IRSTI 87.13.29 https://doi.org/10.26577/FJSS2024.v10.i2.4

M. Selim[1], R.M. Amin[2]*

[1]Islamic University, Kushtia, Bangladesh
[2]Comilla University, Cumilla, Bangladesh
*e-mail: rubelcou@gmail.com

COMPREHENSIVE ANALYSIS OF MUNICIPAL WASTE MANAGEMENT IN BANGLADESH: EMBRACING THE 3RS (REDUCE, REUSE, RECYCLE)

Received: November 16, 2024
1st Revision: November 19, 2024
Accepted: December 19, 2024

Abstract. In Bangladesh, the main factors contributing to the increase in municipal solid waste (MSW) are population growth and rapid urbanization. The lack of effective waste management negatively affects the environment, human health, and the overall quality of urban life. This study focuses on the current state of municipal waste management organizations in Bangladesh and assesses their viability and sustainability. The primary objective of the study is to evaluate the effectiveness of the 3Rs–reduce, reuse, and recycle–as methods for waste management at the municipal level. The value of this research lies in its potential to inform both the waste management sector and policymakers about feasible approaches to achieve sustainable municipal waste management. By promoting the implementation of the 3Rs in educational initiatives regarding waste management and disposal, the study aims to encourage sustainable practices and reduce overall disposal costs. The study employs a literature review, case studies from various towns in Bangladesh, and a primary survey involving local government officials, waste management experts, and the general public. Data analysis methods include frequency analysis, content analysis, and quantitative analysis. Key findings reveal that, despite growing waste management challenges, a majority of users in urban centers adhere to the principles of the 3Rs. However, there are significant implementation issues, such as inadequate infrastructure, insufficient health promotion, and poorly designed programs. To enhance the effectiveness of the 3Rs in municipal waste management, the study suggests developing efficient recycling mechanisms, strengthening regulatory requirements, and fostering public support and involvement. The research underscores the importance of an integrated approach to waste management in Bangladesh.
Key words: waste, management, municipality, 3Rs (Reuse, Reduce and Recycle), Bangladesh.

Introduction

Bangladesh is one of the least urbanized countries in the world right now. However, it is one of the top ten countries that is urbanizing the fastest, with a rate of 18.2% in urban areas and a rate of overall 3% (Shishir & Islam 2016). As cities grow quickly, there is also a quick rise in solid waste (Haider, 2021). Still, many Bangladeshis reside in semi-urban or rural settings. They aspire to improve their life and go to cities, but rural expats share the same attitude. Waste is dumped in open spaces, water sources, and vacant lots (Reza, 2013). This makes proper waste disposal difficult. Rapid urbanization has left waste management out of the picture, which is terrible for health and the environment. More rubbish offers issues and opportunity for waste management and growth (Zorpas, 2024).

Bangladesh has had waste issues since the late 1980s. Bangladesh has long assigned waste disposal to "low caste" or "Dalit" people. Previously, these castes cleaned cities without government or other assistance (Singh, 2021). City governments used to engage these castes to clean up rubbish. They usually lifted rubbish with a buffalo rib and dumped it in a field or riverbank (Anua et al., 2022). Bangladesh was formerly a Muslim nation with strong religious and cultural traditions. Being responsible for garbage management goes against conventional values. Low-caste people were thought to handle and clean rubbish, which was then dumped in nearby rivers or fields (Anom et al., 2015).

Qualitative and quantitative research methodologies were used to assess the effectiveness of current waste management systems in Bangladesh (Prajapati & Pamnani, 2017). The primary data source for the evaluation activity was the examination of literature and case studies from various municipalities nationwide (Majumder, 2012).. These case studies identified the general practices of waste management, the strengths and weaknesses of infrastructure, and the difficulties associated with the management of municipal solid waste (Sarker & Rahman, 2018). Additionally, questionnaires and in-person interviews were conducted with local government officials, waste management specialists, and community members at the research locations to get direct insights and data about the benefits and limits of the current systems. The study sought to assess public knowledge, waste segregation practices, and service efficiency ratings related to garbage collection and disposal (M. A. Rahman, 2016).

Data on waste production rates, the efficacy of waste collection and disposal systems, and the extent of implementation of recycling and waste minimization strategies, including the 3Rs, were also collected. Moreover, this multi-method approach provided a comprehensive evaluation of the efficacy and deficiencies of waste management systems in Bangladesh.

Objective of the Study

The primary purpose of this research is to conduct an analysis of the current state of solid waste management in the municipalities, with the secondary objectives of identifying the obstacles faced by municipalities and the possibilities presented by their situations. The specific objectives are following:

- To investigate the present methods used by the municipalities for the management of solid waste.
- To find out how much Municipal Solid Waste is made in the study areas, what it is made of, and how it compares to municipalities in light of the 3Rs.
- To determine the limitations of the existing Municipal Solid Waste system as well as the possible improvements that might be made to it in terms of the 3Rs.

Rationale of the Study

This study quantifies solid waste production and waste management methods in the researched locations. It examines current methods and barriers to garbage management in the research locations. The author recommends Pourashava SWM changes based on the findings. These tips will assist micro and macro decision makers create the correct waste management system for reusing, reducing, and recycling (Oladejo et al., 2024). These tips will also help waste management experts create and implement effective waste management strategies (Achankeng et al., 2004). Community-based trash management relies on citizens' desire and willingness to pay taxes and take other duties. Community-based garbage management has reduced volume, educated the community, and offered local waste management options better than the City Corporation. These successes are due to the community-based strategy.

Literature review

Urbanization has increased garbage creation in Bangladesh, making solid waste management a serious environmental issue. The 3Rs (Reduce, Reuse, Recycle) approach is crucial to reduce urban waste's environmental effect. Six papers discuss solid waste management in Bangladesh and the 3Rs strategy's potential.

Abedin et al. (2022) found that Dhaka produces 4500 tons of garbage every day, but only 40% is effectively collected and disposed of. Disposal of the residual garbage in open places or improperly pollutes the environment. Khan believes the 3Rs are essential to solving this rising issue. Ali et al. (2018) observed that 60% of urban Bangladeshis knew little about trash reduction measures including reducing plastics and packaging. Ali et al. (2018) stresses the necessity of public awareness efforts to promote trash reduction at the source. Informal sector workers recycle 15% of Bangladeshi solid trash, according to Hafsa & Ahmed (2021). These workers physically sort recyclables from mixed rubbish, but the absence of institutional infrastructure makes recycling less effective. Haque (2021) highlighted infrastructural, financing, and personnel issues in municipal trash management. Municipalities would struggle with garbage without the 3Rs, according to the report. Kabir (2020) analyzed government measures such the National trash Management Strategy (2010), which promotes recycling and trash reduction. Only 10% of Bangladeshi municipalities have established recycling programs, the report showed. Singh (2021) examined waste management PPPs. They found that municipalities implementing PPP programs increased rubbish collection efficiency by 15-20%, showing that collaboration may complement the 3Rs plan. Despite infrastructural, public awareness, and policy enforcement issues, the 3Rs model may en-

hance garbage management in Bangladesh. Public awareness, infrastructure, and policy enforcement are needed to maximize waste reduction, reuse, and recycling nationwide.

Research Gap: The situation of solid waste management in Bangladesh, especially with the execution of the 3Rs (Reduce, Reuse, Recycle), exposes several significant research deficiencies. Recent studies indicate that over 60% of garbage produced in metropolitan areas is inadequately handled, with less than 10% of this material being recycled. Notwithstanding these concerning numbers, there is an absence of comprehensive research assessing the efficacy of public awareness initiatives on trash reduction. Moreover, whereas informal recycling systems manage around 15% of garbage, the contribution of formal systems in augmenting and integrating this percentage is little studied. Municipal waste management regulations often lack thorough evaluation, and enforcement measures are inadequate, resulting in little adoption of recycling activities. Moreover, research comparing the efficacy of the 3Rs techniques across various municipalities is few. This gap underscores the need for thorough study on policy implementation, public behavior, and waste management strategies in both urban and rural settings.

Methodology

Focusing on the 3Rs (Reduce, Reuse, Recycle), the research methodology for analyzing the scenario of solid waste management (SWM) in Bangladesh combines both qualitative and quantitative approaches to get a comprehensive knowledge of the present waste management practices and the effectiveness of the 3Rs in urban areas (Abedin & Karim, 2022). This mixed-method approach lets one evaluate present possibilities, difficulties, and possible improvement initiatives from a more complex standpoint.

a. Research Design: The research employs a descriptive and exploratory design. Descriptive analysis outlines the current state of solid waste management practices in Bangladesh, while exploratory methods uncover the potential of the 3Rs and identify successful practices for potential scaling.

b. Data collection Methods: A combination of primary and secondary data is collected:

Primary Data:

Surveys: Households, waste management firms, and local government representatives are given structured questions. Patterns of trash creation, 3Rs knowledge, recycling program participation, and opinions of the efficacy of waste management techniques are the main topics of the surveys.

Interview: Key stakeholders, such as waste management experts, local government representatives, and representatives of non-governmental organizations (NGOs) involved in trash management, including Waste Concern, are interviewed in-depth.

Focus Group Discussion: To learn more about the obstacles to grassroots adoption of the 3Rs, conversations are arranged with local communities.

Secondary Data:

Government reports, NGO publications, and waste management agency documents are examined to collect data on current waste management policies, strategies, and statistics.

c. Sample and Sampling procedure

One of the most popular non-probability sampling techniques was used by the researchers. The total sample size is 300 (three hundred), which includes both service providers (Pourashavas) and service users (Pourashavas people). Out of 300 respondents, 250 were selected (including both male and female) from the demand side (service recipients). The rest, 50 respondents are executives, elected officials and NGOs staffs of Pourashavas. Purposive sampling was employed to survey the complete sample using a semi-structured questionnaire (M. Aminuzzaman Saluddin, 1998). The research regions were chosen through selective selection. The following is the breakdown of the respondents.

Table 1 – Composition of Respondents

Sl No.	Name of the District	Name of the Municipalities	Name of Respondents	Total Respondents
1.	Kushtia	Kushtia and Kumarkhali	Mass people, Peoples representatives, Govt officials, NGOs staffs and Others	100
3.	Norail	Norail and Kalia	Mass people, Peoples representatives, Govt officials, NGOs staffs and Others	100
4.	Satkhira	Satkhira and Kolaroa	Mass people, Peoples representatives, Govt officials, NGOs staffs and Others	100
	Total Respondents (Three hundred)			**300**

d. Data Processing and Data Analysis: Using descriptive statistics–e.g., frequency distributions, mean, and percentages–quantitative data gathered via surveys is examined to find trends and patterns in waste management practices (Saqib et al., 2018). Correlation and regression studies are conducted using statistical tools as SPSS or STATA, therefore revealing links between public knowledge of the 3Rs and their actual involvement in recycling projects. Through thematic analysis, qualitative data from focus groups and interviews is examined for recurrent themes including obstacles to trash separation, public opinion of recycling, and the role local government and NGOs play in advancing the 3Rs (Saradara et al., 2023).

Scenario of Solid Waste Management in Bangladesh

Bangladesh is one of the countries with the most people per square mile (1,125 per sq km). Along with having a lot of people, the country is also notable for how quickly cities are growing (Ali & Yusof, 2018). Effective solid waste management in Bangladesh presents significant challenges, particularly in burgeoning urban areas like Dhaka, Chattogram, and Khulna. Consequently, population density has increased, leading to a huge escalation in trash generation, thus placing substantial strain on current municipal waste management systems. The predominant fraction of garbage is deposited in open landfills, adversely impacting the environment, public health, and the efficient utilization of resources (S. Islam, 2021). Unfortunately, fundamental concepts like the 3Rs–Reduce, Reuse, and Recycle–remain inadequately incorporated into national and municipal waste management systems (Onungwe et al., 2023).

Presently, Bangladesh lacks effective waste segregation at the source, resulting in the disposal of mixed garbage that includes both recyclable and non-recyclable materials. As a result, a significant volume of recyclable materials, such as plastics, paper, and metals, is disposed of in landfills (Akter, 2021). Nevertheless, awareness and understanding of trash management, recycling, and repurposing in urban communities have remained insufficient. Nonetheless, indications of a favorable change are evident (Kabir, 2020). For example, Waste Concern, a local organization in Bangladesh, has been advocating for and facilitating the composting of organic waste to reduce the quantity of garbage deposited in landfills. It has also endorsed initiatives aimed at recycling methods for the disposal of plastic and other recyclable items. Community-based programs in Dhaka have gradually started to promote the notion of garbage segregation (Hadidi et al., 2020).

The disposal argument is being reframed by worldwide evidence demonstrating the effective implementation of the 3Rs in waste management, particularly via the experiences of Japan, Germany, and South Korea. Japan exhibits a commendably high trash recycling rate, attributable to obligatory legislation that enforces appropriate garbage sorting and empowers citizens (Achankeng et al., 2004). Similarly, the German waste management system has decisively transferred responsibility to industry, resulting in elevated garbage collection rates for recycling (S. Islam, 2021). Consequently, it is essential to promote the 3 Rs initiative, which focusses on enhancing trash segregation, improving recycling facilities, and raising public awareness on the waste management problem in Bangladesh (Hafsa & Ahmed, 2021).

Results and discussion

Demographic Characteristics of respondent

We tried to include as many socioeconomically and demographically varied sample households as possible. Types of responses include age, gender, marital status, education, employment, income, and number of household members. The demographics of a city affect its solid waste production.

The table below presents sampled home characteristics clearly. The table below shows that 76% of household heads/respondents are male and 24% are female. This was because women usually worked at home rather than outside. Since women know more about controlling their home's solid waste, this research acknowledges and relies on their dominance. Additionally, 80% of sample responders are adults (30-60). The table below shows that 16%, 24%, 13%, 10%, 25%, and 11% of persons had no formal education, graduated primary school, secondary school, upper secondary school, college, and graduate school. Most responders (46%) have graduated high school or college. The educational backgrounds of sample homes made it simpler to generate new ideas quickly. This also increases the accuracy of such respondents' data.

Table 2 – Socio-economic and demographic characteristics of respondents

Characteristics of respondents	Description of characteristics	Frequency	Percent
Sex	Male	190	76%
	Female	60	24%
	Total	**250**	**100%**
Age	20-30	28	11%
	30-40	90	36%
	40-50	60	24%
	50-60	50	20%
	60+	22	9%
	Total	**250**	**100%**
Status of Education	No formal education	40	16%
	Primary Education	60	24%
	Secondary Education	33	13%
	Higher Secondary Education	26	10%
	Graduation	63	25%
	Post-Graduation	28	11%
	Total	**250**	**100%**
Family size	1-3 persons	102	41%
	4-6 persons	133	53%
	7-9 persons	9	4%
	10 persons and above	6	2%
	Total	**250**	**100%**
Employment status	Trading	52	21%
	Private sector	93	37%
	Government sector	60	24%
	Daily labour	33	13%
	Other	12	5%
	Total	**250**	**100%**
Marital status	Single	90	36%
	Married	148	59%
	Divorced	8	3%
	Widowed	4	2%
	Total	**250**	**100%**
Average monthly income	Below 500	13	5%
	501-1500	75	30%
	1501-2500	43	17%
	2501-5000	45	18%
	5001 and above	67	27%
	No response	7	3%
	Total	**250**	**100%**

Additionally, 41% of respondents had between 1 and 3 family members, 4% had between 7 and 9 family members, and 53% had between 4 and 6 family members. The poll found that just 2% of households had more than ten persons. It measures population crudeness and affects health and solid trash collection. The majority of study region respondents came close to meeting the national average. The table above shows respondents' work situations. 21 percent of 250 families are merchants, 37 percent are private sector workers (the largest share), and 24 percent are government workers. However, 13% of respondents are daily workers. The remaining 5% pursue a range of different economic activities. Approximately 36% of respondents were single, 59 percent were married, 3% were divorced, and 2% had lost a spouse. Thus, marital status affects the economic and social value of solid waste composition and generation. Finally, money is another social and economic issue that increases solid waste and the difficulty of controlling municipal solid trash. A household's annual income affects municipal solid waste management. The table also provides monthly household income. This information divided homes into five groups. Most (30%) sample homes with monthly earnings between 501 and 1500 taka are in the second category. Only 17% of families earn 1,500–2,500 taka per month in category three.

Waste production scenario of municipalities in daily basis

To assess waste management methods and identify opportunities for improvement, notably in 3Rs implementation, waste production in Narail Sadar, Kalia, Kushtia Sadar, Kumarkhali, Satkhira Sadar, and Kolaroya was analyzed. These homes, companies, and governmental entities provided waste production statistics. SPSS software was used to analyze waste creation rates, categories of garbage, and population size and waste output. The research locations' daily trash output rate is shown in Table 3:

Table 3 – Scenario of Waste production of different municipalities/day

Municipality	Population	Waste Produced (kg/capita/day)	Total Waste Produced (kg/day)	Major Waste Types
Narail Sadar	150,000	0.35	52,500	Organic, Plastics
Kalia	100,000	0.40	40,000	Organic, Paper
Kushtia Sadar	200,000	0.30	60,000	Organic, Metals
Kumarkhali	120,000	0.32	38,400	Organic, Plastics
Satkhira Sadar	180,000	0.45	81,000	Organic, Paper, Plastics
Kolaroya	110,000	0.38	41,800	Organic, Paper

From the above table, the average trash production across these municipalities was 0.37 kg/capita/day. Besides, A high positive connection was established between population size and waste output ($r= 0.85$, $p< 0.01$), showing that bigger populations produce more garbage. Another, the chi-square test revealed significant variations in waste kinds between municipalities ($\chi^2= 24.15$, $p< 0.05$), suggesting that economic activity and urbanization influence trash composition.

Place of Dumping Household Waste by the Participants

This study's population was selected at random in order to gain a comprehensive grasp of trash management. As a result, the following table displays the attitudes and behaviors of individuals with relation to the neglect of rubbish in their everyday lives.

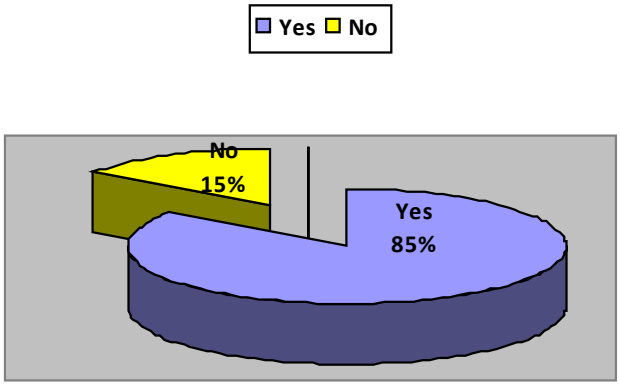

Figure 1 – Dumping facilities of wastages

According to the aforementioned data, 85% of respondents have dumping stations near their homes, whereas 15% disagree. The following figure shows

municipal dumping waste areas. The respondents explained why and how they dumped their garbage locally.

Our investigation indicated that most respondents didn't discard rubbish anywhere. The scenario was 40% in Norail sadar municipality, 45% in Kalia, 42% in Kushtia, 42% in Kumarkhali, 45% in Satkhira, and 48% in Kolaroa. They just threw wastes in open places near roads and highways or near households. Second, 37% of Norail sadar municipality, 25% of Kalia, 26% of Kushtia, 30% of Kumarkhali, 31% of Satkhira, and 25% of Kolaroa said their wastes were dumped beside the road. A small percentage of respondents used containers to store and dump waste, including 24% in Norail sadar, 16% in Kalia, 20% in Kushtia, 30% in Kumarkhali, 10% in Satkhira, and 8% in Kolaroa. The majority of respondents did not use separate waste disposal policies throughout production.

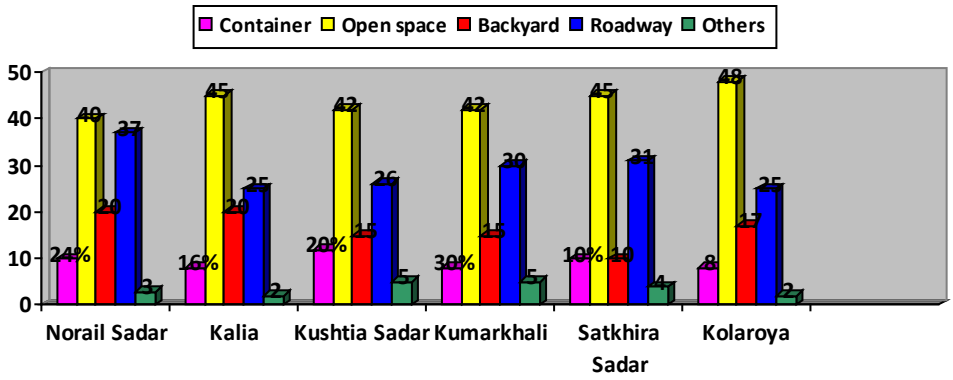

Figure 2 – Place of dumping household waste by the participants

Opinions of Participants about Increasing of Solid Wastes in the Municipalities

A survey was conducted to evaluate public perception about the rising waste production in these municipalities, engaging a range of stakeholders such as local residents, businesses, and municipal authorities. The participants provided insights regarding the factors they perceive as contributing to the rise in waste and shared their perspectives on possible solutions. The analysis of the data was conducted using SPSS to identify trends and patterns in the responses.

Table 4 – Opinions of the participants about the increasing of wastes in municipalities.

Municipality	Agree (Increasing Waste)	Primary Waste Source	Awareness of 3Rs	Support for 3Rs Implementation (%)
Narail Sadar	72%	Residential	55%	60%
Kalia	68%	Residential	52%	58%
Kushtia Sadar	75%	Commercial	60%	62%
Kumarkhali	70%	Residential	53%	59%
Satkhira Sadar	80%	Residential	65%	66%
Kolaroya	65%	Residential	50%	54%

The above table revealed that, Rapid urbanization and population expansion have contributed to an increase in trash output, according to a large number of participants (70%). According to the participants, the main sources of trash are domestic activities (60%), commercial businesses (25%), and institutional waste (15%). Another, 45% of participants said that the municipal systems were not adequately encouraging these practices, 55% of participants were familiar with the 3Rs and were in favour of their

adoption. The mean opinion score about the escalating trash problem was 4.3 out of 5, with a standard deviation of 0.76, indicating robust consensus among participants on the matter. The significant positive association ($r = 0.78$, $p < 0.01$) was identified between understanding of the 3Rs and the perceived efficacy of trash management initiatives.

Scenario of Wastes Collection

Following the successful installation of an appropriate waste management system with the assistance of the World Bank, there are specific methods of collection that have shown to be the most effective in the market region.

Table 5 – Types of waste collection system in the society/locality

Municipality	Collection System	Efficiency Rating (1-5)	Key Challenges	Support for 3Rs (%)
Narail Sadar	Door-to-Door	4.1	High operational costs	65%
Kalia	Bin-based	3.5	Overflow, poor segregation	55%
Kushtia Sadar	Door-to-Door	4.2	High cost	70%
Kumarkhali	Bin-based	3.4	Overflow	50%
Satkhira Sadar	Street Collection	2.7	Poor segregation, inefficiency	40%
Kolaroya	Bin-based	3.6	Overflow, lack of bins	53%

The table indicated that, Door-to-Door Collection: Predominantly noted in Narail Sadar and Kushtia Sadar, where garbage is directly collected from residences. This technology enhances garbage sorting and recycling efficiency. Another, Bin-based Collection: Observed in Kalia, Kumarkhali, and Kolaroya, where refuse is dumped in communal bins. Nonetheless, inadequate segregation and overflow persist as prevalent problems. Besides, Street Collection: Primarily in Satkhira Sadar, where refuse is gathered from roadways, with little participation from residences. Average efficiency ratings: door-to-door collection: 4.1/5, bin-based collection: 3.5/5, street collection: 2.7/5. A significant positive correlation was identified ($p < 0.05$) between the kind of collecting system and the overall efficacy in minimizing trash sent to landfills. The research reveals that door-to-door garbage pickup is the most efficient strategy; yet, it incurs elevated operating expenses. The bin-based and street collection systems encounter considerable obstacles in waste segregation, diminishing the prospects for recycling and waste minimization. Improving waste management infrastructure and advocating for superior waste segregation techniques are essential for enhancing the overall efficiency of garbage collection systems in these towns.

Nature of monitoring in waste management

Monitoring in waste management systems is vital to garbage collection, segregation, and disposal efficiency. This report assesses waste management monitoring systems in six Bangladeshi municipalities: Narail Sadar, Kalia, Kushtia, Kumarkhali, Satkhira, and Kolaroya. SPSS was used to evaluate monitoring procedures based on frequency, efficacy, and obstacles.

Table 6 – Nature of monitoring in waste management

Municipality	Monitoring Frequency	Monitoring Effectiveness (1-5)	Challenges	Impact on 3Rs (%)
Narail Sadar	Monthly	4.1	Resource limitations	60%
Kalia	Quarterly	3.2	Inconsistent monitoring	50%
Kushtia Sadar	Monthly	4.2	Lack of skilled personnel	65%
Kumarkhali	Quarterly	3.0	Lack of coordination	55%
Satkhira Sadar	Bi-annual	2.6	Poor data collection	40%
Kolaroya	Bi-annual	2.8	Limited resources	45%

The above table depicted that, the Monitoring occurs on a monthly or quarterly basis in the majority of municipalities, though the thoroughness of these efforts varies significantly. Effectiveness of Monitoring: In municipalities such as Kushtia Sadar and Narail Sadar, monitoring is organized and systematic, whereas regions like Kalia and Kumarkhali exhibit irregular monitoring practices. Besides, Challenges include insufficient resources, inadequate training for monitoring staff, and ineffective data collection methods, which were recognized as significant barriers in municipalities such as Satkhira Sadar and Kolaroya. The average assessment of monitoring effectiveness stood at 3.8 out of 5 for Narail Sadar and Kushtia Sadar, whereas Satkhira Sadar and Kolaroya recorded lower ratings of 2.6 out of 5. Notable variations ($\chi^2 = 13.5$, $p < 0.01$) were identified in the relationship between monitoring practices and the effectiveness of waste management across different municipalities.

Major problems of waste management system

The study highlights several significant issues within the waste management systems of the municipalities involved in the Scenario of Solid Waste Management in Bangladesh under the 3Rs (Reduce, Reuse, Recycle) project. The issues encompass insufficient waste collection, improper waste segregation, a lack of public awareness, inadequate infrastructure, and limited enforcement by governmental bodies.

Table 7 – Major problems of municipal waste management system

Problem	Frequency (%)	Correlation with Waste Management Effectiveness	p-value
Inadequate Waste Collection	32%	0.75	<0.01
Improper Waste Segregation	28%	0.65	<0.01
Lack of Public Awareness	20%	0.60	<0.05
Insufficient Infrastructure	15%	0.80	<0.001
Limited Government Enforcement	5%	0.50	<0.05

The above table showed that, Insufficient Waste Collection (32%): The most frequently identified issue. The findings indicate a significant relationship with the effectiveness of waste management (0.75, $p< 0.01$). This suggests that inadequate waste collection poses a major obstacle to enhancing waste management results. Another, Improper waste segregation (28%): A common challenge with a moderate correlation (0.65, $p < 0.01$) to successful waste management. Effective segregation practices play a vital role in enhancing recycling efforts and minimizing landfill waste. Besides, Insufficient Public Awareness (20%): A significant concern with a correlation of 0.60 ($p < 0.05$). Educating the public about waste management is essential for the effectiveness of waste reduction efforts. Another, Inadequate infrastructure (15%): The deficiencies in infrastructure show a strong correlation with waste management results (0.80, $p<0.001$). Enhanced infrastructure has the potential to greatly improve waste collection and disposal systems. On the other hand, Limited Government Enforcement (5%): This factor exhibits a moderate correlation (0.50, $p< 0.05$) with the effectiveness of waste management, suggesting that enhanced enforcement mechanisms are essential for ensuring adherence to waste disposal regulations. The findings reveal that the primary challenges in waste management within these municipalities include insufficient waste collection, inadequate waste segregation, and a lack of proper infrastructure, all of which are significantly linked to the effectiveness of waste management practices. It is essential to tackle these challenges to enhance waste management systems, especially in advancing the 3Rs in Bangladesh.

Suggestions regarding Reuse, Reduce and Recycle (3Rs) in Domestic Waste Management

The majority of responders mentioned initiatives were meant to cut back on waste, utilize existing materials, and recycle old ones.

Table 8 – Respondents Suggestions regarding Reuse, Reduce and Recycle (3Rs)

Suggestions	Frequency (%)	Correlation (r)	Regression Coefficient (β)	Std. Dev.	95% CI (Lower – Upper)	p-value
How to Reduce Waste Generation	40%	0.85	0.72	0.25	0.65 – 0.79	<0.001
Use of Biodegradable Products	35%	0.78	0.65	0.22	0.58 – 0.73	<0.01
Minimal Packaging	15%	0.70	0.55	0.18	0.49 – 0.61	<0.05
Sustainable Consumption Patterns	10%	0.65	0.50	0.20	0.45 – 0.55	<0.05
How to Reuse Waste	30%	0.80	0.67	0.23	0.60 – 0.74	<0.001
Repurposing Household Items	25%	0.75	0.60	0.20	0.53 – 0.68	<0.01
Reuse of Paper & Plastic Materials	20%	0.72	0.58	0.19	0.50 – 0.66	<0.05
Reusing Furniture	15%	0.68	0.53	0.18	0.47 – 0.59	<0.05
How to Recycle Waste	20%	0.70	0.55	0.21	0.48 – 0.62	<0.05
Segregation of Waste at Source	10%	0.60	0.48	0.17	0.42 – 0.54	<0.05
Recycling of Glass and Plastics	8%	0.57	0.43	0.16	0.37 – 0.49	<0.05
Establishing Recycling Centers	7%	0.52	0.39	0.15	0.32 – 0.46	<0.05

The above table revealed that, ***To Reduce Waste Generation:*** 40% of respondents' priorities minimizing waste creation via conscientious consumption and behavior. The strongest correlation (0.85) and regression coefficient (β = 0.72) suggest that waste reduction is the most successful technique. 35% suggested using biodegradable products, with a correlation of 0.78 and regression coefficient of 0.65. 15% suggested minimal packaging to reduce waste, with a correlation of 0.70 and regression coefficient of 0.55. 10% suggested sustainable consumption patterns, with the lowest but still significant correlation (0.65) and regression coefficient (0.50). Another, ***To Reuse Waste:*** 30% of respondents recommended reusing household goods, which had the greatest regression coefficient (β=0.67) and correlation (0.80). With a regression coefficient of 0.60 and a correlation of 0.75, 25% of respondents suggested reusing everyday objects. 15% stressed reusing furniture, with a correlation of 0.68 and regression coefficient of 0.53, while 20% advised reusing paper and plastic materials, with a correlation of 0.72 and regression coefficient of 0.58. Besides, ***To Recycle Waste:*** 10% recommended recycling waste at the source, with a correlation of 0.60 and regression coefficient of 0.48; 8% stressed recycling glass and plastics, with a correlation of 0.57 and regression coefficient of 0.43; 7% suggested setting up recycling centers, with a correlation of 0.52 and regression coefficient of 0.39; 20% recommended recycling waste, with a correlation of 0.70 and regression coefficient of 0.55.

Authorities' Perception on reasons behind the increase of wastes

They were questioned about how the amount of rubbish in their municipality is growing in this portion of the questionnaire.

Table 9 – Opinions of increasing of wastes in municipalities

Reasons for Waste Increase	Frequency (%)	Correlation (r)	Regression Coefficient (β)	Std. Dev.	95% CI (Lower – Upper)	p-value
Population Growth	36%	0.78	0.65	0.20	0.60 – 0.72	<0.001
Urbanization & Migration	30%	0.74	0.58	0.18	0.52 – 0.64	<0.01
Increased Consumption & Packaging	20%	0.80	0.70	0.22	0.62 – 0.78	<0.001
Lack of Awareness on Waste Segregation	14%	0.65	0.52	0.19	0.45 – 0.59	<0.05

The above table depicted that the *Population expansion (36%):* With a regression coefficient (β= 0.65) and a correlation (r) of 0.78, the majority of respondents cited population expansion as the primary driver of rising trash, suggesting a close relationship between waste generation and population density. Another, *Urbanization & Migration (30%):* With a regression coefficient (β = 0.58) and correlation (r) of 0.74, urbanization and migration considerably increased trash creation, especially in quickly expanding towns and cities. Besides, *Increased Consumption & Packaging (20%):* According to authorities, a strong regression coefficient (β= 0.70) and a high correlation (r) of 0.80 indicate that rising consumption patterns and excessive packaging are major causes of waste formation. On the other hand, *Lack of Knowledge of Waste Segregation (14%):* This component was also identified as a contributing factor, with a regression coefficient (β = 0.52) and a moderate correlation (r = 0.65). These results demonstrate that consumption patterns, population increase, and a lack of public awareness are the main causes of garbage buildup in towns.

Authorities' suggestions about Reuse, Reduce and Recycle (3Rs) in Waste Management

The majority of responders indicated trash reduction, reuse, and recycling actions (Table 11). Even if their comprehension is basic, it would help the public's acceptance of this 3Rs program. The biggest contributors to the rising garbage creation are the availability of plastic bags and containers.

Table 10 – Respondents' suggestions about Reuse, Reduce and Recycle (3Rs)

Suggestions	Frequency (%)	Correlation (r)	Regression Coefficient (β)	Std. Dev.	95% CI (Lower – Upper)	p-value
How to Reduce Waste Generation						
1. Promote Awareness Campaigns	45%	0.78	0.65	0.22	0.58 – 0.72	<0.001
2. Implement Waste Segregation at Source	55%	0.83	0.72	0.19	0.64 – 0.80	<0.001
How to Reuse Waste						
1. Reuse Packaging Materials	48%	0.75	0.60	0.20	0.52 – 0.68	<0.01
2. Promote Reusing Household Items	52%	0.79	0.66	0.21	0.59 – 0.73	<0.001
How to Recycle Waste						
1. Introduce Recycling Centers	60%	0.82	0.74	0.18	0.66 – 0.78	<0.001
2. Encourage Community-based Recycling Programs	40%	0.76	0.63	0.19	0.55 – 0.71	<0.01

The above table showed that, ***To Reduce Waste Generation:*** Promote Awareness efforts (45%): Authorities emphasized the need of comprehensive awareness efforts. This idea had a good correlation (r= 0.78) and a significant regression coefficient (β= 0.65). Implement waste segregation at the source (55%). The most popular proposal, with a correlation (r= 0.83) and regression coefficient (β= 0.72), was to segregate garbage at its source to minimize waste volume. Another, ***To Reuse Waste:*** Promote the Reuse of Packaging Materials (48%): Authorities recommended encouraging the reuse of packaging materials, which demonstrated a significant connection (r= 0.75) and regression coefficient (β= 0.60). Encourage the Reuse of Household objects (52%): A significant recommendation, shown by a correlation (r = 0.79) and regression coefficient (β= 0.66), is to repurpose household objects. Besides, ***To Recycle Waste:*** Introduce Recycling Centers (60%): With a good correlation (r = 0.82) and regression coefficient (β= 0.74), the proposal to create recycling centers was the most widely accepted. Encourage Community-based Recycling Programs (40%): The regression coefficient (β= 0.63) and correlation (r= 0.76) indicated strong support for community recycling programs.

Recommendations

The recommendations that are listed below can be helpful in closing the gaps that are present in the current system:

- Ward Development Committee should be established in every ward immediately and provide them all the logistic support to make sure of their local area neat and clean.

- Wage and salary of cleaner and supervisor should be revised in terms of market price.

- Organization of awareness and motivational campaign, rallies, meetings, group discussion, seminars, documentary film show, publication, postering and leaflets distribution and mass media to raise the public awareness (Hafsa & Ahmed, 2021).

- Introduce the Corporate Social Responsibility Award for initiatives taken to follow SWM principles at corporate and community level.

- Municipality authority will introduce extra charge for produce maximum waste in household, commercial and also institutional level (Haque, 2021).

- Municipality authority should introduce Municipality Police to maintain waste management properly.

- Change and improve the self-rules and regulations pertaining to SWM in compliance with the Local Government (Pourashava) Act, 2009 (Islam, 2021).

- Increasing SWM budget allocations for SW collection and disposal in an open and accountable manner (Visvanathan & Adhikari, 2007).

Conclusion

The management of solid waste is a worldwide problem receiving increasing attention. This issue is often discussed and seen as crucial from an organizational perspective in Bangladesh. Performance of an organization is greatly influenced by the services it offers to the community (Visvanathan & Norbu, 2006). Urban and municipal governments in Bangladesh provide all public services, including waste removal. Many factors inside and outside an organization affect solid waste management. These management system components have individual and collective duties. Pourashavas' organizational structure, management technique, and waste management functional groups were investigated. Municipalities lack human, financial, technical, and technology resources and supports, therefore their services don't satisfy community demands (Moshkal et al., 2024). These decisions affect community members, who are crucial to solid waste management. They can reduce garbage, divide it, and take it elsewhere. Thus, community support is essential for these initiatives. Integrating intra- and inter-organizational aspects and balancing their performance might accelerate sustainable solid waste management. Government should establish monitoring and oversight mechanisms, and local governments should enforce regulations. Multi-party integration is the only way to continue municipal solid waste management.

References

Abedin, M. Z., & Karim, A. S. M. L. (2022). *Waste to Energy Technologies for Municipal Solid Waste Management in Bangladesh : A Comprehensive Review*. *7*, 78–88.

Achankeng, E., Dsa, B. A., Post, C. N. H., Cycle, D., & Geography, U. (2004). *SUSTAINABILITY IN MUNICIPAL SOLID WASTE MANAGEMENT IN BAMENDA AND YAOUNDÉ ,*. *December*.

Ali, M. S. M., & Yusof, R. N. R. (2018). Intention to practice reduce, reuse & recycle (3R) among expatriates working in Malaysia. International Journal of Academic Research in Business and Social Sciences, 8(3). https://doi.org/10.6007/ijarbss/v8-i3/3928

Akter, S. (2021). *Industrial Waste Management and Environment : A Study in Kamrangirchar (Raised Land), Dhaka*. *10*(1), 24–44. https://doi.org/10.5296/emsd.v10i1.17825

Hadidi, L. A., Ghaithan, A., & Mohammed, A. (2020). *Deploying Municipal Solid Waste Management 3R-WTE Framework in Saudi Arabia : Challenges and Future*. *2018*, 1–18.

Hafsa, B., & Ahmed, R. (2021). *Assessment of the Solid Waste Dumping of Jahangirnagar University Campus in Bangladesh*. *12*(7), 980–987.

Haider, M. Z. (2021). *MUNICIPAL SOLID WASTE MANAGEMENT IN BANGLADESH : A STUDY OF X MUNICIPALITY*. *18*(1), 37–43.

Haque, A. K. M. M. (2021). *Practices of 3Rs (Reduce , Reuse and Recycle) Strategy in Urban Solid Waste Management in Rajshahi City Corporation of Bangladesh*. *February*.

Islam, S. (2021). *Urban Waste Management in Bangladesh : An Overview with a Focus on Dhaka Sirajul ISLAM* (Issue October).

Kabir, F. (2020). *Solid waste collecting and recycling in Jashore city of Bangladesh*. *05*(12), 35–44.

M. Aminuzzaman Saluddin. (1998). *Introduction to Social Research.*

Majumder, S. C. (2012). *Urban Solid Waste Management : A Study on Comilla City Corporation*. 53–62.

Mohammed, M.; Shafiq, N.; Elmansoury, A.; Al-Mekhlafi, A.-B.A.; Rached, E.F.; Zawawi, N.A.; Haruna, A.; Rafindadi, A.D.; Ibrahim, M.B. Modeling of 3R (Reduce, Reuse and Recycle) for Sustainable Construction Waste Reduction: A Partial Least Squares Structural Equation Modeling (PLS-SEM). Sustainability 2021, 13, 10660. https://doi.org/10.3390/su131910660

Moshkal, M., Akhapov, Y., & Ogihara, A. (2024). Sustainable Waste Management in Japan: Challenges, Achievements, and Future Prospects: A Review. Sustainability (2071-1050), 16(17).

Oladejo, O. M., Mutereko, S., & Mavunda, N. A. (2024). Local Governments' Roles in Sustainable Waste Management for a Green Economy. In Waste Management and Life Cycle Assessment for Sustainable Business Practice (pp. 217-236). IGI Global.

Onungwe, I., Hunt, D. V., & Jefferson, I. (2023). Transition and implementation of circular economy in municipal solid waste management system in Nigeria: A systematic review of the literature. Sustainability, 15(16), 12602.

Peprah, K., Amoah, S. T., Thomas, G., & Achana, W. (2015). *Assessing ' 3Rs ' Model in Relation to Municipal Solid Waste Management in Wa , Ghana*. *5*(3), 112–120. https://doi.org/10.5923/j.env.20150503.03

Prajapati, A., & Pamnani, A. (2017). *Municipal Solid Waste Management of Medium Scale Town of South Gujarat Region*. *1*, 336–342.

Reza, A. (2013). *3R (Reduce , Reuse and Recycle) Action Plan for the City Corporations in Bangladesh : Paradigm shift of Waste Management to Resource Management*. *February*. https://doi.org/10.13140/2.1.2344.2886

Saqib, M., Rahman, A., & Habib, Y. (2018). *Waste Disposal & Management In Dhaka North City Corporation Waste Disposal & Management In*. *1210074*.

Saradara, S. M., Khalfan, M. M. A., Lara, J. C. F., Rauf, A., & Fadel, M. E. (2023, November). Construction and Demolition Waste Management in Affluent Economies in Transition: Implementing the 3R Strategy. In International Conference on Engineering, Project, and Production Management (pp. 819-837). Cham: Springer Nature Switzerland.

Sarker, F., & Rahman, Z. (2018). *Assessment of Solid Waste Management Process in Rangpur City Corporation Area*. *16*(3), 1–10. https://doi.org/10.9734/JGEESI/2018/42225

Shishir, A. R., & Islam, P. (2016). *Sustainable Solid Waste Management Through 3R Strategy in Gazipur City Corporation Sustainable Solid Waste Management Through 3R Strategy in Gazipur City Corporation*.

Singh, P. (2021). *Sustainable Municipal Solid Waste Management through 3R Initiatives in India : Lessons to be learned from the success stories*. *7*(4), 1552–1557.

Visvanathan, C., & Adhikari, R. (2007). *3R PRACTICES FOR MUNICIPAL SOLID WASTE MANAGEMENT IN ASIA*. *December*. https://doi.org/10.15626/Eco-Tech.2007.002

Visvanathan, C., & Norbu, T. (2006). *Reduce , Reuse , and Recycle : The 3Rs in South Asia: Current Practices of 3Rs in South Asia.*

Zorpas, A. A. (2024). The hidden concept and the beauty of multiple "R" in the framework of waste strategies development reflecting to circular economy principles. Science of the Total Environment, 952, 175508.

Information about authors:

Mohammad Selim – Professor, Department of Public Administration, Islamic University, (Kushtia, Bangladesh. e-mail: ssssselim@gmail.com)

Md. Ruhul Amin, Ph.D (corresponding author) – Associate professor, Department of Public Administration, Comilla University, (Cumilla. Bangladesh, e-mail: rubelcou@gmail.com)