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MORALITY BEFORE KNOWLEDGE

Characterization of waste composition as a basis for developing a community-based 3R Waste Transfer Station in waste management efforts

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ABSTRACT

Background: The issue of waste management has become a major concern in many regions, including Pandansari Lor Village, Malang Regency. To address this challenge, it is necessary to develop an effective waste management system that involves the active participation of the community. This study aims to determine the waste composition in Pandansari Lor Village as a basis for developing a 3R (Reduce, Reuse, and Recycle) Waste Transfer Station system that is tailored to the needs of the community. **Method:** The research methodology includes primary data collection through sampling and analysis of waste composition, as well as secondary data collection from relevant sources. **Findings:** The results show that the waste composition in Pandansari Lor Village is dominated by organic waste, including food waste (58.42%) and garden waste (3.84%), followed by plastic waste (26.74%), paper waste (5.89%), and other types of waste. **Conclusion:** These findings provide valuable insights for the design and implementation of a community-based 3R Waste Transfer Station system that can effectively manage the waste generated in the village. The proposed system aims to maximize resource recovery, reduce the amount of waste sent to landfills, and promote sustainable waste management practices within the community. **Novelty/Originality of this article:** This study develops a waste disposal model tailored to the specific waste composition of the village, focusing on processing organic waste into high-quality compost and recycling plastic into products of economic value. The model also integrates a community-based education system to increase participation in waste sorting at source.

KEYWORDS: community-based; 3R Waste Transfer Station; waste generation; waste management.

1. Introduction

Waste management has become a pressing issue worldwide, and Indonesia is no exception. The rapid population growth, urbanization, and changes in lifestyle and consumption patterns have led to a significant increase in the volume and complexity of waste generated (Damanhuri & Padmi, 2011; Sumantri, 2010). In Indonesia, the total waste generated in 2021 was estimated to be 18.2 million tons per year, with only 72.95% of that waste being properly managed (Badan Standardisasi Instrumen Lingkungan Hidup dan Kehutanan, 2022). This issue is particularly prevalent in rural areas, where waste management infrastructure and resources are often limited. Pandansari Lor Village, located in Malang Regency, East Java, is one such community facing challenges in waste

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management. The village lacks a well-functioning waste management system, leading to the improper disposal of waste, including burning and dumping in water bodies (Noerhayati & Rahmawati, 2022). This not only poses environmental and health risks but also hinders the sustainable development of the village.

To address this issue, the development of a community-based 3R Waste Transfer Station system can be a promising solution. The 3R Waste Transfer Station system involves the collection, sorting, reuse, and recycling of waste at the community level, reducing the amount of waste that needs to be transported to final disposal sites (Ditjen Cipta Karya, 2017). However, the success of such a system largely depends on the understanding of the waste composition in the target community, as this information is crucial for the design and implementation of an effective waste management strategy (Nugraha et al., 2015).

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The village lacks a well-functioning waste management system, leading to the improper disposal of waste, including burning and dumping in water bodies (Noerhayati & Rahmawati, 2022). This not only poses environmental and health risks but also hinders the sustainable development of the village. To address this issue, the development of a community-based 3R Transfer Station system can be a promising solution. The 3R Waste Transfer Station system involves the collection, sorting, reuse, and recycling of waste at the community level, reducing the amount of waste that needs to be transported to final disposal sites (Ditjen Cipta Karya, 2017). However, the success of such a system largely depends on the understanding of the waste composition in the target community, as this information is crucial for the design and implementation of an effective waste management strategy (Nugraha et al., 2015).

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2. Methods

The research methodology employed in this study involves both primary and secondary data collection. The primary data collection focused on the analysis of waste composition in Pandansari Lor Village, while the secondary data included information on population, socio-economic characteristics, and existing waste management practices in the village. Waste Composition Analysis The waste composition analysis was conducted in accordance with the Indonesian National Standard/*Standar Nasional Indonesia* (SNI) 19-3964-1994 on methods for sampling and measuring waste generation and composition (Badan Standardisasi Nasional, 1994).

The sampling process involved several steps. First, the sampling locations were conducted in three hamlets in Pandansari Lor Village, namely Bayang Hamlet, Tegir Hamlet, and Begawan Hamlet, to ensure that the samples taken were representative of the village. Second, the sample size was determined based on the number of village residents by following the formula stated in the SNI standard. A total of 30 households were selected for sampling, with the number of samples from each hamlet proportional to the population distribution. Third, the sampling frequency was conducted for 8 consecutive days to take into account daily and weekly variations in waste production. Finally, waste composition analysis was conducted by sorting and weighing the collected waste according to the waste composition categories specified in the SNI standard, including organic waste (food waste and garden waste), paper, plastic, textiles, metal, glass, rubber, wood, and other types of waste.

The data collected from the waste composition analysis were then used to calculate the percentage of each type of waste and its contribution to the total waste flow in Pandansari Lor Village. Secondary data collection was carried out by collecting data such as population statistics, socio-economic characteristics, and existing waste management practices in the village from various sources, including the village government, regional statistical institutions, and related literature (Damanhuri & Padmi, 2011; Sumantri, 2010). Analysis of data collected from primary and secondary sources was carried out to understand the composition of waste and the factors that influence it in Pandansari Lor Village. This analysis involved calculating the percentage of various types of waste, identifying the dominant waste fraction, and exploring the relationship between waste composition and socio-economic variables (Nugraha et al., 2015; Mallongi & Saleh, 2015).

3. Results and Discussion

The waste composition analysis conducted in Pandansari Lor Village revealed that the waste stream is dominated by organic waste, including food waste and garden waste, which account for 62.26% of the total waste generated (Table 1). The high proportion of organic waste in Pandansari Lor Village is consistent with the findings of previous studies on waste composition in rural and semi-urban areas in Indonesia (Damanhuri & Padmi, 2011; Mallongi & Saleh, 2015). This is primarily due to the predominance of agricultural and household activities that generate a significant amount of food waste and garden waste (Sumantri, 2010). The high percentage of plastic waste, on the other hand, can be attributed to the increasing use of plastic packaging and single-use plastic products in the community, a trend that is observed in many developing countries (Nugraha et al., 2015; Mallongi & Saleh, 2015).

Table 1. Composition of Household Waste in Pandansari Lor Village

Type of waste	Waste composition (%)								Total	Average (kg)	Percentage (%)
	H1	H2	H3	H4	H5	H6	H7	H8			
Leftovers	14.54	10.20	11.14	9.04	12.77	10.51	10.58	12.20	90.98	11.37	58.42%
Leaf trash	0.69	0.93	0.62	0.34	0.83	1.06	0.18	1.33	5.98	0.75	3.84%
Papers	1.92	1.03	0.84	1.68	0.79	1.40	0.90	0.61	9.17	1.15	5.89%
Plastic	5.26	6.73	5.48	5.76	3.76	3.45	5.45	5.76	41.65	5.21	26.74%
Textiles	0.91		0.14	0.36			0.56		1.97	0.49	1.26%
Metals		0.13	0.59		0.23	0.24	0.06		1.25	0.25	0.80%
Glass	0.13		0.75		0.34			0.18	1.40	0.35	0.90%
Rubber		0.07							0.07	0.07	0.04%
Wood		0.31			1.06	0.37	0.15	0.21	2.10	0.42	1.35%
Other			0.98		0.19				1.17	0.59	0.75%
Total	23.45	19.40	20.54	17.18	19.97	17.03	17.88	20.29	155.74	20.64	100 %

Plastic waste emerged as the second-largest component of the waste stream in Pandansari Lor Village, comprising 26.74% of the total waste. This finding is consistent with the results of previous studies on waste composition in rural and semi-urban areas in Indonesia (Damanhuri & Padmi, 2011; Mallongi & Saleh, 2015), and can be attributed to the predominance of agricultural and household activities that generate significant quantities of biodegradable waste (Sumantri, 2010). This high proportion of plastic waste is indicative of the increasing use of plastic packaging and single-use plastic products in the community, a trend that is observed in many developing countries (Nugraha et al., 2015; Mallongi & Saleh, 2015). The proliferation of plastic waste poses significant environmental challenges, as plastic materials are non-biodegradable and can persist in the environment for hundreds of years, contributing to land and water pollution, as well as posing risks to wildlife and human health (Barnes et al., 2009; Jambeck et al., 2015).

Plastic waste, the second-largest component of the waste stream in Pandansari Lor Village, can be addressed through the implementation of a comprehensive recycling program within the 3R Waste Transfer Station system. Recycling involves the collection, sorting, processing, and conversion of waste materials into new products, thereby reducing the demand for virgin raw materials and the environmental impacts associated with their extraction and processing (Hopewell et al., 2009; Vilaplana & Karlsson, 2008). Plastic recycling can be carried out through various methods, including mechanical recycling (melting and re-molding), chemical recycling (depolymerization and re-polymerization), and feedstock recycling (thermal or catalytic conversion) (Al-Salem et al., 2009; Ragaert et al., 2017). The choice of recycling method depends on factors such as the type and quality of plastic waste, the desired end products, and the available technology and infrastructure (Ragaert et al., 2017).

Plastic waste, which constitutes 26.74% of the total waste in Pandansari Lor Village, would require dedicated sorting, cleaning, and recycling facilities within the 3R Waste Transfer Station system (Ditjen Cipta Karya, 2017). The plastic waste should be segregated by type (e.g., PET, HDPE, PVC, LDPE, PP, PS) and color to facilitate efficient recycling and maximize the quality and value of the recycled products (Al-Salem et al., 2009; Ragaert et al., 2017). The recycling process can involve mechanical recycling, where plastic waste is melted and re-molded into new products, or chemical recycling, where plastic polymers are broken down into their constituent monomers and re-polymerized to create new plastics (Al-Salem et al., 2009; Vilaplana & Karlsson, 2008). The choice of recycling method will depend on the available technology, infrastructure, and market demand for recycled plastic products (Ragaert et al., 2017).

The waste composition analysis also reveals insights into the waste generation and management practices within Pandansari Lor Village. The high proportion of organic waste, which includes food waste and garden waste, suggests that the community engages in a significant amount of food preparation and gardening activities. This aligns with the village's predominantly rural and agricultural nature, as reported in the secondary data (Damanhuri & Padmi, 2011; Sumantri, 2010). The high proportion of organic waste presents an opportunity for composting, which can help divert a significant portion of the waste stream from landfills and provide a valuable soil amendment for local agricultural activities (Ditjen Cipta Karya, 2017). Furthermore, the waste composition analysis provides valuable insights for the design and implementation of the 3R Waste Transfer Station system. Composting is a biological process that involves the aerobic decomposition of organic matter by microorganisms, resulting in the production of a stable, humus-like material that can improve soil structure, fertility, and water retention capacity (Haug, 2018). The composting process can be optimized by ensuring adequate aeration, moisture content, and carbon-to-nitrogen ratio, as well as by employing appropriate composting methods such as windrow composting, static pile composting, or in-vessel composting (Bernal et al., 2009; Diacono & Montemurro, 2010). Meanwhile, the high proportion of organic waste suggests that the system should prioritize the processing and treatment of this waste fraction, potentially through the use of aerobic composting methods (Ditjen Cipta Karya, 2017).

The secondary data collected on the socio-economic characteristics of Pandansari Lor Village also provides important context for understanding the waste composition. The village's predominantly rural and agricultural nature, as well as the relatively low income levels of the residents, are likely contributing factors to the high proportion of organic waste and the relatively low generation of other waste types, such as paper and electronic waste (Damanhuri & Padmi, 2011; Sumantri, 2010). The relatively low percentage of paper waste (5.89%) and textile waste (1.26%) in the waste stream may be indicative of the community's limited access to or usage of paper-based products and textile-based materials, which are often associated with higher-income households and urban areas (Nugraha et al., 2015; Mallongi & Saleh, 2015). Similarly, the low proportion of metal (0.80%) and glass (0.90%) waste suggests that the community's consumption patterns and material usage are skewed towards more biodegradable and plastic-based products (Nugraha et al., 2015; Mallongi & Saleh, 2015). Overall, the waste composition analysis conducted in this study highlights the need for a tailored waste management approach in Pandansari Lor Village, one that capitalizes on the high proportion of organic waste and addresses the growing challenge of plastic waste. The development of a community-based 3R Waste Transfer Station system, informed by the understanding of the local waste composition, can be a promising strategy for sustainable waste management in the village (Ditjen Cipta Karya, 2017; Nugraha et al., 2015).

The waste composition analysis also sheds light on the socio-economic and cultural factors that shape waste generation and management practices in Pandansari Lor Village. The village's predominantly rural and agricultural character, coupled with the relatively low income levels of its residents, are likely contributing factors to the high proportion of organic waste and the comparatively low generation of other waste types, such as paper

and electronic waste (Damanhuri & Padmi, 2011; Sumantri, 2010). These findings underscore the importance of tailoring waste management solutions to the specific needs, constraints, and opportunities of the local context, taking into account factors such as waste composition, socio-economic conditions, cultural practices, and institutional capacities (Guerrero et al., 2013; Marshall & Farahbakhsh, 2013).

The development of a community-based 3R Waste Transfer Station system in Pandansari Lor Village should be informed by the waste composition data and guided by the principles of sustainable waste management, which seek to balance environmental, social, and economic objectives (Seadon, 2010; Wilson et al., 2015). The system should prioritize waste reduction at the source, followed by reuse, recycling, and recovery of materials, with disposal being the last resort. This waste management hierarchy serves to maximize resource efficiency, minimize environmental impacts, and foster a circular economy approach that keeps materials in use for as long as possible (Ellen MacArthur Foundation, 2013; European Commission, 2015).

The design and dimensioning of the various waste processing units within the 3R Waste Transfer Station system should be based on the waste composition data, taking into account the specific characteristics and volumes of each waste fraction. For instance, the high proportion of organic waste in Pandansari Lor Village would require a larger composting area and more efficient composting methods, such as windrow composting or in-vessel composting (Ditjen Cipta Karya, 2017). The composting process should be carefully monitored and controlled to ensure optimal conditions for microbial activity, including appropriate temperature, moisture content, aeration, and carbon-to-nitrogen ratio (Bernal et al., 2009; Epstein, 1997). The resulting compost can be used as a soil amendment in local agricultural activities, improving soil health, fertility, and crop yields, while reducing the need for synthetic fertilizers (Diacono & Montemurro, 2010).

By aligning the 3R Waste Transfer Station system design with the local waste composition, the waste management solution can be tailored to the specific needs and challenges of Pandansari Lor Village. This approach, in turn, can improve the system's efficiency, effectiveness, and long-term sustainability, as it addresses the root causes of the waste management problem within the community (Ditjen Cipta Karya, 2017; Nugraha et al., 2015). It is important to note that the waste composition in Pandansari Lor Village may be influenced by various socio-economic, cultural, and behavioral factors, as highlighted in the secondary data. The village's predominantly rural and agricultural nature, as well as the relatively low income levels of the residents, are likely contributing to the high proportion of organic waste and the relatively low generation of other waste types, such as paper and electronic waste (Damanhuri & Padmi, 2011; Sumantri, 2010).

The successful implementation of a community-based 3R Waste Transfer Station system in Pandansari Lor Village will require the active participation and support of the local community. Community engagement and awareness-raising campaigns should be conducted to educate residents about the importance of waste segregation at the source, proper waste disposal practices, and the benefits of reducing, reusing, and recycling waste (Ditjen Cipta Karya, 2017; Nugraha et al., 2015). The 3R Waste Transfer Station system should be designed and operated in a way that is inclusive, accessible, and responsive to the needs and concerns of the community, fostering a sense of ownership and responsibility for sustainable waste management (Guerrero et al., 2013; Marshall & Farahbakhsh, 2013). Moreover, the 3R Waste Transfer Station system should be integrated into the broader waste management framework at the regional and national levels, aligning with policies, regulations, and programs that support sustainable waste management and the transition towards a circular economy. This integration can facilitate the exchange of knowledge, resources, and best practices, as well as the development of market linkages for recycled products and compost (Ellen MacArthur Foundation, 2013).

Ongoing monitoring and evaluation of the waste composition in Pandansari Lor Village will be crucial to track any changes or trends over time, which may necessitate adaptations to the 3R Waste Transfer Station system design and operations. Additionally, community engagement and awareness-raising efforts will be essential to foster the active participation

of residents in the waste management process and promote sustainable waste management practices within the village (Ditjen Cipta Karya, 2017; Nugraha et al., 2015).

The waste composition analysis conducted in Pandansari Lor Village has revealed valuable insights into the types and proportions of waste generated by the local community, providing a solid foundation for the development of a community-based 3R Waste Transfer Station system. The high proportion of organic waste and the significant presence of plastic waste underscore the need for tailored waste management solutions that prioritize composting and recycling, respectively. The successful implementation of such a system will require a holistic and participatory approach that takes into account the socio-economic, cultural, and institutional factors that shape waste management practices in the village. By designing and operating a 3R Waste Transfer Station system that is informed by the waste composition data, integrated into the broader waste management framework, and supported by community engagement and awareness-raising efforts, Pandansari Lor Village can make significant strides towards sustainable waste management and serve as a model for other rural and semi-urban communities in Indonesia and beyond.

4. Conclusions

This study aimed to determine the waste composition in Pandansari Lor Village, Malang Regency, as a basis for developing a community-based 3R Waste Transfer Station system for waste management. The analysis of waste composition revealed that the waste stream is dominated by organic waste, including food waste (58.42%) and garden waste (3.84%), followed by plastic waste (26.74%), paper waste (5.89%), and other types of waste. The high proportion of organic waste in the village's waste stream presents an opportunity for the implementation of a 3R Waste Transfer Station system that prioritizes composting and resource recovery. The segregation and processing of plastic waste can also be integrated into the system, contributing to the overall sustainability of waste management in the community.

The findings of this study provide valuable insights for the design and implementation of a tailored 3R Waste Transfer Station system in Pandansari Lor Village. By understanding the local waste composition, community-based waste management strategies can be developed that address the specific needs and challenges of the village, promoting sustainable practices and reducing the environmental impact of waste. Further research is needed to explore the socio-economic and behavioral factors that influence waste generation and composition in Pandansari Lor Village, as well as the feasibility and operational aspects of the proposed 3R Waste Transfer Station system. Ongoing community engagement and capacity-building efforts will also be crucial for the successful implementation and long-term sustainability of the waste management.

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Author Contribution

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