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Research Article

Al-Amin Living Lab and Industrial Park Waste Management Program

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Abstract: The population growth that aligns with the increasing diverse needs will lead to an increase in waste or residues, both from consumption processes and the results of activities carried out, in the form of garbage. The purpose of this study is to understand the planning of the waste management system at Al-Amin Living Lab and Industrial Park. The research material is the site location in Sampe Cita Village, Kutalimbaru District, Deli Serdang Regency, considering and taking into account the existing waste management system. Littering will affect the activities of the surrounding community, which can ultimately lead to disease. The data used in the study of the management system involves several data collection techniques, namely, field observation and document analysis, direct observation in the field to observe waste management practices, such as collection, sorting, transportation, and disposal. Based on the results of the study, it is explained that the general activities of waste management planning at Al-Amin Living Lab and Industrial Park include containment, collection, transfer, and transportation of waste to the landfill. In terms of waste management planning at Al-Amin Living Lab and Industrial Park, it will consider the needs of people, the amount of waste generated, containment, and the TPST of Al-Amin Living Lab and Industrial Park area, as well as effective waste management.

Keywords: Industrial Park, Living Lab, Management, Planning, Waste.

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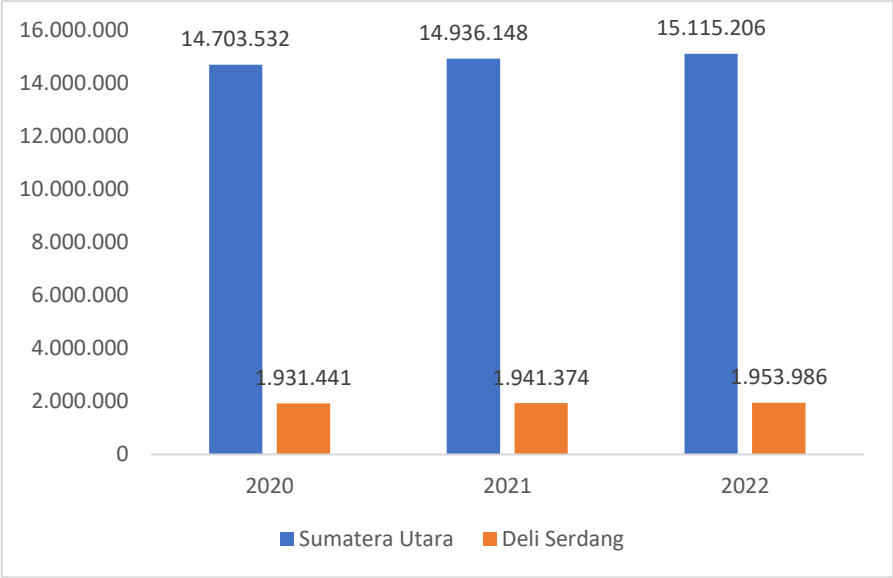
1. Introduction

The population growth rate, which aligns with the increasing variety of needs, will increase the amount of waste or residue, both from consumption processes and the results of activities carried out, in the form of garbage. Garbage can be defined as residual material that cannot be reused or is unwanted and is eventually discarded, thus it is stated that garbage is a concept related to humans and the consequences of human activities and natural processes (Kahfi, 2017).

Regarding the increase in waste volume, for example, humans produce a lot of waste due to a consumptive lifestyle and the production of goods and services (Novalinda, 2023). Daily household activities generate waste such as food scraps, paper, plastic, and others, which increase over time with the emergence of new materials and substances that in turn require special processing and handling systems (Saputro et al., 2016). Therefore, cleanliness and environmental health issues (including waste) are complex problems faced by all countries, including Indonesia, and extend to provinces and districts/cities.

According to data from BPS (Central Bureau of Statistics), North Sumatra is a province with great potential. In terms of population, North Sumatra is the fourth largest province in Indonesia after West Java, East Java, and Central Java. One of the regencies/cities in the province of North Sumatra is Deli Serdang. This regency has the second largest population after Medan City, according to data collected by BPS Deli Serdang. This can be seen from the following graph of population growth in North Sumatra and Deli Serdang.



Source: (Central Statistics Agency of North Sumatra Province, 2023; BPS Deli Serdang Regency, 2023)

Figure 1. Population Growth of North Sumatra Province and Deli Serdang Regency from 2020 to 2022

The information from Figure 1 indicates that over the past three years, there has been an increase in the population in both North Sumatra Province and Deli Serdang Regency. However, this increase is not significant. Population growth in an area is fundamentally based on three main elements: fertility, mortality, and migration.

This study focuses on Sampe Cita Village, which is one of the villages in Kutalimbaru District, Deli Serdang Regency, North Sumatra Province. Administratively, the village is located on the border of Medan City and Deli Serdang Regency. Kutalimbaru District is part of Deli Serdang Regency, North Sumatra Province. The natural conditions of Kutalimbaru District generally have two seasons, the dry season and the rainy season, both influenced by sea and mountain winds. Sampe Cita Village has a population of approximately 2,888 people, consisting of various ethnic groups, such as Batak, Karo, Javanese, Mandailing, etc. (Siregar et al., 2023).

Therefore, waste management is necessary as an action to reduce environmental pollution. Waste management involves applying the 3 Rs (reuse, reduce, and recycle) by involving the community to participate in managing waste, starting with the separation of organic and inorganic waste, and processing organic waste using household composters. Additionally, at the waste disposal site (TPS), local community managers are involved in recycling inorganic waste and conducting environmental-scale composting (Fitri & Siregar, 2023).

2. Literature Review

2.1 Garbage

Garbage is defined as all forms of solid waste originating from human and animal activities, which are then discarded because they are no longer useful or their presence is no longer desired (Tchobanoglous et al., 1993).

Meanwhile, according to Law Number 18 of 2008 on Waste Management, waste is defined as the residue of daily human activities and/or natural processes in solid form.

Additionally, Government Regulation No. 81 of 2012 on Household Waste Management and Similar Household Waste further explains that household waste is waste originating from daily activities within households, excluding feces and specific waste. Similar household waste refers to household-like waste originating from commercial areas, industrial areas, special areas, social facilities, public facilities, and/or other facilities.

2.2 Waste Management System

Waste processing is part of waste handling and is defined by Law No. 18 of 2008 as the process of changing the form of waste by altering its characteristics, composition, and quantity. Waste processing activities are intended to reduce the amount of waste while utilizing the value still contained in the waste itself (recyclable materials, other products, and energy). Waste processing can include composting, recycling, incineration, and other methods (Kementrian PUPR, 2022).

2.3 Sources of Waste

As explained in Law No. 18 of 2008, sources of waste are defined as the origin of waste generation. The waste to be managed is categorized as follows:

a. Household waste is defined as originating from daily activities within households, excluding feces and specific waste.
b. Waste similar to household waste originates from commercial areas, industrial areas, special areas, social facilities, public facilities, and/or other facilities.
c. Specific waste includes:
    - Waste containing hazardous and toxic materials;
    - Waste containing hazardous and toxic waste;
    - Waste generated due to disasters;
    - Construction debris;
    - Waste that cannot be processed by current technology; and/or
    - Waste generated irregularly (Purnaini, 2011).

2.4 Classification of Waste Sources

The percentage of waste generation is 75% from residential areas and 25% from non-residential areas (Sinaga, 2023).

There are several categories of waste sources that can be used as references:

- Waste sources from residential areas
- Waste sources from commercial areas
- Waste sources from public facilities
- Waste sources from social facilities

The classification of waste sources can essentially reflect the economic classification, which can be used to assess the community's ability to pay waste fees and determine a cross-subsidy pattern.

2.5 Waste Management Scale

Based on the processing method and management responsibility, the scale of processing can be categorized into several levels (Damanhuri & Padmi, 2010):

1) Individual Scale: This refers to waste processing carried out directly by the waste producer at the source (household/office). An example of processing at this scale is individual waste separation or composting.

a) Separation **b) Composting**

Figure 2. Individual Scale Processing

2) Community Scale: This refers to waste processing that serves a specific area or community (residential, office, market, etc.). The processing at this scale is conducted at an Integrated Waste Processing Site (TPST). The typical processes at a TPST include waste separation, organic waste shredding, composting, compost screening, compost packaging, and plastic shredding for recycling.

a) Waste Separation b) Composting Process

Figure 2. Community Scale Processing

3) City scale: This refers to waste processing carried out to serve part or all of a city's area, managed by the city's sanitation department. The processing takes place at an Integrated Waste Processing Facility (IPST), which generally uses mechanical equipment.

a) City-scale MRF location **b) City-scale composting process**

Figure 1. City waste processing process

2.6 Waste Recycling

Recycling is defined as the process of collecting, separating, processing, and selling materials that can be reused or converted into new materials (Hidayah, 2018). In integrated waste management, recycling is a key component, as illustrated in the hierarchy shown in Figure 2.4 below.

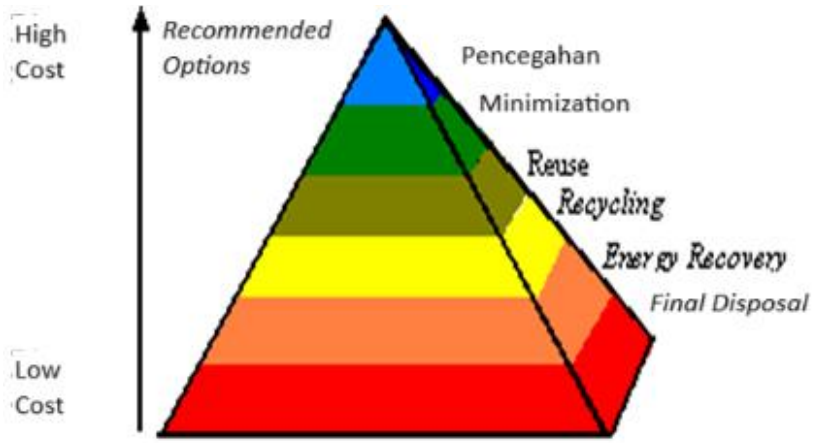


Figure 2. Waste Management Hierarchy

3. Proposed Method

3.1. Research Material

The research material is the site location in Sampe Cita Village, Kutalimbaru Subdistrict, Deli Serdang Regency, with consideration given to the existing waste management system. Improperly disposed waste can negatively impact the activities of the surrounding community and ultimately lead to disease.

3.1 Research Procedure

The procedures to be followed are as follows:

3.1.1 Place and Time of Research

This research is conducted at Al-Amin Living Lab and Industrial Park in Sampe Cita Village, Kutalimbaru Subdistrict, for a duration of 1 (one) year.

3.1.2 Type and Scope of Research

This research is a descriptive experimental study.

3.1.3 Data Collection Techniques

The required data for the waste management system study involves several data collection techniques, including field observation and document analysis. Field observations are conducted to directly observe waste management practices such as collection, sorting, transportation, and disposal. This helps identify operational issues and best practices. Additionally, collecting and analyzing documents related to waste management, including government reports, statistical data, regulations, waste management planning, and relevant scientific literature, is part of the process.

4. Results and Discussion

Based on data from the Deli Serdang Sanitation and Parks Office in 2017, the composition of waste at the Terjun Landfill consists of: organic 71.5%; paper 2%; plastic 10.1%; wood 2%; fabric 2.5%; rubber 2.5%; metal 0.6%; glass 0.8%; debris 1%; diapers/pads 3.1%; and others 3.8%. Given these conditions, achieving the national target for service levels will be challenging without effective waste management efforts.

The government recognizes that waste management has become a national issue. A comprehensive and integrated management system, from upstream to downstream, is necessary. Furthermore, effective waste management requires legal certainty, clear responsibilities and authorities for the government, local governments, as well as the involvement of the community and businesses. Therefore, a law governing waste management is needed. In 2008, Law No. 18 of 2008 on Waste Management was enacted with the following objectives:

a. To ensure that waste management provides economic benefits (treating waste as a resource), promotes public health, and is safe for the environment, while also encouraging changes in public behavior;
b. To reduce the negative impacts of waste on health and the environment;
c. To ensure that waste management is conducted proportionally, effectively, and efficiently.

4.1 Factors Preventing Effective Waste Separation

Waste separation is a crucial step in waste management and processing. Inefficient waste management can hinder the proper separation of mixed waste, including recyclable organic waste and non-recyclable inorganic waste. In the Al-Amin Living Lab and Industrial Park area, effective waste separation has not been achieved due to the involvement of multiple parties, including waste management authorities and the community as waste producers. The government provides policies on waste management and participates in its management and supervision, such as implementing waste management, facilitating waste management infrastructure, and coordinating between Work Units, the community, and businesses.

Efforts to promote waste sorting in the Al-Amin Living Lab and Industrial Park have been intense, but the separation process often fails when the collected waste is mixed again during transportation. The lack of awareness and concern among the community regarding waste management is evident in various behaviors. The government has promoted waste management programs through the implementation of the 3Rs: reduce, reuse, and recycle. However, the habit and lack of awareness in the community, where waste is mixed without being properly separated and managed, remain significant obstacles.

Calculation of Waste Generation in Al-Amin Living Lab and Industrial Park, Sampe Cita Village, Kutalimbaru Subdistrict

In this context, waste generation refers to the volume or weight of waste produced from a specific source within a certain area per unit of time. Waste generation is expressed as:

- Weight units: kg/person/day, kg/m^2/day, kg/bed/day, etc.
- Volume units: L/person/day, L/m^2/day, L/bed/day, etc.

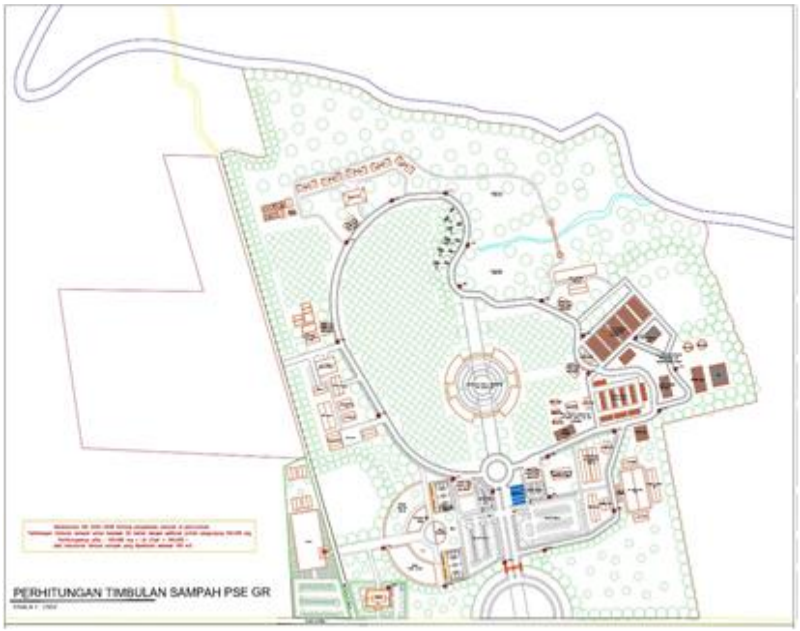


Figure 5. Calculation of Waste Generation in Al-Amin Living Lab and Industrial Park, Sampe Cita Village, Kutalimbaru Subdistrict

4.2 Evaluation of TPS Transportation to Landfill

The waste transportation pattern applied at Al-Amin Living Lab and Industrial Park Sampe Cita Village, Kutalimbaru District uses the HCS (Hauling Container System) system. The steps of this system pattern are: the garbage truck arrives at the TPS in the Al-Amin Living Lab and Industrial Park area, the garbage is loaded into the truck manually, that is, the cart officer puts the garbage into the truck with the help of makeshift tools, after the truck is fully filled, the truck is closed, and the truck then goes to the landfill. In the landfill in the Al-Amin Living Lab and Industrial Park areas, there is only one time to transport waste to the landfill every day, therefore for the schedule of transportation is not on.

Table 1. Operational Evaluation at the Landfill

No.	Parameter	Kondisi Eksisting	Evaluasi operasionalnya
1.	Penerapan Sel	pembuangan sampah eksisting ke sel masih sangat buruk, dikarenakan pada saat unloading truk sampah ke sel sangat dekat dengan badan jalan, (sel sudah overload)	Perlu adanya pengaturan lokasi pembuangan sampah yang signifikan, termasuk pemsangan rambu – rambu lalu lintas truk sampah, kedisiplinan supir truk untuk membuang sel yang telah ditentukan
2.	Pemadatan Sampah	Pemadatan yang dilakukan belum maksimal, dilihat dari kondisi alat berat yang tidak sesuai dengan pemakaiannya.	Perlu dilakukan pemadatan sampah 700kg/m3 yaitu dengan lintasan alat berat 5x, dan perlunya memperhatikan jaringan pipa lindi agar tidak menyebabkan kebocoran
3.	Penutupan tanah	Penutupan dilakukan secara periodik dengan tebal 30cm	Perlunya penutupan tanah yang dilakukan secara harian atau per minggu dengan syarat harian (tebal= 20 cm); intermediate (tebal 30 cm); dan penutup tanah akhir (50cm). perlunya memperhatikan jenis tanah untuk mempertimbangkan tingkat kekedapannya dan juga perlu adanya penyemprotan insektisida dalam mengurangi vector lalat
4.	Pengolahan lindi	Tidak menjalankan SOP dengan optimal (penggunaan aerator yang tidak teratur)	Mengoptimalkan proses pengolahan agar mencapai effluent yang memenuhi standar baku mutu (BOD 30 – 150 ppm)
5.	Kesesuaian Alat Berat	Masih terdapat alat berat yang rusak, oleh karena nya terjadi antrian akibat unloading sampah pada truk yg hanya menggunakan satu eksavator	Alat berat yang digunakan untuk operasi pengurugan sampah dilakukan setiap hari dan mampu memelihara serta menggunakan alat – alat berat sesuai spesifikasi teknik dan rekomendasi fabrik.
6.	Pipa gas ventilasi	Pipa gas ventilasi dilindungi hanya menggunakan bahan seperti bambu, dan tidak ada teknologi untuk menangkap gas metan tersebut, akibatnya gas metan (energi) terbuang begitu saja	Perlu Pipa yang berlubang dan dilindungi oleh kerikil dan casing dipasang secara bertahap sesuai dg ketinggian lapisan timbulan sampah

4.3 Gas Environmental Impact Evaluation

The gases contained in the landfill from the measurement results are CO2, O2, and CH4 gases. According to the US EPA (2012), CO2 and CH4 are gases that have the potential to cause global warming. One ton of CH4 if released into the air is proportional to seventy-two tons of CO2. So, the more CO2 and CH4 released into the air will increase greenhouse gases in the air and can cause global warming. In addition, when released into the air, CH4 can cause an impact on human health, namely respiratory system disorders. Therefore, it is better to capture and utilize methane gas. The methane gas can be used as an energy source. In addition, if the landfill catches methane gas so that the risk of adding greenhouse gases to the air is reduced, then this reduction can be calculated to gain profits in carbon trading activities.

4.4 Efforts to Achieve Sustainable Waste Separation

a. Government Establishes Policies on the Obligation of Waste Type Separation from Waste Producers to Final Waste Processing
   There is a need for changes in Article 30 of the Deli Serdang Regional Regulation Number 10 of 2013 concerning Waste Management, as it does not yet regulate sustainable waste separation. Waste type separation is only required at the source or waste producer level. When waste producers do not process but only separate waste at the collection point, waste transporters do not continue the separation but mix it in the waste transport vehicle. If special waste transport vehicles are provided to carry separated waste types, modifications to the waste transport vehicle's container can be made to ensure that the waste being transported does not get mixed again.
b. Socialization of Waste Sorting as an Effort to Achieve Integrated Waste Management
   The government can certainly perform its duties as expected if the community is also ready. Waste sorting must begin at the source or waste producer level, at least by separating waste types if they are unable to process the waste. The government will function effectively if the community is prepared. If waste producers have already sorted waste, the government will automatically strive to continue the waste separation, as it is the first step in waste processing, such as processing for biogas, compost fertilizer, and recycling. All types of waste management begin with waste type separation. Therefore, continuous and ongoing socialization is needed, both directly and indirectly. Direct socialization, like the one conducted by the Magelang city government, involves inviting sub-district and village heads. When sub-districts or villages hold routine meetings, socialization is conveyed by inviting neighborhood and community leaders. Subsequently, during routine meetings at the neighborhood and community levels, socialization is communicated to the public. Indirect socialization can be done through mass media, social media, and communication channels, such as using banners, billboards, stickers, websites, and print media.

4.5 Community Participation in Waste Management

The community's significant role in waste management is crucial. According to SNI 3242:2008, the community must separate organic and inorganic waste, process waste using the 3R (Reduce, Reuse, Recycle) concept, pay fees, and comply with established disposal regulations. Unfortunately, in reality, most people have not separated organic and inorganic waste. The results of waste separation can be reused or sold to waste banks for recycling. To increase public awareness of waste separation, socialization efforts can be made. The community should be educated about the new paradigm that waste generated is not simply "collected and disposed of," but can be utilized or even sold. Socialization should be tailored to the community's characteristics to ensure the message is well-received.

Community participation in waste management also involves paying cleanliness fees. The unmet cleanliness fee targets indicate that not all community members contribute to paying these fees, even though they aim to support waste management in Deli Serdang, particularly in the Al-Amin Living Lab and Industrial Park area. If waste management is well-executed, the community can enjoy a comfortable environment.

Deli Serdang Regency's efforts to achieve community-based waste management include activating waste banks, with four active waste banks in Deli Serdang. One of the waste banks' goals is to reduce waste generation, further strengthened by the issuance of the Deli Serdang Regent's Circular Number 660/1928 of 2019 on the Obligation to Become a Waste Bank

Customer. The circular targets all Regional Apparatus Organizations in Deli Serdang, all Village/Sub-district Offices, health centers, schools, and junior high schools in Lubuk Pakam District, Deli Serdang General Hospital, and the planned Al-Amin Living Lab and Industrial Park area. With this circular, it is hoped that the community will become waste bank customers, following the local government and its ranks. Based on the author's observations, the main waste bank there, named "BERSERI" Main Waste Bank, generally meets the requirements and standards in the Ministry of Environment Regulation Number 13 of 2012 (covering construction requirements, management standards, and implementation).

4.6 Government Participation in Waste Management

The increasing rate of growth, population, and socio-economic activities of the community have contributed to the rise in waste generation. Therefore, the old paradigm of waste management, "collect-transport-dispose," is no longer feasible. Consequently, the Deli Serdang Regency Government is committed to implementing 3R-based (Reduce, Reuse, Recycle) waste management. This management begins with upstream management (from the waste source), involving sorting at the waste source. This step is further reinforced by the issuance of a Circular on the Implementation of 3R Waste Management (Reduce, Reuse, Recycle) in Office Environments by the Regent of Deli Serdang Regency. The circular encourages limiting waste generation, such as serving food buffet-style and providing water dispensers during meetings, reusing waste by providing sorted waste bins and becoming waste bank customers, and recycling through composting.

To support waste reuse through waste banks, the Regent of Deli Serdang Regency issued a Circular on the Obligation to Become a Waste Bank Customer. All regional apparatus organizations and their subordinates are required to become waste bank customers. This serves as an example for the community to raise awareness that community-based waste management, like waste banks, can benefit the community itself and reduce the government's waste management operational costs.

1. Additionally, the Deli Serdang Regency Government has initiated programs as innovations to improve the quality of life in Deli Serdang, including the following:
2. Deli Serdang Berseri Deli Serdang Berseri is an information technology innovation by the Deli Serdang Regency Government, initiated by the Deli Serdang Environmental Agency. It is an Android-based application available on the Playstore that connects people who want to sell waste with the nearest Waste Bank from their location.
3. Jumpa Madu (Jemput Sampah Terima Duit) This program is an innovative waste collection service organized by the Deli Serdang Environmental Agency, where people with economically valuable waste can contact the service admin (Main Waste Bank "BERSERI") to have their waste picked up and purchased by the waste bank.
4. Sumber Bumi (Sampah Bersih, Hubungi Kami) Sumber Bumi is a waste collection service innovation organized by the Lubuk Pakam District Office, where people who see waste piles outside permitted disposal sites can contact the call center/service admin, and service personnel will promptly come to clean up the waste pile.
5. TPS Basah Komisi (TPS 3R-Bank Sampah-Sampah Rumah Kompos Terintegrasi) This program is an innovation for the operationalization of 3R TPS integrated with Waste Banks and Compost Houses by the Deli Serdang Environmental Agency, ensuring that waste collected at TPS is sorted. Organic waste is composted, economically valuable inorganic waste is managed by the waste bank, and residues are transported to the landfill.
6. Opung Sari Basah Bang (Operasi Pungut Sampah Setiap Hari, Bank Sampah Sekolah, dan Pembinaan Berjenjang) This innovation embodies a clean and environmentally conscious school culture, where students are encouraged to reduce and sort waste and manage School Waste Banks. It also includes innovations in tiered school guidance.

5. Conclusions

In general, the waste management planning activities in the Al-Amin Living Lab and Industrial Park area include the activities of containment, collection, transfer, and transportation of waste to the landfill. In terms of waste management planning in the Al-Amin Living Lab and Industrial Park area, it will consider the needs of people, the amount of

waste generated, containment and the Al-Amin Living Lab and Industrial Park TPST (Temporary Waste Processing Site), as well as effective waste management.

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