ASSESSING SOLID WASTE MANAGEMENT IN BWAISE TO DESIGN AN APPROPRIATE HANDLING SYSTEM

FINAL YEAR PROJECT REPORT SUBMITTED TO THE SCHOOL OF ENGINEERING AND APPLIED SCIENCE AT KAMPALA INTERNATIONAL UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD

OF BACHELOR'S OF SCIENCE IN CIVIL ENGINEERING

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DECLARATION

We declare that this project report for the fulfillment of the requirements for the award of a Bachelor of Science in civil engineering is based on our own efforts and has never been submitted to any academic institution for any award.

KHABUYA ASHA
Sign…………………………….. Date………………………………..
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Sign…………………………….. Date………………………………….

APPROVAL

This is to certify that KHABUYA ASHA and GOBERA MIKE did their research under my supervision. I therefore approve the project report for submission for the award of a Bachelor's degree of Science in Civil Engineering of Kampala International University.

Sign…………………………………. Date……………………….………….

Supervisor. MR MUSIIME ENOS BAHATI

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LIST OF ABBREVIATIONS

SW- Solid Waste

SWM- Solid Waste Management

ABSTRACT

This report is from a study that looks at the nature, practices, challenges, and possible solutions for solid waste management systems in Bwaise, Kampala. The study used mainly questionnaires, interviews and observation. The findings suggest that in Bwaise, poor communities could generate income from waste disposal activities, if certain measures are put in place. Furthermore, in this area, 60% of the garbage is biodegrable, composed mainly of food related waste. Non-biodegradable wastes constitute of the 40%, of which the main component is polythene bags. It was also established that a good part of the communities currently use illegal methods of disposal which include burning and open space dumping. Among the challenges facing solid waste management are the inactivity of institutional framework to support and mobilize for effective waste disposal. As a result there is little community effort to reduce on the problem. So sensitization of community should be given more attention.

The communities suggested the following solutions: sensitization and community work.

The study recommended the following: composting, sensitization, and building strong institutions at grassroots levels and participation of the community from the initial stage of designing the project. After analyzing the background, the waste flows the appropriate method that will be used will be composting using a composting tumbler made in order to convert organic waste into compost.

If maintained, the compost will benefit the division in the ecological and the financial level.

Money can be saved by using this organic fertilizer with a minimum cost.

This report contains chapters whose contents are as below;

Chapter one: Introduction which gives the general background of the study, statement of the problem, significance of the project, project objectives and scope of the project.

Chapter two: Literature review which reviews documents related to the study topic.

Chapter three: Methodology which contains the tools and softwares used in the research to obtain the specific objectives.
Chapter four: Results obtained, their analysis and discussions.
Chapter five: Conclusions and recommendations.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Waste is a man-made substance in a given time and places which in its actual structure and state is not useful to the owner or is an output without an owner and purpose. In other words, waste is anything that we no longer need. It is also commonly referred to as rubbish, trash, garbage, refuse, effluents and "unwanted or unusable materials". It is important to note that wastes take two forms that is; solid or liquid wastes;

The term solid waste (SW) may be used to refer to municipal waste and can be categorized in seven groups. They are residential (or household or domestic waste), commercial, institutional, street sweeping, construction and demolition, sanitation and industrial wastes. (Rush brook, 1999). While municipal solid waste refers to solid wastes from houses, streets and public places, shops, offices, and hospitals, which are very often the responsibility of municipal or other governmental authorities, solid waste from industrial processes are generally not considered "municipal". However it should be taken into account when dealing with solid waste as they often end up in the municipal solid waste stream.

Urban dwellers generally consume more resources than rural dwellers, and so generate large quantities of solid waste and sewage. For example, solid waste disposal is a major problem in urban African centers, where more than half the population now lives in urban areas. Northern Africa is the most urbanized, while in Southern and in Western and Central Africa, urbanization levels are still lower (about 33-37 percent.)

Although human or animal excreta often ends up in the solid waste stream, generally the term solid waste does not include such waste materials.

Uganda is facing rapid urbanization of 5.1% per annum; leading to overcrowding and the development of slums and informal settlements with poor waste management practices. Waste management in these areas is hampered by multiple land tenure system with many tenants not having a right to the land and therefore not able to manage waste domestically. Human activities create waste, and the way these wastes are handled, stored, collected and disposed-off can cause risks to the environment and to public health.

Furthermore, there is no comprehensive national urban policy and the institutional framework to regulate and support urban development· The consequence is that many towns and urban settlement, drainage channels and roads are highly littered· Some families especially in crowded high density areas don't have access to garbage disposal skips and while private collectors are too expensive for these poor households hence forced to dispose of garbage in drainage channels, road sides and abandoned buildings·

Solid Waste (SW) collection is currently one of the most critical services; whose quality and coverage has caused serious public outcry in slum areas. Kampala Capital City Authority (KCCA) acknowledges that the amount of Solid waste generated overwhelms the capacity of the Authority to collect and dispose it given the fact that the cost of solid waste collection is enormous·

Out of 1, 200–1,500 tons of garbage generated per day, only 400-500 tones are collected giving a collection efficiency of only 40%. This implies that 60% of Solid waste generated daily is not properly collected and disposed which has resulted into indiscriminate disposal by the public. It is estimated that Kampala City Council (KCC) now KCCA spends United States Dollars 1.53 million per month to remove only 30% of the total waste generated (Ngategize2009). As the amount of solid waste increases, the cost of its removal increases yet KCCA does not have sufficient resources to completely and efficiently carry out this responsibility. The result has been delays in disposing of this garbage. Also the communities are ignorant of the best way to manage the waste, as there is little community initiative to undertake collective action. Given this situation there is need to promote complimentary alternatives such as to manage garbage in a sustainable manner in addition to being a potential source of income for the poor.

1.2 Problem statement

Poor solid waste collection and disposal is a threat to public health and reduces the quality of life for urban residents' especially in-unplanned settlements. Bwaise area is one of the typical examples of such settlements. The city council has failed to solve the problem of solid waste management in Bwaise evidenced by roadside heaps and trench heaps of uncollected waste. The municipal council engaged a private contractor, (Nabugabo Ventures) in the area who have failed to provide sufficient service due to lack of willingness of the residents to pay the fee for solid waste collection. This has created vulnerability to health hazards and environmental negative effects. Thus there is need to design a system that can handle waste properly.

Figure 1: poor waste disposal in Bwaise

1.3 Main objective

To assess solid waste management in Bwaise so as design an appropriate handling system.

1.3.1 Specific objectives

- To determine the current service status and the nature of solid waste in Bwaise.
- To determine the amount of solid waste generated in Bwaise.
- To design an appropriate solid waste management system.

1.4 Significance of the project

1. This research will generate more information to the already existing body of knowledge in the area of solid waste management and to Bwaise in particular.
2. Also the findings will enlighten the policy makers, local leaders and the local people of the gaps existing in the solid waste management. These findings will help in drafting appropriate solid waste management that will empower citizens and make them aware of how to handle solid waste so that both the council and citizens would join efforts to solve the problem at hand.
3. The study will provide future scholars and researchers with information regarding the solid waste management.
4. The project will bridge the gap between theoretical skills studied in class and the practical skills that are always needed in day today practice in the field of Civil Engineering.
5. The project will help us to enhance our academic experience through carrying out research, engineering practice to come up with the secondary data for the assessment.
6. The project also will expand our creativity while seizing the profession ethical values as a basis to venture into our professional career in future. This will build confidence and skills among us to be competitive in the current job market.

1.5 Scope of the project

1.5.1 Content scope

The study was limited to household and commercial enterprises waste generated in Bwaise with special emphasis on the Solid waste management cycle from collection to ultimate disposal.

1.5.2 Geographical scope

The study was conducted in Bwaise which is located in Kawempe Division, Kampala district, three miles north of the city centre. It is divided into three parishes, Bwaise I, Bwaise II and Bwaise III with a population of 45510 people (National Population and housing census, 2014).

Figure 2; the location of Bwaise

1.5.3 Time scope

The project started in September 2018 and ended in May 2019.

1.6 Justification

One way of estimating the scale of poor solid waste management in urban centers is to base it on the number of people who live in poor quality houses or neighborhood that lack the basic infrastructure services such as solid waste management systems.

Several approaches have been suggested in order to improve solid waste management in developing countries including Uganda. This situation challenges Communities and Community Based Organizations to operate in providing solid waste collection services.

To a large extent the solid waste collection efficiency depends on the involvement and participation of the communities themselves in supporting the whole concept.

Furthermore, it also depends on the useful information and lessons from current best practices in the provision of this important service. Such information and lessons can be obtained only through studies; hence a study such as this can assist in the improvement and performance of SWM in the urban settlements.

Poor waste management has been found to result into pollution of both surface and ground water through the leachate draining and impairing the permeability of soils as well as blockage of drainage systems (NEMA, 1998).

It is against this background that the study on waste management was carried out to assess solid waste management in Bwaise and design appropriate solid waste management system.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

In this chapter, attempts were made to review relevant literature to help in the understanding of solid waste management. We acknowledge the fact that there is some literature on solid waste management in towns of Uganda and in other countries of the world. Most of the literature reviewed is from the different sources these are text books, websites, Newspapers and journals. In this section, the main purpose is to review issues related to solid waste management that have been investigated by other researchers, in order to gain more insights into the subject under the study and avoid duplications of efforts in this area.

2.2 Definitions of terms and concepts.

Waste is a man-made substance in a given time and places which in its actual structure and state is not useful to the owner or is an output without an owner and purpose (Zerbock O. (2003)).. In other words, waste is anything that we no longer need. It is also commonly referred to as rubbish, trash, garbage, refuse, effluents and "unwanted or unusable materials".

There are two forms that is; solid or liquid wastes;

Solid wastes refer to particles or materials which are no longer useful to their owners and which require to be discarded. They are both organic/biodegradable for instance the waste generated from animal and plant remains; it may be broken down by living organisms such as bacteria, protozoa and fungi e.g. green plant tissue waste, food remains, paper, animal and waste (feaces and urine), and non-organic/non bio- degradable wastes, is that form of waste that cannot be broken down by living organisms. It includes metals, polyethylene, most plastics and rubber. Most non bio degradable wastes are produced from manufacturing industries.

On the other hand, **Liquid wastes** refer to waste materials that contain full liquids. These include waste water from industries, households; sewerage and leachate from land fill or garbage heaps.

2.3 Classifications of solid waste by nature

- Biodegradable waste; is the waste that can be decomposed by the biological process to form compost.
- Non-biodegradable; is the waste that cannot be decomposed.

2.4 Waste Management Waste Management

The term '**Waste Management'** includes all issues and processes associated with the generation, processing, and disposal of all categories of wastes produced by human activities or related to human existence; it includes, therefore, the stages of production and minimization, collection, handling and transportation, reuse and recycling, treatment and disposal of all such wastes.

Despite the fact that waste handling and transport varies from region to region, country to country, there are waste management concepts that are universally accepted and implemented like the 3Rs (reduce, reuse and recycle). According to (NEMA, 2000), **Solid waste management** encompasses generation, collection, transportation and disposal of wastes. Authorities have the responsibility to ensure safe, reliable and cost effective removal and disposal of solid waste. Garbage is collected from both the well to do households and poor ones. It is also the process by which products and by-products generated by business and industry are collected, stored, transported, treated, disposed of, recycled or reused in an effort to reduce their effect on human health. Therefore, a properly managed waste; that is well collected and sorted recycled, treated, disposed of hygienically will promote a clean and safe environment to live in. Waste management is practiced by small businesses when they collect and sort their wastes, recycle their wastes, treat their wastes, dispose of their wastes or implement ways of reducing their waste (EPA, 2008).

2.4.1 The ways of managing solid waste

There are various solid waste management systems. Which are;

- **Landfills**; this focuses attention on burying the waste in the land.
- **Pyrolysis**; is the decomposition or transformation of a compound caused by heat. Pyrolysis typically occurs at temperatures in the range of 650 to 1,500 degrees Fahrenheit. Most pyrolysis systems use a drum, kiln-shaped structure, or a pyrolysis tube, which is externally heated, either using recycled syngas or another fuel or heat source.
- **Waste Prevention** This is the avoidance of waste generation of waste.
- **Waste reduction**; This is by finding ways of making a particular item whilst producing less waste in the process, this is one of the most effective ways to reduce pollution, save natural resources, protect the environment and save money. Industry has a major part to play in waste reduction.

Challenges met in waste reduction at the global level

Until recently, the focus in South Africa for example; has been on waste disposal and impact controls or "end of the pipe" treatment (DEAT, 2000). However, this focus has faced a number of challenges and these include:

- Lack of waste avoidance, minimization and cleaner production technology initiatives.
- Lack of regulatory initiatives to manage waste minimization.
- Few incentives for reducing waste.

- Industries not required to submit plans for waste disposal when applying to establish new enterprises.
- Inadequate resource recovery and a general lack of commitment to recycling – no legislation, policy or waste management culture that promotes resource recovery or makes it financially viable.
- Lack of appropriate waste management strategies and treatment technologies associated with these policies also have a negative effect on human health.

- **Waste reuse**. Reuse can be defined as using a waste product without further transformation and without changing its shape or original nature. This is the second option in the waste hierarchy. Different types of solid wastes can be reused, such as bottles, old clothes, books and anything else that is used again for a similar purpose to that originally intended.

Figure 3; showing collection and selling reusable plastic bottles.

- **Waste recycling.** Recycling waste means that the material is reprocessed before being used to make new products. Recycling means treating the materials as valuable resources rather than as waste. It has many benefits but it is important to have a market for the end product, otherwise the process will not be economically sustainable. For example, waste paper can be broken down to its fibres in a process called pulping (Nyakaana et al, 2006).
- **Composting:** Composting is the process where biodegradable organic wastes (food and garden waste) are converted into compost in a natural biological process (DEAT and DWAF (1999)). Composting can be done by individual householders and community groups or on a commercial scale. On the larger scale, the waste from an entire town or city could be composted if sufficient land, labor and equipment is available. The benefits of composting are not only the reduction of waste, but also the production of compost which is a valuable **soil improver**. Compost is a term for organic matter that has

decomposed into a form that plants can use. Compost can be used in potting mixes or mixed in with garden soil.

2.5 Types of Composters:

Compost heap; this is a traditional open-air heap. This type of composting used to exist in the past and can still be found in some gardens. It is usually a wide foot high heap that contains six layers of green garden waste and kitchen waste, placed over the brush core. Two layers of cow or chicken manure cover the layers. The heap type unlike the modern composting must be turned every 6 weeks.

Figure 4; showing compost heap compost

Wooden compost bin; this bin is easy to make. It can be made using four pallets and an additional one as a floor, stuck together using a metal pole. The pallets should contain gaps to allow aeration, then covered by a piece of plastic that will play the role of an isolator and will protect the compost from heavy rain too. This bin is suitable for a house garden, as it usually does not take a lot of space.

Figure 5; showing wooden compost bin

Compost multi-bin; in this bin, the compost should be turned every week first, and then left to mature for a month. This composter needs to be watered regularly too and its compost can be ready in few weeks. However, this kind of bin requires a lot of indoor space and a fair amount of effort.

Figure 6; showing compost multi-bin

Composting tumbler; this type of composters is easy to use because it can be turned easily. The materials inside it can then be mixed thoroughly, which allows the compost to be ready quickly two-three weeks. The tumbler generates high-quality compost, but is not as easy to make as the previous composters.

Figure 7; showing Composting tumbler

A well-made compost is dark brown and smells like the forest. It is composed from carbon, nitrogen, oxygen, and water. These four ingredients are mandatory for the composting organism to work effectively.

Carbon: brown material, provides energy and the microbial oxidation of carbon produces the heat.

Nitrogen: such as fruits and vegetables are used to grow and reproduce more organisms to oxidize the carbon.

Water: An adequate level of moisture is very important to maintain too. It lowers the structural strength of the organic waste and consequently speeds the decomposition process.

Oxygen; the availability of oxygen is crucial too since our process is a biological oxidation. Therefore, the compost should be turned daily to supply O_2 and to allow the aerobic respiration. It is important to keep the percentage of oxygen in the compost from falling below 18%.

Temperature; High temperatures are essential for good compost, excessively high temperature slow down the decomposition activity of the organic matters. Indeed, only few bacteria can perform above 70°C. The best-case scenario will be a varied temperature from 45 to 50°C. In a higher level of accuracy, the C/N ratio must be between 25 and 35. If the ratio is below 20, nitrogen is lost and ammonia is released, which leads to a bad smell in the compost.

However, if the C/N ratio is above 40, the decomposition process slows down.

The following chemical reaction summarizes the composting process:

Organic waste + O_2 → Compost + CO_2 + H_2O + Heat

The composting process.

1. Blending or proportioning of materials**:** Composting works best with the right mixture of wastes so that the moisture content and the proportions of the chemical elements carbon and nitrogen are suitable. Generally, the ideal mix for composting is three parts, for example, of 'brown' waste (such as leaves, hay, straw, eggshells, shredded paper, card and woody material), with one part 'green' material (such as grass, food waste and animal manure). 'Brown' waste contains a higher proportion of carbon and 'green' waste, contains more nitrogen and has a higher moisture content. Thus the ratio of brown waste to green waste is 3:1.
2. Composting**:** Finally the waste is fed into the composter to be composted.

2.6 Opportunities from wastes.

It should be noted that though the word "waste" refers to something that is "no longer serving a purpose", something "without value" (as the Concise Oxford Dictionary puts it), Obviously, however, certain people in certain circumstances consider waste materials as a resource for their family, their livelihood, or their enterprise. The so- called waste materials may serve as a crucial resource within households. For example, oily milk packages may be used as fuel; leftover food may be fed to pigs and goats; discarded cardboard may serve as walls and roofs of houses. If that is the case, one can expect that household members re-value waste materials and see their usefulness for different purposes, such as domestic utility, saving on household expenditures, earning money, or other purposes (ERL, 2008). Therefore, this study will be seeking to find out whether the people in Bwaise have some of these practices that serve to promote a clean and safe environment.

2.7 Solid waste management collection systems

Based on their mode of operation, collection systems are classified into two categories: hauled-container systems and stationary-container systems.

2.7.1 Hauled-Container Systems (HCS):

This is a collection system in which the containers used for the storage of wastes are hauled to the processing, transfer, or disposal site, emptied, and returned to either their original location or some other location are defined as hauled-container systems. There are two main types of hauled-container systems:

(1) Tilt-frame container
(2) Trash-trailer.

Systems that use tilt-frame-loaded vehicles and large containers, often called drop boxes, are ideally suited for the collection of all types of solid waste and rubbish from locations where the generation rate warrants the use of large containers. Open-top containers are used routinely at warehouses and construction sites. Large containers used in conjunction with stationary compactors are common at commercial and industrial services and at transfer stations.

The application of trash-trailers is similar to that of tilt-frame container systems. Trash-trailers are better for the collection of especially heavy rubbish, such as sand, timber, and metal scrap, and often are used for the collection of demolition wastes at construction sites.

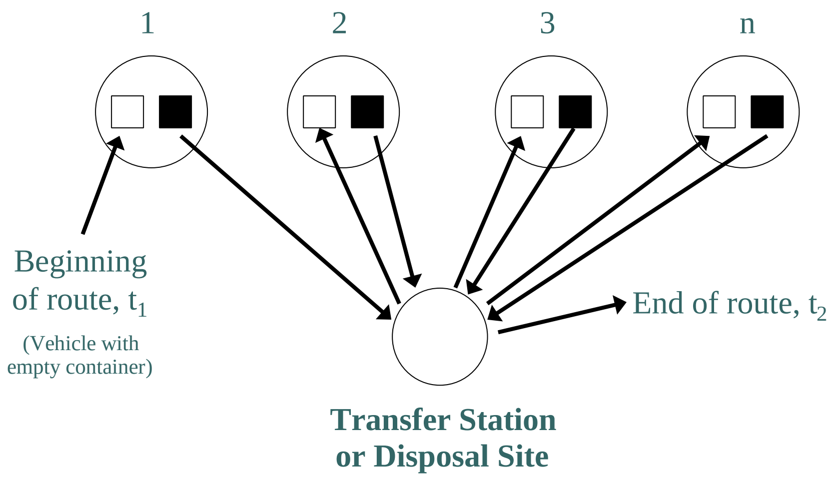


Figure 8; showing a hauled container system

2.7.2 Stationary-Container Systems (SCS)

Collection systems in which the containers used for the storage of wastes remain at the point of waste generation, except when moved for collection are defined as stationary-container systems. Labor requirements for mechanically loaded stationary-container systems are essentially the same as for hauled-container systems.

There are two main types of stationary-container systems: (1) those in which self-loading compactors are used and (2) those in which manually loaded vehicles are used.

Because a variety of container sizes and types are available, these systems may be used for the collection of all types of wastes.

The major application of manual transfer and loading methods is in the collection of residential wastes and litter. Manual methods are used for the collection of industrial and residential wastes where pickup points are inaccessible to the collection vehicle.

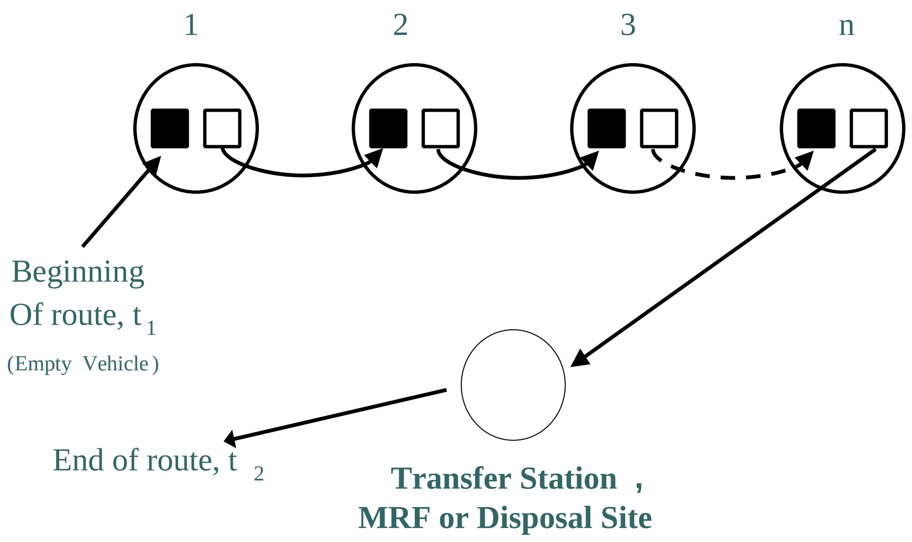


Figure 9; showing the stationary container system

CHAPTER THREE

3.0 METHODOLOGY

3.1 Introduction

This chapter specifies the study strategy, study instruments, data analysis techniques and design softwares that were used to explore the underlying solid waste management and seek the opinions on how the problem would be handled.

3.2 Research design

The research strategy that the study utilized was the descriptive method. A descriptive research presents facts concerning the nature and the status of the situation, as it exists at the time of the study and describes the present conditions, events or systems based on impressions of the respondents of the research. The time horizon of the research was cross-sectional design where data was collected over a two weeks period. The research also used a mixed methods approach (i.e. qualitative and quantitative designs), both methods were utilized for instance the qualitative opinions that we got were confirmed by statistical data. Finally, the study also used approaches like questionnaires, in-depth interviews, observations (qualitative) as well as survey and statistical records like graphs, pie-charts and tables (Quantitative).

The unit of analysis was the phenomenon solid waste management using the residents in the selected four zones with at least one from all the three parishes. The observation design consisted of the selected participants making careful observation of their environment and contributing to the participatory discussion and analysis of the situation in their community.

The Statistical design involved tabulating the methods and types of waste generated.

3.3 Sample size estimation

The study involved the selection of 4 zones out of the 23 zones in Bwaise. In Bwaise I Parish, Kulumba Zone was selected, in Bwaise II Parish Jambula and Katale zone were selected, and in Bwaise III Parish Bukasa zone was selected. Bukasa zone was selected to represent to least developed area, Kulumba represented the most developed area, Katale was selected to represent the highly generating waste and Jambula was selected randomly.

The sample size was determined by the use of Yamane formula, which is;

$n=N/(1+Ne^2)$

n=sample size

N=total population

e=marginal error

Assuming confidence of 95%, e=0.05

$n=45510/ (1+ (45510*0.05^2))$

$=396.5$ approximately 397people

The sample size comprised of 397 respondents (local people- considering a number of issues like residential, business-small or high etc.) from different zones of Bwaise. A non–probability sampling procedure was used where purposive techniques were employed. This is because, in purposive/judgmental sampling, the researcher purposively chose respondents who, in his opinion, thought to be relevant to the research topic. In this case the researcher was convinced that his judgment is more important than obtaining a probability sample because waste management is not a new phenomenon therefore, to obtain relevant data, one must choose relevant respondents.

3.4 Methods of data collection

Both qualitative and quantitative methods of data collection were used because qualitative methods involve the use of words rather than numbers; the methods involved descriptions of the study and this approach helped to generate quality information that gave meaning to numbers. While quantitative methods involved the collection of numerical data in order to explain, predict and control phenomena of interest and the data collected was presented as a table in numbers. The numerical data obtained was used to explain the social life of the people of Bwaise in relation to solid waste management. These methods included, administering questionnaire, interviewing and observation.

a) Interviews

Personal interviews were conducted and at same time using observation method where the occurrence of the social events or phenomenon recorded. While interviewing, the researcher was guided by both structured and unstructured questionnaires which worked as interview guide. Questionnaires were used as guide to people who cannot read or write.

b) Questionnaires

The questionnaires consisted of questions both open and closed in which well answered questions exhausted the research objectives. This method gave the respondents enough time to reflect, concentrate and at times consult. This was used to collect in-depth household information to establish the authenticity of information got from the other methods. In addition, the questionnaire was used to collect the following data: Current service status, methods of waste management and nature of waste generated.

c) Document Review (secondary data)

This was used to collected data that was not specifically gathered for the research question at hand. The researcher got information from the study of documents about waste management. This data helped the researcher with the starting point for additional research. More to that documents related to the topic were studied to give more information on the issues under investigation.

Figure 10; a researcher interviewing a resident of Kimombasa, Jambula zone, Bwaise II

Figure 11; a researcher interviewing a resident of Kulumba zone, Bwaise I

3.5 Data analysis and interpretation

This entailed editing, repeating interviews where necessary, summarizing, categorizing and grouping similar information, analyzing according to the theme of the study. Quotations and observations made were noted during the interviews and their sources or the name of the interviewee. All the questionnaires were analyzed whether completed or not.

Statistical analysis was done manually and where necessary Microsoft Excel Spreadsheets were used to present the data in a tabular or graphic form like pie-chats, bar graph generated.

It was from the results of analysis that interpretation and discussion of the data obtained in relation to phenomenon solid waste management.

The volume of the collection vehicle for a stationary container system was determined basing on the BS EN 12574- 2

The tumbler composter was designed using Civil 3D

CHAPTER FOUR

4.0 RESULTS, INTERPRETATION AND DISCUSSION

4.1 The current state of solid waste management in Bwaise

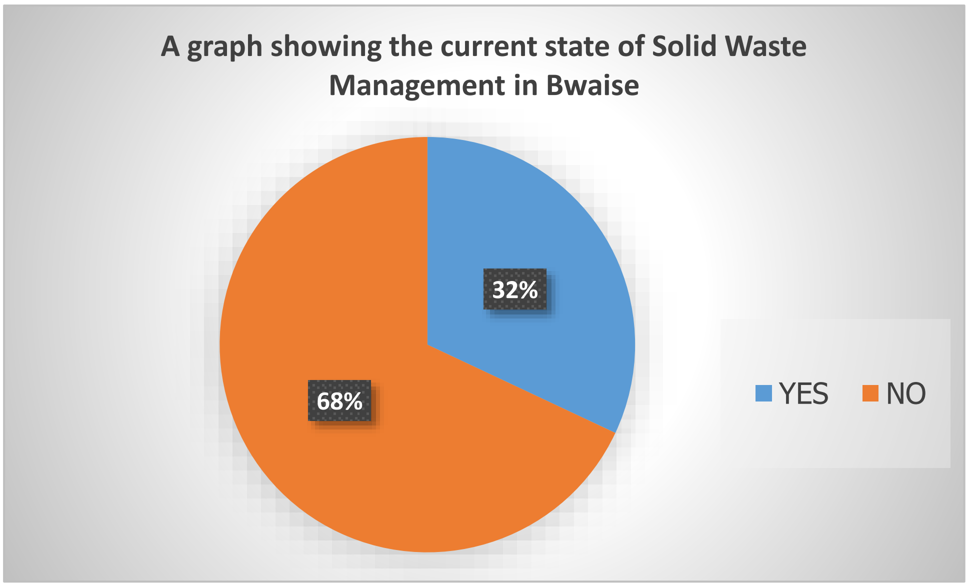
This results were obtained from question 11 of the questionnaire which was closed ended and the respondents were required to say 'yes' if the services were good and 'No' if they were not.

From the categorizing it was observed the majority said 'No' which is represented in the table 1 below;

Table 1; showing the current service state of solid waste management

YES	NO
127	270
32%	68%

Figure 12; a graph showing the current service state of Solid Waste Management in Bwaise



From the graph above it is observed that the 'No' with 68% is greater than the 'Yes' with 32%. The results mean that the current service status of solid waste management is the really poor hence there is need for improvement by coming up with an appropriate solid waste management system.

4.2 Nature of solid waste

The solid waste generated in Bwaise was categorized into two i.e. biodegradable and non-biodegradable.

The results concerning the nature of waste were got from question 9 of the questionnaire which was open ended and respondents gave an average of two answers and they were categorized and represented in tables below.

Table 2; showing biodegradable waste

Item	Rate
Peelings	65
Banana leaves	76
Yard wastes	36
Sweeping dust	20
Ash	18
Animal wastes	58
Left over foods	82
Papers	68
Total	**423**

This table shows the different types of biodegradable wastes generated in Bwaise. It was found that out of the 705 responses concerning types of wastes generated 423 of them were the biodegradable ones as shown above.

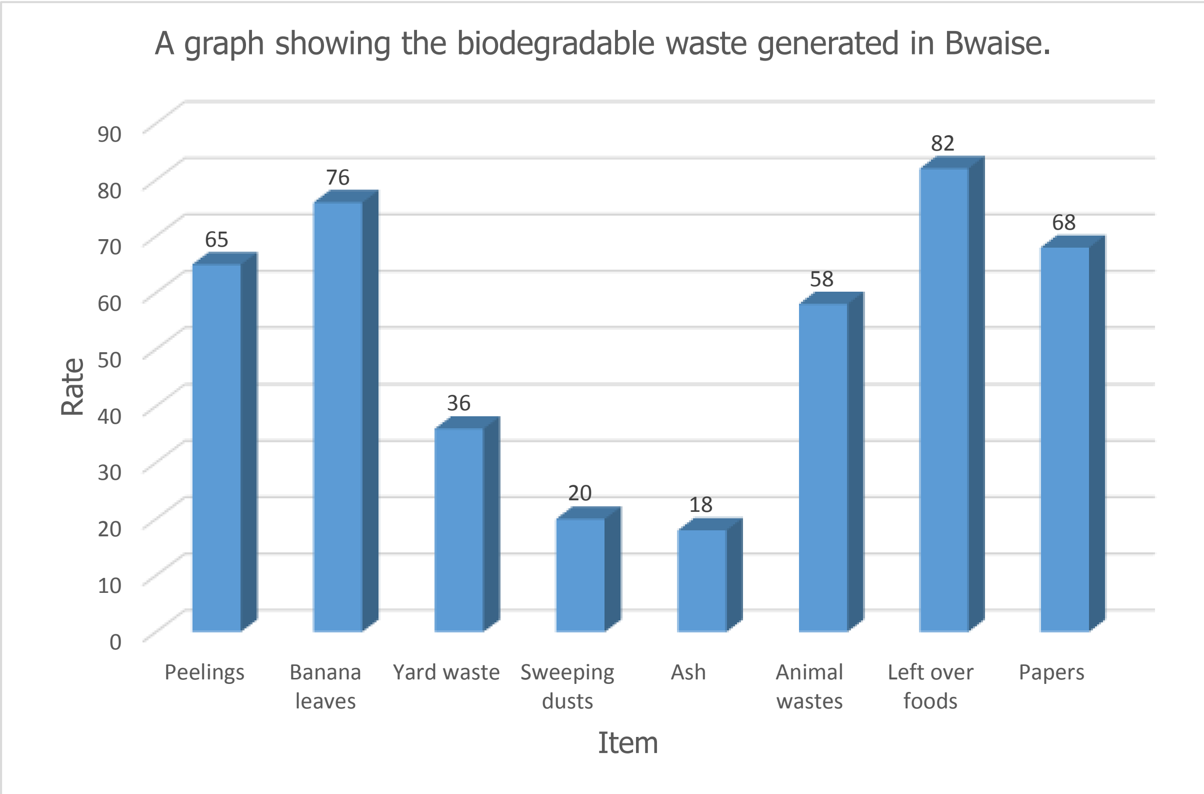


Figure 13; a graph showing the biodegradable waste generated in Bwaise

Graph above shows the amount of each biodegradable generated with food remains, banana leaves, peelings, papers and animal wastes having higher values.

Table 3; showing non-degradable waste generated

Item	Rate
Polythene (Buveera)	70
Plastics	60
Old sacks	27
Metals	40
Glass	34
Broken clay plates and clays	21
Old cloth	30
Total	**282**

This table shows the different types of non-biodegradable wastes generated in Bwaise. It was found that out of the 705 responses concerning types of wastes generated 282 of them were the non-biodegradable ones as shown above.

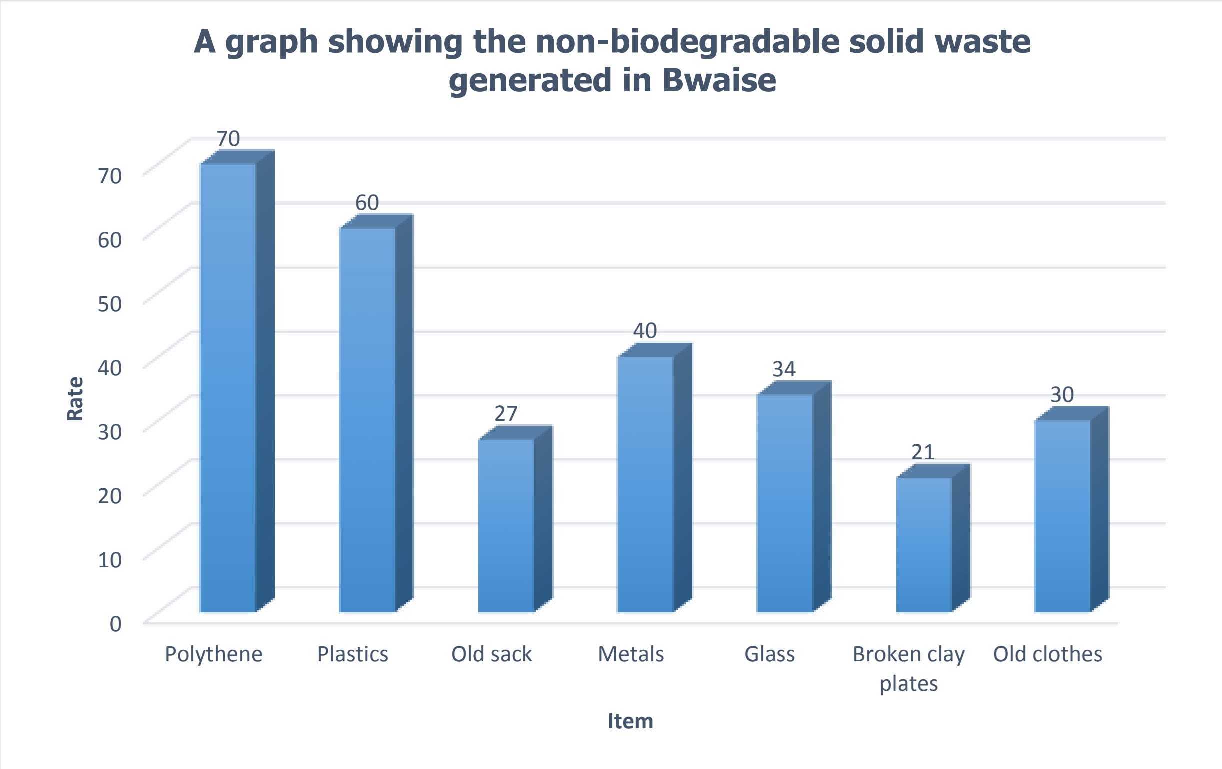


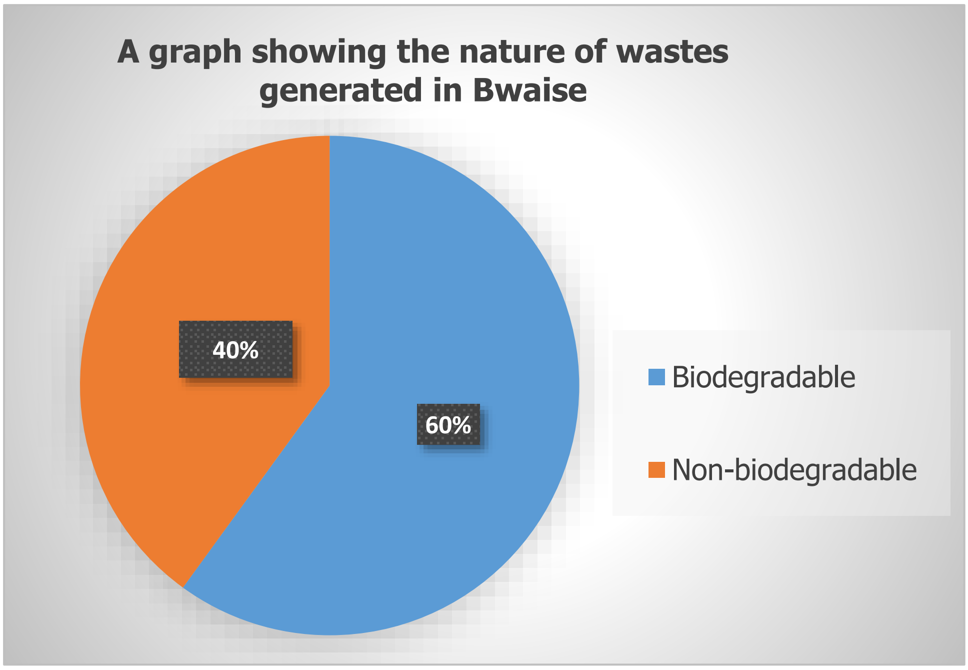
Figure 14; a graph showing the non-biodegradable solid waste generated in Bwaise

Graph above shows the amount of each non-biodegradable waste generated with polythenes and plastics having higher values.

Table 4; showing percentage of each nature of waste generated in Bwaise

	Non-biodegradable	**Biodegradable**	**Total**
Items registered	282	423	705
Percentage	40 %	60%	100 %

Figure 15; a graph showing the nature of wastes generated in Bwaise



This graph shows that the biodegradable waste with 60% is greater than the non-biodegradable with 40%. It shows that the biodegradable need quick solution compared to the non-biodegradable since they are more by 20%. It was from this that a composter was found to be the best solution of the poor state of solid waste management in Bwaise.

4.3 Determining the appropriate Solid waste management system

This was obtained from question 12 of the questionnaire which was an open ended question where respondents gave an average of 2 responses each.

This was tabulated in table below.

Table 5; showing the suggested solid waste management methods

Method suggested	Rate of use	Ranking
Burning /incinerating	45	7
Sensitization	70	1
Dust bins	48	6
Composting	58	3
Recycling and reuse	54	4
Bulungi Bwansi/community based	64	2
Tendering private firms	28	8
Warning posters	54	4
By laws	49	5

Figure 16; a graph showing various Solid Waste Management methods that were

suggested by residents in Bwaise

As observed above, the results from ranking indicate preference for the following approaches and methods in this order: Sensitization, 'Bulungi Bwansi' (Community Work), composting, recycling, warning posters, by laws, Dustbins/containers, burning. The approach of tendering to private firms was the least liked yet this is the approach currently being implemented under the Kampala Solid Waste Ordinance. In Bwaise, Nabugabo Ventures is the company that won the tender to collect garbage from this area. Given this unfavorable response, a lot of effort needs to be done to convince the public to accept and support this initiative.

Despite clear advantages, these approaches nevertheless, have some drawbacks. Remedy measures like recycling, for example, may involve high initial and capital costs; it also necessitates the identification of markets for recycled material and requires educating the general public to accept the need to separate materials at sources. And reducing waste arising at source may require the regulation of industry, the development of economic instruments to encourage plant modification or redesign, and the education of consumers as to the benefits of "environment friendly" products.

Public awareness through sensitization has an important role to play. This is the key to the success of any SWM policy. It is no surprise that the local communities ranked it first in their solutions to SW problem.

Community works was a good suggestion which showed that the community is really concerned about the waste management and are willing to work hand in hand with the council to solve the problem of poor solid waste management though it needed another method that it can work with. This community work majorly focuses on the collection part and leaves out the disposal part. Thus there was need to design an appropriate waste management which can work with the community works and the sensitization to improve on the current status.

Basing on the observations and analysis the major cause of the poor waste management was that the community was not willing to pay the collectors.

Some of the interviewees said;

"We see no reason why we should pay a fee for garbage disposal, where do the taxies we pay go?"

4.4 Determination of the amount of waste generated in Bwaise

One of the basic considerations when designing a solid waste management system is the amount of waste to be handled.

The amount of waste generated in Bwaise was calculated as shown below;

Table 6; showing conversion factors used for calculations taken from draft 16 UK waste classification scheme

Type of waste	UK Waste Classification Category	Conversion factor (CF) (Tonnes pe cubic metre)
Rock and stone	21.01.01	1.2
Glass (cullet)	21.02.01	0.75
Concrete and/or mortar	21.02.03	1.3
Mixed construction and demolition	22.02.01	1.2
Plaster	22.03.01	1.0
Paper and/or card	22.04.01	0.6
Wood	22.04.07	0.7
Vegetable matter including food and bark	22.06.00	0.75
Household	22.09.01	0.27
Street sweepings and litter	22.09.05	0.2
Sewage	22.10.00	1.0
Healthcare sharps	25.01.01	0.2

CALCULATING THE VOLUME OF WASTE GENERATED IN BWAISE PER DAY			
REFERENCE	**CALCULATION**	**OUTPUT**	**UNITS**
National Population and housing census ,2014	Population of Bwaise I+ BwaiseII+BwaiseIII =19058+18269+8183	45510	People
KCCA, Kawempe Division, Solid Waste Management department	Estimation of waste generated	1.0	kg/person/day
	Total waste generated=population *weight generated by each person. =45510*1	45510	kg/day
Analysis of questionnaire data	60% of the waste is biodegradable =60*45510/100	27306	kg/day

Conversion table ,table 6	1tonne of household waste=0.27tonnes/m^3 but 27306kg=27.307tonnes, Therefore the volume of biodegradable waste =Mass/density =27.307/0.27	101.13	m^3/day

4.5 Design of the appropriate solid waste management system

Table 7; showing the typical values of haul constant coefficients a and b (Peavy et al1985)

Speed limit (km/h)	a (h/trip)	b (h/km)
88	0.016 (1 min/trip)	0.011 (0.66 min/km)
72	0.022 (1.3 min/trip)	0.014 (0.84 min/km)
56	0.034 (2.0 min/trip)	0.018 (1.08 min/km)
40	0.050 (3.0 min/trip)	0.025 (1.5 min/km)
20*	0.083 (5.0 min/trip)*	0.050 (3 min/km)*

Table 8; showing data for computing equipment and labor requirements for hauled and stationary container collection systems

Collection Vehicle	Loading method	Compaction ratio, r	Pick up loaded container and deposit empty container. h/trip	Empty contents of loaded container h/continer	At site times h/trip
Hauled Container systems					
Tilt frame	Mechanical		0.40		0.127
Tilt frame	Mechanical	2.0-4.0	0.40		0.133
Stationary container systems					
Compactor	Mechanical	2.0-4.0		0.050	0.10
Compactor	Manual	2.0-4.0			0.10

4.5.1 Determining the required volume of the collection vehicle

The container system selected is the manually loaded stationary container system.

REFERENCES	CALCULATIONS	OUT PUT	UNIT
	volume of waste generated=(total weight of biodegradable*1000)/0.27	101.13	m^3/day
	Off route factor, W	0.15	
	Length of work day, H	8.0	h
	Time from garage to the first container location, t1	0.25	h
	Time from last container location to the garage,t2	0.33	h

	Number of trips per day, Nd	3.0	trips/day
	Time per trip for stationary container system, Tscs=(H(1-W)-(t1+t2))/Nd =(8*(1-0.15)-(0.25+0.33))/3	2.07	h/trip
From KCCA	Average speed	40.00	km/h
table 8	At site time per trip, s	0.10	
Table 7	Empirical haul constant, a	0.050	
Table 7	Empirical haul constant, b	0.025	
KCCA, Kawempe Division, Solid Waste Management department.	Round trip haul distance, x	5.0	km/trip
	Pick up time per trip for a stationary container system, Pscs=Tscs-(s+a+bx) =2.07-(0.1+0.050+(0.025*5))	1.8	h/trip
	Rear off house pickup location, PRH, considering 50% backyard and 50% kerbside	50.0	
	Average number of containers per pick up location, Cn	2.0	cotainer/location
	Average pick up time per location, tp=0.72+(0.18*Cn)+(0.014*PRH) =0.72+(0.18*2)+(0.014*50)	1.78	min/location
	Number of collectors, n	2.0	Collectors

	Number of pick up locations per trip, Np=(60*Pscs*n)/(tp*3) =(60*1.8*2)/1.78	41	location/trip
	Compaction ratio (2.0-4.0),r	2.5	
	Volume of waste collected per pick up location, Vp =Volume of waste generated/(3*Np)	0.83	m^3/location
	Volume of collection vehicle, V=Vp*Np/r =0.28*121.2/2.5	13.5	m^3/trip

4.5.2 Designing a solid waste tumbler composter

The proposed location of composter is in Jambula where there is an open land which is currently used as an open dumping disposal area, the land is accessible in all directions which will allow easy inlet of trucks to dispose the waste and easy outlet of trucks carrying the compost. The settlements within are also scarce which will not incur a lot of cost for compensation.

The idea of a large scale composter was adopted as the appropriate solid waste management system since it is environmental friendly due to the fact that the waste is composted while enclosed. It was also selected because it can help in the income generation so as to pay the waste collectors.

The tumbler kind of composters specifically has been chosen because the turning action it requires provides the compost with a fair amount of air. As mentioned previously, bacteria need oxygen to keep up the respiration process that happens within aerobic systems. Additionally, putting the compost in a closed container will help to retain the temperature inside.

The tumbler composter is capable of composting a given volume of waste under favorable condition for a maximum of 3days.Hence its size should be able to accommodate thrice the volume generated per day in Bwaise.

The large tumbler has a cylindrical metal barrel container painted with rustproof paint. Air will flow inside this container through multiple big size holes similar to those pierced in the pilot tumbler to allow the aerobic process to occur. In order to allow the composter to let enough O_2 in the composter, ¼ of the composter needs to remain empty.

The tumbler composter was designed considering the following factors:

- **Aeration:** first of all, the composter designed is a tumbler that contains a cylindrical metal barrel with an axle that has sharp metallic sticks of a length of 5m. This allows turning the material inside the tumbler which allows air circulation. Additionally, holes of a diameter of 5cm each are pierced on the upper area of composter. Also, the composter contains a door that allows air entrance even when closed.
- **Temperature:** The compost temperature may go from 20°C to 70°C. Therefore, the composter has to offer the adequate heat capacity. The material that meets the best this requirement is metal, known for its high capacity to retain heat. That is why our composter is metallic.
- **Easiness of the task:** In addition to produce high quality compost, this tumbler also aims to ease the task of composting. To do so, the composter contains a handle that has two control sticks from the two sides of the container to allow turning the axe inside the composter, which turns the components. Sharp metallic sticks have been put on the axle to shred the composted materials and lower their size to accelerate the composting process. Additionally, the material of the composter is made of light metal to allow turning the tumbler easily upside down to remove the finish product. Furthermore, the composter is attached with metallic belts to keep it from falling down or moving during the turning action. The composter is put on a support to keep it stable and easy to reach.

Basing on the results of the amount of waste generated in Bwaise, the tumbler composter capacity was to be of (101.13*3)=303.39m^3 and additional space that is 1/3 of the diameter to allow aeration and proper turning.

Sizing the tumbler composter.

The volume that the composter is to accommodate =V*3

=101.13*3

=303.39m^3

Since the composter is cylindrical, its volume=pi*r^2*h

303.39=3.14* r^2*h

96.62= r^2*h

Using try and error method

R	H	v/pi
2	12	48
2.5	13	81.25
3	13	117
3	10.74	96.66

From the calculation a tumbler composter of 3m radius and 10.74m can accommodate a volume of 303.39m^3, but there should a free board of ¼ of the diameter for aeration purpose.

D=2*r

=2*3=6m

¼*6=1.5m

Therefore the d=1.5+6=7.5m, r=3.75

CHAPTER FIVE

5.0 CONCLUSIONS, CHALLENGES AND RECCOMENDATION

5.1 Introduction

This chapter discusses the conclusions drawn from the research and different recommendation as far as the research was concerned. It also highlights alternative areas of further research in reference to this research. The challenges faced are also highlighted to act as an eye opener to all students and relevant staff towards the execution of better researchers in this field of study.

5.2 Conclusion

The solid waste management service status was found not to be good environmental wise which was observed by garbage heaps along the roadsides and in trenches which leads to rise in drainage blockage of the drainage system and water borne disease outbreaks.

There is a diversity of waste generated in Bwaise. The largest percentage is biodegradable waste consisting of food related items. The non-biodegradable waste is the least consist mainly of polythene bags and plastic bottles. Therefore, it can be stated that diversity of waste will need diversified disposal approaches for effective and efficient management of the solid waste.

The amount of waste generated in Bwaise is extremely high due to its high population, thus there was need to use a container system that could collect the all the waste every day.

The idea of a tumbler was found to be the most appropriate one due to its ability to handle worst generated waste and also generating income for the waste collectors.

5.3 Problems and challenges

There is a positive correlation between community's involvement in policy evolution and its successful implementation. Where people are involved it is easy to enlist their cooperation to support the policy than where they are not involved, it is an uphill task to implement such policies. This could be the reason why the Kampala Solid Waste Ordinance has been difficult to implement especially at its initiation. Secondly, there is a relationship between effective solid waste management in communities and presence of active environmental institutions.

5.4 Recommendations

- The Local Authorities should install a motor to ease the rotation of the composter, since the manual rotation is time consuming and requires a lot of energy.
- KCCA should excavate the ground where the composter is to be placed to meet a level that the person operating can reach.
- The primary role of the KCCA should be to sensitize the community of Bwaise to do the separation waste at the point of generation so as to ease the collection process of the biodegradables.
- Environmental Education to the communities should be taken seriously. This will help communities appreciate sound practices such as sorting and recycling. This will help encourage communities to abandon illegal practices such as burning, and open space dumping.
- The central government should establish links between recycling companies and community groups. This will help in handling the non-biodegradable waste like plastics and old clothes.
- Appropriate technologies in line with the nature of garbage generated. Possible options include: In the case of non- biodegradable waste, since polythene bags are generated in such large and increasing quantities and yet without any immediate foreseeable solution, one option could be to convert them to energy, through use of combustors or incinerators. This would serve in the meantime as other solutions are sought.

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APPENDICES

APPENDIX I: SCHEDULE OF THE WORK

The project will be executed following the time schedule as follows

	MONTHS	SEP	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL	MAY
ACTVITY	Reconnaissance Survey									
	Proposal Writing.									
	Data collection									
	Data analysis									
	Designing									
	Report Writing									

APPENDIX II: QUESTIONNAIRE

Hello respondent,

We are students of Kampala International University in our final year of study pursuing a bachelor degree in science in Civil Engineering. We are carrying out a research study entitled "***Assessing solid waste management***" a case study of Bwaise. This study is part of the requirements leading to the award of the above stated degree programme.

It is upon this, that I kindly request you to respond to this questionnaire with all the honesty and sincerity. The information you will provide will be entirely for study purposes and it will be treated with utmost confidentiality.

The researchers do not have enough funds to pay you for responding to the questions in this form but your positive response is highly appreciated.

Thank you.

PARISH…………………………………

WARD……………………………………………..

1. What is your name? (Optional)____
2. What is your age bracket
   □10-25 □26-30 □31-35 □36-above
3. Gender
   □Male □ female
4. How many are you in your household?
5. Who heads the household
   □ Father □ mother □ wife □ husband
6. What is his/her occupation? …………………………………………………………….
7. Do you have a toilet
   □ yes □ No

8. If No where do you ease your selves from?

…………………………………………………………………………………………………..

9. Which waste does your household generate?

………………………………………………………………………………………………………
………………………………………………………………………………………………………
…………………………………………………………………

10. How do you manage your wastes? State the various methods used in Bwaise.

....
....
....

11. Are the methods used efficient to solve the current problem of poor solid waste management?

□Yes □ No

12. If No, what do you think should be done for a better management?

....
....
....
....
...

APPENDIX III: BUDGET

Activity	Cost in shillings
Printing of questionnaires	100000
Transport	100000
Internet	50000
Facilitation of research assistants	300000
Consultation	150000
Stationary	100000
Others	150000
TOTAL	1000000