A Cross-Sectional Study on the Efficiency and Challenges of Solid Waste Management in a Sri Lankan Urban Municipality: A Case Study of Akkaraipattu

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Abstract

Municipal Solid Waste Management (MSWM) in developing nations is severely challenged by rapid urbanization, population growth, and constrained infrastructure. This study evaluates the current MSWM practices in Akkaraipattu, Sri Lanka, to identify key challenges. Data were collected through semi-structured interviews with 20 municipal officials and surveys of 385 households, supplemented by field observations and secondary data from the Akkaraipattu Municipal Council and local composting plant. Quantitative analysis revealed that Akkaraipattu generates approximately 49.75 tonnes of solid waste daily, with kitchen waste constituting 6.5 tonnes. The average waste collection rate is only 50%, and composting efficiency remains low at 28.8%. Major impediments to effective waste management include inadequate infrastructure, limited funding, poor public adherence to waste segregation, and logistical constraints. Despite initiatives like community outreach, long-term success hinges on sustained local involvement and stronger policy enforcement. Recommendations include investing in waste-to-energy technologies, expanding composting facilities, implementing smart collection systems, enhancing public education, and fostering public-private partnerships. This study provides practical insights for policymakers and communities aiming to transition towards more sustainable and efficient waste management systems.

Keywords: **infrastructure, compost, sustainable development, environment. Sri Lanka, policy**

I. INTRODUCTION

Solid Waste Management (SWM) encompasses the control of waste generation, storage, collection, transport, processing, and disposal, adhering to principles of public health, economics, engineering, and environmental conservation (Akolkar, 2005). Effective SWM is crucial for environmental protection, safeguarding public health, conserving resources, and ensuring regulatory compliance. However, improper waste management remains a pervasive environmental issue, particularly in developing countries like Sri Lanka. For example, unorganized systems, lack of public participation, and inadequate treatment and disposal mechanisms lead to significant environmental degradation and public health risks (Singh et al., 2011).

Municipal Solid Waste Management (MSWM) is directly linked to the United Nations Sustainable Development Goals (SDGs), specifically SDG 11 addressing the management of municipal solid waste and SDG 12, which emphasizes the need to substantially reduce waste generation through prevention, reduction, recycling, and reuse by 2030 (United Nations, 2024). For Sri Lanka, this implies an urgent need to minimize the per capita environmental impact of its cities.

The challenges of MSWM are especially acute in urban areas of developing nations, where rapid urbanization, population growth, and insufficient infrastructure coverage to create complex waste management problems (Wilson et al., 2015). Akkaraipattu, a growing urban center in Sri Lanka, exemplifies these challenges. The challenges of MSWM are especially acute in urban areas of developing nations, where rapid urbanization, population growth, and insufficient infrastructure coverage to create complex waste

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management problems (Wilson et al., 2015). Akkaraipattu, a growing urban center in Sri Lanka, exemplifies these challenges.

This research aims to: (1) map the existing MSWM practices in Akkaraipattu; (2) identify and analyze the challenges hindering effective waste management; (3) benchmark these practices against international standards to identify gaps; and (4) propose strategic, sustainable solutions for improvement. By evidence-based guidance for local policymakers and communities contributes to the broader discourse on sustainable waste management and offers.

II. LITERATURE REVIEW

Municipal solid waste (MSW) is the assorted mixture of solid discards generated by urban and rural conurbations/societies. Although highly diverse, the common constituents of this household waste include kitchen scraps, garden litter, and packaging (Nanda and Berruti, 2021). Municipal Solid Waste refers to dry waste materials produced by households, agricultural operations, industries and institutions across both public and private sectors (Farrell & Jones, 2009; Samarasinha et al., 2015).

Managing solid waste has emerged as a major sustainability challenge for local government across the globe (He et al., 2022). However, this problem is particularly severe in Sri Lanka (Batista et al., 2021). Municipal solid waste management policy gaps are largely due to the limited research conducted on the subject (Saja et al., 2021). Under current legal provisions of the Pradeshiya Sabha, the responsibility for managing this waste falls to local government authorities, yet they often lack the guidance and support needed for effective implementation. Additionally, at the national level, authorities work in partnership with relevant international organizations on matters related to municipal solid waste management (Saja et al., 2021).

As per the relevant sections of the Municipal Council Ordinance, sections 129, 130, and 131, the Urban Council Ordinance Sections 118, 119, and 120; and *Pradesheya Saba* Act No. 15 of 1987, Sections 93 and 94, in Sri Lanka, all waste gathered by local authorities such as street litter and household refuse becomes the property of the respective council, which holds complete authority to sell or dispose of these materials as it deems appropriate (Arachchi 2016). As a result, solid waste has become a core responsibility of local government authorities. However, these authorities often function as income-generating ventures (Sinnathamby et al. 2016).

Municipal solid waste management aligns with Sustainable Development Goal (SDG) 11 which promotes sustainable cities and communities, as well as SDG 12, which focuses on responsible consumption and production; both address aspects of municipal solid waste management (United Nations, 2024). In line with this commitment, Sri Lanka, as a member of the UN, is expected to minimize the negative per capita environmental impact of its cities by the year 2030. SDG 12 further emphasizes reducing solid waste generation at the source through prevention, reduction, recycling, and reuse by 2030 (United Nations, 2024). Therefore, managing solid waste by converting it into compost can contribute to sustainability on several fronts (Manea et al, 2024).

Recent studies show that the efficiency of composting systems can be significantly upgraded by addressing key challenges, including source reduction, the adoption of improved management practices, and merging technological and methodological innovations. Emerging composting approaches, such as the Bokashi and Takakura methods, have demonstrated potential in accelerating organic matter degradation while mitigating operational challenges commonly associated with conventional composting processes (Danny et al., 2023).

To ensure the financial viability of the waste management system, it is important to establish stable and recurring revenue streams. Key sources of income should include garbage collection fees, tipping fees, government transfers, and the sale of compost. Furthermore, to enhance the marketability and safety of compost products and to reduce the risk of rejection by end users, strict quality control measures and adherence to established composting standards must be implemented (Siles-Castellano et al., 2021).

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financial risks and inefficiencies would be expected where financial performance was worse. A heavy reliance on subsidies and external grants further exacerbated sustainability challenges. In Sri Lanka, under the Pilisaru project, numerous waste facilities were established using capital investments provided by the central government and international donors. However, once these external financial supports were withdrawn, many of the facilities proved to be financially unsustainable, highlighting structural weaknesses in operational and financial planning (Dinushika, 2021)

Solid waste composting faces several persistent challenges that hinder its widespread adoption and economic viability. A major constraint is the lack of sufficient market demand for compost products, which limits the ability of producers to identify and secure reliable outlets for distribution. This issue is exacerbated by assurance protocols are essential to enhance the credibility, demand, and overall sustainability of composting operations. (Roy et al, 2021)

Secondary data were obtained from official reports and records from the Akkaraipattu Municipal Council and the local composting plant. Qualitative insights were gathered through semi-structured interviews with key informants (see Table 01 for participant details) and field observations at waste management sites.

III. METHODOLOGY

This study employed a mixed method approach to gather comprehensive data on MSWM in Akkaraipattu. This study was carried out at the Akkaraipattu Municipality Region and Alim Nagar composting plant. The population was selected from the Akkaraipattu Municipality, the region which includes 23GN Divisions. The Study conducted for the population more than 15 years of age. The study period was January 2024 to December.

A. Data Collection

Primary data were collected through two pretested, structured questionnaires: A survey on MSWM services targeting 20 employees of the Akkaraipattu Municipal Council, selected purposively based on their roles. A household survey on kitchen waste management practices. The sample size of 385 households was determined using the Krejcie and Morgan (1970) formula for a finite population.

Table 01 Data Collection of Participants

No	Anonymous name	Designation	Years of Experience
1	Participant A	Mayor	7
2	Participant B	Secretary	13
3	Participant C	Commissioner	3
4.	Participant D	Head for Waste Management Branch	10
5.	Participant E	Development Officer-Planning	6
6	Participant F	Development Officer-Planning	5
7.	Participant G	Management Assistant	2
8.	Participant H	Management Assistant	3
9.	Participant I	Compost Plant Supervisor	5
10.	Participant J	Management Assistant	4
11.	Participant K	Management Assistant	3
12.	Participant L	Development Officer	2
13.	Participant M	Development Officer	3
14.	Participant N	Development Officer	3
15.	Participant O	Management Assistant	2
16.	Participant P	Development Officer	3
17.	Participant Q	Development Officer	2
18.	Participant R	Municipal Waste Collection Supervisor	3
19.	Participant S	Accounts Officer	5
20.	Participant T	Public Health Inspector	5

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B. Data Analysis

Quantitative data from the surveys were analyzed using SPSS version 20.0, employing descriptive statistics to calculate means, standard deviations, and frequencies. Qualitative data from interviews

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and observations were analyzed thematically to identify recurring challenges and perspectives.

IV. Results

A. Waste Generation and Composition

During the study period, Akkaraipattu generates an average of 49.75 tonnes of solid waste daily (SD = 3.29), amounting to approximately 1400 tonnes monthly (SD = 57.74). Kitchen waste constitutes a significant portion of the total, with 6.5 tonnes generated daily (195 tonnes monthly). representing 17.8% of the total waste. sources of waste are residential, commercial and industrial areas.

B. Waste Collection and Management Efficiency

On average, the municipality collects only about 50% of the waste generated daily, resulting in significant uncollected waste. Composting efficiency, defined as the proportion of compostable waste that is actually composted, is low at 28.8% indicating that less than a third of compostable material is processed. Financial allocations for SWM have fluctuated significantly, as shown in Table 02, with a notable spike in "Other Expenses" in 2023 (Table 02), indicating potential capital investments or irregular funding patterns.

The household survey revealed a complex public perception of waste management in Akkaraipattu. Nearly half (43.6%) of the respondents identified waste disposal as a problem within their neighborhood, and a similar proportion (46.7%) rated municipal collection services as merely "fair". In contrast, a majority (58.8%) expressed satisfaction with the processes at the local waste management center. This suggests a distinction between satisfaction with centralized processing and dissatisfaction with collection services.

Despite high levels of awareness, 83.3% recognizing the importance of recycling, 89.4% acknowledging the environmental impacts of waste, and 90.4% of respondents still observed litter in public areas. Furthermore, an overwhelming majority (94.5%) were concerned about the health impacts of mismanaged solid waste, and 86.8% believed that most environmental issues in Akkaraipattu could be minimized with proper waste management.

Complementing these public views, interviews with municipal officials identified several systemic institutional challenges. The foremost issue is inadequate infrastructure, where existing waste processing facilities are insufficient to handle the current volumes of waste generated. This challenge is compounded by significant financial constraints. Insufficient and inconsistent funding severely hampers daily operations as well as long-term development. Officials also cited public indifference, particularly poor adherence to waste segregation practices, as a major impediment to efficiency. Additional operational obstacles include logistical and human resource issues, such as a shortage of skilled labor and transportation challenges.

Finally, the existing policy and regulatory framework was considered as outdated and crucially poorly enforced which greatly influences it's overall effectiveness.

V. DISCUSSION

The findings of this study paint a comprehensive picture of a Municipal Solid Waste Management (MSWM) system in Akkaraipattu that is under significant strain. The system faces interconnected challenges: increasing waste generation, operational inefficiencies, and a gap between public awareness and action. These occur within a broader context of financial and infrastructural constraints.

The daily waste generation of 49.75 tonnes underscores the substantial burden placed on the municipality's waste management system. This volume is characteristic of rapidly urbanizing areas in developing nations (Kumar & Samadder, 2017). It aligns with global trends, where economic development and population growth directly correlate with increased waste production (Hoornweg & Bhada-Tata, 2012).

The significant portion of kitchen waste (6.5 tonnes daily), a biodegradable stream, represents both a challenge and a critical opportunity. While its high organic content contributes to leachate formation and greenhouse gas emissions if landfilled, it is also a prime candidate for composting and anaerobic digestion. This process can recover valuable resources and reduce the overall waste volume (Singh et al., 2011). The fact that residential areas are a primary source highlights the need for targeted household level interventions.

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Table 02: Expenses of Solid Waste Management of Akkaraipattu Municipality in LKR

Year	Remuneration	Traveling expenses	Materials & Supply	Repairing Properties	Other Expenses	Total Cost
2018	1, 009,198.50	78,500.00	75,000.00	65,000.00	10,669,199.00	10,887,699.00
2019	1,009,549.50	155,610.00	440,462.00	565 260.98	536,354.40	2,141,975.90
2020	878,500.00	78,500.00	480,462.00	350,000.00	354,513.90	2,141,975.90
2021	978, 500.00	79,500.00	470,400.00	250,000.00	2,721,599.78	4,499,999.78
2022	858,500.00	78,500.00	480,500.00	210,000.00	3,372,500.00	5,000,000.00
2023	858,500.00	99,500.00	480,500.00	220,000.00	48,341,500.00	50,000,000.00
2024	858,500.00	78,900.00	330,500.00	200,000.00	3,532,100.25	5,000,000.25

Source: Budget 2018, 2019, 2020, 2021, 2022, 2023, 2024 Municipal Council, Akkaraipattu

However, the system's capacity to manage this waste is severely limited. A collection rate of only 50% is alarmingly low. This signifies a critical failure in the first step of the waste management hierarchy. This result is consistent with challenges noted in other Sri Lankan municipalities, where collection systems often fail to keep pace with urban expansion (Saja et al., 2021). Uncollected waste, as reported by 90.4% of respondents observing litter in public areas, inevitably leads to illegal dumping, environmental pollution. This also increases public health risks, creates nuisance and obstructs drainage systems (Guerrero et al., 2013). Furthermore, the low composting efficiency of 28.8% indicates that even the collected organic waste is not being optimally processed. This inefficiency suggests potential issues such as poor feedstock quality due to a lack of source separation, inadequate technology, or operational mismanagement at the composting plant. These factors lead to missed opportunities for waste diversion and soil amendment production (Samarasinha et al., 2015).

The financial analysis reveals a pattern of instability that directly contributes to these operational shortcomings. The dramatic fluctuation in annual budgets, particularly the anomalous spike in "Other Expenses" in 2023, points towards inconsistent funding and a reactive rather than strategic approach to financial planning. This inconsistency hampers the ability to invest in reliable collection vehicles, maintain infrastructure, or launch sustained public awareness campaigns. As noted by Sinnathamby et al. (2016), a lack of financial capacity is a fundamental barrier for local authorities in Sri Lanka to establish effective, income-generating waste processing facilities. Stable and adequate funding is essential for long-term planning and investment in sustainable MSWM.

The study reveals a crucial paradox in public perception. There is a high level of awareness (83.3% on recycling, 89.4% on environmental impacts) and deep concern (94.5% about health impacts). Yet, this knowledge does not lead to effective action, as shown by widespread littering. This "value-action gap" is a common pattern in environmental behavior (Kollmuss & Agyeman, 2002) and indicates that barriers beyond awareness exist. These may include a lack of convenient infrastructure (e.g., separate bins), insufficient collection services considered unreliable by 46.7% of respondents, or a sense of futility if individuals do not see their efforts reflected in systemic efficiency. The fact that 58.8% were satisfied with the waste center's processes, while 43.6% saw disposal as a neighborhood problem, may suggest that

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residents blame illegal dumping on others rather than the system itself, or that they are satisfied with limited services given their low expectations.

Institutional challenges identified by officials—inadequate infrastructure, financial constraints, public indifference, logistical issues, and weak policy enforcement—form a complex, self-reinforcing cycle. For instance, poor enforcement of segregation rules (a policy failure) leads to contaminated waste streams, which reduces composting efficiency (an operational failure). This, in turn, erodes public trust and participation (a social failure), making for cities in developing countries making entire system less effective. This aligns with findings of Guerero et al (2021) who identified that the most significant challenges for cities in developing countries or not technical but rather governance-related, involving institutional, financial, and social factors.

VI. CONCLUSION

This study concludes that MSWM in Akkaraipattu is hampered by a combination of integrated approach that addresses both hardware (infrastructure, technology) and software (policy, community behaviour). Future research could focus on pilot interventions to improve source segregation or evaluate the effectiveness of targeted outreach campaign.

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