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Household Solid Waste Management and Environmental Impacts in the Ibadan Metropolis, Nigeria

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ABSTRACT: Given the current rate of urbanization, municipalities in most Nigerian cities have struggled with the collection, transportation, and disposal of solid waste. This is due to waste generation, both residential and commercial, occurring in a dispersed manner across homes, buildings, streets, parks, and even vacant spaces within communities. This manuscript aims to evaluate the state of municipal solid waste management in Ibadan, household solid waste storage practices, and the locations of solid waste storage containers (skip points) in relation to accessibility and health risks to the community, in accordance with Nigerian National Solid Waste Management Standards and other pertinent international standards. A structured questionnaire was distributed to 21 micro and small firms and 250 homes in each of the three local government areas of the metropolis, with descriptive statistics used to interpret the data. According to the study results, inadequate Municipal Solid Waste Management (MSWM) service delivery in the Ibadan metropolitan area can be attributed to several issues, including a lack of institutional coordination among urban planners. The study's conclusions indicate that the state of MSWM in the sampled areas is either inadequate or has poor spatial coverage and container utilization. Lastly, the study primarily suggests that these measures can reduce problems associated with MSWM by encouraging public-private partnerships, fostering effective institutional coordination with urban planner consultants in MSWM and skip-point location, and motivating the community to adopt integrated sustainable Solid Waste Management (SWM) strategies.

KEYWORDS: Micro and small firm; household waste; solid waste management; waste impact; Ibadan metropolis

1. Introduction

The term municipal solid waste (MSW) generally refers to most non-hazardous solid waste generated by a city, town, or village, which requires frequent collection and transport to a processing or dumping site. It primarily includes household waste (domestic waste), along with occasional commercial waste collected by a metropolis within a given area [1]. Solid waste is an inherent part of human life. Municipal solid waste management is more advanced in wealthier cities, where most industrialized nations have mean waste generation rates of 0.8 to 1.4 kg per person per day, and they manage it effectively [2]. In contrast, in developing nations, the average generation rate is typically between 0.3 and 0.5 kg per person per day, but waste handling and management practices are often inadequate [2]. Due to population growth, rapid urbanization, economic development, shifting consumption patterns, industrial expansion in urban centers, and improved living conditions, managing MSW has become a significant challenge in many cities of less developed countries. As a result, municipalities in growing nations often serve fewer residents than average and spend 20–50% of their available budget on solid waste management (SWM) [3]. However, these nations face a challenge, as local governments often lack the resources to invest in modern waste collection, treatment, and disposal technologies, and do not generate sufficient revenue from waste management operations to cover costs. Consequently, the limited infrastructure and services lead to negative impacts, especially in sanitation, road connectivity, environmental quality, and public health protection [4].

Therefore, there is an urgent need for Integrated Municipal Solid Waste Management (IMSWM) plans that address poor waste management while simultaneously increasing revenue from waste management activities. Proper management of MSW is crucial for public health, as improperly handled waste can lead to odors, flies, and other hazards [2]. In fact, [5] state that Nigeria has experienced a range of outcomes regarding MSWM, similar to other less developed nations. The country faces numerous challenges in managing solid waste, including the absence of sanitary landfills for final disposal at the town or city level, a lack of sanitation facilities to reduce transportation burdens for micro and small businesses, inadequate road infrastructure to transport waste to disposal sites, unclear policies and strategies for involving private partners, budget constraints in the MSWM sector, a shortage of trained professionals, poor coordination between towns and cities, low public awareness about the need to pay for services, rampant littering, sectoral overlaps, a lack of prioritization of waste management by authorities, and inefficient fee collection systems for micro enterprises currently providing MSWM services. In addition, waste containers are poorly managed, harming the environment and posing health risks due to the lack of convenient skip-point locations [6]. Given the current pace of urbanization, municipalities in most Nigerian cities have struggled with the collection, transportation, and disposal of solid waste. Waste is generated in a decentralized manner across households, buildings, commercial and industrial facilities, as well as streets, parks, and vacant spaces within communities [7]. Contributing factors such as mountainous terrain, a shortage of personnel and equipment, and

financial limitations further exacerbate the issue. Furthermore, [8] highlight that the key challenges to sustainable waste management at the community level in Nigeria remain the lack of information and advocacy around waste reduction, recycling, recovery, composting, and energy production. As urbanization accelerates, the per capita waste generation in Nigeria is rising, and the overall MSWM system requires greater attention [8].

The mean daily trash generation rate in Ibadan is 0.53 kg/person [9]. Nonetheless, seasonal differences exist in the amount of solid waste generated per person [9]. According to [9], the city generates 635,000 metric tonnes of solid waste per day. Of this, the majority (70%) originates from residential areas, followed by commercial areas (9%), street sweeping (6%), industrial waste (5%), and other sources such as hotels, hospitals, and so on [8]. Of the waste generated in the city, 68-88% is classified as organic solid waste, and 12-32% is considered recyclable [10]. The solid waste door-to-door collection rate and system in Ibadan is currently exhibiting high levels of improvement. When compared to previous decades, the city's solid waste collection coverage showed significant improvement, rising steadily from 37% in 1982 to 60% in 1999 and 82% in 2011 [10]. This improvement is being attributed to the significant involvement of micro and small firms (MSFs) in door-to-door collection as well as the private sector's collection of waste from various institutions and industries. The remaining 18% of waste is simply dumped on open sites, drainage channels, rivers, and valleys as well as on the streets. Therefore, the entire 635,000 metric tons of solid waste are conveyed or carried to and disposed of at four landfills, the Ajakanga, Lapate, Awotan, and Abe-Eku dumpsites, after being placed in a solid waste storage container (skip-point) [5]. Additionally, the way solid waste is handled still performs at a very poor level, which has an impact on the locals and the environment. Waste that is not properly managed or controlled can contaminate the air, water, and soil. Consequently, worms, gastrointestinal parasites, and other associated organisms are spread among numerous workers (MSF) who handle trash and people who reside close to or on disposal areas. As a result of the entry of heavy metals and other contaminants, proper waste management actually lowers the risk of communicable diseases as well as the toxicity of food and water [11]. In addition, SWM would lessen resource depletion brought on by needless mining, energy use, and pollution issues during the production of the new product. Because unneeded forest and vegetation destruction occurs above the mineral resources, proper recycling or reusing would contribute to species conservation [12].

In précis, efforts to maintain or improve environmental quality ought to be at least commensurate with those made to achieve development advancement. A good MSWM also includes safeguarding public health; enhancing urban environment quality; bolstering economic productivity and efficiency; and creating jobs and revenue [11]. For this reason, this study planned to record the current circumstances. As a result, the authors too often conduct investigation on this important topic. Therefore, in accordance with the Nigerian National Solid Waste Management Standard, this study will critically evaluate the current MSWM practices and related issues with household solid waste storage, solid waste storage container locations, and health risks to the community in the suburban zones of Ibadan North, Ibadan South-West, and Ibadan North-East.

2. Materials and Methods

2.1.The sampling locations' suitability and depiction.

The evaluation was conducted in Ibadan, the capital of Oyo State and one of the oldest towns in Africa. Along with its sister cities, Abeokuta and Ile-Ife, Ibadan is a major development hub in southwest Nigeria. It is located between latitudes 3° 35’ and 4° 10’N, and longitudes 7° 20’ and 7° 40’E [13], situated 133 km northeast of Lagos and 530 km southwest of Abuja, the federal capital [13]. Both colonial and conventional urban sprawl have influenced Ibadan's development. The city was established in the 1830s as a refugee camp following the fall of the Old Oyo and Owu Empires [13]. Since then, Ibadan has experienced significant geographic and demographic growth. As of 2011, its developed land area covered 463.33 km² [13]. In 2006, the National Population Commission (NPC) estimated Ibadan's population to be approximately 3 million. With a national population growth rate of 3.18%, the city’s population was projected to reach 3,565,108 by 2018 [14].

The rapid population growth in Ibadan has greatly impacted the amount of solid waste produced in the city. As both the city's territory and population expand, managing urban solid waste has become a major environmental concern. Ibadan comprises eleven local government areas (LGAs), namely: Ibadan North-East, with its administrative center at Iwo Road; Ibadan North; Ibadan South; Ibadan South-East; Ibadan South-West; Ibadan North-West; Egbeda; Lagelu; Ona-Ara; and Iyana-Offa. Additionally, there are three non-municipal organizations: Oluyole, headquartered in Idi-Ayunre; Ido, headquartered in Ido; and Akinyele, headquartered in Moniya (Figure 1). The five municipal LGAs include Ibadan South-West, with 27 districts; Ibadan North-East, with 24 districts; Ibadan South-East, with 25 districts; Ibadan North-West, with 32 districts; and Ibadan North, with 22 districts [15]. The households surveyed in this study, as well as the micro and small firms (MSFs) of the waste operators, are located in the LGAs of Ibadan North, Ibadan South-West, and Ibadan North-East.

2.2.Methodology.

Purposive sampling and systematic random sampling were the two main sampling methods employed in this study. Additionally, sample size proportions were calculated using a simplified approach. Initial investigations revealed a higher concentration of micro and small firms (MSFs) involved in refuse collection in Ibadan's three municipal LGAs: Ibadan South-West, Ibadan North, and Ibadan North-East. Purposive sampling was used to select key informants for interviews from various sectors, including the state sector (OYSWMA, Ibadan Metropolis Town Planning Personnel, and OYSMEnv Effluent Inspectors), micro and small firm (MSF) waste operators (such as Urban Care Ltd. and JUTO Services Ltd., both involved in household solid waste collection), and residents. These participants were selected because they play a crucial role in the state’s Household Solid Waste Management (HSWM) chain, from waste generation to final disposal.

In contrast, a systematic random sampling technique was applied to select respondents who completed the survey questionnaires. To determine the sample size for households, the study referred to publicly available Statistical Tables, which provide sample sizes for specific criteria. According to [13], a smaller sample size is required when considering specific combinations of accuracy, significance level, and variability for large and relatively

homogeneous populations. Based on this information, the total number of households in the study area was calculated to be 16,189. To compute the sample size, this study utilized a formula while referring to the table provided by [13]. Given that household variability (P) was less variable or more homogeneous at a 95% significance level, a precision range (e) of 7% (or 0.07) was selected for the study. As [13] state, the following is the basic formula for calculating sample sizes:

$$n=\frac{\mu}{1+\mu\,(e)^2}$$

where μ=total number of residential units; n= sample size of residential units; e= tolerable error or precision range; 1= unity (a constant).

Ultimately, the sample households from the selected LGAs were picked by the authors using a proportionate allocation approach. By obtaining the household lists from the housing development office of each LGA, the sample households residing in those areas were contacted for data collection using a systematic random sampling method. Furthermore, 21 key informants were purposefully selected for interviews. These included public authorities such as OYSWMA Dumpsite Engineers (3), Ibadan Metropolis Town Planning Officers (3), and OYSMEnv Effluent Inspectors (3). Additionally, Micro and Small Firm (MSF) solid waste collectors, such as the Director of Urban Care Venture (1), field workers from Urban Care Ltd. (4), and the Operations Manager of JUTO Services Ltd. (3), were included. Informal private operators like garbage scavengers at the dumpsite (3), and members of the public, including the Director of UCODEA (1), Local Council I Chairmen (3), and community representatives (150), were also part of the sample.

The questionnaire, prepared in English, was administered by ten graduate-level, well-trained field assistants who could translate the questions into the local language for respondents who did not speak English. The survey was conducted between eight in the morning and six in the evening over a period of twenty-four days, from Saturday to Thursday, with completed copies of the questionnaire collected daily. In total, 271 samples were used in the study—250 from the questionnaire and 21 from interviews. The response rate for each LGA was based on the total number of households in that area. Descriptive statistics such as simple percentages, means, and frequencies were used to present the fieldwork data. For more advanced statistical analysis, the Statistical Package for Social Sciences (SPSS) 20.0 software was utilized. Ethical considerations were carefully addressed, including the study's objectives, the contents of the research instruments, respondents' rights to privacy and confidentiality, obtaining informed consent, and preparing participants for interviews. The sampling summary is presented in Table 1. According to the 2019 annual review of the Oyo State Environmental Sanitation Law, Ibadan North, Ibadan South-West, and Ibadan North-East were identified as having significant challenges with household solid waste management compared to other suburban areas of Ibadan [13].

Table 1. Shows the total number of households and the size of the questionnaire respondent sample.

Ibadan metropolis	Local District	Total number of household (μ)	Sample size (n) Number	%
Ibadan North	7	3556	82	32.8
Ibadan South-West	7	6409	85	34.0
Ibadan North-East	7	6224	83	33.2
Total	21	16189	250	100

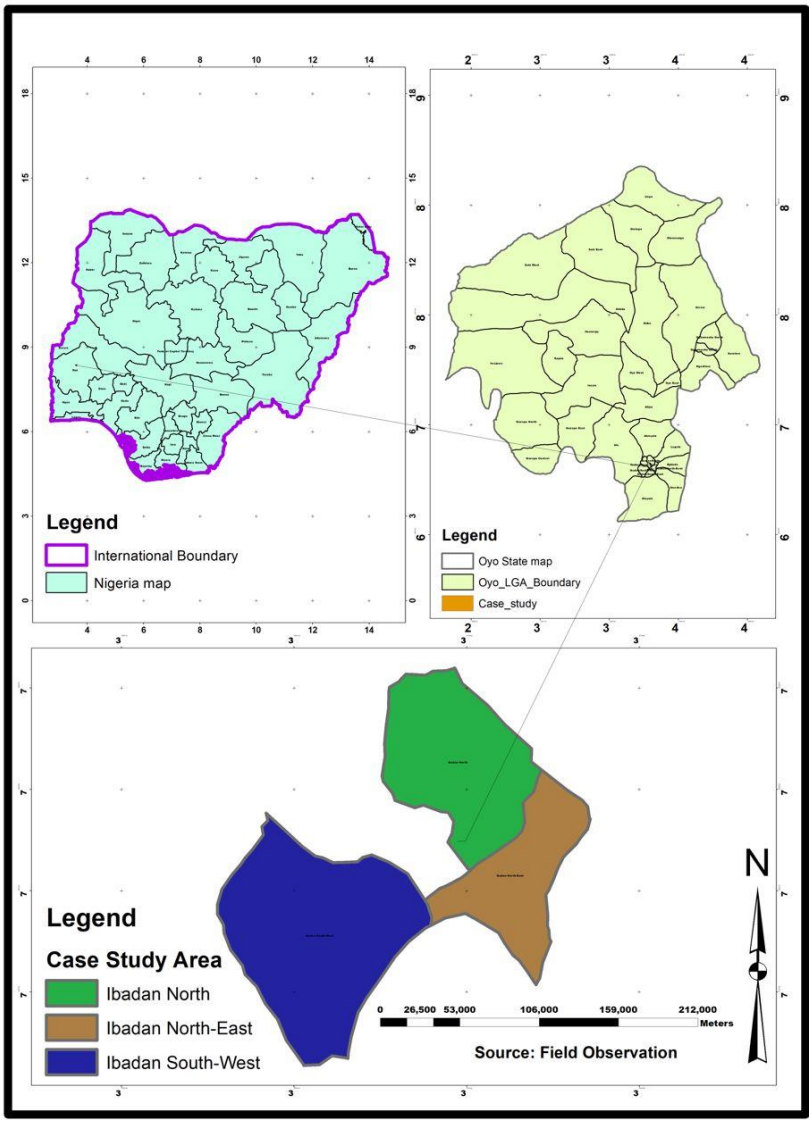

Figure 1. Ibadan local governments' map showing study locations [16].

3. Results and Discussion

3.1. Summary of the sample households' socioeconomic and demographic details.

This study aimed to gather a diverse sample of households with a range of socioeconomic and demographic attributes for the investigation. The respondents' socio-demographic characteristics included age distribution, gender, marital status, employment status, educational attainment, average monthly income, and household size. These factors were considered because the socio-demographic makeup of a population influences the solid waste situation in a particular area, especially in terms of the amount and composition of solid waste generated in urban centers [17]. The characteristics of the sampled households are presented in the accompanying Table. As illustrated in Table 2, 67.6% of the household heads/respondents were female, while 32.4% were male. This gender disparity stems from the fact that women tend to spend more time indoors and are more involved in household activities. Women's prominent role in this study is particularly noteworthy and valued, as they often possess superior knowledge of residential solid waste management compared to men [18].

Additionally, around 55.6% of the respondents were aged 41 and above. The Table also shows the educational levels of the participants: approximately 11.2% had no formal education, 14% had completed primary school, 20% held an SSCE qualification, 51.2% had a diploma or higher, and 3.6% had completed first or second-degree education. In terms of educational attainment, the majority of participants (51.2%) held at least a first-degree qualification, while a substantial portion (20%) had completed an NCE or diploma. This high level of education among respondents contributed to the accuracy and reliability of the data collected. The educational background of the sample households also had a positive impact on obtaining clear and distinct perspectives [19].

Table 2. Respondents' socioeconomic and demographic details.

Characteristics of respondents	Description of features	Frequency	Percent
	Female	169	67.6
Sex	Male	81	32.4
	Total	250	100
	20-30	51	20.4
Age	31-40	60	24.0
	41 and above	139	55.6
	Total	250	100
	No formal education	9	3.6
Educational status	Primary	28	11.2
	SSCE	35	14.0
	Diploma/NCE	50	20.0
	First degree	128	51.2
	Total	250	100
	1-3	85	34.0
Family size	4-6	104	41.6
	7-9	20	8.0
	10 and above	41	16.4
	Total	250	100
	Trading	50	20.0
Employment status	Private sector	83	33.2
	Government sector	45	18
	Daily labour	6	2.4
	Other	66	26.4
	Total	250	100
	Single	81	32.4
Marital status	Married	144	57.6
	Divorced	18	7.2
	Widowed	7	2.8
	Total	250	100
	Below 20,000	41	16.4
Average monthly income	21,000-30,000	110	44.0
	31,000-40,000	42	16.8
	41,000 and above	22	8.8
	No response	35	14
	Total	250	100

Additionally, regarding the household sizes in the sample, 34% of respondents had 1-3 family members, 8% had 7-9 family members, and 41.6% had 4-6 family members. Only 16.4% of the households reported having ten or more family members. Household size has a significant impact on health and solid waste collection and is often used as an indicator of population density [20]. According to [21], the average household size in Ibadan in 2023 was 5.1, which is consistent with the national average. This suggests that the majority of respondents in the study area had household sizes similar to the national average.

Table 2 also presents the employment status of the respondents. Of the 250 sampled households, 20% were traders, 33.2% worked in the private sector (the largest group), 18% were employed by the government, and 2.4% were daily laborers. The remaining 26.4% were involved in various other types of economic activities. Regarding marital status, 32.4% of respondents were single, 57.6% were married, 7.2% were divorced, and 2.8% were widowed. Marital status has its own implications for both economic and social values, particularly in relation to solid waste generation and management [20]. Lastly, income is another socioeconomic factor that contributes to the challenges of Municipal Solid Waste Management (MSWM) and the volume of waste produced. As noted by [22], household income, influenced by the socioeconomic environment, plays a role in MSWM. Table 2 categorizes the households based on their monthly income. The majority of households (44%) fell into the second income category, earning between 21,000 and 30,000 Naira per month. Meanwhile, the smallest group (8.8%) comprised households earning over 51,000 Naira per month.

3.2.*The current state of municipal solid waste management and its geographic reach*.

Municipal Solid Waste Management is one of the fundamental services in Nigeria's Ibadan metropolis that is currently gaining a lot of attention [23]. This is primarily due to improper handling and management of the solid waste produced in Nigerian cities. However, by carefully designing and putting various MSWM components into practice, these issues can be minimized and resolved [23]. Furthermore, in line with the study's objectives, the Table that follows shows how the sampled respondents for the SWM service priority were identified in relation to other services in the study area.

Table 3. Shows the frequency distribution of SWM service priority levels in relation to other municipal services.

Among other municipal services, SWM is not the most important.	Frequency	%	Valid %	Cumulative %
Highly accepted	50	20.0	20	20.0
Accepted	71	28.4	28.4	48.4
Neither accepted nor rejected	5	2.0	2.0	50.4
Rejected	86	34.4	34.4	84.8
Highly rejected	34	13.6	13.6	98.4
No response	4	1.6	1.6	100
Total	250	100	100	

According to Table 3, 20.0% (50 SHHs) strongly agreed, and 28.4% (71 SHHs) agreed with the statement that solid waste management (SWM) services were not the top priority when compared to other basic services like running water, electricity, drainage, safety and security, transportation, sports, and other municipal services. Conversely, 2% (5 SHHs) were neutral, and 1.6% (4 SHHs) chose not to respond. Meanwhile, 13.6% (34 SHHs) strongly disagreed, and 34.4% (86 SHHs) disagreed. According to [24], there was a lack of information regarding the extent to which improper solid waste disposal impacts human health and the aesthetic quality of the community, as well as a gap in prioritizing SWM. Additionally, several respondents indicated that they did not prioritize SWM due to the absence of other essential services, stemming from a lack of awareness about effective SWM.

3.2.1. Households' perceptions and knowledge of solid waste laws, regulations, proclamations, and standards.

The government of Ibadan metropolis had demonstrated significant interest in SWM and developed a workable waste management business model. The industry benefited from the government's implementation of laws, regulations, and standards, which played a crucial role in managing solid waste at every stage [25]. Households were questioned about paying fees or charges for the government-provided SWM service. The households' perceptions and knowledge of solid waste laws, regulations, proclamations, and standards are summarized in Table 4. As indicated by Table 4, 71.5% of respondents reported paying a service fee or charge for government-provided SWM services, whereas 15.6% said they did not pay, and 12.8% did not respond. When initially asked why they were unwilling to pay a fee, respondents explained that in certain areas, such as newly developed residential settlements (especially in Ibadan North), local governments had not requested payments, and households had not received any waste-related services. On the other hand, when asked how much they paid each month, only 15% provided a response. It was found that urban residents paid 25% of their water bill for sanitation services, but even those who responded did not specify the exact fee for SWM [18]. Thus, the enforcement of laws and regulations was not adequately addressed. Respondents were also asked whether they had participated in awareness-raising or educational programs related to solid waste management. Further questions assessed their awareness and legal compliance, including their knowledge of the national SWM law and the presence of proclamations, rules, and regulations. According to [26, 27], behavioral changes are an indicator of knowledge of SWM, and this concept shaped the study's attempt to assess the awareness level of respondents. However, raising awareness requires a well-planned and sustained effort [26, 27], especially for the effective implementation of sustainable SWM.

As shown in Table 4, 60.8% (152 SHHs) of respondents reported that they had not received any education aimed at raising awareness about SWM, while 39.2% (98 SHHs) said they had. Further questions were directed at those who had received education, to assess the impact of such training on their behavior and SWM practices. Respondents also confirmed that apart from yearly events like Environmental Day or Sanitation Day, the relevant authorities had not carried out community mobilization or awareness-raising activities. Consequently, the low level of public awareness about SWM, exacerbated by people's attitudes, contributed significantly to the problem [28]. When asked about their knowledge of the proclamations, regulations, and standards issued by NESREA and OYSWMA, 67.2% of respondents admitted they were unaware of these guidelines, while only 30.0% had some knowledge, and 2.8% were unsure whether the laws and standards had been implemented locally (Table 4). The Enforcement Service Regulation No. 59/1992 on Sanitation and Waste Management for Ibadan Metropolitan was established to prevent illegal activities such as improper waste disposal. This regulation penalizes the improper handling of waste in residential areas. Respondents were asked a hypothetical question regarding penalties for dumping rubbish in public areas like streets, roadsides, or bodies of water. According to the data, 72.8% (182 SHHs) were aware that fines could be imposed for such behavior, while 27.2% (68 SHHs) were unaware. Despite this awareness, respondents were not personally responsible for taking legal action against individuals who illegally disposed of waste. However, when asked how they would react to such actions, 44.0% said they would try to persuade the violator, 29.6% said they would do nothing because it was not their

responsibility, and 4.8% declined to respond due to lack of knowledge about the regulations. Some respondents indicated they would report violators to different authorities: 10.4% preferred to report to OYSWMA staff, 4.0% to the local government, 2.8% to the police, and 4.4% at public meetings on health issues. Additionally, a few respondents reported taking action themselves by advising violators to pick up waste and warning them about the health risks associated with indiscriminate dumping.

The researcher observed that some areas in Ibadan were well-maintained, with posters discouraging illegal waste dumping that read, "Throwing waste is prohibited and punishable by law." Despite these efforts, some residents continued to engage in improper waste disposal without understanding the true extent of the health risks involved. Rules and regulations emphasize the responsibilities of individuals and institutions in handling solid waste [29]. Since the establishment of Ibadan Metropolitan Code Enforcement Service Regulation No. 59/1992 on Sanitation and Waste Management, the office had been tasked with monitoring violations and preventing unlawful activities. However, the lack of a regulatory framework and the weak enforcement of laws continued to hinder the effectiveness of Ibadan's waste collection, storage, and disposal systems [29].

Table 4. Households' perceptions and knowledge of solid waste laws, regulations, proclamations, and standards.

Do you pay a fee or charge for the government's SWM services?	**Frequency**	**%**	**Valid %**	**Cumulative %**
Yes	179	71.5	71.5	71.5
No	39	15.6	15.6	87.1
No response	32	12.8	12.8	100
Total	250	100	100	
Have you ever received household-level education or awareness of SWM?				
Yes	98	39.2	39.2	39.2
No	152	60.8	60.8	100
Total	250	100	100	
Are you aware of the SWM standards, proclamation, and guidelines in your district?				
Yes	75	30.0	30.0	30.0
No	168	67.2	67.2	97.2
Don't know	7	2.8	2.8	100
Total	250	100	100	
Do you believe that discarding trash on streets, at the side of the road, or near bodies of water will result in fines?				
Yes	182	72.8	72.8	72.8
No	68	27.2	27.2	100
Total	250	100	100	
When you witness someone unlawfully tossing solid garbage over a suburban area, what do you do?				
I'll give the LG administration a call to let them know about the circumstance and to take appropriate action.	10	4	4	4
To take action, I shall report to the OYSWMA employees.	26	10.4	10.4	14.4
I'll contact the local police to put an end to his unlawful behavior	7	2.8	2.8	17.2
I'll politely request that he cease his unlawful behavior and make an effort to persuade him not to do it again.	110	44	44	61.2
Since it is not my duty or responsibility, I will not take action.	12	4.8	4.8	66
I'll confront the man at a public meeting about health-related or related issues.	11	4.4	4.4	70.4
Not a reply	74	29.6	29.6	100
Total	250	100	100	

3.2.2. How do households feel about the SWM service they currently receive?

Additionally, respondents were asked for their overall opinions on the current situation and their level of satisfaction with the SWM services provided in each LGA. As shown in Table 5, the majority of respondents (40.4%) reported that the SWM service had improved, 28.8% said there had been no change, 22.8% noted a deterioration in the service, and 8.0% had no opinion. The results of the sample survey are displayed in Table 5. In line with the previous discussion, an additional question was asked of those who had observed an improvement in the quality of services to determine the factors contributing to this improvement. The results indicate that 31.2% of respondents did not answer this question, while 68.8% provided various reasons for the improvement (Table 5). Among the households surveyed, 30.8% attributed the improvement to a combination of factors, while 23.6% credited the government's increased service provision. Additionally, 20.4% believed that heightened awareness contributed to the improvement, 15.6% cited source reduction strategies as a key factor, 8.8% pointed to the private sector's involvement, and 0.8% mentioned other factors without specifying them (Table 5).

Table 5. How do households feel about the SWM service they currently receive?

How would you rank the quality of solid waste management in your local government area?	Frequency	%	Valid %	Cumulative %
Has become better	101	40.4	40.4	40.4
Stays unchanged	72	28.8	28.8	69.2
Has become worse	57	22.8	22.8	92.0
Absent opinion	20	8.0	8.0	100
Total	250	100	100	
Do you see the supply of improved SWM services?				
Yes	172	68.8	68.8	68.8
Absent opinion	78	31.2	31.2	100
Total	250	100	100	
Are you aware that SWM has improved services as a result of?				
A number of things combined to improve service.	77	30.8	30.8	30.8
Intervention by the government	59	23.6	23.6	54.4
Awareness-raising	51	20.4	20.4	74.8
Excellent beginning for source reduction programs	39	15.6	15.6	90.4
Intervention from the private sector	22	8.8	8.8	99.2
Other	2	0.8	0.8	100
Total	250	100	100	

3.3. The primary home storage of solid waste.

The researcher also gathers data regarding household-level solid waste handling and storage practices in Ibadan metropolis. In their compound, residents of the city of Ibadan employed a variety of storage materials, including baskets and plastic bags. Approximately 250 residences were surveyed to determine the kind and quantity of storage goods that the inhabitants possessed. According to Table 6's results, 44.8% of households have used plastic bags in the past. This is closely tied to how cheap sacks are, how readily available they are in the market, how well can carry big volumes of solid waste, and how easily the MSF of the LGAs can supply them [24]. Due to their frequent but minimal waste production and ability to afford repeatable storage materials like plastic bags, 16.42% of households have also used waste baskets in addition to plastic sacks. The rest 18.4%, 6.4%, and 1.2% used polythene bags, empty sacks, and carton storage material, respectively. However, there is a great deal of

variance in the kinds of storage materials utilized by homes. This is primarily because household storage material types depend on solid waste characteristics (such as generation rate, chemical and physical makeup, and moisture level), as well as equipment types and frequency of collection, available space for storing materials, and the financial strength of solid waste generators [23].

It has also been noted that the majority of households that utilize "plastic sacks" to store their solid waste at home discard the sacks along with the rubbish they contain. The households' experience demonstrates that storage materials are intended for single use only. This indicates that after being used to store waste, storage materials lose their value and are quickly incorporated into the waste, adding to the amount of non-biodegradable solid waste that is increasingly strewn throughout the majority of the city [30, 31]. Reducing the amount of garbage we produce at the source is one strategy to manage solid waste, thus storage materials must be made to last for a long period in order to prevent these products from wearing out too rapidly and ending up in the trash [18]. The subsequent Table 6 provides specific proof of this circumstance.

Table 6. Materials used by households to store garbage.

Materials used by households to store garbage	Frequency	%	Valid %	Cumulative %
Plastic sacks	112	44.8	44.8	44.8
Waste basket	73	29.2	29.2	74
Polythene bags	46	18.4	18.4	92.4
Empty sack	16	6.4	6.4	98.8
Carton	3	1.2	1.2	100
Total	250	100	100	

In contrast to the preparation and use of storage materials, most inhabitants, however, lack standardized handling procedures and pays little attention to it. Additionally, the study saw that nearly all SHHs practiced not separating trash that was decomposable from waste that was not, and they all stored garbage using a single piece of storage material. Furthermore, disagreeable characteristics resulting from improper treatment and solid waste dropout around storage items characterize domestic storage materials. Due to a lack of available space, the majority of households also place their garbage quite close to other houses, especially inhabitant households that place their waste within their homes. Additionally, it is evident that practically all of the households' use of the aforementioned items for solid waste storage has been limited to moving rubbish from each residence to the MSF or communal solid waste storage containers. Therefore, a thorough professional investigation is required to determine the proper type of storage material and the optimum frequency for disposing of solid waste [8].

3.3.1. Household strategies for reducing solid waste.

Adopting trash reduction techniques is crucial for both municipalities and garbage generators, as it reduces disposal costs, yields income, and extends the life of disposal sites [3, 30]. Waste storage and segregation are essential components of the MSWM system because they establish whether recycling and composting can be done in an environmentally and economically viable way [32]. Additionally, it has a major impact on the quality of recovered materials, which in turn affects the market value and quality of recycled goods [32]. As a result, pertinent questions on the study subjects' solid waste segregation practices and

practical experience were posed in relation to their awareness level. Only 24% (60 SHHs) of the respondents remained completely silent, whereas 76% (190 SHHs) of the sample families revealed their habits. Regarding the respondents to this question, 138 SHHs or 54.4% said they do not separate decomposable solid waste from non-decomposable trash, 105 SHHs or 42% said they do, and 9 SHHs or 3.6% said they are unaware of waste segregation.

A question about why households do not classify their solid waste into biodegradable and non-biodegradable categories was posed in light of the previous discussion. Sample households provided an explanation for their preference not to segregate their solid wastes in response to the given question. Approximately 40.8% (102 SHHs) reported lacking knowledge, 28.4% (71 SHHs) thought separation was a challenging task, 20% (50 SHHs) thought waste had no value, 6.4% (16 SHHs) said they lacked time and space, and 4.4% (11 SHHs) said they had no opinion. Researchers found that while some households with monthly incomes of 41,000 Naira and higher (Table 1) think that "separating waste is a very important issue, those MSF have been seen as mixing all waste; as a result we have not practiced segregation of waste." Although the respondents believe that waste separation is a crucial issue to ensure that waste collection is efficient, no materials have been given to carry out waste separation by kind, and no communication medium has been used to raise awareness. In order to find out which respondents have used solid waste materials such as bottles, tins/cans, plastics, metals, shoes, or clothing after sorting them for various uses, more questions were asked in Table 7.

Table 7. Household strategies for reducing solid waste in Ibadan metropolis**.**

Do you segregate waste into biodegradable and non-biodegradable categories before discarding		Frequency	%	Valid %	Cumulative %	
Yes		105	42	42	42	
No		136	54.4	54.4	96.4	
Don't know		9	3.6	3.6	100	
Total		250	100	100		

What use do you typically have for separated solid waste materials such bottles, cans, tins, plastics, metals, shoes, or clothing?		Mean monthly earnings					Total
		Less than 20,000	21,000-30,000	31,000-40,000	41,000 and more	No opinion	
To reuse	Count	6	8	2	4	0	20
	%	30.0	40.0	10.0	20.0	0	100
To sell	Count	12	18	8	4	8	50
	%	24.0	36.0	16.0	8.0	16.0	100
To give to others as a gift	Count	6	12	8	2	6	34
	%	17.7	35.2	23.6	5.9	17.7	100
To recycle	Count	1	3	1	1	1	7
	%	14.3	42.9	14.3	14.3	14.3	100
To assist rubbish collectors (to facilitate the collection process)	Count	7	21	10	7	9	54
	%	13.0	38.9	18.5	13.0	16.7	100
other, state	Count	2	6	3	0	2	12
	%	16.7	50.0	25.0	0	16.7	100
No opinion	Count	7	42	10	4	10	73
	%	9.6	57.5	13.7	5.4	13.7	100
Total	Count	41	110	42	22	35	250
	%	16.4	44	16.8	8.8	14	100

That being said, this study found that respondents who separate their waste are able to lower the cost of the solid waste collection and disposal service. For instance, nobody has given much thought to the so-called "Sagolorago"—those people who, via door-to-door sales,

purchase recyclables from various homes, including glass, plastic, tin cans, metals, shoes, and the like—and then sell them to tiny recyclers and enterprises. These individuals visit dumpsters and waste sites in addition to gathering useful things from homes in order to acquire various commodities that they require. Other persons who work in similar jobs are known as "Onipaasiparo or Onipaaro ti de," and they travel the city exchanging new home utensils for discarded clothing and shoes that they then sell to low-income individuals. Their involvement in the management of solid waste collection and disposal should therefore be viewed as a significant informal method of waste management since it lowers the amount of solid trash that would have been collected by the government [33]. Co-disposal of hazardous and non-hazardous waste without segregation is standard procedure in less developed nations [1]. As a result, the respondents from the city of Ibadan similarly did not place a high value on trash segregation; instead, their rubbish was collected, kept, and disposed of in open areas or MSF. Thus, more research is required to raise knowledge among solid waste producers about waste reduction techniques, including reuse, recycling, and recovery [10].

3.4.Community solid waste storage accessibility containers, pickup, and delivery services in the city of Ibadan.

An important way to improve MSWM activities is to research solid waste storage facilities and how they are managed. This is from the standpoint of determining the kind and amount of storage material to be utilized, where to put it (sit) appropriately, choosing the best technique for collecting, and avoiding the effects of storage materials on the environment, human health, and aesthetics [26]. Table (8) shows that, up until early 2018, OYSWMA had placed 170 public solid waste containers in various parts of Ibadan city where there had been a lot of illegal waste dumping, particularly in 12 districts. It also placed these containers in areas where there was likely to be a high population density and 21 MSFs in the suburbs. However, this procedure resulted in dust and odor issues. The diseases induced by various solid waste-related conditions greatly exposed and attacked the residents living near those containers. Because of the lifter truck's unavailability, the lack of regular collection of those public solid waste containers, the maintenance team's frequent technical failures and incompetence, and the carelessness of the operators (drivers and loaders), those containers have not been emptied on a regular basis. Consequently, the OYSWMA was compelled to gather such public solid trash containers rather than carrying out its original function [27]. Based on this, the researcher gathers data regarding OYSWMA's solid waste treatment and storage procedures.

Districts 3, 6, and 12 are served by designated compactors, while districts 1, 2, 4, 5, 7, 8, 9, and 11 were served by lifting cars. District 10 is entirely served by compactors for the transportation and disposal of solid waste. 8 m^3 volume communal storage containers are available, and 148 of them are effectively dispersed throughout the city; yet, some have observed that this is a rare gathering of automobiles. Usually, the most challenging issue with using these containers is how they sit. The amount of land that the containers occupy is comparable to a sizable store. Furthermore, some containers have been positioned in an unsuitable area on a road, causing inconvenience.
These kinds of sites are typically exceedingly expensive to acquire and hard to find. As stated by [18], the collection vehicle that is chosen has to be suitable for the terrain, the kind and density of trash producing sites, the route it takes, and the sort and quality of material that it is

carrying. When compared to serving with lifting hauling automobiles, using compactors reduces health hazards to collectors and odors on the streets, making them a good practice activity [1]. The positioning and placement of solid waste storage containers should comply with the [33] which states: The ease of access for both the general population and the vehicles used for collecting rubbish. Therefore, it is necessary to take into account variables like telephone cables, overhead power and wire cables, and traffic density. A lid or cover mechanism is usually used to protect the containers from scavenging animals and birds. Public safety – people should not be required to cross busy, heavily trafficked roads in order to access the containers. ¬ Visibility – which is greatly improved by the presence of street lighting in the vicinity of the containers? The containers used for storing garbage need to be maintained neat and tidy, and they should undergo a monthly inspection and cleaning. Every three months, at the very least, a 10-meter radius around each shared container spot needs to be cleaned.

On the other hand, as one researcher noted, this analysis revealed that the majority of containers in OYSWMA have been put without taking into account the aforementioned criteria and do not meet the minimal requirements [27]. In order to verify that adequate solid waste collection and transportation services are available, the stated sample houses were also questioned regarding the presence of solid waste community bins in their specific neighborhoods. As a result, the outcome that follows was achieved in Table 8. According to Table 8, 105 HHs, or 42% of the sample, reported that there is a public solid waste container available in their neighborhood, whereas 145 HHs, or 58% of the sample, reported that there is no communal solid waste container nearby. The availability of storage containers for solid waste was found to have an impact on the disposal habits of the respondents. When the door-to-door collectors have not been showing up, some homes (HHs) that are close to a container get rid of their rubbish. Conversely, the researcher noted that in certain places, people have the option to dispose of their waste close to containers. However, in those areas, people who have been using "empty bags" to store their solid waste at home—whether or not the containers are full—throw the empty bags away with the waste they contain.

The average distance between a dwelling and a communal container was found to be less than 100 meters, in addition to the mentioned availability of the communal solid waste container and the accessibility of solid waste storage container. Most homes are fewer than a 100 m away by foot. It indicates that a large number of individuals may reside within a 100 m radius of the container, but the other households must travel a considerable distance to access the containers. Generally speaking, 38.4% of households (96 SHHs) have a container within a radius of less than 100 meters; 29.2% of households (73 SHHs) have it between 101 and 200 meters; 23.6 percent of households (59 SHHs) have it between 201 and 300 meters; 8% of households (20 HHs) have it between 301 and 400 meters; and 0.8 percent of households (2 SHHs) have it more than 400 meters. The same respondents were then questioned about their participation in and ability to influence the positioning of the containers in their local communities. Table 8 displays the sample households' responses. According to [33], responsible authorities must make sure that locals are involved in choosing where to put the community garbage bins (where applicable). This will balance the requirement that the container be close enough for convenience with any worries over possible odor, the presence of dogs, cats, and rodents, as well as other aesthetic considerations.

Table 8. Community solid waste storage accessibility containers, pickup, and delivery services in the city of Ibadan.

District	Quantity of containers that received a full service	Containers for which no service was provided	Number of MSF		
	Ibadan North				
1	13		2		
2	15	5	2		
3	14		2		
4	12		1		
	Ibadan South-East				
1	20	6	2		
2	15		2		
3	20		2		
4	10		1		
	Ibadan North-West				
1	13		2		
2		7	2		
3	10		2		
4	6	4	1		
Total	148	22	21		
Does your area have access to a container for storing solid waste?		Frequency	%	Valid %	Cumulative %
	Yes	105	42	42	42
	No	145	58	58	100
	Total	250	100	100	
Do you have any influence or involvement over where the public container is placed?					
	Yes	45	18	18	18
	No	136	54.4	54.4	72.4
	Don’t know	69	27.6	27.6	100
	Total	250	100	100	
Where do you dispose of the everyday solid garbage you produce?					
	Utilize the MSFs to gather my home's trash	84	33.6	52.8	52.8
Valid	Into a valley/stream	13	5.2	8.2	61
	On the nearby open space	22	8.8	13.8	74.8
	Bury yourself in the compound	10	4	6.3	81.1
	Burn	6	2.4	3.8	84.9
	Other	24	9.6	15.1	100
	Total	159	63.6	100	
Missing	System	91	36.4		
	Total	250	100		
How is the communal solid waste storage container typically located?					
	Always packed to overflowing	128	51.2	51.2	51.2
	Constantly filled	69	27.6	27.6	78.8
	Not full, not empty	38	15.2	15.2	94
	No reply	15	6.0	6.0	100
	Total	250	100	100	

Nevertheless, there was little community involvement in SWM in the city of Ibadan. This was mostly brought about by a lack of promotion through targeted SWM information campaigns and programs for raising general awareness. The majority of respondents, or roughly 54.4% (136 SHHs), said they had no say or participation in choosing or deciding

where the containers would be placed in their communities; however, 18% (45 SHHs) of the respondents acknowledged that they had a say in selecting and deciding where the containers would be placed, and the remaining 27.6% (69 SHHs) said they were unaware that they had a say in the matter. However, a follow-up question was posed to find out where families typically dispose of their solid waste in the event that garbage containers are either unavailable or that households are unaware that containers are accessible in their neighborhood. As a result, the subject households' responses yielded the following results. Table 8 shows that approximately 52.8% of respondents utilize MSFs, and every family stays until MSFs arrive; 8.2% of SHHs dispose of their waste in a nearby river valley and roadside ditches, and 13.8% of SHHs dispose of their waste in open spaces. available in their neighborhood, 6.3% of the respondents use alternative techniques like burying solid waste in their compounds, and the remaining 3.8% of SHHs burn their waste; however, 15.1% of SHHs disclosed using other methods, such as having their servant dispose of their waste or hiring laborers for a fee when a container is unavailable or the MSF isn't showing up. As per Table 8, the respondents who reside in a squatter community in Ibadan city have been disposing of their solid waste carelessly in the vicinity of open spaces, roadside ditches, rivers, and their own enclosure. In addition to causing harm directly, careless solid waste disposal would promote the growth of street animal populations. In a similar vein, a survey was conducted to find out how householders felt about the surroundings of the public solid waste containers. Based on their daily observations, sample households provide the following explanation of the state of affairs.

In reference to the state of the solid waste containers, 78.8% (197 SHHs) of the study participants stated that the city of Ibadan's communal containers are constantly full and overflowing, while 15.2% (38 SHHs) of the respondents stated that the communal containers are never empty; the remaining 6 percent (15 SHHs) of the respondents did not answer this question. This conclusion so indicates that the foregoing conditions have been impacting the biological life surrounding the municipality and the people who live near containers as a result of the infrequent collection of a container.

From the sample households, 59.2% (148 SHHs) reported that the smell of the solid waste was bothering bystanders, that the solid waste was being eaten by domestic animals, that the container was a haven for flies, mosquitoes, and other scavengers, that it caused uncontrollable fires and diseases, and that it looked bad because semi-fluid matter was coming out of waste as a result of incidents they had seen from overflowing solid waste containers; 10.4% (26 SHHs) of the respondents reported that they had witnessed incidents involving only the stinking odor; 8.8% of the respondents (22 SHHs) reported that they had seen the container serving as a haven for fly, mosquito, and cockroach vectors; 7.6% of the respondents (19 SHHs) claimed that domestic animals had eaten solid waste; and 1.2% of the respondents claimed that they were the source of an uncontrollable fire and that the semi-fluid matter that emerged from the waste was unsightly. Conversely, 4.4% of the participants considered this question to be non-responsive.

The results of Table 9 show that the community's health and safety are at risk if storage containers are not routinely emptied. Therefore, improper waste management and disposal are major contributors to environmental pollution of surface water, groundwater, air, and soil resources; they also decline aesthetic values; encourage the growth of pests and worms; gastrointestinal parasites; increase the incidence of AIDS/HIV infection and Hepatitis A, B,

and C; burn municipal waste in an incinerator, which releases heavy metals like Cd, Pb, As, Hg, and dioxin into the air; bury biomedical waste, which contaminates water sources; and openly dump waste to attract flies, rodents, and other dangerous animals [11].

Table 9. Occurrences that homes have ever observed in and/or near an overflowing container.

Which of the following instances have you ever observed in or around a solid waste container that is overflowing?	Frequency	Percent	Valid Percent	Cumulative Percent
The repulsive stench bothering bystanders	26	10.4	10.4	10.4
Eaten by household animals (dogs, cats)	19	7.6	7.6	18
Serving as a haven for insects such as cockroaches, mosquitoes, and flies	22	8.8	8.8	26.8
Reason behind sickness and uncontrollably burning	3	1.2	1.2	28
Give the impression that semi-fluid stuff is stemming from the garbage;	21	8.4	8.4	36.4
All of the above	148	59.2	59.2	95.6
no response	11	4.4	4.4	100
Total	250	100	100	

3.4.1. Solid waste collection designated by MSFs.

In Ibadan metropolis, the collection coverage of solid waste has risen to about 92% [9]. As [5], the waste production rate per person is about 0.53 kg/day. However, Solid waste generation rate has been increased in the day to day activity. Currently, the city solid waste has been collected by designated MSFs and they collect in the door to door collection system. Accordingly, to compare and contrast the household's response given for places where respondents do dispose of their household solid waste, they were also asked a question if they have ever been served by MSFs. Based on the above question, the following result was observed from the response of the sample households. Table 10 shows that 83.2% (208 SHHs) of the respondents used the solid waste collection service that MSFs provided, while 16.8% (42 SHHs) of the respondents did not use the service. Those that have not been, they were in the habit of carelessly disposing of their garbage in roads, ditches, waterways, and open areas even though they were contracted by approved MSFs.

Table 10. Solid waste collection designated by MSFs.

Have you ever received SWM services from private MSEs?	Frequency	%	Valid %	Cumulative %
Yes	208	83.2	83.2	83.2
No	42	16.8	16.8	100
Total	250	100	100	
Do you think the current level of service provided by these private MSFs is adequate?				
Yes	70	28	28	28
No	165	66	66	94
No response	15	6	6	100
Total	250	100	100	

In addition to the aforementioned, sample homes were requested to provide feedback in order to determine whether or not the current services provided by the MSFs are adequate and satisfactory. The outcome is shown in Table 10. As can be seen in Table 10, 66% of the respondents think that MSFs' solid waste collection services are inadequate and unsatisfactory. In contrast, 28% said that it is adequate and satisfactory. Merely 6% of the homes in the sample opted not to respond to this inquiry. As a result, this demonstrates the limited coverage of service delivery. Chief informants and MSF estimate that the mean

number of households served by the organization is 1600, and that this figure is correlated with the total number of MSF locations. On the other hand, low coverage could be the consequence of low desire or ineffective MSF assistance in terms of ongoing training, insurance, first-aid supplies, and safety [23].

3.5.Elements impacting the city of Ibadan's municipal solid waste management service.

From the explanation above, it is clear that the city of Ibadan manages MSWs badly in terms of maintaining ecological life. It's obvious that the service is subpar. It is well established that inappropriate SWM and disposal negatively impacts the environment and public health [31]. A few problems are noted as possible roadblocks to better SWM service delivery in the city of Ibadan. These include poverty and population pressure, weak institutional capacity, poor infrastructure, poor decision-making, slow progress in enacting behavioral changes, and issues with space, money, and awareness [8], inadequate institutional coordination, financial constraints, sociocultural factors, ignorance, a lack of laws and regulations, standards, and proclamation execution all contributed to the inadequate MSWM in the city of Ibadan [31–34].

4. Conclusion

Home engagement is a prerequisite for waste management strategies to have long-lasting effects; this means involving the home at various project cycle phases and intensities. Members of the household can contribute in a variety of ways, for instance by paying collection fees, separating recyclables, and offering waste at the proper time. Moreover, household members can take part in committees that oversee garbage services, attend meetings to influence the project's course, or organize awareness-raising events. It takes effective communication techniques, such awareness-raising initiatives, to provide household members a general understanding of solid waste issues. Micro and small firms, community-intended organizations (CIOs), and local leaders are significant facilitators of household engagement. They can make certain that the requirements of the home are met. However, leaders and CIOs need to be among the stakeholders in order to be able to energize the home and community. In order to maintain and run the trash service, MSFs and the local government must work together, perhaps through a partnership or contract. This will increase rubbish collection efficiency and provide for a clear division of responsibility. Achievable goals, a suitable time range, and flexible planning can all positively impact community involvement. Even though the actual tasks may not always be visible, a household's participation in a neighborhood activity should be seen as a voluntary act of civic responsibility, a commitment by the residents to one or more stages of a collective project (control, awareness-raising, providing information, promoting, decision-making). The best results from waste collection or clean-up efforts come from residents taking an active role in educating the public, keeping an eye on the service, and/or increasing awareness at the home level. This is when residents truly take control over their content and the social and sanitary scope of their actions. Background information on home solid waste management practices and their effects on the local environment have been made available by this effort. Data about the suitability and potential health effects of household SWM at the study location have been provided. Additionally, the effort has expanded the baseline data on SWM investigations in our setting.

Abbreviations: OYSWMA: Oyo State Solid Waste Management Authority; MSFs: micro and small firms; MSWM: Municipal Solid Waste Management; SWM: Solid Waste Management; LGAs: local government areas; SHHs: Sample households; HHs: households; kg: kilogram; UCODEA: Urban Communal in Development Association; CIOs: community-intended organizations; NNSWMS: Nigerian National Solid Waste Management Standard; NESREA: National Environmental Standards and Regulations Enforcement Agency.

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Author's Contribution

All of the authors worked together to complete this noble work. Oladeji, PB, Oyedare, AB, and Ogunwale TO conceptualized, designed, and participated in the work. sampling collection were done by Oyedare, AB and Oduah, OA. The original draft of the manuscript was written by Ogunwale, TO, Oyetola, SO, and Oluwalana, AI. The study's introduction and literature searches were handled by Basiru, TA and Balogun, FA. Ogungbile, PO and Ogunrinola, OF did the stastical analysis. The final manuscript paper was read, corrected, and approved by all the authors.

Conflict of Interests

The authors have not declared any conflict of interests.

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