

The Impact of Solid Waste Generation, Storage and Separation Practices among Households on the Environment in Freetown

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Abstract

As urbanization and population growth continue to increase in Freetown, due to changes in economic, social, environmental, political, and demographic factors, the municipal solid waste (MSW) generation also continues to increase, making its management difficult for the municipal authority. Efficient separation and storage of solid waste at the source of generation can boost resource and energy recovery from MSW. This study examines the municipal solid waste management (MSWM) process, focusing on generation, storage and separation practices among households and their impact on the environment in Freetown. It emphasizes the inclusion of MSWM programs in primary schools to raise public awareness, the implementation of effective waste management practices, and the enforcement of related policies to enhance the MSWM sector, contributing to sustainable MSWM in Freetown. By utilizing both qualitative and quantitative methods, 393 structured questionnaires were administered across three selected sections to collect data on household solid waste storage and separation practices. The analysis employed descriptive statistics, using Origin-Pro9 and MS Excel. The findings show that with a population of 1.53 million people in Freetown, the per capita solid waste generation is 0.58 kg per day. The findings also show that 97% of the households have storage facilities as a result of the increase in awareness and education about the proper storage of solid waste. However, 96% of respondents do not practice separation of solid waste at the source of generation, which has become a concern among researchers in Sierra Leone. Additionally, 88% of respondents are unaware of ISWM principles, with only 12% aware, most of whom have received some education on proper solid waste management. The study recommends improving MSWM in Freetown to protect public health and the environment.

Keywords

Generation, Storage, Separation, Household, Municipal Solid Waste, Freetown

1. Introduction

Globally, the problem of municipal solid waste management (MSWM) remains a major challenge in municipal cities, especially in developing countries where cities and towns are experiencing rapid population growth and urbanization (Seik, 1997). This increase in population and urbanization has led to a corresponding increase in municipal solid waste (MSW) generation in urban cities calling for a need for more efficient solid waste management practices, focusing on the separation of solid waste at the source of generation to help reduce and find ways to utilize the solid waste (Harir et al., 2017) and (Hoornweg et al., 2013). In 2012, the global MSW generation was approximately 1.3 billion tons per year, with a projection to increase to 2.2 billion tons per year by 2025 (Hoornweg & Xie, 2012). According to the World Bank report in 2018, it was estimated that the global generation of MSW will potentially reach a volume of 3.4 billion tons by the year 2050 (Kaza, 2018). According to other reports, the global yearly generation of MSW was estimated to exceed 2 billion tons as of 2021 (Shah et al., 2021), with 33% not properly managed. It is predicted to quadruple to 4 billion tons by 2100 if appropriate measures are not put in place, causing substantial problems for human existence and the environment as a whole (Ebrahimian & Karimi, 2020). These trends have highlighted the urgent need for policies, and cooperation to deal with the rising global MSW generation rates. Poor MSWM can result in several environmental problems that pose risks to the environment and human health (Abuabdou et al., 2020; Seng et al., 2011). According to Kaza et al., (2018), these GHG emissions pose substantial hazards to marine ecosystems and human health (Das et al., 2019). This is extremely disappointing considering the importance of promoting sustainable urban development outlined in the 6th and 11th Sustainable Development Goals (SDGs) (Assembly, 2014). In 2015, efforts to reduce urban environmental impacts, as outlined in the SDGs by the United Nations Environment Programme (UNEP), emphasized the importance of effective waste management (UNEP Foam Technical Options Committee, 2015). Owing to these efforts, many developed nations have established efficient waste management systems that prioritize conserving resources rather than disposing of them (Gómez-Sanabria et al., 2022). According to Jaunich et al. (2019), a comparison of MSWM systems in developed and developing countries emphasized that developing countries like Sierra Leone, and Liberia, among others, need to focus on reducing environmental effects and establishing cost-effective solid waste management systems despite the limited municipal funds. Rather than simply emulating waste management practices from developed countries, sustainable evaluations should be conducted to ensure their

practicality in developing nations. A comprehensive assessment of influencing factors and potential outcomes is essential for the effective planning and implementation of strategies aimed at developing sustainable MSWM systems for the future.

Solid waste separation at source is the initial phase of waste recycling and is crucial for sustainable MSWM. Developed countries like the United States, Sweden, Japan, etc., have successfully implemented this practice (Takahashi, 2020; Nainggolan et al., 2019; Wen et al., 2014). Although solid waste separation policies have been well-established since the late 20th century in developed nations, there are still regions, particularly in many parts of Africa, Asia, and South America, where the practice is not officially recognized. In these areas, dumping sites, and landfills, continue to receive mixed solid waste without any pre-treatment or separation. According to Zhang et al. (2023), implementing waste separation improves the current waste management system by enhancing integrated waste management practices, ultimately leading to the efficient utilization of resources for a circular economy.

While government and private stakeholders provide institutional frameworks for environmental safety achievements, individuals play a vital role in successful policy implementation. The adoption of environmentally friendly behaviors is essential for achieving policy goals in the separation of solid waste at the source for environmental conservation. Factors such as households' socio-economic status, demographics, and the level of knowledge about the importance of a safe environment are closely linked to promoting waste separation, enabling reuse and recycling behaviors among residents in municipal cities.

In Freetown, MSWM faces several challenges, like inadequate coverage, limited funds, and insufficient resources, leading to poor storage and separation of solid waste at the source. These lead to the burning, littering, and dumping of solid waste causing environmental problems and health risks. These challenges also lead to high costs, poor services, and negative perceptions. Uncontrolled MSW disposal also results in flooding, insect infestations, and rodent problems, affecting the city's impoverished population. Additionally, low levels of public awareness and education exacerbate the situation.

In 2004, Freetown, the capital city of Sierra Leone generated 270,830 tons of MSW, with 0.45 kg/person/day leading to 742 tons of MSW generated daily. Only 30% - 35% of this MSW is collected and transported to authorized dumping site daily (Sood, 2004). The remaining 65% of the MSW accumulates, emitting harmful gases and leaching into groundwater systems (Sankoh & Yan, 2013). The quantity of MSW generation continues to increase to 272,290 tons in 2020, with an urban population growth rate of 4.2%. However, landfill remains the primary technology used in the treatment of MSW in Freetown. The inefficient separation of solid waste at the source has led to a significant quantity of MSW being disposed of in dump sites, resulting in the loss of resources. According to Antonis et al. (2014), among municipal cities in developing countries, Granville Brook (Kissy) located in the East of Freetown has been listed as one of

the 50 biggest dumping sites in the world. Although there are potential risks to human health and the environment, MSW is increasingly being recognized as a renewable resource that can be converted to fuel (Białowiec et al., 2018), energy (Triyono et al., 2019; Ngegba & Bertin, 2020), materials (Rodriguez-Narvaez et al., 2019), and higher-value by-products (Liu et al., 2018).

2. Background of MSWM in Freetown

In Freetown, Sierra Leone, the concept of separating solid waste at the point of generation has recently been introduced to address the escalating MSWM problem in the city. With over one million residents, Freetown faces significant daily waste generation, posing environmental and health risks. About 40% of the waste in Freetown is appropriately collected and disposed of, while the remaining waste accumulates in public areas (Gogra et al., 2010). To address this issue, the Sierra Leone government has launched several initiatives to improve MSWM, such as encouraging solid waste separation among households at source. An example of this is the “Pay as You Throw” program initiated by the Freetown City Council (FCC) in the 2018 FCC report, where households and businesses pay for the waste they generate, aiming to motivate waste separation and reduce landfill-bound waste.

2.1. Solid Waste Generation at Household Level in Freetown

Having comprehensive data on the amount of MSW generation is vital for efficient waste management practices. Factors like population growth and urbanization have contributed to a global increase in MSW generation, including Freetown. The urban population growth rate in Freetown is significantly higher than the national average (Statistics Sierra Leone, 2015), suggesting an increasing trend in the MSW generation. Statistics show that Freetown generates over 742 tons of MSW daily, with a larger portion being biodegradable waste (Sood, 2004). In 2020, other estimates indicate a notable increase in MSW generation at 0.5 kg per person per day in Freetown, which could potentially harm the environment and public health if not properly managed. In the same report, projections suggest that MSW generation in Freetown is expected to further increase in the coming years, potentially influenced by demographic changes and poor waste management infrastructure (Ngegba & Bertin, 2020). According to another study conducted by (Kanty et al., 2024), the city of Freetown generates approximately 851 tons of MSW per day with 0.58 kg of MSW generated per capita daily.

2.2. Access to Solid Waste Storage Facilities among Households in Freetown

In Freetown, the bulk of the MSW generated by households and institutions is stored in sacks or small containers meant for storage of solid waste at household and institutional levels. The MSW is later transferred to specific stations where communal skip containers are placed for collection and transportation to land-

fills by MSW collectors. The city faces challenges with an inadequate amount of skip containers at these specific stations for the transfer of solid waste from households. These skip containers are often overfilled to the extent that a significant portion of solid waste is deposited on the ground, leading to environmental problems such as air pollution and the spread of offensive odor detrimental to human health. When these containers are collected, they are not returned leading to further uncontrolled disposal of MSW at the intended container locations. Additionally, delayed container collection results in uncontrolled littering of MSW.

2.3. Solid Waste Separation Practice among Households in Freetown

In Freetown, the concept of separating solid waste at the source has recently been introduced to address the escalating MSWM problem in the city. With over one million residents, Freetown faces significant daily solid waste generation exceeding the collection capacity, posing environmental and health risks. Households continue to provide mixed solid waste without separating it into different recyclable fractions due to the absence of community waste collection bins that facilitate proper waste separation (Löytty, 2023). The bulk of the MSW generated by individuals in Freetown is stored unseparated in sacks or small containers at household, and institutional levels. This unseparated solid waste is then transported to dump sites making material recovery and recycling difficult. Freetown's municipal solid waste management faces problems with public participation, and low community responsibility due to cultural barriers, low levels of awareness, inadequate participation mechanisms, and insufficient enforcement. Additional issues include the lack of targeted training, leadership programs, effective, communication, adequate collection services, and collaboration with NGOs (Shah et al., 2021).

According to another community study conducted by Chen et al. (2020), source separation which is neglected in Freetown may increase the disposal loads, and moisture content from the solid waste combustion, and decrease the lower heating or calorific value of MSW, among other things. Study shows that sorting and separation of MSW, at the source of generation is a beginning point for material flow management which helps to reduce solid waste generation, resource recovery, and disposal of toxic/hazardous waste (Zhang et al., 2019). Building a top-down management system and enforcing policies by pressuring residents' sorting and separation behavior is believed to be a practical approach to promote the separation of MSW at the source of the generation before storage in developing countries (Zhang et al., 2022). This is done to lower intermediary processing centers and enhance the recovery rate; a practical source separation before storage and transportation are done (Calabro & Satira, 2020).

Vision 2035 which is built upon Public-Private Partnership (PPP) and geared towards building a circular economy in Freetown for sustainable MSWM fo-

cused on household separation of solid waste at the source of generation. The Freetown municipality collects the portions of solid waste, stocks them separately, and offers them as free raw materials for private companies to process new products leading to avoiding landfills as a common method of solid waste disposal. This is summarized in **Figure 1** below:

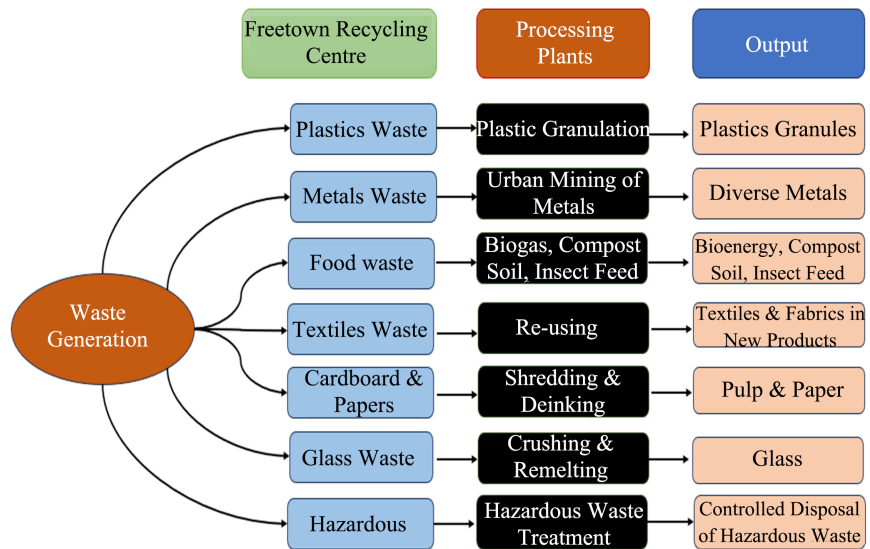


Figure 1. Summary of the solid waste separation strategy for recycling in Freetown.

2.4. Level of Public Education and Awareness about Integrated Solid Waste Management (ISWM) among Households in Freetown

In Freetown, the low level of awareness and knowledge about proper MSWM and ISWM approaches negatively impacts the sustainability of the MSWM system. Study shows that improving public education on solid waste recycling leads to higher recycling rates and can help increase the level of awareness and reduce costs. (Chen et al., 2009; Sidique et al., 2010a; Sidique et al., 2010b). Additionally, if citizens were well-educated and informed about the need to pay for the service of solid waste collection to keep the environment clean and healthy, they would have committed themselves to paying for the service. However, this is not the case in Freetown (Debrah et al., 2021).

2.5. The Influence of Existing Policies on Sustainable Municipal Solid Waste Management in Freetown

Brazil which is a developing country in South America, is excelling in municipal solid waste management (MSWM) due to effective policies, offering valuable lessons for other developing countries to learn from (Jabbour et al., 2014). In Freetown, Sierra Leone, sustainable MSWM depends on the implementation of existing policies. Evaluating these policies reveals challenges in creating a universally applicable model (Soltani et al., 2015). Laws and policies significantly impact environmental sustainability and MSW processes, including collection,

disposal, and recycling. They outline the roles of stakeholders and provide guidelines for minimizing environmental impact. The growing demand for renewable chemicals and fuels, coupled with stricter regulations on organic solid waste, pushes industries towards sustainability (Arancon et al., 2013). Despite numerous policies for effective MSWM in Sierra Leone, poor implementation hinders citizen compliance and effective waste management.

3. Materials and Methods

3.1. Study Area

Freetown which is the capital city of Sierra Leone, is situated on the coastal plain along the Atlantic Ocean. It is an economic, cultural, and political centre. Freetown has an estimated population of 1.53 million people and covers an area of 82.44 km². The city, being a large coastal area is challenged with MSWM. This threatens the ocean environment due to poor MSWM systems and improper disposal of MSW. As a result, it leads to environmental pollution, and degradation, endangering marine life and ecosystems.

Generally, Sierra Leone has a tropical climate and experiences rains between May and October, and the dry season starts in November and ends in April (Gogra et al., 2010). In Freetown, the average temperature is 26.2°C, or 79.2°F. About 3657 mm of rain falls there on average each year. April is the warmest month, with a temperature of 83.0°F (28.3°C). July is typically the coolest month, with an average temperature of 78.0°F (25.6°C). Study indicates that the production of solid waste is directly related to both the population and the level of economic development (Komba, 2021). The city is divided into three major municipal regions: the East End, Central, and West End. These regions are further divided into eight sections: East I, East II, East III, Central I, Central II, West I, West II, and West III. Out of the eight sections, only three were selected for this study. These are; Central I, East II, and West II which fall within different regions in the municipality of Freetown. According to the 2015 Population and Housing Census report of Sierra Leone, the East End region has the densest population (Statistics Sierra Leone, 2015). These regions have diverse socioeconomic and environmental conditions. The city faces challenges with inadequate infrastructure, inefficient MSW collection services, and poor disposal opportunities, leading to a reliance on informal waste collectors and open dumping, which pose risks to public health and the environment. Nonetheless, the estimated population of Freetown for 2024 is 1.53 million people, calculated using a specific formula as shown in Equation (1) below:

$$P_n = P_o \left(1 + \frac{r}{100} \right)^t \quad (1)$$

where;

P_n is the estimated population;

P_o is the old population as of 2015 (Statistics Sierra Leone, 2015);

r is 4.2% which is the urban population growth rate;

t is the intercensal period.

The study conducted by Pinka identified key factors that influence the amount and nature of solid waste generation in Freetown, particularly in residential areas. Factors such as family size, employment status, and income were linked to the generation of MSW at the household level in Freetown (Sankoh & Yan, 2013). To manage MSW effectively in Freetown, awareness raising concerning solid waste separation at the source of generation should be intensified, and also policies geared to source separation of solid waste should be formulated and implemented. The study aimed to assess the generation, storage and separation practice of solid waste at the source of generation among households in Freetown. It also examined the impact of policy implementation awareness raising, and knowledge in solid waste separation at the source of generation to improve the MSWM system in Freetown for a cleaner environment and human health. **Figure 2** depicts the study area Freetown, the capital city of Sierra Leone.

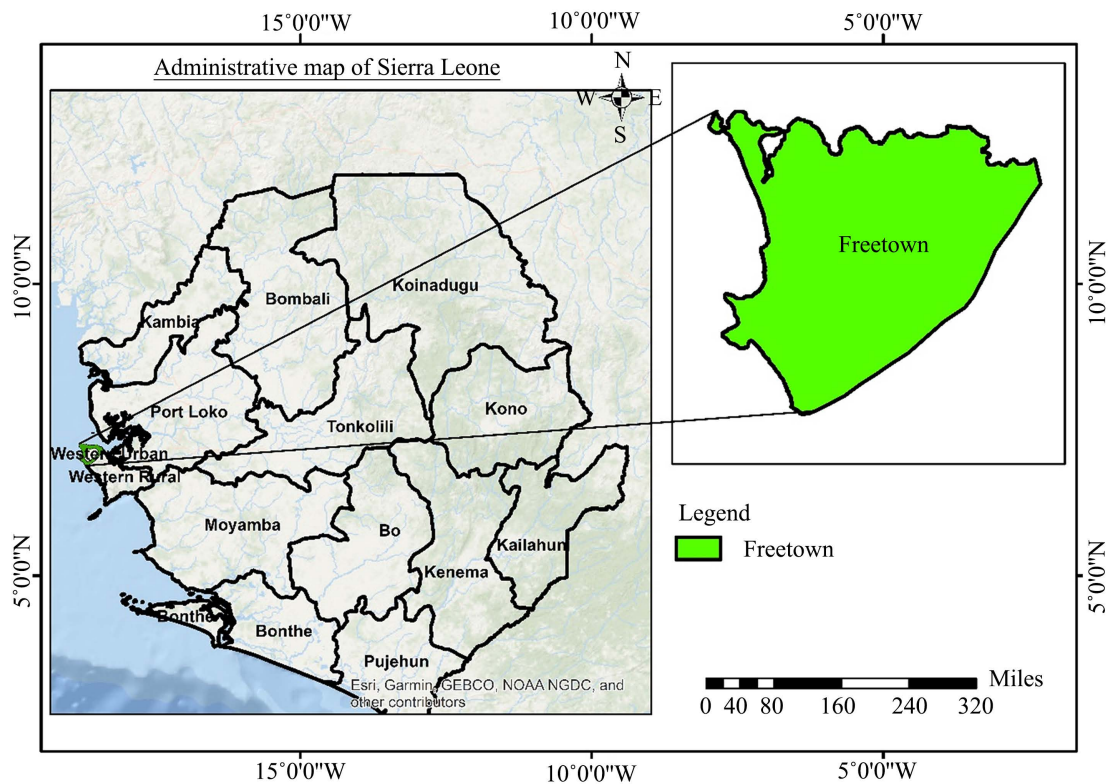


Figure 2. Administrative map of sierra leone showing the study area Freetown.

3.2. Methods, and Target Population

The study involved a combination of quantitative and qualitative methods to collect primary data for assessing the generation, storage, and separation of solid waste at the source of generation in Freetown (Lomax, 2007). By using a combination of quantitative and qualitative methods of data collection, study can account for the strengths and weaknesses of each approach (Connaway & Radford,

2017; Cooper, 2014). This dual-method analysis enhances the accuracy and depth of study findings (Cataldo et al., 2020). The study included three sets of questionnaires for households, landfill workers, and various institutions dealing with MSW in Freetown. The study was conducted in three different sections of the city simultaneously over 15 days. While this study provides important insight into the impact of solid waste storage and separation practices on the environment in Freetown, it is important to acknowledge the limitation of sampling only three sections of the city. This constraint driven by budget limitations, practices, and environmental impacts observed in the sampled sections may not fully represent those across the entire municipality of Freetown. However, each of the three sections was selected from the three regions in the municipality of Freetown. Each of these sections is found in regions with different economic statuses, environmental conditions, and cultural behaviors of the residents. The contiguity of these sections was also taken into consideration to ease the data collection process for the study. The sample size of 399 respondents was selected within the three selections with a population of 408,632 people using a specific formula in Equation (2).

$$n = \frac{N}{1} + N(e)^2 \quad (2)$$

where;

n : is the sample size;

N : total population in the study area;

e : sampling error (0.05).

3.3. Sampling Technique and Target Population

The study randomly selected households for participation, ensuring each had an equal chance of being included. Questionnaires were developed and tested before being used in the face-to-face interviews conducted by the enumerators. The study captured 390 respondents during the face-to-face survey. Secondary data was also collected from scientific papers, government documents, and international organization sources. While this study provides important insights into the impact of solid waste generation, storage, and separation practices on the environment in Freetown, it is important to acknowledge the limitation of sampling only three sections of the city. This constraint, driven by budget limitations, might affect the generalizability of the results. The specific practices and environmental impacts observed in the sampled sections may not fully represent those across the entire city of Freetown or other areas in Sierra Leone. However, further study can be done extensively in other parts of the city to enhance generalizability.

4. Results and Discussion

4.1. Population Structure

Understanding the population structure is crucial for studying MSWM in any

city. Out of 390 surveyed households, 88% of those actively involved in managing solid waste at home were female, and 12% were male. The majority of the respondents were between the ages of 15 and 44 years old, indicating that they might have likely had primary or secondary education and were knowledgeable about ISWM principles if it was introduced and taught at the primary level.

Table 1 and **Table 2** provide the frequency distributions of gender, and age characteristics of the respondents involved in the household solid waste management survey.

Table 1. Gender characteristics of the respondents.

Gender Characteristics	Frequency	Percentage (%)
Female	345	88
Male	45	12
Total	390	100

Table 2. Age characteristics of the respondents.

Age Characteristics	Frequency	Percent
15 - 24	20	5
25 - 34	124	32
35 - 44	138	35
45 - 54	69	18
55 and above	39	10

4.2. Level of Education of the Respondents

Since education is a determining factor in a person's lifestyle and social standing, the study has constantly shown that educational attainment significantly influences solid waste generation and attitudes toward solid waste management for a safer environment in Freetown. The level of education also affects the MSWM activities that households follow; the higher the level of education, the more information households have on solid waste generation and consumption behaviors in society. Additionally, the education level can influence the adoption of any new MSWM technology and help increase the level of awareness of solid waste management practices among households in Freetown. It was revealed that those with tertiary education who accounted for 13% of the respondents, were more efficient in responding to the questions during the interview, and a portion among them was well-informed about the ISWM approach. Furthermore, 41% of the respondents had primary education, 22% had no formal education, 20% had secondary education, and only 4% had vocational education.

In conclusion, it is recommended that residents be provided with the necessary knowledge about ISWM to increase their chances and willingness to actively participate in MSWM at the national level, thereby helping sustain the MSWM in Freetown. **Table 3** below shows the education characteristics of the respondents.

Table 3. Education characteristics of the respondents.

Education Characteristics	Frequency	Percent
No Formal Education	85	22
Primary Level	158	41
Secondary Level	69	20
Tertiary Level	61	13
Vocational Level	17	4

4.3. Generation of Solid Waste among Households in Freetown

The generation of municipal solid waste (MSW) in Freetown, Sierra Leone's capital, is a major environmental and public health concern. Urbanization and inadequate MSW management infrastructure, including collection systems, land-fill capacity, recycling, and composting facilities, contribute to the increasing MSW. Rapid population growth has outpaced MSW management facilities, resulting in poor waste management. Improper disposal practices, such as open dumping, burying, and burning, are common due to limited collection services at the household level. Low public awareness and knowledge exacerbate the issue. Many studies have shown that there have been remarkable changes in MSW generation in Freetown over the years due to population growth and urbanization. Therefore, the study used the data collected from the households to estimate the MSW generation in the entire Freetown. In 2024, Freetown, with a population of 1.53 million, generated 889 tons of MSW daily. This represents a significant increase in waste generation in Freetown in 2024 when compared to 2023. The study also shows that the per capita solid waste generation 2024 is 0.58 kg per day. However, this study indicates that the per capita solid waste generation remained unchanged between 2023 and 2024, which aligns with the findings of another study conducted by [Kanty, et al. \(2024\)](#). This stability could be due to changes in economic activities, income levels, and consumption patterns of the residents. However, there was an increase in consumption behaviors between 2020 and 2024 due to economic recovery, which subsequently led to an increase in solid waste generation among households. The study indicates that with continuous population growth and economic activities, MSW generation in Freetown will likely continue to increase significantly. While personal consumption cannot be halted, it can be regulated through effective municipal solid waste management policies. **Figure 3** illustrates the trends of per capita solid waste generation in kg/day among households in Freetown between 2020 and 2024.

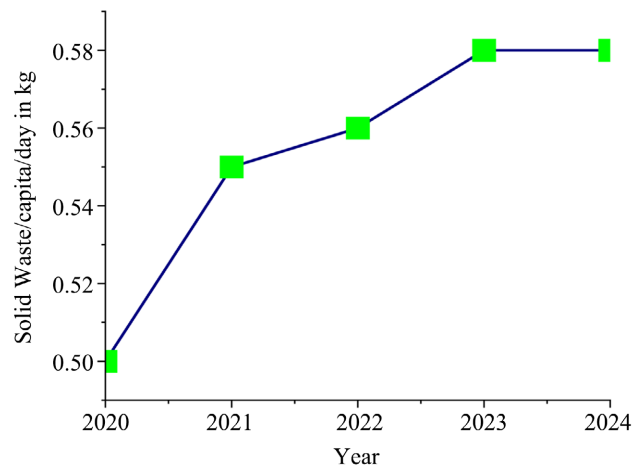


Figure 3. Trends of per capita solid waste generation in kg/day in Freetown between 2020 and 2024.

4.4. Availability of Solid Waste Storage Facilities among Households in Freetown

The availability of storage facilities among households and institutions in Freetown has progressed dramatically since 2008. The study showed that 97% of the respondents had storage facilities, while only 3% reported not having them. Through field observation, the study revealed that the way solid waste is stored at the household level in Freetown varies depending on factors like the level of income, education, and household attitudes. However, several common practices can be observed: many households in Freetown use waste containers or bins to store their solid waste. These containers are made of different materials such as plastic, metal, or repurposed drums. They are usually placed outside the house, either in the yard or along the street, for easy access and collection. Most households with higher education and economic status have different containers where different types of solid waste are stored separately at the source of generation.

In areas with limited MSWM infrastructure, many households use plastic bags to store their solid waste. These bags are often tied up and placed outside the house or hung on fences until collection day. However, this practice contributes to environmental pollution. The solid waste stored is not collected on time, resulting in anaerobic decomposition, releasing methane, hydrogen sulfide, volatile organic compounds (VOCs), and other harmful gases into the air. This process contributes to air pollution and poses multiple health and environmental hazards. The government and non-governmental organizations are making efforts to improve MSW storage and separation at the source of generation, promote recycling, and establish proper waste disposal facilities. These efforts towards effective MSW management in Freetown do not only involve educating the populace, providing necessary resources, enacting legislation, building infrastructure, facilitating public-private partnerships, and ensuring ongoing monitoring and regulation but also addressing the limitations of the current waste

collection system. Despite these comprehensive efforts, a significant challenge remains in the inadequate capacity of the skip containers placed at designated stations for the collection of MSW from households, institutions, and market-places. These small-capacity containers are insufficient to handle the volume of solid waste generated, thus complicating the collection and transportation efforts by formal MSW collectors and undermining the overall effectiveness of waste management strategies in the city. **Figure 4** below shows the percentage distribution of the availability of solid waste storage facilities among households.

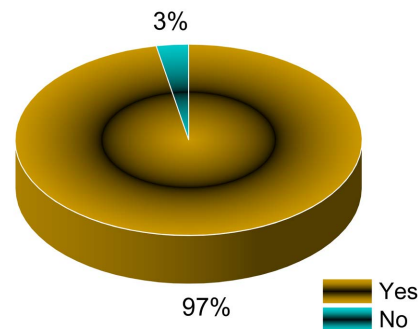


Figure 4. Percentage distribution of storage facility among households in Freetown.

4.5. Separation Practices of Solid Waste at the Source of Generation

The capital city of Sierra Leone, Freetown, is still struggling with managing MSW due to inadequate infrastructure, limited resources, and poor MSWM practices. However, efforts have been made to promote the separation of solid waste practices among households to reduce solid waste generation and improve MSW collection and disposal. Study showed that 96% of the respondents do not practice separation of solid waste at the source of generation while only 4% practice source separation of solid waste. The practice of separating solid waste involves segregating different types of solid waste materials at source, typically at the initial stage of solid waste generation at households, markets, and public places. The primary objective of this practice is to separate recyclable materials from non-recyclable materials, which can then be collected and processed separately. There are some initiatives and programs aimed at promoting solid waste separation and recycling in the city of Freetown. One such initiative is the Freetown Waste Management Project, which is a partnership between the government of Sierra Leone and the World Bank. The project aims to improve solid waste management practices in Freetown by promoting solid waste separation and recycling among households and providing support for MSW collection and disposal. Under this project, households are encouraged to separate their solid waste into different categories, such as organic waste, plastics, paper, and metals. The project will provide the households with separate waste bins for each category, and solid waste collection trucks will be equipped with separate compartments for each type of waste.

In addition to the Freetown Waste Management Project, there are also several community-based initiatives aimed at promoting solid waste separation and recycling among households. These initiatives involve community education and awareness campaigns, as well as the provision of solid waste separation bins and collection services. Overall, the separation of solid waste practices among households in Freetown is still in its early or embryonic stage. However, there are promising initiatives and programs aimed at promoting this practice and improving waste management practices in the city. With continued support and investment, it is hoped that solid waste separation and recycling will become more widespread, leading to a cleaner and more sustainable city. **Table 4** below shows the frequency distribution of the separation of MSW at the source of generation.

Table 4. Frequency distribution of the separation practice of solid waste at the source of generation.

Separation at Source	Frequency	Percent
No	375	96
Yes	15	4
Total	390	100

4.6. Knowledge of Integrated Solid Waste Management

The Integrated Solid Waste Management (ISWM) approach aims to effectively and sustainably manage solid waste in Freetown. There are significant obstacles in waste management due to rapid urbanization, population growth, and limited resources. Knowledge about the existing situation provides a detailed understanding of the ISWM approach. The municipality has implemented various initiatives to enhance public knowledge, attitudes, and practices regarding solid waste reduction and separation. The contemporary challenge of solid waste management necessitates a multifaceted approach. Municipalities are increasingly implementing initiatives to foster positive environmental attitudes and responsible waste management practices within their communities. Modern challenges in managing solid waste require a comprehensive strategy. Municipalities are now introducing various measures to encourage environmentally friendly practices and responsible waste management among their citizens. Some examples include educational campaigns, integrating waste management into school curricula, developing user-friendly infrastructure for waste collection, implementing incentive programs, and engaging communities through workshops and events. These efforts aim to promote positive environmental attitudes and behaviors through different approaches. Efforts have been applied to raise awareness about ISWM. The outcome of this study has shown a need to intensify the awareness-raising campaign. Freetown has limited recycling and resource recovery facilities. This has significantly hampered effective waste management in the city. The scarcity of modern recycling plants and organized waste collection

systems means that most waste ends up in landfills or is improperly disposed of, contributing to environmental pollution and health hazards. This infrastructural gap is evident in the absence of large-scale separation and processing facilities for recyclables, which are essential for sustainable waste management.

In the face of these limitations, informal waste pickers play a crucial role in mitigating Freetown's waste crisis. These individuals collect, sort, and sell recyclable materials such as plastics, metals, and paper from the waste stream, providing an essential service that the limited formal sector lacks. In other words, waste pickers augment the work of the formal sector. Their efforts help to reduce the volume of waste that ends up in landfills which in turn extends the lifespan of these facilities. They also promote recycling, albeit on a smaller scale, support local businesses, and contribute to a circular economy.

However, the absence of formal recycling infrastructure and low level of awareness hampers recycling and resource recovery in the city since public awareness and education about waste management practices are critical for the success of ISWM in Freetown. The local government, NGOs, and international organizations have put modalities in place to ensure effective public education regarding waste segregation, recycling, and the importance of proper waste management. The study findings also showed that 88% of the respondents did not know about the integrated solid waste management (ISWM) principle while only 12% of the respondents knew about it. Interestingly, 12% of the respondents who knew about the ISWM have some form of education. **Figure 5** shows the percentage distribution of respondents' knowledge about integrated solid waste management.

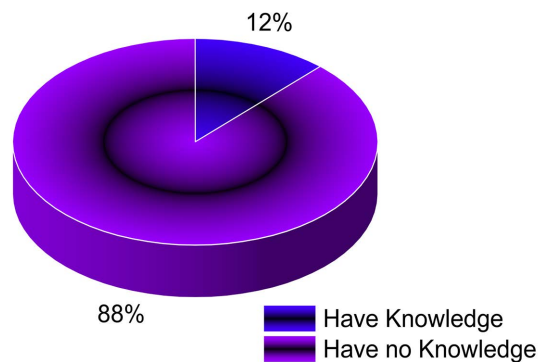


Figure 5. Knowledge of integrated solid waste management.

4.7. Role of Policy in MSWM

Sierra Leone has numerous policies and legal frameworks that support the enforcement of the MSWM system in the country, but these policies are ineffective and inefficient. In Freetown, these ineffective policies on managing MSW in the city have led to negative outcomes for the environment, public health, and residents' overall well-being. Regulations affecting waste management in Sierra Leone comprise the following:

The Environmental Protection Act (2008): “An Act (amended in 2010) which authorizes the Minister of Lands, Country Planning, and the Environment to make rules and strategies that protect the environment. This act shaped and authorized the Environment Protection Agency (EPA) which has the overall mandate of setting and monitoring environmental standards (Ministry of Health and Sanitation, 2011; Change, 2023).”

Local Government Act 2022: “Purpose: Local councils are the highest political and development authority in the district, empowered to manage waste in their localities and enact by-laws for development, improvement and management of human settlements and the environment in their locality. The Act devolves the water supply and sanitation responsibilities to District and Town Councils.”

Fishery Products Regulations (2007): “Despite the high influence of the fisheries industry on waste generation in Sierra Leone, the Fishery Products Regulation did not give due attention to the waste management issues. Part XII of the regulation mentioned the Best Waste Disposal Practices (Para 218) but did not stipulate the regulations in detail. This part gives, in a very narrow way, the scope of best waste disposal practices as treatment of byproducts, separation of edible from non-edible by-products, and draining and treatment of sewage emanating from fishery by-products processing. Thus, the integrated national waste management guidelines are a better tool for managing the waste the industry produces. All these policies were geared towards Encouraging the expansion of waste reduction and recycling programs through planning support, technical aid, grants, and other motivations in the form of incentives. Promoting the education of the general community or public and the training of MSW professionals to reduce the generation of solid waste, ensure correct disposal of solid waste, and boost recycling (Ministry of Health and Sanitation, 2011).”

5. Conclusion

In conclusion, the findings of this research highlight the urgent need for effective solid waste management practices in Freetown, given the significant threats posed by improper waste separation and storage on public health and the environment. The prevalent issues of littering, indiscriminate dumping, and inadequate separation practices have led to the contamination of land, water, and air, adversely affecting the community’s well-being. To mitigate these environmental challenges, Freetown must strengthen its waste management infrastructure, enforce robust policies, and promote public awareness through targeted education and community engagement. Incorporating solid waste management principles into the primary school curriculum can play a pivotal role in cultivating a culture of sustainability among future generations. The successful implementation of these recommendations will not only enhance the overall environmental quality of Freetown, but also create economic opportunities through recycling initiatives. Overall, fostering an ISWM approach to municipal solid waste management is essential for the sustainable development of the city and the well-being of its residents.

6. Recommendations

The exponential growth of urbanization and population in Freetown has resulted in a significant increase in municipal solid waste (MSW) generation, posing pressing challenges for the municipal authorities tasked with its management. This study sheds light on the solid waste generation, storage, and separation practices among households, emphasizing the need to adopt more efficient waste management approaches. The findings highlight the critical gap between awareness and practical application of waste separation at the source, underscoring the necessity for comprehensive public education and improved infrastructure. While the results presented herein do not encompass every factor influencing residents' attitudes and perceptions regarding solid waste management, they serve as a baseline for future study exploring other underlying issues that may affect community engagement and compliance with sustainable practices.

Enhance Public Awareness and Education: Implement comprehensive public awareness campaigns, integrate waste management into the educational curriculum, and provide practical training to foster a sustainable mindset and responsible waste management practices

Improve Waste Management Infrastructure: Establish efficient waste collection systems, including separate bins for different waste types, and invest in recycling facilities to improve waste processing and management.

Strengthen Policy and Enforcement: Develop and enforce stringent regulations, establish a monitoring system, and foster collaboration among government, the private sector, and communities to ensure compliance and effective waste management.

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Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this paper.

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