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Potential Waste Reduction Through 3R (Reduce, Reuse, and Recycle) in Surabaya City: Focus on East and South Surabaya

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Abstract

Surabaya, the second largest city in Indonesia, faces significant environmental challenges, particularly waste management. To address this issue, the Surabaya City Government, through the Surabaya City Environmental Service (DLH), has introduced an innovative solution: the waste bank program. This practical work aims to evaluate the potential for waste reduction in East Surabaya and South Surabaya using the 3R (Reduce, Reuse, and Recycle) system facilitated by the waste bank program. The waste bank involves the sorting and collecting of recyclable and reusable waste with economic value. Initially, waste sorting was done at the waste bank, but there has been progress. Now, many customers are sorting their waste by type at home. However, some waste bank administrators still need to sort waste on-site due to some customers' inability to do so. The waste bank program also maintains organized weighing and management procedures. All transactions are meticulously recorded in both cash books and passbooks. The results of this program show that waste reduction in active waste banks in East Surabaya and South Surabaya is 0.088%, while the overall waste reduction managed by the Environmental Service (DLH) is 0.571%. To enhance the effectiveness of the waste bank program, it is essential to conduct awareness campaigns to educate the public on the importance of waste management. Additionally, offering rewards to customers could further motivate them to actively participate in the waste bank program.

1. Introduction

Waste is a complex and pressing issue faced by both developing and developed countries worldwide, including Indonesia. Across nearly every island in Indonesia, litter is a prevalent problem, particularly on Java, and specifically in East Java's city of Surabaya. As the second-largest city after Jakarta, Surabaya bears a significant burden and responsibility for managing its waste effectively. Pollution from waste has numerous adverse effects, including the decline of environmental aesthetics and overall quality of life for residents [1].

Improper waste management and insufficient infrastructure can cause severe environmental issues. These include flooding, landslides, fires, traffic congestion, and pollution of water, soil, and air. If waste is not properly processed and utilized, it will negatively impact cleanliness, the environment, and public health. For example, uncollected waste can clog drainage systems, leading to urban flooding, while improperly disposed of hazardous waste can contaminate water sources, posing health risks to the community [2].

In response to these challenges, Indonesia has implemented legislative measures to tackle waste management issues. According to Law No. 18 of 2008 and Government Regulation No. 81 of 2012 [3], the country's waste management strategy focuses on two primary objectives: waste reduction and waste handling. These laws emphasize the importance of community involvement and the use of sustainable practices to manage waste effectively. One of the key approaches promoted by these regulations is the 3R system (Reduce, Reuse, Recycle), which encourages reducing waste generation, reusing materials, and recycling waste products.

A pivotal component of this strategy is the establishment of waste banks. Waste banks operate as community-driven initiatives where residents can bring their recyclable waste, sort it, and deposit it in exchange for financial compensation or other benefits. This system not only promotes recycling and waste reduction but also provides economic incentives for participants. Waste banks facilitate the sorting and collection of recyclable and reusable waste, turning what was once considered trash into valuable resources with economic potential [4].

The waste bank program has proven to be an effective initiative for managing and sorting both organic and inorganic waste. Customers of waste banks can utilize waste according to its type, ensuring that materials are appropriately processed and recycled. Surabaya is home to 623 waste banks, reflecting the city's commitment to improving waste management practices. Specifically, East and South Surabaya host 242 of these waste banks, with 92 located in East Surabaya and 150 in South Surabaya.

This practical work aims to understand the processes involved in waste management through the waste bank program and to determine the percentage of waste reduction achieved. By examining the operations of waste banks in East and South Surabaya, the study seeks to highlight the effectiveness of community-based waste management strategies and the potential for scaling such initiatives to other regions.

Moreover, this work underscores the need for continuous public education and awareness campaigns to ensure that more residents participate in waste reduction efforts. Educating the public on the importance of waste management and the benefits of recycling can lead to greater community involvement and more sustainable waste management practices. Additionally, offering rewards or incentives to customers can further motivate them to actively participate in the waste bank program, enhancing its overall effectiveness.

In conclusion, waste management remains a critical issue for Surabaya and many other urban areas in Indonesia. The waste bank program represents a promising solution by leveraging community participation and the principles of the 3R system. By continuing to support and expand such initiatives, Surabaya can make significant strides in reducing waste, improving environmental quality, and fostering a culture of sustainability.

2. Literature review

Waste refers to the remnants of products or items that are no longer in use but can still be recycled into valuable materials. According to Law No. 18 of 2008 on Waste Management, waste is defined as the residual daily activities of humans or natural processes in solid or semi-solid forms, consisting of organic or inorganic substances that can decompose or are non-degradable and are deemed useless, thus discarded into the environment (Kai, H. N., 2018). Waste sources can be categorized into several origins:

a. **Residential Waste**: This type of waste is generated by families living in individual homes or dormitories. It primarily consists of organic waste such as food scraps, which are often wet, along with dry waste, ash, plastic, and other materials.

b. **Public and Commercial Waste**: Public places and markets, where large numbers of people gather and engage in activities, generate substantial amounts of waste. Typical waste from these areas includes food scraps, spoiled vegetables and fruits, dry waste, ash, plastic, paper, cans, and other materials.

2.1 Waste Management

According to Government Regulation No. 81 of 2012 on the Management of Household Waste and Waste Similar to Household Waste, waste management is a systematic, comprehensive, and sustainable activity encompassing waste reduction and handling. Waste management includes processes from the source, containment, collection, transfer/transport, processing, and final disposal. Reduction involves limiting waste generation, recycling, and reusing waste. Handling includes activities like sorting, collecting, transporting, and final processing of waste.

Effective waste management planning for a city requires initial data on waste generation, composition, and characteristics. This information optimizes waste management from the source, containment, collection, transfer, transport, processing, and final disposal stages. Waste generation refers to the volume or weight of waste produced from various sources within a specific area over a certain period.

2.2 Waste Banks

A waste bank is a system used in waste management that operates similarly to a banking mechanism. Residents can deposit their recyclable waste in exchange for a bank account and savings book. The waste bank functions like a traditional bank, with directors and tellers, managing transactions and accounts, but instead of depositing money, customers deposit waste with economic value. Waste bank managers must be creative, innovative, and entrepreneurial to enhance community income (YPN, 2015).

The operational model of waste banks involves customers (depositors) bringing sorted waste to the bank. In exchange, they receive a savings account, where the value of the waste is credited. Waste banks play a significant role in educating the community about waste management and promoting recycling.

2.3 Standards for Waste Bank Management

The Ministry of Environment Regulation No. 13 of 2012 provides guidelines for implementing the 3R (Reduce, Reuse, Recycle) through waste banks. This regulation emphasizes waste management by reducing waste generation. The following are the standard management practices for waste banks:

a. Waste Depositors:
   - Conduct waste bank education at least once every three months.
   - Provide three separate containers for waste segregation.
   - Issue savings accounts and account numbers to depositors.
   - Ensure waste is sorted before deposit.
   - Promote efforts to reduce waste.

b. Waste Bank Operators:
   - Use personal protective equipment (PPE) while serving depositors.
   - Wash hands with soap before and after serving depositors.
   - The director of the waste bank must have at least a high school education.
   - Must have undergone waste bank training.
   - Conduct monthly monitoring and evaluation meetings.
   - Have at least five daily operators.
   - Provide monthly salaries or incentives to operators.

c. Waste Collectors/Buyers/Recycling Industries:
   - Prohibit waste burning.
   - Have a cooperation agreement (MoU) with the waste bank as a partner in waste management.
   - Maintain cleanliness to prevent mosquito breeding in waste containers.
   - Possess a business permit.

d. Waste Processing at Waste Banks:
   - Collected recyclable waste must be taken by collectors at least once a month.
   - Creative waste should be recycled by artisans supported by the waste bank.
   - Compostable waste should be managed on a neighborhood or communal scale.
   - Residual waste should be collected by municipal services twice a week.
   - Serve at least one village (more than 500 households).
   - Reduce waste transported to landfills by 30-40% monthly.
   - Increase the number of depositors by 5-10 monthly.
   - Facilitate the replication of waste banks in other areas.

e. Role of Waste Bank Operators:
   - Act as facilitators in establishing and running waste banks.
   - Provide data on waste collectors/buyers for waste banks.
   - Provide data on recycling industries.
   - Offer rewards to waste banks for their efforts.

Through these standards and practices, waste banks significantly contribute to waste reduction, environmental preservation, and community economic empowerment. By promoting the 3R principles, waste banks help mitigates the environmental impact of waste and foster a sustainable culture of recycling and waste management.

3. Methodology

This research was conducted over one month, from August 1, 2022, to August 31, 2022, at the Environmental Service Department (DLH) of Surabaya City. The study utilized a combination of sampling methods and the collection of both primary and secondary data to achieve a comprehensive understanding of waste management practices in the region. The sampling method involved collecting samples twice a week, specifically on Saturdays and Sundays. This regular sampling schedule allowed for consistent data collection, capturing variations and patterns in waste management activities over the course of the study. The collected samples provided critical data on the types and quantities of waste being managed, as well as the efficiency of waste sorting and recycling processes.

Primary data collection was carried out through direct field observations. Researchers visited various waste management sites, including waste banks and landfill areas, to observe and document the operations firsthand. This approach provided invaluable insights into the day-to-day functioning of waste management practices, the challenges faced by waste management personnel, and the overall effectiveness of the waste sorting and recycling processes. By being on-site, researchers were able to gather detailed and accurate information, including the behavior and participation of residents in waste segregation and recycling efforts. In addition to primary data, secondary data collection was an essential component of the research. Secondary data was sourced from existing records and reports provided by the Environmental Service Department (DLH) of Surabaya City. This included historical data on waste generation, previous studies on waste management practices, and official reports on the performance of waste banks. By integrating this secondary data, researchers were able to contextualize their findings within the broader landscape of waste management in Surabaya, understanding long-term trends and evaluating the impact of various initiatives over time.

The integration of both primary and secondary data ensured a robust and comprehensive analysis. Primary data offered current and direct observations, while secondary data provided historical context and broader insights. This dual approach allowed for a nuanced understanding of the waste management system's strengths and areas needing improvement.

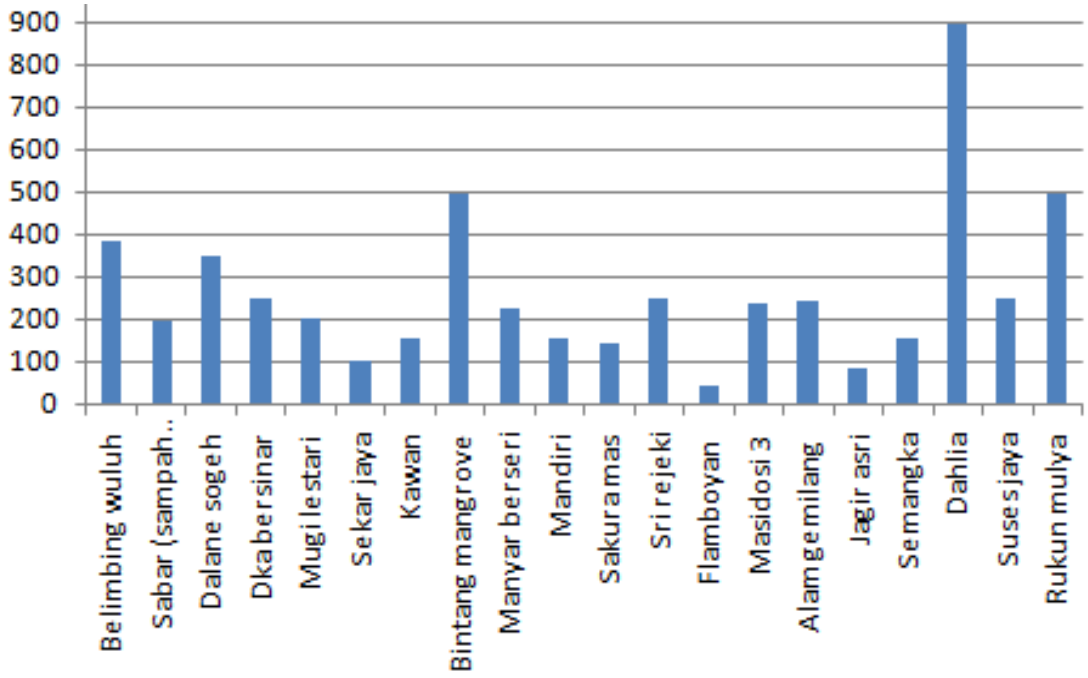

Figure 1. Monthly Waste Input in Sample Waste Banks (kg/month)

Ultimately, this study aimed to evaluate the impact of waste banks on waste reduction in Surabaya, identify best practices, and highlight areas for enhancement. The findings are intended to inform future waste management strategies, contribute to policy development, and promote more effective and sustainable waste management practices in Surabaya. By leveraging a combination of direct field observations and historical data, the research provides actionable insights that can help optimize waste reduction efforts and improve overall environmental management in the city.

4. Results and discussion

4.1 Existing Conditions

The existing conditions refer to the state observed at the time of the study, which involved direct field observations and data collection. Primary data was obtained through direct contact with waste bank managers, including inquiries about operational procedures, institutional aspects, the establishment year of the waste banks, the tonnage of waste weighed, and the types of waste accepted.

In East and South Surabaya, there are 242 waste banks, with 92 in East Surabaya and 150 in South Surabaya. According to data collected via chat or phone calls with waste bank managers, 37 of these waste banks were actively operating. Field observations revealed that of these 37 active waste banks, 20 were available for interviews to provide detailed information.

The primary reasons some waste banks were inactive included the COVID-19 pandemic, which caused many waste banks to temporarily close due to the need for team-based sorting activities, which posed a risk of virus transmission among staff. Another significant factor was a shortage of personnel, which also contributed to the inactivity of some waste banks.

Waste weighing at these banks occurred 1-2 times per month. From the 20 active waste banks interviewed, a total of 5,316.57 kg of waste was weighed per month. The types of waste measured included plastic, metal, mixed waste, and paper.

4.2 Waste Reduction

This study focused on 20 sample waste banks. Each bank had a different number of customers, ranging from 11 to 239, resulting in varying amounts of waste received. Waste banks typically serve at the community level, such as neighborhood associations (RW) and smaller residential units (RT).

Field observations and interviews with waste bank managers revealed that waste weighing and sales activities occurred twice a month. The amount of waste each bank received varied monthly. Detailed monthly waste input data for each sample waste bank is presented in the Figure 1.

To calculate the average waste tonnage per customer, consider the Belimbing Wuluh waste bank as an example:

Waste per customer (kg/month) = Total waste (kg/month) / Number of customers
= 386.3 kg/month / 75 customers
= 5.1 kg/customer/month

The following table presents the waste capacity calculations for several waste banks:

Average waste capacity (kg/month) = Total waste (kg/month) / Number of sample banks
= 5,316.57 kg/month / 20 banks
= 265.83 kg/bank/month

The table 1 below summarizes the waste tonnage per customer in East and South Surabaya:

Table 1. Total waste tonage (Kg/month per customer) in East and South Surabaya

Waste Bank	Total Waste (kg/month)	Number of Customers	Waste per Customer (kg/month)
Belimbing Wuluh	386.3	75	5.1
Sabar (Sampah Barokah)	195.8	60	3.2
Dalane Sogeh	351.5	90	3.9
DKA Bersinar	246.7	25	9.8
Mugi Lestari	199.51	50	4.0
Sekar Jaya	100.0	14	3.8
Kawan	154.9	40	7.1
Bintang Mangrove	500.0	239	2.1
Manyar Berseri	226.7	45	5.0
Mandiri	153.0	70	2.2
Sakura Mas	143.0	45	3.2
Sri Rejeki	250.0	31	8.0
Flamboyan	40.0	28	1.42
Masidosi 3	235.0	38	6.2
Alam Gemilang	245.3	11	22.3
Jagir Asri	84.78	40	2.1
Semangka	154.08	32	4.8
Dahlia	900.0	47	19.1
Suses Jaya	250.0	32	7.8
Rukun Mulya	500.0	35	14.2
Total	5,316.57		

4.2 Waste Composition

Waste composition refers to the breakdown of various components in waste and their distribution. The physical components of waste include food scraps, paper, cardboard, wood, textiles, rubber, plastics, metals (ferrous and non-ferrous), glass, and other materials such as soil, sand, stones, and ceramics. Most waste entering the waste banks had already been sorted at home.

Table 2. Waste Composition

Composition	Weight (kg)	Percentage (%)
Plastic	134.32	23
Paper	348.33	58
Mixed	68.45	12
Metal	25.34	4
Glass Bottles	19.9	3
Total	596.34	100

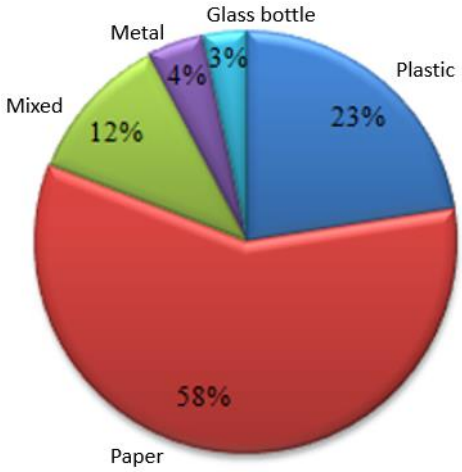

Figure 2. Waste Composition Diagram

The diagram above shows that the majority of waste in East and South Surabaya's waste banks is paper, comprising 58% of the total, followed by plastic at 23%, mixed waste at 12%, metal at 4%, and glass bottles at 3%. This composition highlights the significant potential for recycling and waste reduction through proper sorting and management practices.

4.3 Institutional Aspects of Waste Banks

The institutional aspects of waste banks are primarily driven and directed by Non-Governmental Organizations (NGOs). NGOs are organizations established by individuals or groups to provide services to the general public. In Surabaya, the institutional framework of waste banks involves three main NGOs: Bank Sampah Induk Surabaya (BSIS), Wehasta, and Lohginawi. These NGOs play a crucial role in supporting and guiding waste bank operations. They provide training, resources, and frameworks for waste banks to follow, ensuring consistency and effectiveness in waste management practices. The involvement of NGOs helps in standardizing procedures across different waste banks, promoting best practices, and facilitating the sharing of knowledge and resources.

However, some waste banks operate independently without direct collaboration with these NGOs. The reasons for this independence vary. In some cases, waste bank managers may not be familiar with the NGOs or their services. In other instances, the proximity of waste banks to local waste collectors might make direct cooperation with collectors more convenient. These independently operating waste banks often prefer to manage their operations and handle waste collection directly with recyclers or waste processors, bypassing NGO coordination.

4.4 Calculation of Waste Reduction in East and South Surabaya

This section presents the results of waste reduction calculations for East and South Surabaya. The average capacity of each waste bank is 263.83 kg per month. To estimate the total waste reduction in these regions, we calculate the reduction for the active waste banks.

Total Waste Reduction Calculation for Active Waste Banks:
Total Reduction = 265.83 kg/month × 37 active banks
= 9,835.65 kg/month

Total Waste Generated in the Area:
Total Waste =Waste generation rate × Population × Days Total Waste
=Waste generation rate × Population × Days
=0.25 kg/person/day × 1,488,441 people × 30 days
=11,163,307.5 kg/month

Percentage Reduction Calculation:
% Reduction = (9,835.65 kg/month / 11,163,307.5 kg/month) × 100%
= 0.088%
The total waste reduction for the 37 active waste banks in East and South Surabaya is 0.088%.

Total Waste Reduction Calculation for All Waste Banks Registered with DLH:
Total Reduction = 265.83 kg/month × 240 waste banks = 63,799.2 kg/month

Percentage Reduction Calculation:
% Reduction = (63,799.2 kg/month / 11,163,307.5 kg/month) × 100%
= 0.571%
The total waste reduction for all 240 waste banks registered with the Environmental Service Department (DLH) in East and South Surabaya is 0.571%.

The results indicate a significant difference in waste reduction between active waste banks and the total registered waste banks. Active waste banks show a modest reduction of 0.088%, whereas the total registered banks account for a reduction of 0.571%. This disparity highlights the importance of ensuring that more waste banks become and remain active. Enhanced engagement with NGOs, increased awareness, and better resource allocation can contribute to activating more waste banks and, consequently, improving overall waste reduction efforts in Surabaya.

These findings underscore the need for continuous public education and institutional support to optimize waste management strategies. By fostering greater cooperation between waste banks and NGOs, and ensuring that more waste banks operate effectively, Surabaya can achieve higher waste reduction percentages and make substantial progress in its environmental sustainability goals.

The implementation and effectiveness of waste management strategies, particularly through the application of the 3R (Reduce, Reuse, Recycle) principles, stand at the forefront of addressing significant waste management challenges in urban settings. The collective insights from various studies underscore the comprehensive understanding of community-based waste reduction strategies, the integration of technological innovations, and the supportive role of regulatory frameworks in facilitating efficient waste management.

L. Indriati and A. N. Fadilla [1] focus on the importance of visual brand communication in enhancing public engagement with waste bank programs, indicating that effectively communicated visuals can significantly influence public participation and awareness. This aligns well with the findings of D. P. Kusuma and Y. Astuti [2], who discuss the critical role of data management systems in waste banks, emphasizing the necessity for robust technological infrastructures to streamline operations and ensure sustainable practices.

The regulatory backdrop is crucial, as outlined by the 2008 Waste Management Law and its subsequent 2012 amendments [3], which provide structured guidelines for waste reduction and highlight the need for community involvement in sustainable waste management practices. These laws facilitate the community-driven initiatives described by M. K. Wardhani and A. D. Harto [4], who present a comparative analysis demonstrating the successful application of waste bank principles in varying urban contexts.

Further expanding on this framework, Mohammed et al. [5] explore the modeling of 3R strategies for sustainable construction waste management, using advanced statistical methods to emphasize the efficiency of these strategies in reducing construction waste. Similarly, Hazam et al. [6] discuss the implementation of the 3R program in managing school environment waste, showcasing how educational settings can significantly benefit from properly implemented waste reduction programs.

Prastyabudi and Permata [7] introduce a conceptual design for smart waste management, proposing the deployment of 'Smart Bins' in Surabaya, which could revolutionize the way waste is collected and

processed, enhancing efficiency and participation. On the community empowerment front, Masithoh et al. [8] highlight efforts to improve 3R literacy among communities, which is crucial for fostering a culture of recycling and waste reduction.

In contrast, Warmadhewanti and Haqq [9] focus on the implementation challenges of waste banks in reducing solid waste specifically in South Surabaya, suggesting the need for improved operational strategies and public awareness campaigns. Oliveira et al. [10] extend this discussion to the construction industry, examining actions aimed at waste reduction through recycling and reuse, providing a broader perspective on the application of 3R principles beyond municipal waste management.

The study by Aziz et al. [11] explores the development of waste management systems within the tourist beach areas of Kota Pariaman, employing the 3R (Reduce, Reuse, Recycle) approach. Their work emphasizes the specific challenges and strategies pertinent to maintaining environmental sustainability in tourist-heavy areas, which are particularly vulnerable to rapid waste accumulation. This research underscores the necessity of tailored waste management practices that align with the unique demands and capacities of tourist destinations.

Artha et al. [12] describe a community-based waste management strategy implemented in Bantas Village, illustrating how localized initiatives can effectively integrate the 3R principles within rural settings. Their study highlights the benefits of community engagement and local governance in managing waste, suggesting that grassroots involvement is crucial for the sustainability of such programs. This approach complements the findings of broader urban studies, emphasizing the adaptability and effectiveness of the 3R framework across different societal and geographic contexts.

Furthermore, Arimbi et al. [13] focus on the identification and application of waste management practices in the Kelurahan Jambangan area of Surabaya. Their research provides insights into how specific communities within urban settings approach waste management, highlighting variations in implementation and the impact of local conditions on the effectiveness of 3R strategies. This study adds depth to our understanding of urban waste management, showing the importance of contextual and cultural considerations in the design and execution of waste reduction programs.

Integrating these studies with the previously discussed literature enhances our understanding of waste management as a multifaceted challenge that requires a range of strategies tailored to different environments and community needs. From tourist beaches to rural villages and urban neighborhoods, the application of the 3R principles proves to be a versatile and effective approach to reducing waste and promoting sustainability.

5. Conclusion

The technical and operational aspects of community-based waste bank management in East and South Surabaya remain suboptimal. A significant number of waste bank customers are still unable to adequately sort their waste by type, necessitating that sorting activities continue to be carried out by waste bank staff. This indicates a need for further education and training to improve the efficiency of waste segregation at the source. The waste reduction achieved by active waste banks in East and South Surabaya is 0.088%. In contrast, the total waste reduction for all waste banks registered with the Environmental Service Department (DLH) stands at 0.571%. These figures highlight the potential impact of increasing the number of active waste banks and enhancing their operational effectiveness to achieve greater overall waste reduction. There is a noticeable lack of public understanding regarding waste management practices at waste banks. To address this, it is crucial to implement continuous educational campaigns and provide rewards or incentives to waste bank members. Encouraging active participation and proper waste sorting through incentives can significantly boost the effectiveness of waste banks and enhance community engagement in waste reduction efforts.

To address the challenges and improve the performance of waste banks in Surabaya, several recommendations are proposed. First, implementing targeted education and training programs can teach

residents the importance and methods of proper waste segregation. Workshops, community meetings, and school programs can be effective in raising awareness and building the necessary skills for efficient waste management. Introducing incentive schemes to motivate residents to participate actively in waste segregation and recycling is also recommended. Rewards such as discounts on utility bills, vouchers, or recognition programs can encourage more people to contribute to waste reduction efforts. Strengthening collaboration between waste banks and NGOs can leverage their expertise and resources. NGOs can provide essential support in training, resource allocation, and the implementation of best practices, thereby enhancing the overall effectiveness of waste bank operations. Establishing a system for regular monitoring and evaluation of waste bank performance is another important step. This can include monthly reports, audits, and feedback mechanisms to track progress, identify challenges, and implement corrective measures promptly. Developing community engagement initiatives to foster a culture of sustainability and environmental responsibility is also essential. Community clean-up events, recycling drives, and educational campaigns can help build a collective effort towards waste reduction. The findings of this practical work underscore the importance of effective waste management practices and the significant role that community-based waste banks can play in achieving environmental sustainability. By addressing the identified challenges and implementing the proposed recommendations, Surabaya can enhance its waste management system, reduce environmental pollution, and create a cleaner, healthier urban environment for its residents. Continuous efforts in education, community engagement, and institutional support will be key to achieving long-term success in waste reduction and management.

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