Challenges and Prospects of Solid Waste Management in Monrovia City, Liberia

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ABSTRACT

Poor solid waste management practices can affect the environment and people's health in a number of ways. Therefore, limiting these negative consequences may be achieved by establishing effective solid waste management systems. The primary objective of the study was to identify the mechanisms behind solid waste management practices in Monrovia, Liberia. Information was acquired from 400 (female: 294; male: 106) participants from four important districts of the city using a questionnaire. A simple random sampling approach was used to collect data. The results showed that leftover food accounted for 47.79% of the solid waste generated, with plastic (28.25%), paper (18.2%), metal (1.51%), and miscellaneous materials (4.16%) respectively. On average, each person created 0.3 kg of solid waste daily. 384 respondents or 96% of those surveyed, confessed to never having separated recyclables from garbage. 384 of the collection, or 89%, are done by children. 94.75% the respondents (379 respondents) acknowledged using unlawful means to dispose of their garbage, including burning in the complex (394, or 98.5%), dumping in their yard (294, or 73.5%), burying (275, or 68.8%), and discarding on the road (312, or 78%). This was confirmed through the collection of field data, and it stands as one of the biggest threats to people's health. This investigation also showed that there was no efficient solid waste management system in the area under examination. The respondents agreed that there was a lack of clear environmental rules and legislation, community connection, door-to-door solid waste collection, and government involvement in any way. They said that the government only tried to spread awareness when outbreaks like Ebola and COVID-19 were present. The administration is therefore urged to concentrate more on introducing and increasing knowledge of the country's policies and strategies. Additionally, there should be useful lessons (techniques) for handling solid waste that is imported into the nation from abroad.

Keywords: Challenges, prospects, Solid Waste Management, Monrovia City and Liberia

INTRODUCTION

Solid waste refers to the unwelcome and pointless results of human and animal activities that are mostly made of solid materials. Industrial, social, and agricultural activities can all contribute to them. Solid waste is an inevitable part of life, and it looks different in each culture. Solid waste management is the umbrella term for all activities related to solid waste (Maria et al., 2020). These duties comprise all aspects of storage, collection, transport, handling, processing, and disposal. Social, economic, public health, and technological considerations are the main themes that should be kept in mind while managing solid waste. This endeavor

can benefit from a variety of aspects, including financial, legal, planning, engineering, sociology, public health, and communication. These make managing solid waste more difficult (Sharma et al., 2020). Choosing the most efficient waste treatment technology, limiting environmental impact, and educating the public about garbage separation are just a few of the many issues that might arise with waste management (Fernando, 2019). The solid waste management system is a complex one due to multiple waste treatment methods as well as several other economic and technological concerns. In contrast to industrialized countries, many less developed countries, like Liberia, have just one choice for disposing of waste: landfills. But landfills have detrimental consequences for both people and the environment (Marshall and Farahbakhsh, 2013). Uncollected solid waste poses a major threat to public health because it regularly transmits contagious illnesses like cholera and dysentery, which are watery diseases (Kwun et al., 2021). Such sickness prevalence increases the burden on the limited health care provided in developing countries with limited resources. The rubbish attracts rats and bug vectors. (Nicholas, 2018) Unchecked waste fermentation contributed to the epidemic by making it easier for rodents and insects that spread disease to grow and have babies. According to a study by the WHO, in 1994, Angola, Malawi, Mozambique, and Tanzania recorded 616,960 cases of cholera, resulting in 4,389 fatalities (1995). Water that seeps through waste is likely to spread viruses like hepatitis, poliomyelitis, and gastroenteritis into the groundwater. These viruses can cause dysentery, cholera, and even long-term health problems (Sarder, 2017). Trash workers, rag pickers, and scavengers in impoverished countries face the most immediate health danger associated with solid waste. There are few protections in place in underdeveloped countries to protect garbage workers and rag pickers from direct contact and injury. Combining hazardous and medical wastes with municipal rubbish poses a serious health concern. (Majumder and Karim, 2012; Alam and Ahmade, 2013). Other factors that affect health are burning trash in the open, making dust when getting rid of trash, and the exhaust emissions from garbage trucks. Garbage is burned indiscriminately at disposal facilities in less developed countries. Burning causes heavy metals like lead, toxic gases, and smoke to be spread throughout residential areas. In addition, the wind carries trash, dust, and decomposition smells (Ayilara et al., 2020). Air pollution brought on by the burning of garbage and the release of toxic gases has many detrimental consequences for the environment and human health (Medina 2002). Manisalidis et al. (2020) say that when waste rots in the open, it causes bad smells, blurred vision, and a general lack of atmosphere. The main barrier to a sustainable solid waste management system is the fact that several persons, groups, and organizations are involved with rubbish as service customers, service providers, intermediaries, and/or regulators. The goals, functions, and conflicts of these participants weave an intricate web that establishes and characterizes the typical waste management system in each developing nation (Goggins, 2018). In urban regions, it has long been believed that the local municipal government is in charge of trash collection and disposal (the formal public sector). The local government's supply of a waste management system, however, is often inadequate, centralized, top-down, and, in most instances, inefficient in a scenario involving a poor country. Then, in many developing countries, garbage has turned into a thriving informal sector that feeds a big part of the urban poor (Kohler, 2019).

METHODOLOGY

Study Area

Liberia's capital city, Monrovia, was chosen for a study because of how poorly it manages solid waste and how vulnerable it is to environmental problems. With an average annual temperature of 25.7 °C and 3583 millimeters of rain spread out from May to October, the climate is mostly tropical.
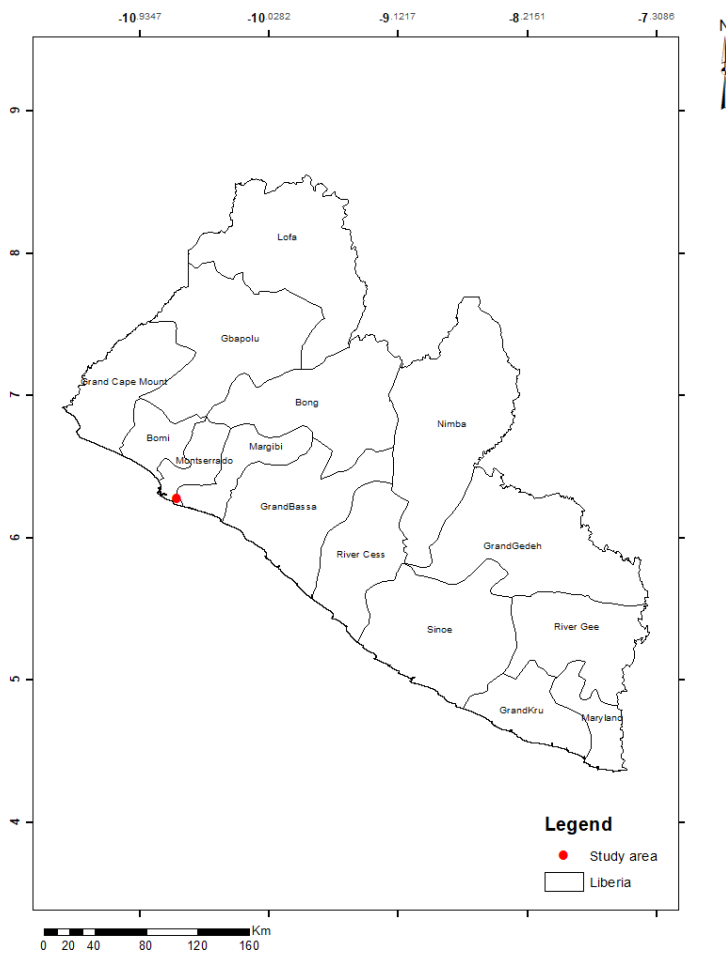
Figure 1. Map of Liberia and the study area (red)

Overpopulation and diseases like tuberculosis, typhoid, and malaria are examples of endemic issues. The beach surrounding the city is frequently used as a latrine and dumping site. An annual average temperature of 25.7 °C and annual average rainfall of 3583 mm distributed from May to October.

Research Design

The quantitative research method was used to conduct this research. A survey was conducted to collect quantitative data from 400 respondents. More specifically, a descriptive research design which is theory-based design method was performed to collect the field data. This research was conducted in Monrovia city, Liberia and it relies on several data collection methods which include: Field observations, interviews, and a questionnaire survey were used to gather information on the mechanisms of solid waste management practices in Monrovia city.

Sample Size Determination

From an approximate population of 1.6 million which are perceived to be residents of Monrovia city, the required sample size was using the following formula: Sample size=N/(1+N(e^2)) Where: N is the total number of population; is the margin sampling error. Sample size=1,600,000/(1+1,600,000(?0.05?^2)) Based on the result from the above calculation, 400 individuals were considered for the study.

Sampling Techniques and Data Collection Procedures

A structured questionnaire survey using Kobo Collect App was used for collecting the primary data. It included details of primary data on the respondents' socio-economic characteristics, solid waste production scale, income-expenditure scenario and perceptions of residents on solid waste management.

Data Analysis Procedures

Data on the mechanics of effective solid waste management in Monrovia city were collected, organized, and analyzed. Descriptive data analysis such as frequency and percentage were performed. Spearman correlation matrix was also done to see the relationship between different variables such as income, expenditure, solid waste expenses, and family size.

FINDINGS AND DISCUSSION

Demographic characteristics of the respondents

400 respondents were chosen at random from the research region during the field data collection. 73.5% of the respondents were women, which is the majority. Only 24.75 percent of respondents, who made up the majority, were from age categories other than 30 and 35. Secondary school had the largest performance in education (176, 44%), followed by primary education (141, 35.3%), with just a few responders in tertiary education (32, 8%) and informal education (51, 12.8%). Only a small number of respondents worked in agriculture and other occupations; the majority of respondents (47.5%) were married and worked in business (54.25%), wage labor (21.75%), and services (17%). The majority of respondents to the study, 214 (53.5%), had 1-3 persons living in their home, followed by 4-6 (133, 33.25%), 7-9 (42, 10.5%), and >10 (11, 2.75%). The respondents' average monthly income was between $100 and $200, while their average monthly spending was about $100.

Table 1. Demographic characteristics of the respondents

Characteristic	Category	Frequency	Percent (%)
Gender	Female	294	73.5
	Male	106	26.5
Age	20-25	35	8.75
	25-30	76	19
	30-35	99	24.75
	35-40	92	23
	40-45	60	15
	>45	38	9.5
Marital status	Single	94	23.5
	Married	190	47.5
	Divorce	89	22.25
	Widow	27	6.75
Educational Level	No formal education	51	12.8
	Primary	141	35.3
	Secondary	176	44
	Tertiary	32	8
Family size	1-3	214	53.5

	4-6	133	33.25
	7-9	42	10.5
	>10	11	2.75
Occupation	Agriculture	13	3.25
	Service	68	17
	Business	217	54.25
	Wage labor	87	21.75
	Others	15	3.75
Monthly income ($ USD)	1-100	65	16.25
	101-200	152	38
	201-300	71	17.75
	301-400	42	10.5
	401-500	33	8.25
	>500	37	9.25
Monthly (expenditure $ USD)	1-100	103	25.75
	101-200	84	21
	201-300	75	18.75
	301-400	39	9.75
	401-500	32	8
	>500	67	16.75

Types of solid waste generated by the respondents

The majority of respondents admitted that they created solid trash from food remnants (47.79%), plastic (28.25%), paper (18.2%), metal (1.51%), and miscellaneous sources (4.16%) (Figure 1). It is possible that the majority of families produce a large amount of solid trash since it is a big product that takes up more storage space. Additionally, the respondents thought that solid trash would collect until it was disposed of since it would not always be cleaned up when they wanted it to be.
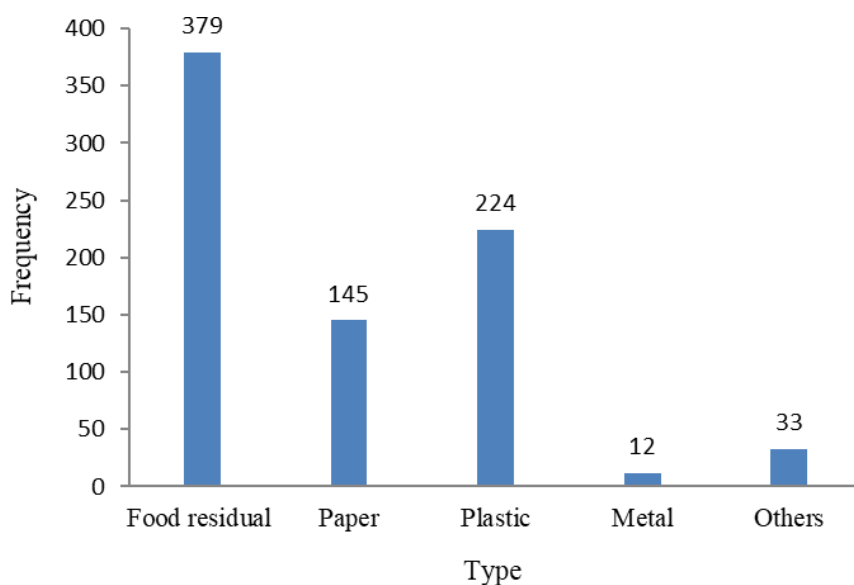

Figure 1. Multiple response analysis results of the types of solid waste generated by the respondents' households.

The amount of solid waste (kg) that each respondent generates monthly was requested of him or her. The greatest number of kilograms for responders, according to the results, was between 6 and 10 kg (45.25%). A solid waste generation of 1-5 kg, 11-15 kg, 16-20 kg, and >20 kg was followed by 29.5%, 13.5%, 7.5%, and 4.25%, respectively. Similar to this, the majority of respondents (277) stated that they spend $10–15 per month on solid waste disposal operations. Only 11 respondents admitted they spend between $26 and $30 each month. The Table 5 correlation matrix demonstrates a positive link between trash creation and the monthly cost of solid waste handling and management. In other words, when solid waste creation rises, so do solid waste expenses. This association is also statistically ($p = 0.001$) significant.

Table 2. Respondent monthly income and expenditure and how much generate and spend in waste solid disposal service.

Option	Category	Frequency	Percentage
How much solid waste do you generate monthly (Kg)	1-5	118	29.5
	6-10	181	45.25
	11-15	54	13.5
	16-20	30	7.5
	>20	17	4.25
How much do you spend in a month for the service? ($ USD)	10-15	277	69.25
	16-20	93	23.25
	21-25	19	4.75
	26-30	11	2.75

Solid waste separation

As previously mentioned, most respondents created the following primary solid waste types: food residue, plastic, paper, metal, and others. However, the respondents' reported separation level was relatively low. 96% of respondents said they had never separated solid trash previously, whereas just 4% of respondents said they did (Figure 2). They suggested that segregating solid waste was not necessary. But the large number of people who didn't separate their solid waste showed that the solid waste management methods in the research area weren't working.
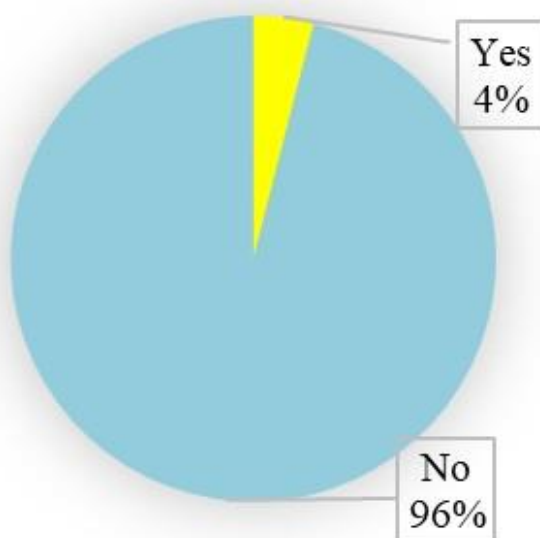

Figure 2. The level of solid waste separation by the respondents

Table 3. Percentage of solid waste separation, collection methods, and type of vehicle used by the respondents

Variables	Frequency	Percent (%)
Waste separation		
Yes	16	4
No	384	96
Collection of waste is done by		
Children	357	89
Waste pickers	15	4
Children and waste pickers	28	7
Type of vehicle(s) used to collect the waste		
Wheelbarrow	356	89
Rickshaw	9	2.25
Wheelbarrow Tricycle	10	2.5
Rickshaw Tricycle	6	1.5
Wheelbarrow Tricycle Rickshaw	19	4.75

Solid waste collection interval

Figure 3 displays the outcomes for the solid waste collection period. It was found that 63.5% of respondents collected their solid garbage once a week, compared to 34.3% who did so once every two weeks or more.
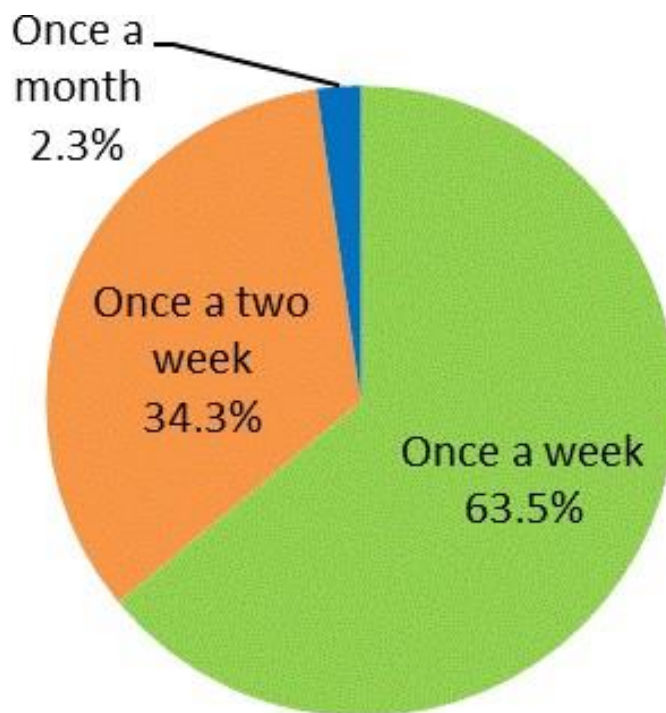

Figure 3. Solid waste collection interval by the respondents in Monrovia city

Solid waste handling by the respondents

Table 4. Solid waste handling by the respondents

Variables	Frequency	Percent (%)
Burn SW in the compound		
No	6	1.5
Yes	394	98.5
Dump in the yard		
No	106	26.5
Yes	294	73.5
Dispose in the ditch		
No	125	31.3
Yes	275	68.8
Dispose on the road		
No	88	22
Yes	312	78

Figures 4 and 5 show that Monrovia City is now dealing with a trash issue because of an inadequate solid waste management system, particularly pollution from plastic bags. Every part of the city is experiencing severe drainage issues because of these bags. As a result, the adjacent towns are experiencing major health issues as the area turns into a favorable environment for mosquito breeding. To stop this terrible issue at its root, the nation urgently needs to restrict the use of plastic bags. Other east African nations, including Kenya, Uganda, Tanzania, Ethiopia, and Botswana, have some positive examples to share.

Figure 4. Dumping of waste in un-finished buildings in the city

Figure 5. Dumping of solid waste materials under the bridge, river in the center of Monrovia city

Variables were correlated with one another, as seen in Table 5's correlation matrix. It has been demonstrated that the variables have a significant positive correlation. This association is also statistically (p = 0.001) significant. For instance, solid waste expenditures rise along with rising solid waste creation. All other factors showed comparable patterns as well.

Table 5. Correlation between variables

Item	Income	Expenditure	SW expense	SW generation	Family size
Income					
Expenditure	.826**				
SW expense	.788**	.803**			
SW generation	.814**	.838**	.816**		
Family size	.802**	.867**	.847**	.876**	

Citizens participating in the decision-making processes for SWM?

This research's main goal was to explore the accessibility of low-cost SWM technology, public involvement in SWM decision-making, the existence of local health initiatives, and the presence of environmental awareness campaigns in the city. However, all participants said that their community lacked any low-cost technology that supports SWM. In addition, they all agree that no one has ever made an official decision about how SWM operates.

Table 6. Respondents' collaboration and their perceptions on the available policies

Item	Very bad	bad	good	very good	excellent
Collaboration among stakeholders	318 (79.5%)	82 (20.5%)	0	0	0
Level of coordination and cooperation between service users and service providers	223 (55.75%)	177 (44.25%)	0	0	0

Adequacy of policy and legal frameworks to manage SW	280 (70%)	120 (30%)	0	0	0
Environmental legislation in place	249 (62.25%)	151 (37.75%)	0	0	0
Practice of law enforcement	179 (44.75%)	221 (55.25%)	0	0	0
Clear implementation of the country's law by the municipality	171 (42.75%)	229 (57.25%)	0	0	0

DISCUSSION

Solid waste generation and separation

A person's degree of affluence is mostly associated with how much solid trash they create. Colorado and Echeverri-Lopera (2020) assert that countries with smaller GDPs produce less solid waste overall. The average amount of solid garbage produced daily by an individual was 0.3 kilograms. This outcome matched the findings in Elmnifi et al. (2020). They said that a person typically produces between 0.16 and 5.7 kilograms of solid waste every day.The study investigated how frequently families collected their solid garbage. As shown by the data in Figure 3, 34.3% of respondents stated they collected their solid garbage once a week, while 63.5% claimed they did it once every two weeks or more. However, the fact that trash is not noticed time shows that solid waste is not being handled properly, which could lead to environmental and health problems. 96% of respondents, according to the findings, never split their solid trash into several categories. The lack of efficient solid waste management procedures in the research region indicates a lack of adequate solid waste separation. The results of this study were in line with those of studies from Ghana (Kanhai et al., 2021) and Nigeria (Ike et al., 2018), which found that both nations had major waste management issues. Kabera et al. (2019) say that the way solid waste is managed now is very different from how it is done in Kampala. Although the economies of Kampala and Monrovia are comparable, Kampala has considerably superior solid waste management techniques and produces manure from its solid waste. In contrast, people in Monrovia dump it in their yards, dump it in ditches and rivers, and burn it carelessly in their complexes. In the city of Monrovia, using solid waste is not practicable. In Tanzania, 62% of households inappropriately disposed of their solid waste, according to Banaga (2020). This high percentage of improper solid waste disposal was linked to the difficulty in accessing some locations because of squalid housing and narrow roads, which is a similar issue in Monrovia city. (Kanhai et al., 2021) found that 75% of the people who lived in Debre-Birhan, an important city in Ethiopia, threw away their solid trash in the wrong way. These findings show that a lack of knowledge about waste management technology and best practices, a lack of equipment for gathering sorted materials, and a lack of decision-makers engaged in environmental concerns prevent municipalities from implementing trash separation programs (David et al., 2020). Waste separation awareness campaigns have an impact on people's behavior because they care about the environment and want to participate in finding answers. To support their daily existence, many underprivileged people go from door to door, on the streets, or to the disposal site to collect recyclables (Uddin et al., 2020). Due to the numerous fees that these garbage pickers must pay, households separate their trash in order to sell it for money (Adeyemi, 2020). Recycling companies have sprung up in the cities because of the rising expense of these secondary materials. Together, these two facts seem to have supported a rise in household separation. Lastly, separation is improved when people and the city government work together to make decisions about the waste system (Wang et al., 2021).

Solid waste collection services

Poor solid waste management methods in Monrovia City have been linked to a lack of door-to-door solid garbage collection services by the town administration. Lema et al. (2019) found that 76.6% of respondents burned waste in their complex, 7.2% dumped it in their yard, 8.5% dumped it in a ditch, and 24.2% dumped

it on the road. They concluded that homes that received door-to-door solid trash collection had a roughly threefold higher likelihood of using good solid waste management techniques. However, in Monrovia City, the percentage was enormous: dumping in their yard (293, 73.25%); discarding in the ditch (269, 67.25%); disposing on the road (312, 78%); and burning in their compound (394, 98.5%). Many respondents claimed that burning their garbage was their only alternative, mostly because of not having access to door-to-door solid waste collection services and the lengthy wait times or delays experienced while using the infrequently accessible informal solid waste collectors. This was in stark contrast to other African cities like Mombasa, Kenya, where better door-to-door solid waste collection services are available (Farrah and Ng'ang'a, 2022), and Addis Abeba, Ethiopia, where 84% of households had access to door-to-door solid waste collection services (Tassie et al., 2019). In addition to the subpar door-to-door solid trash collection service, homeowners also have little knowledge of the rules and regulations governing the management of solid waste, or the 3Rs (reduce, reuse, and recycle). As a result, as compared to citizens of other African nations like Addis Ababa, Ethiopia, and Mombasa, Kenya, people in Monrovia city lag far behind in terms of knowing the 3R solid waste management concepts. This difference in knowledge may be due to the work of government and non-government groups, whose main goal is to raise awareness about how to manage solid waste well in these cities. Although door-to-door solid trash collection is almost impossible in the study region, the payment rate is still a significant element in determining how effectively a community manages its garbage collection. The majority of the solid trash collectors in Monrovia City are kids whose survival depends on their work. People make individual arrangements to pay for these services. The results of this survey revealed that consumers spend, on average, $10 to $30 each month. Among the 400 people surveyed, 69.25% claimed to spend $10–15 per month, whereas 23.25% claimed to spend $16–20 per month. Thus, the majority of people (92.5% of them) only spend $20 or less every month. According to Table 5, there was a strong relationship between solid waste output and income ($r = 0.81$, p 0.001), spending ($r = 0.84$, p 0.001), and family size ($r = 0.88$, p 0.001). Other elements that may affect the collection, separation, and transport methods in a specific community include the availability of roads and the quantity of vehicles, information and the organization of neighborhood businesses, and bin collecting systems. Other researchers, Sujauddin et al. (2008), who discovered that a variety of variables, including family size, educational attainment, and monthly income, could affect the output of garbage, also came to similar conclusions. Their expenditures have an impact on how they feel about waste separation. Residents in the community have a significant impact on this area.

Communities' awareness on the importance of solid waste management

A shortage of awareness of waste treatment facilities, a lack of garbage containers and a greater distance to the collection locations, a lack of money, and the absence of appropriate laws and legislation are all factors that increase the possibility that waste will be deposited in public areas and on the roadside. One of the problems restricting the safe disposal of garbage in well-equipped and constructed landfills is reportedly high disposal costs. Even though it is thought that some populations have a natural tendency to recycle trash, there are no signs of recycling in the research region. This is because recycling is heavily influenced by social, altruistic, and regulatory factors that do not exist there. Other studies have shown that people who often use trashcans to dispose of their ordinary rubbish also recycle certain waste products at home and that, in most cases, people separate and gather more fractions as they get closer to the trashcans (Struk, 2017). To increase recycling rates, the government should support markets for recycled products and improve the professionalism of recycling companies. The funding of recycling infrastructure projects, recycling enterprises, buy-back and drop-off sites, and informal sector groups are other factors that other researchers have brought up.

Effect of policies and legal frameworks on solid waste management

The system's supporting elements, or enabling factors, influence waste management as well. Some of these

are technical, environmental, financial, socio-cultural, institutional, and legal. Nawaz et al. (2020) list several technical system issues, such as inadequate infrastructure, dangerous roads and automobiles, outdated equipment, and inaccurate data, as well as a lack of technical experience among municipal and governmental workers. Iklhayel (2018) stated that the challenges influencing the environmental side of solid waste management in developing nations are the absence of environmental control systems and the evaluation of the genuine consequences. Aparcana (2017) proposed that a nation should have effective policies that incorporated active environmental-related concerns in order to have improved solid waste management systems. Municipalities have struggled financially to manage solid waste, claim Kumar and Agrawal (2020). The high cost of providing the service, the lack of financial support, the lack of resources, the users' reluctance to pay for the service, and the wrong use of economic instruments have all made it difficult to provide adequate waste management services. The involvement of the business sector, according to Sharma et al. (2020), is one factor that can boost the system's efficacy. Garbage management is often considered the major responsibility and duty of local authorities and is not anticipated to include the public. As a result, decision-makers, community knowledge, and society's indifference toward problem solving are some socio-cultural variables mentioned by certain academics. The active participation of the public and the municipal agency is essential for the operational efficacy of solid waste management. Municipalities regularly display management flaws, such as a municipal waste management authority's lack of professionalism and organizational abilities, which affect the system and produce institutional variances. Additionally, Guerrero et al. (2013) draw the conclusion that there is not a lot of information available to the general audience. Since there is so little information available and it is spread out across so many different entities, it is very difficult to gain an understanding of the complex topic of municipal solid waste management. Because they frequently work in low-status settings, solid waste personnel lack motivation (Aparcana, 2017; Furedy, 1992). Politicians give other municipal duties precedence over managing solid trash, which leaves the local government short on trained and skilled staff. Support from the government and strategic waste management plans that allow for annual review and system monitoring are cited as good aspects that improve the system (Sulemana et al., 2018). Researchers have demonstrated that having a strong legal framework is beneficial for building an integrated approach to solid waste management systems, but it is detrimental to have insufficient regulations and weak laws

Way forward

After carefully reviewing and analyzing the results, the following recommendations are forwarded:

- The government needs to focus more on introducing and raising awareness of the nation's policies and strategies on solid waste management related issues.
- There should be an introduction of good solid waste management techniques (lessons) to the nation from other regions of the world.
- Residents should avoid burning and dumping in their yards.
- There should be a mechanism in place to stop people from illegally disposing of waste along roadsides and ditches and bridges. Both the individuals and the communities should take their own initiation to stop such acts, which has serious health consequences.

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