THE CHALLENGES OF SOLID WASTE MANAGEMENT IN NYALENDA ESTATE – KISUMU COUNTY, KENYA

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ABSTRACT

Solid waste management comprises the functions of generation, storage, collection, transportation, treatment and disposal of solid waste with the objectives of protecting the health of the population, promotion of environmental quality, supporting economic productivity and generation of employment and income. The achievement of these objectives requires sustainable systems which are adapted to and carried by the municipality and its local communities. Most municipalities often fail to adapt systems which are necessary to improve their existing waste management methods despite the fact that population growth rates and the socio economic status of the population affect waste generation rates and compositions and thereby affect the related management functions. Mainstream environmental management in the Kisumu Municipality seems not to serve low-income areas of Kisumu Municipality. This study therefore focused on the low-income residential areas of Kisumu Municipality that feature rapid population growth and where planning with respect to solid waste management seems to have been ignored. The objectives of the study were; to assess the solid waste management practices of the households and their influence on the environment in Nyalenda Estate, Kisumu; to assess the efficacy of solid waste management practices of Municipal Council of Kisumu, and their influences on environmental management in Nyalenda Estate, Kisumu; to establish future solid waste management characteristics and densities and their projected influences on environmental management in Nyalenda estate The study examined these residential areas in terms of the socio-economic conditions of their populations, physical infrastructure, waste generation rates and waste characteristics with a view to creating ground for appropriate solid waste management approaches.The study used surveys, physical observations and measurements from households. Data was collected through the use of questionnaires, Simple Random sampling was used to select 384 households for the survey. Physical measurements of waste characteristics were collected over a period of 7 days. The data generated was analyzed using qualitative and quantitative approaches. Theoretical framework employed were systems thinking and systems theory. The study found that there is a close relationship between low-income residential area factors and solid waste management practices. It also found that the Municipal Council of Kisumu is ill equipped to manage solid waste effectively. The study made recommendations on ways that the Municipal Council of Kisumu can implement safe Solid Waste Management practices and employ a more integrated approach to Solid Waste Management. It is hoped that this research will be useful to those involved in planning Solid Waste Management and Environmental Management in the Municipal Council of Kisumu as well as local authorities in other parts of Kenya and in other developing countries.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Solid waste is composed of refuse that is generated in households (domestic waste), non-hazardous solid waste from industrial, commercial and institutional establishments (offices, hotels, shopping complexes/shops, schools, hospitals and other health care facilities), from municipals services such as street cleaning and maintenance of recreational areas and waste generated from sweeping markets. Solid wastes can also be defined as non-liquid and nongaseous products of human activities, regarded as being useless. It could take the forms of refuse, garbage and sludge (Leton and Omotosho, 2004).

Solid waste management (SWM) comprises the functions of storage, collection, transportation, treatment, recycling, and disposal of waste. Its primary target is to protect the health of the population, develop sustainability, support economic productivity and create employment especially among low-income earners who are viewed here as the most affected by improper waste disposal. The achievement of SWM goals requires sustainable systems which are adapted to and carried by the municipality and its communities. Munala and Moirongol (2001) in JAGSTI vol.13(1)2009 pg 65.

The appropriate management of municipal and industrial solid waste continues to be a major problem throughout the world. In the United States of America, traditionally, solid waste management was practiced through transporting the solid wastes to nearby low-value lands for disposal. Frequently then, and, in some parts of the world, today, the combustible parts of the

solid wastes were set on fire at the disposal site. This practice, while now terminated in many developed countries, is still in use in some developing countries.

In Europe as society has grown wealthier, it has created volumes of waste. The higher living standards mean that people are buying more products and as a result producing more rubbish because consumers have much more choice and products are designed to have shorter life spans. There are also many more single use and disposal products. Advances in technology mean that people own and use many more personal devises, and update them more often. These lifestyle changes have increased the quality of life, but it also means more waste than ever is being generated in Europe. (European commission- Environment, 2011).

The impact, proximity and relevance of this landfill problem for local readers, and its currency in relation to the national landfill crisis not only made waste disposal newsworthy in Nova Scotia, but crutial in setting municipal and provincial agendas. Important to its rise in the agenda is the impact of the story; Every Nova Scotian generates waste and therefore has a direct connection and familiarity with the issue. It is not an abstract or arcane environmental concern, but something one touches, sees and smells on a daily basis. Local news information is recalled and understood better than distant news and information. Connecting this daily exposure to solid waste with real environmental and public health consequences meant that the public more easily comprehended the solid waste problem. By 1987 there were 202 inactive abandoned waste disposal sites and 70 active landfills lacking liners (Wagner, 2007).

In the late 1980s awareness of environmental issues led Estonians to stage their first large demonstrations against Soviet government policies. They organized to protest the expansion of open-pit phosphorite mining in northeastern Estonai. Their success in stopping the expansion prompted further demonstrations as part of the country's independence movement. Since independence Estonia has taken measures to protect the environment. The government has ratified international agreements to reduce emissions of hazardous wastes and greenhouse gases, as well as to protect biodiversity, wetlands and endangered species. Estonians cherish the countryside, and 8 percent of the land is protected in national parks and nature reserves Taagepera, (2007).

Developing countries have solid waste management problems different than those found in fully industrialized countries; indeed, the very composition of their waste is different than that of 'developed' nations. Although low-income countries' solid waste generation rates average only 0.4 to 0.6 kg/person/day, as opposed to 0.7 to 1.8 kg/person/day in fully industrialized countries, Cointreau (1984) noted several common differences in the composition of solid waste in developing nations: waste density 2 – 3 times greater than industrialized nations, moisture content 2 – 3 times greater, large amount of organic waste such as vegetable matter, large quantities of dust, dirt (street sweepings) smaller particle size on average than in industrialized nations. These differences from industrialized nations must be recognized both in terms of the additional problems they present as well as the potential opportunities which arise from their waste composition.

In most towns of developing countries, private or public systems of waste management tend to be inadequate. According to estimates form the World Resources Institute and USAID, many local

authorities in developing countries spend over 30% of their budgets on refuse collection and disposal but can only collect at most 50-70% of solid waste (Matrix, 1993). Most cities and towns dispose solid waste in ways that are most detrimental to the environment such as open burning or damping in rivers, lakes and oceans (Hoornweg and Thomas, 1999). .

Since local governments typically consume between 20 – 50% of municipal budgets in developing countries, SWM has been their responsibility (Van Beukering et al. 1999). Because of this, town residents expect local governments to make provisions that ensure public health and safety. However, this task depends as much upon organization and corporation between households, communities, private enterprises and government authorities as it does upon the selection and application of appropriate technical solutions for waste collection, transfer, recycling and disposal (UNEP, 1996).

Municipal solid waste management constitutes one of the most crucial health and environmental problems facing governments of African cities today. This is because even though these cities are using 20-50 percent of their budgets in solid waste management, only 20-80 percent of the waste is collected. The uncollected or illegally dumped wastes constitute a disaster arising as a consequence of increasing urbanization, incomes and changing consumption habits fuelled by globalization. This scenario places the already-desperate urban councils in a difficult situation especially as they have to develop new strategies to deal with increasing volumes as well as new varieties of wastes.

Solid waste generation, as one would expect, varies between countries and cities in Africa. Reliable data is hard to come by and cities' economic and political conditions are quite dynamic over time. Insurgence of war, economic crises or booms, political strife etc can have immediate and profound changes on waste generation and management. Global forces including multinational companies are sometimes, but not always, behind these national upheavals. For example, in Mogadishu, Somali huge heaps of garbage accumulated over the city over ten years of civil and war (Barise 2001).

In Kenya, problems arising due to poor SWM have been felt in most of the urban centers as well; sometimes with very harmful consequences upon public health, the environment and national economy. (UNDP/UNCHS(Habitat)/World Bank/SDC(1996). A decisive move towards complete eradication of poor SWM based on a well founded approach, serious involvement of all the stakeholders and sufficient allocation financial and other resources is therefore necessary. In 2006, the Ministry of Environment and Natural Resources gazette the Environmental Management and coordination (Waste Management) Regulations; (2006) which have been put in force by NEMA (National Environment Management Authority) which is also mandated with authority to license local authorities in Kenya with licenses to manage waste.

Demographically, Kisumu town has expanded rapidly due to migration from the rural to urban areas leading to unplanned settlements in the suburban areas accommodating about 60% of the urban population on only 5% urban land area leading to generation of volumes of waste that cannot be easily bio-graded in the environment as well as waste dumped in areas that are not designated for dumping of waste. As a result, services such as regular collection of domestic solid

waste have been inadequate especially in the peri-urban areas of Kisumu, BG Associates (2002). As has been noted with other local authorities, collection and management of solid waste is the sole responsibility of the Municipal Council of Kisumu (MCK) through the City Environment Department. However, efforts towards SWM in Kisumu appear to have been continuously frustrated by the increasing population of residents as well as economic activities in the absence of proper SWM. Presently, refuse is seldom collected, and when collected, it is never really cleared. In most instances these collection services are restricted to market places within the city, the central business district, and areas often characterized as politically sensitive (Carl bro consultants, 2001).

This study looked at how the unique nature of waste characteristics, a community's socio-economic status and existing physical infrastructure could be used by MCK and the community for the planning, implementation and managerial operation of a SWM system. The urban focus of the study was been influenced by the poor waste management conditions resulting from rapid urbanization, poverty and poor planning on the part of local governments. It was hoped that the results obtained from this study would be beneficial to the local authorities as well as all the actors in the SWM sector.

1.2 Statement of the Problem

The Municipality Council of Kisumu appears not to be able to meet the demands of solid waste collection, transportation and disposal. This is due to inadequate finance, inadequate political commitment or lack of comprehensive planning on the part of MCK making the waste provision a vicious cycle of problems (SWECO, 2003). In 2001, it was estimated that the waste generated in Kisumu was approximately 400 tonnes per day, with 80% of this remaining uncollected (Carl, 2001). Since whatever efforts at collection and disposal have tended to favour well to do neighborhoods, people living in the poor residential areas have been exposed to higher risk of waste related problems such as a polluted environment that breeds verminous populations that give rise to diseases such as cholera, dysentery, malaria and various forms of skin diseases as well water borne diseases and air pollution, which inevitably lead to negative health effects.

It is evident that uncollected garbage is a recurrent problem in Kisumu Municipality. The crisis of uncollected garbage has also led to other problems such as dumping in the nearby Lake Victoria, leading to pollution of the Lake thus having negative effects on the aquatic life and the fishing industry around the town. Uncollected rubbish has also led to blocked drainage systems and sewages, and contamination of surface and ground water reservoirs. Children's playgrounds have also been turned into dumping grounds in most of the low-income neighborhoods, leaving children to play on the busy roads. (KISWAMP, 2008).

An essential prerequisite for any successful programme to improve solid waste management is to establish it as a political priority. This has not been achieved by MCK largely because MCK appears not to effectively recognize public health and environmental consequences of inadequate

solid waste management practices which are here categorized into five major aspects which are that most of the municipal refuse contains human faecal matter. In Kisumu, this may be due to inadequacies in the sanitation infrastructure and management, or due to the practice of using disposable nappies (diapers) for young children. Human excreta is a critical vehicle for transmission and spread over a wide range of communicable diseases, and municipal refuse is one important pathway for those pathogens. Decomposition f the organic materials in the municipal solid waste can give rise to heavily contaminated waste, known as "leachate", which may pollute both surface waters and ground water. Water pollution from leachate is a major problem associated with uncontrolled dumping of solid wastes in MCK leading to water borne diseases such as typhoid fever and amoebiasis among others. A common problem associated with dumping of refuse is air pollution form continuous burning. Additional problems are associated with the uncontrolled disposal of hazardous wastes. The uncontrolled discharge of toxic waste into water courses may pollute drinking or irrigation water supplies. Uncontrolled disposal with urban wastes in open dumps exacerbates all of the previous problems, for example posing a health risk to scavengers and others who are in direct contact with the refuse, polluting groundwater resources and adding to the air pollution risk. An area of particular current concern is the uncontrolled disposal of clinical wastes, given the reports of AIDS and Hepatitis epidemics which are a threat in urban and rural centres (Nair, 1993).

This study therefore sought to determine the relationship between factors such as physical infrastructure, socio-economic status, and solid waste characteristics in Nyalenda estate on the one hand and methods of waste management focusing on waste generation rates, collection, storage, transportation and disposal on the other. It was hoped that results arising from the study would

guide future planning for SWM and in the identification of appropriate and sustainable SWM methods adaptable to the local characteristics of waste.

1.3 Purpose of the study

The purpose of this study was to assess the influence of SWM on environmental management in Nyalenda Estate - Kisumu County.

1.4 Objectives of the study

The study was guided by the following objectives:-

i. To determine solid waste management practices of the households and their influence on the environment in Nyalenda Estate, Kisumu County.

ii. To assess efficacy of solid waste management practices of County Council of Kisumu, and their influences on environmental management in Nyalenda Estate, Kisumu County.

iii. To establish future solid waste management characteristics, densities and their projected influences on environmental management in Nyalenda estate, Kisumu County.

1.5 Research Questions

To achieve these goals, the following research questions were addressed:-

i. What are the solid waste management practices of the householders and how do they influence environmental management in Nyalenda Estate, Kisumu County?

ii. How can Solid Waste Management practices of the County Council of Kisumu be assessed effectively and what is their influence on environmental management in Nyalenda Estate, Kisumu County?

iii. How can future trends be projected on solid waste management, waste characteristics and waste densities and their influences on environmental management in Nyalenda Estate, Kisumu County?

1.6 Significance of the study

It is hoped that the findings of this study may help raise awareness on issues pertaining to waste management for better environmental management in Nyalenda Estate, Kisumu County and that it would help build initiatives to reduce the problem of SWM. The study was also showed by the logic that it is easier to devise a method of SWM than to deal with diseases and degradation of the environment. It was hoped that the study would provoke a debate that would lead to the development of better options for SWM.

This research highlighted the roles of the different stakeholders and the extent to which they had been active in addressing the waste management problem. Partners in development such as local governments through the County Councils and private waste management firms could use this information by identifying sustainable solid waste management practices and making provisions to ensure public safety. This will therefore ensure safe collection and disposal of residential solid waste sustainably avoiding aforementioned bad effects.

1.7 Basic Assumptions of the study

The study was conducted with the following basic assumptions in mind: - SWM is a problem in Nyalenda Estate, Kisumu County and MCK recognize it as a problem. MCK and the residents of Nyalenda Estate, Kisumu County are fully aware of the health hazards caused by uncollected

waste and its effects on the environment, but are unable to contain the situation and SWM can be made effective in Kisumu Municipality and the mushrooming mounds of garbage can be eliminated thus reducing the effects of uncontrolled waste disposal. The study was conducted with the hoe that the respondents would give honest and true information.

1.8 Limitations of the Study

The poor road network in the interior of Nyalenda estate made data collection difficult. The researcher had to walk to reach some households or use a motorcycle to access areas where a care could not reach but which a motorcycle could access. A wheel burrow was used to ferry garbage collected for sampling to the road in areas which were inaccessible by a car. The researcher relied on the good will of the respondents in the study and hoped that they would give accurate responses in the questionnaires.

Selection of a wider location and population would have enabled the researcher to have a wider view of responses on the problem under review. The decision to select this area among many others in the country and in Kisumu does not minimize the importance of other areas. The researcher undertook the study fully aware the some MCK officials and some residents of Nyalenda estate would be reluctant to volunteer information concerning their waste disposal behaviour and those of their neighbours. The researcher therefore devised a data collection instrument that allowed privacy.

1.9 Delimitations of the Study

The study was conducted in Nyalenda, estate of Kisumu County. This area features rapid population expansion against the backdrop of relatively poor infrastructure and services such as sewerage, tarmac roads and running water. Its rate of environmental deterioration also appears worse than other areas within Kisumu. It is also heavily populated by households of relatively low income.

1.10 Definitions of Significant Terms as used in this study

Storage of Waste: Means temporary placement of waste in a suitable location or facility where isolation, environmental and health protection of human control are provided in order to ensure that waste in subsequently retrieved for treatment and conditioning and/or disposal.

Collection of waste: Means by which waste is removed from storage area

Transportation of waste: Means manner in which waste is conveyed to the final disposal site

Disposal of waste: Manner in which waste is treated at the final disposal site.

Treatment: Means any method technique or process for altering the biological, chemical or physical characteristics of waste to reduce the hazards it presents.

Biodegradable: Means a substance that can be degraded by Microorganisms.

Disposal/dumping site: Means any area of land on which waste disposal facilities are physically located or final discharge point without the intention of retrieval but does not mean a re-use or re-cycling plant or site.

Domestic waste: Means waste generated from residences.

Incineration: Means the controlled burning of solids, liquids, gaseous combustible waste to produce gases and residues containing little or no combustible materials

Recycling of waste: Means the processing of waste into a new product of similar chemical composition

Characterization of waste: Means any activity that separates waste materials for processing by clustering them according to type

Waste generation: Means activities that produce waste

Waste management: Refers to the activities, administrative and operational, that are used in handling packaging, treatment, conditioning, reducing, re-cycling, re-using, storage and disposal of waste.

1.11 Conceptual Framework

Since this study addressed the challenges of solid waste management in Nyalenda, Kisumu County, which is a low-income urban area, affect the management of waste, a focus on the interaction and relationship among principle elements of SWM was necessary to guide the analysis of the key variables in this study.

The waste management factors of waste generation, characteristic, storage, collection, transportation and disposal show that the variables are related to each other and are components of a system. The waste related variables as well as the connection between SWM and Environmental Management can be diagrammed as shown in Figure 1.

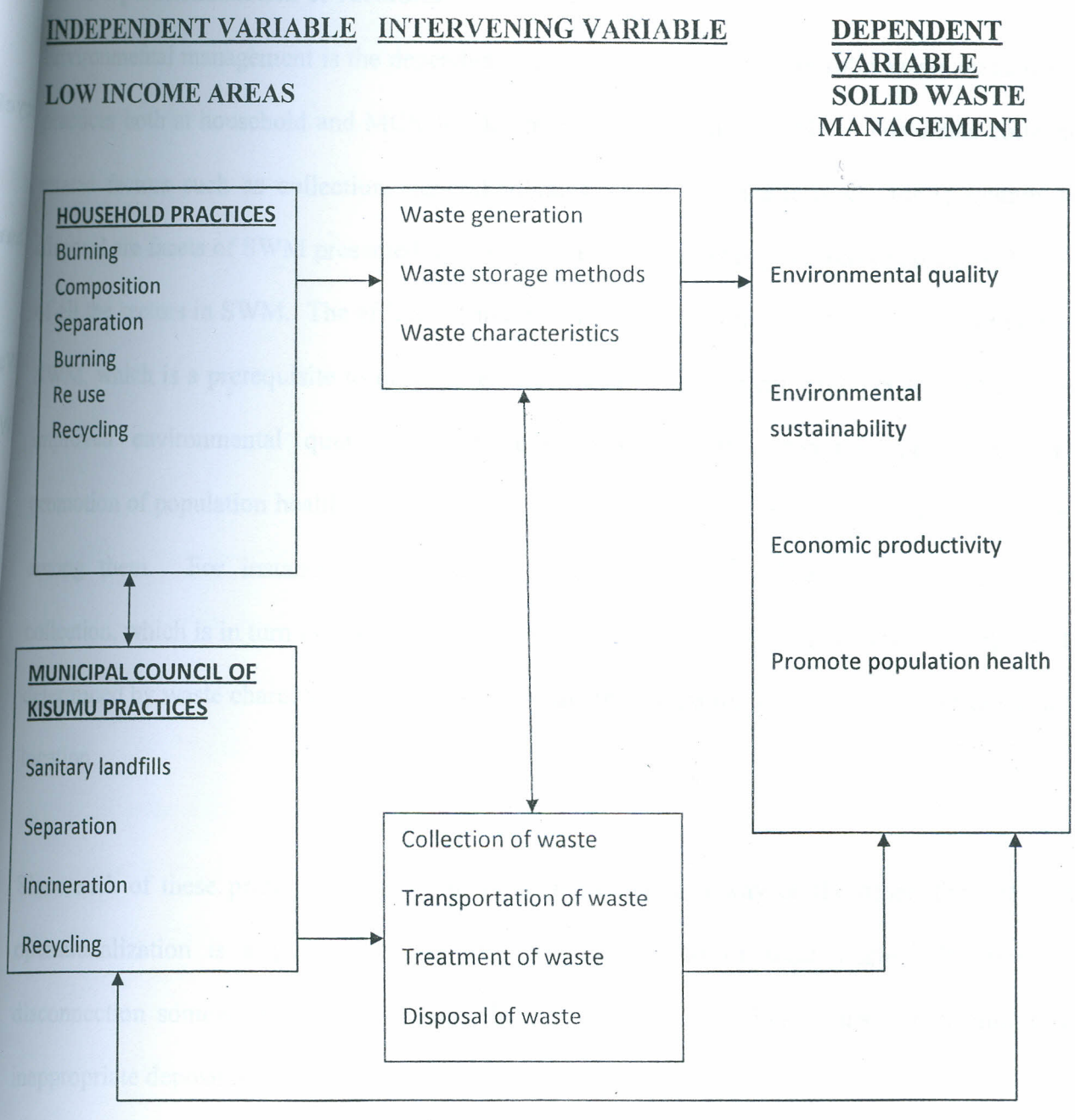

Figure 1: Shows the relationship between variables in the study

1.11.1 Operationalization of variables

Environmental management is the dependent variable in this study while solid waste management practices both at household and MCK levels are the independent variables. The waste collection related factors such as collection, generation rates, storage, characteristics, transportation and disposal are facets of SWM presented in this study as the intervening variables and show the roles of all the sectors in SWM. The efficient handling of these intervening variables precedes efficient SWM, which is a prerequisite to efficient environmental management which is reflected through improved environmental quality, environmental sustainability, economic productivity and promotion of population health. The intervening variables in this study also project a relationship among them. For instance, waste transportation determines efficient and effective waste collection, which is in turn directly determined by waste storage. On its part, waste storage is also determined by waste characteristics. Likewise, waste transportation is a function of waste disposal location.

Since each of these principle elements relate to the other in a way or the other, their effective operationalization is a prerequisite to efficient management of solid waste. If there is a disconnection somewhat along the chain, chances are that a backlog occurs, which may cause inappropriate deposit of waste.

The low-income residential factors and socio-economic status of the population on the other hand also determine the characteristics of waste generated, storage methods and waste densities as well as waste disposal methods used.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter highlights what other scholars have so far contributed in the area of SWM in relation to the influences of solid waste management practices on environmental management, solid waste characteristics and densities and their influences on environmental management, as well as the solid waste management practices of local governments and their influences on environmental management.

2.2 Solid waste management

The management of solid waste is one of the challenges facing many urban areas in the world. Where there is an aggregation of human settlements with the potential to produce a large amount of solid waste; the collection, transfer and disposal of that waste has been generally assumed by municipal authorities in the developed world. The format varies, however in most urban areas. Garbage is collected either by a government agency or private contractor, and this constitutes a basic and expected government function in the developed world (Zerbock, 2003).

The appropriate management of municipal and industrial solid waste continues to be a major problem throughout the world. Traditionally, following the Dark Ages, solid waste management was practiced through transporting the solid wastes to nearby low-value lands for disposal. Frequently then, and, in some parts of the world, today, the combustible parts of the solid wastes were set on fire at the disposal site. This practice, while now terminated in many developed countries, is still in use in some developing countries (Lee, 2000a).

Beginning in the 1950s, in the USA and a number of other countries, the open-landfill, with or without burning, method of solid waste disposal was changed to what became known as the "sanitary" landfill, where burning was stopped and a few inches of soil was placed over the waste at the close of each day. When the landfill became full, some additional soil was placed.

Over the landfill to grade the landfill surface. Sometimes these closed landfills were then used for parks, industrial/commercial development and other purposes. While the sanitary landfill, if properly operated in accord with recommended procedures, addressed to some degree some of the most significant problems associated with landfills, such as severe odours, they did not and do not address some of the most significant problems associated with land filling of municipal solid wastes and many industrial solid wastes (Lee, 2000b).

Throughout history, property owners in the USA, living, or working near municipal and industrial landfills have had a justified "NIMBY" not in my backyard approach toward the sitting of a new landfill, expanding existing landfills and the continued operation of landfills. This justified "NIMBY" stems from the fact that the landfill developers, whether public agencies or private entities, do not address at all, or do not adequately address, the many adverse impacts of solid waste landfills on those within the sphere of influence of the landfill. This sphere of influence is normally intense within a mile (several kilometers) of the landfill, and can readily extend several miles from the landfill. Lee and Jones-Lee 91994a) discussed the variety of factors that influence the ability of an operating or closed sanitary landfill to be adverse to those within the sphere of influence of the landfill. These include: public health, economic and aesthetic aspects of groundwater and surface water quality, explosions and toxicity to plants, illegal roadside dumping

and litter near landfill, truck traffic noise, dust and wind-blown litter, odours, vectors – insects, rodents, birds, condemnation of adjacent properly for future land uses, decrease in property values impaired view.

In Europe each of the 500 million people living in the EU throw away around half a tone of household rubbish every year. This is on top of huge amounts of waste generated from activities such as manufacturing (360 million tones) and construction (900 million tones), while water supply and energy production generate another 95 million tones. Altogether, the European Union produces up to 3 billion tones of waste every year. All this waste has a huge impact on the environment, causing pollution and greenhouse gas emissions that contribute to climate change, as well as signify cant losses of materials – a particular problem for the EU which is highly dependent on imported raw materials. The amount of waste generated is increasing and the nature of waste itself is changing, partly due to the dramatic rise in the use of hi-tech products. This means waste now contains an increasingly complex mix of materials, including plastics, precious metals and hazardous materials that are difficult to deal with safely. EU waste management policies aim to reduce the environmental and health impacts of waste and improve Europe's resource efficiency. The long-term goal is to turn Europe into a recycling society, avoiding waste and using unavoidable waste as a resource wherever possible. The aim is to achieve much higher levels of recycling and to minimize the extraction of additional natural resources. Proper waste management is a key element is ensuring resource efficiency and the sustainable growth of European economies (European Union, 2010).

Whether it is re-used, recycled, incinerated or put into landfill sites, the management of household and industrial waste comes at a financial and environmental cost. First, waste must be collected, sorted and transported before being treated which can prove expensive and result in greenhouse gas emissions and pollution of air, soils and water. One major challenge is the fact that a large amount of the waste generated in the EU each year – some 100 million tones – is hazardous, containing heavy metals and other toxins. These substances make the waste particularly difficult to treat as special processes are needed to deal with the hazardous components. The EU is working to reduce the hazardous materials used in products which then end up in our waste, as well as ensuring that hazardous waste is dealt with in the safest way possible. Several types of chemicals have been banned and the use of other materials has been significantly restricted. Waste treatment facilities are being improved across the EU to make sure hazardous material can be dealt with safely. There is also a risk that hazardous waste is exported developing countries where it may be dealt with in unsafe conditions. The EU is working hard to support member states in monitoring activities to stop illegal waste shipments (European Union, 2010).

Municipal solid waste management constitutes one of the most crucial health and environmental problems facing governments of African cities. This is because even though these cities are using 20-50 percent of their budget in solid waste management, only 20 – 80 percent of the waste is collected. The uncollected or illegally dumped wastes constitute a disaster for human health and the environmental quantities increasing but also the variety, both a consequence of increasing urbanization, incomes and changing consumption habits fuelled by globalization. This scenario places the already-desperate urban councils in a difficult situation especially as they have to develop new strategies to deal with increasing volumes as well as strange varieties of waste. Not

only the solid waste generation, as one would expect, varies between countries, cities, and parts of cities in Africa. Reliable data is hard to come by and cities' economic and political conditions are quite dynamic over time. Insurgence of war, economic crises or booms, political strife etc can have immediate and profound changes on waste generation and management (Achankeng, 2003).

These situations can cause abrupt stop of waste management, reduce generation or completely stop removal. For example, in Mogadishu, Somali huge heaps of garbage accumulated over the city over ten years of civil and war (Barise 2001). Barise (2000) explains that soldiers turned this problem into an opportunity to get money as they interrupted clean-up operations demanding payment for allowing refuse to be removed. These interruptions may also explain why some cities such as Kinshasa register zero collection of waste as seen in Table 1 below. Nevertheless generation rates for the continent's major cities are estimated to range from 0.3 – 1.4 kg per capita per day (See table 1). This gives an average of 0.78 compared to an average of 1.22 kg per capita for developed countries (Beukering et al. 1999:9). Extreme cases may exist in both situations. Field experiments show that the per capita per day generation for Yaounde and Douala, Cameroon are 0.8 and 0.7 respectively.

Table 1: Per capital solid waste generation and households with garbage collection in selected African cities with their population estimates in millions (2000).

Country	City Name	*Per capita SW Generation Kg/day	+Households with garbage collection (%)	Population > 0.5 million
Benin	Porto Novo	0.5	25	0.6
Burkina Faso	Ouagadougou	0.7	40	1.6
Burundi	Bujumbura	1.4	41	-
Cameroon	Douala	0.7	60	1.1
	Yaounde	0.8	44	1.0
Congo DR	Kinshasa	1.2	0	6.3
Congo Rep	Brazzaville	0.6	72	0.9
Cote d' Ivoire	Abidjan	1.0	70	3.4
Egypt	Cairo	0.5	6.5	14.5
Ghana	Accra	0.4	60	1.7
Morocco	Rabat	0.6	90	1.6
Namibia	Windhoek	0.7	93	-
Nigeria	Lagos	0.3	8	8.0
Tanzania	Dar es Salaam	1.0	25	2.3
Uganda	Kampala	0.6	20	0.8
Zimbabwe	Harare	0.7	100	1.5

Source: (UNCHS Habitat, Nairobi 1997)

*Solid waste generated per person, in kilograms per day

+Percentage of households enjoying regular waste collection

= Actually based on city levels of 1993 by UNCHS (Habitat, Nairobi 1997)

Even though many factors influence municipal solid waste management, population size is an important one. There is a positive correlation between city population size and both the percentage of waste moved and rate of households enjoying regular waste collection. This suggests that

ncreasing city size poses a greater problem to the solid waste management in Africa. In Yaounde ity, Cameroon Current figures show that the current population is estimated at 1.2 million people, p from 600 000 in the 1960s. Not only have the quantities, of the waste increased from about 300 to 1 200 tons per day but also the variety of solid waste. The city area is estimated to have also increased from 5000 hectares in 1963 to 20 000 hectares in 2000 with 1400 hectares residential being (Vermande et al. 1994).

The problem is compounded by rapid urbanization rapidly taking place in many developing countries where 30-50% of populations is urban (Thomas-Hope, 1998). Indeed the overall problem of SWM is multi-faceted: many organizations, including the United Nations (UN) and various non-governmental organizations (NGOs) advocate for an integrated approach to SWM management by identifying key stakeholders, identifying specific issues which comprise important "stumbling blocks", and making recommendations based on appropriate technologies, local information, and pressing human and environmental health concerns (UNEP, 1996, Thomas – Hope, 1998, Senkoro 2003;).

According to Dalla Torre, 1992 Different actors have experimented with a variety of technological options to find viable alternatives for appropriate collection and disposal of waste. Observations from these experiments indicate that SWM is more than just a technical issue Its scope includes socio-political and cultural dimensions that need solutions through imaginative policies, administrative reorientation, and an informed population. A view growing in popularity has been that private or public management of these systems would be the most efficient irrespective of the nature of the resource to be managed or the socio-economic conditions of people associated with

the resource (Kant and Berry, 2001). Local governments in Kenya and elsewhere often suffer a lack of financial, technical, and human resources that create some incapacity on their part to manage waste efficiently.

2.3 Influence of Solid Waste Management on Environmental Management

In the 1970s, some studies examined the impact of socio-economics factors on the generation of solid waste. The results showed that the household income had a statistically significant impact on household demand for solid waste management services. For instance, in a study undertaken in Indianapolis, Richardson and Havlicek (1978) report income-elasticity of demand for total household solid waste management services. However, both of these studies were based on very small sample sizes. More recently, studies have been undertaken involving much larger datasets. They are all based on American data, except the study by Hong (1999), which draws upon Korean data. Nonetheless, the studies confirm the earlier findings that household solid waste generation is income-inelastic. Some of these studies also give estimates of the impacts of average household size on waste generation rates. Not surprisingly, the effect is negative, indicating that there are household diseconomies of scale in waste generation. This may be due to factors such as the tendency to conserve on packaging for consumer items such as food and beverages which are purchased for larger family sizes. However, Podolsky and Spiegel (1998) showed that there is likely a limit to this economizing effect. In addition, Jenkins (1993) looks at the age composition of the household and also finds that median age decreases waste generation, while Podolsky and Spiegel (1998) find that increases in the percentage of the population between 18 and 49 increases waste generation. Kinnaman and Fullerton (1996) found no link between the number of children under the age of 3 and solid waste generation, whereas Van Houtven and Morris (1999) explained

that mixed waste increases significantly with the number of small children and adults 25 to 64 years old.

Some studies show that urban households generate less solid waste, suggesting perhaps that people take into account the rise in the cost of space (Van Houtven and Morris 1999; Podolsky and Spiegel 1998). However, rural households may have a number of alternative waste management strategies (that is, compositing, burning, illegal disposal), which are less readily available to urban households. In addition, education levels can be significant, having a positive effect on solid waste generation rates (Kinnaman and Fullerton 1997). However, a number of studies have found that the effect is not statistically significant (Hong and Adams 1999; Kinnaman and Fullerton 1996). The importance of price factors has been addressed in more recent studies as more and more unit pricing programs have been set up.

The household utility maximization proposed by Kinnaman and Fullerton (1997). Assume that each household derives utility from a single aggregate consumption good and household municipal solid waste collection services. The use of household municipal solid waste collection services can be considered dependent upon a vector of demographic characteristics such as average household size; the number of children in the household (child); the number of working age people in the household; and the proportion of the population which lives in urban areas (urban).

As noted above, household size is thought to be important because there may be household diseconomies of scale in generation of waste. For instance, there may be proportionally less packaging for larger volume items. The number of children in the household is thought to be

important since consumption expenditure patterns for households with children tend to be very different than for households with only adults, and this may result in different patterns of solid waste generation, and thus demand for household municipal solid waste collection services. Similarly, the proportion of members of a household of working age may be significant for comparable reasons. And finally, the proportion of households which live in urban areas may be important, since rural households may have greater potential opportunities associated with adopting alternative waste management strategies (that is, recycling or burning), reducing demand for municipal waste collection services. The cost for the provision of such services will depend upon factors such as the density of residential development. The extent to which this is reflected in the "price" which households actually face for the provision of household municipal waste collection services is, however, partly a function of the nature and extent of cost recovery for waste collection services. For instance, this will depend upon whether such services are financed (wholly or partly) out of unit-based fees, property taxes administered at the municipal level, or the general tax base (Johnstone and Labonne, 2004).

At the level of the built environment, the size and structure of a settlement has an important influence on the character and urgency of waste management needs. In quite low-density semi-urban settlements, for example, some form of local or even on-site solution to the management of organic solid wastes may be more appropriate than centralized collection and disposal. In urban areas, the physical characteristics of a settlement including such factors as density, width and condition of roads, topography, that is need to be considered when selecting and/or designing waste collection procedures and equipment such as containers and vehicles.

Secondly, at the level of natural systems, the interaction between waste handling procedures and public health conditions is influenced by climatic conditions and characteristics of local natural and ecological systems. The degree to which uncontrolled waste dump sites become breeding ground for insects, rodents and other disease vectors and a gathering place for dogs, wild animals and poisonous reptiles – depends largely on prevailing climatic and natural conditions. In practical terms, climate determines the frequency with which waste collection points must be serviced in order to limit negative environmental consequences (Schubeler, 1996).

Hazardous wastes have been defined as wastes that pose a potential hazard to humans or other living organisms for one or more of the following reasons: such wastes are non-degradable or persistent in nature, their effects can be magnified by organisms in the environment, they can be lethal or they may cause detrimental cumulative effects. General categories of hazardous wastes include toxic chemicals and flammable, radioactive, or biological substances. These wastes can be in the form of sludge, liquid, or gas, and solid.

Radioactive substances are hazardous because prolonged exposure to ionizing radiation often results in damage to living organisms and the substances may persist over long periods of time. No satisfactory method has yet been demonstrated for disposing permanently of radioactive wastes (Huang, 2007).

Hazardous wastes may pollute soil, air, surface water, or underground water. Pollution of soil may affect people who live on it, plants that put roots into it and animals that move it. In Times Beach, Missouri, in 1983, oil contaminated with dioxin was spread on roads to keep dust down; thus,

residents were exposed to high levels of dioxin. Sludge from municipal sewage disposal may contain toxic elements if industrial waste is mixed with domestic sewage. If the sludge is used as a fertilizer, these elements may contaminate fields. Toxic substances that do not break down or bind tightly to the soil may be taken up by growing plants; the toxic substances may later appear in animals that eat crops grown there and possibly in people who do so (Huang, 2007).

In Nigeria Folorunso and Awosika (2001) state that flooding in Lagos is related to clogging of drainage channels by dumped solid wastes. There is abundant release of gaseous toxic substances into Nigerian environment as well as jeopardizing of health of scavengers as a result of burning of obsolete e-wastes. Due to contact with smokes from burning of solid wastes and gaseous emission from dumpsites, cases of several diseases have been recorded (Oyelola et al. 2009).

The decomposition of waste into constituent chemicals is a common source of local environmental pollution. This problem is especially acute in developing nations which very few existing landfills would meet acceptable environmental standards, due to limited budgets. The problem is again compounded by the issues associated with rapid urbanization. As land becomes scarce, human settlements encroach upon landfill space, and local governments in some cases encourage new development directly on top of operating or recently closed landfills. A major environmental concern is gas release by decomposing garbage. Methane is a by-product of the anaerobic respiration of bacteria, and these bacteria thrive in landfills with high amounts of moisture. Methane concentrations can reach up to 50% of the composition of landfill gas at maximum anaerobic decomposition (Cointreau-Levine, 1996).

The eventual objective of efficient SWM should be the development of a system which does not allow waste products to come in contact with the ground before disposal so as to ensure sustainable SWM. This can be best achieved through conducting field studies, developing sampling methodology, identification of waste characteristics, development of waste categories and assessing factors affecting waste generation rates. Community participation should also be encouraged through different ways such as collection frequency (that affect amount collected), extent of salvaging and recycling, changing public attitudes by educating them and putting legislation on dumping of solid waste as it will help in the management of solid waste.

2.4 Influence of Waste Densities, Characteristics and Generation rates on Environmental Management

A global solid waste crisis is emerging, and the world's municipalities are affected the most severely. The volume of municipal solid waste (MSW) produced annually is increasing rapidly as a result of global urbanization, rapid industrialization and economic development. Global MSW production in 1997 and 0.49 billion tons, with production of MSW growing at 3.2 – 4.5% each year in developed countries, and at 2-3% per annum in developing countries. Based on these data, the problem of MSW management has earned increasing attention as a major hindrance to urbanization and economic development all over the world. By the end of 1998, China's accumulated volume of MSW totaled about 6 billion tons, occupying 50,000 hectares of land. Annual per capita production of MSW is about 440 kg (about 1.16 times China's annual per capita grain production by weight), and the recorded annual production of MSW has expanded at a 9.3% compound annual growth rate over the past decade. In 1998 alone, China produced some 0.14 billion tons of MSW, of which 0.11 billion tons was collected for disposal, implying a pickup and disposal rate of 79%. The simple landfill rate was 59%, while the sanitary landfill rate was

extremely low; sanitary landfill plants exist only in Beijing, Shenzhen, Chongquing and Guangzhou cities. China already produces 29% of the world's MSW each year, and with the economy continuing to grow rapidly, it is clear that China bears what may be the heaviest MSW management burden in the world (Suocheng et al., 2002).

Also to be noted is that beginning in the 1970s in the USA and in several other developed countries, associated with the finding that municipal sanitary landfills were causing severe groundwater pollution in the vicinity of the landfill, regulatory agencies such as in the USA have been developing approaches to minimize/control groundwater pollution by the landfilled wastes. Under the US Congress' Resource Conservation and Recovery Act (RCRA), industry and commerce were prohibited from disposal of large amounts of industrial solvents in municipal landfills. Prior to that time, 55 gallon drums of solvents and other chemicals of industrial origin were dumped in municipal landfills. RCRA established the management of what became classified as "hazardous" wastes in hazardous waste landfills, which under US regulations are called "Subtitle C" landfills. These landfills were required to be lined, initially with a clay liner, then a plastic-sheeting liner, then, when both of these were found to readily fail to prevent groundwater pollution, a composite liner of clay and plastic sheeting, then, when the single composite liner was found to fail, double composite liner. Today's RCRA (Subtitle C) landfills consist of a double composite liner of clay and plastic sheeting, with a leak-detection system between the two composite liners. Further, Subtitle C landfilled waste must be detoxified/immobilized to some extent before disposal (Lee, 2002).

Kiely (1997) proposes the relevant physical properties of waste to include density (in kilogram), percentage of moisture content and percentage of field capacity. The density dimension is significant to this study because this property is important in estimating the landfill sizing and transportation type to be decided of the waste. This information is also useful for the purposes of determining waste handling procedures and techniques. Matters of field capacity and sheer strength are also somewhat related to management of dumpsites. Chemical composition of waste is important for landfill manage in so far as it relates to sites for disposal, site protection and the safety of the waste pickers (scavengers). The main generators of waste at residential level are food wastes, demolition and construction, paper, plastic, glass, tin cans (these comprise solid waste which forms the theme of this study).

Several factors influence the solid waste generation in Nigeria. Lack of advanced technology, facility for separation at source, strength of solid waste management policy and enforcement, environmental education and awareness and income status of individuals among others, are factors affecting solid waste scenario in Nigeria. Abel (2009) showed that education, income and social status are important factors influencing per capita solid waste generation in Ogbomoso, Oyo state. Age, location, occupation and amount charged for waste collection are determinant factors for using public waste collection services in Ibadan (Ajani, 2007). The quantity and categories of solid waste generation also varies with socio-economic groups in which the high and middle groups take the lion share (Sridhar et al., 1985).

Several studies have been done to determine waste generation rates but they have met hurdles in accuracy due to discrepancy between the generation and disposal. Wastes relate to quantities disposed of or collected for offsite recycling, hence the domestic wastes that can find an on-site re-use such as composting of garden wastes, will in most cases not be quantified. If this is not overcome, securing comparable data may be difficult.

Domestic waste from industrialize countries has a high content of packaging made of paper, plastic, glass and metal, and so the waste has a low density. In many developing countries wastes contain large amounts of particles such as sand, ash, dust, and stones and high moisture levels because of high usage of fresh fruit vegetables. These factors make the waste very dense (high weight per unit volume). The consequences of this high density are that vehicles and systems that operate well with low-density wastes in industrialized countries are not suitable or reliable when the wastes are heavy. The combination of extra weight, the abrasiveness of the sand and the corrosiveness caused by the water content, can use very rapid deterioration of equipment. If the waste contains a high proportion of moisture, or is mostly inert material, it is not suitable for incineration, and so is the treatment upon is ruled out. Recycling or salvaging operations often reduce the proportion of combustible paper and plastic in waste before it reaches the treatment stage.

2.5 Efficacy of Solid Waste Management practices and their influence on Environmental Management

There are many factors that vary from place to place and that must be considered in the design of a solid waste management system (Zurbrugg, 2000). These include waste amounts and composition, access to waste for collection, awareness and attitudes.

The strain experienced by MCK has apparently been compounded by fact that SWM is perceived by residents to be within the responsibilities of MCK causing a laxity among these residents regarding waste. Since domestic waste constitute the bulk of solid waste, their poor collection implies that the waste is left at the doorsteps of the households that release or expel them but are unable to meet the costs of private collection, thereby aggravating incidences of disease or accidents.

As is common now in al Kenyan towns – with no exception – the problem of SWM has gained an even much dangerous phase. Plastics, mainly low-density polythene carrier bags, and other non biodegradable waste are strewn in many areas of the town (especially in the peri-urban settlements), and are causing great concern both to the public health and environment. The most intractable problem relating to plastics and the environment is their disposal. In Kisumu, plastics are disposed off in the open dumpsite or burned. These plastics get blown around easily and are sometimes ingested by livestock and lately have been blamed for causing some deaths. Others find their way into drains, causing blockages. The 'plastic menace' as it is now known, has become a symbol of what is wrong with the entire solid waste management strategy in the country (ILO, 2001).

The decomposition of waste into constituent chemicals is a common source of local environmental pollution. This problem is especially acute in developing nations; very few existing landfills in the world's poorest countries would meet environmental standards accepted in industrialized nations, and with limited budgets there are likely to be few sites rigorously evaluated prior to use in the future. The problem is again compounded by the issues associated with rapid urbanization. As land becomes scarce, human settlements encroach upon landfill space, and local governments in some cases encourage new development directly on top of operating or recently closed landfills.

A major environmental concern is gas release by decomposing garbage. Methane is a by-product of the anaerobic respiration of bacteria, and these bacteria thrive in landfills with high amounts of moisture. Methane concentrations can reach up to 50% of the composition of landfill gas at maximum anaerobic decomposition (Cointreau-Levine, 1996). In well designed and well sited landfills there is the potential for methane recover; few landfills in the developing world are designed to capture and make use of methane; in all of Latin America and the Caribbean, only three such landfills were in operation, all in Chile (UNEP 1996). Generally the required capital for methane recovery installations is lacking and the low price of commercially produced gas does not make methane recovery an economically viable enterprise. In the absence of proper methane venting and/or flaring, the gas seeps into porous soil surrounding the waste and eventually migrates into basements and homes, posing an explosion risk. Carbon dioxide is a second predominant gas emitted by landfills; although less reactive, buildup in nearby homes cold be a cause of asphyxiation.

A second problem with these gasses is their contribution to the so called greenhouse gasses (GHGs) which are blamed for global warming. Both gases are major constituents of the world's problem GHGs; however while carbon dioxide is readily absorbed for use in photosynthesis; methane is less easily broken down, and is considered 20 times more potent as a GHG (Johannessen 1999). Hoornweg, et al., (1999) state that for every metric ton of unsorted municipal solid waste (containing 0.3 Mt carbon), 0.2 Mt are converted to landfill gasses. Of this gas, carbon dioxide and methane each comprise .09Mt. Since it is believed that landfill gasses supply 50% of human –caused methane emissions and 2-4% of all worldwide green house gasses (Johannessen 1999), this is clearly an area of concern in global environmental issues. Liquid leachate management varies throughout the landfills of the developing world. Leachate poses a threat to local surface and ground water systems, and is carefully managed in developed nations. The use of dense clay deposits at the bottom of waste pits, coupled with plastic sheeting-type liners to prevent infiltration into the surrounding soil, is generally regarded as the optimum strategy to contain excess liquid. In this way, waste is encouraged to evaporate rather than infiltrate. The need for such measures depends largely on climatic conditions, as arid areas with high rates of evapotranspiration will not have nearly the potential for leachate problems as areas with high rainfall on snowmelt. Current practices in the developing world range from absolutely no leachate management (unofficial dumps or those operating continuously for years without 'sanitary' specifications) to discharge into municipal sewer and sewage systems, direct discharge into surface water systems (rivers), multi-pond aeration and settlement systems, chemical treatment facilities, and recirculation systems (Johannessen 1999).

International agencies (such as UNCHS and UNEP, 1987; UNHCS, 1988) identify five principle elements of any SWM plan as waste characterization, storage, collection, transportation and disposal. However, while the efficiency and effectiveness of a collection system is determined by the equipment used for waste transportation, there seems to be a relationship between the storage of waste and methods of collection. Other relationships also obtain between these elements, as is already shown in the conceptual framework section.

Many sources of waste might only be reached by roads or alleys, which might be inaccessible to certain methods of transport because of their width, slope, congestion or surface. This is especially critical in unplanned settlements such as slums or low-income areas and thus largely affects the selection equipment (Gombya 1994).

Public awareness and attitudes to waste can affect the whole solid waste management system. All steps in solid waste management services, the opposition to the sitting of waste treatment and disposal facilities, all depends on public awareness and participation. Thus this is also a crucial issue, which determines the success of failure of a solid waste management system (Gombya 1994).

Also to be noted is the fact that operational inefficiencies occur due to inefficient institutional structures, inefficient organizational procedures, or deficient management capacity of the institutions involved as well as the use of inappropriate technologies. With regard to the technical system, often the "conventional" collection approach, as developed and used in the industrialized countries, is applied in developing countries. The used vehicles are sophisticated, expensive and

difficult to operate and maintain, thereby often inadequate for the conditions in developing countries. After a short time of operation usually only a small part of the vehicle fleet remains in operation. Transport also relies on operational vehicles, and frequent breakdowns coupled with parts shortages can immobilize collection vehicles for extended periods of time. For example, UNEP 91996) estimated that in cities in West Africa, up to 70% of collection/transfer vehicles may be out of action at any one time.

2.6 Conclusion

The literature reviewed confirms that solid waste management influences the management of the environment and that socio-economic status plays a role in waste generation. It is important to note that most of the previous studies conducted on SWM were done in western countries and urban areas where the characteristics of waste and management practices are considerably different and more sophisticated. This study focused on the management of solid waste in Nyalenda, Kisumu County, where the influence of improper deposit of waste is most detrimental to management of the environment. The study outlines how some studies conducted in the 1970s examined the impact of socio-economics factors on the generation of solid waste and how results showed that household income had a statistically significant impact on household demand for solid waste management services. For instance, in a study undertaken in Indianapolis, Richardson and Havlicek (1978) report income elasticity of demand for total household solid waste management services.

The literature reviewed also states that generation rates for the Africa's major cities are estimated to range from 0.3 – 1.4 kg per capita per day. This gives an average of 0.78 compared to an average of 1.22 kg per capita for developed countries (Beukering et al., 1999:9). It also states that

the volume of municipal solid waste (MSW) produced annually is increasing rapidly as a result of global urbanization, rapid industrialization and economic development. Global MSW production in 1997 was 0.49 billion tons, with production of MSW growing at 3.2 – 4.5% each year in developed countries, and at 2 – 3% per annum in developing countries (Suocheng et al, 2002).

Also to be noted is the fact that operational inefficiencies occur in local authorities due to inefficient institutional structures, inefficient organizational procedures, or deficient management capacity of the institutions involved as well as the use of inappropriate technologies. With regard to the technical system, often the "conventional" collection approach, as developed and used in the industrialized countries, is applied in developing countries. The used vehicles are sophisticated, expensive and difficult to operate and maintain, thereby often inadequate for the conditions in developing countries. After a short time of operation usually only a small part of the vehicle fleet remains in operation transport also relies on operational vehicles, and frequent breakdowns coupled with parts shortages can immobilize collection vehicles and frequent breakdowns coupled with parts shortages can immobilize collection vehicles for extended periods of time. For example, UNEP (1996) estimated that in cities in West Africa, up to 70% of collection/transfer vehicles may be out of action at any one time (Gombya, 1994).

Solid waste management has been largely dominated by studies focusing on the factor of waste management such as storage, collection, transportation, treatment and disposal, while research on the influences that exist between solid waste management and environmental management with a focus on low-income residential area factors in respect to domestic waste has been seriously overlooked and that is what this research attempted to bridge.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter deals with how the researcher acquired the data with which the research questions here were addressed. The section captures the research design, local area of study, the target population, population sample, sampling procedure, research instruments, data collection procedure, data analysis techniques and ethical considerations.

3.2 Research Design

This study focused on the household level and quantitative survey, physical observation, and physical measurements to collect the data. A survey design involves asking a large group of respondents' questions about a particular issue (Mugenda, 1999).

By definition, measurement must be objective, quantitative and statistically valid. A scientifically calculated sample of people from a population are asked a set of questions on the survey to determine the frequency and percentage of their responses. For purposes of the study, 384 people (one per household), were used. Because the sample size is statistically valid, the findings were projected to the entire population from which the sample was selected.

The sample size for the survey was calculated using Fisher's formula to determine how large a sample size would be needed from the given population in order to achieve findings with an acceptable degree of accuracy. Generally, the researcher sought sample sizes which would yield findings with a least a 95% confidence level (which means that if the survey is repeated 100 times,

95 times out of a hundred, you would get the same response) and a plus/minus 5 percentage points margin of error.

3.3 Target Population

This study focused on low-income residential areas of Kisumu Municipality. The study specifically focused on Nyalenda Estate, owing to its rapid population growth and also because planning with respect to SWM there appeared to have been ignored. There are approximately 13,956 households in Nyalenda (CBS, 1999). The households in Nyalenda constitute the population of the study.

3.4 Sample Size and Sample Population

The sample consisted of 384 households. Simple random sampling was used to select households for the survey from a population of 13,956 households. The researcher selected the first household randomly followed by every 10^{th} household until 384 households were selected.

3.4.1 Sample Size

The sample consisted of 384 households. The formula below developed by Fisher et al as cited in Mugenda (2008) was used to determine the sample size.

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

Where:

n = the desired sample size (If the population is greater than 10,000)

z = the standard normal deviate at the required confidence level

p = the proportion in the target population estimated to have characteristics measured

$q = 1 - p$

d = the level of statistical significance test

Given p = 0.5 to give max sample

$q = 1 - p = 0.5$

z statistic = 1.96 at 95% confidence level

d = tolerable error = 5%

$\frac{1.962 \times 0.5 \times 0.5}{0.52} = 384$ for population of over 10 000

Physical measurements of waste characteristics collected over a period of 7 days was also be done in line with the World Health Organization (WHO) guidelines. The data generated was analyzed and tested using SPSS and other appropriate statistical applications.

3.4.2 Sampling Procedures

The sample frame consisted of 384 households selected through simple random sampling so as to achieve a desired representation from the population. Every 10^{th} household was selected from the population until the desired number of 384 households was reached so as to ensure equal inclusion in the sample.

3.5 Research Instruments

Data for the study was collected using, questionnaires, and physical observation. Questionnaires were used in this study because some of the variables at the centre of the study did not lend themselves to direct observation or even physical measurement. For instance, one cannot directly

observe people's attitudes or opinions. Also, the questionnaires were favored for their clarity and convenience purposes.

As is typical with questionnaires, some questions were open-ended while others were closed. But for purposes of easy coding and analysis, most of the questions were closed. However, since both kinds of questions bear advantages and disadvantages, a combination of both were applied. Issues regarding the variables of low-income urban residential area factors as well as waste management details of the householders mentioned above were presented in question form or formulated as situations for observation or measurement.

The questionnaire was divided into sections that addressed all three aspects of the study; namely the Household details, the Financial (Economic details), and the Waste details. The household and economic details were required for purposes of identifying the socio-economic statuses of the respondents, and the waste details were used to identify the waste management practices of both the households and the MCK.

To address the objectives of this study, secondary sources of data were used to form a basis for explaining the relationship between SWM and environmental management as well as MCK solid waste management practices.

3.5.1 Piloting of the Instruments

A pilot test is a small scale preliminary study conducted before the main research, in order to check the feasibility or to improve the design of the research. They are frequently carried out before large-scale quantitative research, in an attempt to avoid time and money being wasted on an

inadequately designed project. A pilot study is usually carried out on members of the relevant population, but not on those who will form part of the final sample. This is because it may influence the later behaviour of research subjects if they have already been involved in the research.

The pilot test was conducted by the researcher in Manyatta Estate of Kisumu Municipality. A total of 38 questionnaires were administered to 38 households using simple random sampling. The 38 households selected represent 10% of the sample size. The researcher then identified the shortcomings in the questionnaires and made the necessary corrections before proceeding for data collection at Nyalenda Estate, Kisumu County in Kenya.

3.5.2 Validity of the Instrument

Validity is defined as the accuracy, and meaningfulness of inferences, which are based on the research results. In other words, validity is the degree to which results obtained form the analysis of data actually represent the phenomenon under study. Validity therefore has to do with how accurately the data obtained in the study represents the variables of the study (Mugenda and Mugenda, 1999).

In this study, a pilot test was conducted in low-income residential areas in Kisumu Municipality as an important step in making the instrument valid for the purposes of the study. During the pilot testing, vague questions and unclear instructions were revealed. Important suggestions and comments were captured from the respondents that enabled the researcher to improve efficiency of the instrument and adjust strategies and approaches to maximize the response rate. The range of

responses was analyzed in order to come up with a generalized position which could stand the validity test.

3.5.3 Reliability of the Instrument

Reliability is a measure of the degree to which a research instrument yields consistent results or data after repeated trials. Reliability in research is influenced by random error. As random error increases, reliability decreases. Random error is the deviation from a true measurement due to factors that have not effectively been addressed by the researcher (Mugenda and Mugenda, 1999).

Reliability was measured using test retest methods which involved selecting 38 respondents from 38 households in Nyalenda estate. The research instrument was administered twice to the same group fo participants after a period of two week. The following procedure was used; selection of the participants, administration of the interview schedule, keeping all the initial conditions constant and administration for a second time of the schedule after one week and finally analysis of the three sets of results. If the results generated turn out to be similar then it can be inferred that the instrument is reliable for data application.

Internal consistency was assessed by using Cronbach's coefficient alpha which is a general form of the Kunder-Richardson (K – R) 20 formula. The formula is as follows:

$$K - R_{20} = \frac{(K)\,(S^2 - \sum_s^2)}{(S^2)\,(K - 1)}$$

Where: KR_{20} = Reliability coefficient of internal consistency

K = Number of items used to measure the concept

S^2 = Variance of all scores

S^2 = Variance of individual items

A high coefficient will imply that items correlate highly among themselves (Mugenda, 2008)

3.6 Data Collection Procedure

A questionnaire was prepared by the researcher. A research permit was obtained from the Ministry of Education which gave the researcher authority to conduct the study. The researcher then conducted a pilot study in Manyatta Estate of Kisumu Municipality to make the instrument clearer for actual data collection in Nyalenda Estate. After the pilot test, the preliminary results were analyzed, and the researcher got a rough idea of what the data collected from the field would look like. Data was then collected from a sample of 384 households in Nyalenda Estate using questionnaires which were administered to the householders by the researcher, with clear instructions on what was expected of the householders. Due to the large number of respondents required, the researcher used 4 research assistants to administer and also to collect the questionnaires after completion by the householders.

3.7 Data analysis techniques

The data was analyzed using qualitative and quantitative approaches such as arithmetic means and standard deviations using statistical package for social sciences (SPSS). The study utilized quantitative surveys to identify the socio-economic issues of the respondents. A total of 384 households were issued with questionnaires depending on their willingness to participate. A questionnaire was administered to obtain socio-economic data. Questionnaires were used in this

study because some of the variable (such as attitudes and opinions) at the center of the study do not lend themselves to direct observation or even physical measurement. Some questions were open-ended while others were close ended. But for purposes of easy coding and analysis, most of the questions were closed ended.

Descriptive and quantitative techniques were used in data processing analysis and presentation. Descriptive techniques involving arithmetic mean, and standard deviation, were used to outline various intangible and non-quantifiable issues, while quantitative data was processed and analyzed using SPSS. The socio-economic characteristics of education, housing tenure, quality, number of household residents were analyzed based on the waste characteristics and relationship established by coding.

Before analysis, a codebook was constructed in which the values were entered to describe each and every variable to be used in the data analysis and a data clerk and engaged to enter the data into the data base to be ready for analysis. In this study, the descriptive statistics for all the variables were examined to make sure they fell within the acceptable range. Since each respondent or situation (in case of observation) yields one choice for every item, it was possible that each question yield a column, while each line, a response. Where a single response brought together a range of choices, the same procedure was applied such that every range chosen as assigned a numerical value. The data was then fed into the data editor (using the SPSS software) to run summaries and generate trends.

3.8 Ethical Considerations

The subjects in this study were not required to use their names or provide any form of identification. The full consent of all the respondents was sought before the questionnaires were administered. All the subjects were assured to total confidentiality and the information they gave was used only for research purposes. This study did not create a risk to the participants or cause any form of anxiety among the participants. There were no direct benefits to the subjects, but the results were expected to be of value to them.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS, INTERPRETATION AND DISCUSSIONS

4.1 Introduction

The household solid waste management practices in Kisumu Municipality, the waste characteristics and waste generation rates, the SWM practices of the Municipality Council of Kisumu, and characterization of waste are discussed and analyzed in this chapter. Also discussed are the findings on the relationship between poverty indicators of household monthly income, tenancy types, educational levels and the Solid Waste Management patterns of storage and disposal including the residents' willingness to contribute to safe waste disposal. The influence of SWM on Environmental Management will also be discussed here.

4.2 Questionnaire return rate

For the purpose of this study, 384 households were sampled by administering 384 questionnaires. A total of 254 questionnaires were returned and this gave a response rate of 66.15% Mugenda and Mugenda (2003) note that a response rate of 50% is adequate for analysis and reporting; a response rate of 60% is good and that of 70% and above is very good. Therefore a response rate of 66.15% was sufficient for the study to continue.

4.3 Assessment of Household solid waste management practices

The study sought to assess the household waste management practices in Nyalenda, Kisumu County in Kenya and the influences of these practices on environmental management. In so doing, the study assessed the socio-economic characteristics of the residents in terms of material used for building the house, type of roofing material, type of tenancy, financial and employment details of

the residents. This section also profiled the residents according to their gender and age groups. The waste management practices of the residents were also studied.

4.3.1 Housing qualities

The study sought to assess the low-income residential area factors such as housing qualities based on the materials used for constructing the houses mainly because housing quality reflects on the wellbeing of a community which is directly proportional to the amounts of waste that the particular community will generate on one hand and on the other hand, tenancy types are related to the willingness of the householders to have long term management system (especially storage) in place. The houses were categorized as permanent for those constructed using bricks, stones and cement; semi permanent for those using clay before plastering; iron sheets for those constructed using iron sheets; and mud houses for those constructed using clay. The various types of floors were also studied since the nature of the floor in use will affect waste quantities and compositions (Cointreau, 1982). Floors which are not cemented normally contain some clay and sand sweeping which influence waste density.

Table 2: depicts the household characteristics based on the kind of material used to construct the houses

Table 2: **Households distribution by material used to construct house**

Material of house construction	Frequency (f)	Percentage (%)
Blocks	7	2.76
Bricks	29	11.42
Cement	108	42.52
Mud	84	33.07
Timber and clay	26	10.24
Total	**254**	**100.00**

The houses in Nyalenda are planned. However general characteristics include fairly heavily built up plots haphazardly arranged with more than one household on every plot. Table 2 shows that a majority of the respondents had no separate kitchens because they live in one room and two room houses 14.96% and 32.28% respectively. The housing quality varied with 14.18% residing in permanent houses, 42.52% in semi-permanent houses, 33.07% in mud houses and 10.24% in houses made of timber and clay.

Similarly, the presence of a separate kitchen was also determined. This was deemed necessary because the presence of a kitchen would guide in determining the various options of temporary waste storage. Those with separate kitchens normally prefer keeping storage containers in the house while those without a kitchen keep the containers outside the house. The study therefore sought to investigate the household distribution by the number of rooms in the households. This

would help in determining whether or not the households had a separate kitchen. Table 3 shows the household distribution by number of rooms per household.

Table 3: Household distribution by size of house

Size of house (Number of rooms)	Tenancy f (%)	Owner occupier f (%)	Total f (%)
1 room	36 (14.17)	2 (0.79)	38 (14.96)
2 rooms	73 (28.74)	9 (3.54)	82 (32.28)
3 rooms	46(18.11)	8 (3.15)	54 (21.26)
4 rooms	13 (5.12)	19 (7.48)	32 (12.60)
5 rooms	7 (2.76)	22 (8.66)	29 (11.42)
6 rooms	2 (0.79)	13 (5.12)	15 (5.91)
7 rooms	0 (0.00)	3 (1.18)	3 (1.18)
10 rooms	0 (0.00)	1 (0.39)	1 (0.39)
Total	**177 (69.69)**	**77 (30.31)**	**254 (100.00)**

f- Frequency % - Percentage

Table 3 shows that from the data collected it was established that out of majority of the respondents in Nyalenda, 14.96% resided in single room dwellings, 32.28% in two room dwellings and 21.26% in three room dwellings. These dwellings were considered to be of higher density.

4.3.2. Household Demographics

The study categorized the house holders into age groups and their gender. They were categorized into male and female of various age groups. A total of 384 households were sampled as shown in table 4.

Table 4: Households occupants' distribution by gender and age

Ages	Male	Female	Total
	f (%)	f (%)	f (%)
0-5 years	139 (13.63)	174 (17.06)	313 (30.69)
5-12 years	112 (10.98)	148 (14.51)	260 (25.49)
13-20 years	99 (9.71)	137 (13.43)	236 (23.14)
Above 21 years	87 (8.53)	124 (12.16)	211 (20.69)
Total	**437 (42.84)**	**583 (57.16)**	**1020 (100.00)**

f - Frequency % - Percentage

The findings as depicted in table 4 show that the general household composition was 42.84% male and 57.16% female. It was also established that the majority of the house holders were children 0-5 years old 30.69%, while children of the age group 5-12 years made up 25.49% of the population. Teenagers in the group 13-20 years made up 23.14% of the households while the percentage of adults over 21 years of age was 20.69%.

The proportion of the children of the age 5-12 years is an important factor to consider when planning the community containers for waste disposal. Normally, children of this age group are

given errands/tasks of emptying the household waste into the communal containers, meaning the planning aspect should take into consideration their heights and the physical sizes of the household storage facilities which they will be required to empty. Similarly females from the ages 13 upwards normally perform domestic chores, so it goes without saying that they are the ones to dispose of waste as well. It is therefore important community waste containers be placed at locations accessible to the women and children who dispose of house hold waste.

4.3.3 Education levels

The study sought to categorize the respondents according to their education levels. From data collected it was noted that the majority of the respondent had primary school education followed by people with secondary school education. The lowest percentage on the scale was 5.11% for people with University education.

This establishes the fact that solid waste management practices are a function of education level, and that there is a close relationship between education level and waste management practices of the house holders. It can be inferred that education level has a direct influence on household SWM practices and awareness of environmental impacts.

4.3.4 Householder distribution by type of employment

To establish the kinds of employment the respondents were engaged in, the respondents were asked whether they were in formal, informal or any other form of employment. This was necessary so as to determine the employment type in relation to income levels of the house holders. Table 5 shows the frequency of responses.

Table 5: **Households occupants' distribution by type of employment**

People per household	Type of employment			Total households
	Formal	Informal	Others (e.g boda)	
	f (%)	f (%)	f (%)	f (%)
One	15 (5.91)	68 (26.77)	29 (11.42)	112 (44.09)
Two	25 (9.84)	46 (18.11)	17 (6.69)	88 (34.65)
Three	17 (6.69)	24 (9.45)	0 (0.00)	41 (16.14)
Four	0 (0.00)	13 (5.12)	0 (0.00)	13 (5.12)
Total	**57 (22.44)**	**151 (59.45)**	**46 (18.11)**	**254 (100.00)**

f - Frequency % - Percentage

As shown in table 5, the study established that the majority (59.45%) of the respondents were in informal employment followed by, 22.44% in formal employment. 18.11% of the respondents were in other various undefined forms of employment. This finding explains the types of tenancy at Nyalenda and also explains why a majority of the respondents earn between Kshs.5000 – 10,000 per month. It also confirms the fact that the majority of the residents do not have tertiary education.

4.3.5 Employment and in-come levels

The study sought to establish the income levels of the householders since this would help a determining if there is a close relationship between income level and household waste management

practices. The monthly incomes were grouped into levels of Kshs. 0 – 5000, Kshs. 5000 – 10,000, Kshs. 10,000 – 15,000, above Kshs.15,000 as shown in table 6

Table 6: Monthly income of households

Monthly Income	Frequency (f)	Percentage (%)
Below Kshs.5,000	51	20.08
Kshs.5000 – 10,000	135	53.15
Kshs.10,000 – 15,000	34	13.39
Over Kshs.15,000	25	9.84
Confidential	8	3.15
Total	**254**	**100.00**

The findings as shown in table 6 showed that a majority of the respondents in Nyalenda estate estimated at 20.08% were earning below Kshs.5000 per month; 53.15% were earning Kshs.5000 – 10,000 per month; 13.39% were earning Kshs.10,000 – 15,000 while those earning over Kshs.15,000 were 9.84%. Some of the respondents (3.15%) declined to respond to the question about their income status.

4.3.6 Household Expenditure on SWM

The study ranked householders expenditure priority in relation to SWM. The expenditures compared were food, rent, medication, water and school fees. Table 7 presents the household priorities in expenditure.

Table 7: **Households' order of priorities in expenditure**

First priority = 6, second priority = 5, third priority = 4, fourth priority = 3, fifth priority = 2 and sixth priority = 1

Area of expenditure	Households' order of priorities in expenditure n = 254						
	First Priority	Second Priority	Third Priority	Fourth Priority	Fifth Priority	Sixth Priority	MEAN
	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	
Food	175(68.90)	52(20.47)	23(9.06)	4 (1.57)	0(0.00)	0(0.00)	5.5669
Rent	44(17.32)	146(57.48)	37(14.57)	22(8.6)	5(1.97)	0(0.00)	4.7953
School fees	26(10.24)	31(12.20)	139(54.72)	45(17.72)	13(5/12)	0(0.00)	4.0472
Waste Disposal	0(0.00)	0 (0.00)	2 (0.79)	8(3.15)	27(10.63)	217(85.43)	1.1929
Water	2(0.79)	6(2.36)	11 (4.33)	19(7.48)	92(75.59)	24(9.45)	2.1693
Medication	7(2.76)	19 (7.48)	42 (16.54)	156(61.42)	17(6.69)	13(5.12)	3.2283

Note: the MEANS show the area of expenditure of priorities

The findings showed the expenditure on SWM services was not ranked as a major priority. This is explained by the fact that 85.43% of the respondents ranked SWM at the bottom of their expenditure list. The highest priority ranking on SWM was only fourth.

The priority ranking list was expressed in the following order; food > rent > fees > medication > water > waste as depicted in Table 8.

4.3.7 Waste Storage Practices

For purposes of evaluation, the study listed the storage methods in categories such as; No storage for those who did not store their waste but disposal them off directly after generation; in a pile on the floor, for those who kept their waste in a pile somewhere on the floor for later disposal; In a plastic bucket or similar container; In a plastic bag for those who were using plastic or polythene bags; and other for those who used other methods not included in the study. Table 8 presents the frequencies of various responses on the household waste storage practices.

Table 8: Households' main places for garbage storage

Where do you mainly store your garbage?	Frequency (f)	Percentage (%)
In a heap on the floor	57	19.39
An iron bucket	18	6.12
A plastic bucket	48	16.33
A plastic bag	92	31.29
Others – throw them out	39	13.27
Total	**254**	**100.00**

It was established that 16.33% of the respondents use a plastic bucket. The most common options were 31.29% plastic bags, and 13.27% throw it out. It was established that few respondents (19.39%) stored their waste on the floor. 6.12% of the respondents used galvanized buckets. This registers the fact that there is a need to store waste properly, but after the house holders take it out, it remains uncollected majorly because the responsibility lies with MCK which overwhelmed by the waste generation rates.

4.3.8 Removal of waste from the household

In order to identify the person who removes waste from the house, the respondents were given a total of three choices namely, householder, house help and other children to choose from as depicted in table 9.

Table 9: Removal of waste from households for disposal

Person removing garbage	Frequency (f)	Percentage (%)
Householder	161	63.39
House help	55	21.65
Others – children	38	14.96
Total	**254**	**100.00**

The findings of the study as depicted in table 9 shows that 63.39% of the waste is removed from the house by the householder while 21.65% of the waste is removed by the house help. While 14.96% of the waste is taken out by children. It can be inferred that without supervision, the children and/or the househelp may not throw the waste properly in the communal bin and this may explain the growing mounds of rubbish in undesignated areas such as Nyalenda, Kisumu County.

4.3.9 Waste Disposal Methods

The study could not establish the exact amount of waste reaching the dumpsite despite the fact that the amounts generated was established. The study however came up with findings on how the households disposed of their waste. The respondents were asked to choose from the following disposal options; bins, open pits, burning, private collection, open disposal where waste is disposed

of haphazardly, compost pits, road sides and any other. Table 10 presents the frequencies of responses.

Table 10: Waste Disposal Methods

Methods of disposal of wastes	Frequency (f)	Percentage (%)
Bins	47	18.50
Open pits	106	41.73
Burning	144	56.69
Private collection	68	26.77
Open disposal	80	31.50
Road side	51	20.08
Others	8	3.15
Total responses	**504**	**100.00**

Note: Respondents gave multiple responses to this item

From the findings, it was established that most of the generated wastes never reached the dump site and were disposed off in various ways around the settlements. The most common disposal mode was use of open pits such as a drainage system or dug pits in the homesteads (41.73%) and open disposal 31.50%. These facts can justify why these settlements are littered with garbage in most open spaces. 20.08% of the respondents disposed of their waste on the road side. 56.69% of the respondents opt for burning their refuse. Use of bins (18.50%) was limited. The order of choice for waste disposal can be expressed as burning > open disposal > open pits > burning > roadside.

4.3.10 Willingness to participate in safe waste disposal practices

The findings of the residents' willingness to participate in an improved waste management system established that all the respondents were willing to contribute in various ways as seen in table 12.

Table 11: Type of contribution on safe disposal of the solid waste in your neighborhood n = 389

Type of contribution	Frequency (f)	Percentage (%)
• Bringing in my own garbage to the communal container or whatever the community identifies as the communal container	114	29.31
• Bringing in my own neighbors garbage to the communal container or whatever the community identifies as community container	89	22.88
• Separate recyclable and compostable waste	34	8.74
• Cleaning the rubbish around the site where the containers are emptied	64	16.45
• Paying the amount agreed upon by the community for solid waste collection	89	22.88
Total responses	**389**	**100.00**

Note: A number respondents gave multiple responses to this item

Among those wishing to participate, 22.88% were willing to pay the amounts agreed upon by the community. 29.31% were willing to bring their garbage to what the community identifies as their communal container, 22.88% were willing to bring their own and their neighbors garbage to what the community identifies as their communal container, 16.45% were willing to clean the litter around what the community identifies as their communal waste container. The percentage of respondents who were willing to pay for SWM services was considerably low (22.88%). This can be explained by the fact that most of their in-come is targeted towards purchasing food items and school fees as in presented in section 4.3.7. Those willing to participate in separation of recyclable and organic waste constituted 8.74% of the respondents.

4.4 Waste characteristics, densities and generation rates

The second objective of this study was to identify the various waste characteristics, the waste densities and generation rates, and their influences on environmental management. To achieve this, the frequency of generation at the house hold level was determined. The density was also estimated.

4.4.1 Solid waste characteristics

The study estimated the waste density in Nyalenda at 225 kg. This figure travels well within the limits of waste densities in Kenya estimated by JICA (Nairobi city council, 1998) and Carl Bro Consultants (2001). They are also comparable to the estimates for low-income countries which are estimated as being in the range of 250 – 500 kg (Cointreau, 1982).

4.4.2 Waste Composition

The study established the composition and quantities of the generated amounts. Most of the waste stream was organic. Other waste compositions were as follows; plastics, paper, metal, glass, wood, and cloth.

It was necessary to determine the willingness of the respondents to participate in separation of waste at the household level while also confirming the components of waste generated as presented in table 12.

Table 12: Waste Compositions

Type of material sorted from waste	YES		NO	
	(f)	(%)	(f)	(%)
Glass	80	31.50	174	68.50
Paper	114	44.88	140	55.12
Plastic	157	61.81	97	38.19
Batteries	34	13.39	220	86.61
Metal	47	18.50	106	41.73
Textiles	97	38.19	157	61.81
Wood	207	81.50	47	18.50

f- frequency % - Percentage

minimal amounts of cloth, metals and glass were found in the waste stream. The minimal cloths found were mainly as a result of home based tailoring and scavenging activities. The findings are relevant when compared to the guidelines of low-income countries.

It is evident that if waste reduction, recycling and reuse strategies were introduced, then the need for collection would only be in the range above 81.50% assuming that most organic waste at the domestic level will find alternative uses such as composing and feeding animals. This would result in huge savings in real collection and waste management costs. The challenge would then be to find sustainable uses for the waste stream (Table 12).

The study also established that 61.81% of the respondents willingly separate plastic from the waste stream. This establishes the fact that plastic is viewed as being unfriendly to the environment and that plastic can also be recycled and used for income generation. Items such as wood and glass which can be reused registered high percentages at 81.50% and 31.50% respectively.

4.4.3 Household waste generation rates

In order to determine the waste generation rates, it was necessary for the study to determine the amounts to waste generated per household per day. The breakdown of household waste stream components is shown in table 13:

Table 13: Average household generation rate (Kg/day)

Waste category	Amount (Kg)
Plastic	0.302
Paper	0.051
Organic waste	1.246
Metals	0
Glass	0

Cloth	0.100
Total	**1.699**

The study established that the daily waste generation rate per household is 1.699 kg as shown in table 13. Based on household population findings, (4 Persons per household), the per capita generation rates were calculated as 0.423 kg. These generation rates are comparable to the findings of similar studies which have been performed in Nairobi which was 0.4 kg per day (Nairobi City Council, 1998).

4.4.4 Frequency of house hold waste disposal

Table 14 details the frequency of generation of waste at the household level. It was necessary to determine the frequency of disposal because this directly affects the rate at which the rubbish mounds outside the households grow.

Table 14: Frequency of disposal of waste from the house

Frequency of disposal of waste	**Frequency (f)**	**Percentage (%)**
Once a Day	79	31.10
Every 2 days	43	16.93
Every 3 days	15	5.91
Every 4 days	52	20.47
Others – week, don't collect	65	25.59
Total	**254**	**100.00**

The frequency of disposal of waste by the householders was also studied and it emerged that 31.10% of them dispose off their waste once a day, while 25.59% of the respondents threw their waste outside their houses as soon as it was generated since they had no storage container. This can be said to be the main reason why open and roadside disposal is common in Nyalenda. Also to be noted is the fact that household waste is generated faster than it can be collected by MCK and this contributes to the growing mounds of rubbish.

4.5 Efficacy of solid waste management practices of Municipal Council of Kisumu

The study sought to assess the MCK waste management practice and to determine their efficacy. Through informal interviews with MCK officials, it was established that at the municipality level, SWM falls under the subsection of town cleaning and refuse collection which is coordinated under the environmental planning section. This sub-section has only 4 vehicles on 7 ton Renault Compactor, donated by the World Bank and three 4 ton high sided trucks. They also have a total of 34 staff, 7 office based and 28 field based. The latter are composed of 1 supervisor, 3 headmen, 3 drivers and 21 cleaners. The budgets and expenditures including the operations of this subsection are centrally managed by the town clerk and the treasurer who together manage all the departments.

It was noted that each collection vehicle was expected to serve over 100,000 people while the staff population ratio was approximately 1: 13,500, yet the monthly income in the form of salaries for the staff in the Department of Environmental Planning consumed approximately 89% of the total budget.

According to the MCK budget, the annual cost spent on SWM for each person residing in Kisumu was Kshs.5.33 which at the exchange rate at the time of the study was 1 US$ = Kshs.90

The MCK was yet to work out modalities of how waste management collection charges would be levied implying that this service was being offered free of charge. Hazardous, industrial and sometimes health care wastes were dumped on the dumpsites and were not treated in a special manner.

4.5.1 Waste Collection

Table 15 show the fate of household waste once it has been thrown out of the household. It was necessary to determine what happens to the waste because it would also help in establishing the Solid Waste Management practices of the Municipal Council of Kisumu.

Table 15: Fate of dumped refuse

Fate of dumped refuse	Frequency (f)	Percentage (%)
Stays there	87	34.25
Removed by municipality	42	16.54
Burnt	123	48.43
Searched by scavengers or waste pickers	47	18.50
Total responses	**299**	**100.00**

The study established that there existed no official collection system in Nyalenda by the Municipal Council of Kisumu within the study area. Through informal discussions with the residents, it came

light that the private collectors were a community self help group who were using mainly manual transportation with the help of hand carts and a private company which hires a pick up vehicle every collection day (usually once a week). The reason for low collection can be attributed to inadequate funding within the Department of Environment, and secondly inadequate interest from private entrepreneurs.

Approximately 34.25% of the respondents stated that the waste stays there when they throw it out while most of the resident 48.43% opt to burn it personally when the quantities become too high 16.54% stated that the MCK removes the waste.

This low percentage confirms the fact that MCK rarely collects waste at Nyalenda Estate and that the waste remains lying on the open ground where it stays until the residents dispose of it through burning. Table 15 shows the fate of waste once it is thrown out of the houses; it also shows how the waste is treated when it is uncollected.

4.5.2 Frequency of communal bin transfer

Table 16 presents the frequency of collection of the communal bins by MCK

Table 16: Opinion of respondents on the frequency of communal bin transfer

Opinion	Frequency (f)	Percentage (%)
Too infrequent	64	25.20
Satisfactory	42	16.54
Too frequent	13	5.12
Others – such as they never reach us	135	53.15

Total	254	100.00

The majority of the respondents (53.15%) expressed dissatisfaction with the frequency of communal bin transfer by the MCK. Most of them stated that they had never been reached by the MCK waste collectors, or that they had never seen them. 16.54% of the respondents expressed satisfaction while it is interesting to note that 5.12% thought that the frequency of communal bin transfer was too frequent. This may be as a result of their proximity to the tarmac Ring Road Nyalenda or their proximity to the community waste collection organizations that operate in Nyalenda and collect waste that is accessible by road, but ignore the ones deposited in the interiors of Nyalenda estate where there is poor infrastructure such as road networks. 25.20% of the respondents felt that the communal bin transfer was too infrequent. This fact is confirmed by the growing mounds of rubbish littering the road side trenches and upon sewers.

4.5.3 House Holder Opinions on disposal practices

The residents opinion on their current disposal practices was expressed to them such that they were expected to give their opinion on environmental and health effects of haphazard disposal of solid waste with the following problem options; pollution of their living ara and playground for their children, personal health, littering of neighborhoods, no opinion for those who did not want to comment, and nothing wrong for those who thought it was normal and healthy to continue with the current practices. Table 17 presents the house holder responses on the problem related to solid waste disposal.

Table 17: Responses on the problem related to solid waste disposal n = 406

Problem related to solid waste disposal	Frequency (f)	Percentage (%)

Personal health	152	37.44
Pollution of living area and playgrounds for children	97	23.89
Littering of solid waste in the neighborhood	131	32.27
Nothing is wrong	17	4.19
No opinion	8	1.97
Total responses	**406**	**100.00**

Note: Some respondents gave multiple responses to this item

The findings show that a majority of the respondents knew that their disposal practices exposed them and their families to pollution and health risks. This argument can be strengthened by the fact that only 4.19% of the respondents thought that they did not see anything wrong. On the other hand, 23,89% of the respondents selected their main problem as pollution of their living area and playground for their children. Other problems selected were 37.44% for personal health and 32.27% for littering. 1.97% of the respondents had no opinion on the matter. Personal health registers the highest percentage. This establishes the fact that the haphazardly disposed of waste are a vehicle for verminous populations which breed disease such as malaria, typhoid skin disease as well as other communicable diseases.

Also to be noted is the fact that pollution of the living area and playground for children 28.89% and littering of solid waste in the neighborhood 32.27% together carry a total percentage of 56.16%. This finding establishes the fact that haphazard disposal of waste has a negative influence on the environment.

4.5.4 Sensitization on Waste Management

Willingness of the respondents to acquire knowledge about SWM was tested by requiring the respondents to make a choice from the following options about their preferred mode of learning; open seminars, brochures distributed to residents, pilot waste minimization projects, waste reduction campaigns, exhibitions presenting good practices in waste minimization, and education programs at school. Table 18 presents the house holder response frequencies on their most favored methods of increase holder response frequencies on their most favored methods of increase holder response frequencies on their most favored methods of increasing knowledge on solid waste management practices.

Table 18: Favored method of increasing knowledge on waste management and environmental impact of waste

Methods of increasing your knowledge on waste Management and environmental impact of waste	Frequency (f)	Percentage (%)
Open seminars	97	20.82
Brochures distributed to residents	157	33.69
Pilot waste minimization projects	34	7.30
Waste reduction campaigns	59	12.66
Exhibitions presenting good practices in waste minimization	68	14.59
Education programs at school	51	10.94
Total responses	**466**	**100.00**

Note: Some respondents gave multiple responses to this item

A total of 33.69% of the respondents preferred the distribution of brochures, followed by 20.82% who preferred open seminars. 12.66% of the respondents were willing to attend waste reduction campaigns, while 14.49% wanted exhibitions where they could get demonstrations on effective

waste management, 10.94% preferred that Waste Management be taught in education programmes in schools.

The findings revealed that all the respondents of Nyalenda Estate view solid waste as a major problem, and all of them were willing to learn about solid waste management practices so as to conserve their environment. 71.65% were interested in learning about the environmental impact of waste while 28.35% were unwilling to learn.

4.6 Future waste characteristics, densities and generation rates

Through the development process and technological advancement, living standards are expected to go higher. This means people will buy more products and as a result produce more rubbish because they will have many more single – use and disposable products. On an average as seen in section 4.4.2, the households generate approximately 1.699 kg of waste per day which translates to 0.423 kg of waste per capita. This will make management of waste even more difficult, and will also lead to serious environmental degradation if the local authority practices remain the same.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter will discuss the conclusions and recommendations based on the findings of this study. Areas of further research relevant to this study are also discussed in the chapter.

5.2 Summary of the findings

At the level of household solid waste management practices, the study found that a majority of the respondents lived in one or two bedroom houses, which leads to the conclusion that they do not have separate kitchens. This influences where they store their rubbish. Th constitutions of the households were 42.84% male and 57.16% female of which 25.29% were children between ages 5 – 12 years and the people over the age of 13 years constituted 43.83%. The proportion or children and adults ages 5 onwards represent the people responsible for disposal of waste. The study also found that a majority of the respondents did not prioritize SWM in their expenditure. Solid waste management was ranked last in their monthly expenditure. At the household level, most of the respondents had a container in which they store waste generated in the residence before they threw it out. The study revealed that 56.69% of the waste was burnt by the residents, 41.73% was disposed of in open pits and 31.50% disposed of in the open. The study revealed that 100% of the respondents were willing to participate in safe waste disposal practices in one way or the other.

The study found that the density of waste generated in Nyalenda in 225kg while the households generate waste approximately 1.699 kg per day per household which translates to 0.423kg per

capita. It was found that 31.10% of the householders throw out their waste once a day while 25.59% throw it out once it is generated.

The study also found that the Municipal Council of Kisumu rarely collects waste from Nyalenda Estate. The percentage of respondents stating that their waste remains where they threw it were 34.25% while 53.15% claim they have never seen MCK coming to collect waste from the disposal sites. The findings show that 37.44% of the respondents felt that the MCK practice of not collecting waste was a threat to their health, 23.89% felt it polluted their living area and playground of their children and 32.27% felt that the uncollected waste littered the neighborhoods. All the residents agreed that there was need for sensitization on safe solid waste management practice.

5.3 Conclusions

The study showed that the household sampling technique is reliable in estimating waste quantities at the generation sources. The results of the field study were able to provide enough information to successfully demonstrate the potential use of the method and me recommendations to strengthen waste management practices. However, care must be taken in interpreting the results as they might be affected by other factors such as dumping, burning householder participation rates among others. Simple Random sampling is a reliable method since it not only presents the different components of the household waste and waste management practices, but also the socio-economic characteristics of the respondents. It was evident that most households never stored their waste at the household level due to various reasons such as lack of space, or lack of storage equipment. It can also be concluded that the tenancy type of a household influences the willingness of the respondents to contribute to safe waste disposal. Most residents either threw their waste directly

after generation in pits dug within the compound or in any other convenient place. Most of the residents were willing to contribute to a safer SWM system irrespective of their income or education levels. Expenditure on SWM was not a top priority in all the households. It can also be concluded that there is a strong correlation between monthly income and willingness to contribute to safe waste disposal. Residents with owner occupier status tended to practice waste disposal methods which were more long term oriented as compared to rental tenant who practiced all methods of disposal. This is mainly because the residents with owner occupier status tend to stay for a longer period at the same residence. It can also be concluded that the level of a household's monthly income will influence how they dispose their waste. With an effective collection method currently in practice, waste storage, collection and disposal is a major challenge for the householders.

A detailed characterization is a mandatory step first to the development of sound strategies for a SWM system. This study has assisted in developing figures in the generation and composition of SW. it can be used as a baseline for further characterization studies especially within Kisumu municipality and other urban areas in the developing world. It must however be noted that this study excluded the analysis of other sources of MSW such as Industrial wastes. The study showed that most of the waste remains uncollected after generation, and when collected, most of it remains lying on the open ground unless it is burnt with the initiative of the householders. The waste that is left lying on the ground is an eye sore and a health hazard. The waste also polluted the environment by contamination of ground water, spread of disease and emission of bad odours. It may be concluded that; as was expected, the respondents are willing to engage in reducing, recycling and reusing their waste. It may also be concluded that per capita waste generation rates

were lying between 0.22 and 0.43 kg/capita/day. The study found that waste was generated in the households at the rate of 1.699 kg per day, but it was seldom collected. This added to the ever growing mounds of rubbish.

Given its importance, planning for an effective waste collection system in desirable, which implies investment in waste collection. MCK was found to be understaffed and lacking in adequate resources for adequate SWM. It is however important for MCK to have a more integrated approach to SWM involving the local communities and sensitizing them on safe SWM practices.

5.4 Recommendations

Some of the main factors which the study recommends to enhance SWM within Kisumu City and other similar urban set ups are:- The urban waste stream being mainly organic, more efforts should be directed towards initiatives that support recycling initiatives, specifically compositing. Kenya as a country relies mainly on farming as a source of income. Compositing can produce fertilizers for agricultural activities and in so doing increase the crop quality and yields.

The study area that is Nyalenda, Kisumu County is lacking adequate space for communal collection points. There is therefore need for dialogue between the authorities (MCK), community members and other stakeholders regarding availability of land and appropriate sites should only be used after appropriate impact assessments and feasibility studies have been carried out. All the respondents were willing to participate in the management of their waste. It is therefore important for MCK to integrate its local communities in the waste management exercises.

The study confirmed the fact that the respondents are very willing to contribute to safe SWM within their residential areas despite the fact that they had financial constraints, therefore the waste collection schemes should consider collaboration and contribution based on affordability. This can be achieved if the community is sensitized on the need for safe SWM. The study therefore recommends Solid Waste Management awareness campaigns which can be conducted through open exhibitions, door to door campaigns and promotions on the media so as to promote effective solid waste management and to educate the people about the environmental impacts of haphazard waste disposal practices so as to promote environmental quality.

Finally, the study also recommends that the communal waste containers be built in such a way that they can be reached by children who are sent out to dispose of waste since the waste may end up on the ground if the children are unable to reach the heights at whicy they are built.

5.5 Contributions to the body of knowledge

This research made the following contributions to the existing body of knowledge about solid waste management.

OBJECTIVE	CONTRIBUTION TO THE BODY OF KNOWLEDGE
Influence of household SWM practices on Environmental Management	It emerged that there is a strong correlation between income level and Solid Waste Management practices. The poor tend to overlook SWM, therefore, the lower the income and education level, the more likely the subject will engage in improper SWM
Characteristics and densities of Solid Waste and their influences on Environmental Management	It emerged that the residents are willing to engage in separation of waste at household level. Some of the waste items are recyclable and reusable and can therefore be used as a source of extra income generation by the residents and in so doing reducing the amounts of waste lying at the dump sites
Solid Waste Management practices of Municipal Council of Kisumu and their influence on Environmental Management	It emerged that the Municipal Council of Kisumu does not collect waste from the interior parts of Nyalenda. It appears that some of the waste is only collected from parts of this region with some road access. It is also evident that some of the waste is left scattered about the bin, the reason being that the children sent to throw away the waste fail to dispose of it properly owing to high mounds of the deposits already made by adults.

	It also emerged that the respondents are willing to be sensitized about Solid Waste Management, thus a need for the Municipal Council of Kisumu to develop community initiatives to educate Nyalenda residents through processes like open exhibitions, the media, Solid Waste Management campaigns, and also in schools as a subject to be taught in the same way as hygiene or home science subjects
Establishment of future solid waste characteristics and densities and their influence on environment management	Through technological advancement, living standards are expected to go higher. The waste which is generated at the rate of 1.699 kg per household per day will reach unmanageable levels unless the Municipal Council of Kisumu changes its approach to waste management and adapts a more integrated approach involving its local communities.

5.6 Suggestions for further research

The author recommends further research in the following areas:-

1. Technical sittings and designs of communal collection points, containers and transfer stations. Different residential areas have different characteristics within them and will not necessarily adapt to the same equipment and conditions. The technical specifications should look at the various designs taking into consideration the quantities and characteristics of waste to be collected, accessibility by secondary collection vehicles,

loading height of the containers for easy emptying by children and disabled people, time and motion surveys of the vehicles in relation to the local situation. The technical designs should be relevant and compliant with the Acts and regulations of National Environmental Management Authority (NEMA) on such waste management.

2. Demographic trends and identification of the major reasons for inadequate SWM such as appraisal, charges and revenue collection etc.
3. Effectiveness of waste management campaigns and training in the management of waste and its impact on the environment.
4. The roles of Community Based Solid waste management projects in income generation in low-income neighborhoods and methods and ways of income generation of income for the residents through separation and recycling of waste products.

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