Assessment of solid waste segregation practices and their determinants in Bungoma municipality, Kenya

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ABSTRACT

Solid waste segregation is an important component of sustainable solid waste management because it facilitates the separation of waste materials at the point of generation, thereby promoting recycling, reuse and appropriate disposal. However, inadequate public awareness, limited infrastructure and weak institutional participation continue to undermine waste segregation in many developing-country municipalities. This study assessed the level of solid waste segregation and the factors influencing the practice in Bungoma Municipality, Kenya. The study was guided by The Integrated Sustainable Waste Management Model (ISWMM) designed by Klundert and Anschutz. The study adopted a descriptive research design and employed questionnaires, interviews, observation and focus group discussions to collect data from households, commercial enterprises, institutions and county government employees. The study targeted approximately 106,000 residents from selected neighbourhoods of Bungoma Municipality, namely Kanduyi, Namuyemba, Mashambani, Kiwanja Ndege, Marrel, Pamus, Milimani, Muteremuko, Main Stage, Wings, Mujini and Musikoma, alongside municipal personnel and staff from the County Departments responsible for Public Health and Sanitation and Environment. Residents were drawn from households, businesses and institutions, which constitute the main sources of municipal solid waste. The sample comprised 162 households systematically selected from 14 residential areas, with every eighth household selected. Purposive sampling was used to ensure representation of low-, middle- and high-income residential areas, while 100 business premises, 73 institutions and 25 Jua Kali artisans were systematically selected. Additionally, six municipal waste collection employees were randomly selected, while two officers from the relevant county departments were interviewed. Two focus group discussions, each comprising nine participants, were also conducted. Purposive sampling enabled the selection of information-rich participants relevant to the study objective. Quantitative data were analysed using frequencies and percentages, while qualitative information was analysed descriptively. Findings revealed that only 11% of the households practised waste segregation, whereas 89% disposed of their waste without systematic separation. Most households undertook limited separation of biodegradable and non-biodegradable materials, with very few proceeding to distinguish reusable, recyclable and combustible materials. Lack of awareness was the leading reported barrier to segregation, accounting for 53% of responses, followed by inadequate space (24%) and the perception that segregation was tedious and time-consuming (9%). Other constraints included lack of time, inadequate waste containers and limited institutional support. The study further established that county government employees did not systematically segregate collected waste, while segregation among commercial enterprises and institutions remained limited. Household size, age, gender, income, availability of gardens and public awareness were among the factors associated with the practice. The study concludes that waste segregation in Bungoma Municipality was generally low and requires strengthened environmental education, provision of appropriate waste receptacles, institutional capacity development and coordinated participation between households, businesses and the county government.

Keywords: Bungoma Municipality, Environmental Awareness, Household Waste, Kenya, Municipal Waste, Solid Waste Management, Waste Segregation

1. INTRODUCTION

Management of solid waste has become an issue of concern in urban areas that are rapidly urbanizing in developing countries. There is increase in solid waste due to increase in population, migration from rural areas, changes in consumption patterns, increase in industrial activities and increase in commercial activities (Rahman & Moore, 2020). This has placed a great deal of pressure on existing waste management systems as municipal authorities lack sufficient financial, technical and institutional capacity. Many urban areas lack proper waste collection systems leading to indiscriminate dumping of solid waste. This leads to pollution, blockage of drains, disease vectors and poor

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urban environments. In many African countries this is made worse by the rapid urbanization, lack of proper waste management infrastructure and low public participation in waste management (Chanda & Mumba, 2021).

Proper waste segregation plays an important role in solid waste management. Waste can be divided into biodegradable and non-biodegradable waste. However, other types of waste may need to be separated such as hazardous, e-waste and recyclable waste (Mwangi et al., 2021). By properly segregating waste we prevent recyclable waste from being contaminated. Biodegradable waste like food waste, vegetable waste and organic waste can be turned into compost. Non-biodegradable waste like plastic, metal, glass and paper can be recycled and reused. According to National Environment Management Authority [NEMA] (2014) this reduces the amount of waste that needs to be transported to final disposal sites. Proper waste segregation will reduce pollution, save natural resources and reduce pressure on disposal sites. Waste segregation at source is important for sustainable solid waste management.

In many developing countries waste segregation can be difficult to implement. Waste collection and storage systems lack, low recycling infrastructure, lack of awareness, poor enforcement and lack of institutional capacity can discourage households, businesses and institutions to segregate their waste (Liew et al., 2021). In some urban areas waste generators will place different types of waste in the same container as they do not have proper waste collection points. If waste has already been segregated and then mixed when collected this can reduce public confidence. Poor infrastructure and institutional capacity have been observed to be a problem in many African municipalities as they affect waste collection and recovery (Bello et al., 2016) (Okalebo et al., 2014). This shows that waste segregation can only be improved if there is proper infrastructure, institutional support, proper waste collection methods and community participation.

In Kenya, solid waste management is an important responsibility of county governments. They should develop effective waste management programs, collect and dispose of waste, conserve the environment and ensure that the public participate in managing the environment (NEMA, 2014). Kenya has laws and policies in place to help manage the environment, however in many urban areas there are problems in implementing these. There is lack of equipment to collect waste, lack of disposal and recycling facilities, lack of funding and poor enforcement of waste management regulations. Waste segregation is not consistent and many households, businesses and institutions are not segregating their waste at source (Mwangi et al., 2021). This means there is less opportunity to recycle waste and create compost. More waste will need to be disposed of and this causes increased pressure on the county waste management systems.

Bungoma Municipality is one area that is seeing an increased demand for effective waste management. With increased population, residential areas, commercial activities and institutions there is an increase in different types of solid waste. This means that effective waste management systems are needed such as waste segregation, proper storage, regular collection, transport, recycling and safe disposal. However there are many issues facing waste management. There is poor waste segregation, indiscriminate dumping and lack of community participation. Households, businesses and institutions are not segregating their biodegradable and non-biodegradable waste meaning there is less opportunity to recover useful resources. This makes the waste difficult to manage and process. Poor waste segregation at source may lead to environmental degradation, poor waste collection and increased pressure on waste disposal facilities.

Previous research has shown that there are issues with waste management in Bungoma Municipality. Poor waste disposal and lack of community participation were identified (Roussel, 2012). Although this research shows us that there are issues with waste management in the area it does not show how much different types of waste generators are segregating their waste. It is important to understand how households, businesses and institutions are segregating their waste and what factors are influencing them. The socio-economic factors of the waste generators may affect how aware they are, their attitude and their ability to segregate their waste. Institutional factors, regulation enforcement, public education and waste collection/storage facilities may all affect whether waste is segregated.

This research looked at how much solid waste is being segregated in Bungoma Municipality and what factors are influencing this. Socio-economic, institutional and infrastructural factors were looked at to see how they are affecting waste segregation in households, businesses and institutions. This information can help identify what barriers are causing waste not to be segregated at source and what opportunities there are to improve waste recovery and recycling. This information will be useful to county authorities, environmental management agencies, community groups and other stakeholders to create effective interventions. Interventions could include increasing public awareness, improving waste collection/storage facilities, increasing regulation enforcement and increasing community participation. Improving waste segregation in Bungoma Municipality can improve solid waste management, create a sustainable environment and encourage a clean and healthy urban environment.

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1.1 Statement of the Problem

Waste segregation by waste producers plays a critical role in effective solid waste management. However, in many developing country, municipalities do not segregate their waste due to multiple reasons. Bungoma Municipality produces varied types of solid waste from households, commercial and institutional sectors. However, there is poor segregation of waste leading to accumulation of mixed waste, less recovery and increased pressure on current waste disposal systems. This is attributed to the lack of adequate waste bins, lack of technical knowhow and poor awareness on waste management by the county government who is responsible for waste management in the municipality. Moreover, it was not clear how much the household characteristics, institutional practices and availability of waste management facilities were influencing waste segregation in the municipality. This study aimed at determining the extent of waste segregation by waste generators in the municipality and what factors influence waste segregation. This will help develop targeted intervention strategies to enhance sustainable solid waste management in Bungoma Municipality.

1.2 Objective of the Study

To assess the level of waste segregation within Bungoma Municipality, Kenya.

1.3 research question

What is the level of solid waste segregation carried out in Bungoma Municipality?

II. LITERATURE REVIEW

2.1. Theoretical Review

The study was guided on the Integrated Sustainable Waste Management Model (ISWMM) designed by Klundert and Anschutz (2001).

2.1.1 The Integrated Sustainable Waste Management Model

The ISWMM is a paradigm that acknowledges stakeholders, elements, and aspects as three crucial factors in solid waste management (Hoornweg & Bhada-Tata, 2012). The conceptual framework of the study was informed by this model. The stakeholders in solid waste management are the local governments/ county governments, NGOs and CBOs, the service recipients, the private sector, the unorganized sector and donor organisations (Klundert & Anschutz, 2001). To attain sustainability in waste management (Visvanathan et al, 2004), it is imperative to analyse the roles, interests and power dynamics in waste management. While the city's government has the legal responsibility to manage solid waste, it has no legal means to dictate or implement acts alone in the absence of other stakeholders in the system who have their own duties and obligations (Wilson et al, 2012). It has been proven that collaboration and coordination amongst the various groups of stakeholders such as city council, provincial government, service users, NGOs, CBOs, the private sector (formal and informal) and donor agencies can lead to behavioural changes and financial responsibility sharing which can enhance the sustainability of a waste management system in the long term (Visvanathan et al, 2004). The stakeholders in this study in the Bungoma municipality were residents, the county administration, Public Health and Sanitation ministry and NEMA. As municipal services are not able to fully reach underprivileged neighbourhoods and informal settlements, inclusiveness in service provision is essential (Wilson et al., 2012).

Elements are the technological elements of solid waste management (Hoornweg & Bhada-Tata, 2012). These are made up of the production and separation, collection, conveyance and transportation, processing and disposal (Klundert & Anschutz, 2001). Incorporated in these activities are practices like reduction, re-use, recycling and recovery; all aiming towards sustainability (Hoornweg & Bhada-Tata, 2012). This study aimed at finding out how solid waste segregation is used in the reduction of the amount of solid waste dumped and therefore improving sustainability in Bungoma municipality. It also analyzed the impact of solid waste segregation on other practices such as recycling, reuse and composting which aim to manage waste in a sustainable way.

Aspects refer to the technical, environmental, institutional, socio-cultural and financial realities within which the waste management systems operate (Hoornweg & Bhada-Tata, 2012). Solutions that are locally relevant and economical can be found when there is a strong political commitment and leadership, as well as where the local community is actively involved (Wilson et al., 2012). The management of solid waste won't be successful until the entire community participates with regard to source segregation, recovery of reusable and recyclable items, and storage of waste prior to collection (Visvanathan et al, 2004). For instance, in Kibera, Nairobi, youth self-help groups participate in solid waste management activities, including waste collection, segregation, transportation, recycling and disposal, thereby contributing to improved waste management within the community (Mwangi et al., 2021).

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In Bungoma municipality, the main challenges revealed by Roussel (2012) include; inappropriate equipment, weak legal policies and institutions and inadequate financial support. In a paper by Ogawa (1996) entitled Sustainable Solid Waste Management in Developing Countries, Ogawa presents some of the factors that hinder the sustainability of solid waste management efforts in developing nations. These include institutional constraints, financial constraints, technical constraints, economic constraints and social constraints. According to Chanda and Mumba (2021), while there have been several solid waste management efforts in developing countries, most of these efforts are not sustained once external assistance is withdrawn. This problem indicates the need for capacity building in terms of institutions, financial processes, technology and social involvement in order to sustain solid waste management efforts (Okot, 2012). According to the researcher, the lack of clearly defined roles or responsibilities for various national agencies with regard to SWM, as well as the lack of a single organization or committee designated to coordinate their projects and activities, results in duplication of efforts, resource waste, and the inability of the overall SWM program to be sustained.

2.2. Empirical review

Waste segregation is an important aspect of sustainable solid waste management as it separates different types of wastes to help reduce waste being collected and disposed, by making the waste manageable for reuse and recycling (Eugenia et al., 2002). Waste segregation can be made effective by segregating at source, collecting and transporting the different types of waste. For example in the Philippines, Barangay Sun Valley have successfully used an ecological waste management programme to help compost biodegradable waste, recycle recyclable waste and dispose of residual waste (Eugenia et al., 2002). The European Union have also placed importance on reducing waste and increasing waste recovery. This being a key part to creating a recycling society. Countries like Japan and Germany have also created systems to help increase recycling by having a more structured method of waste segregation (Wilson et al., 2012).

In developed countries waste segregation can be made effective due to legislation, increased awareness, efficient collection and having the correct infrastructure. In Ontario, Canada there is promotion of source segregation through initiatives like the Blue Box and Green Bin. These are for recycling and organic waste respectively. They are supported by legislation called the Resource Recovery and Circular Economy Act (Government of Ontario, 2016). Research has shown that increased awareness, efficient collection, legislation and sociocultural factors can help increase waste segregation (Rahman & Moore, 2020). However, studies have shown that in developing countries waste segregation is hindered due to lack of infrastructure, lack of knowledge and low levels of public involvement. For example, Choma, Zambia had some households that did not see the need to segregate their waste or did not have the knowledge to do so (Chanda & Mumba, 2021). Kuching South, Malaysia also had issues with lack of infrastructure, lack of motivation and lack of access to recycling centres (Liew et al., 2021).

Bungoma Municipality has little infrastructure, low awareness and poor enforcement of waste management requirements. There is little designated bins for waste segregation. Some areas do not have enough bins and instead have shared bins (Nzeadibe et al., 2023). Whilst Kenya do have legislation in place for waste management and sustainability, there is little source segregation taking place in households, commercial areas and institutions (NEMA, 2014). The Bungoma County Integrated Development Plan of 2021 noted that waste collection, waste segregation and illegal dumping was a consistent issue. Challenges have also been highlighted regarding waste management practices, waste generation and solid waste. This shows that it is important to look into how much households, businesses and institutions are getting involved with waste segregation.

Evidence from East Africa shows that households do tend to recover certain valuable items but not in a structured way. Households often separate out food waste, plastic bags, bottles, tins and scrap metal (Okot, 2012). Bungoma has little formal segregation but some items were recovered (Roussel, 2012). Increasing public involvement, environmental awareness and changing behaviours can help improve waste management. Initiatives have been put into place within communities to help increase waste recovery. For example, youth have been involved in waste collection, segregation, transport and recycling in Kibera, Nairobi. This shows that structured groups can help increase resource recovery and create jobs (Mwangi, 2021). However, there is little evidence available to show how much source segregation is taking place in households, commercial businesses and institutions in Bungoma Municipality. This means that it is important to look at how waste is being segregated currently and what socioeconomic and institutional factors are affecting this.

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III. METHODOLOGY

3.1 Research Design

The study adopted a descriptive research design to establish the level of solid waste segregation and the factors influencing the practice in Bungoma Municipality. The design enabled the researcher to obtain information concerning existing waste management practices among households, commercial enterprises, institutions and county government employees.

3.2 Study Area

The study was conducted in Bungoma Municipality, located in Bungoma County, Kenya. The municipality accommodates residential areas, commercial enterprises, educational institutions, government offices and other waste-generating establishments. These different land uses provided an appropriate setting for examining variations in solid waste segregation practices.

3.3 Study Population and Sampling

The Bungoma municipality's total population was predicted to be 68031 as of the 2019 census. This was an increase from 43,516 in 2009; a 25% rise, showing that the town's population is expanding rapidly. This problem is not unique to Bungoma Municipality since the rapid growth of urban centers in Kenya has continued to pose a major difficulty in solid waste management. According to Kimutai & Waweru, who presented their paper at a conference in August 2012, the urban population of Kenya was experiencing rapid growth over the last decade. The increase in the urban population in Kenya has been characterized by more human settlements, activities and consumption. Therefore, the rate of generation of solid waste has increased, putting the municipal waste collection, transport, recycling and disposal system under strain. The relationship between urban growth and solid waste generation is significant since as the urban population grows, the rate of waste generation increases and vice versa. The increase in urban growth calls for waste management strategies such as waste segregation, waste recycling and waste disposal among others.

The study population comprised approximately 106,000 residents drawn from the selected neighbourhoods of Bungoma Municipality, namely Kanduyi, Namuyemba, Mashambani, Kiwanja Ndege, Marrel, Pamus, Milimani, Muteremuko, Main Stage, Wings, Mujini and Musikoma, together with Bungoma Municipality personnel and staff from the departments responsible for public health and sanitation and environment. The residents were selected from households, businesses and institutions, which constitute the major generators of solid waste within the municipality. Based on the population estimates presented for the selected areas, the study population provided a basis for examining waste segregation practices and their contribution to sustainable solid waste management. The sampling frame therefore comprised eligible municipal personnel, relevant public health, sanitation and environmental staff, and residents representing households, businesses and institutions within the selected areas of Bungoma Municipality.

3.4 Sampling and sample size

The sample size was determined using the formula for large populations (Mugenda & Mugenda, 1999):

$$n = \frac{Z^2 pq}{d^2}$$

Where:

n is the required sample size, Z is the standard normal deviate at a 95% confidence level (1.96), p is the estimated population proportion (0.5), q=1- p), and d is the margin of error (0.05). Substituting these values yielded a sample size of 384 respondents.

The study employed systematic sampling to select 162 households from 14 residential areas, with every eighth household included. The sample also comprised 100 business premises, 73 institutions and 25 Jua Kali artisans, systematically selected across the study areas. Six municipal waste collection employees were randomly selected, while two county officers from the relevant environment and public health departments were purposively selected for interviews. Additionally, two focus group discussions, each comprising nine participants, were conducted. Households were purposively distributed across low-, middle- and high-income residential areas to ensure representation of different socioeconomic groups. This approach enabled the selection of information-rich participants relevant to the study objectives (Kombo & Tromp, 2016).

3.5 Data collection instruments and Procedure

Both primary and secondary data was collected. Primary data was gathered through interviewing, focus group discussions, questionnaires and observation techniques. These three methods were appropriate as they allowed the collection of data from both literate and illiterate respondents. The methods were applied as follows:

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3.6.1 Observation

Observation was used to verify some of the information collected through interviews and questionnaires. A check list of some of the items that needed to be observed during the visits was made and included types of waste, places of waste disposal, presence of a garden and items recycled. The method was helpful in collecting information on the types and composition of waste and on methods used by residents in disposing their waste. Wastes were observed, measured and estimations made on composition and percentages. Photographs of some scenes were captured using a camera as evidence of the current state in Bungoma municipality.

3.6.2 Focus group discussions

Two focused groups were included in the study. The groups were created with the factors of gender and age in mind. The first group constituted nine businessmen and businesswomen in the municipal market and the second group consisted of casual workers at a construction site in Pamus The first group constituted mainly female as more women than men engaged in businesses in Chebukube market, while the second group constituted more males than females. Discussions between these organizations and the researcher revealed what needs to be done to enhance sustainability in Bungoma Municipality's solid waste management systems, as well as how frequently waste is collected , what kind of waste is produced , and the methods they employ to manage it.

3.6.3 Key informant interview

Respondents in the health and the environment ministries in Bungoma County as well as in institutions were interviewed using this technique. Information gathered here included whether the county segregates solid waste, their challenges and future plans. Oral interviews were also used to make clarifications in cases where the respondents didn't clearly understand the questions written in questionnaires. Interviews were also held between the researcher and residents in low-income residential areas of Wings, *jua-kali* artisans and workers at a construction site.

3.6.4 Questionnaire Survey

These were used to gather information from literate respondents. They were helpful in gathering information on types and components of Wastes, level of segregation and factors that influence segregation among the residents of Bungoma. Some questions had to be translated into Kiswahili for the respondents to understand better. The researcher and the assistants paid visit to some residential areas where information was collected through verbal questions and by issuance of questionnaires. Observations were made regarding the types of waste generated and the methods for managing solid waste throughout these visits.

3.6 Data Analysis

Quantitative data were analysed using descriptive statistics, particularly frequencies and percentages. The findings were presented through tables, graphs and charts. Qualitative information obtained through interviews, observation and focus group discussions was analysed descriptively and used to explain the quantitative findings.

3.7 Ethical Considerations

The study adhered to ethical standards and guidelines. Ethical clearance was sought from the Ethics and Review Committee of Masinde Muliro University of Science and Technology (MMUST). Research permission was obtained from NACOSTI, Bungoma County Government and other relevant authorities. Informed consent was obtained from participants after explaining the purpose of study, the process, possible risks or benefits. Participants were made aware they could refuse to take part, not answer specific questions or withdraw at any time. Informed consent was obtained from parents and assent from minors. Anonymity and confidentiality was achieved by not using any personal information, coding participants and summarising results. Data was stored safely, if in digital format it was password protected and only accessible to authorised people. The researcher ensured that participants would not suffer any unnecessary harm (physical, psychological, social or professional). Respondents were treated fairly and with respect. Data was collected accurately, analysed and reported honestly. Proper referencing was used. Potential conflicts of interest were declared.

IV FINDINGS & DISCUSSION

4.1 Level of Household Waste Segregation

The results showed poor waste segregation was practiced by business and institutions within the Bungoma Municipality. Most waste was disposed of as mixed waste. Although some waste was separated into biodegradable waste for reuse, the amount of non biodegradable waste being separated into for reuse and recycling was low at 15%.

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Industrial establishments generally had waste stockpiled without effective segregation. Most institutions also disposed of their waste as mixed waste. This indicates poor waste segregation is an issue across sectors generating waste.

This is different to countries like Japan, Germany and Canada, who have good waste segregation due to having the correct legislation, raising awareness and having the right infrastructure in place (Government of Ontario, 2016). However this is in line with studies by Chanda and Mumba (2021) and Liew et al (2021) who found that a lack of infrastructure, low awareness and little motivation from the public hindered waste segregation within developing countries. Bungoma has been recorded to have issues with waste management (Roussel, 2012) including poor waste disposal and little community involvement.

The results are also aligned with findings by Rahman and Moore (2020) who highlighted the importance of awareness, effective collection and community involvement. As a small amount of recyclable waste was separated it indicates that the area lacks resource recovery. To improve waste segregation there needs to be increased environmental education provided. This can be done by providing specific waste bins, a reliable collection system and working with recycling companies. This should be targeted at households, businesses and institutions.

4.2 Waste Segregation among County Government Employees

It was found out that county government workers handling waste collection do not systematically separate the solid waste. After interviews were carried out with workers from the Ministry of Environment, it was found out that biodegradable and non-biodegradable waste was mostly collected together and taken to the collection point. The waste was then moved to the main dumpsite. One of the institutional respondents explained that:

> *"We don't segregate our waste. The process is tedious plus we don't know how it should be done, we are thinking of looking for partners who can teach us on how to segregate waste properly."* (Respondent 1, 13th May 2025)

This shows that technical knowledge and capacity was low which caused issues with segregation.

A lack of suitable refuse bins was reported as a large issue by county government staff. Sometimes the bins they had were stolen, meaning they could not have enough bins to allow proper segregation. As the county government workers did not segregate rubbish systematically it had a large impact on the waste system in the municipality. As they are responsible for collecting and transporting waste from households, if they cannot segregate properly, it can cause issues at source.

4.3 Waste Segregation among Commercial Enterprises and Institutions

It was found that there is poor waste segregation practices among businesses, industries and institutions in Bungoma Municipality. Most establishments threw waste together and only some businesses separated biodegradable waste for selling purposes or used as animal feed. Only 15% of businesses separated non-biodegradable waste for re-use. Industrial establishments had poor waste segregation practices whereas most institutions threw waste together. This shows that waste segregation practices are an issue within the different sectors generating waste.

The results support the work of Eugenia et al. (2002) who stressed the importance of source segregation for successful composting, recycling and resource recovery. However, these results do not support the waste segregation practices in the Philippines, Japan, Germany and Ontario, Canada where there is effective waste management systems in place with laws, dedicated waste collection areas and recycling systems (Government of Ontario, 2016). The results agree with the works of Rahman and Moore (2020), Chanda and Mumba (2021) and Liew et al. (2021), who found that poor infrastructure, lack of awareness, poor motivation and lack of recycling opportunities were issues with waste segregation.

This supports concerns within Kenya that there is poor source segregation (NEMA, 2014) and waste management issues. This agrees with Roussel (2012) who found there was poor waste management practices locally. Although there was some informal recovery practices for biodegradable waste there was little waste segregation and recycling opportunities.

Overall, this shows that there needs to be actions put in place to improve waste segregation within households, businesses, industries and institutions. This can be done by having dedicated waste segregation areas, increasing awareness of the environment, implementing waste management rules and having effective recycling and collection systems. Having community involvement and waste recovery opportunities (Mwangi et al., 2021) can help to increase resource recovery within Bungoma Municipality.

4.4 Socioeconomic Factors Influencing Household Waste Segregation

The study identified several socioeconomic characteristics associated with household waste segregation, including age, gender, household size, income, education and availability of gardens.

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4.4.1 Age

Age was identified as one of the factors influencing household participation in waste segregation. The study's age distribution of persons involved in segregation was as follows:

Table 1

Age of Persons involved in Segregation

Age category	Percentage
Children	28%
Youth	61%
Elderly	11%

The analysis revealed that young people make up the greatest percentage of waste segregation (61%) with children making up 28% of the total. Only 11% were elderly participants. The data shows that the majority of waste segregation in Bungoma Municipality is carried out by the younger individuals within the household. They may be involved because they are interested in reusing recyclables, separating biodegradable waste and finding usable items. Children being included shows that waste segregation is sometimes a family activity.

This is backed up by Okot (2012) who observed that in East African households, it is common to retrieve useful items from waste including food waste, plastic bags, bottles, tins and scrap metal. However this is usually done informally. Roussel (2012) also found that there was little waste segregation in Bungoma however some reuse was still taking place. Young people were found to play an important part in the informal waste segregation within households. However not many elderly people were involved which could be due to roles within households being linked to age. Some elderly participants stated they relied on the younger members of the household or staff to deal with waste. Households with no young people were more likely to dispose of general waste.

This backs up Hoornweg and Bhada-Tata (2012) as they highlighted the importance of community involvement, awareness and behaviour change to improve waste management. As a large amount of young people are involved within waste segregation, it can provide opportunities for environmental education. Organising young people to help with waste retrieval can be beneficial due to the large amount of young people involved. Mwangi et al. (2021) found that in Kibera, Nairobi organised young people helped with waste collection, segregation, transportation and recycling. This improved resources being retrieved, and provided jobs. Bungoma County Government and other stakeholders can improve youth focused waste management, and provide education to children and households. This can improve waste segregation at source and encourage more systematic involvement from different age groups..

4.4.2 Gender

253 of the 384 interviewed respondents were female, while 131 were male, for a total of 384. This suggests that more women participated in the study than men. The distribution of respondents by gender is depicted in Figure 1 below:

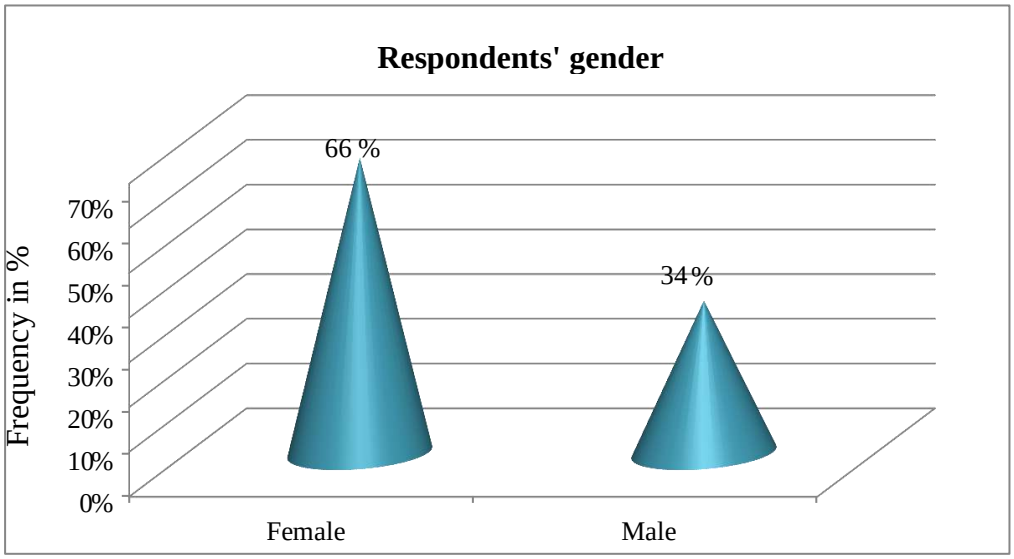


Figure 1

Respondents Distribution by Gender

Source: Field survey

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According to the findings, 66% of the 384 respondents were female, while 34% were male, indicating that women constituted the majority of the respondents. The higher representation of women may be attributed to the fact that some women remained at home while their husbands were away at work. In addition, some men perceived solid waste management as primarily a woman's responsibility and were therefore less willing to participate in the study. The male respondents who participated were mainly individuals working in business establishments, institutions, and the County Government.

The study indicated that gender, age, and education level had no correlation with the level of waste segregation among Bungoma municipality residents. While conducting study on home segregation in Malaysia's Kuching South City, Otitoju and Seng (2014) made comparable discoveries.

4.4.3 Household Size

Regarding household sizes in Bungoma Municipality, it was found that the number of individuals per household ranged from one to twenty. The smallest households typically consisted of newly employed individuals and college or university students. On average, households comprised five members. The study revealed that both the quantity and complexity of household waste increased with household size. Larger households not only generated more waste but also produced waste with more varied components compared to smaller households. Specifically, households with 1 to 5 members produced approximately 0.5 kg to 5 kg of waste per day, while larger households with up to 20 members generated as much as 12 kg per day. These findings align with the observations made by Okalebo et al. (2014) in a study on household solid waste generation in Eldoret, Kenya, where similar patterns were noted.

4.4.4 Education and Income

The majority of interviewed Bungoma municipality people had formal education. Table 2 provides a summary of the respondents' education levels;

Table 2

Respondents Level of Education

Levels of Education	Frequencies	Percentage
No education	4	1.04%
Primary	123	32.03%
Secondary	101	26.30%
Tertiary	91	23.70%
University	65	16.93%

Source: Field survey

According to Table 2, The data on levels of education reveals a varied distribution of educational attainment among the surveyed population. The largest proportion of respondents, 32.03%, have completed primary education, indicating it as the most common level of education. This is followed by 26.30% who have attained secondary education, and 23.70% who have reached the tertiary level. A smaller portion, 16.93%, have a university education, suggesting fewer individuals advance to higher academic qualifications. Notably, only 1.04% of respondents reported having no formal education at all, indicating a relatively high overall access to basic education within the group.

The distribution of education levels observed in this study is consistent with findings from other research in the field of waste management. Several studies have highlighted a strong link between education and awareness or participation in proper waste management practices. For instance, individuals with higher levels of education—particularly tertiary and university education—tend to have greater awareness of environmental issues and are more likely to adopt sustainable waste disposal practices. This supports the notion that education plays a critical role in shaping environmental behavior.

In studies conducted in various urban and rural contexts, such as those by Nzeadibe et al. (2023) and Liew et al. (2021) similar patterns were observed: communities with higher educational attainment generally demonstrated better knowledge of waste segregation, recycling, and the health impacts of improper waste management. Conversely, populations with lower educational levels often lacked awareness or access to proper waste disposal methods, resulting in higher instances of illegal dumping and poor hygiene practices.

Therefore, the findings of this study, where the majority of respondents possess at least primary or secondary education, suggest potential for effective waste management interventions, provided they are supported with proper education and community engagement strategies. However, the relatively smaller proportion of university-educated

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individuals might point to a need for more targeted educational campaigns that reach all education levels to improve overall waste management outcomes.

4.5 Institutional and Infrastructural Factors Influencing Waste Segregation

The study established that inadequate infrastructure and limited institutional support significantly constrained waste segregation within Bungoma Municipality.

4.5.1 Inadequate Public Awareness

It was found that the lack of knowledge was the main factor why participants were not separating their waste. Most participants mentioned that they have never been given any guidance on how to properly separate their waste. They did however mention that they would like to start separating their waste, but would need sufficient education and guidance. This implies that low awareness may be a key barrier to households engaging in sustainable waste management. This is in agreement with Chanda and Mumba (2021) who found that some households in Choma, Zambia were not separating their waste due to a lack of knowledge. Liew et al. (2021) also found that insufficient awareness was a challenge to waste separation in Kuching South, Malaysia. In addition to this low motivation was also a challenge. It is therefore evident that environmental education and awareness is vital to encourage source separation.

The results are in agreement with Rahman and Moore (2020), who identified awareness, legislation, effective waste collection and sociocultural factors as being important factors in waste separation. Okot (2012) observed in East Africa that households do sometimes separate their valuable resources, such as food waste, plastics, bottles, tins and scrap metal. However, this tends to be at an informal level. Roussel (2012) also noted that there was very little formal waste separation within Bungoma. However, some resource recovery was evident. The results show that there is an opportunity to improve this by educating the community. Demonstration and guidance on how to separate biodegradable, recyclable and residual waste can be provided. This is in agreement with Mwangi et al. (2021), who highlighted the importance of engaging the public, increasing awareness and changing behaviour to improve waste management.

Furthermore, it was found that awareness campaigns should be supported by sufficient waste separation and reliable collection. If households are educated but do not have bins to separate their waste, easily accessible collection points and assurance that their waste will not become mixed during collection, this may not encourage them to engage in sustainable practices. The Bungoma County Government should therefore ensure that there is increased environmental education within the community. This can be done by holding community meetings, household awareness and within institutions. Working with community based organisations and waste collectors can also help. This, along with easily accessible waste separation and regular waste collection can increase household engagement, increase resource recovery and encourage sustainable solid waste management within Bungoma Municipality.

4.5.2 Inadequate Space

Limited household space was another major constraint. Some residents occupied small houses with limited compounds and could not conveniently accommodate several waste containers.

One respondent from Marrel explained:

> *"The house I live in is small and it is not possible to keep more than one dustbin in such a house. I have only one dustbin in which I throw all my waste and take it to the pit once it is full."* (Respondent 2, 13th May 2025)

This finding demonstrates that household infrastructure and living conditions influence the practical ability of residents to separate waste.

4.5.2 Inadequate Space

The findings showed that small houses were a major challenge in the practice of waste segregation. Several people have small houses and the space in the compounds is not sufficient enough for waste segregation. As a result, they are forced to put all their waste in one bin. This shows that people are less likely to segregate their waste depending on the type of house they live in as well as the amount of storage they have. Similarly, Chanda and Mumba (2021) found that waste segregation was difficult due to household situations and lack of capacity in Choma, Zambia. Meanwhile, Liew et al. (2021) found that waste segregation was challenging because there was a lack of proper infrastructure in Kuching South, Malaysia. This shows that waste segregation in the homes can be improved by taking practical steps such as using small bins with labels. Waste segregation in Bungoma Municipality should take these limitations into consideration.

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4.5.3 Inadequate Waste Containers

This study has shown that there are not enough bins for effective waste segregation in Bungoma Municipality. Some people have created their own bins from cutting up jerricans, broken buckets, basins, boxes and sacks. These bins have generally been used to store mixed waste. The county government admitted that there were not enough bins in the public area due to some being stolen. This has shown that there is a lack of proper facilities for storing waste, meaning that people are unable to properly separate their waste. Nzeadibe et al. (2023) found that there was a lack of specific waste bins and many people had to share bins. Similarly, Liew et al. (2021) found that waste segregation was difficult because of a lack of infrastructure and recycling facilities. However, the Blue Box and Green Bin project in Ontario show that using specific bins can help with separating recyclable and organic waste. (Government of Ontario, 2016). This shows that Bungoma County Government need to invest more in providing accessible, labelled and properly designed bins. They also need to implement more security so they are not stolen. This will encourage waste segregation in the homes and make the collection process more effective.

4.5.4 Limited Institutional Support

The findings have shown that there is a lack of support from institutions which has discouraged waste segregation in the homes. Many people believe that waste management is the county governments responsibility and therefore they do not feel the need to segregate their waste. When they do segregate their waste, the municipal workers mix it up again. This shows that there is a lack of co-ordination between the waste segregation in the homes and the waste collection from the municipality. Rahman and Moore (2020) found that effective waste segregation requires support from institutions, efficient collection methods, legislation and awareness. Similarly, Nzeadibe et al (2023) found that there was a lack of proper waste management infrastructure and support from institutions meaning waste segregation was poor. The waste recovery initiatives need to be co-ordinated. For example, in the Philippines community waste management initiatives have been implemented to manage biodegradable, recyclable and residual waste. (Eugenia et al, 2002). This shows that waste segregation in the homes will depend on how willing people are to segregate their waste and how effective the county government can be in providing consistent collection, transport and disposal. If there is more support from institutions, strict rules can be put in place which will make people feel responsible for segregating their waste.

Overall, the findings show that there is a lack of space in the homes, not enough bins and a lack of support from institutions which has caused waste segregation to be difficult in the homes. This is supported by research which shows that waste segregation is difficult in developing countries due to a lack of infrastructure, awareness and support from institutions. (Chanda & Mumba, 2021; Liew et al, 2021; Rahman & Moore, 2020). This can be improved by implementing waste segregation initiatives which involve homes, businesses, institutions and county government. Providing appropriate bins, reliable waste segregation collection methods and increasing public engagement will improve resource recovery, recycling and sustainability.

4.6 Reasons for Not Practising Waste Segregation

The study established that households had several reasons for not participating in waste segregation. These included inadequate awareness, limited space, insufficient time, lack of waste containers and perceptions concerning institutional responsibility.

The reported reasons were as follows:

Table 3

Reasons for not Segregating Waste

Reason for not segregating waste	Percentage
Lack of awareness	53%
Inadequate household space	24%
Process is tedious and time-consuming	9%
Not authorised by county government	3%
Inadequate waste containers	3%
Perceived responsibility of county government	3%
Lack of time	1%

Source: Field study (2019), as reported in the thesis.

It was established that there were a lack of awareness on waste separation which was the major challenge faced, as 53% of participants mentioned this. This shows that many waste generators do not have enough knowledge on how to properly separate their waste and the benefits of doing so. Chanda and Mumba (2021) found that some households in Choma, Zambia did not have enough knowledge or motivation to separate waste. Liew et al (2021)

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found lack of awareness and motivation was a challenge to separating waste in Kuching South, Malaysia. This shows that raising awareness and educating people on the environment is important to increase participation from households. Increasing awareness of the environment and changing behaviour will lead to increased participation from communities (Wilson et al., 2012).

A lack of enough space in households was another major challenge faced, with 24% of participants mentioning this. Those living in smaller houses stated they struggled to separate their waste into different categories. This shows that how much people earn and where they live can affect their ability to separate waste. Liew et al (2021) found a lack of proper facilities and lack of access to recycling centres was a challenge to separating waste. This means that due to a lack of space and not having proper waste containers in Bungoma Municipality, households may be less inclined to separate their waste into biodegradable and non-biodegradable items.

Other challenges mentioned were that separating waste can be a tedious process (9%), not enough bins for waste, no authorisation from institutions and that it is the responsibility of county government workers. This shows that separating waste can be affected by personal behaviours, economic factors, facilities and institutional factors. Rahman and Moore (2020) found that legislation, awareness, efficient waste collection and sociocultural factors can affect waste separation. This also shows that having proper facilities and clear institutional factors is important to help with source separation. Although there are policies in place in Kenya on sustainable waste management (NEMA, 2014), these depend on how aware people are, how much they are enforced and how many facilities there are. To improve waste separation in Bungoma Municipality there needs to be co-ordinated actions taken.

4.7 Responsibility on waste separation

There were different opinions on who should be responsible for separating waste. Those who separated their waste mainly believed that it was a personal responsibility. They believed that it was the responsibility of households and other waste generators to separate their waste and keep their areas clean. However, those who don't separate their waste believed it was the responsibility of the municipality, community based organisations and county government workers. Of the 22 households whose waste was collected by county government workers, 83% believed it was the responsibility of the county government whilst 17% believed it was a joint responsibility between individuals and county government workers. This shows that opinions on who should be responsible can affect how willing households are to separate their waste.

These results show that it is important to involve the public and have clear responsibilities for sustainable waste management. Eugenia et al (2002) showed that it was important to separate waste at source and have co-ordinated collection, composting and recycling at a community level in Barangay Sun Valley, Philippines. Mwangi et al. (2021) showed that organised youth groups in Kibera, Nairobi helped with waste collection, separation, transport and recycling. This shows that working together with waste generators, community organisations and relevant authorities will help with effective waste management.

This also shows that if there isn't clear opinions on who should be responsible for separating waste then there may not be much participation. If households believe it is the responsibility of county government workers to separate their waste and the municipality believe it is the waste generators responsibility to separate their waste at source, this could lead to little personal commitment and inefficiencies in waste management programmes. Bungoma County Government need to increase public education and make it clear what the responsibilities of households, businesses, institutions and waste collectors are. By doing this it will encourage more community involvement, increase source separation and improve resource recovery, recycling and environmental sustainability in Bungoma Municipality.

V. CONCLUSION & RECOMMENDATIONS

5.1. Conclusion

The study confirmed that waste segregation is generally low in Bungoma Municipality. Some households segregated biodegradable waste but further segregation into reusable, recyclable and combustible waste was uncommon. The study also confirmed that waste segregation was not widespread in commercial organizations and institutions. A few commercial organizations practiced further segregation of non biodegradable waste while most industrial facilities disposed their waste without segregation.

County government officials did not practice systematic segregation of waste collected. This therefore undermined the segregation practice since waste segregated at household level could be mixed again.

Segregation practice was influenced by socio-economic factors such as age, gender, household size and income. Institutional and infrastructural factors included lack of awareness, little waste containers, lack of enough space in households and poor coordination between waste generators and the municipality.

To improve waste segregation there should be collaboration between households, commercial organizations, institutions and county government. Steps should be taken to increase awareness among the public, increase

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availability of waste containers and build institutional capacity to increase involvement of waste segregation in Bungoma Municipality.

5.2. Recommendations

From the findings, the following recommendations were made:

The County Government of Bungoma should strengthen public education and awareness programmes to equip residents with the knowledge and skills required to separate biodegradable, non-biodegradable, reusable and recyclable waste at source. This should be complemented by the provision of adequate, clearly labelled waste segregation bins in residential areas, markets, institutions and other public spaces to facilitate proper waste separation. In addition, county employees responsible for waste collection and management should receive appropriate training on segregation practices to ensure that separated waste is handled correctly throughout the collection and transportation process.

The county government should also promote community participation by involving community-based organisations, youth groups, women's groups and other local associations in creating awareness and encouraging household waste segregation. Businesses, industries and institutions should be engaged to adopt and implement appropriate waste segregation practices within their premises. Furthermore, collaboration between households and the county government should be strengthened to ensure that waste separated at source is not mixed during collection and transportation. Finally, the county government should establish partnerships with recycling companies and material recovery facilities to create reliable markets for recyclable materials and provide economic incentives for waste generators. These interventions would enhance public participation, improve resource recovery and promote sustainable solid waste management in Bungoma Municipality.

Declaration of Interest

The authors declare that they do not have any known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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