Number: **161 A /UN7.F3.6.8.TL/DL/II/2024**
162 A /UN7.F3.6.8.TL/DL/II/2024

UNDERGRADUATE THESIS

DEVELOPMENT PLANNING OF WASTE MANAGEMENT AND PROCESSING BY DESIGNING INTEGRATED WASTE PROCESSING SITE *(TPST)* FOR INORGANIC WASTE USING REFUSE-DERIVED FUEL (RDF) IN KARANGPANDAN AND TAWANGMANGU SUB-DISTRICTS

Arranged By:

Maurelitya Priskayla Dayinta	**21080120140107**
Nerissa Lenjau	**21080120120007**

DEPARTMENT OF ENVIRONMENTAL ENGINEERING

FACULTY OF ENGINEERING

DIPONEGORO UNIVERSITY

2024

VALIDATION PAGE

Declaring that the Undergraduate Thesis entitled:

DEVELOPMENT PLANNING OF WASTE MANAGEMENT AND PROCESSING BY DESIGNING INTEGRATED WASTE PROCESSING SITE *(TPST)* FOR INORGANIC WASTE USING REFUSE-DERIVED FUEL (RDF) IN KARANGPANDAN AND TAWANGMANGU SUB-DISTRICTS

Arranged by:

Maurelitya Priskayla Dayinta

21080120140107

Has been approved and authorized on:

Day/Date: Thursday, 20th of June 2024

Approved by,

Chief Examiner	Examiner Member
Ir. Nurandani Hardyanti, S.T., M.T., IPM., ASEAN Eng.	Dr.Ling., Ir. Sri Sumiyati, S.T., M.Si., IPM., ASEAN Eng.
NIP. 197301302000032001	NIP. 197103301998022001
Academic Advisor I	Academic Advisor II
Prof. Ir. Mochamad Arief Budihardjo, S.T., M.Eng.Sc, Env.Eng, Ph.D., IPM., ASEAN Eng	Dr. Ir. Ika Bagus Priyambada, S.T., M.Eng.
NIP. 197409302001121002	NIP. 197103011998031001

Approved by,

Head of Environmental Engineering Department

Dr. Ing. Sudarno, S.T., M.Sc.

NIP. 197401311999031003

VALIDATION PAGE

Declaring that the Undergraduate Thesis entitled:

DEVELOPMENT PLANNING OF WASTE MANAGEMENT AND PROCESSING BY DESIGNING INTEGRATED WASTE PROCESSING SITE *(TPST)* FOR INORGANIC WASTE USING REFUSE-DERIVED FUEL (RDF) IN KARANGPANDAN AND TAWANGMANGU SUB-DISTRICTS

Arranged by:

Nerissa Lenjau

21080120120007

Has been approved and authorized on:

Day/Date: Thursday, 20th of June 2024

Approved by,

Chief Examiner	Examiner Member
Dr.Ling., Ir. Sri Sumiyati, S.T., M.Si., IPM., ASEAN Eng.	Ir. Nurandani Hardyanti, S.T., M.T., IPM., ASEAN Eng.
NIP. 197103301998022001	NIP. 197301302000032001
Academic Advisor I	Academic Advisor II
Prof. Ir. Mochamad Arief Budihardjo, S.T., M.Eng.Sc, Env.Eng, Ph.D., IPM., ASEAN Eng	Dr. Ir. Ika Bagus Priyambada, S.T., M.Eng.
NIP. 197409302001121002	NIP. 197103011998031001

Approved by,
Head of Environmental Engineering Department

Dr. Ing. Sudarno, S.T., M.Sc.
NIP. 197401311999031003

ABSTRACT

Solid waste is one of the crucial problems faced by Karanganyar Regency. This condition can be reviewed from the regency's existing waste conditions. The amount of waste disposed into their only landfill, the Sukosari Landfill, reaches 170 tons/day. Not to mention Sukosari Landfill has used 70% of its area by 2021 and reported being in serious condition due to waste overloading. Out of 17 Sub-districts, only 8 of them has received waste services from the Environmental Services of Karanganyar Regency while the rest has not. Included in these 8 Sub-districts, are Karangpandan and Tawangmangu. However, their waste services still lack in many ways, such as the limited capacity of waste facilities and limited scope of services. Therefore, there needs to be a new waste management system plan to handle and reduce waste disposal in the landfill. The waste management system will include five aspects, organizational/institutional aspect, laws and regulations aspect, funding aspects, technical operational aspects, and community participation aspect. The waste management's operational technicality will be divided into waste containerization and sortation, waste collection, waste transfer, waste transport, waste processing, and final processing at the landfill. This plan will built an Integrated Waste Processing Site with a Refuse Derived Fuel (RDF) facility to process inorganic waste. This facility is planned to work alongside a previous project, a Vermicompost Facility, which will process the organic waste. By implementing this plan, the amount of domestic waste to be disposed of in the landfill is reduced significantly, only 5.89% of waste will end up in the landfill. The total cost amount needed for this plan in Karangpandan and Tawangmangu Sub-district until 2043 is Rp 395.907.550.120. The planned system will be executed by Karanganyar's Environmental Services together with the people's participation to create a good waste management system.

Key words: Waste Management Planning; Integrated Waste Processing Site; Refuse Derived Fuel; Domestic Waste

CHAPTER I
INTRODUCTION

1.1 Background

One of the most crucial environmental problems that needs to be handled by the Indonesian Government is solid waste. Based on the 2022 data provided by the Ministry of Environment and Forestry, the number of waste generation in Indonesia reached 68.7 million tons/year with organic waste as the dominant waste composition showing 53.64%, with 42.56% of food waste and 11.08% of leaves and branches, and 46.36 % of inorganic waste consisting of paper/carton, plastic, metal, cloth, leather, glass, and others. With this amount of waste, as much as 65.83% of solid waste still ends up in the landfill. The number of waste production continues to increase as the human population rises, along with the changes in human lifestyles (Damanhuri et al., 2010). The large amount of waste production is not proportionate with the amount of landfill area. The Indonesian Government has made a regulation regarding Solid Waste Management in the Law of the Republic of Indonesia Number 18 of 2008. Even so, managing waste using the old paradigm, namely collect-transport-dispose will not be able to solve waste problems. This old way of waste management will have a bad impact on landfills in the upcoming years when they can no longer collect the amount of waste dumping. The landfills will end up being overloaded and can no longer be used, therefore new areas of landfills will need to be opened. Meanwhile, finding a replacement area for the landfill is becoming more difficult, considering limited land availability and increasing resistance to the existence of landfills, especially in areas around or near residential areas (Prihatin, 2020). For this reason, it is necessary to implement waste processing to reduce the amount of waste generation. Practicing the 3R principle (reduce, reuse, recycle) as stated in reference to the Law of the Republic of Indonesia Number 18 of 2008 (UURI-18, 2008) starting from the source of waste generation would reduce the amount of waste generation that will be thrown in landfills.

Karanganyar Regency is located in Central Java Province with 17 sub-districts in total and covers an area of 76,778.64 hectares (Badan Pusat Statistik, 2023). In

2022, Karanganyar Regency has a population of 947,642 with a 0.94% growth rate. The increase in the human population would have an impact on the amount of waste generation. Karanganyar Regency has a total of 137,065.97 tons/year of generated waste in 2022, which has risen from 2021 which is 132,071.89 tons/year (SIPSN, 2022). This becomes a serious concern for Karanganyar, since their only landfill, Sukosari Landfill has been filled up to 70% (Karanganyar Environmental Services, 2021). Another waste problem that Karanganyar faces is their waste management system, because of the few numbers of provided temporary waste collections *(Tempat Pembuangan Sementara)* and their limited scope of waste collection. Currently, their scope of waste collection services is only provided to 8 sub-districts out of 17, which are Karanganyar, Tasikmadu, Karangpandan, Jaten, Kebakkramat, Colomadu, Gondangrejo, and Tawangmangu. The limited capacity of waste facilities and scope of services often cause waste accumulation in some temporary waste collections. This is due to waste collection not being done routinely and the community's habit of throwing waste without prior process. With these conditions, there needs to be systematic waste management to prevent waste accumulation at certain points which would cause further environmental and health problems. The waste management system planning includes 5 aspects, Organizational/Institution, Funding, Laws and Regulations, Community Participation, and Technical operation. Managing waste in Karangpandan and Tawangmangu sub-districts would require participation from every component starting from the government including the citizens to work together and create a synergistic waste management.

Aside from planning the waste management system, it is important to reduce waste generation that ends up in the landfill starting from processing waste from the source. Karanganyar's waste composition is dominated by organic waste up to around 65% and 35% of inorganic waste (SIPSN, 2022). By understanding the waste characteristics, planning the right facility to process waste could be done. There are a few methods to process organic waste, and one of them is vermicomposting. Vermicomposting has been widely implemented in waste processing. Vermicompost is a compost obtained as a result of the breakdown of organic materials by *Lumbricus rubellus*, a type of earthworm. These worms

survive by decomposing organic matters which act as their food (Warsana, 2009). In the process, microorganisms in organic matter will start the decomposing process, which will then be continued by these earthworms that will actively consume and dig through the organic matter. This method is efficient and can be implemented both indoors and outdoors, with relatively low funding, and can be done anytime (Enebe et al., 2023). Meanwhile, the inorganic waste would be processed and handled using a different method. One of them is transforming waste to energy (WTE) as an eco-friendly energy. There are a few ways to transform waste into energy, such as RDF, incineration, biogas, etc. Refused Derived Fuel is the form of implementing the Waste to Energy (WtE) concept that makes use of the energy in combustible solid waste (Hutabarat et al., 2018). The calorific value of garbage becomes an important parameter in processing waste into RDF, where one of the parameters to determine the calorific value is water content (Batutah, 2019). Therefore, the lower the water content, the higher the calorific value (Batutah, 2019). There are a few ways to decrease the water content of solid waste before processing it into RDF, namely fermentation, bio-drying, rotary drum, etc. Bio-drying is a waste processing method to decrease water content by aerobic degradation using an aerobic convective evaporation process (Tom et al., 2016).

For this plan, an RDF facility will be built to improve the initial plan of building an Integrated Waste Processing Site for processing inorganic waste. The final option for utilizing RDF methods in this waste management planning is due to its numerous benefits. This method is perfect for processing waste, especially since fossil fuels are prone to be extinct in the future and people need another alternative (Astrup et al., 2015). RDF as a form of waste-to-energy application is not only contributing to an eco-friendly move by reducing the usage of fossil fuels but also promoting the circular economy movement. RDF's main contribution to the circular economy can be seen from its ability to reuse municipal solid waste to become something with a higher value such as alternative fuel for cement industries. RDFs are also positively contributing to most Sustainable Development Goals (SDGs) aspects such as good health and well-being, affordable and clean energy, industry

innovation and infrastructure, and responsible consumption and production (Shehata et al., 2022).

This final project is planned to improve waste management and processing in Karanganyar Regency by developing an Integrated Waste Processing Site plan by adding a Refuse Derived Fuel (RDF) facility, to process inorganic waste, alongside a Vermicomposting facility to process organic waste. Planning a waste management system and development-building of the Integrated Waste Processing Site *(TPST)* will be an effective solution to reduce waste problems in Karanganyar Regency, especially in Karangpandan and Tawangmangu sub-districts.

1.2 Problem Identification

Based on the stated background, the identified problems of this final project are as written below.

1. The amount of generated waste increases along with the amount of population growth in Karanganyar Regency with a 0.94% growth rate.
2. The landfill condition of Sukosari Landfill has almost reached its maximum capacity in accommodating the waste produced by residents of Karanganyar Regency and is projected to be overloaded by 2026.
3. The waste management system in Sukosari Landfill still uses open dumping which causes environmental problems and disturbance to surrounding residents.
4. Community awareness and participation in waste management from the source is still low.
5. The funding priority budgeted for waste management is not comparable to service needs in Karanganyar Regency.

1.3 Problem Limitation

Problem limitation is done to focus on a certain scope of the planning and does not stray from the original plan. Therefore, the problem limitations for this planning are:

1. This planning focuses on domestic waste management planning and analyzing the condition of inorganic waste in two sub-districts, namely Karangpandan and Tawangmangu in Karanganyar Regency.
2. This planning will take into account the results of population and waste generation projections until the year 2043.
3. Waste management planning which includes the 5 waste management aspects (Organizational/Institution, Funding, Laws and Regulations, Community Participation, and Technicality operation) would be based on prior evaluation of existing waste management conditions in Karangpandan and Tawangmangu Sub-District.
4. Planning a Refuse Derived Fuel (RDF) facility to develop a planned Vermicomposting-based Integrated Waste Processing Site *(TPST)* with the output of CAD drawings, planned area maps, and Cost Budget Plans.
5. Collection of primary and secondary data will be sourced from Karangpandan and Tawangmangu Sub-district, Karanganyar Regency.

1.4 Conceptualization of Problems, Goals, and Benefits

1.4.1 Problem Conceptualization

Based on the problem identification described above, the problem conceptualization can be described as follows.

1. How is the existing condition of domestic waste in Karangpandan and Tawangmangu Sub-district, including the characteristics, waste generation, and waste management which covers the 5 aspects?
2. How is the waste management technicality planning that is suitable for Karangpandan and Tawangmangu Sub-district?
3. How are the building plan and location determination of the Refuse Derived Fuel (RDF) facility using the bio-drying method in developing an Integrated Waste Processing Site in Karangpandan and Tawangmangu Sub-district?
4. How much end–product is produced from waste processing using the bio-drying method and how is the influence on reducing the amount of waste generation?

1.4.2 Goals Conceptualization

The goal in planning to develop the waste management system and an Integrated Waste Processing Site *(TPST)* using Refuse Derived Fuel (RDF) technology can be described as follows.

1. Acquaint and analyze the existing condition of domestic waste, as of its characteristics, waste generation, and waste management that covers the 5 aspects in Karangpandan and Tawangmangu Sub-district, Karanganyar Regency.
2. Planning a fitting waste management system that suits Karangpandan and Tawangmangu Sub-district areas.
3. Planning an RDF facility using the bio-drying method and its location to develop the usage of an Integrated Waste Processing Site *(TPST)* in Karangpandan and Tawangmangu Sub-district.
4. Calculating the amount of RDF product produced from the bio-drying waste–processing method and acquaint its influence towards waste reduction in Karangpandan and Tawangmangu Sub-district.

1.4.3 Benefits Conceptualization

The benefits of this planning are as follows:

1. For The Author/Planner
    a. To expand knowledge, insight, skills, character, and profession ability through an implemented study by planning and developing an Integrated Waste Processing Site *(TPST)*;
    b. Allows the author to implement concepts and theories gained from academic studies into practical planning;
    c. To fulfill the Final Project course requirements in the Environmental Engineering Study Program, Faculty of Engineering, Universitas Diponegoro, and graduation requirements for the Environmental Engineering Study Program.
2. For The Government

    The plan results can be used by the government or related institutions as consideration for building a waste processing building and transforms

waste into energy, including optimization of the waste management system in Karangpandan and Tawangmangu Sub-district to fix their waste problems and improve the environment quality.

3. For The People of Karanganyar Regency
   a. Reduce the impact of environmental pollution caused by waste.
   b. Provide information or description regarding an alternative of handling and processing waste into energy.

REFERENCES

Ab Jalil, N., et al. (2015). The potential of biodrying as pre-treatment for municipal solid waste in Malaysia. *Journal of Advanced Review on Scientific Research* 7(1): 1-13.

Afifah, N. A., et al. (2023). Potensi Sampah TPA Banyuroto Kabupaten Kulon Progo sebagai Bahan Baku Refuse Derived Fuel (RDF). *Jurnal Teknik Sipil dan Lingkungan* 8(03): 147-156.

Aminah, S., et al. (2017). Pengaruh Aerasi Terhadap Karakteristik Lindi Hasil Pengolahan Sampah Organik Secara Biodrying Studi Kasus: Sayuran Kangkung, Diponegoro University.

Arceivala, S. J. (1973). Simple waste treatment methods: aerated lagoons, oxidation ditches, stabilisation ponds in warm and temperate climates. *(No Title)*.

Astrup, T. F., et al. (2015). Life cycle assessment of thermal Waste-to-Energy technologies: Review and recommendations. *Waste management* 37: 104-115.

Batutah, M. A. (2019). Metode Pengeringan Ampas Tebu (Bagasse) Dengan Pemanfaatan Kembali Panas Gas Buang Boiler Di Pg. Pradjekan Bondowoso. *Journal of Research and Technology* 5(1): 1-5.

Busyairi, M., et al. (2015). Perencanaan Pengelolaan Sampah Terpadu di Kelurahan Sempaja Selatan Kota Samarinda. *Jurnal Bumi Lestari* 15(2): 136-146.

Chaniago, N. and Y. Inriyani. (2019). Pengaruh Jenis Bahan Organik Dan Lamanya Proses Pengomposan Terhadap Kuantitas Dan Kualitas Vermikompos. *Bernas: Jurnal Penelitian Pertanian* 15(1): 68-81.

Damanhuri, E. (2006). Lesson learning from landslide of leuwigajah landfill towards a better SWM in Indonesia. SWAPI-meeting, Kitakyushu.

Damanhuri, E. and T. Padmi. (2010). Pengelolaan sampah. *Diktat kuliah TL* 3104: 5-10.

Damanhuri, E. and T. Padmi. (2019). Pengelolaan sampah terpadu, ITB Press.

Enebe, M. C. and M. Erasmus. (2023). Vermicomposting technology-A perspective on vermicompost production technologies, limitations and prospects. *Journal of Environmental Management* 345: 118585.

Faadhilah, A.S, & Mustika B. 2024. Perencanaan Pengolahan Sampah TPA Menjadi Produk Refuse Derived Fuel (RDF) Studi Kasus di TPA Blondo Kabupaten Semarang.

Fiki, A. C., et al. (2022). Teknologi Biodrying untuk Meningkatkan Nilai Kalor Sampah dan Proyeksinya sebagai Bahan Bakar Alternatif pada Tahun 2028. *Jurnal Ilmu Lingkungan* 20(1): 139-146.

Giras Hasfiawan, H. and R. Anferditya Bagaskhara (2023). PERENCANAAN PENGOLAHAN SAMPAH DENGAN METODE BIODRYING DI KOTA SALATIGA, Universitas Diponegoro.

Gobai, K. R. M. and B. Surya (2021). Pengelolaan Sampah Perkotaan, Pusaka Almaida.

Guo, H.-n., et al. (2021). Application of machine learning methods for the prediction of organic solid waste treatment and recycling processes: A review. *Bioresource technology* 319: 124114.

Hapsari, D. S. A. and W. Herumurti. (2017). L aju Timbulan dan Komposisi Sampah Rumah Tangga di Kecamatan Sukolilo Surabaya. *Jurnal Teknik ITS* 6(2): C92-C95.

Hutabarat, I. N., et al. (2018). Potensi Material Sampah Combustible pada Zona Pasif TPA Jatibarang Semarang sebagai Bahan Baku RDF (Refuse Derived Fuel). *Jurnal Teknik Mesin (JTM)* 7(1).

Hutagaol, V. and B. Sudarsono. (2015). Penentuan potensi lokasi ATM BNI menggunakan Analytical Hierarchy Process (AHP) dan sistem informasi geografis (studi kasus: Kecamatan Tembalang). *Jurnal Geodesi Undip* 4(2): 25-32.

Mara, D. (1976). Sewage treatment in hot climates.

Mara, D. (2013). Domestic wastewater treatment in developing countries, Routledge.

McDougall, F. R., et al. (2008). Integrated solid waste management: a life cycle inventory, John Wiley & Sons.

Meiring, P., et al. (1968). Guide to the use of pond systems in South Africa for the purification of raw and partially treated sewage.

Naryono, E. and S. Soemarno. (2013). Pengeringan Sampah Organik Rumah Tangga. *The Indonesian Green Technology Journal* 2(2): 61-69.

Parker, H. (1975). Wastewater Systems Engineering.

Perrina, M. G. (2021). Literature Review Sistem Informasi Geografis (SIG). *Journal of Information Technology and Computer Science (JOINTECOMS)*.

PP-81. (2012). Peraturat Pemerintah (PP) No 81 Tahun 2012. *Pengelolaan Sampah Rumah Tangga Dan Sampah Sejenis Sampah Rumah Tangga*.

Prihatin, R. B. (2020). Pengelolaan Sampah di Kota Bertipe Sedang: Studi Kasus di Kota Cirebon dan Kota Surakarta. *Aspirasi: Jurnal Masalah-masalah Sosial* 11(1): 1-16.

PU (2013). Peraturan Menteri Pekerjaan Umum Republik Indonesia Nomor 03/PRT/M/2013 Tentang Penyelenggaran Prasarana Dan Sarana Persampahan Dalam Penanganan Sampah Rumah Tangga Dan Sampah Sejenis Sampah Rumah Tangga**:** 374.

Rania, M. F., et al. (2019). Analisis potensi refuse derived fuel (rdf) dari sampah pada tempat pembuangan akhir (tpa) di kabupaten Tegal sebagai bahan bakar incinerator pirolisis. *SINTEK JURNAL: Jurnal Ilmiah Teknik Mesin* 13(1): 51-59.

Shehata, N., et al. (2022). Role of refuse-derived fuel in circular economy and sustainable development goals. *Process Safety and Environmental Protection* 163: 558-573.

SIPSN (2022). "Grafik Komposisi Sampah Berdasarkan Jenis Sampah." Jakarta: Kementerian Lingkungan Hidup dan Kehutanan. from https://sipsn.menlhk.go.id/sipsn/public/data/komposisi.

SIPSN (2022). "Grafik Timbulan Sampah." Jakarta: Kementerian Lingkungan Hidup dan Kehutanan. from https://sipsn.menlhk.go.id/sipsn/public/data/timbulan.

SK-SNI-T-13-1990F. (1990). Tata Cara Teknik Pengelolaan Sampah Perkotaan. Jakarta: Departemen Pekerjaan Umum.

SNI-19-2454. (2002). Tata Cara Teknik Operasional Pengelolaan Sampah Perkotaan.

SNI-19-3964. (1994). Metode Pengambilan dan Pengukuran Contoh Timbulan dan Komposisi Sampah Perkotaan

SNI-8632. (2018). Tata cara perencanaan teknik operasional pengelolaan sampah perkotaan.

Staber, W., et al. (2008). Methods for determining the biomass content of waste. *Waste Management & Research* 26(1): 78-87.

Suryani, A. S. (2014). Peran bank sampah dalam efektivitas pengelolaan sampah (studi kasus bank sampah Malang). *Aspirasi: Jurnal Masalah-masalah Sosial* 5(1): 71-84.

Taufiq, A. (2015). Sosialisasi sampah organik dan non organik serta pelatihan kreasi sampah. *Asian Journal of Innovation and Entrepreneurship (AJIE)* 4(01): 68-73.

Tom, A. P., et al. (2016). Biodrying process: A sustainable technology for treatment of municipal solid waste with high moisture content. *Waste management* 49: 64-72.

Ummatin. (2019). Prastudi Kelayakan Pembangunan RDF Plant di Kabupaten Tuban.

UURI-18, U.-U. R. I. N. T. (2008). Pengolahan Sampah.

Warsana (2009). "Kompos Cacing Tanah (CASTING)." Jawa Tengah: Tabloid Sinar Tani. from https://cacinglumbricus.wordpress.com/2009/08/08/kompos-cacing-tanah-casting/.

Wiryono, B., et al. (2020). Pengelolaan sampah organik di lingkungan bebidas. *Jurnal Agro Dedikasi Masyarakat (JADM)* 1(1): 15-21.