# FACTORS INFLUENCING MANAGEMENT OF LIQUID WASTE IN KENYAN URBAN CENTRES: THE CASE OF MACHAKOS TOWN, KENYA

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## DECLARATION

This research project report is my original work and has not been presented for an academic award in any other university.

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L50/70171/2013

This research project report has been submitted for examination with my approval as the University Supervisor.

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## DEDICATION

This research project report is dedicated to my parents, Agnes Syokau and Daniel Mutuku, who have always encouraged me to pursue to higher education despite having never gone beyond primary education level.

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## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| AAEE | Australian Association for Environmental Education |
| AICD | African Infrastructure Country Diagnostics |
| AS | Activated Sludge |
| EMCA | Environmental Management and Coordination Act |
| IPCC | Intergovernmental Panel on Climate Change |
| O&M | Operations and Maintenance |
| SIM | Singapore Institute of Management |
| SPSS | Statistical Package for the Social Sciences |
| UCT | University of Cape Town |
| UN | United Nations |
| UNDESA | United Nations Department of Economic and Social Affairs |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environmental Programme |
| UNFPA | United Nations Population Fund |
| WHO | World Health Organisation |

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**ABSTRACT**

The purpose of the study was to investigate the factors that influence liquid waste management in urban areas in Kenya, the case of Machakos Town. It was guided by four objectives; to establish the extent to which funding of sewerage projects influences management of liquid waste in Machakos town; to establish the extent to which adoption of modern technology influences management of liquid waste in Machakos Town; to investigate how level of training of personnel influences management of liquid waste in Machakos Town, Machakos County; and to establish how physical town developmental planning influences management of liquid waste. Descriptive survey design was employed under which questionnaire method was used in data collection from the staff of Machakos Water and Sewerage Company were the main target population. The data was manually edited, coded and analysed using mainly descriptive statistics and inferential statistics that was done with the help of Excel and SPSS. Pearson's Correlation Coefficient analysis was used to establish the association and relationship between the independent and dependent variables. The research results were presented in percentages and tables. The major findings of this study was that there is significant relationship between financing of liquid waste management projects, use of appropriate technology, training of personnel and physical urban planning, and quality liquid waste management. The study therefore recommends that proper urban development maps be drawn before any development projects are initiated to ensure there is proper liquid waste management plan in place.

# CHAPTER ONE

# INTRODUCTION

## 1.1Background to the study

Environmental conservation and management is key to sustainable development throughout the world. Sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their needs by maintaining the carrying capacity of the supporting systems (EMCA, 1997). Liquid waste is any water that has been adversely affected in quality by anthropogenic influence. Liquid waste generally come from, and not limited to: human waste (black water) from lavatories, cesspit leakage, septic tank discharge, sewage treatment plant discharge, industrial site drainage.

Liquid waste is a global concern and has a direct effect on the biological diversity of aquatic eco systems, disrupting the fundamental integrity of life support systems, on which a wide range of sectors from urban development to food production and industry depend. As indicated previously nearly all human activities result in the production of liquid waste. With the increasing population and economic activities, the amount of liquid waste keeps on increasing. An approximate estimate of global liquid waste production is about 1,500km3 per day (United Nations World Water Development report, 2003). Up to 90% of untreated liquid waste flows come from densely populated urban areas resulting in high pollution of the receiving water bodies (Sick Water Report, UNEP& UN- Habitat, 2010).

Urban areas are both consumers and producers of large amounts of liquid waste. Most of the rapid expansion in urbanization is taking place in small and medium sized cities

(UNFPA, 2007). It is estimated that currently more than one billion people currently live in urban slums without even the basic services (UN-HABITAT, 2009). Because these informal settlements lack land tenure, providing water and sanitation services through investment in large infrastructure is extremely difficult.

In Africa, urban sanitation services serve very few people than those served by piped water. A little more than half of the households with piped water also have flush toilets, which are often connected to septic tanks rather than to sewers. In most African countries, sewerage serves less than even 10% of the urban areas (AICD, 2011). Pit latrines are the most common facility for most urban dwellers. It is also important to note that very few cities in Africa have functioning liquid waste treatment plants (World Bank, 2012). According to an assessment report carried out in 2009 by the United Nations Environment Programme, there are 43 sewerage systems in Kenya. As at the end of this assessment only 15 towns had liquid waste treatment plants and the operation of these plants is estimated at around 16% of the design capacity due to inadequate operation and maintenance and low connection rate to sewers.

Liquid waste in urban areas is usually channelled to a sewer and treated at a treatment plant. It is then discharged into receiving water which is mostly rivers, streams, lakes or oceans through effluent sewer leading to pollution of these water bodies. Pollution in this context, means any direct or indirect alteration of the physical thermal, chemical or biological properties of the water resource so as to make it less fit for any beneficial purpose for which it is or may reasonably be expected to be used; or harmful or potentially harmful to the welfare, health or safety of human beings; any

aquatic or non-aquatic life or property; or the environment (Kenya Water Act, 2002). Most municipal sewerage plants and partially treated or untreated industrial effluents in the country discharge liquid waste directly into surface water courses. The long-term objective of the Government is to ensure that all residents in the country have access to clean and potable water, and that water is available for key economic activities such as agriculture, industry, power generation and tourism. This is only possible if the available water resources are protected from pollution. Lack of effective pollution control compromises the quality of water, posing potential health hazards, increasing treatment and maintenance costs, and affecting inland, estuarine and coastal aquatic ecosystems. Water pollution exacerbates water scarcity because it limits the use by, or imposes a higher cost for treatment on downstream users (Kenya National Water Development Report, 2006).

Most water sources in urban centres in Kenya are polluted by solid waste and silt, huge volumes of detergents used by the dam side communities that discharge waste directly into the dam; the dam also contains all sorts of wastes both industrial and domestic, including aborted foetuses that have sunk to the bottom; municipal as well as domestic effluents, animal dung and animal remains like blood and bones from the slaughterhouses. The effect of pollution on water resources include; Health hazards which include water related diseases leading to increased mortality and morbidity, poverty increase, cost increase in water treatment and supply, eutrophication caused by detergents, fertilizers and sewage and habitat modification from soil erosion.

In most towns of Kenya there is poor management of solid and liquid wastes. In fact the most visible solid waste is the plastic bags that litter most of the landscapes in

these towns. Unsightly waste mounds in town estates and in various parts of the central business districts are common features. The Nairobi City Council is only able to collect about 10% of the more than 474,500 metric tons of solid waste generated in Nairobi per year. The rest is disposed by private means, natural decomposition, and individual arrangement such as burning.

The issues in Environmental Sanitation are lack of municipal coverage for garbage disposal, disposal of liquid wastes, drainage, sanitation facilities and disposal of solid wastes. 56% of the residents in the informal settlements have no access to adequate sanitation facilities. Whatever toilets are provided is inadequate and unsanitary. Toilets are the open pit type, which are often filled up and overflow during the rainy season. The 'flying' toilets, which are wrapped in paper and thrown in drains and streams, are often the method of faecal disposal in households. Open pit latrines are the common toilets as there is no piped sewerage system in the informal settlements. Drainage and sewerage system is combined in open canals that lead to pools of stagnating water logged by garbage denying the children clean and safe place to play. These open earth canals drain into the surrounding rivers within the urban centres.

Due to the heavy congestion of dwellings, landlords often do not provide ample space for bathrooms as this is sometimes viewed as a waste of space. The unavailability of bathrooms also forces the people to bath outside, or inside their dwelling or not take a bath at all. Often the rivers become the dumping grounds for garbage and other wastes. Proper garbage disposal is needed as most settlements are littered with garbage contaminated with human waste that poses great health hazard to dwellers in these communities. Children often lack a sanitary environment to play and are

exposed to disease and chemical poisoning when they play in garbage dumps, and contaminated streams and ponds. Sewage is a subset of liquid waste that is contaminated with faeces or urine but is often used to mean any waste water. It includes domestic, municipal or industrial liquid waste products disposed of via a pipe or sewer. In some urban areas, sewage is carried separately in sanitary sewers and run-off from streets is carried in storm drains. Access to either of these is through man holes. During high precipitation periods a sanitary sewer overflow may occur, causing untreated sewage to flow back into environment, thus posing a serious public health threat.

In Machakos county access to sewerage facilities is less than 10%. This is so in Machakos town and Athi River town. Machakos town is partially connected on sewer system and parts of Kariobangi and Mjini are not. There is a sewage treatment pond at Kariobangi which emits foul smell and pollutes the surrounding residential areas and offices (Machakos DEAP 2009-2013)

**1.2 Statement of the problem**

Liquid waste management is a challenge in many urban areas in the world. The impact of liquid waste is felt mostly during the rain seasons when sanitary sewers overflow thus posing a serious public health threat. Sanitation has been neglected throughout the developing world as a means of disease prevention. Governments in developing countries are very keen and devoted to do as much as possible on the improvement of water supplies both for urban and rural communities but not for liquid waste management. Access to safe water is a human right (UNDP, 2006). However, the right to pollute and discharge contaminated water back into the

environment, polluting the water of downstream users is not. The population of the Machakos town is increasing rapidly and so does the production of liquid waste and the number of people vulnerable to the effects of liquid waste pollution.

Provision of infrastructure and utilities in Machakos Town is poor. The household level of access to water supply and liquid waste disposal is low. Inadequate liquid waste and solid waste disposal services has resulted in wide spread pollution of the environment (Ministry of Nairobi Metropolitan Development (2008), Nairobi Metro2030, Nairobi). The sewerage systems of Machakos Town are not efficient. Most of the residential areas do not have channels for liquid waste and where they are available they are most a time blocked at some points leading to frequent spillage of sewage on the roads. Man-holes are not closed and they pose a great risk to the public. The sewage is channelled to the surrounding rivers and it is usually not treated (Machakos Water Company). Liquid waste management is a challenge due to lack of capacity in Machakos Town in terms of skill as well as equipment. Not many houses have piped water and access to clean water is not guaranteed. The development of good sewerage systems by the County Government of Machakos since its inauguration in April 2013 is an effort to reckon with but the challenges are still being experienced. This study was therefore to establish factors influencing liquid waste management in Machakos Town, Machakos County, Kenya.

### 1.3 The purpose of the study

The purpose of the study was to investigate and establish the challenges facing liquid waste management in Machakos Town, Machakos County, Kenya.

## 1.4 Objectives of the study

1) To establish the extent to which funding of sewerage projects influences management of liquid waste.
2) To establish the extent to which adoption of modern technology influences management of liquid waste in Machakos Town.
3) To investigate how level of training of personnel influences management of liquid waste in Machakos Town, Machakos County.
4) To establish how physical urban developmental planning influences management of liquid waste.

## 1.5 Research questions

1) To what extent does funding of sewerage projects influence management of liquid waste in Machakos Town, Machakos County?
2) To what extent does adoption of modern technology influence management of liquid waste in Machakos Town, Machakos County?
3) To what extent does the level of training of personnel influence management of liquid waste in Machakos Town, Machakos County?
4) To what extent does the urban developmental planning influence management of liquid waste in Machakos Town, Machakos County?

## 1.6 Significance of the Study

The study was to establish important knowledge about the challenges facing liquid waste management in Machakos Town. This knowledge is important in management of liquid waste projects. The information can be of much help to the government in formulation of policies and strategies in liquid waste management. The knowledge

found can be of help to the officers of water sewerage services. It can also be used in promoting sustainable plans of liquid waste management projects in the county.

### 1.7 Limitations of the study

The study encountered challenges in terms of geographical coverage since it was carried out within Machakos town only. Sometimes the respondents were uncooperative since they were visited in their work stations. A budgetary limitation was also a challenge to the study. To overcome these challenges, the researcher tried as much as possible to use assistance from local officers as well as referring to reports done at the Ministry of water, irrigation and sanitation. To ensure the research is timely done, the researcher used research assistants especially in administering the questionnaires and compiling the data collected.

### 1.8 Delimitations of the study

The study covered factors influencing management of liquid waste in Machakos town. Liquid waste in this context included sanitary sewerage as well as storm water and industrial effluents.

### 1.9 Assumptions of the study

The research study assumed that the respondents would be willing to cooperate in giving responses to the research questions. It was also assumed that duly completed questionnaires would be returned in time, respondents give honest responses, officials and project officers would be willing to give the required information from their specific areas. The study also assumed that the variables under investigation remained constant.

### 1.10 Definitions of significant terms.

**Funding** is the act of providing financial resources usually in the form of money, or other values such as effort or time to finance a project by an organisation or government.

**Technology** is a general term used to describe any kind of waste treatment and disposal. It can refer to specific infrastructure, methods or services that are designed to contain, transform or transport liquid waste.

**Training** in this project report means transferring of information and knowledge to potential staff of water and sewerage companies.

**Personnel** is the people working for the local water and Sewerage Company.

**Urban development plan** is a guide to be used by developers in making building planning and construction easier and more efficient for both the municipality and private developers in liquid waste management.

**Liquid waste** is any water that has been adversely affected in quality by anthropogenic influence.

**Management** is the function that coordinates the efforts of people to accomplish goals and objectives concerning liquid waste management.

**Sewage** is liquid waste that is contaminated with faeces and urine. It includes domestic, municipal, or industrial liquid waste products disposed of, usually via a pipe or sewer (sanitary or combined), sometimes in a cesspool emptier.

**Storm water drain** is a drain system designed to drain excess rain and ground water from paved streets, parking lots, sidewalks and roofs.

**Project** refers to liquid waste management project especially one dealing with sewerage systems or storm drains.

**Sanitary sewer** is underground carriage system specifically for transporting sewage from houses and commercial buildings through pipes to treatment or disposal sites.

**Sewerage** is the physical infrastructure, including pipes, screens, pumps, and channels used to convey sewage from its origin to the point of eventual treatment and disposal.

### 1.11 Organisation of the study

This research project work is organised in five chapters. Chapter one focuses on the background of the study, statement of the problem, purpose of the study, the objectives of the study, the research questions, and significance of the study, delimitation of the study, limitation of the study, assumptions of the study and the definition of significant terms. Chapter two contains the literature review and the conceptual framework. Chapter three comprises of the research methodology: research design, target population, sampling procedure, methods of data collection, validity and reliability operational definition of variables and methods of data analysis. Chapter four contains data analysis, presentation and interpretation, and discussion of the findings. Chapter five consists of summary of the findings, conclusion, recommendations and suggestions for further research. The research project report ends with references and the appendices.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Introduction

The literature review section of the study includes the account of what scholars have written about this subject matter. The review compressively looks at what scholars have written about liquid waste management in urban areas. The review lays the ground for this research study and guides the direction of gathering the research data.

## 2.2 Liquid waste management in urban areas

Global populations are growing rapidly, particularly so in urban areas where the rate of urbanisation far outstrips planning and waste water infrastructure development**.** Existing liquid waste infrastructure of most cities is decaying or no longer appropriate and in slum areas there is no planning and few facilities. Management of liquid waste in urban context must be adapted according, not only to the size, but also to the economic development and governance capacity of the urban area. Urban areas use large amounts of water and at the same time produce large a lot of liquid waste. Providing good quality sanitation services in urban areas involves significant planning and infrastructure. Over the next 25 years the annual growth rate in urban areas is predicted to be twice as high as that projected for the total population (1.8 per cent versus almost one per cent). As soon as 2030, 4.9 billion people will be living in urban areas (UNDESA, 2006).

Most of the rapid expansion in urbanization is taking place not in megacities, but in small and medium sized cities (UNFPA, 2007). This growth is often unplanned and attracting government and private investment to infrastructure development in areas

that lack the economic clout of the megacities. These urban areas have large areas of impervious surfaces which increases surface run-off and reduce ground water discharge. This leaves the sewerage channels with extremely large volumes of water to carry, especially during wet weather (Nyenje et al, 2010). Big cities with little sanitation infrastructure can easily be swamped by human waste. In Jakarta, the capital city of Indonesia with population of nine million people, less than 3 per cent of the 1.3 million cubic metres of sewage generated each day reaches a treatment plant. In Jakarta there are more than one million septic tanks in the city, but these are poorly maintained and have contaminated the ground water with faecal coliform bacteria. When tanks are emptied their contents are often illegally dumped untreated into waterways (Marshall, 2005).

Attracting funds to develop and maintain liquid waste infrastructure requires a coherent governance structure and financial and technical feasibility. Investments for modern water and sewer systems have been estimated to be $30 billion per year and by 2025 it may cost $ 75 billion per year, excluding costs for operation and maintenance (Esrey et al, 2001). Both the cost of building and maintaining these systems and the reliance on a regular supply of water means this may not be an appropriate economical or environmental solution particularly for smaller or secondary urban centres in developing countries. Instead urban planners are investigating decentralised systems where the liquid waste is treated close to where it is generated. This may be an appropriate option for urban areas prone to natural hazards. These systems can be designed to use no water or very little water and can be managed by households or communities. An example is the closed loop “ecological”

toilet that separates urine and faeces so that they can be easily treated and then used safely in agriculture.

The increase in population and urbanisation increases the demand for food. Urban liquid waste is, therefore, vital for agriculture in many areas. However while many urban centres in developing countries have household sewer connections, these often discharge in combination with storm water, into open drains that flow untreated into local water ways. Local governments do not have the resources to build collection and treatment facilities so that untreated liquid waste is used in peri-urban agriculture. Most cities in developing countries have an aging, inadequate or even non-existent sewage infrastructure, unable to keep up with rising population. Effective treatment also requires a transportation infrastructure to deal with the growing masses and frequently unorganised settlement patterns. As cities continue to expand their size, footprint and slum areas, it is essential that liquid waste management is brought into urban management and planning.

Liquid waste treatment results in the emission of greenhouse gases, particularly carbon dioxide, methane and nitrous oxide. It is worth noting that methane has an impact 21 times greater than the same mass of carbon dioxide. Nitrous oxide is 310 times more potent (AAEE, 2008). Although a relatively small contribution to global emissions, liquid waste and its management is a growing impact. Methane emissions from liquid waste are expected to increase almost 50 per cent by 2020, while estimates of global nitrous oxide emissions suggest an increase of 25 per cent by 2020 (IPCC, 2007). There is a pressing need to investigate and implement alternatives to

current liquid waste treatment, which minimize the production of greenhouse gases and power consumption.

### 2.3 Funding of liquid waste Projects

In 2013, the county governments were formed and various services devolved. This formalised local government responsibility for the delivery of urban sanitation services did not lead to any significant improvements on the ground. A critical constraint was that responsibility was devolved without clarifying what exactly county governments should do, how they would be held accountable and how services should be funded. Public expenditure on sanitation and sewerage development has been minimal. County governments are expected to finance sanitation improvements primarily from their resources, most of which come from central government, with a small amount raised locally. This means that expenditure has to be projected annually, with little provision for long term planning.

The architecture of the water supply and sanitation subsectors in Kenya has undergone significant change in the last decade, in response to a slow deterioration of urban services through the 1980s and ’90s. Initiated with a new Water Act in 2002, significant policy revision and restructuring of institutional roles is still ongoing and will need to be aligned with the new Constitution of Kenya 2010. Most of the reform emphasis has been in the water supply subsectors, especially urban, but sanitation is now regaining emphasis with a new policy published in 2007 and a strategy and investment plan in development. These reforms of the enabling environment are beginning to yield impacts in the coverage and quality of services. Kenya’s challenge is to finalize the reform of enabling aspects such as strategies and investment plans,

further clarifying roles and responsibilities, at the same time as significantly scaling up resources and systems for implementing the development of new services on the ground.

If rates of progress on water supply and sanitation coverage are not accelerated, sector targets in Kenya will be missed in both rural and urban areas. The biggest overall gaps are for rural and urban sanitation, and at current rates of progress only a third of the population will have access to safe sanitation in 2015. Urban water supply coverage is currently lower than it was in 1990, though there are signs that this downward trend is reversing. For water supply, financial allocations to the main sector ministry have increased six-fold since 2003/04, while development partner contributions have almost quadrupled since 2006/07. Estimates for required and anticipated capital investment suggest that urban water supply has sufficient funds for water supply infrastructure, but additional funding needs for urgent water storage and bulk transfer schemes will require consideration.

For sanitation, though anticipated capital investments are close to requirements, this assumes households will meet a substantial share of costs. However, there is currently no clear policy on promotion and marketing to encourage households to invest in sanitation. Significant improvements can still be made throughout the ‘service delivery pathway’ through which finance is turned into services. Upstream, separation and clarification of roles is incomplete for all subsectors (especially rural and urban sanitation) including for governance, regulation, ownership, and operations. Baker (2000). Levels of disbursement and expenditure can still be improved to make the most of increased allocations to the sector from donors and government.

Among policy issues, public support for sanitation hardware vs. software must be clarified. While finance for a national network of environmental health workers is available they have very limited operational funding and no capital funding to subsidize sanitation. Moving downstream, aspects for sustaining and developing services are comparatively underdeveloped. Sanitation coverage in urban areas is the lowest of any subsector: the government's estimate and SIM baseline is 29 percent for 2006, while the JMP puts 2008 coverage at 27 percent, up just 3 percent from 24 percent in 1990. As in the rural subsector, reaching the Government's target of 78 percent would require a massive acceleration of past progress.

The JMP estimates that in fact a majority of urban Kenyans (51 percent) use shared latrines, with 2 percent resorting to open defecation. To meet the government target by 2015, the SIM estimates that US$115 million per year is needed for sanitation hardware. The expected household contribution is slightly lower than in the rural subsector, at around 50 percent (though subsidy policy is again unclear). This is due to.high prevalence of sewerage in urban areas, which is fully subsidized despite the fact it is unlikely to benefit the poorest.

**2.4 Use of Technology in Liquid waste Management**

Early efforts in water pollution control began in the late 1800s with construction of facilities to prevent human waste from reaching drinking water supplies. There are emerging technologies that appear to be viable, but have not yet been as established processes in the United States. There are various levels of technologies which include: Research technologies, emerging technologies, innovative technologies, adaptive technologies. In most cases the adaptive / established technologies are used at more

than 1 per cent full-scale facilities in North America: but these are some exceptions based upon specific considerations. In some cases, an established technology such as the UCT (University of Cape Town) process may have been modified or adapted resulting in an emerging technology such as the modified UCT. In other cases, a process like Actiflo was developed to remove solids from wet weather flows but is now also being used to polish final effluent (Emerging Technologies- Report 2).

Knowledge about technologies tends to evolve. The information provides a snapshot at a point in time, what is understood at one point in time may change as more information develops. This includes knowledge about operating mechanisms as well as the relative and absolute costs and features of a particular technology. Inquiries into the current state of knowledge are an important step when considering implementation of any technology. The coverage with improved sanitation in different African countries ranges between 34 per cent and 72 per cent for combined improved sanitation and share/ public toilets (WATER BIOTECH, 2012).

In Africa liquid waste treatment plants face challenges such as high organic loads, uncontrolled waste input, power cuts, increasing liquid waste flow rates, high energy costs and lack of re-investments. Treatment performance expected from treatment plants in Africa is sometimes barely achievable technically. Activated sludge (AS) and stabilization ponds (either aerated or not) are the most used technologies in Africa. In addition, a wide range of treatment processes are also operated. Trickling filters were popular some years ago while ponds have now the preference. Combinations of treatment systems for polishing and tertiary treatment rarely exist.

Many liquid waste treatment plants in Africa are subject to transition, especially in the fast growing urban centres.

**2.5 Level of Training of Personnel in liquid waste management projects**

Most liquid waste management entities in Africa cannot afford the high energy prices and operation costs of the systems, which require a trained and qualified staff as well, needed to be implemented in order to meet the current staff as well, needed to be implemented in order to meet the current standards. Well trained staff is necessary both to provide cost effective operations and maintenance (O and M) of the facilities and to ensure compliance with all regulatory requirements. All certified liquid waste operators are required to renew their certificates every five years. Treatment technologies are changing and operators need to keep abreast with the latest operational approaches. Operators are required to attend seminars for refresher courses. Local officials need to vigorously support continuing education to comply with the regulations. Certified operators generally do a better job. Annual budgets should include line items for certification training (when appropriate) and for renewal training.

In addition to ensuring compliance with certification regulations, a comprehensive training program for liquid waste operators will provide other significant benefits for a local government. Well-trained staff is essential for efficient utility of O and M. Good training will result in a substantial payback over the years in terms of well-run facilities. Far-sighted local officials will make sure that O and M budgets provide adequate funds for staff to go to the best training available. This may mean sending staff to off-site training events, paying for their tuition and other costs involved to

have staff attend training programs during working hours and other personnel to fill in during that time. Another training option is to contract on-site training customised to the individual waste water facility. Training programs relating to management, supervision, and other important skills are also important in developing a more efficient and productive staff.

### 2.6 Urban Development Planning

Innovative financing of appropriate waste water infrastructure should incorporate design, construction, operation, maintenance, upgrading and/or decommissioning (Sick Water Report 4). Responsibility for physical planning and development of urban areas in Machakos resides with Department of Decentralised units. This is a multi-disciplinary department working on urban development and land use planning in the metropolis. Land use planning is undertaken based on old methods of planning without combination of modern trends, technologies and tools of planning.

According to the Town Planning Act, permissions to develop are granted by local authorities with approval from the public works office and County Planning. Any new development applications are required to build an appropriate waste water treatment system, at least septic tank, as of the specified standards. The land commission, survey department and statutory committee are key institutions, which are involved in the process.

### 2.7 Theoretical framework

According to WSP report of 2002, relevant, practical and well-tailored training seems to have a major influence on liquid waste management. Suitable training, combined

with good funding of liquid waste projects, proper town planning and use of appropriate technology can enable efficient management of liquid waste.

### 2.7.1 Ajzen's Theory of Planned Behaviour

Ajzen's theory is one of the theoretical frameworks that have been used in explaining the constructs of attitude, subjective norms and perceived behavioural control on water reuse. The various constructs identified in the theory are discussed herein. Behavioural beliefs link the behaviour of interest to expected outcomes and suggest the possibility that a given behaviour will produce a certain outcome. The theory stipulates that although a person exhibits many behavioural beliefs, only a relatively small number are accessible at a given moment. The accessible beliefs in combination with the subjective values of the expected outcome determine the prevailing attitude toward the behaviour. Attitude toward the behaviour refers to the degree to which performance of the behaviour is positively or negatively valued. According to expectance value model attitude towards behaviour is determined by the total set of accessible behavioural beliefs linking the behaviour to various outcomes and other attributes.

Normative beliefs refer to the perceived behavioural expectations of such important referent individuals or groups as the person's spouse, family, friends, and, depending on the population and behaviour studied, teacher, doctor, supervisor, and co-workers. It is assumed that these normative beliefs, in combination with the person's motivation to comply with the different referents, determine the prevailing subjective norm. That is, the strength of each normative belief (n) is weighted by motivation to comply (m) with the referent in question, and the products are aggregated

Subjective norm is the perceived social pressure to engage or not to engage in behaviour. It is assumed that subjective norm is determined by the total set of accessible normative beliefs. Control beliefs have to do with the perceived presence of factors that may facilitate or impede performance of a behaviour. It is assumed that these control beliefs, in combination with the perceived power of each control factor, determine the prevailing perceived behavioural control.

Perceived behavioural control refers to people's perceptions of their ability to perform a given behaviour. It is assumed that perceived behavioural control is determined by the total set of accessible control beliefs. The equation shows the strength of each control belief (c) is weighted by the perceived power (p) of the control factor, and the products are aggregated. Intention is an indication of a person's readiness to perform a given behaviour, and it is considered to be the immediate antecedent of behaviour. The intention is based on attitude towards the behaviour, subjective norm and perceived behavioural control, with each predictor weighted for its importance in relation to the behaviour and population of interest. Behaviour is the manifest, observable response in a given situation with respect to a given target. Single behavioural observations can be aggregated across contexts and times to produce a more broadly representative measure of behaviour. In the TPB, behaviour is a function of compatible intentions and perceptions of behavioural control. Conceptually, perceived behavioural control is expected to moderate the effect of intention on behaviour, such that a favourable intention produces the behaviour only when perceived behavioural control is strong. In practice, intentions and perceptions of behavioural control are often found to have main effects on behaviour, but no significant interaction.

Actual behavioural control refers to the extent to which a person has the skills, resources, and other prerequisites needed to perform a given behaviour. Successful performance of the behaviour depends not only on a favourable intention but also on a sufficient level of behavioural control. To the extent that perceived behavioural control is accurate, it can serve as a proxy of actual control and can be used for the prediction of behaviour (Ajzen, 1991), In general the intention to perform a behaviour is strong when performance of a particular behaviour elicits favourable attitude from individual, the surrounding social environment is conducive to the behaviour, and the individual feels confident of their ability to perform the behaviour (Ajzen I. 1988) Syme and Nancarrow attempted to use Ajzen's theory of planned behaviour to model the different factors that influence people's willingness to use recycled water for horticultural purposes.

According to the research conducted by Murni Po, Juliane D. Kaercher and Blair E. Nancarrow application of Ajzen's theory to water reuse proposes that people's willingness to use recycled water, that is, behavioural intention, depend on their attitude towards using the water, their perception of what their significant others think about using recycled water, that is, subjective norm and their perceived ease or difficulty in using recycled water, that is, perceived control. This study concludes that people's attitude towards water reuse is determined by their beliefs about the outcomes of using recycled water (Murni Po, 2003).

### 2.7.2 Input Output Principle

Wassily Leontief (1905-1999) introduced the input-output model in 1930's which depicts inter-industry relations of an economy and shows how the output of one

industry is an input to the other and vice versa. Leontief presented this information in the form of a matrix in which an input is enumerated in the column of an industry and its outputs are enumerated on the corresponding row. This shows interdependence of industries to each other both as customers of their outputs as well as suppliers of their inputs. Each columns of the input-output matrix reports the monetary value of the industry's inputs and each row represents the value of an industry's outputs. (Steins, 2012) The input-output theory has been adopted by a number of scholars including De Haan (1976), Hedricks et al (1977), Raitano (1978), Bengoechea (1979) among others. Their works majorly focused on the water transfer between individual system components i.e. physical pathways of distributing water to various users. When applying the input-output principles to water resource systems, internal components take over the roles of various industries in Leontief's model. These components represent selected water resource system features whose relationships and interactions that various scholars have investigated.

The features can be water conveying facilities such as rivers, canals, ditches, water storage facilities such as lakes, groundwater reservoirs, surface reservoirs; and water use systems such as municipal water supplies, industries and agriculture. In addition to the mentioned internal components, the set of system components is completed by entry and exit components. Through the entry components, water enters the water resource system under consideration; and through the exit components, the water leaves it. Considering a system components as origins and destinations then the entry components are just but origins as long as they do not receive water from the system while the internal components can be considered as both origins and destinations

because water enters and leaves them. Exit components are the destinations of water which leaves the system (Hendricks, 1980).

The purpose of wastewater treatment is to remove the waste or pollutants from town and industry effluent by using engineering means to best protect the environment in a manner commensurate with public health, economic, social and political concerns. In most parts of the world, liquid waste collection and treatment are now mandated by legislation.

### 2.8 Conceptual Framework

The conceptual framework for this study was based on prior studies. It comprises of independent and dependent variables. The independent variables for the study are: availability of funds, modern technology, and level of training of personnel, urban planning and lack of capacity / insufficient resources. These influence the dependent variable which is high quality liquid waste management.

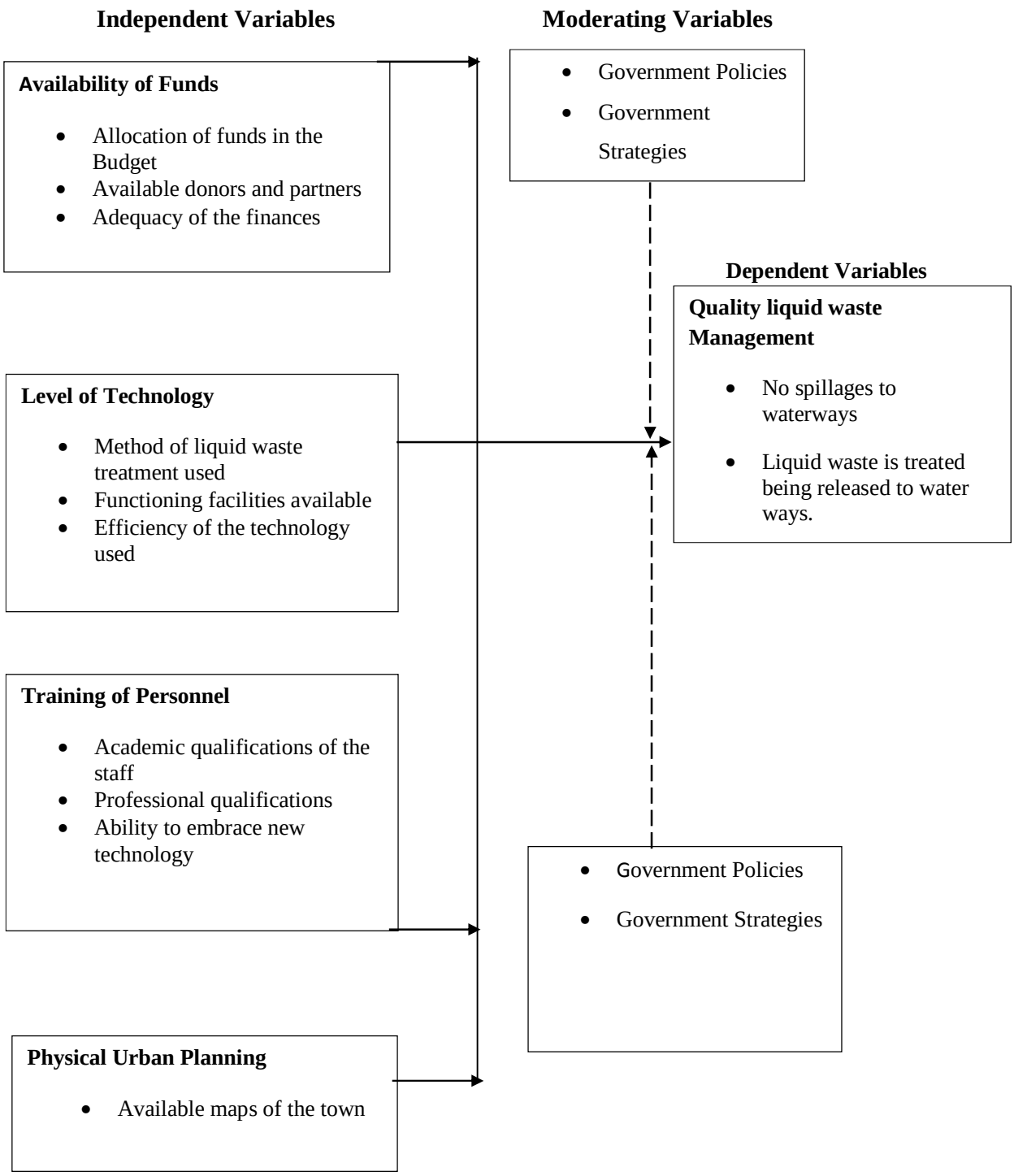


**Figure 1 Conceptual framework**

# CHAPTER THREE

# RESEARCH METHODOLOGY

## 3.1 Introduction

This chapter presents the procedures which were used in the study. The chapter focuses on research design, location of the study target population, sample strategy, sample size, research instruments and data collection techniques and data analysis and ethical consideration pertaining to the research.

## 3.2 Research design

The research adopted a descriptive survey design. Descriptive survey was used in preliminary and exploratory studies to gather data at a particular point in time. With intentions of describing the nature of the existing conditions or identifying standards against which existing conditions can be composed of or determining the conditions and the relationship that exists between specific variables. According to Kombo and Tromp (2006), a design was used to structure the research to show how the various parts of the research project collaborate to address the central research questions. The descriptive survey design was chosen because the study involved asking questions to a large number of respondents in order to get their opinions as per the factors influencing the management of waste water. This design was used because it provides the researcher with an opportunity to probe the respondents for more information and it was also relatively cheap to use. Both qualitative and quantitative data was collected in the study.

### 3.3 Target population

This refers to the group, or individual to whom the survey applies, the element of population whom the study seeks response from in relation to the research questions. The study targeted people who are directly involved in the water and sanitation projects in Machakos town, Machakos County. There are a total of 90 employees in the WRMA offices and Machakos water and Sewerage Company (Manager, Machakos Water And Sewerage Company). There are also 44 employees of Machakos County Government serving in the Department of Water and Irrigation. The target population comprised of all the 90 employees in the WRMA offices and Machakos water sewerage Company as they were available to participate in the study. The respondents included the water and sanitation employees.

### 3.4 Sample size and sampling procedures

Sampling is the procedure whereby a fraction of the data is taken from a large set of data, and the reference drawn from the sample is extended to the whole group (Raj, 1972). According to Kothari (2004) 'a sample design is a definite plan for obtaining a sample from a given population, it refers to a technique or the procedure the researcher would adopt in selecting items for the sample'. The researcher employed Yamane's formula. Yamane (1967:886) provided a formula for calculating sample sizes. The formula is as follows:

$$\left[ n = \frac{N}{1 + N(e)\text{^}2} \right]$$

Where n is the sample size, N is the population size, and e is the level of precision. At 95% confidence level, p=.5 (maximum variability) and $\pm 5\%$ precision assumptions, the resulting sample size was 73 respondents. The respondents were picked using the

random sampling method to ensure that all the respondents stand equal chance of being selected to avoid sample bias and ensure that the results are reliable enough to be generalized.

### 3.5 Data collection instruments

Both primary and secondary data was used for this study. Primary data was collected using data collection instruments which comprised of questionnaires, interview schedules and observation reports. The questionnaires were administered to the respondents who filled them on their own. The researcher obtained a letter of introduction from the University and attached to the questionnaires before delivering them to the targeted respondents. The questionnaires were collected after one week.

Secondary data was obtained from journals, published materials, government reports and articles and also from the United Nations library on water and sanitation projects. This was of much importance since it provided information which may not be readily available from the respondents of the questionnaires. It is good for comparison especially situations in other urban centres of the world other than Machakos.

The interviews were conducted randomly to the residents of Machakos town. Interviews were also conducted to the employees of Machakos County Government dealing with water and sanitation. The interview method helped to extract more information by probing the respondent further. The researcher was also able to seek clarification of unclear responses. The data was collected using Likert type questionnaire items using a scale (1-5). The values in the Likert questionnaire items are as follows: 1- strongly disagrees, 2- disagree, 3- fairly agree, 4- agree, 5- strongly agree. Fairly agree was used to provide an alternative answer from any of the

statements provided in case the respondent was not willing to select from the multiple choice given. Observation was used to discover the real situation of the sewerage systems on the ground. A systematic description the phenomenon was done and photos captured to support the description. The study used the questionnaire, interview and the observational instruments to collect the data from the field.

### 3.6 Validity and Reliability of the research instruments

The reliability of the research instruments concerns the extent to which the instrument yields the same results on repeated trails while validity can be the degree to which the test items measure what is supposed to measure and do this in a consistent manner.

#### 3.6.1 Validity of the instruments

Sekaran (2003) defines validity as the accuracy and meaningfulness of inference using the validity index which measures the degree of accuracy of the data collected representing a specific domain of indicators or constructs of a concept. Gay (1992) identified that content validity is a matter of judgement by the researcher and professionals, and has no specific formula for determination. The instruments for this study were therefore validated through application of content validity, which was determined by knowledgeable lecturers and the advice from the expert (supervisor).

#### 3.6.2 Reliability of the instruments

Sekaran (2003) defines reliability as the measure of degree to which a research instrument yields consistent results. Joppe (2000) defines reliability as the extent to which results are consistent over time and an accurate representation of the total population under study, and if the results of the study can be reproduced under similar

methodology then the research instrument is considered to be reliable. To ensure reliability, the research instruments were pretested in a selected group of 10 respondents to ensure consistency and comprehensiveness. Reliability of instruments in this study was assessed using test-retest method, in which the same respondents were subjected to a test twice, the second being two weeks from the first. To attain the reliability coefficient, each questionnaire item was awarded specific maximum scores for relevant response by the respondents. The responses in the first test were scored on the scale of each of the scores of each questionnaire item. The same was repeated in the second test. Pearson's product moment correlation coefficient of reliability was calculated for the scores of corresponding items of the two sets of tests using the formula:

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{n\{x^2 - (\sum x)^2\}} X \sqrt{n\{y^2 - (\sum y)^2\}}}$$

Where: r is the coefficient of reliability required

n is the number of questionnaire items being correlated

x is the set of scores obtained in the first test

y is the set of scores of corresponding items in the second test

**3.7 Data Analysis**

It is a key step in the research process, the researcher organised the data collected to attach meaning applicable to the research questions and research objectives. Data was compiled, sorted, classified into qualitative and quantitative data. Factor analysis was conducted on the variables. The intent was to reduce the variables to a manageable number and eliminating variables that may belong together and have overlapping measuring characteristics to fit well into the model. Quantitative data was analysed

using descriptive statistics. Descriptive statistics was worked out and percentages formed for the presentation. Correlation analysis was also conducted and correlation coefficients obtained for analysis. The results were presented in tables.

### 3.8 Ethical considerations

Ethical issues are issues a researcher must be aware of before starting the research; the awareness protected the integrity of the researcher and ensured honest results. In this research project report ethical issues were highly upheld by the study throughout the process (Mugenda and Mugenda, (2003)). Among the ethical issues would be integrity, it was the duty of the researcher to ensure all those involved were people of integrity and high moral values who command respect in the society, the study totally avoided all acts of plagiarism, that is, the act of stealing other people's ideas and referring to other people's work without acknowledging them.

This study tried as much as possible not to misuse the privileges by the researcher; the study totally upheld the principle of confidentiality and privacy of the respondents by properly handling the information and keeping it confidential. The design of the research tool was such that it was to conceal the identity of the respondent, reason being not to disclose their identity and also to encourage honesty responses. Another ethical principle to be followed by the study is that of voluntary and informed consent. It was the duty of the researcher to introduce the purpose of the research and seek consent of the respondent to voluntarily participate in the study without coercion or undue inducement whether in kind or monetary form. Another issue was about findings of the study which were not to be concealed for any purpose.

**Table 3.1: Operational Definitions of Variables**

| Objective/ Research question | Type of Variable | Indicator | Data Collection | Level of scale | Approach of Analysis | Level of Analysis |
|---|---|---|---|---|---|---|
| To investigate to what extent funding of sewerage projects influence liquid waste management. | Independent variable | Access to funds.<br>Adequacy of the funds. | Questionnaire<br>Interview<br>Observation | Nominal<br>Ordinal | Qualitative and quantitative | Descriptive: percentages of respondents<br>Pearson Correlation |
| To establish to what extent adoption of modern technology influences liquid waste management in Machakos Town. | Independent variable | Technology used.<br>New technologies under trial. | Questionnaire<br>Interview<br>Observation | Nominal<br>Ordinal | Qualitative and quantitative | Descriptive: percentages of respondents<br>Pearson Correlation |
| To investigate how level of training of personnel is a challenge in liquid waste management in Machakos Town, Machakos County. | Independent variable | Skills among the staff | Questionnaire<br>Interview<br>Observation | Nominal<br>Ordinal | Qualitative and quantitative | Descriptive: percentages of respondents<br>Pearson Correlation |
| To investigate how poor town planning has influenced liquid waste management. | Independent variable | Available maps of town planning | Questionnaire<br>Interview<br>Observation | Nominal<br>Ordinal | Qualitative and quantitative | Descriptive: percentages of respondents<br>Pearson Correlation |

# CHAPTER FOUR

# DATA ANALYSIS, PRESENTATION, INTERPRETATION AND DISCUSSION OF THE FINDINGS

## 4.1 Introduction

The study was conducted to establish the challenges facing liquid waste management in Machakos Town, Machakos County. Specifically, the study sought to establish the extent to which funding of liquid waste projects, adoption of modern technology, level of training of personnel and physical urban developmental planning influence management of liquid waste in Machakos Town.

A sample of 73 respondents was used in the study. The data was gathered exclusively from questionnaires as the research instrument. The questionnaires were designed in line with objectives of the study. To enhance quality, the collected data from all the respondents, was analysed using the Statistical Package for Social Sciences (SPSS) version 20 for Windows. The analysis was presented in line with the objectives of the study as outlined above. Results are presented in this section in form of frequency tables, percentages, and correlations tables. The first section of this chapter contains information on the introduction, followed by the questionnaire response rate. Thereafter, the demographic data was presented followed by the analysis for every objective under study.

### 4.1.1 Questionnaire Response Rate

The researcher sought to collect data to support the study from 73 respondents working in the WRMA offices and Machakos Water Sewerage Company as they were available to participate in the study. The response rate is therefore given as follows

$$Response\ rate = \frac{Total\ number\ of\ responses}{Sample\ size}$$

$$= \frac{72}{73}$$

$$= 0.9863$$

$$\cong 98.6\%$$

**Table 4.1 Response rate**

| Sample Size | Responses | Percentage |
|---|---|---|
| 73 | 72 | 98.6 |

Table 4.1 indicates that 98.6% of the respondents participated in the study. This was a good number to work with as far as the research is concerned.

### 4.2 Demographic characteristics of the Respondents

The study sought to find out the respondent's information of which helps in understanding their population dynamics while relating them with the objectives of the study. This was done by investigating the estates and organizations they work in/with, their gender, positions occupied in the organizations and the length of time they have been working there. The respondents specified their estates and water and sewerage companies but there was no response on the other demographics. The names of the estates they work with are given as shown in the Table 4.2

**Table 4.2 Name of estate**

| Frequency | Frequency(f) | Percent (%) |
|---|---|---|
| Eastleigh | 13 | 18.1 |
| Kariobangi | 16 | 22.2 |
| Kathemboni | 14 | 19.4 |
| Katoloni | 14 | 19.4 |
| Muthini | 15 | 20.8 |
| **Total** | **72** | **100.0** |

Table 4.2 indicates that 13 (18.1%) of the respondents worked in Eastleigh estate, 16(22.2%) in Kariobangi, 14(19.4%) in Kathemboni, 14 (19.4%) in Katoloni and 15(20.8%) in Muthini.

**Table 4.3 Name of water Sewerage Company**

| Company | Frequency (f) | Percent (%) |
|---|---|---|
| Machakos water and sewerage company | 72 | 100 |
| **Total** | **72** | **100** |

The findings in Table 4.3 indicate that all the respondents who took part in the filling out of the questionnaire were from Machakos Water and Sewerage Company.

### 4.3 Funding of liquid waste projects

The study sought to find out the extent to which funding of sewerage projects influenced management of waste water in Machakos County. This variable was measured using four indicators which were measured against quality management of liquid waste. These indicators included availability and management of funds, management of projects records, abiding by the law during decision making, and

whether members pay promptly and out of their own willingness were considered. The respondents were required to indicate their agreement or disagreement on the statements put in a 5 point Likert scale. The analysis of the findings are summarised in Table 4.4

**Table 4.4 Frequency Table for the given variables**

| Factor | | Strongly disagree | Disagree | Fairly agree | Agree | Strongly agree |
|---|---|---|---|---|---|---|
| Sewerage projects are well financed | Count | 0 | 3 | 24 | 41 | 4 |
| | % | 0.0 | 4.2 | 33.3 | 56.9 | 5.6 |
| Available funds are well managed | Count | 4 | 5 | 35 | 25 | 3 |
| | % | 5.6 | 6.9 | 48.6 | 34.7 | 4.2 |
| Projects records are properly kept | Count | 1 | 6 | 33 | 31 | 1 |
| | % | 1.4 | 8.3 | 45.8 | 43.1 | 1.4 |
| Constitution/by-laws are followed during decision making | Count | 6 | 15 | 32 | 17 | 2 |
| | % | 8.3 | 2.8 | 44.4 | 23.6 | 2.8 |
| Members pay their dues promptly and willing | Count | 3 | 5 | 43 | 20 | 1 |
| | % | 4.2 | 6.9 | 59.7 | 27.8 | 1.4 |

Table 4.4 above shows the level of agreement or disagreement on whether liquid waste projects were well financed varied. 24(33.3%) of the respondents fairly agreed that sewerage projects are well financed, 41(56.9%) agreed and 4 (5.6%) strongly

agreed while 3 (4.2%) disagreed. This may signify that financing of liquid waste projects influences the quality of liquid waste management. Table 4.4 also shows varied level of agreement and disagreement on whether the available funds for liquid waste management were well utilised. 35(48.6%) of the respondents fairly agreed that funds are well managed while 25(34.7%) agreed on the same. 4 (5.6%) strongly disagreed while 5 (6.9%) disagreed that funds are well managed. According to Table 4.4 45.8% fairly agreed that projects records are properly kept, 43.1% agreed while 1.4% strongly agreed. 44.4% fairly agreed that the constitution by-laws are followed during decision making while 23.6% agreed. 59.7% fairly agreed that the members pay their dues promptly and willing, 27.8% agreed on the same. The respondents were asked to specify their level of agreement with the above statements and the correlations of their responses are given in Table 4.

**Table 4.5 Pearson correlations for the given statements**

| | | Agreement that it is well financed | Available funds are well managed | Projects records properly managed | Constitution or law followed during decision making | Members pay dues promptly and willing |
|---|---|---|---|---|---|---|
| Agreement that it is well financed | Pearson Correlation | 1 | .284* | .241* | .178 | .143 |
| | Sig. (2-tailed) | | .016 | .042 | .135 | .230 |
| | N | 72 | 72 | 72 | 72 | 72 |
| Available funds are well managed | Pearson Correlation | .284* | 1 | .403** | .335** | .245* |
| | Sig. (2-tailed) | .016 | | .000 | .004 | .038 |
| | N | 72 | 72 | 72 | 72 | 72 |
| Projects records properly managed | Pearson Correlation | .241* | .403** | 1 | .377** | .455** |
| | Sig. (2-tailed) | .042 | .000 | | .001 | .000 |
| | N | 72 | 72 | 72 | 72 | 72 |
| Constitution or law followed during decision making | Pearson Correlation | .178 | .335** | .377** | 1 | .539** |
| | Sig. (2-tailed) | .135 | .004 | .001 | | .000 |
| | N | 72 | 72 | 72 | 72 | 72 |
| Members pay dues promptly and willing | Pearson Correlation | .143 | .245* | .455** | .539** | 1 |
| | Sig. (2-tailed) | .230 | .038 | .000 | .000 | |
| | N | 72 | 72 | 72 | 72 | 72 |

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.5 above indicates that there existed positive relationships between projects that are well managed and the availability of funds; projects well financed and proper management of records; availability of funds and proper management of project's records, following the constitution during decision making, and members pay dues promptly; abiding by law in decision making and proper management of projects records. There also existed quite a strong relationship between constitution being followed during decision making and members paying their dues promptly and

willing. Following the findings in Table 4.5, it clearly agrees the level of funding influences management of liquid waste.

The study found that that 95.8% of the respondents agreed (on aggregate) that sewerage projects are well financed. This proves the Kenyan Government's efforts in enacting laws intended to reform and create an enabling environment. Eighty seven point five percent (87.5%) agreed that funds are well managed. The proper management of these funds and projects' records has yielded quality services in liquid waste management and at the same time increased the coverage of the services. This is contrary to government's estimate and SIM baseline that specified that the coverage was 29 percent for 2006, while the JMP puts 2008 coverage at 27 percent, up just 3 percent from 24 percent in 1990.

Appropriate financing is important to ensure results have no serious knock-effects which could lead to diminished public and political confidence and lost opportunity to simultaneously tackle the problem and generate capital. For instance, approximately US$700 billion was spent between 1981-1990, yet absolute numbers of people without safe drinking water stayed static (Elimelech, 2006; Mints et al, 2001).

### 4.4 Technology used in liquid waste management

The researcher sought to know the influence of technology used in liquid waste management and variables such as type of technology used, its efficiency and how to improve on it were measured. The results are presented in Table 4.6, Table 4.7, and Table 4.8.

**Table 4.6 Technology used in liquid waste management**

| Technology | Frequency | Percentage |
|---|---|---|
| Pools/ponds | 15 | 20.8 |
| Sedimentation | 57 | 79.2 |
| Total | 72 | 100 |

The respondents indicated that ponds/ pools are used in waste water management at 15 (20.8%) while 57 (79.2%) indicated that sedimentation is used in water management as shown in Table 4.7. This reveals that sedimentation is preferred over pools/ ponds in the management of liquid waste.

The study then analysed the efficiency of the technology in use and the results are given in Table 4.7.

**Table 4.7 Efficiency of the technology used liquid waste management**

| Efficiency | Frequency | Percentage |
|---|---|---|
| Very efficient | 3 | 4.2 |
| Efficient | 28 | 38.9 |
| Low efficient | 24 | 33.3 |
| Not efficient | 17 | 23.6 |
| Total | 72 | 100 |

Table 4.7 shows 28(38.9%) of the respondents indicated that the technology used is efficient, 24(33.3%) indicated that it is low efficient, 17(23.6%) indicated it is not efficient while 3 (4.2%) indicated it is very efficient. More respondents therefore were of the opinion that the technology is of low efficiency as summarized in the Table 4.7.

The respondents then gave their views on how the technology could be improved and the results are summarized in Table 4.8.

**Table 4.8 Improvement on the efficiency of technology used**

| Technology used | Frequency | Percentage |
|---|---|---|
| Expand infrastructure | 22 | 30.6 |
| Adopt new technology | 36 | 50 |
| Rehabilitation of existing technology | 10 | 13.9 |
| Combine methods | 4 | 5.6 |
| Total | 72 | 100 |

Table 4.8 indicates that 36 (50%) of the respondents indicated that adopting new technology could be the best way to improve on the efficiency of the technology used, 22 (30.6%) indicated that expanding infrastructure could be better, 10 (13.9%) were for rehabilitation of existing technology while 4 (5.6%) thought it better to combine various technological methods in managing liquid waste. The researcher therefore sought to unearth the existence of relationships (correlations) for the above responses on technology use and the results are as shown Table 4.9.

**Table 4.9 Pearson correlations**

| | | Type of Technology Used | Efficiency Of The Technology Used | Improve efficiency of technology used |
|---|---|---|---|---|
| Type of Technology Used | Pearson Correlation | 1 | -.101 | .049 |
| | Sig. (2-tailed) | | .397 | .683 |
| | N | 72 | 72 | 72 |
| Efficiency Of The Technology Used | Pearson Correlation | -.101 | 1 | -.098 |
| | Sig. (2-tailed) | .397 | | .412 |
| | N | 72 | 72 | 72 |
| Improve efficiency of technology used | Pearson Correlation | .049 | -.098 | 1 |
| | Sig. (2-tailed) | .683 | .412 | |
| | N | 72 | 72 | 72 |

There was no relationship between any two or more of the variables at either 0.05% or 0.01% level of significance as shown in Table 4.9.

The study found that 79.2% of the respondents indicated that sedimentation was used in liquid waste management while 20.8% specified that pools/ ponds were being used. It was also revealed that the technology being used was efficient at 38.9%, low efficient at 33.3% of the responses, 23.6% was not efficient while a mere 4.2% was very efficient.

In addition, it was found that 50% of the respondents suggested that adopting new technology could be the best way to improve on the efficiency of the technology used, 30.6% indicated that expanding infrastructure could be better, 13.9% were for rehabilitation of existing technology while 5.6% thought it better to combine various technological methods in managing waste water. This is in support of current

technologies being used in many areas such as North America where adoptive/ established technologies are used at more than 1 percent full-scale facilities. Similarly, an established technology such as the UCT (University of Cape Town) process may have been modified or adapted resulting in an emerging technology such as the modified UCT. Furthermore, a process like Actiflo was developed to remove solids from wet weather flows but is now also being used to polish final effluent (Emerging Technologies- Report 2).

### 4.5 Level of training of personnel

The researcher sought to determine the influence of level of training of the personnel on the quality liquid waste management. Various factors were put into consideration and their responses are summarized as shown in Table 4.10.

**Table 4.10 Frequencies for the specified variables**

| Factor | | Strongly disagree | Disagree | Fairly agree | Agree | Strongly agree |
|---|---|---|---|---|---|---|
| Staff have trained | Count | 0 | 0 | 29 | 42 | 1 |
| | % | 0.0 | 0.0 | 40.3 | 58.3 | 1.4 |
| Training is relevant for proper waste water management | Count | 0 | 5 | 36 | 25 | 6 |
| | % | 0.0 | 6.9 | 50 | 34.7 | 8.3 |
| A different training required for proper management | Count | 0 | 6 | 26 | 27 | 13 |
| | % | 0.0 | 8.3 | 36.1 | 37.5 | 18.1 |
| Training is important in waste water management | Count | 0 | 0 | 42 | 16 | 14 |
| | % | 0.0 | 0.0 | 58.3 | 22.2 | 19.4 |
| There's inadequate training for members of staff | Count | 0 | 5 | 24 | 37 | 4 |
| | % | 0.0 | 6.6 | 33.3 | 51.4 | 5.6 |

Table 4.10 shows that 29 (40.3%) fairly agreed that the staff had trained, 42(58.3%) agreed that the staff had trained while only 1(1.4%) strongly agreed that the staff had trained. 93% agreed that training is relevant for proper liquid waste management, while 6.9% disagreed on the same point. 91.7% (on aggregate) agreed that a different training was required for proper management of liquid waste while only 8.3% disagreed. All the respondents (on aggregate) agreed that training is important in liquid waste management. 93.4% agreed on aggregate that training is important in liquid waste management.

**Table 4.11 Pearson correlations analysis between level of training of personnel and quality waste management**

| | | Staff have trained | Training relevant for Proper Waste Water Management | Different Training of staff for Proper Management | Training is an Important Aspect In Water Management | Inadequate Training for Members of Staff |
|---|---|---|---|---|---|---|
| Staff Have Trained Proper liquid waste Management | Pearson Correlation | 1 | -.093 | -.240* | .072 | -.099 |
| | Sig. (2-tailed) | | .439 | .043 | .548 | .413 |
| | N | 72 | 72 | 72 | 72 | 70 |
| | Pearson Correlation | -.093 | 1 | -.019 | .317** | .035 |
| | Sig. (2-tailed) | .439 | | .873 | .007 | .776 |
| | N | 72 | 72 | 72 | 72 | 70 |
| Training for Proper Management | Pearson Correlation | -.240* | -.019 | 1 | .107 | .368** |
| | Sig. (2-tailed) | .043 | .873 | | .373 | .002 |
| | N | 72 | 72 | 72 | 72 | 70 |
| Important Aspect In Water Management | Pearson Correlation | .072 | .317** | .107 | 1 | -.065 |
| | Sig. (2-tailed) | .548 | .007 | .373 | | .593 |
| | N | 72 | 72 | 72 | 72 | 70 |
| Inadequate Training for Members of Staff | Pearson Correlation | -.099 | .035 | .368** | -.065 | 1 |
| | Sig. (2-tailed) | .413 | .776 | .002 | .593 | |
| | N | 70 | 70 | 70 | 70 | 70 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Positive relationships existed between proper liquid waste management and training being an important aspect in liquid waste management; negative correlation existed between different training of staff for proper management and the staff having trained

as shown in Table 4.11. The study found that 100% of the respondents agreed that the staff had trained. Also, 93.1% agreed that training is relevant for proper liquid waste management. This is in support of the fact that well trained staff is necessary both to provide cost effective operations and maintenance (O and M) of the facilities and to ensure compliance with all regulatory requirements. This is further emphasized by the findings that showed that training is important in liquid waste management.

The study found that significant relationships existed between inadequate training for members of staff versus training for proper liquid waste management; training being important in liquid waste management versus proper liquid waste management and staff having trained and training for proper liquid waste management. These relationships support the fact that comprehensive training program for liquid waste operators will provide other significant benefits for a local government. Well-trained staff is essential for efficient utility of O and M. Good training will result in a substantial payback over the years in terms of well-run facilities.

### 4.6 Physical town planning

The study also sought to understand the influence of physical town planning on management of liquid waste in Machakos County and the frequencies of the responses are given in Table 4.12.

**Table 4.12 Frequencies of the responses on urban development planning**

| Factor | | Strongly disagree | Disagree | Fairly agree | Agree | Strongly agree |
|---|---|---|---|---|---|---|
| Maps exist that show the plan of the town | Count | 0 | 2 | 3 | 57 | 10 |
| | % | 0.0 | 2.8 | 4.2 | 79.2 | 13.9 |
| Maps indicate the sewerage plan of town | Count | 0 | 3 | 13 | 51 | 5 |
| | % | 0.0 | 4.2 | 18.1 | 70.8 | 6.9 |
| Plan followed during development of new structures in town | Count | 0 | 8 | 45 | 17 | 2 |
| | % | 0.0 | 11.1 | 62.5 | 23.6 | 2.8 |
| Plan affects waste water management | Count | 0 | 3 | 34 | 32 | 3 |
| | % | 0.0 | 4.2 | 47.2 | 44.4 | 4.2 |

Table 4.12 indicates that on aggregate, 97.3% of the respondents agreed that maps exist that show the plan of the town. These are majorly located in the offices for use by the staffs who work there. 95.8% (on aggregate) agree that maps indicate the sewerage plan of town. 88.9% (on aggregate) agreed that plans were followed during development of new structures in town. It was also revealed that plans affect waste water management as indicated by the respondents as shown in Table 4.12 (95.8% of respondents on aggregate agree level).

The correlations of the responses were also done and summarized in Table 4.13.

**Table 4.13 Correlations**

| | | **Plan of the Town** | **Sewerage Plan of Machakos Town** | **Developing New Structures in Machakos** | **Waste Water Management in Machakos Town** |
|---|---|---|---|---|---|
| Plan of the Town | Pearson Correlation | 1 | .360** | -.219 | .142 |
| | Sig. (2-tailed) | | .002 | .064 | .236 |
| | N | 72 | 72 | 72 | 72 |
| Sewerage Plan of Machakos Town | Pearson Correlation | .360** | 1 | .260* | .343** |
| | Sig. (2-tailed) | .002 | | .027 | .003 |
| | N | 72 | 72 | 72 | 72 |
| Developing New Structures in Machakos | Pearson Correlation | -.219 | .260* | 1 | .220 |
| | Sig. (2-tailed) | .064 | .027 | | .063 |
| | N | 72 | 72 | 72 | 72 |
| Waste Water Management in Machakos Town | Pearson Correlation | .142 | .343** | .220 | 1 |
| | Sig. (2-tailed) | .236 | .003 | .063 | |
| | N | 72 | 72 | 72 | 72 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.13 shows that there existed relationships between plan of Machakos town and sewerage plan of the town; developing new structures in Machakos and sewerage plan of Machakos; and waste water management in Machakos town and sewerage plan of Machakos. Therefore the plan of Machakos town, development of new structures in the town and waste water management in Machakos town influence sewerage plan of Machakos town positively.

The study found that on aggregate, 97.3% of the respondents agreed that maps exist that show the plan of the town. It was also found 95.8% (on aggregate) agreed that maps indicate the sewerage plan of town. In addition, 95.8% revealed that plans affect liquid waste management as indicated by the respondents. The study also found that relationships between plan of Machakos town and sewerage plan of the town; developing new structures in Machakos and sewerage plan of Machakos; and liquid waste management in Machakos town and sewerage plan of Machakos were significant. Therefore it is justified that innovative financing of appropriate liquid waste infrastructure should incorporate design, construction, operation, maintenance, upgrading and/or decommissioning (Sick Water Report 4). Any new development applications should therefore build appropriate liquid waste treatment systems, at least septic tank, as of the specified standards.

# CHAPTER FIVE

# SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMEDATIONS OF THE FINDINGS

## 5.1 Introduction

This chapter presents the summary of the findings of the study, conclusions, and recommendations arrived at in that order. The study assessed the challenges facing liquid waste management in Machakos town, Machakos County. That is the extent to which funding of sewerage projects influence management of liquid waste in Machakos Town, extent to which adoption of modern technology influence management of liquid waste in Machakos Town, extent to which the level of training of personnel influence management of liquid waste in Machakos Town, extent to which the urban developmental planning influence management of liquid waste in Machakos Town. The study then suggested on further studies related to the same.

## 5.2 Summary of Findings

The completed and returned questionnaires were seventy two out of seventy three (98.6%) which is a good response rate. All the questionnaires were responded to by staff of Machakos water and Sewerage Company.

### 5.2.1 The influence of funding of the sewerage projects on liquid waste management

The study found that that 95.8% of the respondents agreed (on aggregate) that sewerage projects are well financed. Eighty seven point five percent (87.5%) agreed that funds are well managed. Ninety point three percent (90.3%) agreed that projects records are properly kept. Seventy point eight percent (70.8%) agreed that the

constitution by-laws are followed during decision making. Sixty four (88.9%) agreed that the members pay their dues promptly and willingly. There were significant associations between financing the projects and availability of funds; management of records and availability of funds; members paying their dues promptly and willingly versus following the law during decision making.

### 5.2.2 The influence of modern technology in liquid waste management

The study found that 79.2% of the respondents indicated that sedimentation was used in liquid waste management while 20.8% specified that pools/ ponds were being used. It was also revealed that the technology being used was efficient at 38.9%, low efficient at 33.3% of the responses, 23.6% was not efficient while a mere 4.2% was very efficient. In addition, it was found that 50% of the respondents suggested that adopting new technology could be the best way to improve on the efficiency of the technology used, 30.6% indicated that expanding infrastructure could be better, 13.9% of the respondents proposed rehabilitation of existing technology while 5.6% thought it better to combine various technological methods in managing liquid waste.

### 5.2.3 The influence of level of training of personnel on liquid waste management

The study found that 100% of the respondents agreed that the staff had basic training. Also, 93.1% agreed that training is relevant for proper liquid waste management. The findings showed that all the respondents agreed that training is important in waste water management. Furthermore, 93.4% agreed on aggregate that training is important in liquid waste management. The study found that adequate training for members of staff had significant relationship with proper liquid waste management;

training being important in liquid waste management and proper liquid waste management and staff having trained and training for proper management.

### 5.2.4 The influence physical town planning on liquid waste management

The study found that on aggregate, 97.3% of the respondents agreed that maps exist that show the plan of the town. It was also found 95.8% (on aggregate) agreed that maps indicate the sewerage plan of town. The findings also revealed that 88.9% (on aggregate) agreed that plans were followed during development of new structures in town. In addition, 95.8% revealed that plans affect liquid waste management as indicated by the respondents. The study also found that relationships between plan of Machakos town and sewerage plan of the town; developing new structures in Machakos and sewerage plan of Machakos; and liquid waste management in Machakos town and sewerage plan of Machakos were significant.

## 5.3 Conclusion of the findings

The study found that liquid waste management in Machakos town is influenced by factors including funding of the projects, adoption of modern technology, level of training of personnel and physical urban developmental planning. Due to the continuing population growth and urbanization, liquid waste management should be revolutionized to cater for future demands and reduce health hazards caused by discharge of contaminated water into the environment.

### 5.3.1 Funding of liquid waste projects

The analysis of the influence of funding of liquid waste management produced results that indicated that they have great influence. The study found out that 24 (33.3%) of

the respondents agree that liquid waste projects are well funded, 41respondents agree while only 4 respondents strongly agree. It was observed that availability of funds for operations and maintenance of the sewerage systems was influencing the quality and level of liquid waste management in Machakos town.

### 5.3.2 Use of modern technology in liquid waste management

The study found out that there were only two technologies that were in use in Machakos and they are pools and sedimentation. The cost of technology has inverse relation with the liquid waste management and reuse and as the cost influenced the technology used in liquid waste management.

### 5.3.3 Level of training of personnel

The study found that significant relationships existed between inadequate training for members of staff versus training for proper liquid waste management; training being important in liquid waste management versus proper liquid waste management and staff having trained and training for proper liquid waste management. These relationships support the fact that comprehensive training program for liquid waste operators will provide other significant benefits for a local government. Well-trained staff is essential for efficient utility of O and M. Good training will result in a substantial payback over the years in terms of well-run facilities.

### 5.3.4 Physical town planning

The study found that on aggregate, 97.3% of the respondents agreed that maps exist that show the plan of the town. It was also found 95.8% (on aggregate) agreed that maps indicate the sewerage plan of town.  In addition, 95.8% revealed that plans

affect liquid waste management as indicated by the respondents. The study also found that relationships between plan of Machakos town and sewerage plan of the town; developing new structures in Machakos and sewerage plan of Machakos; and liquid waste management in Machakos town and sewerage plan of Machakos were significant. Therefore it is justified that innovative financing of appropriate liquid waste infrastructure should incorporate design, construction, operation, maintenance, upgrading and/or decommissioning (Sick Water Report 4). Any new development applications should therefore build appropriate liquid waste treatment systems, at least septic tank, as of the specified standards.

## 5.4 Recommendations of the Study

Life threatening hazards caused by the release of liquid waste to the environment can be reduced by reducing unregulated discharge of liquid waste and securing safe water. This can improve not only national but global public health and help achieve sustainable development.

### 5.4.1 Funding of liquid waste management projects

Appropriate financing and management is critical in tackling the problem and can help in generating capital. Liquid waste can be treated and reused in agriculture to support livelihoods. This can be done by using the treated water to irrigate land like it is being done in Mexico and US state of California. Safe reuse of untreated and partially liquid waste for agricultural production has been tested in Ghana and Senegal where various options at farm, markets, and food-vender levels were operationally monitored, farming adjustments and management measures trained and verified on the effectiveness in reducing health risks. Other advantage of liquid waste use for irrigation is the savings brought from fertilizer purchase because fertilizer would not

be needed in the process. The government should subsidize the equipment and chemicals used for liquid waste treatment to ensure all the parties in the sector can afford and therefore effectively reuse liquid waste without fear of any contamination.

### 5.4.2 Use of modern technologies

Different technologies should also be implemented in different places/ regions with different population sizes and different stages of economic governance depending on capacity for governance. Many industries perceive water as a dilution media of harmful wastes from factories and so discharge untreated effluents directly into watercourses. Effluents need therefore be pre-treated to the acceptable standards before discharging. Also effluent volumes should be kept to the minimum through observance of clean production/operation procedures (Kenya National Water Report, 2002).

### 5.4.3 Level of training of personnel

Training should also be considered at all levels to create awareness on the proper liquid waste management. It is recommended that a long-term programme of upgrading and developing skills and experience of all levels of personnel within Machakos water and Sewerage Company will need to be developed and implemented. The human resources development programme will encompass the broad process of review and support of career development in order to meet the requirements of professionals, technicians and all staff so that it can attract and keep top staff in the service of the county (Kenya National Water Report, 2002).

### 5.4.4 Physical town planning

Developers especially in real estate should ensure an elaborate design and construction of liquid waste harvesting system that will ensure safe and sound disposal of the sewage and other liquid waste. This will reduce the health risks involved including outbreak of waterborne diseases like typhoid and cholera. Municipal and town planners should also develop a system that encourages liquid waste management and reuse. Such system should involve sewerage systems and good drainage lines that will make it easier for those interested in reusing the water to harvest for treatment and subsequent reuse.

## 5.5 Suggestions for Further study

The study focused on funding of liquid waste management, training of personnel, adoption of modern technology and urban planning to address the factors influencing liquid waste management in Machakos County. Other factors other than the above factors should be considered to fully address the issue at hand, for instance, carrying out a research on liquid waste treatment technologies and their impacts; assessing the liquid waste effluents to measure effects on the environment among others. Similarly, the study can be done in other urban areas in the country for the findings to be generalized.

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## APPENDICES

## APPENDIX I

**Letter of introduction**

Dorothy S. Mutuku

University of Nairobi

P. o Box 28174 – 00200

Nairobi

…….

…….

Dear participant,

This is to inform you that I am undertaking a research study leading to master's degree in project planning and management at the University of Nairobi. The study focuses on challenges facing waste water management in Machakos town, Machakos Central ward, Machakos County. When successfully completed the findings will help to enhance and improve waste water management for reduced pollution and hence less health risks for the residents of Machakos town. In this regard, please take some time and complete this questionnaire, accurate and frank responses will be highly appreciated.

All information received will be treated with confidentiality. The findings for this study will be used only for the research purpose.

Yours faithfully,

Dorothy S. Mutuku

## APPENDIX II

## Questionnaire

**Part A**

1. Name of the estate…….....
2. Name of the water and sewerage company……
3. Gender of the respondent (please tick): Male Female…….
4. Position of the respondent (please tick): Manager….. Deputy Manager….. Treatment/facility operator…… General staff……
5. When was the company established……

**Part B**

**Objective One: Funding and management of liquid waste projects**

1. To what extent has funding of liquid waste projects influenced the management of liquid waste?

(1) Strongly disagree (2) Disagree (3) Fairly agree (4) Agree (5) Strongly agree

| | Score | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1. Liquid waste projects are well financed | | | | | |
| 2. Funds are well managed | | | | | |
| 3. Financial records are well kept | | | | | |
| 4. Proper procedures are followed | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| during decisions making | | | | | |
| 5. Clients pay their dues promptly and willingly | | | | | |

**Objective Two: Technology used in liquid waste management**

1. What type of technology do you use?

   Pools/ponds ☐

   Sedimentation ☐

2. How do you rate the efficiency of the technology used?

   Very efficient ☐

   Efficient ☐

   Low efficient ☐

   Not efficient ☐

3. What can be done to improve on the efficiency of technology used?

   Expand infrastructure ☐

   Adopt new technology ☐

   Rehabilitation of existing technology ☐

   Combine methods ☐

**Objective Three: Level of training of personnel of the sewerage company**

To what extent do you agree?

(1) Strongly disagree (2) disagree (3) fairly agree (4) agree (5) strongly agree

| | Score | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1. The staff have been trained | | | | | |
| 2. The training is relevant for proper liquid waste management | | | | | |
| 3. Staff require additional training for proper liquid waste management | | | | | |
| 4. Training is important in liquid waste management | | | | | |
| 5. Members of staff have had inadequate training | | | | | |

**Objective Four: Physical Town Planning**

| | Scores | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1. There are maps that show the development plan of the town | | | | | |
| 2. Development plan indicates the sewerage plan of Machakos town | | | | | |
| 3. The is followed during development of new structures | | | | | |
| 4. The plan affects liquid waste management | | | | | |

ORIGINAL

# OFFICIAL RECEIPT

AC: 6873

Station NACOSTI Date 18/2/2015

RECEIVED from Dr. Peter Kahuthu Mwaura

Shillings One thousand only cents

on account of Research permit fee

Vote R.A.I

Head

NACOSTI

USD

Kshs 1,000

AC

Item No.

Cash

Cheque No. Direct deposit

*Signature of Officer receiving remittance*