

**WASTEWATER MANAGEMENT: A CASE OF REDUCING WASTEWATER
RELEASE INTO ENVIRONMENT IN MATHARE NORTH, NAIROBI COUNTY**

BY

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DECLARATION

I declare that this is an original report researched by me with the help of professor Mireri and have never been submitted to Kenyatta university or any other institution whatsoever.

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DEDICATION

I dedicate this project to Almighty God for the strength He gave me to see me through this project. My dedication also goes to my family members for spiritual, financial and emotional strength they offered me as well as friends who were always there to offer advice to ensure that I finish this project.

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Finally, I thank Progressive Volunteer members for the information they offered during data analysis and discussion.

EXECUTIVE SUMMARY

This project reinforces waste water management in a holistic manner in order to have a minimal impact of waste water to the environment. This includes sources of water for use to disposal of used water in Mathare North and link between wastewater management in Mathare North in relation to Nairobi as a whole and globally in order to develop mechanisms to help address wastewater management. The project also explores potentials and challenges of wastewater management in Mathare North with respect to Nairobi in its entirety. The project then considers policies, legislative and institutional framework when it comes to wastewater management in Kenya.

Waste water management requires incorporation of all the issues that influence wastewater generation in which 75% of it ends up in the environment to help in planning and development of waste management initiatives. All stakeholders' involvement is crucial to getting and implementing views of different sectors of the population.

There are different types of wastewater which require different technologies to manage to help reduce cost of realizing wastewater management. In addition, there are different purposes for wastewater management which must be considered and addressed which are regarded as components wastewater management. Theoretical framework of the project incorporates planning, participation, advocacy and funding with regard to consideration of environmental impacts of the activities.

The project embraces investigate research where primary and secondary data has been collected and collated to develop mechanisms that addresses wastewater.

ACRONYMS

BOD- Biological Oxygen Demand

COD- Chemical Oxygen Demand

CBOs-Community Based Organizations

CIA- Central Intelligence Agency (CIA World Fact Book, 2012)

CIDWT- Consortium Institute for Decentralized Wastewater Treatment

EMCA- Environmental Management and Coordination Act

FAO- Food and Agriculture Organization on United Nations

GDP- Gross Domestic Product

GoK- Government of Kenya

ICWE- International Conference on Water and Environment

JICA- Japan International Cooperation Agency

NEAP- National Environment Action Plan

NEMA- National Environment Management Authority

NCC- Nairobi County Council

SBR- Sequencing Batch Reactors

SMEs- Small and Medium Enterprises

TF- SCP- Trickling Filter Solids Contact Process

UNCED- United Nations Conference on Environment and Development

UNDP- United Nations Development Program

UNEP- United Nations Environment Program

UNFPA-United Nations Population Fund

UNICEF- United Nations International Culture, Education and Fund

UWM- Urban Water Management

WB- World Bank

WHO- World Health Organization

WWF- World Wildlife Fund

PV- Progressive Volunteers

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Chapter 1

1 Introduction

According to section 42 Kenya's 2010 constitution, every person has a right to clean and healthy environment. The government acknowledges that a healthy environment is crucial to delivering Vision 2030, which is Kenya's long-term development blueprint. However, one of the greatest challenges of the twenty first century is the incessant of supply of clean drinking water for the millions of the living things all over the world. Therefore there is need to provide the new approach to wastewater management and to deal with the issues in an environmentally-conscious manner. Inappropriate or absent wastewater management deteriorates drinking water sources and natural environment and endangers human health. It is a major problem in numerous countries which demands taking appropriate and well considered actions adapted to the specific environment and economic welfare.

Water scarcity can be addressed through improvement of the efficiency of consumptions and seek sustainable alternative sources. Several approaches exist among them efficient and effective wastewater management and reuse to supplement fresh water and keep environment clean. The reuse of wastewater can be a strategy to release freshwater for domestic use, and to improve the quality of river waters used for abstraction of drinking water (by reducing disposal of effluent into rivers).

Aspects of wastewater management are explored with integrated perspective in that a holistic view of the entire wastewater system is required for proper wastewater management, starting from the wastewater generation until the ultimate disposal schemes. The functional elements of integrated wastewater management system are generation, collection, treatment (including sludge treatment) and disposal and reuse. A successful wastewater management decision requires a comprehensive, impartial evaluation of wastewater management approaches.

This paper will look at wastewater management; challenges faced, existing and emerging issues in relation to wastewater management in order to develop mechanisms that can be adopted to help address the issues.

1.1 Background of the Problem

Population growth coupled with a rising global standards of living has resulted into resource consumption including water use that exceeds the current resource of plant earth (Daigger, G.T, 2007), (Daigger, G.T, 2008) leading to production of waste water which when returned to the environment exceeds the natural rate of recycling hence causal of water stress. Kenya is no exception when it comes to surge in population

as according to 2009 census, population was estimated at 40 million people from 1999 census of 28 million people.

Water resource development and management should be based on a participatory approach involving all relevant stakeholders for example, women plays a central role in provision, management and safeguarding water (ICWE, 1992). Furthermore, waste water management development polices have to take place within a multi- stakeholder set up; therefore the strategic plans needs to aim at achieving a sustainable and decent urban environment in Kenya.

The historical development of waste water management has been characterized by the efforts to solve mainly one problem at a time; sanitation during first half of 20th century followed by eutrophication of receiving waters for the past ten or so years, recycling of nutrients. After the Dublin Conference of Water and Environment (ICWE), in Dublin Ireland in 1992, a reversal of the debate occurred where water management was discussed in a more holistic manner (ICWE, 1992). Recently related mega conferences emphasized integrated approach to water resource management and the need to drastically reduce the number of people without adequate access to water and sanitation services. In addition, the need for ecological responsibility has evoked different responses by government and municipalities. Stricter regulations have resulted in huge investment in tertiary waste water treatment (WHO, 2000)

The growth of Nairobi city has surpassed the rate at which infrastructure is developed to meet the needs of the growing population. Urbanization, population growth, and industrialization are putting enormous pressure on the Nairobi Rivers – Mathare, Ngong, Athi and Kiu – the main source of water supply for the city. The rivers are heavily polluted from both domestic and industrial waste which is discharged directly into the rivers without being treated and adversely impacting its ecology. The existing sewer network infrastructure covers an approximate area of 208km² which is 30% of total coverage in the city. The Government of Kenya (GoK), recognizing the magnitude of the problem has requested the Bank for support to develop wastewater facilities in order to enhance the sustainable management of the Nairobi urban environment.

Developing countries are facing water related challenges more so fresh water sources pollution and decline in capacity as according to UNEP, up to 90% of waste water in developing countries flow untreated into rivers, lakes threatening safe drinking and bathing water (UNEP, 1997) and this is resulting to degradation of the water body ecosystems. Mathare North being an informal settlement in a city which is in a developing world (Nairobi Kenya), is not an exceptional due to inadequate wastewater infrastructures or mixed use of existing infrastructures

1.2 Problem Statement

Since 1950s, water use has more than tripled, according to World Health Organization (WHO) and UNICEF report of 2000, lack of access to safe drinking water affects the health of 1.2 billion people annually. In order to address these challenges there is need to improve the efficiency of consumptions and seek sustainable alternative sources. Several approaches exist among (GoK, EMCA 1999, 2002) efficient and effective wastewater management and reuse to supplement fresh water and keep environment clean. Nairobi being the capital city of Kenya is facing rapid population growth with population growth rate of 2.44% with a projected population of 43,013,341 (CIA World Fact Book, 2012) making it impossible for the population to receive adequate facilities needed like wastewater systems. Furthermore, there is inadequacy to treatment of the amount of industrial and municipal effluent entering surface waters like Mathare River making Nairobi lose its meaning which has changed from a place of cool waters to one which its water is no longer potable or fit for many other useful purposes.

It is critical that lessons learnt during the past century influence the design of future wastewater management systems as these lessons influence the decisions being made today which will impact future generations (Shanjay K. Sharma, 2012). Kenya has a flagship program of becoming middle income country by 2030. According to Vision 2030, social pillar seeks to create a just, cohesive and equitable social development in a clean and secure environment however under economic pillar; the country is aiming at achieving economic growth rate of 10 per cent per annum and maintaining the same till 2030 in order. This therefore will lead to increase in use of natural resources such as water hence requiring a strategy to incorporate waste water management with industrialization that Kenya is projected to attain moving from agriculture driven economy. Management of these new sources of wastewater needs to be mainstreamed into environmental conservation programs that are to be developed or that are already in place. Mathare north being an area of a mixed land use; establishment of business premises and residential units, wastewater generated need to be managed in the future as economic developments will expand when streamlined to Vision 2030 projections.

Depletion of water resources and wastewater generation from commercial and domestic centres bring into existence issues with resource conservation and wastewater management (Shanjay K. Sharma, 2012). Kenya's environment has suffered from the impacts of human activities; as according to Millennium Development Goal number 7C, Water pollution is one of the challenges environment is experiencing for example most of untreated waste water generated from Mathare North area in residential areas and Small and Medium Enterprises (SMEs) which are directed in storm water drainages ends up in environment therefore waste water generated from the residential units and industries should be managed in a sustainable manner to enhance environmental sustainability.

1.3 Research Questions

The following questions are to be used to come up with objectives that will be considered when collecting and collating data related to research study.

- a) Is there wastewater generated in Mathare North?
- b) Which wastewater collection systems are used in Mathare North?
- c) Which processes and methods of wastewater management are used?
- d) What is the purpose of wastewater management in Mathare North?

1.4 Research Objectives

The research objectives are to be used to direct researcher on type or kind of data to collect. The following are the objectives to the project.

Broad Objective

To use sustainable comprehensive solutions and integrated approach to realize waste water management so as to enhance human well- being and environmental well- being of the community.

1.4.1 Specific Objectives

- a) To investigate wastewater types, sources and volume
- b) To investigate wastewater management process.
- c) To investigate purpose of wastewater management
- d) To suggest better methods of wastewater management

1.5 Research Premises

Research premises are crucial for approving or disapproving the objectives of the study.

- a) There is no linkage between wastewater generation and environmental degradation.
- b) There is no wastewater collection system adopted to prevent discharge into the environment
- c) Wastewater generated ends up in environment.
- d) There are no factors influencing wastewater generation.
- e) There are no sustainable means for disposing off of wastewater.
- f) There are no better methods implemented on wastewater management.

1.6 Justification

According to Vision 2030, Kenya has a long term plan that is to make her a middle income country by 2030 and economy is supported by industrial developments moving from agricultural based economy. This has therefore facilitated need for management of waste water in line with development changes the

country is to undergo so that these developments do not hinder attainment of environmental sustainability in long term.

A better environment in our towns and cities not only enhances the quality of life for those who live there but also helps to relieve pressure on the country side (DOE 1995). The drastic growth of Nairobi population since inception of 1948 master plan that targeted 198,000 people compared to present estimated population of 3 million people (Government of Kenya, 2009) exerts pressure on environmental well being since clean environment is crucial to availability of environmental goods and services which underpin economic and social development; therefore improving and maintaining the environment's viability is essential for Kenya to adequately support its growing population and achieve its development plans (Steiner, 2006). This therefore calls for formulation, implementation and enforcement of policies, actions plans and legislations that are efficient and effective.

Population growth changes that Nairobi has experienced and continues to experience since its inception have increased resource consumption for instance following its founding in 1902, Nairobi took roughly 40 years to exceed a population of 100 000 people. By independence, 20 years later it had reached around 350 000 people (Olima, 2001). Rapidly increasing population has been ongoing since, surpassing one million in the 1980s, two million in the 1990s and now approaching three million residents. While the annual rate of growth has at times exceeded ten per cent, it has more recently decreased to below four per cent per year still very high by global standards. Nairobi is projected to top 3.8 million by 2015 ((Rakodi, 1997); (CBS, 2001). However, water consumption has increased due to the increase in demand and in the process there is increase in waste water generated which is channelled through sewer systems or discharged into the environment.

The city's wastewater management has not kept up with increasing demands from the growing population and is inadequate to treat the amount of industrial and municipal effluent entering the Nairobi River and other surface waters. Nairobi has changed from a "place of cool waters" to one in which the water is no longer potable or fit for many other useful purposes. There is discharge waste directly into environment more so water bodies. Industrial waste effluents include petro-chemicals and metals from micro-enterprises and "Jua-kali". As well, oil and grease from the busy roads run off into adjacent waters (Tibaijuka, 2007).

1.7 Significance

The study's main aim is to establish comprehensive and sustainable solutions to managing waste water by applying holistic approach and comprehensive solutions hence facilitating reduction of waste water

discharge into environment more so surface water and fragile and protected areas such as wetlands by advocating for sustainable use of water resource for domestic or industrial purposes.

The study will make it possible to attain alternative sources of water as according to United Nations, Water scarcity in Kenya has been an issue for decades as Kenya's natural water resources do not provide an equitable delivery of water to the various regions of the country and the country's water basins do not reach an equitable area of the country. This leaves most of the population without any fresh water.

Study will help push for formulation of policies through public participation by involving relevant stakeholders so as to ensure that the regulatory measures on waste water reuse and reclamation are adhered to.

At the end of the study, community will regard waste water as a resource rather than waste therefore having a stand- alone sector where issues related to waste water is streamlined into other sectors' developments for example; waste water generated in industrial areas is sustainably managed and this is attained through mandate placed upon institutions dealing with wastewater.

The study will help me as environmental planner and manager an opportunity in realization of intergenerational equity principle as the community will be involved in management of the environment.

1.8 Scope of the Study

The study is to be carried out in Mathare North's a residential units and small and medium enterprises established in the area so as to obtain data that covers different types and sources of waste water.

The study is to borrow concepts from previous comprehensive research on integrated water resource management and integrated wastewater management. The study will incorporate general principles that determine water resource management policies into the selection of waste water management interventions.

In addition, the study is to consider the holistic view of the entire waste water management starting from generation until ultimate wastewater disposal schemes and during the process incorporating sustainable and comprehensive solutions. The information required will be obtained from institutions that are mandated to manage water resources.

The study is to link water utilization to wastewater generation in order to develop sustainable ways of using available drinking water.

The research project will be carried out from September 2013 to April 2014.

1.9 Limitations

Insecurity- Mathare North being an informal settlement is facing the challenge of insecurity

Biasness- People tends to exaggerate information concerning any issue being questioned about.

Time limit- time allocated to collect data is minimal and the area to be covered and the extent of the amount of data to be obtained are large

Most of institutions were not willing to offer information

1.10 Definition of Terms

Environment	The sum total of all surroundings of a living organism, including natural forces and other living things, which provide conditions for development and growth as well as of danger and damage.
Environmental sustainability	Environmental sustainability involves making decisions and taking action that are in the interests of protecting the natural world, with particular emphasis on preserving the capability of the environment to support human life.
Integration	Creation of a single consolidated entity or one merged super program and thus getting rid of individual project program
Environmental management	Protection, conservation and suitable use of the various elements or components of the environment
Eutrophication	A process of pollution that occur when a lake or stream become over rich in plant nutrients; a consequence of wastewater discharge.
Fragile area	Important ecosystem with unique features and resources.
Waste water	By-product of many uses of water. There are the household uses, industrial. Storm water run- off
Waste water management	Encompasses a broad range of efforts that promote effective and responsible water use, treatment and disposal and encourage the protection of the nation's watershed
Population	Total member of a defined class of people in an area
Population growth	Change in a population over time, and can be quantified as the change in the number of individuals of any species in a population using "per unit time" for measurement
Reuse	Beneficial use of reclaimed or purified wastewater.
Management	Process of working with and through others to achieve organizational objective in a changing environment

Wetland	Wetlands are areas where the water saturates the ground long enough to support and maintain wetland vegetation such as reeds, bulrush, and cattails.
Non- formal schools	flexible complementary delivery channels of quality basic education to children in especially difficult circumstances, in particular those in need of special care and protection, or those who live or work in circumstances which make it impossible for them to access education through existing conventional formal school arrangements in terms of time, space, and entry requirements” (Gathenya, 2004)

2 Literature Review

2.1 Introduction

Densely populated or ecologically sensitive areas may require wastewater management therefore there is need for a well maintained wastewater collection system to help avert wastewater infiltration and ex-filtration into the environment due to the leaks which majorly results to fresh water pollution. However, other alternative wastewater management such as wastewater reuse, wastewater trade as well as wastewater treatment can be embraced to help in solving the problem of wastewater pollution facilitating environment and human well- being.

Dealing with waste as a resource is becoming a crucial factor in sustainable use of natural resources in that, wastewater is not only a source of water for different purposes but also a source or organic matter, nutrients and energy.

The information concerning the issues to be covered is to be obtained from secondary sources such as internet, books, journals etc

2.1.1 Wastewater types and sources

Wastewater is the liquid waste resulting from all activities using water supply. It is produced in every human society. Wastewater can be divided into different groups, according to its origin (e.g. surface runoff, grey and black waters).

Different types of wastewater are managed with different collection, treatment and disposal/reuse technologies and techniques.

2.1.1.1 Types

There are different wastewater types that need to be managed in order to curb environment pollution. These types are as follows;

2.1.1.1.1 Grey water

Grey water is all the wastewater produced in the home except toilet waste (Ridderstolpe, 2004). Grey water from dish washing, showers, sinks and laundry comprise the largest part of residential water. Amount of grey water produced in a household can vary greatly due to different water consumption patterns and this is always linked to social status of an area for example, water consumption in poor areas is about 20- 30 litres per day while a person in a richer area can generate several hundreds of litres per day (Ridderstolpe, 2004). Grey water normally contains low levels of nutrients compared with normal wastewater from water- borne systems. Levels of nitrogen and other plant nutrients are always low, but in some grey water high concentration of phosphorus can be found (Swedish EPA, 2002). Grey water

management can be achieved through undertaking of water conservation measures as well as managing soaps, cleansers and other household chemicals. To reach and control a conservative use of water, water saving equipments installed in a house should be combined with economical incentives e.g. charging system for water consumed.

Grey water treatment and reuse for example as part of ecological sanitation (ecosan) concepts, is a relatively new concept which is often considered as a more simple form of wastewater treatment, but there is still a lack of experience. Most grey water treatment technologies are derived from conventional wastewater treatment and were not developed specifically for grey water treatment. The quantity of grey water generated depends on the income level of the household. As a general rule: the richer the people, the more grey water they produce. Households without in-house water connection produce grey water which is more concentrated than wastewater from wealthy areas, due to the lower water consumption and existing reuse practices: Water is first used for personal hygiene, then for washing clothes and then for washing the floor.

2.1.1.1.2 Black water

According to Consortium of Institutes for Decentralized Wastewater Treatment (CIDWT, 2004), black water is portion of the wastewater stream that originates from toilet fixtures, dish-washers and food preparation sinks. Black water and its quantity depend on the flush toilet type. Normally the volume varies between 40-60 L/capita/day.

2.1.1.1.3 Storm water

Urbanization has well known adverse hydrological effects (Leopold, 1968); (Klein, 1979). Increase in the peak rate of storm water run- off due to introduction of impervious areas and to improved drainage system has been the main management focus (Ferguson, 1990); Booth and Jackson, 1997). Mathare North being one of the informal settlements in Nairobi consists of high density residential (flats) hence limited unpaved open spaces are left to carter for the infiltration of the storm run- off which carries with it oil from vehicle oil leaks therefore the run- off is directed into the storm drainages which eventually pollute fresh water.

2.1.1.2 Sources

Wastewater is generated from different sources and these are household wastewater (domestic) and water from the rain which are untapped.

2.1.1.2.1 Domestic

Domestic wastewater originates from domestic household activities as well as water that are discharged from commercial and business buildings and institutions. Domestic wastewater consists of liquid discharge from sanitary facilities, bathing, laundry and cooking. Mathare North majorly being a residential area is generating domestic water. Domestic wastewater is majorly composed of grey and black water.

2.1.1.2.2 Surface water run-off

During the past few years it has been recognized that run off from storms is not rain water in terms of quality. Storm runoff contains substantial quantities of impurities so much that it is a more serious source of pollutants in many areas than are municipal wastes. Urban runoff can contribute to a variety of problems including direct pollution of receiving waters, overloading of treatment facilities and impairment of sewer and catch basin functions (James D. Sartor, 1974).

2.1.2 Wastewater management process

For a successful management of wastewater, there is need for wastewater collection system for channelling wastewater to the required area that is sewerage plant for its treatment to prevent wastewater discharge into the environment while in its raw form to avoid environmental degradation.

2.1.2.1 Wastewater collection systems

There are different types of wastewater collection systems used in channelling wastewater. These are:

2.1.2.1.1 Sewer system

Wastewater collection systems are responsible for collection and transmission of liquid wastes to a central treatment facility. Like a distribution system for water supply, the collection system resembles a tree that branches out from the treatment plant to collect the wastewater from individuals. Wastewater from individual homes enters the collection system from a service line. Complexity of the system depends on the size of the community and the type of the system selected. None the less some storm water enters sanitary sewers through cracks, particularly in older lines, and through roof and basement drains. Due to the much smaller volumes of wastewater that pass through sanitary sewer lines compared to combined sewers, sanitary sewer systems use smaller pipes and lower the cost of collecting wastewater

2.1.2.1.2 Drainage systems

Conventional drainage systems are designed to achieve a single objective — flood control during large, infrequent storms. This objective is met by conveying and/or detaining peak runoff from large, infrequent storms. Drainage systems designed to meet a single flood control objective fail to address the

environmental effects of increases in runoff volume and velocity caused by development, as well as flow peaks. Increased runoff from small, frequent storms erodes urban streams and washes eroded sediment and other constituents from the urban landscape into downstream receiving waters, often damaging adjoining property and impairing their use by people and wildlife. Today's drainage systems must cost-effectively manage flooding, control stream bank erosion, and protect water quality. To do this, designers must integrate conventional flood control strategies for large, infrequent storms with three basic storm water quality control strategies for small, frequent storms that is: *infiltrate runoff into the soil, retain/detain runoff for later release, convey runoff slowly through vegetation*

2.1.2.1.3 Combined (sewer and drainage) systems

Many of the earliest sewer systems were combined sewers, designed to collect both sanitary wastewater and storm water runoff in a single system. These combined sewer systems are designed to provide storm drainage from streets and roofs to prevent flooding in cities. Later, lines were added to carry domestic wastewater away from homes and businesses.

Early sanitarians thought that these combined systems provided adequate health protection. We now know that the overflows designed to release excess flow during rains also release pathogens and other pollutants.

2.1.2.2 Wastewater treatment

Waste treatment is now the world's most common "biotechnology" (Wagner et al, 2002); in the US alone, over 15 000 wastewater treatment facilities collectively process 100 billion Litres of wastewater per day (Gabriel, 1999). Despite the massive scale of the wastewater treatment industry, only modest advances have occurred in our basic understanding of these biological treatment processes during the past century or so.

Wastewater treatment systems were first developed in response to the adverse conditions caused by the discharge of raw effluents to water bodies. With this approach, treatment is aimed at the removal of biodegradable organic compounds, suspended and floatable material, nutrients and pathogens.

Wastewater treatment technologies can be designed to provide low cost sanitation and environmental protection. Wastewater treatment systems are classified into different principal types and these are: mechanical treatment system, aquatic system and terrestrial system.

2.1.2.2.1 Mechanical Treatment Technology

Mechanical systems utilize a combination of physical, biological, and chemical processes to achieve the treatment objectives. Using essentially natural processes within an artificial environment, mechanical

treatment technologies use a series of tanks, along with pumps, blowers, screens, grinders, and other mechanical components, to treat wastewaters. Flow of wastewater in the system is controlled by various types of instrumentation. Sequencing batch reactors (SBR), oxidation ditches, and extended aeration systems are all variations of the activated-sludge process, which is a suspended-growth system. The trickling filter solids contact process (TF-SCP), in contrast, is an attached-growth system. These treatment systems are effective where land is at a premium.

2.1.2.2.2 Aquatic Treatment Technologies

According to Source Book of Alternative Technologies for Freshwater Augmentation in Latin America and the Caribbean of 1997, Facultative lagoons are the most common form of aquatic treatment-lagoon technology currently in use. However, there are other technologies such as aerated lagoons and constructed wetlands.

2.1.2.2.3 Terrestrial Systems (Land Treatment System)

Land treatment is the controlled application of wastewater to the soil where physical, chemical, and biological processes treat the wastewater as it passes across or through the soil. Terrestrial treatment systems include **slow-rate overland flow**, **slow-rate subsurface infiltration**, and **rapid infiltration methods**. They depend upon physical, chemical, and biological reactions on and within the soil. Slow-rate overland flow systems require vegetation, both to take up nutrients and other contaminants and to slow the passage of the effluent across the land surface to ensure maximum contact times between the effluents and the plants/soils. Slow-rate subsurface infiltration systems and rapid infiltration systems are "zero discharge" systems that rarely discharge effluents directly to streams or other surface waters. Each system has different constraints regarding soil permeability. In slow-rate systems, either primary or secondary wastewater is applied at a controlled rate, either by sprinklers or by flooding of furrows, to a vegetated land surface of moderate to low permeability. The wastewater is treated as it passes through the soil by filtration, adsorption, ion exchange, precipitation, microbial action, and plant uptake. Vegetation is a critical component of the process and serves to extract nutrients, reduce erosion, and maintain soil permeability. Overland flow systems are a land application treatment method in which treated effluents are eventually discharged to surface water. In rapid infiltration systems, most of the applied wastewater percolates through the soil, and the treated effluent drains naturally to surface waters or recharges the groundwater. Wastewater is applied to soils that are moderately or highly permeable by spreading in basins or by sprinkling. Vegetation is not necessary, but it does not cause a problem if present. The major treatment goal is to convert ammonia nitrogen in the water to nitrate nitrogen before discharging to the receiving water. Subsurface infiltration systems are designed for municipalities of less than 2,500 people. They are usually designed for individual homes (septic tanks), but they can be designed for clusters of

homes. Although they do require specific site conditions, they can be low-cost methods of wastewater disposal (UNEP, 1997).

2.1.3 Purpose of wastewater management

According to the United Nations Population Fund (UNFPA), human impact on the environment is a function of population size, per capita consumption and the environmental damage caused by the technology used to produce what is consumed (UNFPA, 2001)

The environmental problems associated with urban areas are a consequence of the number of people's activities and Mathare North residents have been involved in environmental degradation such as pollution of portable water from wastewater. The environmental consequences of population growth are amplified by the growth in numbers. Rapid increase in population, as has been witnessed in Nairobi since independence, has led to unprecedented sprawl of informal settlements; outstripped the city's delivery of social services. The following are the facilitators of need for wastewater management.

2.1.3.1 Rapid population growth

The world's urban population reached 2.9 billion in 2000 and is expected to rise to 5 billion by 2030. Whereas 30 per cent of the world population lived in urban areas in 1950, the proportion of urban dwellers rose to 47 per cent by 2000 and is projected to attain 60 per cent by 2030 (United Nations, 2001). Population growth will be particularly rapid in the urban areas of less developed regions, averaging 2.4 per cent per year during 2000- 2030, consistent with a doubling time of 29 years. Rural-urban migration and the transformation of rural settlements into cities are important determinants of the high population growth expected in urban areas of the less developed regions over the next thirty years. In combination with the universal reduction of fertility levels that are expected to occur in the future (United Nations, 2001). The accumulation of people, their consumption patterns, travel behavior and their urban economic activities have a large impact on the environment in terms of resource consumption and waste discharges as implications of rapid urban growth include increasing unemployment, environmental degradation, lack of urban services, overburdening of existing infrastructure and lack of access to land, finance and adequate shelter (UNCHS, 2001). Managing the urban environment sustainably will therefore become one of the major challenges for the future as population is a major driver of environmental change in Nairobi and as such is a determinant of other parameters such as solid-waste-generation rates, land-use patterns and settlement, and water consumption.

2.1.3.2 Urbanization

Urbanization is one of the most important demographic trends of the twenty-first century, and growth is particularly rapid in lower-income countries. The majority of urban growth is associated with the rapid

expansion of smaller urban centers and peri-urban developments which are unplanned and informal, with community members and informal-sector developers taking advantage of the fact that the regulatory capacity of government authorities is weak, particularly in those areas that are outside official municipal boundaries.

In urban and peri-urban areas, increasing populations, combined with increasing water consumption and a proliferation of waterborne sanitation, create widespread wastewater disposal problems. In many cases, wastewater is discharged locally onto open ground and vacant plots, creating ponds of foul-smelling stagnant water. Health risks are increased by the fact that household and surface water drainage systems are invariably combined, so that floodwater becomes contaminated with excreta (United Nations, 2001).

2.1.3.3 Social inequality of the population

Human well-being requires a healthy environment. Inadequate sanitation practices negatively impact the environment. For poor families living in congested urban slums and in villages, the lack of any sanitation facility means that waste lies on the streets, clogs the drains and creates an immediate local hazard which is one of the major pollutants and clogging of drainage systems in Mathare North as show in plate 7 in appendix.

Settlements are generally inhabited by communities of different economic status relating to land prices, which are affected by location in relation to the city, and which are considerably higher than in rural areas.

Many industries locate on the edge of the city because land there is relatively cheap and not subject to stringent development controls and, at present, the wastes they produce rarely receive adequate treatment. The limited infrastructure facilities that are provided are often inadequate, and the result is a poor and often deteriorating environment. Provision of infrastructure and services tends to occur in a piecemeal fashion, either through the efforts of residents themselves or as a result of pressure from civil society on elected representatives and government officials. However, even where household sanitation and localized drainage facilities do exist, often there is a lack of a comprehensive system for the collection and disposal of wastewater (United Nations, 2001).

2.1.3.4 Environmental degradation

Urban areas do not have only local environmental impacts but also large so-called ‘ecological footprints’ (WWF, 2000). Waterborne sewage uses scarce freshwater resources and may contaminate surface waters when it is discharged into the environment without adequate treatment – thus endangering downstream users and aquatic resources. The lack of infrastructure and services and effective systems for managing wastewater has led to widespread pollution of surface water and groundwater and deterioration in

environmental health conditions. The greatest impacts are upon the health and livelihoods of poor communities, who often inhabit low lying and marginal land, for instance wetlands and alongside drainage channels, which are polluted with excreta and other wastewater (Birley, 1998). In addition, Pollution from urban run-off and untreated discharges of industries has adversely affected many water bodies, leaving many cities with unsafe water supply.

2.1.3.5 Segregation of wastewater at source

Domestic wastewater consists of “black” water, the mixture of water and faeces flushed from Water Containers and pour-flush toilets, and “grey” water, the sullage from kitchens and bathrooms. Grey water contains much lower pathogen levels and has a lower oxygen demand than black water and therefore represents a much smaller health and/or environmental threat. Grey water and black water are produced separately, and ensuring that they remain separate can facilitate management of the two wastewater streams. This option may be considered where it is possible to dispose of black water to a leach pit or septic tank followed by a soak away. Grey water can then be used for irrigation or discharged into a local watercourse with little or no treatment (Weisburd, 2000)

2.2 Theoretical Framework

2.2.1 Holistic approach

Sustainable management of water requires the involvement and incorporation of stakeholders during decision making stage when formulating policies and legislations and establishment of effective water institutions, development of low water usage or dry sanitation system, rain water harvesting and extensive use of resource recovery and reuse technique for waste water (Lens et al, 2001). The holistic approach sees waste as a resource and its management linked to that of water resources and of nutrients in that resource recovery and reuse result in financial incentives which could be used to cover part of the cost of waste water treatment (FAO, 1999). There has also been an increased emphasis on a more holistic approach to waste disposal that stresses the benefits of reducing the strength or quantity of waste at source and, where possible, recycling or re-using it close to the point where it is produced (Kalbermatten, 1999).

2.2.2 Ecosystem- Based Management and Wastewater

Ecosystem- based management is an integrated approach to management that considers entire ecosystem, including humans. The goals of ecosystem-based management are to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. It acknowledges interconnectedness between systems such as air, land and water and integrates ecological, social, economic and institutional perspectives, recognizing their strong interdependences (COMPASS, 2005). Tackling the broad and cross- sectoral nature of wastewater and its management successfully and sustainably requires an ecosystem based perspective, applied to integrated natural resource management.

Due to the environmental changes that were experienced in late 1950s and early 1960s brought attention to the world leaders and inhabitants that day- to- day activities are impacting on environmental well-being. This scenario thereby led to the enactment and development of international agreements which highlighted the impacts that population has and will have on environment. For example Tragedy of the Commons (Hardin, 1968) and Limits of Growth (Donella H.Meadows et al, 1972) had warned of the possibility that human lifestyle would exceed the capacity of the natural environment to sustain itself. The conformation of this is documented (Meadows et al, 2004)in the book, Limits to Growth which is a 30-year update.

Lack of well managed or protected ecosystems can mean loss of clean water and loss of river waters. Some of key impacts of wastewater discharge on ecosystem relate to eutrophication. Discharge of wastewater into an environment exceeding the natural purification capacity of the environment results in the accumulation of organic materials that cannot be absorbed by ecosystem.

2.2.3 Planning for Wastewater Management

From examining how sanitation problems develop in a community, it becomes obvious that they are related to population density relative to the ability of the environment to cope with the wastes generated, and the ability of the community to respond to the problems that arise.

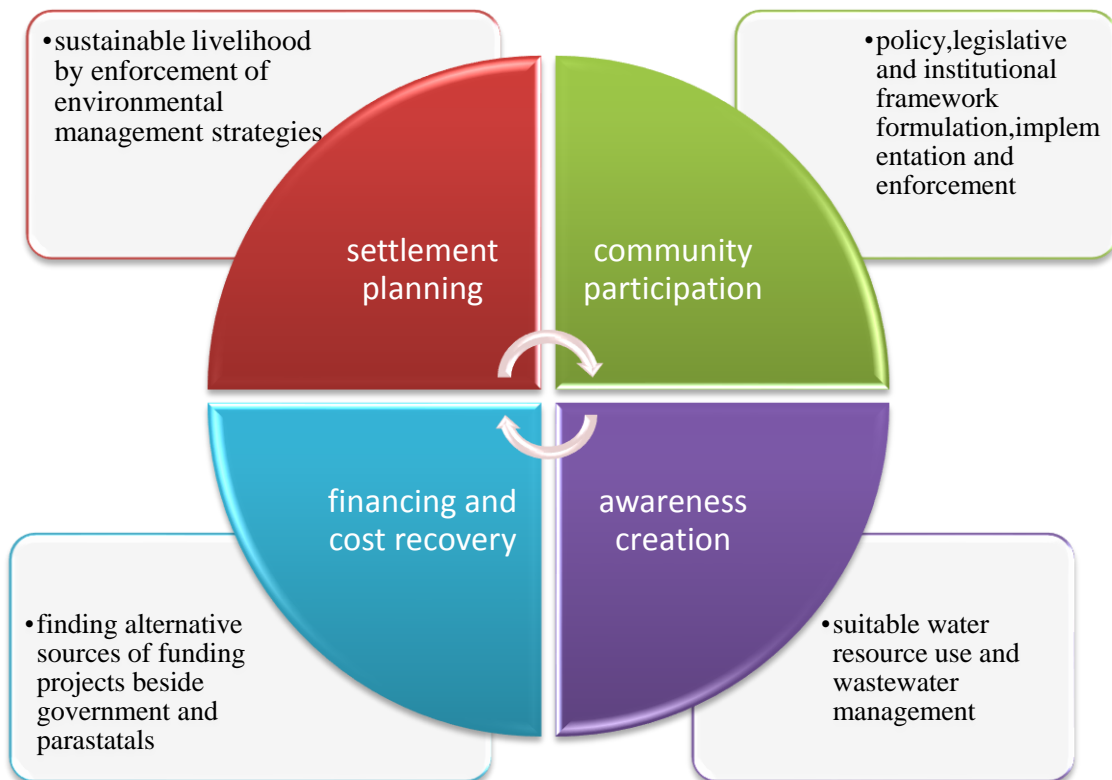
Thus, besides the public health and environmental aspects that have been discussed, there are the social and institutional dimensions that have to be taken into account. These refer to the way communities organize themselves to manage their common affairs, such as arranging collection of household wastes, laying of sewer pipes, and financing these activities. Each community has generally developed means of carrying out these tasks, which may be unique to a particular community or communities in a region. The institutional arrangements in a community evolve with time to meet changes in culture and technology, and may or may not cope with external changes. One such change is rapid urbanization, which leads to rapid population growth in a relatively small area, leading to severe sanitation problems (UNEP, 1997)

2.3 Conceptual framework

Wastewater management requires understanding cross-cutting issues and in this case, the study is to indulge into holistic approach in relation to wastewater management which incorporates planning, control and ecosystem-based management approaches.

In relation to UNEP GPA 'Recommendations for decision making on municipal wastewater' / UNDP/WB 'Resource Guide in Urban Environmental Sanitation', cross cutting issues that have been covered are settlement planning, community participation and hygiene promotion and financing and cost recovery. However during undertaking of any development in relation to wastewater management, environment's well-being should be considered.

Planning appears to be a major and key issue for a community to address. Ideally settlements should be planned ahead of their occupation. Areas should be set aside for treatment and disposal of wastes; community should be involved so that services that are provided is what is needed by community and sanitation services require investment and continuing costs of operation and maintenance. All these measures are crucial in attaining environmental sustainability.



3 Area of Study

3.1 Introduction

Nairobi is the capital and largest city of Kenya. The city and its surrounding area also form the Nairobi County. The name "Nairobi" comes from the Maasai phrase Enkare Nyirobi, which translates to "the place of cool waters". However, it is popularly known as the "Green City in the Sun" and is surrounded by several expanding developments such as residential and commercial units. Nairobi is the most populous city in East Africa, with a current estimated population of about 3 million. According to the 2009 Census, in the administrative area of Nairobi, 3,138,295 inhabitants lived within 696 km² (CBS, 2001).

Location

Nairobi is located at the south-eastern end of Kenya's agricultural heartland, at approximately

1° 9'S, 1° 28'S and 36° 4'E, 37° 10'E and the altitude varies between 1,600 and 1,850 metres above sea level (Mitullah, 2003)

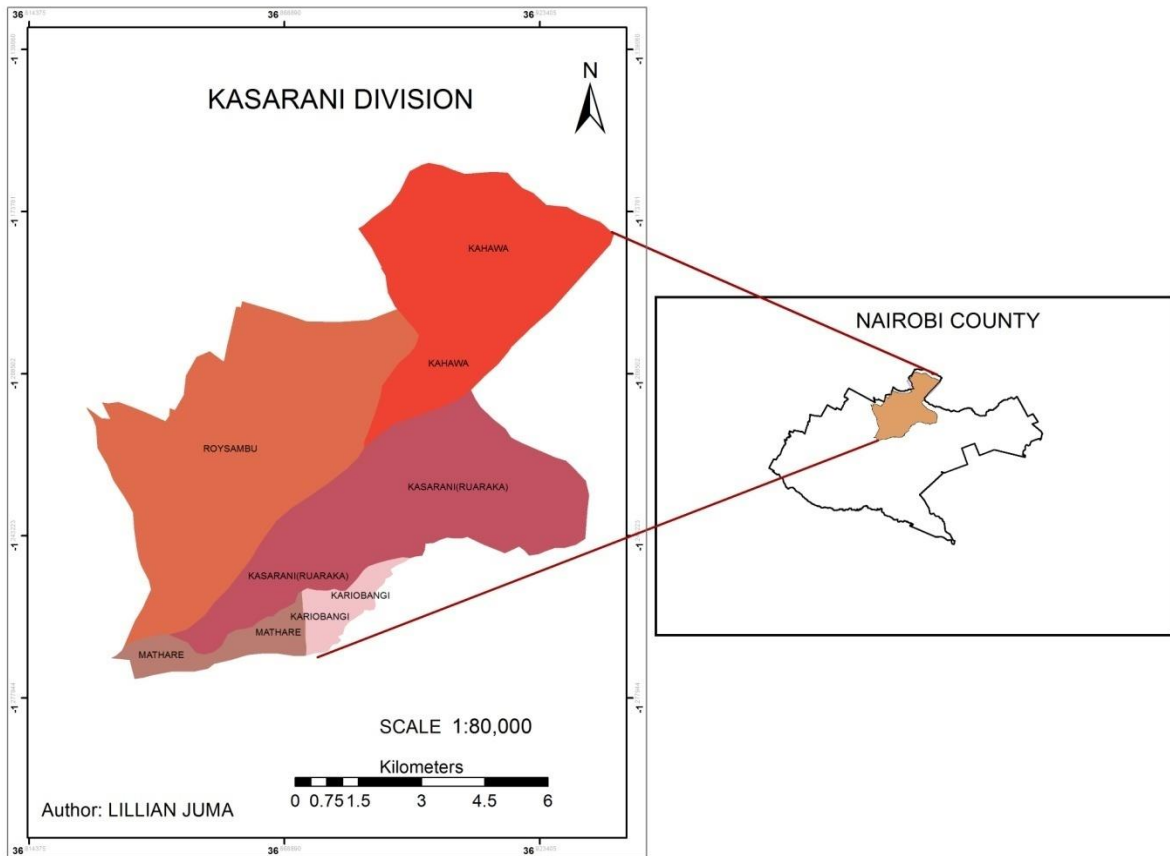


Figure 1: Map of Kasarani Division showing location of Mathare North

3.2 Bio- Physical environment

The Nairobi city is located within the Athi River Catchment and is traversed by three key rivers namely Nairobi, Mathare and Ngong. All the existing trunk sewers run along the riparian reserve of these rivers, posing health risks to population as raw sewage from defective sewers automatically flows into the rivers by gravity causing river pollution. Currently, the rivers experience heavy pollution from both domestic and industrial point sources and from agriculture non-point sources which have turned the colours of the water to greening indicating eutrophication and high content of Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and high turbidity levels. Odors from the rivers also indicate high levels of pollution. Currently, most sections of the rivers are covered by solid waste which is adversely affected the river run-off.

3.2.1 Topography

The western part of Nairobi is on high ground (approximately 1700–1800 msl) with rugged topography, the eastern side is generally low (approximately 1600 msl) and flat (Saggerson, 1991)

3.2.2 Climate

At 1,795 meters above sea level, Nairobi experiences a moderate climate. Under the Koppen climate classification, Nairobi has a subtropical highland climate. The mean daily temperature ranges between 12 and 26°C. It is usually dry and cold between July and August, but hot and dry in January and February (CBS, 2003). There are two rainy seasons but rainfall can be moderate. The long rains form the first season and fall in the months of March to May, and the short rains forming the second rainy season, fall between October and December. The cloudiest part of the year is just after the first rainy season, when, until September, conditions are usually overcast with light drizzles. The mean annual rainfall ranges between 850- 1050mm (Lakin undated).

The mean monthly relative humidity varies between 36 and 55 per cent. The mean daily sunshine hours varies between 3.4 and 9.5 hours (CBS, 2003). The cloudiest part of the year is just after the first rainy season, when, until September, conditions are usually overcast with drizzle. As Nairobi is located close to the Equator, the differences between the seasons are minimal. Climatic conditions more so rainy patterns is essential as during rainy seasons, this is because, wastewater volume increases due to storm water runoff which is not harvested in Mathare North.

3.3 Geophysical environment

3.3.1 Drainage

Nairobi's main drainage follows the regional slope of the volcanic rocks towards the east, while subsidiary internal drainage into the Rift region is confined to the western part (Saggerson, 1991). Water draining eastward from the hill area accumulates on the low-lying ground between Parklands in the north and Nairobi South estate, forming a perched water table above the Nairobi phonolite. The Kerichwa Valley Tuffs lying to the east of the highway function like a sponge and the contact between them and the underlying impermeable phonolite thus forms a perfect aquifer, so much so that a number of channels containing water occur beneath Nairobi (Saggerson, 1991) which can be used as source of water for use in Nairobi thereby wastewater discharge into the environment should be managed in order to prevent pollution of water in this aquifer through polluted water infiltration.

3.3.2 Soils

The soils of the Nairobi area are products of weathering of mainly volcanic rocks. Weathering has produced red soils that reach more than 50 feet (15m) in thickness (Saggerson, 1991). The project will not

cause physical change to the environment because the topography, slope and stability of the soils will be maintained.

The rocks in the Nairobi area mainly comprise a succession of lavas and Pyroclastics of the Cainozoic age and overlying the foundation of folded Precambrian schist's and gneisses of the Mozambique belt (Saggerson, 1991).

3.3.3 Population dynamics

The population of Nairobi grew from 8,000 in 1901 to 118,579 in 1948 (Rakodi, 1997). By 1962, the city had a population of 343,500 people, although some of this could be attributed to extension of the city's boundaries. Between the 1948 and 1962 censuses, the population grew at an average rate of 5.9 per cent per annum, compared with 7.6 per cent in the previous 12-year period. Taking the 1999 census figures as a baseline, it is projected that the city's population by the next census in 2009 will be about 3.1 million, and 3.8 million by 2015 (CBS, 2001). Although it covers only 0.1 per cent of Kenya's total surface area, Nairobi already has about 8 per cent of the country's total population (CBS, 2001) and 25 per cent of Kenya's urban population (UNCHS, 2001) Population distribution.

Nairobi's population distribution is that in some areas of the city, the population density is quite high. The population dynamics have been faced in Mathare North as well being one of informal settlements in Nairobi.

3.3.4 Age Structure

Nairobi's population is young, with 56.5 per cent of the population below the age of 24 years (CBS, 2003). The youthful structure of the population causes high dependency ratios and is responsible for high unemployment rates and demands for education, housing, health, transport and other social amenities.

3.4 Infrastructure

Infrastructure comprises road and railway networks, water supply, power supply and telecommunication systems, sewerage networks and treatment works and airports.

Infrastructure and the provision of services, such as energy, transport, provision of water and sanitation and safe disposal of waste, underpin growth, the improvement of livelihoods and urban development.

Infrastructure development has in the past been the preserve of the government. Provision and maintenance of infrastructure has been a major problem, especially within low-income urban areas. Poor infrastructure is a major constraint on economic performance and a major factor compounding poverty. Components of infrastructure and services discussed in this section are energy supply, transport (access roads), information and communication technology, water supply, sanitation, health and education.

Community (Mathare North) should be involved in management of wastewater collection systems to avoid being in a dilapidated state.

3.5 Economy

The lower income group constitutes about 80 per cent of the population in Nairobi. As Nairobi's population increases, so does the demand for jobs. Currently, 56.6 per cent of women and 68.6 per cent of men aged between 15 and 50 are economically active (CBS *et al.* 2004). Between 1989 and 1997, the combined formal and informal sector employment growth in Nairobi was 2.3 per cent per annum, less than half that of the rate of population growth (Birley, 1998). It is estimated that about 500,000 people join the labour force annually. Most of these are unable to secure employment and thus remain unemployed or end up in traditional agriculture and in the informal sector (Odhiambo, W, and Manda, D.K, 2003) therefore paying

3.6 Education

Illiteracy rates in Nairobi for the 15–54 age groups are 7.8 per cent for women and 5.8 per cent for men. Illiteracy levels are lowest in Nairobi, compared to the rest of the country: 21 per cent for women and 12 per cent for males. 56.4 per cent of women and 67.3 of men have attended secondary school and above, compared with 48.2 and 57.7 per cent respectively for urban areas in general in Kenya (CBS, 2003). Non-formal schools especially those that cater for children in urban slums, are important if the millennium development goal number 2 of Universal Primary Education by 2015 is to be achieved. In Nairobi, 91.4 per cent of non-formal education schools are supported by various civil society groups, 6 per cent by the Government and only 2 per cent by the local authority (Ogachi, 2002). A high literacy level makes it possible for information dissemination in relation to importance of wastewater management amongst people in the community.

4 Methodology

4.1 Introduction

This study covered carrying out reconnaissance, research approach, research design, research types and nature and sources of data.

There was application of research techniques as well as determining which of these methods or techniques are relevant and which are not.

4.1.1 Key Subjects

The principle subjects of this research process who are the primary source of our data. They involved:

Local Community

This involved the residents of our area of interest (AOI). This included locals who reside in the area as well as the business people who carry out their activities during the day but reside outside Mathare North.

Local Administrators (Chief, County representative,)

The area's administrators were informed of the research survey and include them during the survey process. The local administration helped in providing crucial information such as demographic statistics among others.

Community Based Organizations (CBOs)

CBOs such as Progressive Volunteers and Mayudo Youth Group played an important role in providing data relevant to the research study for example PV having an insight into state of economy of Ruaraka was able hence offering better understanding of economic status of people and economic activities carried out in the area.

Nairobi water and Sewerage Company

The company helped in giving data on the issues of wastewater management and water utilization in Mathare North.

Nairobi Water and Sewerage Company is mandated in ensuring water distribution

Nairobi County Government

Since the inception of constitution in 2010, county government are mandated carry out developments for economic prosperity of the regions hence the purpose of visiting NCG is to get information concerning by- laws and policies that are in place or that are being conceptualized to realize wastewater management.

There are no by-laws in place in relation to wastewater management as the mandate is given to Nairobi water and Sewerage Company.

National Environment Management Authority

According to NEMA, Nairobi wastewater quality should fall under its guidelines to be allowed to be discharged or used as nitrates and TDS fall under acceptable NEMA standards. Therefore this research involved NEMA online data on wastewater quality regulations which helped in ensuring recommendations are streamlined to NEMA's guidelines.

4.2 Research Approaches

Methodology is generally a guideline for solving a problem; involved data collection, presentation, analysis and interpretation. It can be qualitative or quantitative. This chapter therefore describes the methods and procedures used during the study, most significant in achieving the set research objectives and goals as per the requirement of the study.

4.2.1 Qualitative research

It concerned systematic collection, analysis and account of social events and objective research in a natural setting. The management of water in urban areas has quantitative and qualitative dimensions, both of which require careful planning if the concept of sustainable cities is to be realized in the future. Urban water management (UWM) involves the qualitative that is hygiene of the environment as caused by wastewater release to human and environmental well-being.

4.2.2 Quantitative research

Quantitative research methods were used when obtaining a large body of data to produce results that are generalized to a target population for example survey. In quantitative research, aspects of all water in urban settings (Nhapi I. H., 2002) included sources of waste water, amount generated, amount treated and disposal mechanism of the waste water.

Therefore the study adopted both the quantitative and qualitative approaches as the waste water cycle is to be studied and analysed from generation to disposal and incorporating factors influencing waste water management in order to develop a sustainable solution to the problem of wastewater discharge into the environment.

4.3 Research Design

Research design is mode of data collection. The purpose of research design in both descriptive and explanatory research and in explanatory research, the purpose is to develop and evaluate causal theories.

This research study employed:

4.3.1 Survey design

Survey was used to gather systematic factual information by interviewing or administering questionnaires to sample of individuals. The methodology entailed collection of both primary and secondary data. The samples are at the appendix.

4.3.2 Sampling design

Sampling is where sampling units of study is selected from sampling frame of a population (R.Panneerselvam, 2004). Simple random and cluster sampling technique were employed to select the households as well since Mathare North is divided into areas 1, 2, 3 hence data collection was conducted in every area while systematic sampling was used to select the various organizations relevant to the research.

4.4 Nature of Data

Data collected and analysed seek to address stated objectives

Objectives	Nature of Data
1. To investigate wastewater types, sources and volume.	Characteristics; domestic, commercial users; water saving technologies used; average wastewater amount generated per capita per day.
2. To investigate wastewater management process.	Wastewater systems; maintenance of wastewater systems; challenges faced;
3. To investigate purpose of wastewater management.	Population growth analysis; water utilization; economic activities; climatic conditions; environmental degradation
4. To suggest better methods of wastewater management	Wastewater treatment/ recycling; wastewater reuse; management techniques; wastewater trade

4.5 Sources of Data

These are types of data that were collected and used where environment is at stake. The data collected in this study are: demographic information, wastewater systems status, water utilization, wastewater reuse and methods of wastewater disposal.

The information required was obtained through observations or user interviews.

4.5.1 Data collection

The reliability of decisions concerning any issue depends on the quality of data. Quality of data can be expressed in terms of its representative feature of the reality which can be assured by usage of a fitting data collection method. Data can be classified into primary data and secondary data.

4.5.1.1 Primary data

Primary data was gathered from the field through interviews and other data collection tools like surveys. Primary data are useful for current studies and future studies.

4.5.1.1.1 Instruments of primary data collection

Direct observation- researcher went to the field and obtained information about the problem through observation. For example information collected about wastewater releases into environment. In this study, information was retrieved from day- to- day activities by residents as well as small and medium entrepreneurs by observing their behaviour concerning wastewater management in order to assess their valuation of the environment.

Personal survey- is a survey method of data collection which employs a questionnaire. There was use of self administered questionnaires.

Questionnaire design- The success of a survey used depends on the strength of a questionnaire used. Questionnaires were used to ascertain facts, opinions, beliefs, attitude and practice about the study area. Structured questionnaires were used to collect education levels and income levels among other parameters. Closed ended questions were used preferably because of the precision and factual nature of answers provided; Open ended questions were included answers that require insight into the issue being deliberated on. An example of a questionnaire sample used is at the appendix.

Scheduled Interviews- This involved verbal interaction between the researcher and the respondents who varied from residents, municipal council, local CBOs to relevant government agencies. Example of interview questions used is presented by a sample at the appendix.

Photography- Photography was used to capture the real situation on the ground such as the waste water discharge into the environment, state of wastewater collection systems.

Mapping and Inventory taking: was used to determine scope of the study area that is in dire need of waste water management by relating waste water to amount of water used and population number of the specific area.

4.5.1.2 Secondary data

Secondary data was collected from sources which have already been created for the purpose for the first-time use and future uses. Secondary data was obtained from ministries and agencies websites who are mandated on ensuring water resources management and waste management; old documents on integrated water resource management and documents on wastewater related issues.

4.5.1.2.1 Instruments of secondary data collection

Secondary data were sourced from different materials for example literature (books, journals), institutional data (reports, topographical sheets, national demographic database), and tertiary data (internet).

4.6 Data Processing and Analysis

After data collection, proper tools and techniques were used for classification and analysis of data. Most of the questions in the questionnaire were closed with few open ended ones. In order to set the responses for analysis, the answers were transcribed, grouped and coded depending on the topic.

4.6.1 Methods of Data Analysis and Presentation

Qualitative and quantitative methods were incorporated to analyze the information gathered from the respondents.

Data presentation was done through pie charts, graphs, photographs and maps.

Processing and analysis involved:

Sorting data: this entailed ordering of questionnaires and other field records for the purpose of subsequent processing and analysis. The questionnaires were numbered and arranged systematically.

5 Data Analysis and Discussion

5.1 Introduction

This chapter presents the analysis of data collected from a research conducted in Mathare North. The main purpose of the study was to use sustainable comprehensive solutions and integrated approach in realizing waste water management. Furthermore, the study is aimed at: investigating wastewater types, sources and volume; investigating wastewater management process; investigating purpose of wastewater management and suggesting better methods of wastewater management. Lastly, the findings from this study can be relied upon to make major decisions in development by both national and county governments.

Study findings show that; three quarters of wastewater generated ends up in environment; wastewater discharge more so grey water and black water into Mathare River is one of the contributors of its water pollution; environmental issues have been addressed as a reactive mechanism as part of project safeguards but not as integrated elements of water and waste water planning and development and their enforcement has generally been very weak. In addition, most of the rented units in Mathare North are small in size in that the room measurements range between 10ft by 10ft and 12ft by 12ft. Therefore one of the strategies adopted by most residential unit owners to ensure accessibility of water for use is that, there is establishment of water point placed at a given area of a residential unit where every lessee accesses water from this point.

During the study, 50 questionnaires were used; 30 household questionnaires and 20 business questionnaires. 50% of the correspondents were women and 46% men and 4% empowerment groups.

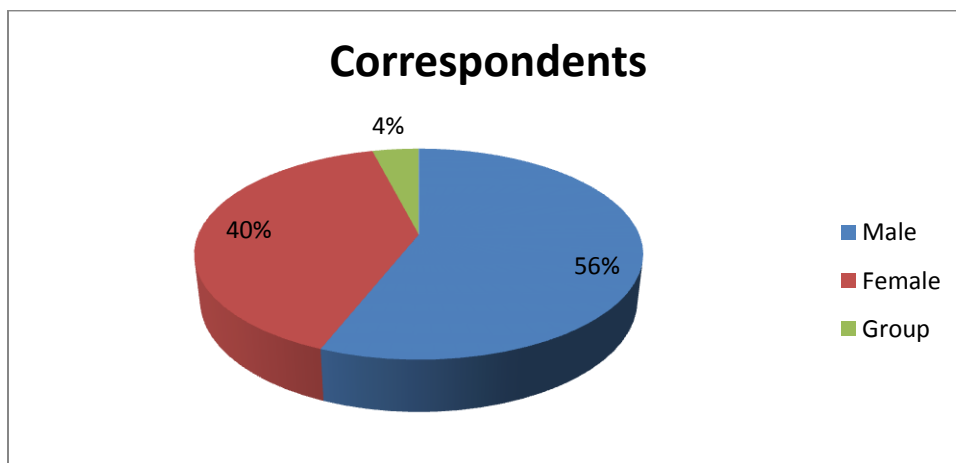


Figure 2: Pie chart showing number of Correspondents

Source: field study

Most of Mathare North residents are youths whose ages mostly range between 20 years and 45 years; this is according to study undertaken in the field. This information is essential since youths are innovative, willing to learn about new developments and are energetic. In addition, they have a desire in wastewater management initiatives enforcement and implementation.

According to correspondents, reasons for settling in Mathare North are; some are landlords and care takers of residential units, affordability of a housing unit, and accessibility of the area due to road connectivity, proximity to town centre and proximity to work place.

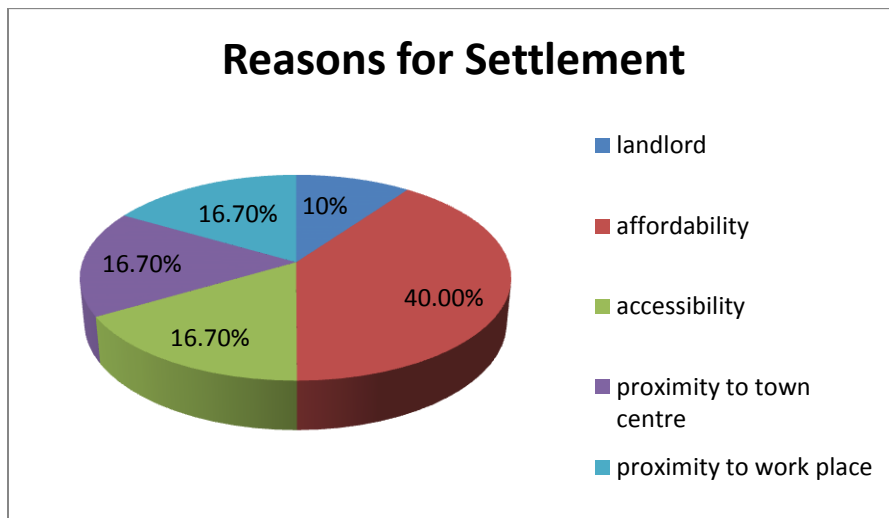


Figure 3: Pie chart showing Reasons for settlement

Source: field study

During field study, 40% of correspondents said that they live in Mathare North due to its pocket friendly nature as tenants pay for instance Ksh. 2800 rent on a 12 by 12 rental room inclusive of water bill per month; 16.7% due to its accessibility; 16.7% proximity to town; 16.7% proximity to work place and 10% landlords.

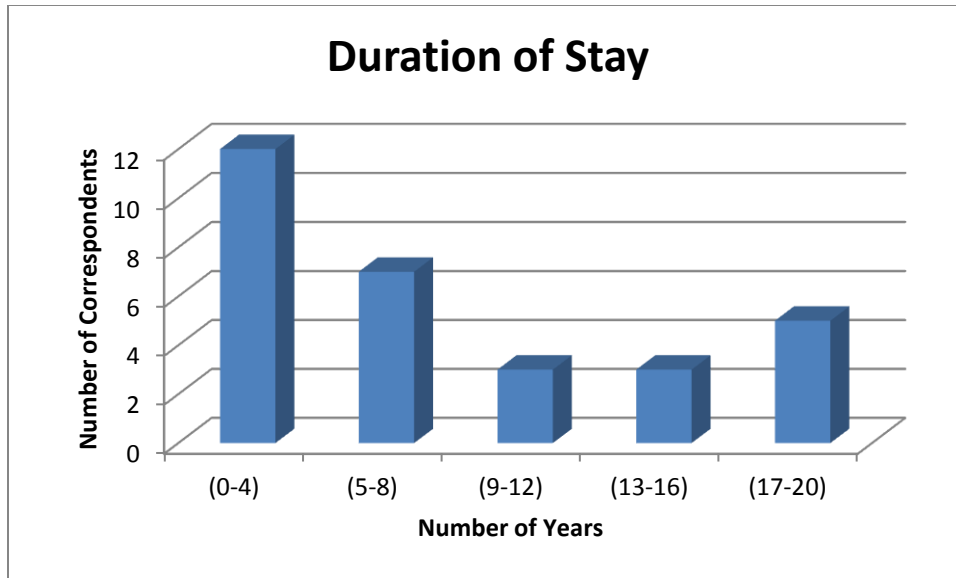


Figure 4: Graph showing Duration of stay

Source: field study

According to data collected from the field, most correspondents have stayed in the area for less than four years. This can translate residents either migrating to new areas with better living standards or poorer in relation to Mathare north's standards. Whichever the case, activities carried out in realizing attainment of wastewater management either regionally or nationally is to be achieved through transfer of environmental conscious ideas and activities in relation to wastewater management to new places by these people.

Level of education and awareness creation/ advocacy on environmental management issues goes hand in hand and according to the data collected from the field, more than fifty percent of population are literate that is 60% have education up to form four level. This is therefore very important when embracing advocacy as a tool in wastewater management on initiatives and projects developed.

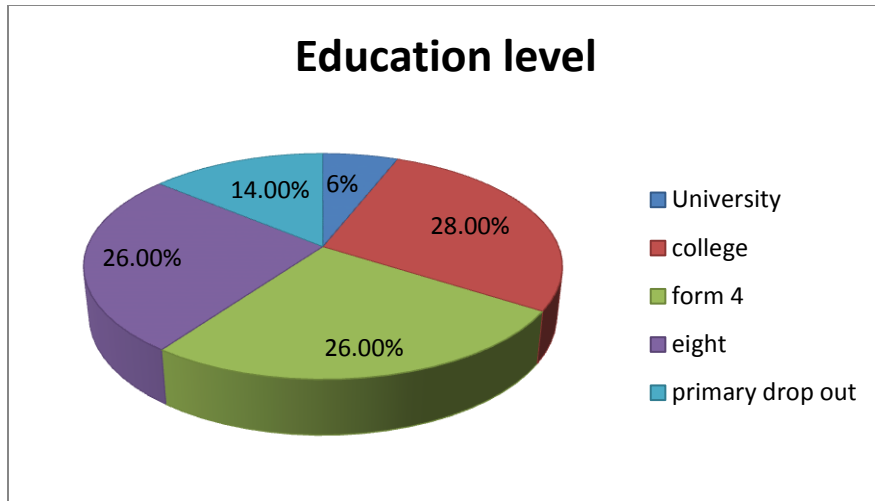


Figure 5: Pie chart showing Educational level

Source: field study

Mathare North is inhabited by people who are literate as according to data from the field, 6% have reached up to university level, 28% college; 26% form four and 26% primary school.

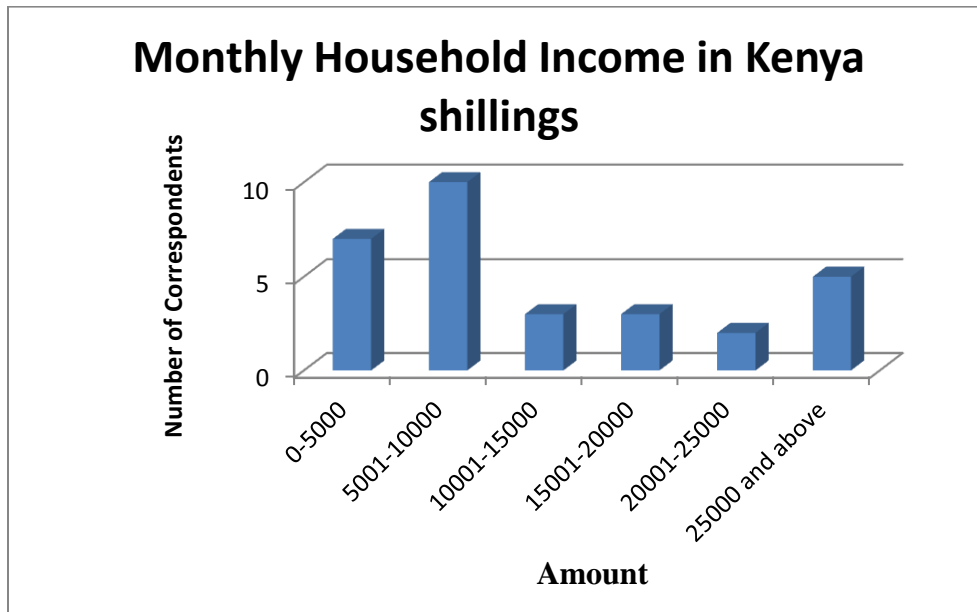


Figure 6: Graph showing Monthly household income

Source: field study

The occupation of people in Mathare North are employed on low wage jobs for instance, driving and businesses practiced are small and medium scale enterprises which they use to boost their source of

income hence majority's household income range between ksh.5001 and Ksh. 10000 respectively and majority's business profit is less than Ksh. 5000 per month.

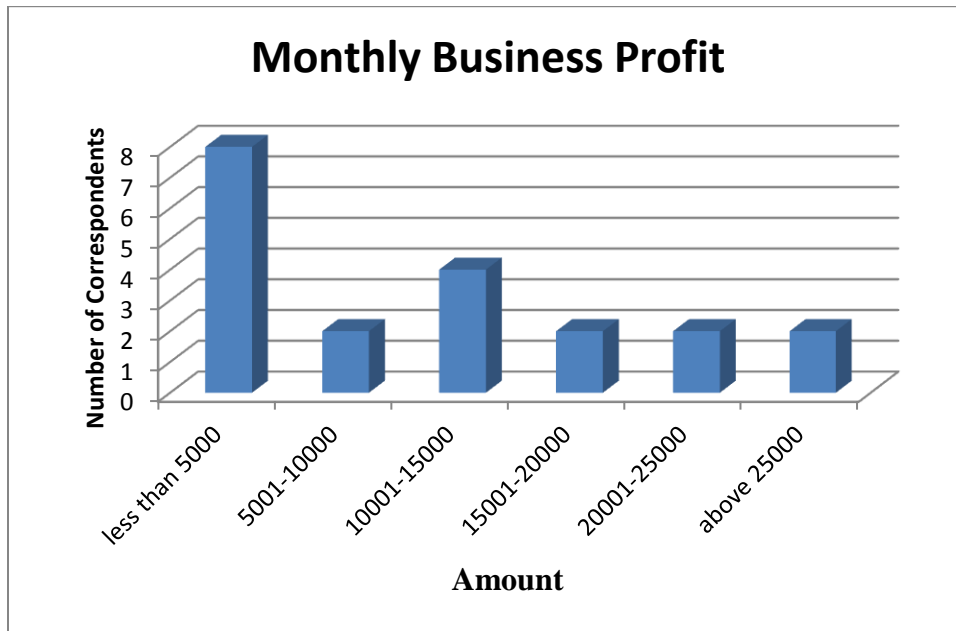


Figure 7: Graph showing monthly business profit

Source: field study

According to figure above, majority of business owners get profit of less than Ksh. 5000 followed by Ksh. 10001 to 15000 from their businesses.

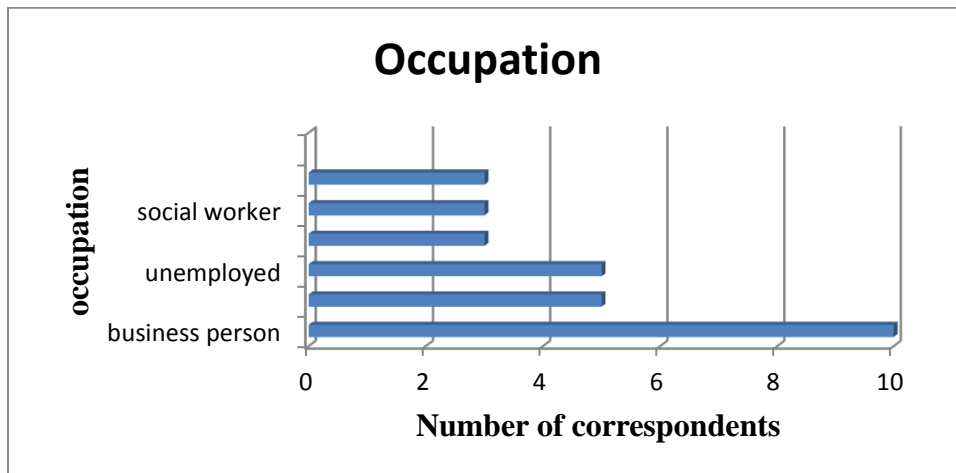


Figure 8: Graph showing Occupation of the population

Source: field study

From figure 7, main occupation of Mathare North residents in order of numbers according to correspondents are small and medium scale businesses; student; unemployed population; drivers; social workers; accountants. From the outcome of the study, there are two groups that doesn't have source of income; students and unemployed yet they are the second and third largest number of people staying in this area this therefore is a limitation in a situation that cost of wastewater management is transferred to residents with regards to funding of new projects related to wastewater management.

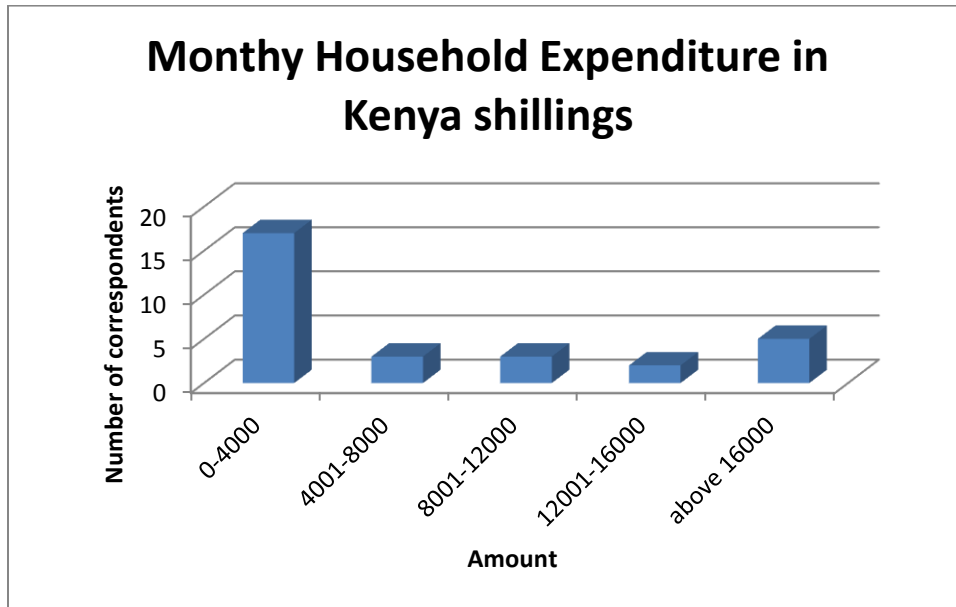


Figure 9: Graph showing monthly household expenditure

Source: field study

According to the study, majority of residents' monthly expenditure is less than Ksh. 4000 per month and this is crucial to residents being able to pay for environmental management initiatives such as wastewater management as from figure 5 the highest monthly household source of income is between Ksh. 5001 and Ksh. 10000 followed by people earning less than Ksh. 5000 hence little disposable income available to pay for such initiatives.

In addition, main economic activity residents practice as source of income and occupation is a linkage to monthly household income of a given group of people as mostly people stay in an area they are capable of having a comfortable stay. Further more, receiving information on economic activities helps in knowing and understanding characteristics of wastewater being generated therefore any undertaking on wastewater management is in sync with wastewater characteristics and type.

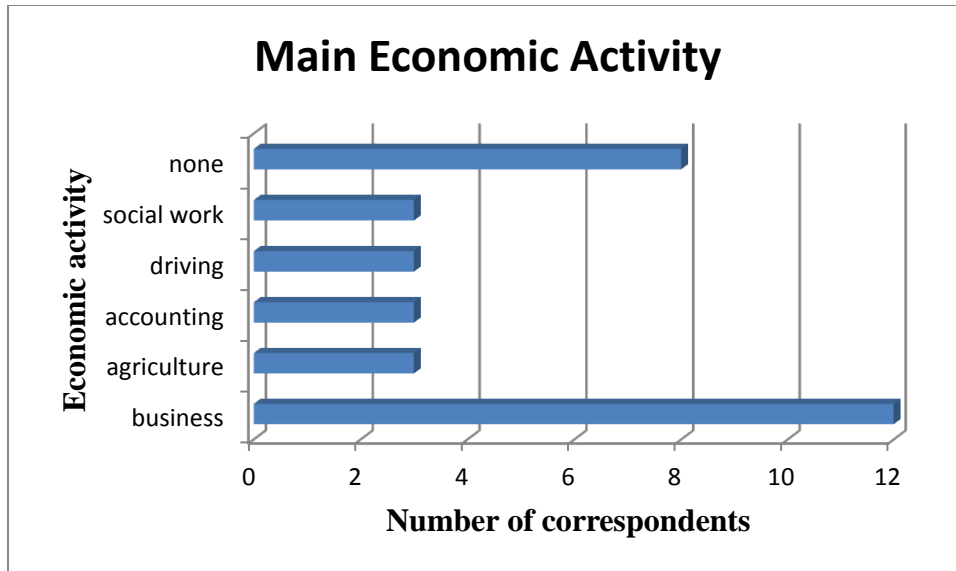


Figure 10: Graph showing main economic activities

Source: field study

An economic activity like business is strategy by Mathare North residents which is used as a surplus source of income as only relying on one source of income will lead to monthly expenditure exceeding monthly income. Further more, getting information on business enterprises is crucial as engaging business community in wastewater management initiatives as well as helping them understand wastewater volume and characteristics they generate and impact it has to the environment when not sustainably managed.

Housing unit characteristics in Mathare North are; residents own house units on a lease basis however others are landlords and care takers respectively; the rooms' sizes range between 10ft by 10 ft and 12ft by 12ft hence water point is outside the rooms being occupied; the housing unit's type is permanent and temporary houses; corrugated iron sheet roofs; cemented and tiled floors with stone, iron sheet and block walls.

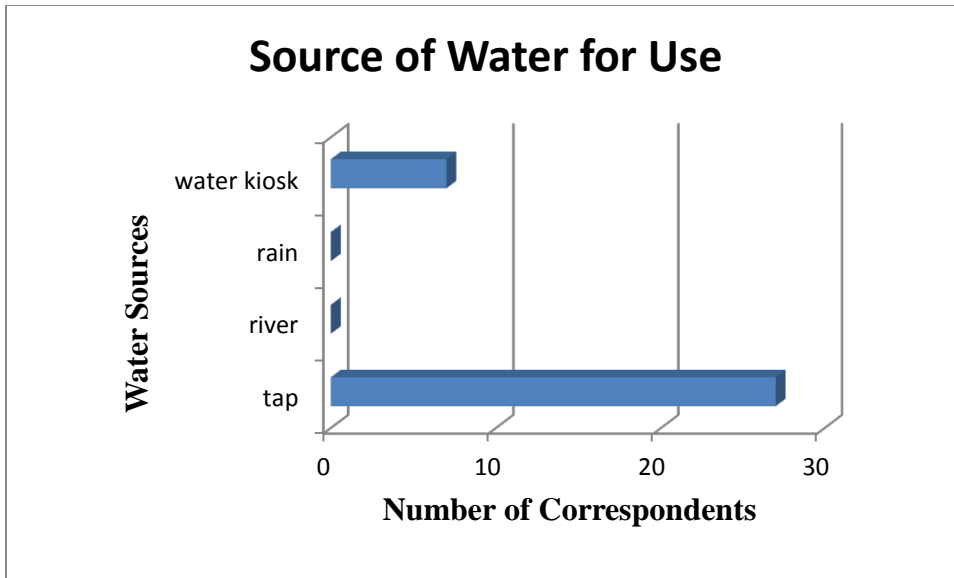


Figure 11: bar graph showing sources of water

Source: field study

Most people in Mathare North access water from taps which is distributed by Nairobi water and Sewerage Company. Other buildings however don't receive water yet they have water connection system forcing them to get their water from water kiosks. At the water kiosks, a lot of water is lost through leaks and running pipes when water not in use more so kiosks owned by groups such as Mayudo Youth Group. The water from the taps and water kiosks are used for drinking, washing, bathing, cooking and cleaning.

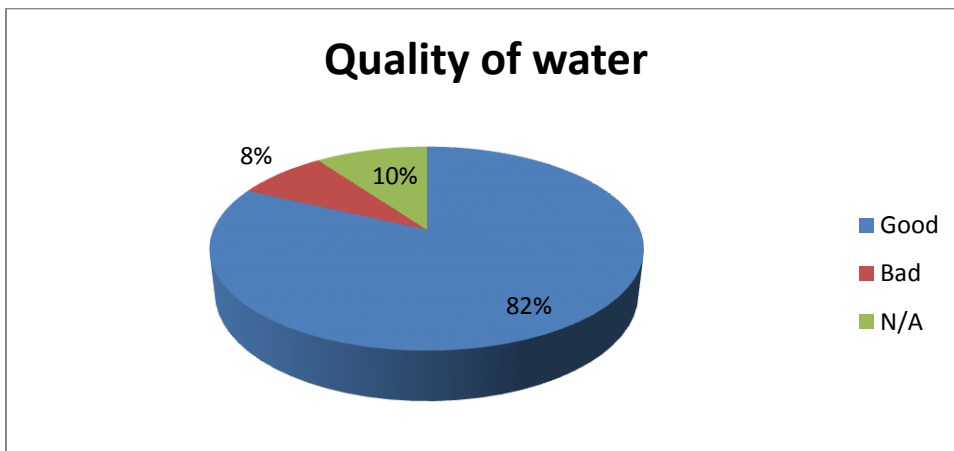


Figure 12: pie chart showing quality of water

Source: field study

According to field study, 82% said water quality is good, 8% bad and 10% had no idea. Those who said that water quality is bad was on the basis of pipes for clean water and wastewater are side by side therefore in case of breakage of water pipes and wastewater pipes since some buildings are constructed above these systems will lead causal of contamination of clean water which is used for drinking and cooking.

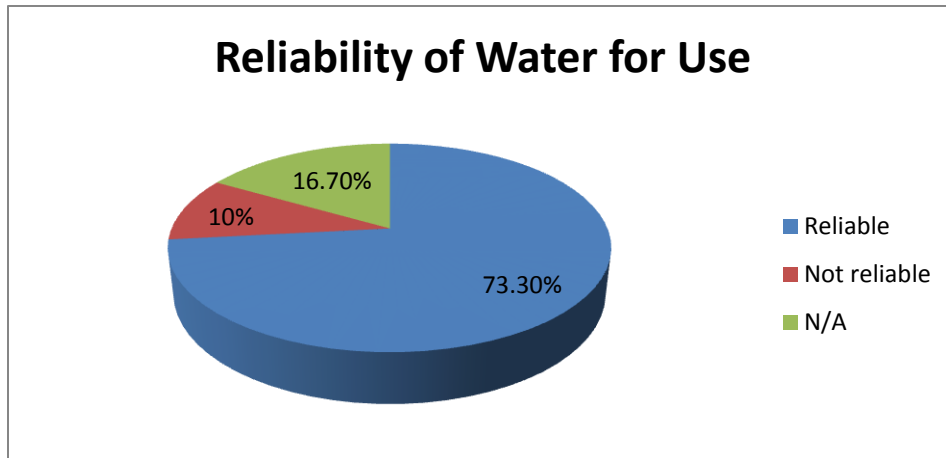


Figure 13: pie chart showing reliability of water

Source: field study

According to data from the field, 73.3% said that water is reliable, 16.7% not reliable and 10% have no idea.

Sources, volume and types of wastewater

Wastewater sources and volume is linked to water utilization and the economic practices undertaken by the residents influences the characteristics of wastewater generated thereby determining best methods for its management.

The average amount of water used per capita per day in Mathare North is 80 litres and according to the study, three quarters of water used ends up in environment as wastewater. Since Mathare North's population according to 2009 census is 53653 inhabitants, average wastewater released into the environment is 60litres per capita thereby the whole population releases $53653 \times 60 = 3,219,180$ litres per day. However, wastewater generation during rainy season increases tremendously due to storm water contribution as a source of wastewater. According to field study, sources of wastewater are business premises, residential units and storm water.

Types of wastewater collection systems

Wastewater collection system starts from the household or business premise that is the existence of pipe connections from premises used in channelling wastewater from the household to wastewater disposal plant which is at Kariobangi. According to the study, 88% of correspondents said that their neighbourhood is connected to a wastewater collection system and 12% differ and this is shown in figure 13 below.

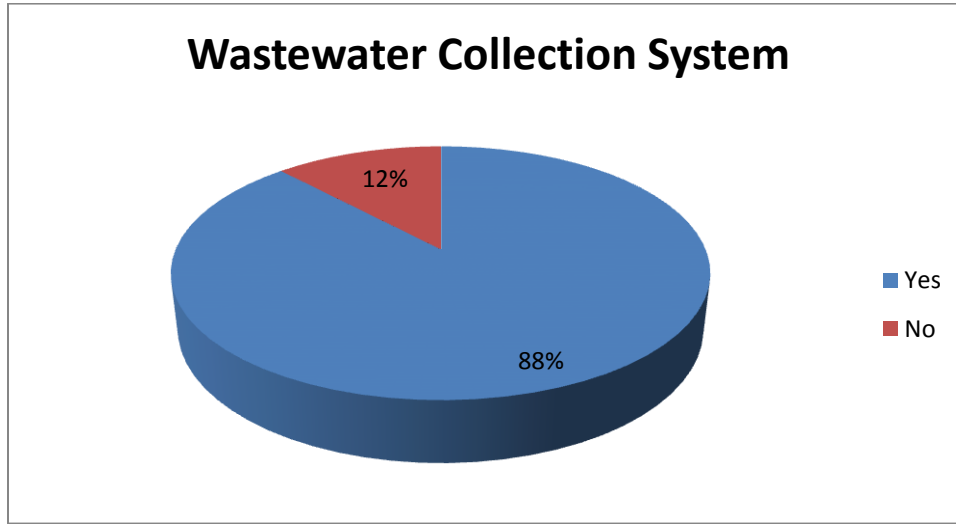


Figure 14: pie chart showing wastewater collection system existence

Source: Field study

There are different types of wastewater collection systems that Mather North is connected to and these are; open storm drainages, sewer line and closed drainages. Sewer is efficient and effective treatment for wastewater which requires a network of pipes, pumps and pump stations within a specific amount of time. However, most of storm water is released into the environment as shown in plate 7 due to blockage of drainage line. Further more, even though there are wastewater collection systems, there is still a problem of wastewater exfiltration and infiltration causing environmental degradation and exceeding of the original capacity of the system respectively. Wastewater exfiltration is evident during rainy seasons as streets flooded and the major cause of this is poor state of drainage systems; during dry seasons, solid wastes is disposed into these systems which is eventually not removed causing blockage of the systems hence environmental pollution. In addition, exfiltration is as well caused by poor maintenance of sewer systems which result to leakages of wastewater from broken wastewater pipes.

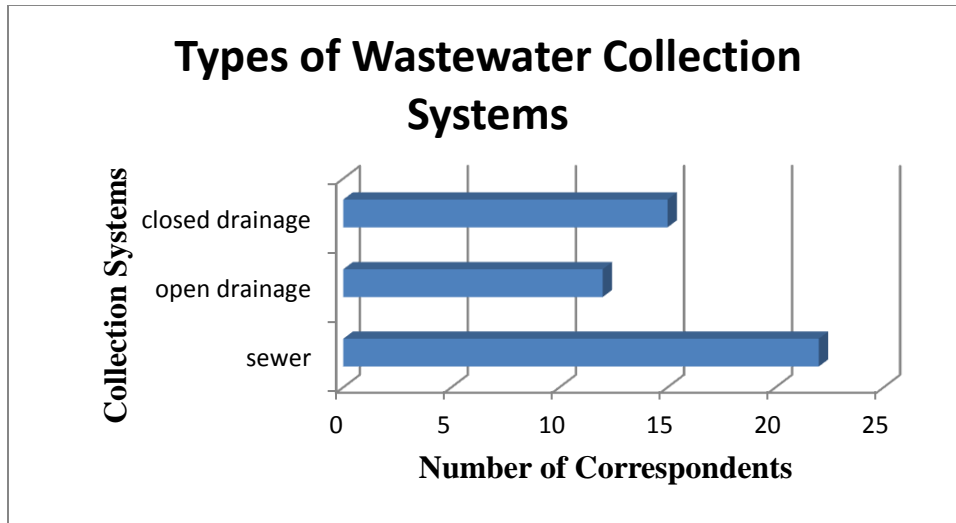


Figure 15: bar graph showing types of wastewater collection systems

Source: field study

According to information from the field study, majority of correspondents said that Mathare North is connected to wastewater connection systems. Even though majority said that the condition of the system is good, there are those whose view is that the system’s condition is bad and very bad respectively. This difference in idea is brought about by location of the residential unit. For example, area three where there is slum- like settlements where storm drainages are in a dilapidated state as portrayed by plate 3 in appendix.

The views of the residents on the condition of wastewater collection system are presented by figure 16 below.

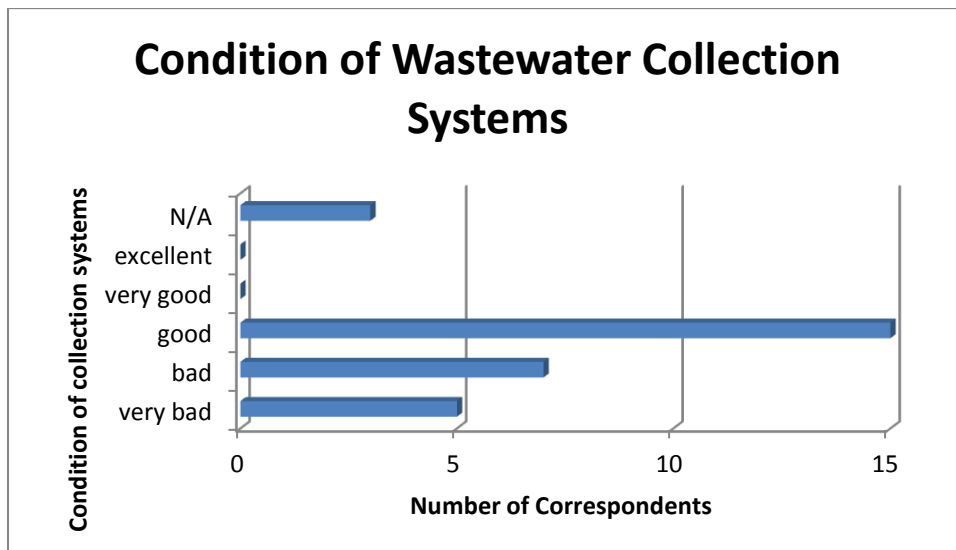


Figure 16: bar graph showing condition of wastewater collection system

Source: field study

Wastewater Management Process

There are different practices adopted or implemented by Mathare North residents to minimize wastewater generation.

Water use management

There are different water use management practices that have been adopted by Mathare North residents. These are; checking pipe leaks, checking toilets for leaks, taking short showers and turning off water when not in use. However checking and maintenance of leaks from water pipes and toilets is done by landlords and care takers.

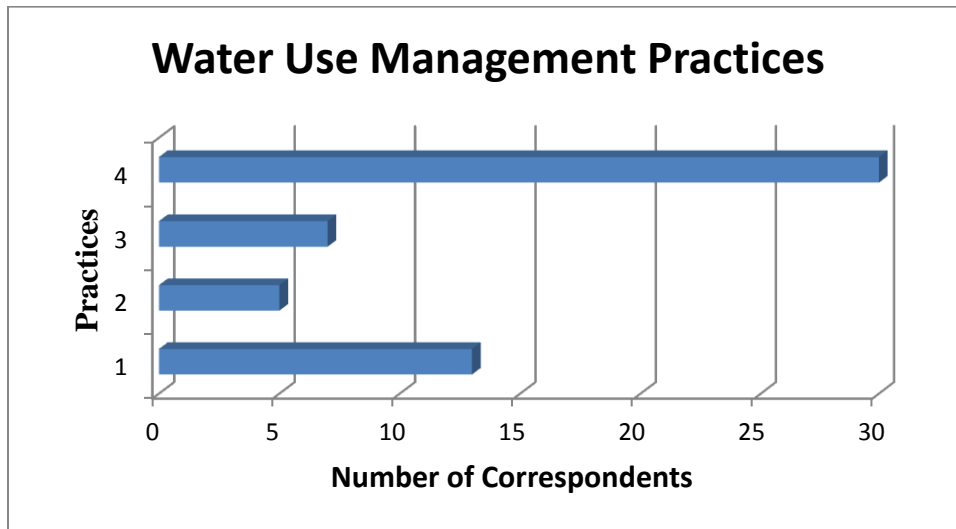


Figure 17: bar graph showing water use management practices

Source: Field Study

Figure 17 above shows that majority turn off water when not in use presented by 4 on the graph as a measure of minimizing water utilization followed by checking pipes for leaks, then taking short showers and lastly checking toilets for leaks which are presented by 1, 3 and 2 respectively.

In addition, there are other residents who use wastewater for urban agriculture purposes with no regard to NEMA or WHO regulations considerations as shown in Plate 1 below which uses wastewater from Mayudo youth group.



Plate 1: Photograph showing urban agriculture

Source: Field study

Wastewater Disposal

Integrated management of wastewater is a holistic approach that requires proper management of wastewater from generation to disposal.

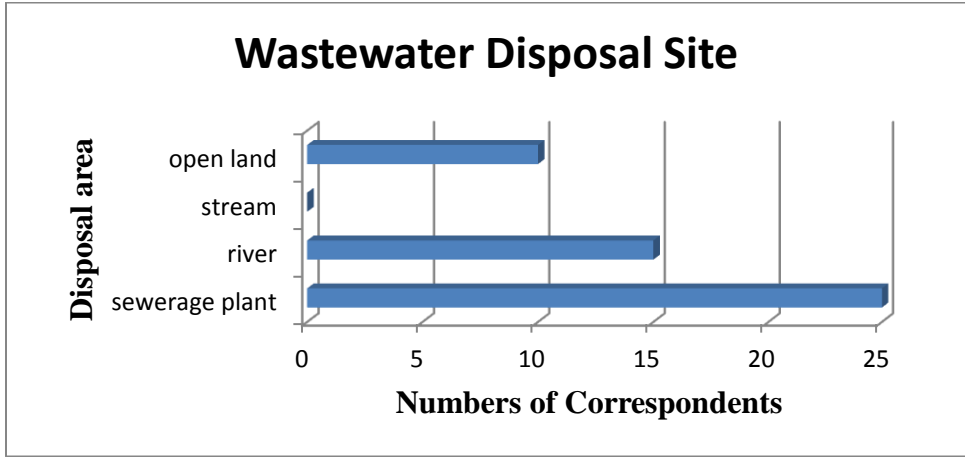


Figure 18: bar graph showing areas used to dispose wastewater

Source: field study

According to correspondents, sewerage plant which is located in Kariobangi is the main wastewater disposal site followed by river and lastly open land. Continuous release of untreated wastewater into the environment can be controlled through: maintenance of leaking pipes, proper and frequent maintenance of drainage systems through unblocking of clogged sewer systems, reusing wastewater, recycling of

wastewater, constructing well planned drainage systems, constructing additional sewerage systems due to increase in number of Mathare North residents over the years

Wastewater management technique

Wastewater management techniques used in Mathare North according to field study are of sewers and drainages due to these infrastructures in place even though they are poorly maintained. However, some people use drainages for both storm water channelling as well as wastewater from the residential units and premises which ends up being disposed of into the river Mathare shown in plate 5.

Purpose for wastewater management

Inadequacy in wastewater management has led to increase in nutrient amount in aquatic environment for instance Mathare River is facing a challenge of pollution from waste water effluents which is facilitated by both direct and indirect activities and this challenge is shown by plate 5 in appendix. According to UNEP Source Book of 1997, up to 90% of wastewater in developing countries flow untreated into rivers, lakes and highly productive coastal zones threatening health, food security and potable water for drinking.

Organizations such as PV has been and continue to be involved in environmental management initiatives like tree planting along Mathare river to help ensuring the river realizes it ecological footprint as shown by plate 2 below. However, these kinds of mechanisms are hindered by continuous wastewater release into the environment.



Plate 2: Photograph showing environmental management mechanism

Source: field study

According to Nairobi county council (NCC), the commonly reported cases of environmental pollution in the city in order of priority include; discharges from wastewater, illegal dumping of solid wastes, noise, excessive vibration and air pollution. Even though wastewater discharge into the environment is the major concern, there are no policies of by- laws enacted to help address it even though NCC has environmental planning and management department which essentially originates the environmental policies and strategies for the department of environment as it initiates and formulates environmental policies as well as by- laws in order to facilitate implementation and monitoring of environmental programmes/ activities and enforcement of legal provisions. The only action taken by the council officers normally take the dimension of awareness creation which majorly has been on the basis of solid waste management.

Policy, Legislation and Institutional Framework

Policies, legislation and institutional framework are essential management tools in addressing key environmental issues and need to be strengthened.

Complementary Policy Framework

Kenya's constitution, 2010 is the highest legislation of the land which incorporates different concerns incorporating as well environmental protection and management.

In Article 60 (e), there should be sound conservation and protection of ecologically sensitive areas; Mathare river being a sensitive area, its functionality and purpose is hindered by human activities in the neighbourhood where it is located for instance, draining/ directing/ channelling of wastewater either grey water, black water or storm water either accidentally or knowingly into Mathare river has caused ecological footprint of the river to be exceeded.

In 1999, Kenya adopted environmental policy that is Environmental Management and Coordination Act (EMCA) which contains institutional instruments such as National Environment Action Plan (NEAP), sectoral policies and environmental management strategies. These efforts have in most cases facilitated review and enactment of legislations as well as establishment of institutional framework for planning, monitoring and enforcement policies

Under section 42(1e), no person is allowed to deposit any substance in a lake, river or wetland or in, on, or under if that substance would or is likely to have adverse environmental effects on the lake, river or wetland without prior written approval of the director general. However, there are no regulations or control measures in place concerning quantity and quality of wastewater to be allowed to be drained in

sensitive areas as mentioned in section 42 (1e) above in relation to lakes and rivers recharge during different seasons.

Section 37 provides for creation and composition of NEAP committee. NEAP committee is required to prepare a NEAP after every five years and should encompass all the contents in section 38 of EMCA. However, NEAP doesn't have any wastewater management component.

EMCA vests the responsibility of environmental conservation and management to National Environment Management Authority (NEMA). The purpose for the establishment of the authority is to exercise general supervision and coordination over all matters relating to the environment in various sectors such as water, agriculture and industrial sectors and to be the principal instrument of government in the implementation of all policies relating to environment.

Emerging policy shift

In recent years there has been a shift in policies being formulated in Kenya for example; Kenya is embracing integrated approach in relation to water resource management, new master plan is being prepared and there is new institutional arrangements due to the devolved system of governance and this has facilitated enactment of devolution laws.

6 Summary of the Findings, Conclusions and Recommendations

Wastewater can be reused for different purposes which may also demand different treatment processes before reuse. Reuse of wastewater can be in different sectors which are; agriculture, industry, residential and urban purposes.

Environmental issues have been addressed in a reactive manner as part of project safeguards but not as integrated element of water and wastewater planning, management and development and their enforcement has been generally weak.

Wastewater management requires a well defined environmental policy framework which is harmonized with other relevant sectors such as water, agriculture, industries and others. Even though EMCA was enacted in 1999 and environmental conservation and management responsibility given to NEMA, the authority has been slow in coordinating policies formulated by different lead agencies and sectors such as water, agriculture and industrial development, thereby contributing to conflicting interests hence creating obstacle during implementation process as different institutions have different perspectives in relation to environmental management.

The origin of wastewater is water consumption that is; increase in level of water consumption results to large quantities of wastewater generated requiring huge investment in collection and treatment infrastructure. There is therefore an urgent need to develop sustainable management strategies that would control both water and nutrient flows into towns and cities environment which is in this case integrated water and wastewater management; for instance, to improve the traditional urban water management system, water supply and wastewater management have to be closely interconnected so that water is used with minimal withdrawal from and reduced recharge to the environment.

The historical development of wastewater management globally has been characterized by the efforts to solve mainly one problem at a time and Kenya is not an exception. For instance sanitation during first half of 20th century followed by eutrophication of receiving waters for the past 10 or so years, recycling of the nutrients. However after the Dublin conference of water and environment (ICWE) in 1992 in Dublin Ireland, a reversal of the debate occurred where water management was discussed in a more holistic manner (ICWE, 1992).

Regulatory policy and institutional framework have not been effective in addressing the threats they suffer such as weaknesses, constraints and shortcomings and this is because;

- Policies and legislations remain compartmentalized (sectoral) making them difficult to enforce for instance environmental concerns in water act, agriculture act and industrial act are addressed as separate entities.
- Weak and poor implementation and enforcement of existing policies and legislation is due mainly to lack of political will, expertise, adequate funding, sectoral and institutional coordination in relation to water and wastewater management.
- Stakeholders are not involved in policy and legislation reforms contrary to Article 69 (1d) of Kenya's constitution which states that the state is to encourage public participation in the management, protection and conservation of environment.
- Ecological data and knowledge is lacking to clarify the linkages between environment and wastewater.
- Policy and legislation frameworks are not well harmonized with implementation of regional and international agreements.

Recommendations

Ways of reducing wastewater release

According to Harremoes, 1999, to ensure that wastewater release reduction is achieved, there are options that can be adopted and these are; No use, reuse, convert, contain and disperse and this will be achieved through storm water run- off reclamation, wastewater reuse and wastewater recycling and environmental management strategies adoption.

Environmental management strategies

Regulatory controls

Wastewater need to be certified before being disposed of. However strategies such as wastewater reuse controls can be enhanced by government through provision of incentives, enforcement of penalties and ensuring that every premise that generates wastewater holds permits and licenses for its disposal. In addition, water pollution and quality controls is to be achieved through; forbidding discharge of wastewater into environment (fresh water), implementation and enforcement of legislative measures related to wastewater management, restricting discharge of wastewater through penalties and licenses which can be strengthened by formulation, implementation and enforcement of policies, by- laws and laws developed specifically for integration of ecological issues into water resource management.

Lastly, consideration and adoption of water quality management strategies such as presence of incentives for water use minimization, wastewater reuse and wastewater trade can help in reduction of wastewater generation which eventually ends up in environment.

Wastewater Reuse

According to Metcalf and Eddy, 1991, humans only require one to two litres of potable water per day yet about 150- 300 litres are consumed in most cities and according to Otterpohl et al, 1997, some believe that this is abusive use of water and recommend that water of different quality to be supplied for different purposes like car washing. Water from bathing, washing machines, dish washers and kitchen could be collected separately and be reused for the purposes that do not require drinking water quality such as gardening.

Wastewater reuse is one of the wastewater management strategies. However in Mathare North, only 44% reuse their wastewater whereas 56% don't. According to field study, majority of household users reuse their wastewater as compared to business people. Wastewater is reused for flushing toilets, controlling dust and cleaning houses and this is represented by figure 18 below. In addition, wastewater can be channelled to dry areas for irrigation; this is because, nitrates and phosphorus present in wastewater is essential for growth of crops. However, there needs to be policy and legislation in place that gives regulatory and control on the quality of wastewater to be used for agricultural purposes.

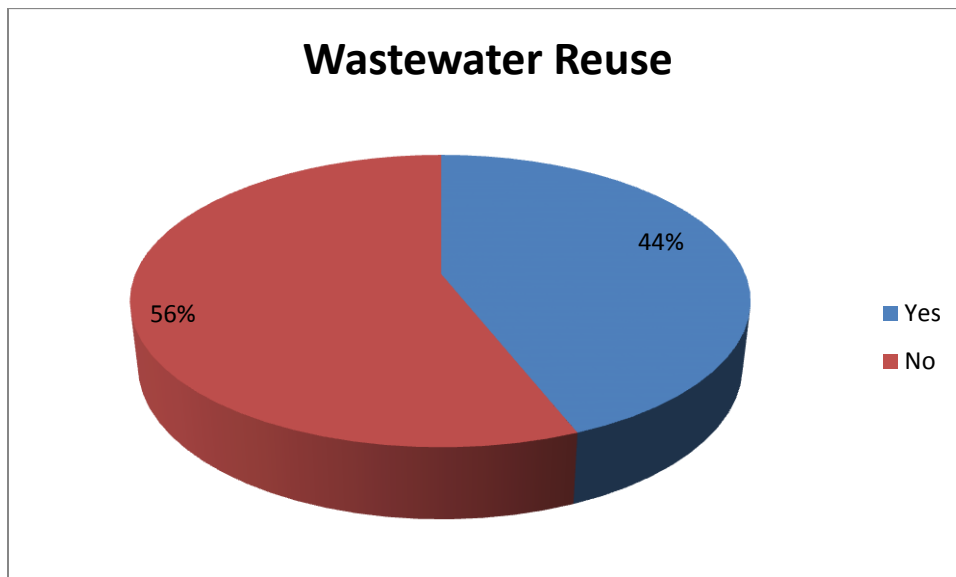


Figure 19: Pie chart showing correspondents reusing wastewater

Source: field study

There is also need for reducing water losses both at treatment plant and at the distribution lines (JICA, 1996) as the detection and repair of leaks and an improvement of equipment and production process could greatly reduce water losses and consumption in industries.

Wastewater Management Payment

Payment of wastewater management initiative is essential to realizing wastewater management as funds are required to run the projects that are to be developed or are being developed. The payment can be direct or indirect. Direct payment is when lessee pays for management of his/her wastewater generation and indirect payment can be through permit sand licenses enforcement requirement by the authorities in charge of water resource management and wastewater management to premise lessers. However, there should be policies and legislations in place to ensure the initiative is successful to avoid cases of corruption and lesser transferring the cost to consumers which in this case are lessees.

According to information collected from the field, 56.7% of correspondents are willing to pay for any wastewater management initiative because; it's a way of creating extra jobs for jobless population; improvement of environmental condition and having alternative sources of water for activities that doesn't require water quality for drinking water such as gardening and cleaning cars. 33.3% are not willing to pay for wastewater management because; they cannot afford; every housing unit should first be connected to wastewater collection system and lastly corruption in existing institutions mandated in ensuring environmental management should be addressed.



Figure 20: Pie chart showing correspondents willing to pay for wastewater management

Source: field study

Wastewater Treatment

The removal or inactivation of excreted pathogens is the principal objective of wastewater treatment; and treatment to levels proposed by (Blumenthal et al., 2000a) Conventional wastewater treatment options (primary and secondary treatments) are often better at removing environmental pollutants than removing pathogens, however, and many of these processes may also be difficult and costly to operate properly in developing country situations like Kenya. Waste stabilization ponds (WSP), when designed and operated properly, are highly effective at removing pathogens and can be operated at low cost where inexpensive land is available. They are designed to use natural processes of biodegradation, disinfection by sunlight, and particle settling under gravity, to purify the water. They form a series of shallow ponds linked together to maximize retention time. However, WSPs should be designed, operated and maintained in such a way as to prevent disease vectors from breeding in the ponds if the wastewater is to be used for agricultural purposes.

Where effective treatment is not available, it may be possible to consider other options that improve microbial water quality, such as storage reservoirs to partially treat wastewater or water abstraction from surface waters some distance from wastewater discharges where dilution has already taken place.

Gender Mainstreaming

There is need for gender mainstreaming in relation to wastewater management. This is in pertinent to two different perspectives while considering gender and wastewater management. That is; women like to apply or develop short term initiatives when solving a given issue whereas men tend to engage in long term measures to solve the same problem. Secondly, as day-to-day activities in the household are carried out by women most of the time and these activities involve utilization of water hence generation of wastewater; any initiative that is to be developed in relation to wastewater management should incorporate this group of people's views.

Policy and Institutional

There should be policy and institutional framework in place with the mandate of ensuring that the owners of any premises whether temporary or permanent, residential or industrial is connected to wastewater collection system to ensure that the wastewater generated is safely channelled to an appropriate disposal site in a sustainable manner. The policy framework must be based on the principles of integrated, sustainable wastewater management and the legislation should be consistent with the spirit and principles contained in the policy; this is possible through issuance of permits and licenses before the building is

occupied or used for any activity. There should be establishment as well of enforcement other strategies in addition to setting out penalties for non compliance. In addition, an appropriate functional institutional framework is required to serve as a vehicle for implementation at national and regional levels. This may require the development of new institutions or restructuring or rebuilding the capacity of existing institutions as well as development of linkages for formal collaboration between institutions of different sectors.

There should be enforcement and implementation of article 69 which addresses environment as a component. To curb discharge of wastewater into the environment, according to Kenya's constitution, every person has a duty to cooperate with state organs and other person's to protect and conserve environment and ensure ecologically sustainable development and use of natural resources (Article 69 (2)). In addition, the state shall encourage public participation in the management, protection and conservation of the environment (Article 69 (1d)) and eliminate processes and activities that are likely to endanger the environment (Article 69 (1g)). However since wastewater pollution is one of the ecological issues/ concerns, wastewater management components should be incorporated in Kenya's constitution to help give added authority in ensuring its attainment to minimize wastewater disposal into the environment more so fresh water bodies. In addition, wastewater components should be added in National Environment Action Plan.

Adoption of Indigenous Knowledge

Different types of indigenous knowledge should be researched upon and appropriate techniques with regard to environmental management more so wastewater management identified so as to be used in realizing sustainable and efficient wastewater management.

Level of Involvement

Government involvement is essential in implementation of most of wastewater management initiatives as well as private sectors and community as a whole. For instance the selection and construction of the appropriate technologies is generally initiated and financed, at least, partially by the government with the subsequent operation and maintenance of the facility should be responsibility of the local community therefore those employed should be people from that neighbourhood. This will help in reduction of surface water degradation which affects the availability of fresh water sources. In addition, government should ensure that the emerging policies incorporates wastewater management as a component of environmental management

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8 Appendices

Sample 1: Household Questionnaire

KENYATTA UNIVERSITY

Department of Environmental Planning and Management

INTERVIEW QUESTIONNAIRE

INTRODUCTION

I'm a Kenyatta university undergraduate student pursuing Bachelor in Environmental Planning and Management. I am carrying out a research on wastewater management a case of reducing wastewater release into the environment in Mathare North, Nairobi County. I am requesting for your contribution in answering some questions. Information provided by you will be for academic purposes only and will be confidential.

Household questionnaire

Name of interviewer.....

Fill appropriate

House hold member	Sex	Age	Highest education	Main occupation	Duration of the stay	Main economic activity

1. Why did you settle in this area?

.....
.....

1. What is your mean monthly household income in Kenya Shillings?

- (a) Less than 5000 [] (c) 10001-15000 [] (e) 20001-25000 []
- (b) 5001-10000 [] (d) 15001-20000 [] (f) More than 25000 []

2. What is your monthly expenditure?

- (a) Less than 4000 [] (c) 8001-12000 [] (e) more than 16000 []
- (b) 4001-8000 [] (d) 12001-16000 []

3. What are your house characteristics?

Ownership	Size	Type	Roof	Floor	Wall

4. Water for use (tick three most preferred)

Source		Distance	Uses	Quantity	Quality (good/bad)	Reliability	Cost/month
Tap	1						
River	2						
Rain	3						
Water kiosks	4						

Any other (specify)

5. What water use management practices have you adopted? Tick appropriately

Management practices		Tick
Checking pipes for leaks	1	
Checking toilets for leaks	2	
Taking short showers	3	
Turning off water when not in use	4	

Other (specify)

6. Is Mathare North connected to wastewater collection system?

Yes [] No [] if yes tick appropriately

Collection system		Tick
Sewer	1	
Open drainage	2	
Closed drainage	3	

Other (specify)

7. What is the condition of the wastewater collection system? Tick appropriately

Condition	Tick

Very Bad	
Bad	
Good	
Very Good	
Excellent	

8. Where is wastewater disposed of? Tick appropriately

Disposal area	Sewerage facility	Environment		
		River	Open land	Stream
Tick				

9. Do you reuse your wastewater?

Yes [] No [] if yes, How? Tick appropriately

Activity	Flashing toilets	Controlling dust	Clean ups		
			Cleaning house	Washing cars	Cleaning carpets
Tick					

10. How can discharge of wastewater into environment controlled?

.....

11. Are you willing to pay for wastewater management initiative? Give reasons

Yes [] No []

.....

Sample 2: Business Questionnaire

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Business questionnaire

Name of interviewer.....

Fill appropriate

Business owner	Sex	Age	Highest education	Duration	Type of business	Source of water

1. What is your mean monthly business profit in Kenya Shillings?

- (a) Less than 5000 [] (c) 10001-15000 [] (e) 20001-25000 []
(b) 5001-10000 [] (d) 15001-20000 [] (f) More than 25000 []

2. Water for use (fill appropriately)

	Uses	Quantity	Quality (good/bad)	Reliability	Cost/month
1					
2					
3					
4					

3. What water use management practices have you adopted? Tick appropriately

Management practices		Tick
Checking pipes for leaks	1	
Checking toilets for leaks	2	
Turning off water when not in use	3	

Other (specify)

4. Is your business premise connected to wastewater collection system?

Yes [] No [] if yes tick appropriately

Collection system		Tick
Sewer	1	
Open drainage	2	
Closed drainage	3	

Other (specify)

5. Where is wastewater from your premise disposed of? Tick appropriately

Disposal area	Sewerage facility	Environment		
		River	Open land	Stream
Tick				

6. Do you reuse your wastewater?

Yes [] No [] if yes, How? Tick appropriately

Activity	Flashing toilets	Controlling dust	Clean ups		
			Cleaning house	Washing cars	Cleaning carpets
Tick					

7. How can discharge of wastewater into environment be controlled?

.....

8. Are you willing to pay for wastewater management initiative? Give reasons

Yes [] No []

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

Sample 3: Interview Questions used

INTERVIEW QUESTIONS

What is average water utilization per capita in Mathare North in context to water utilization in Nairobi?

What are types, volume, sources and trend of wastewater in Mathare North?

What is the state, type of wastewater collection system?

Which are the wastewater disposal techniques employed and why?

What are the strategies employed to ensure sustainable wastewater management?

Which are the standards, regulations, policies and legislations in placed regarding wastewater management in Kenya?

Photographs Taken from the Field



Plate 3: Photo showing dilapidated state of storm drainage

Source: Field Study

Wastewater directed to Mathare River from Mathare primary school



Plate 4: photo showing wastewater directed towards Mathare River

Source: Field study



Plate 5: Mathare River pollution from wastes

Source: Field study



Stagnant water

Plate 6: Photo showing stagnant wastewater

Source: Field study



Plate 7: Photo Showing Blocked storm drainage

Source: Field study