Jurusan/Departemen : Teknik Lingkungan Fakultas Teknik Undip

Judul Skripsi : Optimizing Organic Waste Treatment through Environmental Impact Assessment in Grobogan Regency

**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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Dr.Eng. Ir. Bimastyaji Surya Ramadan, S.T., M.T.

199203242019031016

Ketua Penguji:

Prof. Ir. Mochamad Arief Budihardjo, S.T., M.Eng.Sc, Env.Eng, Ph.D., IPM., ASEAN Eng.

197409302001121002

Anggota Penguji:

Dr. Ir. Budi Prasetyo Samadikun, S.T., M.Si., IPM., ASEAN Eng.

197805142005011001

Semarang, 28 Oktober 2025

Program Studi Teknik Lingkungan

Fakultas Teknik Undip

Ketua,

Prof.Dr. Ir. Badrus Zaman, S.T., M.T., IPM., ASEAN Eng.

NIP. 197208302000031001

# HALAMAN PENGESAHAN

Skripsi ini diajukan oleh  :
NAMA                          : Aprianto Tyas Dwi Nugroho
NIM                           : 21080122130054
Jurusan/Departemen            : Teknik Lingkungan Fakultas Teknik Undip
Judul Skripsi                 : Optimizing Organic Waste Treatment through Environmental Impact Assessment in Grobogan Regency

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Prof. Ir. Mochamad Arief Budihardjo, S.T., M.Eng.Sc, Env.Eng, Ph.D., IPM., ASEAN Eng.
197409302001121002

Anggota Penguji:
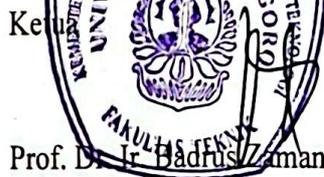Dr. Ir. Budi Prasetyo Samadikun, S.T., M.Si., IPM., ASEAN Eng.
197805142005011001

Semarang, 28 Oktober 2025
Program Studi Teknik Lingkungan
Fakultas Teknik Undip
Ketua

Prof. Dr. Ir. Badrus Zaman, S.T., M.T., IPM., ASEAN Eng.
NIP. 197208302000031001

# ABSTRACT

Grobogan Regency is one of the regions with the highest municipal solid waste generation in Central Java, producing approximately 315,050.32 tons in 2022. However, the existing waste management system remains suboptimal, as indicated by the low transportation rate (only 40% in 2020) and limited infrastructure for Temporary Disposal Sites and Integrated Waste Processing Facilities. The waste primarily originates from organic sources, including households and traditional markets, which, if not properly managed, may lead to environmental issues such as soil and water contamination, foul odors, and greenhouse gas emissions. This study aims to identify sustainable organic waste treatment technologies through an integrative approach using Material Flow Analysis (MFA), Life Cycle Assessment (LCA), and single-score evaluation. The MFA and LCA methods enable comprehensive analysis of organic waste processing technologies and facilitate the inventory of environmental impacts generated at each stage. This research contributes novelty by integrating MFA and LCA to assess both environmental impacts and eco-costs, further analyzed through technical performance using the Simple Additive Weight (SAW) method. The study is expected to provide strategic recommendations and identify the most environmentally and economically efficient waste technologies that applicable in Grobogan Regency.

Keywords: Organic Waste Treatment, Material Flow Analysis, Life Cycle Assessment, Single Score, Simple Additive Weight.

# CHAPTER I
# INTRODUCTION

## 1.1    Research Background

Grobogan Regency is one of the largest regencies in Central Java, covering an area of 2,022.84 km², making it the second-largest after Cilacap Regency (Izza & Purnomo, 2023). Over time, the population growth rate in Grobogan has continued to rise. In 2022, the population growth rate increased by 2.43%, contributing directly to a rise in municipal solid waste generation. In the same year, Grobogan Regency produced approximately 315,050.32 tons of waste annually, ranking it as the fourth-largest contributor of municipal solid waste in Central Java. However, this situation is exacerbated by suboptimal waste management practices. Based on the Regional Medium-Term Development Plan of Grobogan, only 40% of the total waste was transported in 2020. This indicates that a significant portion of the waste remains unmanaged and ultimately ends up as residual waste in the environment, potentially generating harmful impacts (BAPEDA, 2021).

The primary sources of waste in Grobogan Regency are residential areas and traditional markets. Market waste, particularly vegetable waste, tends to be more homogeneous, making it relatively easier to process compared to household waste, which is generally more heterogeneous. The waste collection system in Grobogan is predominantly based on temporary disposal sites (*Tempat Penampungan Sementara* – TPS). However, in several regions, the infrastructure of these TPS units is inadequate and unable to accommodate the daily waste volume. Currently, there are only 23 TPS units across the regency, most of which require physical improvements and operational upgrades, such as scheduling of disposal and collection. During the rainy season, the condition of waste deteriorates as rainwater percolates through the waste mass, generating foul odors and increasing leachate production that may lead to environmental contamination. Furthermore, the number of integrated waste processing facilities (*Tempat Pengolahan Sampah Terpadu* - TPST) operating under the 3R (Reduce, Reuse, Recycle) principle was recorded at 8 units in 2021. These facilities, located in various sub-districts, face operational challenges in managing incoming waste (Rahman et al., 2024). This highlights need

for attention to both infrastructure development and operational capacity. As a result of these infrastructural limitations and the significant proportion of unmanaged waste, Grobogan faces several environmental issues. Organic waste, primarily from households and markets, generates adverse effects such as strong odors, contamination of soil and water, and increased greenhouse gas emissions, particularly methane. Therefore, it is essential to enhance the potential utilization of organic waste into value-added products such as biogas, compost, or other beneficial materials. The development of a Waste Processing Facility specifically located at the Ngembak Landfill is required to manage the waste entering the site. The development of a Waste Processing Facility specifically located at the Ngembak Landfill is required to manage the waste especially organic waste that entering on site. The development of a Waste Processing Facility at the Ngembak Landfill is necessary to manage the incoming waste, particularly organic waste. This program is also aligned with the Waste Management Master Plan of Grobogan Regency, which is currently being prepared, namely the establishment of Recycling Centers in each service area within the regency. Therefore, it is essential to enhance the potential utilization of organic waste into value-added products such as biogas, compost, or other beneficial materials. The conversion of organic waste into useful products requires a well-integrated facility design that includes various processing stages. The selection of appropriate technology plays a critical role in determining the quality and environmental performance of the end products. Hence, this study aims to determine suitable waste processing technologies using an environmentally oriented approach that evaluates both the environmental impacts and associated environmental costs.

Material Flow Analysis (MFA) is a method used to map the flow of mass within a system. MFA includes the quantification of raw material inputs, energy consumption, and waste outputs to assess resource efficiency and environmental impact. It helps to identify key contributors to environmental damage and highlights specific processes within the system that require improvement (Brunner & Rechberger, 2016; Islam & Huda, 2019). MFA can be effectively combined with Life Cycle Assessment (LCA), which is a widely recognized method to evaluate

environmental impacts across a product's life cycle, from raw material extraction to disposal or recycling. LCA identifies all relevant inputs (resources and energy) and outputs (emissions and waste) associated with a system. It offers insight into opportunities for impact reduction through material or process substitution, thereby promoting more sustainable production pathways. LCA also enables the evaluation of environmental costs, often referred to as eco-costs, which represent the monetized cost of reducing environmental impacts to sustainable levels (Hossein et al., 2022; Khoo et al., 2010). In this study, the integration of MFA and LCA, along with single-score analysis, will support the selection of waste processing technologies specifically for organic waste generated from households and traditional markets in Grobogan Regency.

LCA-based technology assessments have been widely applied in prior research on waste management. For instance, Iqbal et al. (2020) compared biological treatment, thermal processing, landfill, and recycling using LCA to determine the most suitable treatment method. Similarly, Hossein et al. (2022) used LCA to compare two waste transportation scenarios, conventional and smart routing, to identify the environmentally optimal option. Another study by Park et al. (2025) assessed three waste-to-energy technologies, gasification, pyrolysis, and incineration, based on emissions and energy output. Despite these contributions, certain gaps remain in the literature. The studies by Iqbal, Liu, and Chen (2020) and Park, Yun, Jeong, and Won (2025) did not comprehensively analyze the environmental costs or provide detailed mass flow data. Meanwhile, the study by Hossein Nematollahi focused only on transport routes without considering downstream waste processing impacts.

This study fills these gaps by integrating detailed MFA, environmental impact assessment through LCA, and economic valuation of environmental impacts using the single-score method. Through this holistic approach, the research aims to propose sustainable waste processing technologies and facility designs for organic waste management in Grobogan. Grobogan Regency was selected as the study area due to its potential for developing an integrated waste treatment system centered in Ngembak Landfill, located in Purwodadi District, which currently serves four

subdistricts. This study is expected to provide a strategic solution to the region's ongoing waste management challenges and to contribute to the development of sustainable waste processing systems in Central Java.

## 1.2 Problem Identification

Based on the aforementioned background, the identified problems in this final project are as follows:

1. The increase in population has led to a corresponding rise in the volume of waste generated, particularly organic waste from both domestic (household) and non-domestic (market) sources in Grobogan Regency. This increase is reflected in the population growth from 1,465,511 in 2022 to 1,492,891 in 2023. The Ngembak Landfill has a service capacity of 70 tons of waste per day. However, the facility currently receives approximately 82 tons daily, exceeding its designed capacity.

2. Waste management efforts in Grobogan Regency mainly focused on Refuse Derived Fuel (RDF) technology, particularly for the treatment of inorganic waste. The absence of studies on organic waste management highlights the need for an in-depth assessment to establish effective processing strategies.

3. Current studies on waste processing, particularly organic waste, have not been based on comprehensive assessments of environmental impacts and associated costs. Therefore, an impact analysis is required, especially in selecting appropriate waste treatment technologies at Ngembak Landfill.

4. There is currently no design plan for waste treatment technology based on environmental impact and cost considerations. A construction design is required for planning the development of the TPST at the Ngembak Landfill.

## 1.3 Problem Statement

Based on the identification of problems, the problem formulation in this final project is as follows:

1. How is the existing condition of Ngembak Landfill for waste treatment in Grobogan Regency?

2. How to analyze the optimal waste treatment for organic waste from domestic and traditional market using MFA approaches?

3. How is the environmental impacts of the organic waste technology methods using the LCA until single score approach?

4. How to plan the construction and location of the Integrated Waste Treatment Site?

## 1.4 Research Goals

Based on the problem statements, the objectives of this final project are as follows:

1. Analyzing the existing waste treatment treatment at Ngembak Landfill, Grobogan Regency.

2. Analyzing the optimal treatment for organic waste using MFA.

3. Analyzing the environmental and economic impacts of the organic waste technologies using LCA single score approaches.

4. Planning the construction and location of the Integrated Waste Treatment Site.

## 1.5 Scope of the Study

The scope of this study is as follows:

1. The scope of this final project is limited to the TPST at the Ngembak Final in Grobogan Regency, Central Java.

2. Projections of waste generation and population size in 4 subdistricts are calculated up to the year 2044.

3. The organic waste to be processed comes from domestic waste and traditional market waste at the Ngembak Landfill in Grobogan District.

4. The MFA method is used to develop a waste management planning scheme for the TPST at the Ngembak Landfill in Grobogan District, Central Java.

5. The LCA method up to a single score was used to analyze the potential environmental impact of the processing technology used at the TPST at the Ngembak Landfill in Grobogan Regency, Central Java.

## 1.6 Research Benefits

1. For Writer

To increase writers' knowledge of organic solid waste treatment technology and waste mass balance, as well as the environmental impact of agricultural solid waste treatment using LCA.

2. For Science

To provide recommendations and knowledge on optimal TPST location planning, which can be used as a model for other regions in overcoming similar waste problems.

3. For the Government

Serve as a reference in developing optimal and structured planning for determining waste collection site locations in Grobogan Regency, with the aim of addressing waste issues and improving environmental quality.

4. For the Community of Grobogan Regency

Providing an optimal design for the TPST location at the Ngembak Landfill and formulating mechanisms for organic waste processing in Grobogan Regency, to minimize the negative environmental impacts of waste-related issues and enhance public understanding of waste management and its consequences for the environment.

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