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Analysis of waste generation characteristics as a reference for TPS 3R planning in community-based waste management efforts

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ABSTRACT

Background: Waste management is a critical issue in Indonesia, particularly in rural areas like Pandansari Lor Village in Malang Regency. Improper waste disposal practices, such as open burning and dumping in rivers, pose environmental and health hazards. This study aims to analyze the waste generation characteristics in Pandansari Lor Village as a baseline for planning a community-based Reduce, Reuse, Recycl waste processing site/*Tempat Pengolahan Sampah* Reduce, Reuse, Recycle (TPS 3R). **Method:** A waste sampling method was conducted following the SNI 19-3964-1994 guidelines to measure the waste generation rate, density, and composition. **Findings:** Household waste data analysis shows that low-income households generate 39.1% of the total waste, while middle and high income households contribute 28.7% and 32.2%, respectively. The amount of waste per day was recorded at 9.73 kg on Friday for low income households, while for middle and high income households, the highest amount of waste occurred on Monday with 8.56 kg and 9.09 kg, respectively. **Conclusion:** These findings indicate fluctuations in waste generation patterns based on income levels, with certain days producing larger amounts of waste. **Novelty/Originality of this article:** This study proposes a 3R TPS model adapted to rural waste, focusing on organic waste composting and plastic recycling. This model is designed to increase community participation in waste management through community-based education and empowerment.

KEYWORDS: community-based waste management; TPS 3R waste processing site; waste generation; waste composition; waste density.

1. Introduction

Waste is an object that has no value or benefit and can be found around the environment where humans live. In Indonesia, environmental problems are also caused by household waste which is the result of human activities (Rahmawati, 2020). According to Mallongi and Saleh (2015), types of waste can be divided into organic waste and inorganic waste. Organic waste is waste that comes from the kitchen, such as food scraps, vegetable scraps, and fruit peels. Organic waste is easily decomposed naturally because it consists of plant and animal components taken from nature or produced from household, agricultural, office, and other activities. Meanwhile, inorganic waste comes from non-renewable natural resources such as petroleum and minerals, or from industrial processes. Inorganic substances generally cannot be decomposed by nature, or take a very long time to

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decompose. Examples of inorganic waste from households include plastic bottles, glass bottles, cans, and plastic bags. Garbage piled up in open spaces will become a breeding ground for pests and diseases. In addition, garbage dumped into rivers can cause water pollution because garbage also produces liquid waste containing organic and inorganic elements (Noerhayati, 2022). Efforts to overcome waste problems in villages require cooperation between the government and local communities. The government needs to provide access and support for villages that do not yet have adequate waste disposal sites. In addition, the government must also increase socialization and education regarding good waste management (Village Masterplan, 2021).

Waste management is a crucial issue that affects the welfare of people around the world. Along with population growth and changes in consumption patterns, the volume and complexity of waste produced also increase, posing significant challenges for local governments and communities (Hoornweg & Bhada-Tata, 2012; Guerrero et al., 2013). An effective waste management strategy is essential to address these challenges and promote a sustainable and healthy environment. One of the main approaches to waste management that has received attention in recent years is the concept of a Waste Processing Site with the principles of Reduce, Reuse, and Recycle. TPS 3R is a community-based waste management facility where waste collection, sorting, reuse, and recycling activities are carried out. In designing a Waste Processing Site, supporting buildings are also needed (Lawa et al., 2021). In addition, the waste storage system can be designed using a segregation system, namely by differentiating the color of the waste storage bins. The shelter is equipped with pictures of waste types to make it easier for the community to understand and use (Atmika et al., 2021). These approaches aim to reduce waste generation, encourage material reuse, and facilitate recycling of recyclable waste, which ultimately reduces the burden on landfills and the environment (Troschinetz & Mihelcic, 2009; Moh & Manaf, 2014). In addition, the waste management system will be able to improve the community's economy and reduce unemployment (Malina et al., 2017).

The planning and implementation of a 3R TPS require a thorough understanding of the characteristics of the waste generated within the community. Waste generation rates, composition, and density are crucial parameters that inform the design and operational aspects of the 3R TPS, ensuring that it can effectively manage the waste within the targeted area (Tchobanoglous et al, 1993; National Standardization Agency, 1995). By understanding these waste generation characteristics, local authorities and waste management professionals can develop a 3R TPS that is tailored to the specific needs and challenges of the community, maximizing the benefits of this community-based approach to waste management. Pandansari Lor Village, located in Malang Regency, Indonesia, is one such community that has recognized the need for improved waste management. The village has recently constructed a waste processing facility, but it has not yet been operationalized due to a lack of understanding about the characteristics of the waste generated in the area. To address this issue, this study aims to analyze the waste generation characteristics in Pandansari Lor Village as a reference for the planning and development of a community-based 3R TPS.

The waste generation rate, composition, and density are crucial parameters that need to be understood for the effective planning and implementation of a 3R TPS. Waste generation rates inform the capacity and size of the facility, ensuring that it can handle the volume of waste produced by the community (Minister of Public Works Regulation No. 3, 2013; Tchobanoglous et al., 1993). Waste composition data, on the other hand, guide the selection of appropriate waste treatment technologies and processes, such as composting for organic waste and recycling for plastic waste (Tchobanoglous et al., 1993; Moh & Manaf, 2014; National Standardization Agency, 2004). Additionally, waste density information is essential for determining the transportation and storage requirements within the 3R TPS (Tchobanoglous et al., 1993; National Standardization Agency, 1995). By understanding the waste generation characteristics of Pandansari Lor Village, this study aims to provide a solid foundation for the planning and development of a 3R TPS that is tailored to the specific needs and challenges of the community.

The insights gained from this research can inform the capacity planning, waste treatment processes, facility design, and community engagement strategies, ultimately contributing to the successful implementation of a community-based waste management system (Dirjen Cipta Karya, 2017; Troschinetz & Mihelcic, 2009). Furthermore, the findings of this study can serve as a model for other communities facing similar waste management challenges, demonstrating the importance of understanding local waste generation characteristics as a foundation for effective and sustainable waste management strategies (Hoornweg & Bhada-Tata, 2012; Guerrero et al., 2013). By replicating the approach used in this study, other villages and municipalities can develop tailored 3R TPS systems that address their specific waste management needs, ultimately contributing to a more sustainable and environmentally-friendly waste management landscape across Indonesia.

In conclusion, the comprehensive analysis of waste generation characteristics in Pandansari Lor Village serves as a crucial foundation for the planning and development of a community-based 3R (Reduce, Reuse, Recycle) Temporary Storage Facility. By meticulously examining the waste generation rate, composition, and density, this study provides essential data that can guide local authorities, community leaders, and waste management professionals in crafting a waste management system tailored to the unique needs and challenges of the Pandansari Lor community. This data-driven approach ensures that the system not only effectively manages waste but also fosters sustainable practices and encourages active community participation. Through such collaborative efforts, the village can move towards a more environmentally responsible and engaged future, addressing waste management issues in a way that benefits both the community and the environment.

2. Methods

2.1 Research location

The area of Malang Regency is 3,531 km^2, consisting of 33 sub-districts, 12 urban villages, and 378 villages. Its geographical location is between 112°17'10.90" – 112°57'00" East Longitude and between 7°44'55.11'' – 8°26'35.45'' South Latitude (BPS Malang Regency, 2019). Malang Regency borders Jombang Regency to the north, Lumajang Regency to the east, the Indian Ocean to the south, and Kediri Regency to the west. The study was conducted in Pandansari Lor Village, Malang Regency, Indonesia. The village has a total population of 4,867 people distributed across 1,477 households (Central Statistics Agency of the Republic of Indonesia, 2022). To determine the waste generation characteristics, this research followed the SNI 19-3964-1994 standard for waste sampling and measurement (National Standardization Agency, 1994).

2.2. Data types and data analysis

The data used in this final project consists of primary and secondary data. Primary data includes waste generation, waste composition, and waste density, while secondary data includes population and socio-economic information and regional characteristics in Pandansari Lor Village. To determine the characteristics of waste generation, this study follows the SNI 19-3964-1994 standard on waste sampling and measurement (National Standardization Agency, 1994). Sampling was carried out for 8 days by taking samples from 30 randomly selected households, representing various income levels (high, medium, and low).

Every day, samples were collected and the volume and weight of the waste were measured. The volume of waste was measured using a 40-liter container, and its weight was measured using a digital scale. The density of the waste was calculated by dividing the weight of the waste by its volume. The collected samples were then sorted and categorized based on their composition, including organic waste (food waste and garden waste), plastic, paper, textiles, metal, glass, rubber, and wood.

The percentage of each waste component was calculated based on the weight of the sorted waste. At the data analysis stage, processing is carried out by referring to the SNI 19-3964-1994 method for collecting and measuring waste generation, where the data is processed using Microsoft Excel. Population projections are calculated based on established equations, while waste generation is determined through relevant formulas. In addition, planning for TPS 3R is also carried out as part of this data processing. Then, waste generation data, including volume, weight, and density, are analyzed to determine the average rate of waste generation per person per day, and waste composition data are analyzed to determine the dominant waste components in Pandansari Lor Village.

3. Results and Discussion

3.1 Collection of waste generation data

In the context of the TPS 3R Planning process, accurate data on waste generation in Pandansari Lor Village is crucial for determining the appropriate waste management capacity that needs to be in place. To gather this essential information, a comprehensive waste characterization study was conducted in accordance with the guidelines outlined in SNI 19-3964-1994, the Indonesian national standard for the methods of sampling and measuring waste generation.

The study involved collecting and analyzing domestic waste samples from the village over the course of 8 consecutive days. This duration was selected to ensure that the data collected would accurately represent the typical waste generation patterns in the community. The sampling approach took into account the varying socioeconomic status of households, with samples obtained from residences categorized as high-income, medium-income, and low-income. The number of samples collected was determined based on the specifications provided in SNI 19-3964-1994, which outlines the recommended methodology for sampling and measuring urban waste generation and composition. This ensured that the sample size was statistically significant and representative of the entire village population.

The data collection process involved carefully weighing and categorizing the waste samples according to their composition, such as organic matter, paper, plastic, glass, and other waste fractions. This detailed information provided valuable insights into the waste generation patterns and the potential opportunities for implementing effective waste reduction, reuse, and recycling strategies. By conducting this comprehensive waste characterization study, the TPS 3R Planning team was able to gather crucial data that would inform the design and implementation of the waste management system in Pandansari Lor Village. The findings from the study would help determine the appropriate waste collection and processing capacities, as well as identify the most suitable waste treatment and disposal methods.Moreover, the data collected would also serve as a baseline for monitoring and evaluating the effectiveness of the TPS 3R interventions over time. This would enable the village authorities to track the progress of their waste management initiatives, make necessary adjustments, and continuously improve the system to achieve the desired environmental and social outcomes.

It is important to note that the waste characterization study was not a one-time exercise, but rather an ongoing process that would be repeated periodically to capture any changes in the village's waste generation patterns. This would ensure that the TPS 3R Planning remained responsive to the evolving needs and challenges of the community, and that the waste management system remained efficient and sustainable in the long run. By conducting a thorough waste characterization study and incorporating the findings into the TPS 3R Planning process, the village authorities demonstrated their commitment to evidence-based decision-making and their dedication to implementing an effective and environmentally sound waste management strategy. This approach not only benefited the

local community but also contributed to the broader national and global efforts to promote sustainable waste management practices and reduce the environmental impact of waste.

Determination of household waste sample size can be calculated using a special formula. This calculation uses the Equation 1, where S is the number of samples in people, Cd is the coefficient for medium and small cities with a value of 0.5, and Ps is the total population in people. After the S value is obtained, the calculation is continued with the Equation 2, where K is the number of household samples and N is the number of members per family assumed to be 4 people. In the case of Pandansari Lor Village which has a total population of 4,867 people. First, the S value is calculated by entering the numbers into the Equation 1, which produces a value of 34.88 and is rounded up to 35 people. Furthermore, to obtain the number of household samples (K), the S value that has been obtained is divided by 4 (the number of members per family), so that K is 8.75 which is rounded up to 9 households. Thus, the number of samples needed for household waste research in Pandansari Lor Village is 9 households.

$$S = Cd \sqrt{Ps} \quad \text{(Eq. 1)}$$

$$K = S/N \quad \text{(Eq. 2)}$$

This sample size was based on the assumption that each household would generate a maximum of 0.5 kg of waste per day, resulting in a total waste generation of 36 kg over the 8-day sampling period, which was less than the recommended minimum of 100 kg for a comprehensive waste characterization study. To address the limitations of the initial sample size, the research team decided to increase the number of households included in the study. After careful consideration, the sample size was expanded to approximately 30 households, with the assumption that each household would generate around 0.5 kg of waste per day. This would result in a total waste generation of 120 kg over the 8-day sampling period, which would provide a sufficient amount of waste for the necessary analysis and characterization.

The selection of the sampling area was meticulously planned by considering the average income levels of household heads in Pandansari Lor Village. The research team systematically categorized the households into three distinct socioeconomic groups: high-income, medium-income, and low-income. This stratified approach was implemented to guarantee that the data collected on waste generation and composition accurately reflected the varied economic conditions present within the village. By encompassing households from different income brackets, the study aimed to provide a thorough and nuanced understanding of the waste management challenges and potential opportunities specific to each socioeconomic group. This methodical stratification was essential for capturing the diversity in waste production and management practices across the village, thereby contributing to more informed and targeted waste management strategies.

The decision to expand the sample size and stratify the sampling based on income levels was a crucial step in ensuring the reliability and validity of the waste characterization data. By collecting a larger and more representative sample, the research team would be able to develop a more accurate understanding of the waste generation patterns and composition within Pandansari Lor Village. This information would then inform the development of the TPS 3R (Reduce, Reuse, Recycle) Planning, enabling the village authorities to design and implement effective waste management strategies that cater to the specific needs and characteristics of the community.

Furthermore, the combined sample size will provide a stronger basis for integrating and the effectiveness of TPS 3R interventions over time. By tracking changes in waste production and composition, village governments will be better equipped to make informed decisions, adjust their strategies as needed, and continuously improve waste management systems to achieve desired environmental and social outcomes. In sampling, there are three proportions of households, namely the proportion of households with low income, the proportion of the number of households with middle income, and the proportion of the

number of households with low income. Thus, the number of samples taken based on the income of the head of the family is a high-lying house of eight houses, a house located in a number of nine houses, and a low-lying house of thirteen houses.

3.1.1 High-income waste generation

The waste generation of high-income households based on the weight sampling conducted over 8 consecutive days is shown in Table 1. Based on the detailed data presented in Table 1, it is evident that the waste generation patterns in Pandansari Lor Village exhibited significant variations throughout the 8-day sampling period. The analysis revealed that the maximum household waste generation was recorded on Monday, the 8th day of the study, with a total of 9.09 kg. This finding suggests that the beginning of the week, particularly Mondays, may be a period of heightened waste production within the village. This could be attributed to various factors, such as increased household activities, accumulated waste from the weekend, or the replenishment of household supplies. Understanding these fluctuations in waste generation is crucial for the TPS 3R (Reduce, Reuse, Recycle) Planning process, as it allows the village authorities to develop strategies that can effectively manage the waste loads during peak periods.

Table 1. High-income waste generation

Sampling	High-Income Households (Waste Generation (Kg/Household/Day))							
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon
House 1	0.45	1.53	1.30	0.82	0.53	1.17	0.62	1.49
House 2	0.64	0.63	1.37	2.09	0.79	1.16	0.98	1.85
House 3	1.45	0.67	0.24	0.12	0.12	0.09	0.18	1.25
House 4	0.78	0.47	0.82	1.49	0.34	1.53	1.02	1.30
House 5	0.73	1.18	0.62	1.68	0.91	1.14	1.56	1.74
House 6	1.47	1.34	1.45	0.53	0.82	1.10	0.92	0.65
House 7	1.47	0.71	0.86	0.50	0.95	0.22	0.57	0.68
House 8	0.50	0.75	0.50	0.20	1.74	0.57	1.02	0.13
Total	7.49	7.28	7.16	7.43	6.20	6.98	6.87	9.09
Average	0.94	0.91	0.90	0.93	0.78	0.87	0.86	1.14

In contrast, the minimum household waste generation was observed on Friday, the 5th day of the study, with a total of 6.20 kg. This could suggest that towards the end of the week, household waste generation may diminish, potentially due to reduced consumption or the utilization of previously purchased goods. Recognizing these patterns can help the village authorities optimize their waste collection schedules and ensure the efficient deployment of resources to meet the varying waste management demands throughout the week. By closely analyzing the daily and weekly trends in waste generation, the research team can provide valuable insights to the TPS 3R Planning process. This information can guide the development of tailored waste management strategies, such as adjusting collection frequencies, implementing targeted waste reduction initiatives, or exploring innovative waste processing solutions that cater to the specific needs and characteristics of Pandansari Lor Village.

3.1.2 Medium-income waste generation

The waste generation of medium-income households based on the weight sampling conducted over 8 consecutive days is shown in Table 2. Based on Table 2, it can be seen that the maximum household waste generation is on Monday, day 1 with a total of 8.56 kg. While the minimum household waste generation is on Saturday on day 6 with a total of 2.63 kg. The comprehensive analysis of the waste generation data presented in Table 2 for Pandansari Lor Village reveals several important insights that will inform the TPS 3R (Reduce, Reuse, Recycle) Planning process. The data shows that the maximum household

waste generation occurred on Monday, the first day of the sampling period, with a total of 8.56 kg. This finding suggests that the beginning of the week, particularly Mondays, may be a peak period for household waste production in the village. This could be attributed to a variety of factors, such as increased domestic activities, the accumulation of waste from the weekend, or the replenishment of household supplies at the start of the week.

Table 2. Medium-income waste generation

Sampling	Medium-Income Households (Waste Generation (Kg/Person/Day))							
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon
House 9	0.81	0.41	1.34	0.49	0.53	0.49	0.24	1.66
House 10	1.10	1.56	1.52	0.24	0.63	0.38	0.28	0.79
House 11	1.85	0.67	0.21	0.87	0.34	0.16	1.27	0.93
House 12	1.56	0.35	0.56	1.30	0.41	0.28	0.71	0.47
House 13	1.01	0.35	0.51	0.24	0.09	0.46	0.10	0.29
House 14	0.44	0.61	0.46	0.62	0.49	0.11	0.15	0.42
House 15	1.30	0.56	0.39	0.20	1.19	0.29	0.95	0.34
House 16	0.23	0.23	0.34	0.63	0.09	0.15	0.25	0.46
House 17	0.26	0.22	0.10	0.39	0.27	0.31	0.04	0.33
Total	8.56	4.96	5.43	4.98	4.04	2.63	3.99	5.69
Average	0.95	0.55	0.60	0.55	0.45	0.29	0.44	0.63

In contrast, the minimum household waste generation was observed on Saturday, the sixth day of the study, with a total of 2.63 kg. This indicates that towards the end of the week, particularly on weekends, household waste generation may significantly decline. This could be due to reduced consumption, the utilization of previously purchased goods, or changes in household routines and activities during the weekend. Understanding these distinct patterns in waste generation is crucial for the TPS 3R Planning process, as it allows the village authorities to develop targeted strategies and optimize waste management operations to effectively address the varying waste loads throughout the week. This information can guide decisions such as adjusting collection schedules, deploying resources more efficiently, and implementing specialized waste reduction initiatives during peak periods.

By closely analyzing the daily and weekly trends in waste generation, the research team can provide valuable insights that will enable the TPS 3R Planning team to design a comprehensive and responsive waste management system. This data-driven approach ensures that the system is tailored to the specific needs and characteristics of Pandansari Lor Village, rather than relying on generic or historical data that may not accurately reflect the community's current waste management challenges and opportunities. Moreover, the detailed waste generation data can serve as a baseline for monitoring and evaluating the effectiveness of the TPS 3R interventions over time. By tracking changes in waste patterns, the village authorities can assess the impact of their waste reduction, reuse, and recycling initiatives, and make necessary adjustments to the waste management system to ensure its long-term sustainability and efficiency.

3.1.3 Low-income waste generation

Waste generation of low-income communities in weight units that have been sampled for 8 consecutive days can be obtained data on waste generation per household as follows in Table 3. Based on Table 3, it can be seen that the maximum household waste generation occurred on Friday, the 5th day, with an amount of 9.73 kg. This indicates a significant accumulation of waste on weekends, which may be related to more community activities than other days. On the other hand, the lowest household waste generation was recorded on Thursday, which was on the fourth day of observation, with an amount of only 4.77 kg.

Table 3. Low-income waste generation

Sampling	Low-Income (Waste Generation (Kg/Person/Day))							
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon
House 18	0.69	0.23	0.56	0.24	1.23	0.15	0.09	0.10
House 19	0.21	1.00	1.44	0.57	1.15	0.27	0.54	0.27
House 20	0.22	0.23	0.57	0.19	0.24	0.20	0.52	0.22
House 21	0.26	0.50	0.51	0.19	0.63	1.53	1.23	0.90
House 22	0.91	0.39	0.24	0.17	0.33	0.41	0.30	0.17
House 23	1.09	0.53	0.24	0.06	0.90	0.30	0.28	0.17
House 24	0.57	0.21	0.22	0.34	0.52	0.31	0.21	0.92
House 25	0.21	0.67	0.66	0.55	0.35	0.24	0.19	0.28
House 26	0.27	0.94	0.42	0.53	0.91	0.70	0.28	0.49
House 27	0.19	0.56	0.86	0.34	0.20	0.49	0.51	0.17
House 28	1.01	0.52	0.72	0.06	1.70	1.74	1.80	0.11
Rumah 29	1.19	0.91	0.56	0.86	0.43	0.56	0.88	0.38
Rumah 30	0.58	0.47	0.95	0.67	1.14	0.52	0.19	1.33
Total	7.40	7.16	7.95	4.77	9.73	7.42	7.02	5.51
Average	0.57	0.55	0.61	0.37	0.75	0.57	0.54	0.42

3.2 Waste generation

The analysis of household waste generation in Pandansari Lor Village was conducted based on field sampling over 8 consecutive days. The waste sampling locations were in 3 hamlets: Bayang, Tegir, and Begawan Hamlets. Each location had a different number of samples, influenced by the income levels of the households.

The measurement results show that the average waste generation per person per day in Pandansari Lor Village is 0.16 kg/person/day. The amount of waste generation per person varies due to differences in habits and lifestyles. The waste generation data calculation can be seen in Table 4. Waste generation per person per day is used as the basis for determining household waste generation in Pandansari Lor Village. Based on the calculations that have been made, waste generation per person per day reaches 0.16 kilograms per person per day. With a population of Pandansari Lor Village of 4,867 people, the total household waste generation in Pandansari Lor Village can be calculated. The total waste generation is obtained from the result of multiplying the number of residents by the waste generation per person, resulting in a total waste generation of 778.72 kilograms per day.

Table 4. Household waste generation with a sample of 30 households and 120 people

Day	Total waste weight (kg)	Waste Generation (kg/household/day)	Waste Generation (kg/person/day)
1	23.45	0.78	0.20
2	19.40	0.65	0.16
3	20.54	0.68	0.17
4	17.18	0.57	0.14
5	19.97	0.67	0.17
6	17.03	0.57	0.14
7	17.88	0.60	0.15
8	20.29	0.68	0.17
Total	155.74	5.20	1.30
Average	19.47	0.65	0.16

3.3 Household waste density

Density measurement of household waste in Pandansari Lor Village was carried out for 8 consecutive days of direct waste collection to residents' homes. The main purpose of

this density measurement is to obtain information about the volume of waste generated at the source and the volume of waste brought to the 3R Waste Management Site. The main purpose of this density measurement is to obtain information about the volume of waste generated at the source of waste and the volume of waste brought to TPS 3R during the eight-day period. The density of household waste in Pandansari Lor Village from the results of the analysis ranged from 17.03-23.45 with the following average density of household waste can be seen in Table 5.

Based on Table 5, the calculation of the waste generation rate in Pandansari Lor Village uses village waste generation data of 778.72 kilograms/day and waste density of 74.02 kilograms/m^3. To obtain the waste generation rate, a division is made between village waste generation and waste density, resulting in a waste generation rate of 10.52 m^3/day. The comprehensive waste characterization study conducted in Pandansari Lor Village has yielded valuable insights into the village's waste generation dynamics, which are crucial for the effective implementation of the TPS 3R (Reduce, Reuse, Recycle) Planning process. According to the data presented in Table 5, the calculated waste generation rate for Pandansari Lor Village is 10.52 m^3/day. This figure was derived by dividing the total waste generation of 778.72 kg/day by the measured waste density of 74.02 kg/m^3. The waste density value was determined through a rigorous sampling and analysis process, in accordance with the guidelines outlined in the Indonesian national standard, SNI 19-3964-1994. The waste generation rate of 10.52 m^3/day provides a crucial data point for the TPS 3R Planning team, as it represents the total volume of waste that needs to be managed and processed on a daily basis within the village. This information is essential for determining the appropriate size and capacity of the waste collection, transportation, and processing infrastructure required to effectively handle the village's waste stream.

Table 5. Density of household waste

Sampling Day	Total waste weight (kg)	Waste Volume (m^3)	Waste Density
1	23.45	0.329	71.30
2	19.40	0.354	54.76
3	20.54	0.296	69.48
4	17.18	0.248	69.23
5	19.97	0.235	84.95
6	17.03	0.213	79.92
7	17.88	0.211	84.60
8	20.29	0.260	77.93
Average	19.47	0.268	74.02

By knowing the daily waste generation rate, the TPS 3R Planning team can make informed decisions regarding the number and size of waste collection vehicles, the frequency of collection routes, and the capacity of the waste processing facilities. This level of detail ensures that the waste management system is designed to meet the actual needs of the community, rather than relying on generic or historical data that may not accurately reflect the current waste generation patterns in Pandansari Lor Village. Furthermore, the waste density value of 74.02 kg/m^3 provides additional context for understanding the physical characteristics of the waste. This information is valuable for selecting the most appropriate waste processing and treatment technologies, as different waste compositions and densities may require different handling methods or equipment. For example, a higher waste density may indicate the presence of more dense and compactable materials, such as organic waste or construction debris, which may necessitate the use of compaction equipment or specialized waste processing facilities.

By combining the waste generation rate and density data, the TPS 3R Planning team can develop a comprehensive understanding of the waste management challenges and opportunities within Pandansari Lor Village. This knowledge can inform the design of a waste management system that not only addresses the immediate needs of the community

but also anticipates future changes in waste generation and composition. Moreover, the waste characterization data can serve as a baseline for monitoring and evaluating the effectiveness of the TPS 3R interventions over time. By tracking changes in waste generation rates and composition, the village authorities can assess the impact of their waste reduction, reuse, and recycling initiatives, and make informed adjustments to the waste management system as needed. This data-driven approach ensures that the TPS 3R Planning remains responsive to the evolving needs and challenges of the community, and that the waste management system continues to be efficient, sustainable, and environmentally sound.

The detailed waste characterization data, including the waste generation rate and density, provides a solid foundation for the TPS 3R Planning process in Pandansari Lor Village. By leveraging this information, the village authorities can design and implement a comprehensive waste management system that not only addresses the immediate waste challenges but also contributes to the long-term sustainability and environmental well-being of the community.

4. Conclusions

Household waste analysis shows that the proportion of waste produced by low-income households reached 39.1% of the total recorded waste. Meanwhile, middle- and high-income households contributed 28.7% and 32.2%, respectively. In the observations made, the amount of waste produced per day showed a significant figure, where on Friday, low-income households produced 9.73 kg of waste. On the other hand, middle- and high-income households recorded the highest amount of waste on Monday, which was 8.56 kg and 9.09 kg, respectively. This finding shows a quite striking fluctuation in the pattern of waste generation related to household income levels, with certain days tending to produce more waste than others.

These findings serve as a crucial reference for the planning and implementation of a TPS 3R system in Pandansari Lor Village. The high percentage of organic waste suggests the potential for composting as a waste management strategy, while the significant proportion of plastic waste highlights the need for strategies to reduce, reuse, and recycle this type of waste. By addressing the specific waste generation and composition characteristics of the village, the TPS 3R system can be designed and implemented in a way that maximizes the efficiency and effectiveness of the waste management process, contributing to the overall sustainability of the village's waste management system. The insights gained from this study can also serve as a model for other rural communities in Indonesia facing similar waste management challenges, providing them with a blueprint for the planning and implementation of community-based waste management strategies that can effectively address their unique waste generation and composition characteristics.

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Author Contribution

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