Planning for the 3R-based waste processing site in Aimas District, Sorong Regency

To cite this article: Hermin Poedjiastoeti and Benny Syahputra 2022 *IOP Conf. Ser.: Earth Environ. Sci.* **1098** 012056

Planning for the 3R-based waste processing site in Aimas District, Sorong Regency

Hermin Poedjiastoeti[1*] and Benny Syahputra[1]

[1] Departement of Civil Engineering, Sultan Agung Islamic University,
Jl. Raya Kaligawe Km 4 Semarang 50112, Indonesia

*hermin@unissula.ac.id

Abstract. A design prototype will be created as part of this research project for the 3R-based Waste Processing Site (TPS 3R) in the Aimas District. The design carried out refers to the Minister of Public Works No. 03 of 2013 concerning the Implementation of Waste Facilities and Infrastructure and Technical Guidelines for 3R-based Waste Management by the Director General of Human Settlements in 2021. According to the study's findings, the average quantity of waste produced daily in the Aimas District was 1.69 liters per person, or 40.87 m^3 per day, with a composition of 38.13 % organic waste, 30.13 % recyclable inorganic waste, and 31.75 % inorganic waste that cannot be recycled. The 3R-based Waste Processing Site building is expected to require an area of 237.75 m^2, made up of a room for managing organic waste of 129.75 m^2 with composting techniques using seven bamboo aerators, a room for managing plastic waste of 29.50 m^2, a space for managing inorganic waste of 6.25 m^2, and supporting buildings covering an area of 72.25 m^2. At the 3R-based Waste Processing Site, processing is divided into five series: waste collecting, waste sorting, organic waste recycling, inorganic waste recycling, and residue recycling.

1. Introduction

Garbage is all solid waste consisting of organic and inorganic materials which are considered useless and must be managed so as not to endanger the environment and protect development investment [1]. Waste production will rise as a result of population expansion and growth, which are both accompanied by increased activity [2]. The imbalance between waste production and waste management processes, as well as the dwindling capacity of nature as a disposal site, can lead to waste concerns. The capacity for processing waste is still insufficient, despite the fact that the amount of waste is increasing quickly [3].

According to Law no. 18 of 2008 concerning Waste Management, waste handling by throwing waste directly to the landfill is no longer allowed. Waste must first be processed before being returned to environmental media in a safe manner for humans and the environment. The law encourages waste management from the source by developing processing in the form of changing the characteristics, composition, and amount of waste. One of them is by making a waste processing facility, namely a waste processing site with the principle of reduce, reuse, recycle (TPS 3R). The 3R concept (Reduce, Reuse and Recycle) is oriented to waste prevention through reduction, reuse, and recycling. TPS 3R work involves community participation to make waste reduction sustainable and environmentally friendly [4].

In general, the management system for household waste and similar household waste in Aimas District, Sorong Regency is still limited to waste handling efforts and has not made any efforts to reduce waste. The waste management procedures used are "collect-transport-disposal" activities and has not yet carried out sorting, processing and final processing of waste. The proportion of waste transported to the landfill only ranges from 20 – 30%. Environmental sanitation conditions in Aimas District can be impacted by the lifestyle of the locals, who frequently accumulate trash on unused land, as well as by the absence of waste management equipment and facilities. This needs to be taken into account because one of the factors that define slum settlements is the lack of suitable waste infrastructure and facilities that do not adhere to technical requirements [5]. On the other hand, there are no district-level profiles or plans for reducing and managing trash because there is no waste management master plan.

Therefore, it is intended to implement TPS 3R in Aimas District, Sorong Regency, in an effort to address the issue of waste generation that has arisen at this time. TPS 3R is expected to play a role in ensuring the increasingly critical need for land for the provision of waste landfills in urban areas. With this plan, it is hoped that it will reduce the volume of waste generated by the community, reduce the operational costs of transporting waste and also extend the life of the landfill. Based on these issues, a waste processing facility using the TPS 3R (Reduce, Reuse, Recycle) approach will be built in the Aimas District of the Sorong Regency, due to the land's availability for the TPS 3R.

2. Methodology

2.1. Study area description

In designing the 3R TPS Prototype, the location used as a basic pilot design is Aimas District, Sorong Regency, West Papua, Indonesia (Figure 1). Sorong Regency consists of 33 districts with Aimas district as the capital with a population of 24,148 people in 2021 [6]. As the new City of Aimas grows and developed into a center of government, economy and trade as well as education, where almost 30% of the total population of Sorong Regency is domiciled in Aimas. Of course, this will have an effect on future sanitary issues, one of which is the issue of solid waste. Based on the data contained in the Sorong Regency Sanitation Strategy Book 2020, Aimas District is one of the districts included in the risk area for waste sanitation in the Risk category 4 [7].

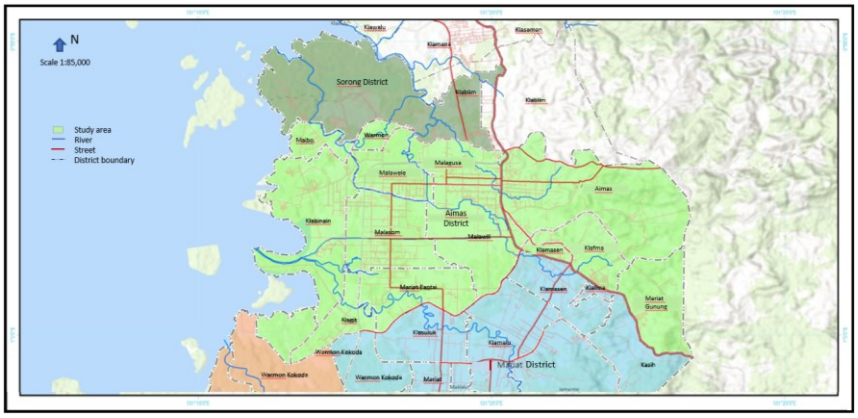

Figure 1. Location map of the study area

2.2. Data Collection and Analysis

Both primary and secondary data were gathered for this study using methods like measurement, observation, and literature reviews. The amount of waste generated and the volume of waste produced were measured over the course of one week by counting the number of waste hauling vehicles, the capacity of those vehicles, and the number of rituals performed each day. A literature review was done

to gather waste management reference information. To calculate the capacity and dimensions required in planning TPS 3R, an analysis of predicted population data and waste generation is conducted [8].

2.3. TPS 3R planning

The TPS 3R building floor plan is designed during planning, and the dimensions of each processing unit are determined. According to Module E.3 on Integrated Waste Management Sites 2017's, planning process for TPS 3R is as follows:

- Material balance analysis to knowing the amount of waste that enters the location of the waste processing site. Mass balance calculated using equations 1 and 2 [9].

  $$Waste\ recovery\ weight = Waste\ generation\ per\ component\ x\ \%\ Recovery \quad (1)$$

  $$Weight\ of\ waste\ to\ TPA = Waste\ generation\ per\ component - Weight\ recovery \quad (2)$$

- Identify all possible uses of the material
  Knowing the characteristics of waste and its utilization to make a material balance flow chart.
- Waste accumulation calculation
  Determine and calculate the amount of accumulated waste, how much waste will be handled by TPS 3R and the rate of accumulation by determining the operating time of TPS 3R
- Calculation of material loading rate.
  This calculation is used to determine the number of workers and tools needed as well as working hours and equipment operation at TPS 3R.

  $$Loading\ rate = \frac{waste\ volume\ (\frac{m^3}{day})}{processing\ time\ (\frac{hour}{day})} \quad (3)$$

- Layout and design
  The amount of waste generation to be managed is estimated to be dependent on the land area and TPS 3R design. The amount of land needed for TPS 3R will also depend on how many units are planned, including compost houses, inorganic waste management, storage, various support buildings such office space, an equipment warehouse, restrooms, and parking lots. AutoCAD software will be used to create the design. The research mechanism can be seen in Figure 2.

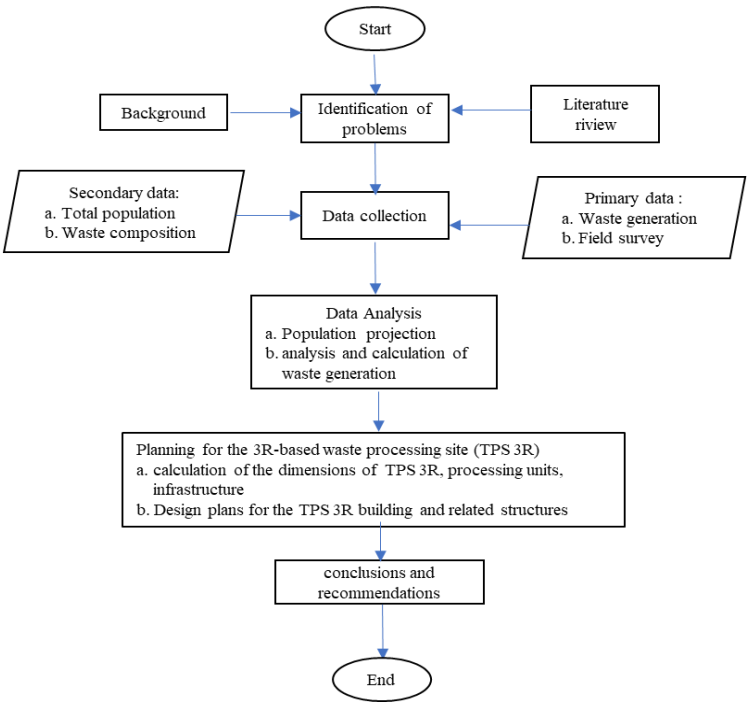

Figure 2. Research Flowchart

3. Results and Discussion

3.1. Existing Condition of Waste Management

The amount of garbage brought to the landfill represents just 35.16 percent of the total amount of waste generated in the Aimas region, which totals 22,678 kg/day (22.8 tons/day) (according to an early assessment by the Department of Housing and Settlement Areas of Sorong Regency, 2017). This is due to the inadequate resources, fleet, equipment, personnel, and community involvement in the Aimas District, which has minimal garbage services that are only provided in a few locations in the city center. In terms of final waste disposal, Sorong Regency as a whole has one Final Processing Site / landfill, specifically TPA 36, which is situated in Mariyat Gunung Village about 17 kilometers from the center of Aimas. TPA 36 has been operated since 2018 with a plan to implement the sanitary landfill method, although until now it is still using the open dumping system.

According to the findings of an interview with the Head of the Environmental Service of Sorong Regency, there are presently 4 motorcycles, 2 dump trucks, and 2 arm roll trucks under the administration of the Environment Agency at the Aimas District waste management facility (previously managed by the Housing and Settlement Areas Office). Motorized rickshaws are built for short distance travel and are used to transfer waste from residents' homes to Temporary Shelters (TPS).

Domestic and non-domestic waste, specifically domestic waste and similar domestic waste, enters the TPS. Depending on the condition of the existing waste, garbage transportation in the Aimas District is typically done twice or once per day. One truck can typically transport up to 7 tons of garbage.

3.2. Population Projection

Planning for waste processing site with the principle of reduce, reuse, recycle (TPS 3R) in Aimas District requires data on the amount of household waste generation that can be identified with population growth projections for the next 5 years. The results of the projected population of Aimas District, Sorong Regency tend to increase and in 2026 the total population is 26,427 people as shown in Figure 3.

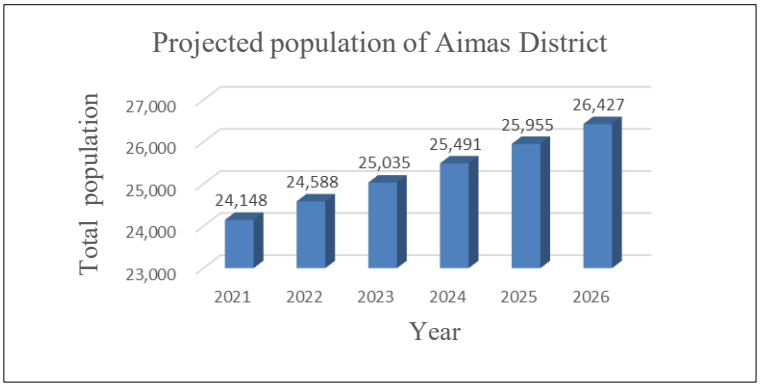

Figure 3. Projected population of Aimas District in 2022 - 2026

3.3. Waste generation

The amount of waste generated in Aimas District based on data on the amount of waste that came to TPA 36 for 7 consecutive days and interviews, the amount of waste per day was 40.87 m^3. According to Nur Lailis (2018) in [10], the density of waste is 0.284 kg/l. The total weight of waste produced in Aimas District per day is calculated by the equation:

$$Weight\ of\ waste = amount\ of\ waste\ x\ density \quad (4)$$

The weight of waste per day in Aimas District using this equation is 1.69 l/person/day. The projected waste generation in Aimas District is presented in Table 1.

Table 1. Waste generation forecast for the Aimas District from 2022 to 2026

	2022	2023	2024	2025	2026
Waste generation (l/person/day)	1.69	1.69	1.69	1.69	1.69
Total population	24,588	25,035	25,491	25,955	26,427
Waste generation (m^3/day)	41.55	42.31	43.08	43.86	44.66

3.4. Waste composition and Projected Waste Generation

The rate of waste generation during the predicted period is exactly proportional to the growth in population [11]. The waste generation projection is made in order to foresee TPS 3R's capacity so that it can operate for the anticipated operational time, which is five to ten years in the future [12]. Based on the results of the JAKSTRADA study of Sorong Regency, Sorong City and Raja Ampat Regency 2019, the composition of waste in Aimas District in general is as shown in Figure 4, while the projected composition of waste for the next 5 years can be seen in Table 2 [13].

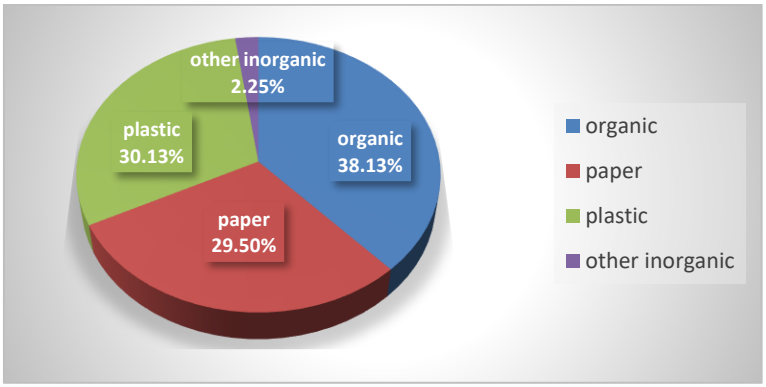

Figure 4. The typical waste composition in the Sorong Regency

The highest percentage of trash in Aimas District is organic waste (38.13%), plastic waste (30.13%), paper waste (29.50%) and other inorganic waste (2.25%). The proportion of organic waste is the biggest in comparison to other types of garbage because it weighs more than the others and because each individual produces more organic waste every day, such as food scraps and cooking residue [11]. The findings of the expected waste generation over the following five years demonstrate that the composition of organic waste still accounts for the biggest percentage (Table 2).

Table 2. Projections on the composition of total waste generation

Year	Waste generation projection (m^3/day)	Waste generation projection (per waste type)			
		Organic	Paper	Plastic	Other inorganic
2022	41.55	15.84	12.26	12.52	0.93
2023	42.31	16.13	12.48	12.75	0.95
2024	43.08	16.42	12.71	12.98	0.97
2025	43.86	16.72	12.94	13.21	0.99
2026	44.66	17.03	13.17	13.45	1.00

3.5. Loading Rate

According to Law No. 13 of 2003, the TPS 3R will be operating for 7 hours during the hours of 8 a.m. to 12 p.m. and 13 p.m. to 16 p.m., processing 0.86 m^3 of trash each hour [14].

3.6. Waste Material balance

The quantity of waste in Aimas District that can be recycled and the amount of waste that becomes residuals are calculated using the waste material balance. Calculating the waste weight from the recovery factor for each waste component yields the material balance. The amount of waste that may be utilised or converted into residue is represented by the recovery factor [9]. In table 3, the total computation is displayed. From the waste material balance data, it can be seen the percentage of waste that can be composted is 28.60% and waste that can be recycled is 31.62%. Meanwhile, the total waste from composting and the sorting that will be transported to the landfill is 39.79%.

Table 3. Waste Material Balance in TPS 3R

Treatment	Component	Waste composition (%)	Factor of treatment	Waste composition (%)
Composting	organic	38.13	75	28.60
	total	**38.13**		**28.60**
Residue	organic	38.13	25	9.53
	total	**38.13**		**9.53**
Sorted	Paper	29.50	50	14.75
	Plastic	30.13	50	15.07
	Other inorganic	2.25	80	1.8
	total	**61.88**		**31.62**
Residue	Paper	29.50	50	14.75
	Plastic	30.13	50	15.07
	Other inorganic	2.25	20	0.45
	total	**61.88**		**30.26**

3.7. Requirements for the area of the TPS 3R

The following equation can be used to determine the amount of land needed [15]; [16] and [17].

- Organic waste

  Quantity of organic waste entering each hour

  $$V_{organic\ waste} = \%_{organic\ waste}\ x\ total\ garbage\ in \quad (5)$$

  Weight of organic waste entering each hour

  $$B_{organic\ waste} = \%_{organic\ waste}\ x \sum resident\ served\ x\ generated\ waste\ weight\ /person/day \quad (6)$$

  $$V_{composting} = \frac{time \times Bweight\ of\ trash\ chopped}{waste\ dentsity\ chopped\ site} \quad (7)$$

- Plastic waste

  $$Plastic\ waste\ volume = \%\ plastic\ waste\ x\ Incoming\ trash\ volume \quad (8)$$

  $$Plastic\ waste\ weight = \%\ plastic\ waste\ x\ number\ of\ users\ x\ trash\ weight \quad (9)$$

- Inorganic waste

  $$Paper\ waste\ volume = 50\%\ x\ \%paper\ composition\ x\ Incoming\ trash\ volume \quad (10)$$

- Total Land Requirement

  Based on the calculation results of waste characteristics, the land area required in this design is 237.75 m^2. The land requirement for TPS 3R is intended for several units such as processing organic waste 129.75 m^2, plastic waste management 29.5 m^2, inorganic waste management 6.25 m^2 and supporting facilities 72.25 m^2.

Table 4. Total land requirement

No.	Room	Land Requirement	
1	Organic Waste Management		
	a. Organic waste storage room	5	m^2
	b. Sorting room	7.5	m^2
	c. Organic waste chopping room	7.5	m^2
	d. Composting room	85.75	m^2
	e. Sieving room	24	m^2
	Total	**129.75**	**m^2**
2	Plastic Waste Management		
	a. Plastic waste storage room	5	m^2
	b. Plastic waste sorting room	3.25	m^2
	c. Plastic waste washing room	2.5	m^2
	d. Plastic waste drying room	15	m^2
	e. Plastic waste grinding room	3.75	m^2
	Total	**29.5**	**m^2**
3	Inorganic Waste Management		
	a. Inorganic waste storage room	2.25	m^2
	b. Inorganic waste sorting room	4	m^2
	Total	**6.25**	**m^2**
4	Supporting facilities		
	a. Warehouse	5.25	m^2
	b. Toilet	9	m^2
	c. Office	6	m^2
	d. Motorbike cart parking	30	m^2
	e. Guardhouse	2	m^2
	f. Maggot nursery, garden and fish pond	20	m^2
	Total	**72.25**	**m^2**
	TOTAL	**237.75**	**m^2**

3.8. Capacity and processing flow for TPS 3R

The waste management system is being used in the Aimas District in accordance with the analysis that was done. The waste processing system that can be used at TPS 3R Aimas District includes turning organic waste into compost, processing inorganic waste so that it can be used as plastic seeds, selling metal or goods that can still be used to collectors or third parties, and discarding the remaining residual waste in landfills.

According to the 2021 TPS 3R Technical Instructions, the TPS 3R must be able to serve or process 4-6 m^3/day of trash. The 3R TPS is intended to serve up to 3,900 people (using the population of Malagusa Village as an example), or can process 6 m^3 of garbage each day, based on the quantity of waste produced in the Aimas District. Figure 5 can be used to depict the processing flow at TPS 3R.

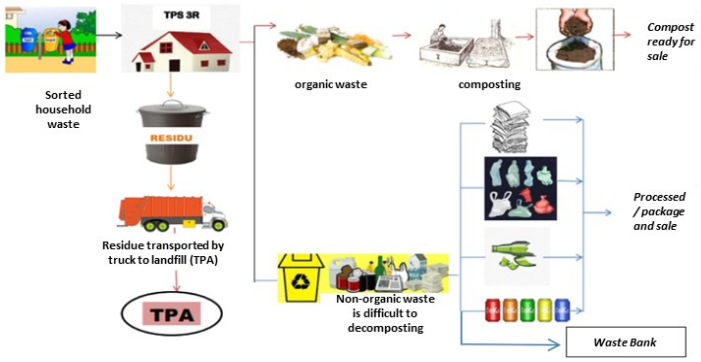

Figure 5. Waste Process Flow at TPS 3R

3.9. TPS 3R building design

The planning of a TPS 3R prototype is as follows: (a) In the form of: walled courtyard; (b) the transport system is HCS / Hauled Container System ; (c) There is a waste selection process; (d) TPS type 2, according to Indonesian Nasional Standard SNI 19-2454-2002 (Badan Standardisasi Nasional, 2002); and (e) Collecting waste generation > 6m^3. The TPS 3R building prototype is shown in figure 6.

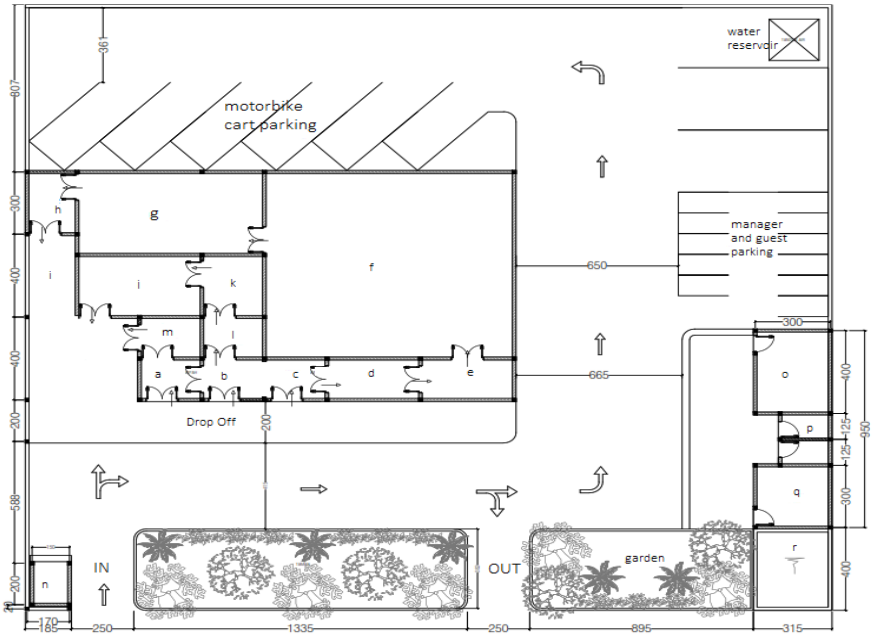

Figure 6. Planning for The TPS 3R Building Prototype (Siteplan)

Explanation:

a : inorganic waste storage room
b : plastic waste storage room
c : organic waste storage room
d : sorting room
e : organic waste chopping room
f : composting room
g : sieving room
h : warehouse
i : loading dock
j : plastic waste drying room
k : plastic waste washing room
l : plastic waste sorting room
m: inorganic waste sorting room
n : guardhouse
o : office
p : toilet
q : maggot nursery
r : fish pond

4. Conclusion

From the waste material balance data in Aimas District, Sorong Regency, it can be seen the percentage of waste that can be composted is 28.60% and waste that can be recycled is 31.62% and the total waste from composting and the sorting that will be transported to the landfill is 39.79%. In order to improve waste management efforts in Aimas District, a land disposal site (TPS) 3R Prototype has been planned which requires an area of 237.75 m^2, with a maximum handled waste generation of 8 m^3. There are several areas in TPS 3R, namely:1) an organic waste management area consisting of an organic waste storage room, sorting room, organic waste chopping room, composting and sieving room; 2) inorganic waste management area, consisting of storage and sorting rooms, 3) plastic waste management area consisting of plastic waste storage room, sorting, washing, drying and grinding rooms; and 4) supporting buildings consisting of warehouse, toilets, office, motorbike cart garages, guard posts and magot nursery areas, gardens and fish ponds. Because there is currently no available land ready for use in Aimas District, the calculations are based on planning, and field measurements have not been followed up. In order to make the planning results more accurate, further surveys are needed on the condition of the village area.

References

[1] Badan Standardisasi Nasional, "SNI 19-2454-2002 :Tata Cara Teknik Operasional Pengelolaan Sampah Perkotaan," *Standar Nas. Indones.*, no. ICS 27.180, pp. 1–31, 2002 [in Indonesian Language].

[2] Firmansyah M and Noor R 2016 Perencanaan Pengelolaan Sampah Terpadu Perumahan Kota Citra Graha Provinsi Kalimantan Selatan Design of Integrated Solid Waste Management in Kota Citra Graha Residence South Kalimantan Province *Jukung (Jurnal Tek. Lingkungan)*, 2 (2) 73–82 [in Indonesian Language].

[3] Kazerooni Sadi M A K, Abdullah A, Sajoudi M N, Kamal M F, Torshizi F, and Taherkhani R 2018 Reduce, reuse, recycle and recovery in sustainable construction waste management," *Adv. Mater. Res.* **446–449** 937–944

[4] Rachmawaty A, Nasution S M, and Juliawati P 2019 Penerapan Teknologi Pengomposan Pada Pengelolaan Sampah Rumah Tangga Di Kabupaten Garut *Tematik* **6**(1) 54–63 [in Indonesian Language].

[5] Menteri PUPR, "Peraturan Menteri PUPR RI Nomor 02/PRT/M/2016 tentang Peningkatan Kualitas terhadap Perumahan dan Permukiman Kumuh." JDIH Kementerian PUPR, Jakarta, p. 36, 2016 [in Indonesian Language].

[6] BPS, *Kabupaten Sorong Dalam Angka*. Kabupaten Sorong: Badan Pusat Statistik Kabupaten Sorong, 2021 [in Indonesian Language].

[7] PokjaSanitasi, *Strategi Sanitasi Kabupaten/Kota Kabupaten Sorong Tahun 2020-2024*. Kabupaten Sorong: Pemerintah Daerah Kabupaten Sorong, 2019 [in Indonesian Language].

[8] Wilson D C, Velis C, and Cheeseman C 2006 Role of informal sector recycling in waste management in developing countries *Habitat Int.* **30**(4) 797–808

[9] Tchobanoglous G, Theisen H, and Vigil S 1993 *Integrated Solid Waste Management: Engineering Principles and Management* (Singapore: Mc. Graw Hill)

[10] Lawa J I J, Mangangka I R, and Riogilang H 2021 Perencanaan Tempat Pengolahan Sampah (TPS) 3R Di Kecamatan Mapanget Kota Manado *Tekno*. **19** 77–89 [in Indonesian Language].

[11] Basri N A, Basri H, and Stentifor E 2005 An Expert System to Design Composting Facilities for Municipal Solid Waste *J. Kejuruter.* **17** 85–99

[12] Damanhuri E and Padmi T 2016 *Integrated waste management* (Bandung: Publisher ITB)

[13] DLH 2019 *Jakstrada Pengelolaan Sampah Rumah Tangga dan Sampah Sejenis Rumah Tangga (Daerah Studi: Kota Sorong, Kab. Sorong dan Kab. Raja Ampat)* Dinas Lingkungan Hidup dan Pertanahan provinsi Papua Barat, 2019 [in Indonesian Language].

[14] Muhashiby M I N, Hasibuan H S, and Wahyono S 2021 Waste Management in Jakarta Recycle Centre: Case Study of Pesanggrahan, Jakarta *IOP Conf. Ser. Earth Environ. Sci.* **940**(1)

012034.
[15] Memon M A 2010 Integrated solid waste management based on the 3R approach *J. Mater. Cycles Waste Manag.* **12** 30–40
[16] Maryanti D F 2017 Performance of Community-Based Solid Waste Management for Integrated and Sustainable Solid Waste Management. The Case of Bogor City, Indonesia," *Unesco-Ihe*, no. 49947, 95
[17] Bovea M D and Powell J C 2006 Alternative scenarios to meet the demands of sustainable waste management *J. Environ. Manage.* **79**(2) 115-312