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Current Situation Analysis and Suggestions for Solid Waste Management Practices among Households in Freetown

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Abstract

Freetown which is the capital city of Sierra Leone is facing challenges with population growth, urbanization, and industrialization, leading to an increase in municipal solid waste (MSW) generation. The study aims to evaluate MSW generation, composition, and disposal methods, as well as the impact of collection fees, policy implementation, and women's participation in municipal solid waste management (MSWM). The study used both qualitative and quantitative methods for data collection and analysis. The study administered 393 structured questionnaires in three selected sections to collect data on variables such as family size, education, level of knowledge, etc. The study used door-to-door data collection to determine the rate of solid waste generation, composition, and disposal in 66 households from two of the selected sections and 34 households from the other section to evaluate the current situation of MSWM practices among households in Freetown. The study used a descriptive statistic to analyze the data collected using Origin-Pro9 and MS Excel software. The findings showed that with a 4.2% urban growth rate, Freetown had a population of 1,467,543 in 2023, generating 851 tons of MSW per day, with organic waste accounting for 78% of the total MSW generated. Plastic waste generation also increased from 7.6% in 2020 to 13% in 2023. The study emphasizes the need to sustain the MSWM system by prioritizing solid waste collection fees, policy enforcement, and women's participation in the MSWM sector. It further suggests and provides recommendations for developing an efficient and sustainable MSWM system in Sierra Leone, including knowledge transfer from countries like China and the US.

Keywords

Freetown, Municipal Solid Waste Management, Waste Composition,

Waste Disposal, Waste Generation

1. Introduction

The issue of municipal solid waste management (MSWM) remains a significant challenge in municipal urban areas worldwide, especially in developing nations where cities and towns are experiencing rapid population growth, and urbanization (Seik, 1997). According to the World Bank report in 2018, it was estimated that the global generation of Municipal Solid Waste (MSW) will potentially reach a volume of 3.4 billion tons by the year 2050 (Kaza et al., 2018). The United Nations population report in 2022 reported that the world's population had reached 8 billion in 2022 of which more than 55% is coming from developing countries. This is due to the increase in population growth and urbanization in these countries. As a result of this growing trend, MSWM has become one of the most important subjects being discussed by many researchers in modern times (Shareefdeen et al., 2015). According to other reports, the global yearly generation of MSW presently exceeds 2 billion tons as of 2021 (Shah et al., 2021) of which 33% is not properly handled, and is anticipated to quadruple to 4 billion tons by 2100 if proper measures are not put in place, causing significant problems for human existence and the environment everywhere (Ebrahimian & Karimi, 2020). These trends have highlighted the urgent need for policies, and cooperation to deal with the rising global MSW generation rates. The over-dependence on landfills and inadequate handling of MSW has persistently caused financial, health, and safety issues for individuals in societies (Sun et al., 2018).

Freetown as the capital city of Sierra Leone is struggling to manage its MSW, with 742 tons of MSW being generated per day at a generation rate of 0.45 kg/person/day in 2004. Annually, the city generates 270,830 tons with 30% - 35% of this amount being collected and transported to authorized dumping sites (Sood, 2004). The remaining 65% of the MSW accumulates, emitting harmful gases and leaching into groundwater systems (Pinka Sankoh & Yan, 2013). The volume of MSW disposed ineffectively continues to increase to 272,290 in 2020 with the urban population growth rate of 4.2%. However, landfill is the main technology in MSW treatment in Freetown. It echoes a weak awareness of resource utilization for MSW through conversion and recycling, which resulted in lots of resource being loss in Freetown. According to (Antonis et al., 2014), among municipal cities in developing countries, Freetown has been listed as one of the municipal cities in the world with the biggest dumping sites. Granville Brook (Kissy) dumping site which is located in the East of Freetown, is among 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 into, 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). To ensure efficient utilization of MSW and reduce its harmful effects on the human health and environment, it is essential to implement a systematic waste management strategy and employ technologies for treatment and resource utilization (TTRU) (Ding et al., 2021).

The MSWM system in Freetown, faces challenges such as insufficient funds, low level of awareness, and inefficient collection, and disposal practices among others. The unhygienic practices of MSWM such as burying, open burning, and illegal dumping are common among households in Freetown municipality. Separation of MSW is not carried out systematically making recycling and recovery of it almost impossible. Also, the unscientific disposal practices used at dumping sites pose environmental concerns. MSW is often dumped outside and along the roads in Freetown, Sierra Leone due to a low level of awareness and unwillingness to practise the proper disposal methods. This has negative implications for the environment (Sood, 2004; Pinka Sankoh & Yan, 2013).

In Freetown, the MSW generation varied among sections due to the difference in the level of urbanization, population density and availability of good road networks. The increase in population, income level, and urbanization in Freetown has led to a significant focus on MSWM. The study aimed to evaluate MSW generation by weighing the MSW generated at the selected residential structures, composition, and disposal practices among households in Freetown between the periods of 2008 to 2023. As far as the study understanding goes, this study is the first piece of research to comprehensively examine MSWM, focusing on the combination of collection fee, policy implementation, and women's participation in MSWM to help improve and sustain MSWM for a healthier environment and human well-being in Freetown.

2. Current MSWM Situation in Freetown

This section provides a global overview of MSWM, with a focus on local practices in Freetown, Sierra Leone. Globally, MSW generation is increasing due to urbanization, population growth, and industrialization contributing to global annual generation of over 2 billion tons, with 33% not properly managed (Shah et al., 2021). Without effective measures, this figure is projected to double to about 4 billion tons by 2100 (Hosseini et al., 2013). Inadequate MSWM globally results in severe environmental consequences, including 1.6 billion tons of Carbon dioxide (CO_2) emissions and water contamination. Another study showed that landfills receive 37% of global MSW, while only 19% is recovered through reuse, recycling, and decomposition (Sohkhlet & Nagargoje, 2020). Challenges in Freetown MSWM include rapid urbanization, population growth like an increase in family size, inadequate waste management infrastructure, and improper waste disposal practices (Gogra et al., 2010). These challenges have led to the littering, illegal dumping, and burning of MSW leading to a lot of environmental problems. The city faces a daily accumulation of MSW in the streets and open

spaces, as the generation rate exceeds the collection rate. Low level of public awareness and education worsens the problem.

2.1. MSW Generation in Freetown

General information on the quantity of MSW generated is necessary and very important to almost all aspects of municipal solid waste management (Tchobanoglous et al., 1993). The increase in population, family size, and urbanization has led to an increase in the amount of MSW generation globally, including Freetown (Harir et al., 2017). The population of Sierra Leone as well has been increasing at a rate of 3.2% per annum since 2004 to 2023. However, the inter-censal urban growth rate between 2004 and 2015 was 4.2%. This is much higher than the national growth rate for the same period (Statistics Sierra Leone, 2015). With this urban population growth rate, the MSW generation is also bound to increase, which makes its management very important. In Freetown, the capital city of Sierra Leone, over 742 tons of MSW are generated daily with an average of 0.45 kg per person per day, with 84% being biodegradable organic waste (Sood, 2004). In 2020, the estimated MSW generation per capita per day in Freetown was 0.5 kg, indicating a significant increase that could pose threats to the environment and public health if not addressed. Ngegba and Bertin also projected the MSW generation per capita per day in Freetown to increase to 0.6 kg with 436,175 metric tons annually by 2027 (Ngegba & Bertin, 2020). Most times, changes in MSW generation are caused by the demographic factors and facilities available in the municipal cities.

2.2. Composition of MSW

The MSW composition of any municipality is very important in MSWM, as it affects the density of the MSW generation, proposed collection, transportation, and disposal methods. Therefore, it is essential to determine the strategy for solid waste re-use, reduction and recycling (Sankoh et al., 2014). In Freetown, the majority of MSW is made up of organic waste which comes from households, followed by plastics, papers and cardboard, metals, glass/ceramics, textiles, rubber, and other waste (Ngegba & Bertin, 2020). Proper management of organic waste can be used for composting or energy generation. Plastics pose a significant problem in the waste stream, taking a long time to decompose and contributing to pollution. Glass, metal, textiles, rubber, and electronic waste are also present, and require specific handling and disposal methods. Lower-income countries tend to have a higher percentage of organic waste compared to higher income countries (Hoornweg & Bhada-Tata, 2012). The composition of MSW influences waste management technology and treatment choices.

2.3. Disposal of MSW in Freetown

Owing to the above-mentioned difficult challenges faced by administrators of the Freetown City Council (FCC) in addressing the increase in MSW generation

in Freetown, Sierra Leone as a nation has made several efforts in adopting and developing new technologies that would be used in managing MSW. For example, incineration technology has been adopted and is in use, but only limited to health facilities for the treatment of medical waste. This is due to budget constraints on the side of the government of Sierra Leone to procure and install those incineration plants at every landfill in all urban cities. Landfill disposal therefore becomes the most common method of MSW disposal in Freetown. Only 34% of the MSW generated in Freetown is collected and transported to authorized landfills (Sood, 2004). There is improper pre-treatment for the MSW, making it difficult to manage due to high moisture content and offensive odour. The city does not have a sanitary landfill, which poses risks to the environment and public health. Open burning and burying of MSW by households are other common methods of MSW disposal among household residents in Freetown. These methods are mostly practised by residents like those living in slums, mountainous and areas with poor road networks who do not have access to MSW collection services.

2.4. Challenges of MSWM in Freetown

The management of MSW in Freetown has become a significant problem that has been worrisome to residents, government, and international donors. The proper management of MSW is essential for a healthy environment and the well-being of all residents in the area. Many findings have stated that if household, industrial, public, and commercial waste are not managed effectively, it will lead to environmental degradation. Open spaces in Freetown are being misused for activities such as illegal disposal of MSW and defecation. Inadequate financial support, technical know-how, attitudes of the residents, and MSW workers, mismanagement of funds, ineffective policy enforcement, low level of awareness and education, inefficient waste collection fees systems, etc, are all challenges that are hindering the sustainability of MSWM in Freetown.

3. Materials and Methods

3.1. Study Area

Freetown faces significant challenges in managing its MSW. There are inadequate infrastructure, inefficient MSW collection services, and disposal options, leading to reliance on informal waste collectors and open dumping. This informal sector operates in unsafe conditions, causing severe consequences for public health and the environment. Efforts to improve MSWM have been slow due to limited funding and inadequate infrastructure. To address this issue, research is needed to understand current practices, challenges, and opportunities for improvement in MSWM among households in Freetown. The study area is divided into 8 sections which are East 1, East 2, East 3, Central 1, Central 2, West 1, West 2, and West 3. Only three of these sections were selected for data collection exercise due to budget constraints. However, for this study, the population of Freetown has been estimated to be 1,467,543 people as calculated for 2023 using the

formula shown in Equation (1).

$$P_n = (1+r)P_o \tag{1}$$

where;

P_n is the estimated population,

r is the urban growth rate for 2015 which is 4.2%, and

P_o is the population obtained from the 2015 Population and Housing Census report (Statistics Sierra Leone, 2015).

According to another study conducted by Pinka Sankoh (Pinka Sankoh et al., 2012), several factors showed significant impacts on the generation and composition of MSW in Freetown, especially in residential structures or households. The factors that contribute to the amount of MSW generated in Freetown include family size, employment status, monthly income, and the number of rooms in households. Larger families and households with higher employment status and income tend to generate more solid waste due to increased consumption and resource use. Policymakers and waste management authorities need to consider these socio-economic factors when developing strategies to address waste collection and transportation in the city. This study aimed to evaluate MSW generation by weighing the MSW generated at the selected residential structures, composition, and disposal practices among households in Freetown. The study also considers the impact of collection fees, policy implementation, and women's participation in MSWM to improve and sustain it for a healthier environment and human beings. **Figure 1** shows the study area, Freetown.

3.2. Methods

The study was conducted using both quantitative and qualitative methods to collect the primary data that was used to evaluate MSWM in Freetown, which was quantified and evaluated using statistical techniques (Lomax, 2007). By using these methods for data collection, researchers can create studies that take into account the strengths and weaknesses of each method, (Connaway & Radford, 2017) and (Cooper, 2014). The ability to analyse data using both qualitative and quantitative methods increase the precision and depth of findings (Cataldo et al., 2020). Three sets of questionnaires were designed for household, landfill workers and institutions like Freetown City Council, Environmental Protection Agency, Ministry of Health and Sanitation, and Ministry of Local Government dealing with MSW. The study was carried out in three (3) distinct sections across the city of Freetown, which is as follows: East 2, Central 1, and West 2 simultaneously within 15 days designed for data collection. The sample size was 399 respondents out of the sample population of 341,815 people within those three sections. The sample size was selected using the formula below shown in (Equation (2)).

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

where;

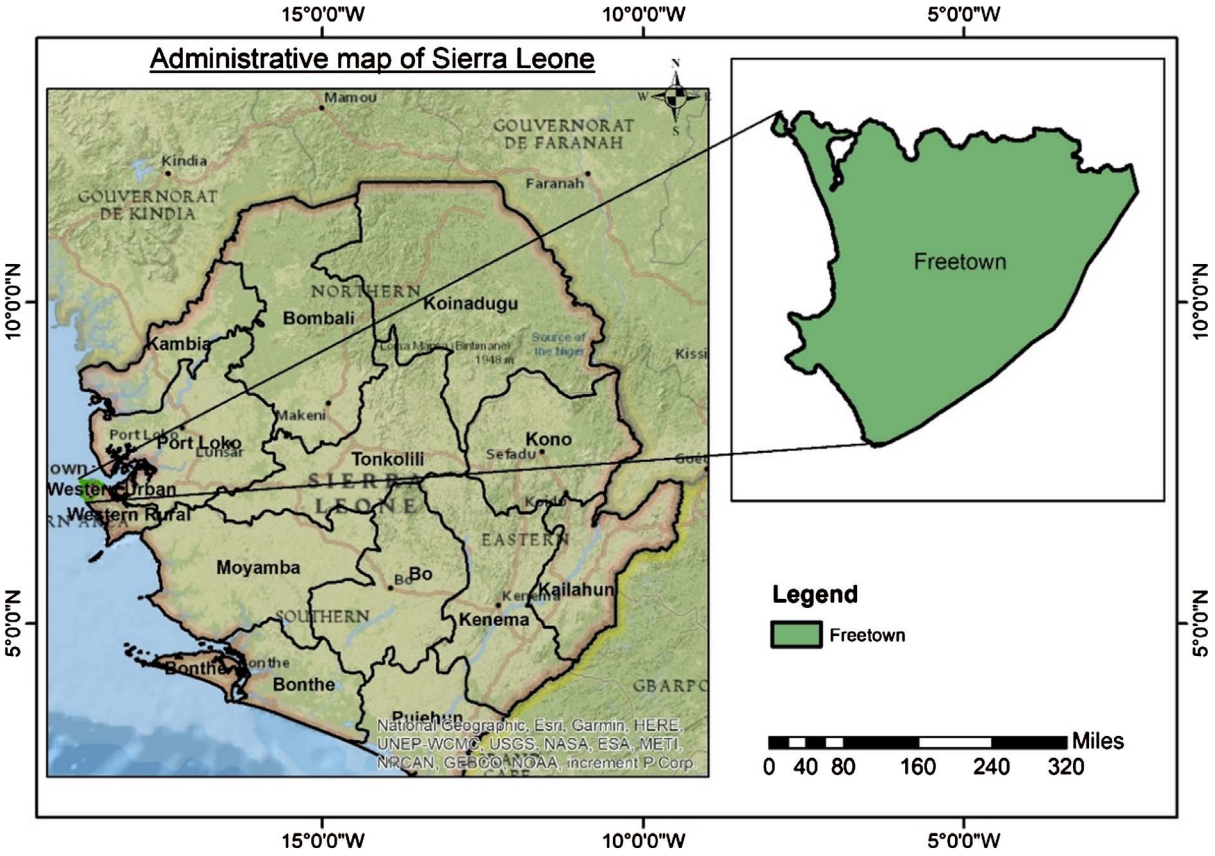

Figure 1. Administrative Map of Sierra Leone showing the study area Freetown.

n = Sample size.

N = Total Population in the study area.

e = Sampling error (0.05).

3.3. Sampling Technique and Data Collection

The households in this study were selected using a simple random sampling method, which means that each household had an equal chance of being selected in the sample. Part of the approach was to design questionnaires and tested during the pilot phase before the final face-to-face interviews to administer the designed questionnaires. Enumerators were employed to conduct a face-to-face survey for data collection for this study. However, a total of three hundred and ninety (390) standardized questionnaires were administered to respondents aged 15 and above in the target sections at household level, while 1 at the institutional level and 2 landfill supervisors which gives a total 393 respondents. Scientific papers/journals, government and other international organisation documents were reviewed as secondary data.

4. Results

4.1. Population Structure

Population Structure plays a very important role in understanding MSWM in

any city. The data collected from 390 respondents at household level showed that 88% were females and 12% were males who actively participate in solid waste management at the household level. Most of the respondents were between the ages of 15 and 44, suggesting that they may have attained primary or secondary levels of education and had knowledge of MSWM. Those with tertiary education were more efficient in responding to the data collection exercise, 33% of the respondents had primary education, 29% had no formal education, 20% had secondary education, 13% had tertiary education, while only 5% had vocational education. Table 1 shows the frequency distribution of the gender characteristics of the respondents who are responsible for managing solid waste at household level.

4.2. Composition of MSW

The study categorized MSW into two main groups: biodegradable and non-biodegradable waste. Biodegradable waste includes household waste like food, ash, leaves, paper, and cardboard, as well as animal remains and leafy vegetables from households. It accounts for 78% of the MSW generated in the study area. Non-biodegradable waste makes up 22% of MSW, with plastic comprising 13% and glass, metal, textiles, and other waste making up the remaining 9%. The composition of organic waste has decreased from 84% in 2004 to 69% in 2020, but again increased to 78% in 2023. Plastic waste generation has increased from 7.6% in 2020 to 13% in 2023, indicating a shift towards plastic products. Hazardous waste was found in MSW at dump sites and some industries and construction sites also generated solid waste, although it was not included in the research findings. Figure 2 shows the percentage distribution of the composition of MSW in Freetown.

4.3. Municipal Solid Waste Generation

The MSW taken into consideration in this study are typically household solid waste generated in residential areas, with little focus on workplaces. The findings showed that with a population of 1,467,543 in Freetown as of 2023, the MSW generation per year was 310,679 tons. This showed that 851 tons of MSW is being generated daily with 0.58 kg/capita solid waste generation per day. The population estimation was calculated for 2023 using a 4.2% urban growth rate as of the 2015 Population and Housing Census report which in turn was used to evaluate the annual, daily, and per capita generation of solid waste in Freetown for the given period. Figure 3 shows the trend of MSW Generation/capita/day/kg for the period between 2008-2023.

Table 1. Gender characteristics of the respondents.

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

Source: Author Survey, Field Data 2023.

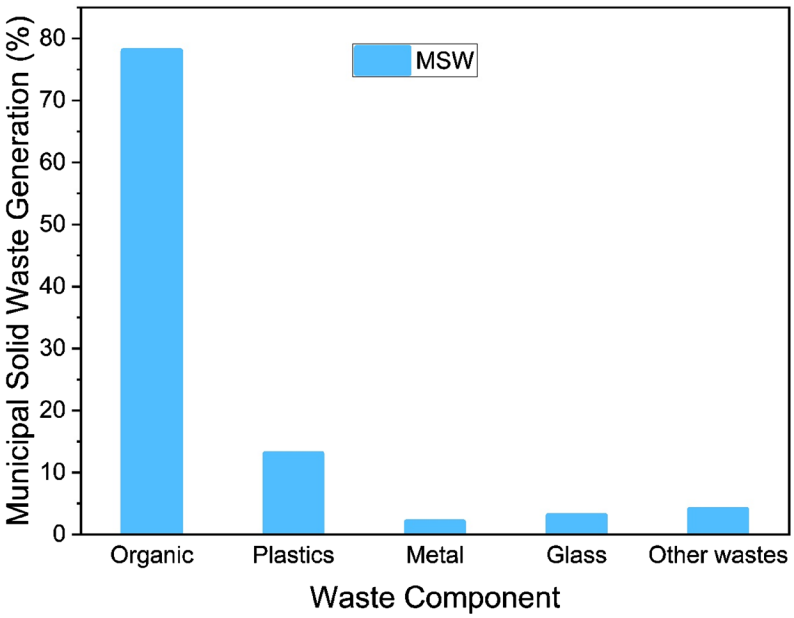

Figure 2. Distribution of the Composition of MSW in Freetown.

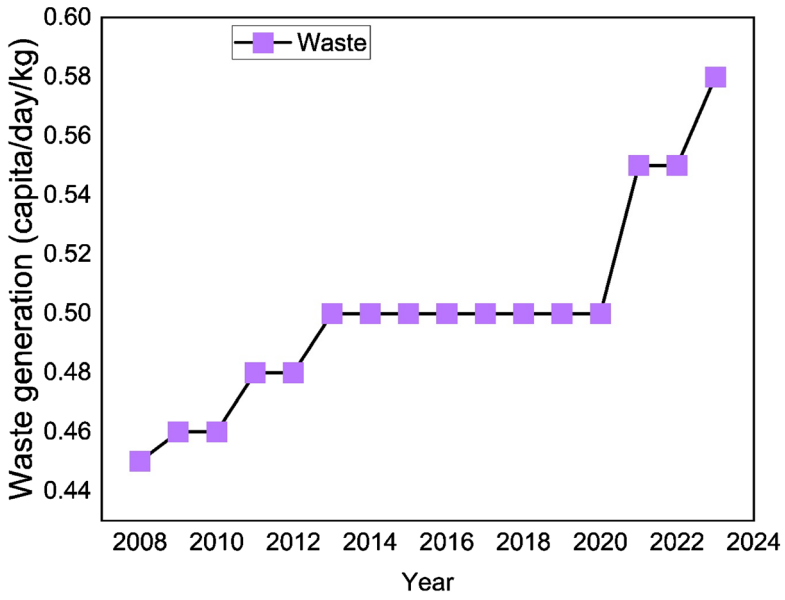

Figure 3. Trend of MSW Generation/capita/day/kg (2008-2023).

4.4. Relationship between Family Size and Municipal Solid Waste Generation

There is a clear relationship between family size and MSW generation in Freetown. In Freetown, 3 persons/household is the average family size, often comprising extended families residing together. The study also showed that as the family size increases, the amount of MSW generation increases which shows that there is a positive relationship between the family size and MSW generation. This was attributed to various factors such as an increase in consumption patterns, which is food consumed, the number of goods purchased, and the amount

of packaging and other waste materials generated and the income level of the household. If the MSW system in Freetown municipality is not improved or re-evaluated to accommodate these scenarios, there will continue to be a greater amount of uncollected MSW, which will continue to harm the environment and human health. Figure 4 shows the relationship between family size and municipal solid waste generation.

4.5. Methods of Disposal of MSW Practices among Households in Freetown

The study showed that approximately 25% of the respondents' dispose of their solid waste in open dump sites, and 25% use communal skip containers. Another 24% dispose of their solid waste along the roads at night, primarily among settlers residing far away from the authorized dump sites, 18% burning it, 6% having it collected by MSW collectors and 2% are collected for disposal by community service workers in the informal sector who transport it to illegal dump sites. Owing to these uncoordinated disposal practices among households, led to discrepancies between the national data on MSW generation and the actual situation on the ground. Table 2 shows the frequency distribution of the MSW disposal practices among households.

4.6. Payment for Disposing MSW

Many cities charge fees or taxes for MSW disposal to cover collection, transportation, and safe disposal costs. The amount varies based on location and solid waste generation, with exemptions for low-income households and certain waste types. This study finding showed that 66% of those without access to MSW collection services don't pay for disposal, while 34% pay to other companies or

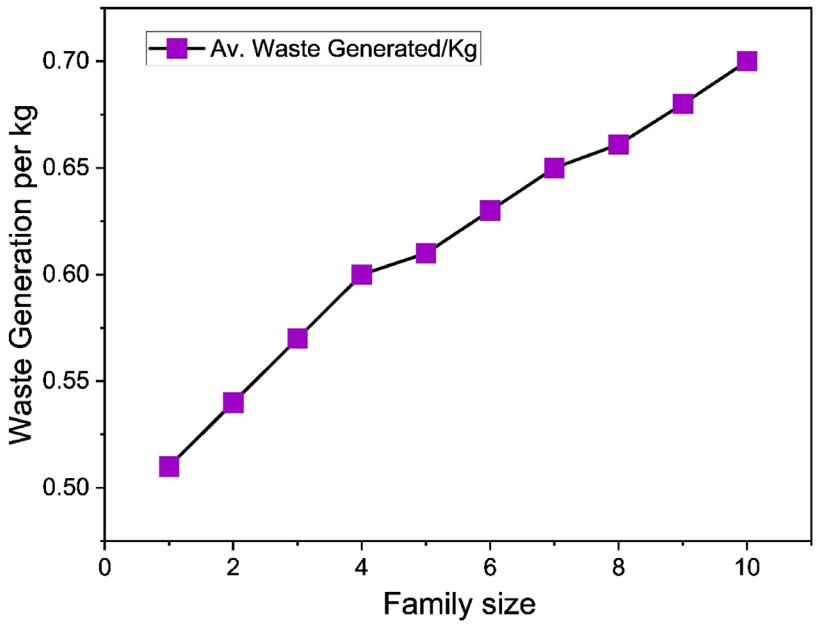

Figure 4. Relationship between Family size and Municipal Solid Waste Generation.

Table 2. Frequency distribution of MSW disposal practices among households.

Solid Waste disposal practices among households	Frequency	Percent (%)
Dump it the open dumpsites	98	25
Take it to Communal Containers	98	25
Dump it along the Road at night	94	24
Burn it	70	18
SW Collector collect it	23	6
Community Service workers	8	2
Total	**390**	**100**

community service workers. The Freetown Waste Management Company, which is owned by the Freetown City Council, does not collect fees from households for MSW collection in the municipality of Freetown. The residents think it is the sole responsibility of the municipal government to manage the MSW without the residents' financial involvement. However, 95% of non-payers said they would be willing to pay for disposal with an effective waste management system. User payments for solid waste disposal can distribute costs fairly to improve and sustain MSWM to protect the environment and human health.

5. Discussion

The current solid waste management situation in Freetown is in danger of collapsing due to improper waste management practices and other challenges surrounding its sustainability. The high amount of waste that remains uncollected or dumped illegally in the city is a serious problem for both human health and the environment. The increase in population, urbanization and profound economic crisis has a great impact on solid waste generation leading to ineffective MSWM system in Freetown.

As demographics change and consumer behaviour changes, Freetown as a municipality in Sierra Leone, is normally faced with new challenges in solid waste management. The city has been actively seeking sustainable solutions to these problems. One area of focus has been the development of integrated solid waste management approach for waste management, including the construction, operation, and maintenance of landfills over the years. The municipal administration is yet to commence recycling activities to cover the costs of MSWM as a valuable source of income for its sustainability in Freetown. For example, in Abidjan, scavengers collect and sell around 50% of the recyclable plastic waste materials to a company that recycles plastic waste materials to produce construction bricks generating some substantial amount for the residents. In Freetown, most of the scavengers are women and children found picking the recyclable materials for sales to the informal recyclers.

Another major environmental issue is the improper disposal of plastic waste which is on an increase in Freetown. Since plastics are composed of hydrocar-

bons, they have a high calorific value. Consequently, they can be burned or incinerated in municipal or specialized waste facilities to generate power and heat, but this is not the case in Freetown. The commonly used and cost-effective method of plastic waste disposal is landfilling which is posing serious threat to the environment and human health. Plastic waste had been piling up due the emergence of many water and beverage manufacturing companies in the city of Freetown. These companies apply little or no effort to help recycle the plastic sachet or rubber bottles they produced.

Organic and other inorganic waste continue to cause a lot of challenges to an extent that no definite solution has been identified yet. The improper storage, collection and transportation methods of MSW using open vehicles, tricycles, and pushcarts, sorting and separation of solid waste, significantly impact the characteristics of solid waste. Segregation and pre-treatment of solid waste are not adequately carried out, especially at the household level, and there is no current environmental monitoring of solid waste management at household level in Freetown. Most industrial waste is privately disposed of in landfills through arrangements with local waste collectors and agencies. The landfills received unseparated solid waste with trace of medical and hazardous waste found in the solid waste transported to landfills for disposal.

The inclusion of the dumpsite supervisors and FCC environmentalist in the data collection process of this study helps to avoid one of the most common failures in attempts to present sustainable changes and modernize MSWM systems: failing to understand how the system is currently working in Freetown. The issues of fairness between the system users in receiving a fair and adequate service and having a say in its planning and evaluation; and fairness among formal and informal, major and minor service providers, in terms of a fair share of economic opportunities for providing the service were the key issues that drew attention to MSWM sustainability. This will also help in providing a link that can be used to determine how the waste collection fee should be structured looking at the distance from dumpsites and the institutional capacity to provide these services. It is important to note that public awareness and women's participation in MSWM in Freetown is essential for sustainable MSWM since women are predominant in managing solid waste at household level. Their inclusion is key. It showed that community engagement and education are essential for a sustainable MSWM as well. There is a need for policy enforcement.

Freetown as a municipal city has an inefficient and uncoordinated tax system for MSW collection and disposal. Taxes on households for solid waste collection are insignificant and go to the informal sector. Only established institutions are taxed, but these taxes do not cover the cost of MSWM. An efficient MSW taxation system is necessary, which can be achieved by implementing a volume or weight-based disposal charge. The tax should be determined based on economic conditions and the quality of disposal facilities in each municipality.

6. Conclusion

In conclusion, the current situation analysis of MSWM practices among households in Freetown reveals a significant need for improvement. The improper waste segregation, limited access to waste collection services, inadequate infrastructure and funding pose significant challenges to effective solid waste management in Freetown. To address these issues, the government and relevant stakeholders must implement comprehensive MSWM strategies, including awareness campaigns, improved waste collection systems, and the establishment of recycling facilities. By taking these steps, Freetown can work towards achieving sustainable and efficient MSWM practices, ensuring a cleaner and healthier environment for its residents. The study also shows high levels of organic and plastic waste in the city, similar to other less developed cities. This suggests that the MSWM generation patterns are influenced by factors like rapid economic growth, urbanization, consumption patterns, family size and cultural habits seen in smaller towns. Therefore, it is important to consider these factors when planning for MSWM in the city.

7. Recommendations

Reducing solid waste generation should be the initial step in managing MSW in Freetown. It is important to encourage individuals to consume less and repurpose waste resources to generate less MSW.

Women should be incorporated and trained to participate in MSWM sector to enable them embark on better MSWM plans, public education and awareness raising about the dangers of improper MSW disposal and the need to adopt ISMW approach to improve the MSWM sector in Freetown.

Embarking on MSW recycling is crucial for Freetown MSWM system. The local government should support the establishment of small and large recycling industries. Municipalities like Freetown should take responsibility for waste recycling as part of their overall MSWM plans.

Waste composition analysis should be conducted to determine the types of waste being generated by households. This will help in identifying the most common types of waste and developing targeted strategies for their management.

Research should be conducted to identify best practices and benchmarks in municipal solid waste management from other cities or countries. The current practices should be compared in Freetown with these benchmarks to identify areas for improvement and develop recommendations for enhancing waste management practices among households.

An efficient MSW taxation system should be instituted, which can be achieved by implementing a volume or weight-based disposal charge. The tax should be determined based on economic conditions and quality of disposal facilities in each municipality.

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Conflicts of Interest

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

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