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Regional Case Study

Solid Waste Management System in Tanjungpura University: 3Rs concept integrated with the Waste Bank

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Abstract

Tanjungpura University is one of the State Universities in West Kalimantan. Waste management in the Tanjungpura University area still applies the old waste management paradigm. Waste management in the Tanjungpura University area still applies the old paradigm of waste management, which has an impact on environmental problems, because waste management has not been handled optimally. Therefore, it is necessary to plan a waste management system with a new paradigm that integrates the 3R concept (Reuse, Reduce and recycle) with the Waste Bank. The research data were obtained through in-depth interviews and field sampling using the SNI-19-3964-1994 method for 8 days. The results of the study show that waste generation in 2035 will be 39,035 l/day. The projected results of waste generation and waste composition form the basis for waste management system planning. The waste management system includes sorting waste at the source, designing segregated containers, designing waste collection cars, processing organic and inorganic waste, and designing 3R-based Waste Processing Site which is integrated with the Waste Bank. This plan is expected to help develop Tanjungpura University with a Green Campus concept.

Keywords: Waste bank; waste management system; 3R-based waste processing site

1. Introduction

The education area is one of the sources of waste such as household waste (Permen PU No 03 of 2013). The university area is considered a "small town" because the campus has a high population density and diversity in terms of academic community and results domestic and scientific activities (Bahçelioğlu, et.al.2020). Some of the waste factors in educational areas are the number of waste producers, the number of activities that have the potential to generate waste, and the area of the building. Waste in the canteen area is affected by the number of visitors to the canteen, and the garden area is affected by the influence of high winds which cause leaves to fall and grass trimming activities (Arindya et al., 2016). The increase in the number of college students is directly proportional to the increase in waste volume (Sudarti and Nadhiroh, 2021). The main cause of problems arising from operational technical aspects in waste management is inadequate sorting, storage, collection, processing, and transportation (Cyntia, et al. 2016).

This will have a negative impact by still applying the old paradigm of waste management, namely requiring an increasingly large budget from time to time if there is no waste management system in accordance with applicable regulations (Prihatin, 2020). The impact is that there are many operational problems, such as waste that is not transported and facilities that do not meet the requirements. The

method of operating waste management facilities that is applied does not refer to Law Number 18 of 2008 concerning Waste Management. Sustainable waste management is a key component in achieving success in the field of green campus (Setyowati et al., 2018). The sustainable waste management plan is the Waste Management Program within the university campus has great benefits to be adopted into practice in the campus community and the larger sector by creating a synergistic effect (Bahçelioğlu et al., 2020). This can help carry out the main function of higher education for the concept of a sustainable environment (Bahçelioğlu et al., 2020). The new paradigm looks at trash as a resource that has economic value and can utilized, for example, for energy, compost, fertilizer, or for industrial raw materials (Masrida, 2017). Waste management with the new paradigm is carried out with waste reduction and handling activities. Waste characterization is very important to choose the right waste management system to consist of collection, selection of means of transportation, energy transformation and reuse of reusable waste, as well as proper design and implementation of optimal waste disposal routes and methods (Ugwu et al., 2020).

Waste reduction includes limiting activities, using return, and recycling, while handling activities including sorting, collecting, transporting, processing and final processing (UU No 18 of 2008). The principle of zero waste and 3R can be used as a general target by the university as a step to reduce the impact of increased waste at the university on environment. The 3R (reduce-reuse-recycle). Most of the waste generated at the university is paper or inorganic waste (Bahçelioğlu et al., 2020). Integrating the waste bank and 3R-based Waste Processing Site is still minimally realized, and little information is obtained. Therefore, with the formation of the 3R-based Waste Processing Site integrated waste bank, it can facilitate, optimize, and have the potential to assist in the process of handling organic waste and inorganic waste worth selling in one location at the same time (Ariesta et al., 2021).

Waste problems can not only be solved by adding Temporary Waste Disposal (TWD) facilities but also supported by changes in the mindset of the campus community by implementing 3R (Reuse, Reduce, Recycle), and it is planned to reduce sources of waste by integrating or matching with the UNTAN Waste Bank. Waste Bank is a facility for managing waste according to the 3R principles (reduce, reuse and recycle), as a means of education, changing behavior in waste management, and implementing a Circular Economy, which is formed and managed by the community, business entity, and/or local government (Permen LHK No 21 of 2021). Based on these problems, it is necessary to determine the amount of generation and composition of waste generated in the southern area of Tanjungpura University. Then plan a waste management system with a new paradigm with the 3R concept (Reduce, Reuse, Recycle) which is integrated with the Waste Bank based on the Regulation of the Minister of Public Works of the Republic of Indonesia No. 03 of 2013. It is hoped that waste management with the new paradigm can reduce waste generation both on campus and in landfill Batu Layang Pontianak City.

2. Methods

Tanjungpura University is one of the universities in West Kalimantan and is located on Jalan Prof. Dr. H. Hadari Nawawi, in Bansir Laut Village, Southeast Pontianak District, Pontianak City, with a supporting building area of ±107,751 m² (UPT TIK, 2021). The Tanjungpura University area is divided into the Southern Region and the Northern Region. The southern area of Tanjungpura University is an academic area with a land area of 74.5 hectares consisting of faculties, offices, canteens and flats. As a result, the majority of the dominant organic and inorganic waste is generated in the UNTAN South area. While the north area is an ecological education business area with a land area of 65.5 Ha (Summary Master Plan, 2021). The waste that will be sampled is waste similar to household waste, namely organic and inorganic waste, excluding hazardous solid waste from campus activities. The existing condition of waste management in the southern region of Tanjungpura University (UNTAN) applies the old paradigm of "collect-transport-burn/dispose" without processing. The temporary shelter provided by the faculty is not used as a waste collection site but instead as a waste burning site.

2.1. Data Collection

Waste sampling is carried out to determine the rate of waste generation and the composition of the waste produced. Waste sampling refers to SNI-19-3964-1994 concerning Procedures for Collection and Measurement of Sample Generation and Composition of Municipal Waste to obtain data on volume, weight and composition of waste for 8 days.

Table 1. Sampling samples in the South UNTAN

No	Facilities Cluster	Sources
1	Education	Faculty of Engineering, Faculty of Agriculture, Faculty of Teacher Training and Education
2	Office	Rectorate, Bureau of General Affairs and Finance, Academic and Student Affairs Bureau, ICT and Language Technical Implementation Unit
3	Canteen	UNTAN Canteen
4	Green Space	parks and roads
5	Student Flats	Student flats consist of men and women

2.2. Data Processing and Analysis

The data analysis stage is needed for the waste management system planning process, which includes waste sorting and containers, waste collection systems, and waste processing systems. In this analysis, the existing criteria are compared with the applicable standards for waste management systems, namely SNI 192454-2002 concerning Operational Technical Procedures for Urban Waste Management, and Regulation of the Minister of Public Works No. 3 of 2013 concerning the Implementation of Waste Infrastructure and Facilities in Handling Household Waste and Household-like Waste, as well as the Ministry of Public Works and Public Housing, Directorate General of Human Settlement, Technical Guidelines for Implementation of Waste Management 3R-based Waste Processing Site 2021.

3. Result and Discussion

In this planning, it is necessary to have a waste generation rate, waste density and waste composition to further plan a waste management system and design a 3R-based Waste Processing Site integrated Waste Bank layout in accordance with applicable regulations.

3.1 Analysis of Waste Generation

The amount of waste generation can be calculated by projecting the rate of waste generation in the academic community. The projection of the academic community is the initial stage in calculating the projection of waste generation up to the planning period (Permen PU No. 3 of 2013). The waste management planning system is planned for the next 13 years, namely in 2035 which shows the number of academics reaching 70,377 people (Masterplan Summary, 2021). The planning period refers to the Minister of Public Works Regulation No. 13 for planning at least 10 years. Waste e is produced by everyone or because of natural processes, according to Law no. 18 of 2008. The source of waste in educational areas is the same as non-residential waste in general, but in a limited area, namely office waste, public facilities, parks and roads.

Table 2. Waste generation in the southern area of Tanjungpura University

Source of Waste	**Generation Waste**		
	m^3/unit/day	**l/unit/day**	**kg/unit/day**
Student flats	0.0017	1.7	0.043
Faculty of Engineering	0.00049	0.49	0.0030
Faculty of Agriculture	0.00061	0.61	0.0080
Faculty of Teacher Training and Education	0.00017	0.17	0.0012
Office	0.00192	1.92	0.12
University Tanjungpura Canteen	0.0022	2.2	0.197
Green Space	0.00012	0.12	0.0043

Waste generated as a result of office activities was sampled, with waste generation of 1.92 liters per employee per day. Meanwhile, for canteen waste generation, it is 2.2 l/m/day, and green space waste generation, it is 0.12 l/m/day. Green space waste consists of road waste and garden waste. The campus's overgrowth of large trees, combined with the ongoing dry season, results in many fallen leaves and broken branches. Many types of cape trees (*Mimusops elengi* L.) scattered in the park area have a shady canopy, single leaves, scattered, and have long stems with a length ranging from 5 to 9 cm (Rifai and Wulandari, 2020). The type of leaves on the cape tree are shady and easily fall, resulting in an increase in the weight of the leaf waste produced. Garden waste and food waste can be grouped into organic waste (Damanhuri and Padmi, 2016). Based on the results of calculations, the estimated amount of waste generation in the South UNTAN Region will increase from 2022 along with the development of campus development and the increasing number of academics in the South UNTAN Region. In 2035 it is estimated that the total volume of waste generation in the South UNTAN Area will reach 39 m3/day or 39,035 l/day and 1438 kg/day.

Tabel 3. Percent waste composition by waste type (%)

Type of Waste	**Composition (%)**
food waste	29
leaf litter	18
paper and cardboard	22
fabrics and textiles	0
rubber and leather	0
plastic	15
metal	2
glass	2
residue	12
Total	**100**

It is known that the results of sampling the composition of waste in the southern region of Tanjungpura University are mostly dominated by organics at 47%, recycled waste at 41%, and residues at 12%. As a result, inorganic waste predominates in the South UNTAN area. Organic waste consists of leaf litter and food waste. Meanwhile, recycled waste is worth selling, namely plastic bottles, paper, iron, cardboard, and so on. Residual waste consists of tissues, masks, and steroform.

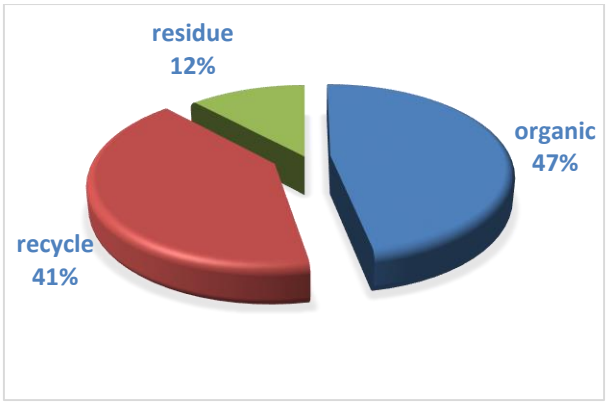

Figure 1. Waste composition in the Southern Area of Tanjungpura University (%)

Educational areas are included in non-residential waste sources. Several factors of waste in educational areas are the number of waste generators, the number of activities that have the potential to generate waste, the area of the building which affects the maximum capacity of people, and the utilization of the potential of the building as an activity center to carry out activities that generate waste. Office buildings are affected by the number of waste generators and types of waste producing activities, the canteen area is affected by the number of canteen visitors, and parks are affected by the influence of wind, which causes leaf fall and grass trimming activities (Arindya et al., 2016).

3.2. Waste Management System Planning in Tanjungpura University

Implemented a waste management system that is sorting and housing on the faculty level, transporting, processing, and processing ends on the university level. The planning of a waste management system with a new paradigm of "collect-sort-process-transport-throw-away" in the southern region of Tanjungpura University includes planning a system of storage, collection, processing with a 3R concept that consists of processing organic waste (composting) that is integrated with a waste bank (proper recycling), selling, and transportation of residual waste to the TPA. The biggest challenge in managing waste based on its source is the limited coverage of waste service areas and the lack of community participation in sorting waste (Purnomo, et al., 2021). The application of a green campus by preventing, reducing and minimizing the amount of waste and waste generated by the campus (An Taisce, 2022).

3.2.1. Storage and Sorting

Waste collection is a way of temporarily storing waste at its source, either individually or communally. Individual trash bins are placed in front of the classrooms or building hallways. Meanwhile, communal trash containers are placed in open areas that are easy to reach. The main purpose of the container is to avoid the occurrence of scattered waste so that it does not have a negative impact on health, cleanliness, or environmental hygiene, facilitates the waste collection process, and does not harm scavengers. the use of containers made of HDPE (High Density Polyethylene) plastic, where this type of plastic has high flexibility and durability, can be recycled, and has good resistance to chemical reactions. In the form of a closed box, so as not to become a medium for the spread of disease, it is light and easy to empty. The selection of the same capacity of the waste container is due to better aesthetics (Santi and Priyambada, 2017). It is planned that a set of containers will consist of three types, namely organic, inorganic, and residue containers that have the same size, so that the volume of waste from organic, recycled, and residue types with the largest value is chosen.

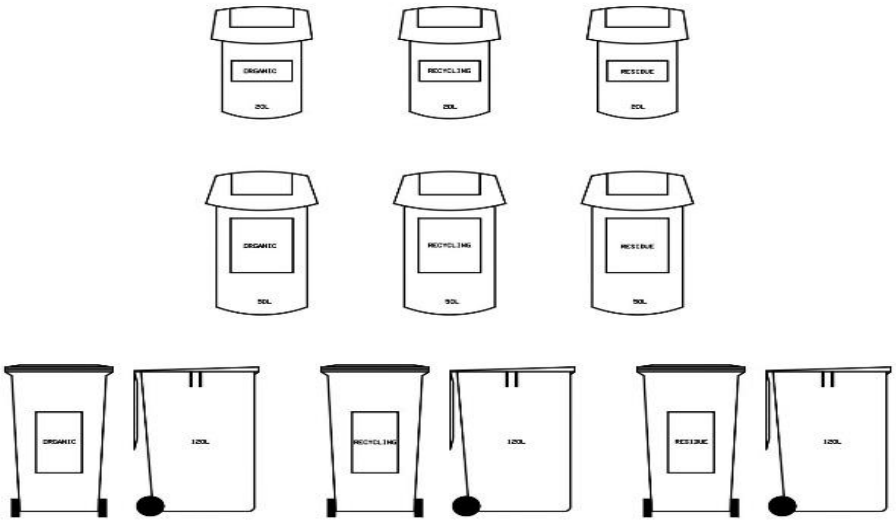

Figure 2. Trash container

3.2.2. Transport and Collection

Waste collection operational planning includes five waste cycles per day, daily waste collection, and specific and permanent service areas, namely Tanjungpura University's southern region. implementing officers, and the workload is carried out evenly based on the criteria for the amount of waste transported, the distance traveled, and the condition of the area. The number of pickups is 1. The same car is expected to be used in 2022, but with a modified collection tank capacity of 3 m x 1,6 m x 1,5 m, the volume of the pickup tank is 7,2 m3 or 7.200 L. usage (lifetime) is estimated to be at least 5-7 years (Permen Pu No 03, 2017). Because the storage plan is carried out separately, the collection is also separate, so there are three separate tanks for the separation of the specified types of waste. The waste collection device is planned to have separators between organic, inorganic, and residual waste. Waste collection by 3R-based Waste Processing Site officers starts at 06.00 WIB until 11.30 WIB and continues at 13.00 WIB until 15.00 WIB.

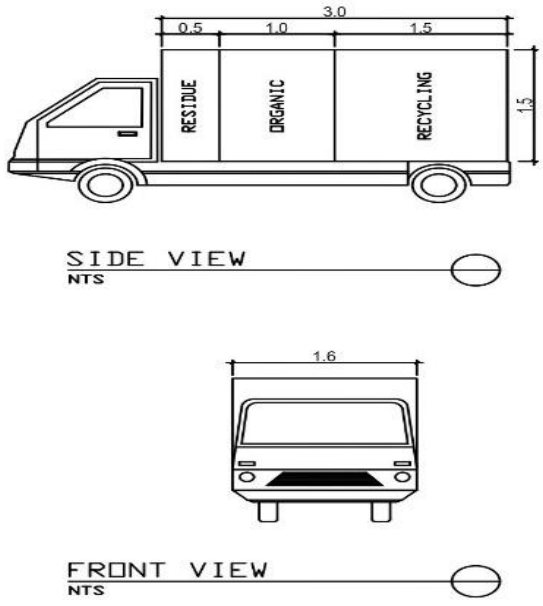

Figure 3. Waste collection car

The process of determining the quickest, most effective, and most efficient waste collection route. Waste collection routes are determined by the location of the waste collection source as well as the amount of waste generated. Take route 1, starting from the office area, and ending on route 5 for the flats and canteen area. Each individual container will be collected into a communal container at each waste source. Waste on open land will be placed in a communal container located on the side of the road, which will then be taken to 3R-based Waste Processing Site.

Table 4. Waste collection time per rotation

Ritase	Transport Routers	number of waste sources	Reach time (minute)	Waste collection time (minute)	Trash unloading time (minute)	Total time (minute)
1	Rectorate - Library	4	2	40	20	68
2	student flats - green space	3	2	30	20	56
3	common college building - conference building	3	2	30	20	56
4	FT-FEB	5	2	50	20	80
5	Faperta-FK	4	2	40	20	68
Total time (minute)						328

It is known that the total time spent collecting waste is 5.5 hours, based on the working hours in this plan, namely 8 hours per day. The cleaning staff collects trash in each lecture and office building into a 240-liter container and then transfers the waste to a 1000-liter communal container located on each side of the building in the morning before office and learning activities begin, namely at 05.00–06.00 WIB. Furthermore, wastee is collected by 3R-based Waste Processing Site officers from 06.00 WIB to 11.30 WIB and continues at 13.00 WIB to 14.10 WIB.

3.3. Waste Management Planning 3R Concept Integrated Waste Bank

The waste management plan at 3R-based Waste Processing Site south Area, Tanjungpura University is planned to have a planning period of 13 years, referring to the PERMEN of Public Works No. 03 of 2013 concerning the Implementation of Waste Infrastructure and Facilities in Handling Household Waste and Waste Similar to Household Waste with a minimum of 10 years of planning. Based on the technical guidelines for the 3R-based Waste Processing Site in 2021, there are three options for the selection of processing facilities at the 3R-based Waste Processing Site. It is planned to choose a 3R-based Waste Processing Site processing facility integrated with a Waste Bank by choosing option 2, namely standard waste processing and adding an increase in the processing of stall waste. This grade selection is very suitable, which has a waste bank business unit. The addition to grade 2 is the addition of a plastic chopper.

Processing of organic waste at 3R-based Waste Processing Site with a composting process. The aerobic hollow brick composting method is used. Aerobic composting is easy to operate and does not produce a strong odor. Examples of aerobic composting include hollow bricks. Hollow brick composting is the process of composting organic waste in boxes of bricks arranged in a zigzag manner with a predetermined volume ((Afifah et al., 2021). Oxygen requirements are obtained from holes in brick boxes or from perforated pipes connected to them with blowers. This method was chosen because it is technically easy to do, does not require special skills to operate, does not require a long time, and does not require operational costs (Afifah et al., 2021). This total land requirement is obtained from the sum of the calculated land analyses. The open hangar area is the area for receiving, storing, and weighing waste. the right and left sides of the closed hangar building, with a roof ceiling height of ± 5 m. Furthermore, it

will be compared with the existing land, which will be planned for a 3R (Reduce-Reuse-Recycle) integrated Waste Bank waste management site in the South UNTAN Region. From the results of this comparison, it will be known that the remaining land can be used for other supporting buildings such as parking lots, Waste containers and guard posts. The following details the land requirements for the 3R (Reduce-Reuse-Recycle) waste management Site in the South UNTAN Region, which can be seen in **Table 5.**

Table 5. Details of land requirements in the construction of a 3R (reduce-reuse-recycle) integrated waste bank waste management site

No	land requirements (m^2)	Length	Width	land area analysis result (m^2)
A	**Hangar**			
1	Loading rate and sorting area	10.0	4.0	40 m^2
2	organic waste collection area	5.0	3.0	15 m^2
3	organic waste enumeration area	2.5	2.0	5 m^2
4	compost area	20.0	12.0	240 m^2
5	compost sifting area	3.0	2.5	7,5 m^2
6	compost storage	6.0	8.0	48 m^2
B	**Student Waste Bank**			
1	Loading rate and Weighing inorganic waste	3.5	3.0	10.5 m^2
2	plastic waste sorting area	5.0	3.0	10 m^2
3	washing and drying plastic waste	5.0	4.0	20 m^2
4	Enumeration plastic waste	2.0	2.0	4 m^2
5	inorganic waste sorting	5.0	2.0	10 m^2
6	Recycle area	6.0	3.0	18 m^2
7	Infiltration wells	5.0	4.5	22.5 m^2
8	inorganic waste storage	5.0	4.5	22.5 m^2
C	**supporting building**			
1	Office	6.0	5.0	30 m^2
2	Water closet	2.0	2.0	8 m^2
3	Kitchen	2.0	2.0	4 m^2
4	Work space	-	-	110 m^2
5	Parking lot	10	4.0	40 m^2
6	Guardhouse	2.0	3.0	6 m^2
7	Septictank and infiltration wells	1.5	3.0	4.5 m^2
8	Residual waste container area	3.5	2.0	6 m^2
9	Organic liquid fertilizer	1.0	1.0	1 m^2
10	Infiltration wells	5.0	4.0	20.0
Total land area 3r waste processing site and waste bank				**1,025 m^2**

The total land area of 3R-based Waste Processing Site integrated with the Waste Bank is 1025 m^2 with a length of 41 m and a width of 25 m. The 3R-based Waste Processing Site Integrated Waste Bank for the Southern Region of Tanjungpura University is planned to be located in the area of the Faculty of Agriculture adjacent to the RKPU (UNTAN Education Compost House) with a land area of 1200 m^2. The choice of this area was due to the availability of vacant land and the access road, which is relatively close to arterial roads. In addition, this location is within the same administrative boundary as the 3R-based Waste Processing Site integrated with the waste bank, collection process and the transportation of waste does not interfere with existing activities in the Tanjungpura University area. Planning for an 3R-based Waste Processing Site integrated Waste Bank aims to facilitate waste management implementers and

follow up on waste bank locations and buildings that were previously not in accordance with Permen LHK No. 14 of 2021.

The 3R-based Waste Processing Site building design is integrated with the UNTAN Student Waste Bank based on data on waste generation and space requirements. In addition, Tanjungpura University should set an example by having an independent waste management system. Types of vegetation that can be used as air filtration at the location are trees and shrubs (Jemali et al., 2022). Trees and shrubs function to reduce pollutants and produce aroma. Because the waste processing site will producean unpleasant odor also gives the impression of being dirty and not beautiful or rundown (Jemali et al., 2022). So it is necessary to choose plants that function as odor reproduction and support the aesthetic aspect environment. Selection of vegetation types for reducing pollutants, windbreaks, vegetation for groundwater conservation, vegetation as shade and added aesthetic value. Selection of vegetation among them *Mimusops Elengi* as noise damper, *Samanea saman* as pollutant absorbent, *Carbera odollam* and *Mahogany Jacq* as air humidity and *Samanea Saman*, *Pterocarpus indicus*, *Mahogany Jacq* as support wind. Some of the plants are up to standard vegetation management in the landfill or 3R-based Waste Processing Site (Jemali et al., 2022).

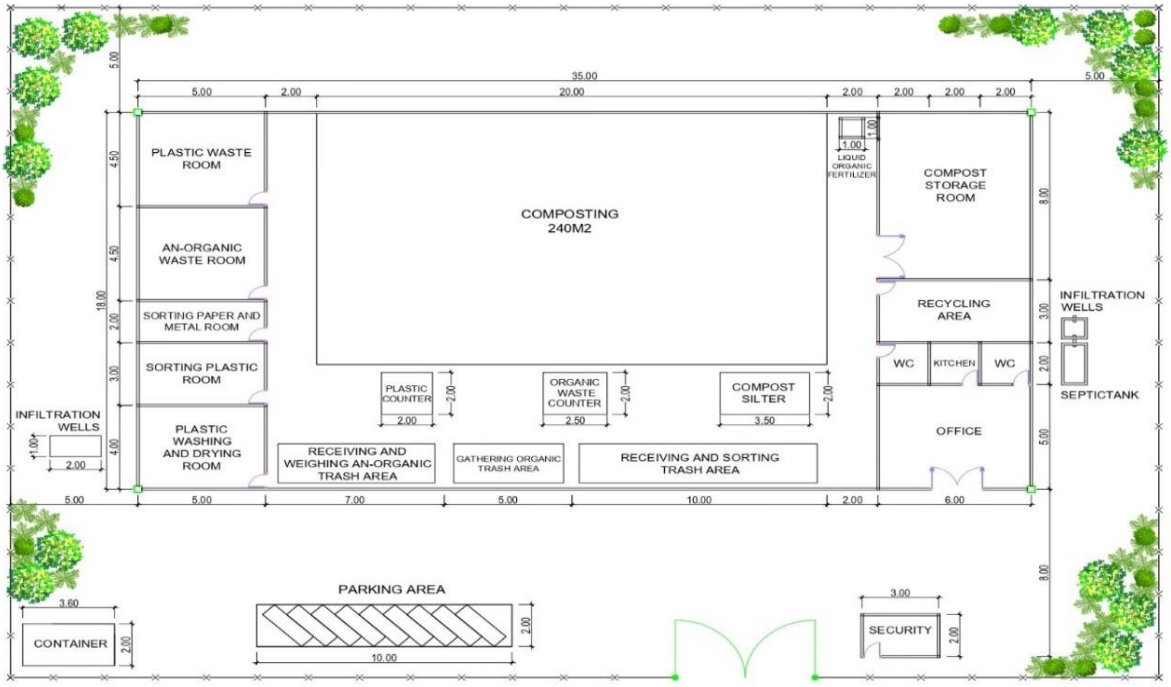

Figure 4. Layout of 3R-based waste processing site integrated with a waste bank

4. Conclusions

The projected waste generation in the planning period of 2035 is 39 m3 per day, or 39,035 liters per day, and the waste weight is 1438 kg/day. The waste composition is organic waste (47%), inorganic waste (41%), and residual waste (12%). Planning for an operational technical system for waste management includes waste storage and waste processing. The waste container is divided into three types organic, inorganic, and residual waste. Waste collection uses an indirect communal system using a pickup truck fleet with five trips in eight working hours. The waste processing that will be planned is 3R-based Waste Processing Site integrated with the waste bank. Organic waste will be processed into compost using the hollow brick method. while inorganic waste will be sold to the waste bank. The area of 3R-based Waste Processing Site integrated with the UNTAN Student Waste Bank required based on the planning results is 1025 m^2. If necessary, promote the concept of a sustainable economy, namely Reduce, Reuse, Recycle, Recovery and Repair, known as 5R, as a form of implementing the Making Indonesia 4.0 roadmap.

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