

HUMAN WASTE MANAGEMENT IN SELECTED PRISONS

IN RWANDA

A Thesis

Presented to the School of
Postgraduate Studies and Research

Kampala International University

Kampala, Uganda

In Partial Fulfillment of the Requirements for the Degree
Master of science in Environmental Management and Development

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MEM/20003/82/DF

August, 2011

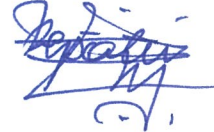
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DECLARATION A

"This Thesis is my original work and has not been presented for a Degree or any other academic award in any University or Institution of Learning".

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"I/We confirm that the work reported in this Thesis was carried out by the candidate under my/our supervision".

A handwritten signature in blue ink, appearing to read "G. Massim". The signature is stylized with a large initial "G" and a trailing flourish.

Name and Signature of Supervisor

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APPROVAL SHEET

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DEDICATION

To my beloved family,
My dearest parents, Brothers and the family Carmen
To my fellows students in Kampala International University,
For your love, support, encouragement and inspiration
Those have made my academic endeavors
a success.

AKNOWLEDGEMENTS

It would have been impossible for me to achieve this dissertation without the help of many professionals and individuals.

My special thanks go to Almighty God, for His manifold blessing and guidance up to now and in future and also to my parents and brothers who made me capable of pursuing my studies from the primary level up to my Post Graduate course.

I would like to express profound thanks and gratitude to my supervisor and lecturer **Dr. SEKABIRA KASSIM**, his scholarly guidance, constructive comments and critical revision of the drafts made it possible for me to complete this thesis.

My sincere thanks go to the Dean Vince Chancellor of SPGSR, administrative staff and all my lectures in the School of Post Graduate studies and Research of Kampala International University,

I am particularly grateful of all the people, who assisted me in my fieldwork especially the administrative staffs of two selected prisons, without their support it would be impossible to pull off the information and hit up key data needed to complete this work.

Last but not least, I would like to express my undying gratitude to my lovely family, Carmen, Sr. Mercedes, Sr. Agnes to their sacrifices and their support in lifting me to this height. My appreciation also goes to all my friends though their sacrifices were generous, their prayers and their support infinite.

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ABSTRACT

Human waste disposal has become a daunting task for the prisons' authorities in Rwanda who seem to lack the capacity to tackle the mounting human waste situation due to the high prison population density. This study was carried out to analyze and understand the situation of human waste management in selected prisons of Kimironko and Muhanga. The main objectives of the study were: to establish the status of human waste management in prisons, investigate health effects related to improper human waste management and establish ways employed to improve human waste disposal in selected prisons.

For the empirical study, a mixed materials and methods were used which combined questionnaires, interviews of all people involved in human waste management in selected prisons, together with observations, photographs, and review of related literature to examine the issue of human waste management in selected prisons.

The key issues identified by the study include: that the selected prisons are experiencing the poor human waste management because of the prisons overcrowded and small number of disposal systems present in the selected prisons (toilets, latrines). That while, a number of infectious diseases (diarrhea, cholera, typhoid, dysentery) and environmental nuisances (drinking water pollution, food chain contamination, air and soil pollution), associated to that problem have been identified.

Based on these findings, it has been observed that the solution to the issue of human waste management problem in selected prisons lies in the prioritization of implementing biogas plants, but also in human waste compost that need more research before it should be adopted.

LIST OF ACRONYMS

UN: United Nations

KJ: Kilojoule

UNDP: United Nations for Development Programme

UNEP: United Nations Environment Programme

REMA: Rwanda Environment Management Authority

NEMA: National Environment Management Authority

CARPE: Central African Region Programme for Environment

IEA: International Energy Agency

UNDP: United Nations Development Programme

GTZ: Gesellschaft für Technische Zusammenarbeit (greater than zero)

WHO: World Health Organization

UNICEF: United Nations International Children's Emergency Fund

ECOSAN: Ecological Sanitation

HWM: Human Waste Management

WSSCC: Water Supply and Sanitation Collaborative Council

KIST: Kigali Institute of Sciences and Technologie

CHAPTER ONE

THE PROBLEM AND ITS SCOPE

Background of the study

One of the key problems facing developing countries is poverty reduction, degradation of environmental resources and inadequate health and sanitation systems. One of the causes which is a really a challenge for developing countries, often making our environment filthy and unhealthy is a large quantity of wastes in various forms produced by human beings, (SOSC, 2006).

Waste management is a serious issue in most of the world's rapidly growing cities, because it is a concern to many stakeholders, most importantly the community and the environment. Lack of waste treatment technologies and policies often results in a very tangible health risk to the population, (New wind press, 2007). More often than not, the generation, collection, processing, transport, and sustainable disposal of Human waste constitute an important issue for both human and environmental health risks, (Rushton, 2003). The potential for human and environmental health effects resulting from poor human waste management practices has been a longstanding concern for many developing countries, (Schonning, 2002).

The current practices of uncontrolled dumping of human wastes in the residences and outskirts of towns/cities have created serious environmental and public health problems. This makes human waste management a major concern for many developing nations, (Ahmed and Ali, 2004).

In Rwanda, like in many other developing countries, the most serious environmental and health problems are related with inadequate human excreta management, (MINISANTE, 2006). Urbanization or increase in population, leads to increased generation and unsafe disposal of human waste in urban areas (MINIRENA,

2010). Besides the GoR's commitment and willingness to provide its citizen with essential services in the aftermath of the genocide of Tutsi in 1994, still make it difficult to overcome social-economic problems.

Unique demographic dynamics as a result of influx of old case refugees who returned to their home land after 35 years in exile and then many of Rwanda's 120,000 prisoners incarcerated because of the genocidal campaign have exaggerated the problem of human waste management in urban areas. The above situations have led to the increase of environmental problems in many towns and cities of Rwanda, this phenomenon has created a situation in which the urban poor face multiple burdens, living in unhealthy local environments characterized by a complex interrelated risks, that include overcrowding, sanitary hazards, unsafe or insufficient water, indoor air pollution, accumulation of human waste and diseases bearing pests (Hardoy *et al.*, 2001; McGranahan, 2002; Elliot, 2005).

There is a need, therefore, for concerted efforts, not only in finding solutions to these problems, but also in creating an enabling environment in which people can develop their full potential and have productive lives.

Statement of the problem

The most effective intervention against water and sanitation related diseases are safe excreta disposal." Jha (2007), in his work on sustainable technologies for waste management, observed that: "Human excreta are the cause of many enteric diseases such as cholera, dysentery, typhoid, paratyphoid, infectious hepatitis, hookworm, and diarrhea."

In Africa, infectious diseases linked to poor environmental conditions are major causes of morbidity and mortality amongst children and adults, (WHO, 2002).

Human Waste collection and disposal is one of the challenges facing both rural and urban areas in Rwanda such as Kigali city and Muhanga town especially in universities, schools, hospitals, prisons, (MINISANTE, 2006).

Many prisons in Rwanda are built in towns which are the case of central prisons of Muhanga (Muhanga district) and Kimironko (Kigali city) and in these selected prisons like in many others in the country are known to be overcrowded. These are very big prisons of the country, each housing 6000 prisoners and more, a legacy of the troubled past of Rwanda in 1994 genocide of Tutsi. This prison overpopulation has created a situation of large amounts of human waste that the prison cannot adequately process, excreta disposal from such concentrated groups of people is a major health hazard for both the prison and the surrounding area, (Sabin, 2010).

It has been observed that human wastes leak out of the disposal pits into natural water bodies and streams, some of which provide drinking water and/or water used to wash clothes and vegetables.

Speece, (1996) argued that waterborne diseases transmitted via human excreta, drinking water and food, are a leading cause of death worldwide, especially in the developing world.

These problems constitute obstacles to the socio-economic development of the country and, therefore, hinder improvements in the lives of the population. Waste can be both a resource and an environmental problem, (Rahman, 1996).

The proper human waste management is very urgent for a better environment, economy and sanitation which deserve highest priority, (Rottier, and Ince, 2003)

So much work remains to improve human waste management and this way improve the healthy and well being of Rwandan people.

Therefore, there is a need to explore the human excreta management in selected prisons with the aim to finding safe ways for disposing and reusing human waste.

Purpose of the study

The purpose of this study examined the human waste management in selected prisons of Rwanda namely Kimironko and Muhanga, they are the largest central prisons of Rwanda, with the aim of examine the issues affecting environmental management and public healthy, from improper human excreta disposal.

Research objectives

The overall objective of this research is to analyze environmentally friendly human waste in selected prisons to improve health and well being of people. In line with this, the specific objectives that will guide the study were formed.

1. To establish the status of human waste management in selected prisons
2. To investigate health effects of improper disposal of human waste in selected prisons
3. To establish ways employed to improve human waste disposal in selected prisons

Research questions

1. What is the status of human waste in selected prisons?
2. What are the environmental and public healthy effects of poor disposal of human waste in selected prisons?
3. What are ways employed to improve human waste management in selected prisons?

Scope

Geographical Scope

The study was conducted in two large selected prisons of Rwanda such as Kimironko Central Prison located in the west of Kigali City the capital of Rwanda and Muhanga Prison located in center of Gitarama town capital of Muhanga district at 45 km of Kigali city. This study will cover the situation of human waste management in two selected prisons of Kimironko and Muhanga. The researcher questioned and interviewed the prisoner's chiefs and staffs of these prisons in order to examine the status of human waste management.

Content Scope

The study was focused on examining the human waste management in selected prisons of Rwanda namely Kimironko Central prison and Muhanga Central Prisons. The study was sought to identify all possible health problems and environmental nuisances considered associated with the improper human waste management in selected prisons, determine how prisoners and people surrounding are affected and establish ways employed to improve that human waste management in selected prisons.

Time scope

This study was covered a time period of 10 years (1999-2009). The idea behind these dates is the period in hat many prisons have known the overcrowding after the genocide campaign of Tutsi in 1994. This time judged also sufficient to discover precisely the problem of human waste management in selected prisons, find out all effects associated to that problem the majors parts that focus on and establish all ways employed to improve that situation.

Theoretical Scope

The study was inspired and guided by different health and sanitation report of MINISANTE, MINIRENA, KIST and NGOs which criticize the human waste management

in different prisons of Rwanda. These reports explain that human waste is not well managed which causes problems to the prisoners and surrounding area. As seems, human waste management in selected prisons of Rwanda is below expected, reason of this study to contribute technically and analytically in order to find out all problems associated to that problems and establish different solutions employed to improve that situation.

Significance of the study

The study examined the status of human waste disposal in selected prisons of Rwanda. The research determined the challenges and health problems faced by both selected prisons and surrounding area and the purpose solutions to the problems.

First, this study is a significant source of information showing current status of human waste management in selected prisons in Rwanda. The document provided guidance human waste management problem to the different stakeholders, private and public health sectors.

The second, the study can be used by the future researchers, interest groups of peoples, to access easily the information about human waste management in prisons as well as in other big institutions (schools, universities, hospitals).

Operational definitions of key terms

In this study the following terms are operationally defined to mean the following:

- ❖ **Biogas** refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Organic waste such as dead plant and animal material, animal dung, and kitchen waste can be converted into a gaseous fuel called biogas. This gas, a mixture of methane and CO₂, is used: for direct combustion

in cooking or lighting applications or to power combustion engines for motive power or electricity generation.

- ❖ **ECOSAN** is a sanitation system that turns human excreta into something useful and valuable, with minimum risk of environmental pollution and no threat to human health.
- ❖ **Excreta** refer to waste from humans, including urine and feces (fecal matter).
- ❖ **Fecal sludge** (faecal sludge) is the material collected from on-site sanitation systems such as latrines, non-sewered public toilets, and septic tanks; it is mostly composed of fecal matter (feces).
- ❖ **Human waste management** is the collection, transport, processing, recycling or disposal, managing and monitoring of human waste materials and is generally undertaken to reduce their effect on health, the environment or aesthetics.
- ❖ **Hygiene** is the practice of keeping oneself and one's surroundings clean, especially in order to prevent illness or the spread of disease. It refers to the set of practices perceived by a community to be associated with the preservation of health and healthy living.
- ❖ **Pathogens** are micro-organisms that can cause disease in humans; these include, for examples, bacteria (Salmonella, Shigella, Campylobacter, some strains of E. coli, etc.), Helminth worms (Ascaris, Taenia, Trichuris trichuria, etc.), enteric viruses (Hepatitis, Norwalk, Rotaviruses, etc.), and protozoa (Cryptosporidium, Entamoeba, Giardia, etc.).

- ❖ ***Sanitation*** deals not only with the collection, storage, treatment, disposal, reuse or recycling of human excreta (faeces and urine), but also the drainage, disposal, recycling, and re-use of wastewater. Sanitation generally refers to the provision of facilities and services for the safe disposal of human urine and faeces.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

The concept of human waste management

In many cities, towns and rural areas of Africa today people live and raise their children in highly polluted environment.

Urban and peri-urban areas are among the worst polluted and disease ridden habitats. Much of this pollution, which leads to high rates of disease, malnutrition and death, is caused by lack of adequate excreta disposal facilities and inadequate solid waste collection and disposal service.

Human fecal matter is present in every waste system; in developing nations the problem varies with the prevalence of adequate sanitary disposal systems such as municipal sewerage or on-site septic systems, outhouses, etc. The purpose of human waste management is to:

- prevent the spread of infection to healthcare workers who handle the waste,
- prevent the spread of infection to the local community, and
- safely dispose of human waste

The problems in the world and especially in developing countries such as Rwanda indicate the importance of excreta disposal as an important part of environmental sanitation. The inadequate and insanitary disposal of infected human waste leads to the contamination of the soil and sources of water supplies.

General understanding of human waste management

Human waste management is one of the most important public health programs. It is considered by WHO as one of the basic steps to be taken to safeguard our environment. Lack of proper waste disposal is one of the most pressing public health problems in where availability of safe excreta disposal is very limited, (WHO/UNICEF 2002).

Human waste is a waste type usually used to refer to byproducts of digestion, such as feces, urines, toilet paper, and possibly, feminine products.

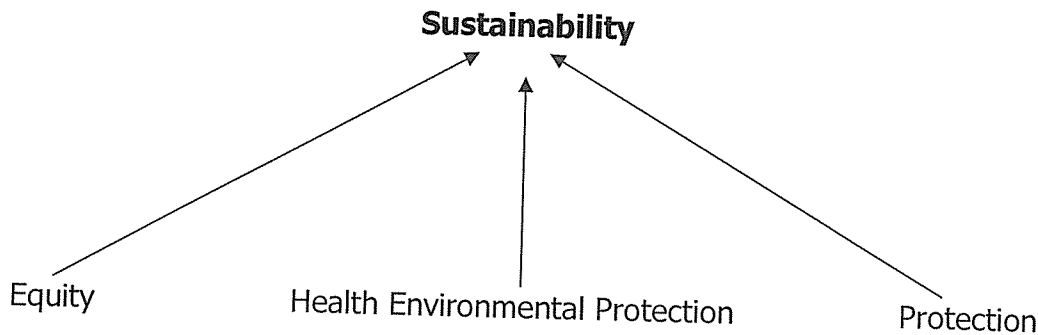
Human waste is a biowaste and can be a serious health hazard, as it is a good vector for both viral and bacterial diseases and is generally undertaken to reduce their effect on health and the environment or aesthetics.

The human waste management is the collection, transport, recycling or disposal, and monitoring of excreta materials. Collection and disposal of human excreta are a serious sanitation problem in most of the cities in developing countries. Human waste management practices differ for developed and developing nations, for urban and rural areas, and for residential and industrial producers, (Pokhrel and Viraraghavan, 2005).

Human waste is most often transported as sewage in waste water through sewerage systems. A major accomplishment of human civilization has been the reduction of disease transmission via human waste through the practice of hygiene and sanitation, including the development of sewage systems, plumbing and appropriate systems human excreta disposal.

An approach to sanitation challenge is concerned with creation of *equity, the protection of the environment the user and the general public*. Its goal is to create socially, economically and ecologically sustainable system.

Fig. 1: After WSSCC (Water Supply and Sanitation Collaborative Council) working group on promotion of sanitation



Source: Report of WHO/UNICEF (2010),

A. Equity

It is mandatory that all segment of the community have access to a reasonable, safe and appropriate sanitation facility adapted to the needs and means (technological, economic etc) of the community.

B. Health Promotion

The Human waste management System should be such that which will prevent disease associated with excreta as well as interrupting the cycle of disease transmission. This implies that:

- The importance of social and behavioral dimensions in achieving health benefits is given priority
- Future sanitation technologies have the demonstrated capacity to prevent the transmission of pathogens

C. Protection of the Environment

The sanitation system must neither pollute the ecosystem nor deplete scarce resources rather should augment to the natural resources.

This implies that:

- Sanitation systems should not lead to water or land degradation
- Sanitation should, if possible, be designed to recycle to the maximum the renewable resources as far as possible

Health implications of improper human waste disposal

Despite the tremendous advances of the previous century, some 2.4 billion people (almost half of the world's population) do not have access to adequate sanitation, (WHO and UNICEF, 2000).

"Sanitation" includes water supply, safe disposal of human waste, waste water and solid waste management, control of vectors of diseases, domestic and personal hygiene, food, sanitation, and housing and has always been a challenging term in the human life, right from the age of civilization to the modern electronic era, etc, (Hutton, and Haller, 2004).

Human excreta and its disposal is one of the bemoan in the modern times since it causes many enteric diseases such as cholera, dysentery, typhoid, infectious hepatitis, hookworm and diarrhea. Studies reveal that over 50 infectious diseases are transmitted through human excreta. In rural areas nearly 80% of the diseases are human excreta borne. Hence safe disposal of human waste is most important for improving the public health and economic growth, (Winblad, 2000).

In the developing world 80% of disease is due to poor sanitation, improper disposal of human waste is one of the developing world's most serious health problems, at least 2.4 billion people, 40% of the world's population, lack access to adequate sanitation, (WHO and UNICEF, 2000).

The safe disposal of human excreta is essential for public health protection. The unsafe disposal of excreta is a principal cause of the transmission of pathogens within the

environment and improvements in excreta management provide significant reductions in diarrhoeal disease (Hutton and Haller, 2004).

Access to improved sanitation lags behind access to water supply throughout much of the world and in particular within developing countries. It is estimated that over twice the number of people lack access to improved sanitation than lack access to an improved water supply (WHO and UNICEF, 2000).

However, the health risks from the absence of improved excreta disposal are likely to exceed those posed by contamination of groundwater from sanitation alone, and this must be borne in mind when planning improvements in sanitation and groundwater protection, (Drangert, 2000).

Furthermore, diarrhoea is a major cause of death and disease, especially among young children in low-income countries. Many of the microbial agents associated with diarrhoea are transmitted via the faecal-oral route and are associated with exposure to human faeces.

Diarrhoeal diseases kill an estimated 1.8 million people each year (WHO, 2005). Among infectious diseases, diarrhoea ranks as the third leading cause of both mortality and morbidity (after respiratory infections and HIV/AIDS). Young children are especially vulnerable, bearing 68% of the total burden of diarrhoeal disease (Bartram, 2003). Among children younger than five years of age, diarrhoea accounts for 17% of all deaths (United Nations, 2005).

Therefore, the lack of clean excreta disposal may be a direct cause of contamination of groundwater sources, contaminated food, poor hygiene and sanitation at personal, household and community levels. In sanitation may also deliver improvements in microbial quality in groundwater (Howard et al., 2003).

Thus, having no disposal system and untreated human excreta is the principal cause in the transmission of pathogens leading to human illnesses. The links between human waste management, water supply service and sanitation options cannot be ignored. The

first stage in the management of sanitation in order to protect against groundwater contamination is to select the right technology for the local environment.

Integrated human waste management systems

Presently half of the human community, most of which is from Africa and Asia, has no access to any type of sanitation (WHO and UNICEF, 2000). An estimated 2.6 billion people or 39% of the world's population lack access to improved facilities for the disposal of human excreta, such as a basic pit latrine, a toilet connected to a septic tank or piped sewer system, or a composting toilet, (WHO/UNICEF, 2010).

The safe disposal of human excreta is essential for public health protection. The unsafe disposal of excreta is a principal cause of the transmission of pathogens within the environment and improvements in excreta management provide significant reductions in diarrhoeal disease (Esrey *et al.*, 1991; Esrey, 1996; Hutton and Haller, 2004).

Reuse of human excreta using safe environmental sanitation approaches would not only improve people's health, but also reduce the problem of accessibility of safe drinking water and sanitation, alleviate poverty, improve the rural economy, relieve women from physical hazards as well as they are concerned in household and laborious tasks and generally safeguard the environment.

Nevertheless, when reusing human excreta, it is imperative to follow scientific procedures, as excreta contain pathogens particularly bacteria, viruses, (Khandaker and Badrunnessa, 2006). Human excreta can be used to generate energy and fertiliser for agriculture and aquaculture, (Quazi and Islam, 2008).

Improper human excreta disposal technologies may be a direct cause of contamination of groundwater sources and improvements in sanitation facilities, may

also deliver improvements in microbial quality in groundwater (Howard et al., 2003), so that can contaminate groundwater and thus lead to public health risks from drinking-water, (Atkinson and Barker, 2004).

The lack of adequate sanitation is a key contributing factor to the ongoing high rates of diarrhoeal disease noted in developing countries. Improvement in sanitation has been consistently identified as being an important intervention to improve health (Esrey, 1996; Esrey *et al.*, 1991).

The human waste practices that are promoted in developing countries fall into one or two broad types: "Flush- and -Discharge" and "drop-and - store". For those who have no or will not have access to flush toilets the conventional alternative is a drop-and-store device; usually a pit latrine. Pit latrines are meant for containment and indefinite storage of human excreta. Drop-and store is often regarded as an inferior and temporary solution compared with flush system. Although this technology can prevent pollution in some places it is not often feasible in urban crowded communities because of lack of space. It is not also a reliable technique in areas where digging deep pits in difficult soil formation and where the ground water is high which in this case are expensive above ground system has to be installed. Unless it is given due attention in cleaning and maintaining it may also be cause of odor and flies nuisance, (Schonning, 2002).

The technologies are different in the size, construction and lining of the pits, whether they use water or not, the type of superstructure and venting systems. It has become evident that in selecting a technology many interrelated factors and many local variables influence the types and construction methods of any sanitation system.

These factors are:

- ✓ Social, cultural, beliefs, values and practices
- ✓ Religious customs
- ✓ Population density and settlement pattern
- ✓ Climatological conditions

- ✓ Topography and soil conditions
- ✓ Geological formations
- ✓ Abundance or scarcity of water
- ✓ Energy
- ✓ Economic standards
- ✓ Political and social organizations
- ✓ Educational level of communities
- ✓ Level of health awareness
- ✓ Safety to users.
- ✓ Availability of resources, and infrastructure that may support sanitation system.

The selection of the technologies should suit to the local condition especially cost. It is a proven fact that water flush toilets are the best installation but they are expensive. There are, at present many different types of excreta disposal or management systems. However, the available technologies are grouped according to the technology involved if they are improved or unimproved.

Table 1: Improved and unimproved sanitation

Improved technologies	Unimproved technologies
Connection to a septic system	Service or bucket latrines (where excreta are manually removed)
Pour-flush latrine	
Simple pit latrine	Public latrines Latrines with an open pit
Ventilated improved pit latrine (VIP)	

Source: report of WHO and UNICEF, 2000

The challenge is to look for an option that will eventually make our environment waste free- the '0' waste option.

Biogas process is currently viewed primarily as a method to stabilize a big amount of human waste, or other wet organic waste and it contributes to a better image of the prisons and community surrounding while reducing odor, pathogens and weeds from the manure and producing an enhance fertilizer easily assimilated by plants.

The implementation of biogas plants has been as an important alternative remedy to reduce waste and tackle the problem in human waste management, particularly Rwandan prisons.

Using biogas digesters to manage animal or human sewage is not a new idea in Rwanda; it has been applied on an enormous scale with great success (SNV/MININFRA, 2005).

Biogas as improved technology for HWM and source of energy

The biogas process is currently viewed primarily as a method to stabilize human waste, or other wet organic waste and it contributes to a better image of community while reducing odor, pathogens and weeds from the manure and producing an enhance fertilizer easily assimilated by plants.

The identification and the implementation for biogas plants is the alternative remedy to reduce waste and tackle the problem of human waste management, particularly in developing countries (Fauziah, 2009).

Biogas systems take organic material such as manure into an air-tight tank, where bacteria break down the material and release biogas - a mixture of mainly methane with some carbon dioxide. The biogas can be burned as a fuel, for cooking or other purposes, and the remaining material can be used as organic compost. The biogas system uses a number of individual digesters, each 50 or 100m³ in volume and built in an excavated underground pit. Toilet waste is flushed into the digesters through closed channels, which minimise smell and contamination, (WHO and UNICEF, 2000).

As we know, respiration and photosynthesis are two major processes that sustain life on the planet earth. The gaseous exchange during the photosynthesis is opposite to that which occurs during respiration.

An average of 1 kg of wet faeces (12% dry matter content, DMC) produces about 0.054 m³ of biogas, while 1 litre of urine produces about 0.009m³ of biogas. Therefore, based on the 35,846kJ/m³ energy potential of methane, the potential production of energy per person per day is 750 kJ and 600kJ in Africa and Europe respectively, (World Health Statistics Report, 2005).

Table 2: Gas constituents of biogas

Substance	Symbol	Per cent
Methane	CH ₄	50 - 70
Carbon-dioxide	CO ₂	30 – 40
Hydrogen	H ₂	5 – 10
Nitrogen	N ₂	1-2
Water vapor	H ₂ O	0.3
sulphide	H ₂ S	Traces

Source: Wikipedia, 2011

The CITT is part of the Kigali Institute of Science and Technology (KIST), established in 1997 as Rwanda's first technological institute for higher education and supported by the Ministry of Education, UNDP Rwanda, GTZ and the Governments of Japan and The Netherlands.

CITT is a centre for applied research leading to environmentally friendly technological innovations and the subsequent transfer of these technologies to rural areas. The centre has agreed to install a number of large institutional biogas systems in prisons in collaboration with the Ministry of Energy, Water and Natural Resources (MINIRENA).

KIST staffs manage the construction of the system, and provide on-the job training to both civilian technicians and prisoners.

The first prison biogas plant started operation in 2001, and has run with no problems since then, (Anne, 2005).

Chapter three

Methodology

Introduction

In this chapter all methods and materials used to collect data from the field were presented and discussed. It gives a description of the process used in selecting the study population and sampling strategies. The research study employed a variety of data collection techniques ranging from questionnaire, Photographs, interviews and observations.

Research design

This study used descriptive research design which adopted both qualitative and quantitative methods. Qualitative methods are used to finding out what people do, know, think and feel by observing, interviewing and analyzing documents. Statistics, tables and graphs were used to present the results of these methods. This study employed a survey research approach with aim of identifying the human waste management problem in selected prisons in Rwanda.

Different techniques of data collection were used including questionnaires, interview, photographs and direct observations. Background information was obtained from central prisons of Kimironko and Gitarama.

Research population

According to Amin (2005), the population is the complete collection (or universe) of all the elements (units) that are of interest in a particular investigation.

and the prisons administrative staffs (heads of prisons and some employees) was 550. These were selected because they have direct involvement in human waste management, control and monitoring of the prisons.

Sample size

The prisons were purposively selected not only they are known as big prisons to shelter a big number of prisoners in the country, but also because they are built in big cities of Rwanda.

According to Amin (2005), the sample is the collection of some (a subset) elements of a population.

The sample for this study consisted of 310 respondents chosen from prisoners' chiefs and the prisons administrative staffs (heads of prisons and some employees) who are currently involved in human waste management of these prisons.

Table 3: Sample size and Sampling procedure

Category of respondents	Sample size	
	Kimironko	Muhanga
Administrative staffs	26	20
Prisoners' chiefs	152	112
Total	178	132
Total sample size (of selected prisons)	310	

To get the sample below Javeau claude's formula was used

Where **$n = 20\% N$** ; $n = 20\% \times 550 = 310$

n_i is the sample size and N is the population size.

In this study, a sample of 310 respondents was used. These were selected using purposive sampling technique in order to attract respondents who are capable of providing the most appropriate information on the subject matter.

Research instruments

During the period of data collection, researcher was provided the respondents with necessary information; the confidentiality of data was assured. The researcher used questionnaire and documentary analysis. In the process of collecting primary and secondary data, the selection of these tools was guided by the nature of data that were required as well as by the objective of study.

Questionnaires were read to the respondents and their responses filled by the researcher since prisoners are not free to take papers with them. This enabled the collection of detailed information from respondents. The questions were both open and close ended.

The interview also was used to the prison administrative staffs. This method involved face to face interaction with the respondents and brought key information not included in the questionnaire.

Observations were made in situations where full and/or acute information cannot be elicited by questioning, because respondents either are not co-operative or are unaware of answers (Kumar, 1999). According to Yin (1994), observations are a form of evidence that do not depend on verbal behaviour, and the method enables the investigator to observe the phenomenon under study directly.

Photographs were taken using a digital camera. This was helpful especially in clarifying and showing how big the problem human waste is, and how is undertaken to solved.

Data gathering procedures

The beginning of the field activities was started by the approval of the research proposal by the university. Thereafter, the researcher secured the permits and the letters of introduction from the School of Postgraduate. The researcher then proceeded with field work to collect data. The data collection was affected by the use of questionnaire and interview of respondents of the selected prisons.

The data generated were then analysed. Descriptive statistics was necessarily be used at this stage to compute the frequencies and percentages, present figures into tables and plot charts. Finally, the research report was compiled and will be submitted to the school of postgraduate and research for approval and viva voce. This marked the closing stage of the research project.

Data analysis

Data from the field were edited and analyzed by use of descriptive methods. Simple qualitative methods were used and hence compilation, sorting, classification and computation of frequencies and percentages involved were presented in tables or / in figures. Microsoft excel as statistical software was used for data analysis. Chi-Square (χ^2) is statistical parameter that was used.

Chi-square (χ^2) is a statistical test commonly used to compare observed data with data we would expect to obtain according to a specific scientific hypothesis. It is the classical method of analyzing frequencies. A non-parametric test, like chi-square, is a rough estimate of confidence; it accepts weaker, less accurate data as input than parametric tests (like t-tests and analysis of variance, for example) and therefore has less status in the pantheon of statistical tests, (Vicki, 2005).

Ethical Consideration

Full explanation was provided to each respondent in the study. Respondents were provided with the letter of introduction written by the supervisor of study before they were questioned and interviewed. Respondents were informed about the purpose of study along with their right not to take part in the study without having to explain why. Each participant took part in the study willingly, and there were no objections. Participants of the study were informed that their responses to questions would be kept confidentially.

CHAPTER FOUR

PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

INTRODUCTION

The results of study presented in this chapter were obtained from the completed questionnaires on to come up whether human waste management is a problem in prisons of Rwanda. Out of 310 questionnaires, a total of 257 were completed at the overall response rate of 83%. The findings and results were analyzed, interpreted, presented and classified into frequency tables according to the objectives, research questions and hypothesis of the research study where Microsoft excel were used.

In most cases, those frequencies were supplemented by graphical depictions in order to provide a visual summary of proportions of various attributes.

Demographic characteristic of respondents

In this section the distribution of respondents of two prisons by age, genders and length of stay in the prisons are reported in the figures one, two and three.

Age of respondents

Figure 2 A and 2 B below show that the majority (52%) of respondents of Muhanga prison were middle aged (30 to 39 years of age). The proportion of young operators (20 to 29 years of age) is quite small (7.5%), and for Kimironko prison the figure 2 shows that the majority (45%) of respondents were 40 to 49 years aged.

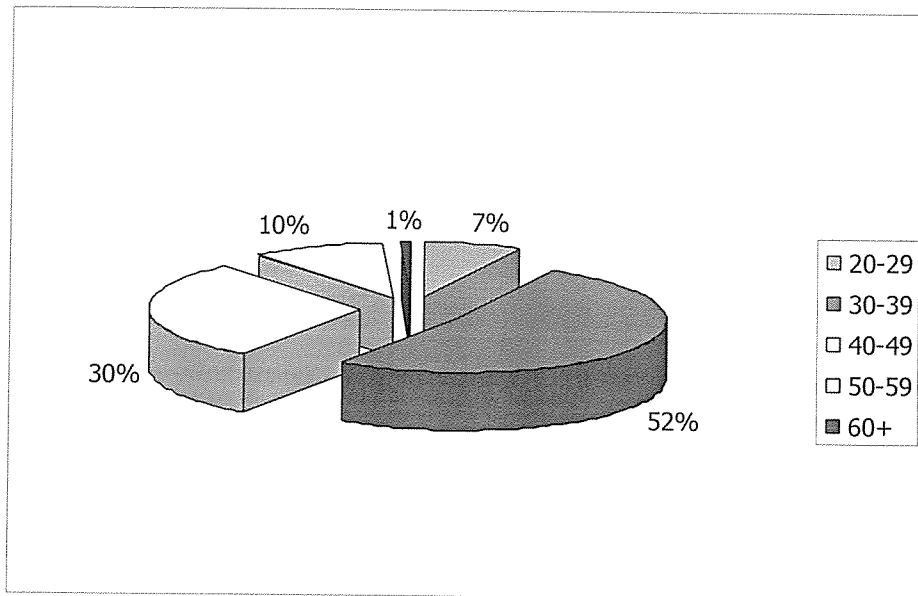


Figure 2 A: Distribution of ages of respondents of Muhanga (=108)

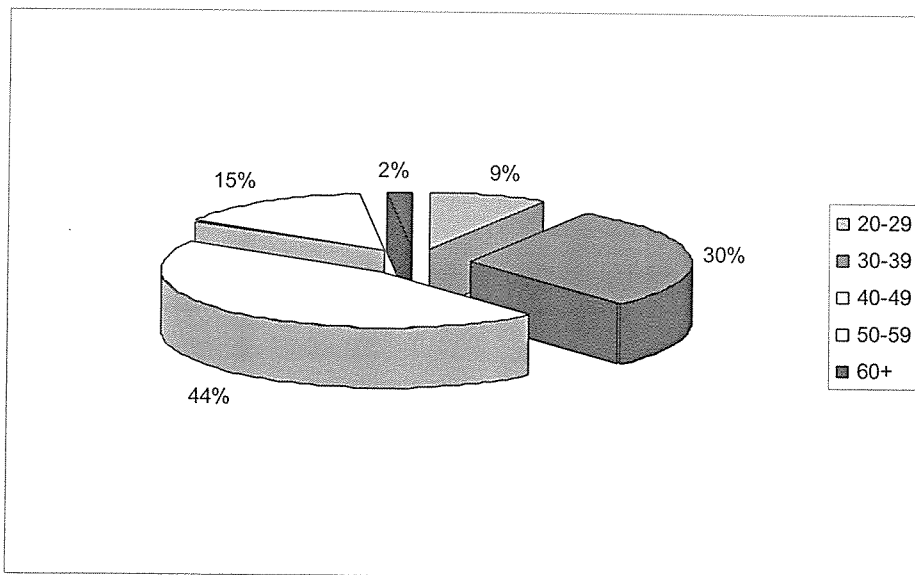


Figure 2 B: Distribution of ages of respondents of Kimironko (n=149)

The fact that 52 % of the 108 respondents are aged between 30 and 39, and 45% of 149 respondents are aged between 40 and 49 years shows that almost half of the respondents of the selected prisons are middle-aged, people working in all services of the prisons including waste management services especially in human waste management and health care. The figures show that over 48% of the 257 respondents have ages between 30 and 49 years. Based on the above results one may conclude that the respondents of the selected prisons are concentrated at the middle age of the adult age.

Gender distribution of the respondents

Figure 4 & 5 below show that in Muhanga prison the majority (91.7 %) of the respondents were male. The proportion of female was 8.3%, and also in Kimironko prison the majority (96%) of the respondents were male and the proportion of female 4%.

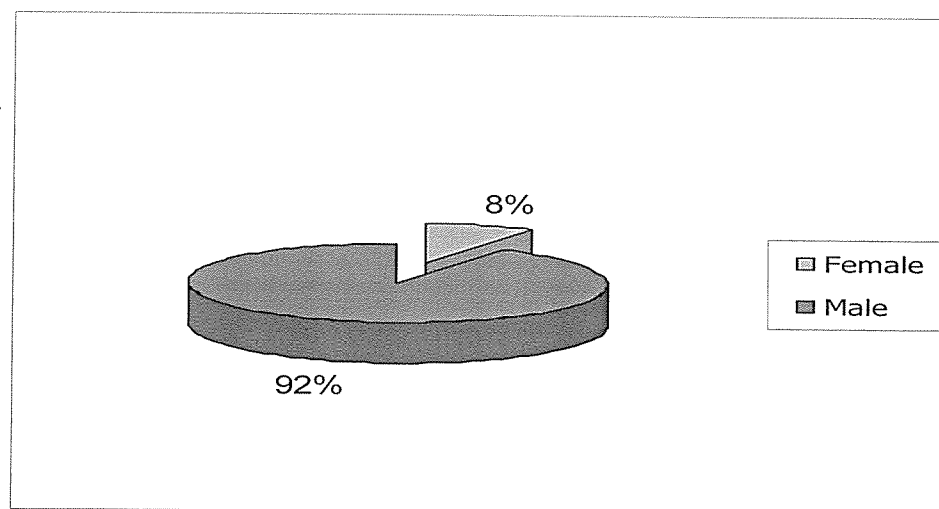


Figure 3 A: Distribution of gender of respondents of Muhanga (n=108)

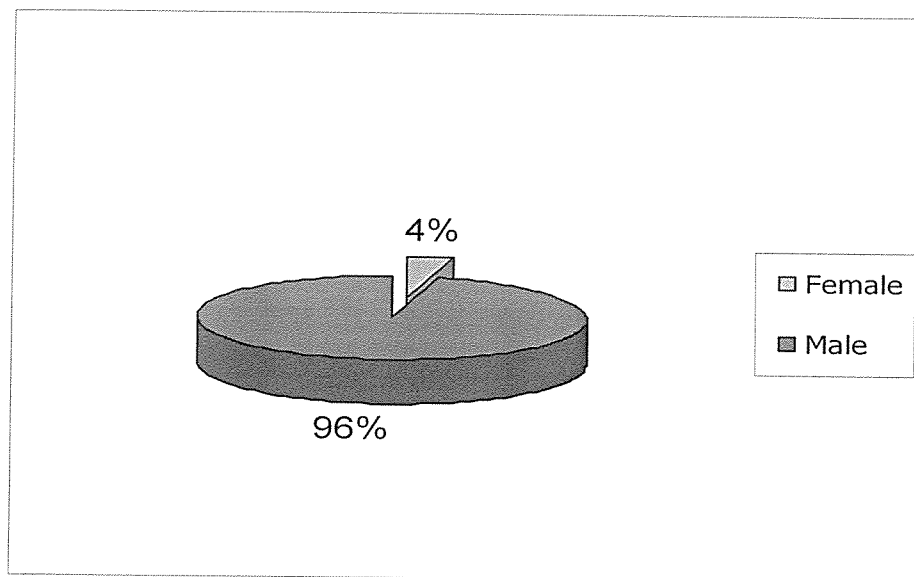


Figure 3 B: Distribution of gender of respondents of Kimironko (n=149)

The figures 3 A and 3 B, show that the respondents in selected prisons are dominated by male. This shows that males are relatively much more efficient than their female counterparts in terms of efficiently managing waste especially in prisons because of the big amount of waste generated.

Number of years of stay of the respondents in selected prisons

The results obtained from the survey were used to summarize the duration of stay of the respondents in the prisons.

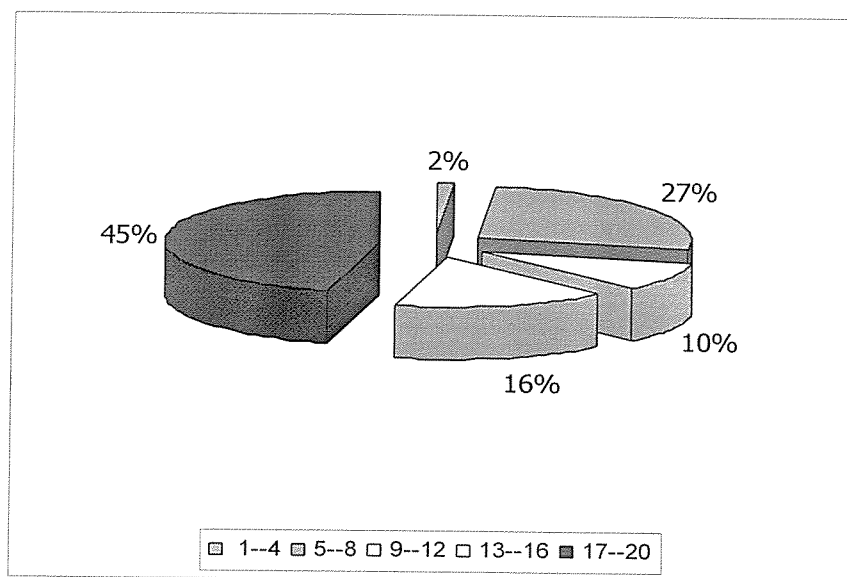


Figure 4 A: Length of stay in Muhanga prison (n=108)

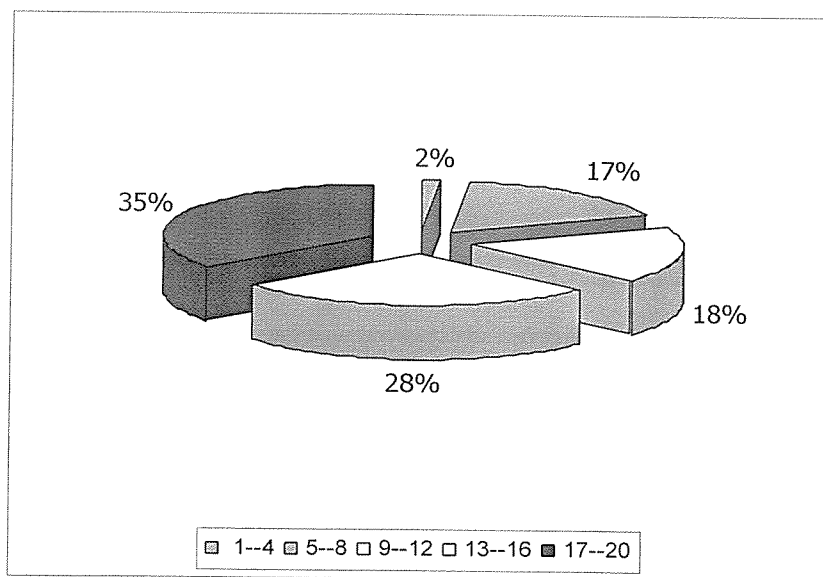


Figure 4 B: Length of stay in Kimironko prison (n=149)

The results show that 46.2% of the respondents of Muhanga prisons and 34.5% of the respondents of Kimironko prison have been in the prison between 17 and 20 years, while 26.5% of them were in the prison between 5 and 8 years in Muhanga central prison and 28% were in prison between 13 to 16 years in Kimironko prison, and less

than 2% of respondents both in Muhanga and kimironko central prisons were in prison for less than a 4 years.

Roughly, these results obtained from the population of respondents with respect to the period or number of years of stay in selected prisons reveal that the majority (63%) of all respondents (n=257) have been operational, in selected prisons, between 13 years or more, with 13 or more years of experience disposing and controlling of human waste in selected prisons. There is a generally positive association between duration of service and overall efficiency awareness in human waste management of the selected prisons.

The status of human waste management in selected prisons

From the research findings the following responses were given to complete the first objective of the study that was to establish the status of human waste management in selected prisons.

The quality of human waste disposal in selected prisons

The research assumed that human waste in prisons is not disposed as may be required. It is in this regard that respondents were asked to rate their satisfaction levels with the quality of human waste management in selected prisons Kimironko (n=149) and Muhanga (n=108).

In order to assure that respondent's expectations are met other three sub questions were made, asking them what they were dissatisfied with, what are the types of disposal or management systems used in the prisons and if yes or no they have a common human waste disposal pit and finally if the pit is the problem for the prison life or people around.

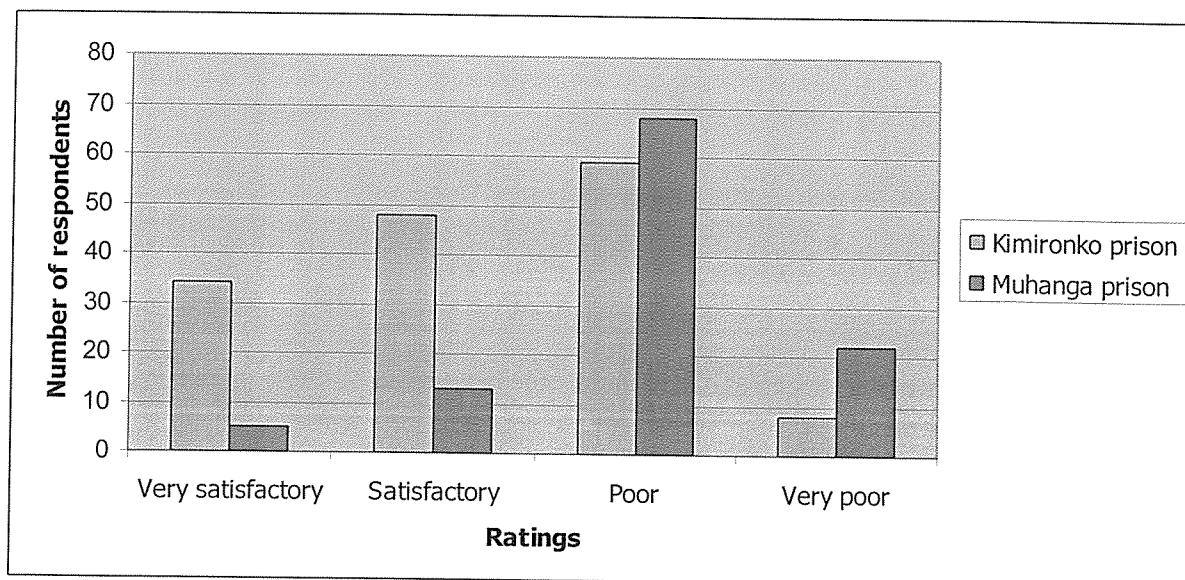


Figure 5: The quality of human waste disposal in selected prisons (n=257), Kimironko (n=149), Muhanga (n=108)

Table 8 shows a graphical depiction of the figures presented in the table below in appendix I. The figure shows that the majority of respondents of both prisons said human waste poorly disposed (68% of Muhanga prison and 39.5% of Kimironko).

A considerable number of respondents (32%) of Kimironko prisons said that the human waste is satisfactorily disposed and 23% very satisfactorily. Only 5.5% rated very poor in relation to the quality of human waste disposal.

The second part of respondents of Muhanga Prisons (20.4%) said human waste is very poorly disposed, 12% rated they are satisfied by the quality of human waste disposal, only 4.6 said they are very satisfied.

In the view of the researcher, in Kimironko prison disposal of human waste has been given more little attention than in Muhanga central prison.

In the sub question where the respondents were asked what they were dissatisfied with, they went on further to say systems used in disposing human waste,

the little number of toilets, and of the because of the problem of prisons overpopulated, they do not have access to the appropriate toilets.

Table 4 A: Types of excreta disposal used in Muhanga Prison (n=108)

Types of excreta disposal	No available	No in use
Bucket	Many	Many
Latrines with open pit	4	4
Public Latrines	4	3
Ventilated improved pit latrine (VIP)	2	2
disposal pits	2	2

Table 4 B: Types of excreta disposal used in Kimironko Prison (n=149)

Types of excreta disposal	No available	No in use
Bucket	Many	Many
Latrines with open pit	3	2
Public Latrines	5	5
Ventilated improved pit latrine (VIP)	3	3
Disposal pit	3	2

Respondents were asked to give the types of excreta disposal used in prisons, the number available and the number in use.

The table 4 A and 4 B show that in selected prisons, they are many buckets used as human waste disposal inside the prison, and help to transport human waste from prisons to common disposal pits.

The table 4 A and 4 B also revealed that in Muhanga prisons they are 4 latrines with an open pit available are in use, 4 public latrines and only 3 are used, 2 ventilated improved pit latrine (VIP) available all are in use, in 2 disposal pits available all are in use.

Whereas, in Kimironko Prisons as shown in the table 3, among 3 latrines with an open pit available only 1 is used, 8 public latrines all are used and 3 ventilated improved pit latrines (VIP) all are used, 3 disposal pits only 2 are in use.

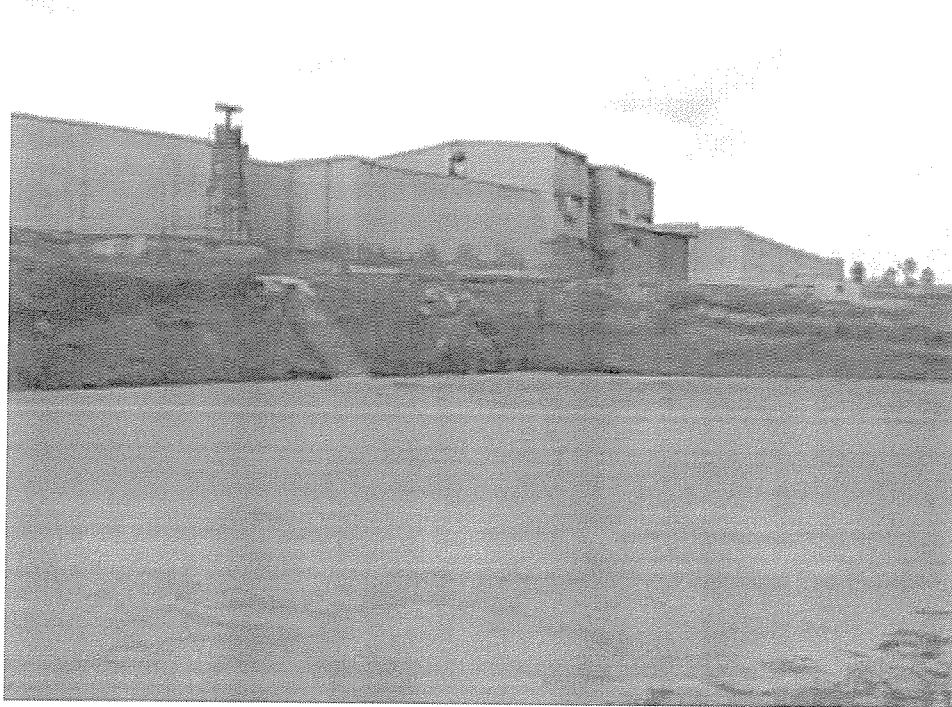


Plate 1: Excreta Disposal pit at Muhanga central prison

It is important to note that in both prisons buckets are used by the prisoners because they are not allowed to go out of the prison every time they need to go to toilets, considering that no one of the public latrines and/or VIP is inside the prisons. Human wastes from buckets are transported to the prisons common pits. Latrines with an open pit, public latrines and ventilated improved pit latrines are used with staffs, prisons guard and some prisoners' chiefs.

Are the common excreta disposal pits a problem on the prison life or community around?

Here non-parametric tests have been used for analyzing the frequencies. Usually non-parametric tests are used with observations on nominal, ordinal and interval scales and are suitable for data which are counts or for derived data, e.g. proportions, indices. In research, to look at the relationship between two discrete variables, for instance when a dependent variable is scaled on nominal (e.g. "yes" or "no", the appropriate non parametric statistic to use is the "*chi square test*".

Chi-square (χ^2) is a statistical test commonly used to compare observed data with data we would expect to obtain according to a specific scientific hypothesis. It is the classical method of analyzing frequencies. This involves computing a test statistic which is compared with a chi-square (χ^2) distribution. The chi-square test is always testing what scientists call the null hypothesis, which states that there is no significant difference between the expected and the observed result. The formula for calculating chi-square (χ^2) is: $\chi^2 = \sum (O - e)^2 / e$

That is, chi-square is the sum of the squared difference between observed (o) and expected (e) data (or the deviation, d), divided by the expected data in all possible categories.

In the purpose of knowing whether human waste disposal is a problem or not in selected prisons, 108 respondents from Muhanga prison and 149 respondents of Kimironko prison sector were asked. The results found are shown in the table below:

Table 5: Respondents who said the disposal pit is a problem or not on the prison life or community around

Response	Muhanga prison	Kimironko prison	Total
Yes	85	105	190
No	23	44	67
Total	108	149	257

To test the claim of the proportion of respondents from each prison who said that disposal pit is a problem, we used chi-square as a statistical test.

The first of all when to come up with this test we start by stating the hypothesis:

- ✓ **The null hypothesis (H_0):** states that there is no significant difference between the expected and observed frequencies.

$$H_0: P_1 = P_2$$

- ✓ **The alternative hypothesis** states they *are* different. The level of significance (the point at which you can say with 95% confidence that the difference is not due to chance alone) is set at **.05** (the standard for most science experiments), where at least one proportion differs from other.

Secondly, it is important to find the critical value. Many statistics rely on a concept called **Degrees of freedom**. The details vary stat to stat, but it's based on the number of variables involved in a calculation. For Chi Square, the degrees of freedom are:

The formula for the degrees of freedom:

$$df = (\# \text{ rows} - 1) * (\# \text{ columns} - 1)$$

$$= (2 - 1) * (2 - 1) = 1$$

The critical value at $df = 1$ is 3.84

Then the following step is to calculate the expected values, as we already know what Chi Square does is compare the actual or **Observed** data (**o**) we have from respondents with an **Expected** value.

$$e = (\text{Row sum} \times \text{column sum}) / \text{Grand Total}$$

➤ (Total Yes * Total Muhanga prison respondents) / TotalTable

$$(190 * 108) / 257 = 80$$

➤ (Total No * Total Muhanga prison respondents) / TotalTable

$$(67 * 108) / 257 = 28$$

➤ (Total Yes * Total Kimironko prison respondents) / TotalTable

$$(190 * 149) / 257 = 110$$

➤ (Total No * Total Kimironko prison respondents) / TotalTable

$$(67 * 149) / 257 = 39$$

Table 6: Calculation of expected values

	Muhanga prison	Kimironko Prison	Total
Yes	o: 96 e: 94.55	o: 129 e: 130.44	225
No	o: 12 e: 13.44	o: 20 e: 18.55	32
Total	108	149	257

Knowing that, $\chi^2 = \sum (O - e)^2 / e$

$$\chi^2 = 0.858$$

The table value for Chi-Square in the correct box of **1 df** and **P= 0.05** level of significance is **3.48**.

Finally, inferences made from the computed value (**0.858**), shows that is less than the critical value (3.48), we declare the χ^2 *not significant*. The observed frequencies of the respondents the two prisons, who said the disposal pit is a problem of the prison life or community around, do not significantly differ from the expected frequencies. The observed frequencies have a "good fit" with what was expected. There is no evidence to reject the claim that the proportions are equal. Hence it seems that there is no difference in the proportions of the respondents who said the disposal pit is problem by each prison; any differences are due to chance alone.

The evaluation of human waste management problems

In this sub question of the study the findings from the field evaluate how most important the human waste management problems are regarded in the selected prisons, to come up with that different scales were:

1. Very Serious
2. Serious
3. No problem

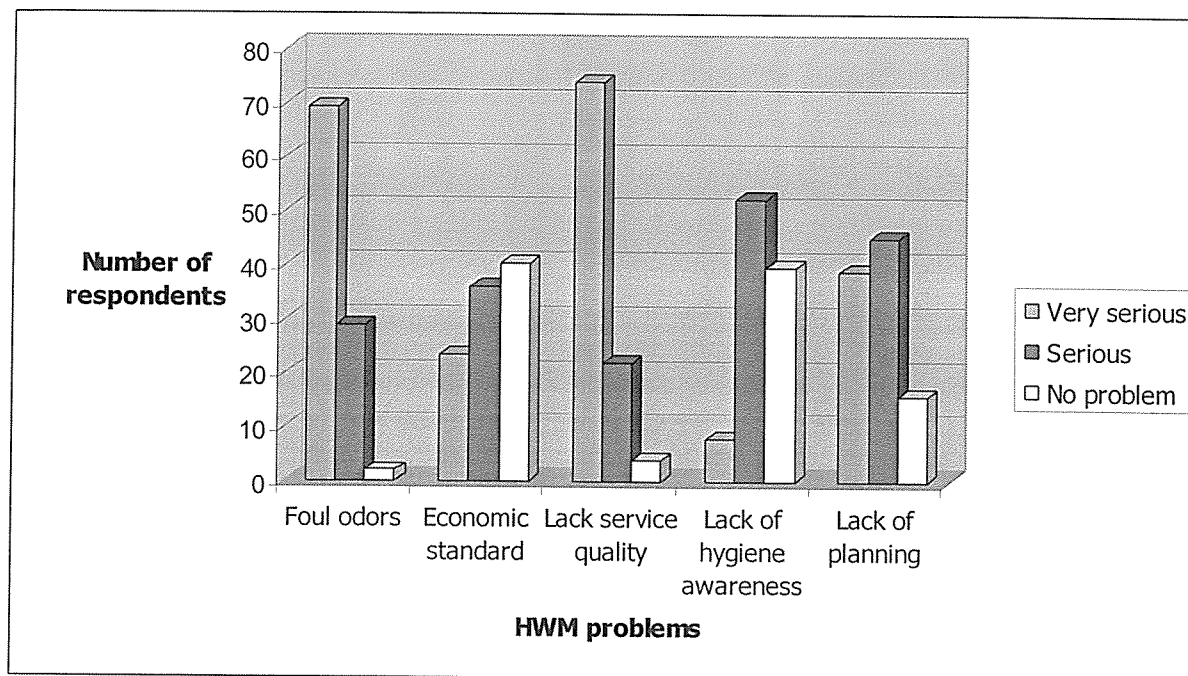


Figure 6: Evaluation of human waste management problems in Muhanga (n=108)

The Figure 9 indicate that the majority of respondents rated the lack of service quality (cause of the prison overpopulation) at 84.2% as well as foul odors at 72% and lack of planning (short medium and long term plan) at 53% to be very serious problems of Muhanga Central Prison.

Whereas, the economic standard (43.5%) were categorized as a serious problem and 49% of respondents stated that lack of Hygiene awareness is not a problem.

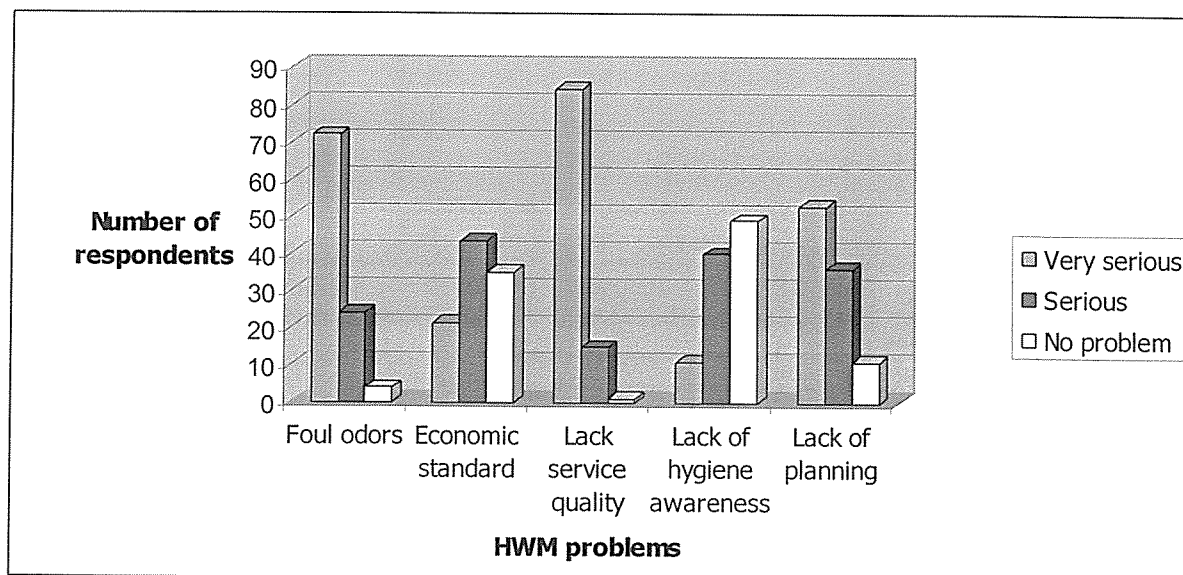


Figure 7: Evaluation of human waste management problems in Kimironko (n=149)

This figure portrays that the majority of respondents of Kimironko prison agree that lack of service quality (cause of the prison overpopulation) (74%), foul odors (69.1%) are very serious problems related to the human waste management of the prison. On the other side, lack of hygiene (52.5%) and Lack of planning (short, medium and long term plan) are seemingly not very serious but serious problems. Here in Kimironko Central prison the economic standard was rated as no problem at (40.3%).

According to the result the foul odors is the major problem related to the human waste management of both prisons, not only inside but also out of the prisons. When an unpleasant odor, especially from human excreta, persists or occurs frequently, especially in an unexpected location, it is likely to create a nuisance and lead to complaints. Odor complaints are often accompanied by claims of impaired health from exposure to the odors (Schiffman et al., 2000).

Complaints about odors have been cited as the most frequent cause of friction with facility neighbors. As both prisons are situated in the towns, population growth and expansion around may even affect facilities originally constructed in remote areas, as residential and commercial growth moves closer. While risk impact studies at facilities with severe odors have shown that odor is rarely an off-site health hazard, odor can be a nuisance for people living or working near a facility and cause issues like:

- ✓ Affecting people's enjoyment of their properties, especially in warm weather.
- ✓ Raising concerns about property values in areas affected.
- ✓ Bringing up health concerns, even where no measurable hazard may exist.
- ✓ Making it difficult to site new waste facilities or expand existing facilities, although other factors may favor a particular location.

The UNEPA (2006) state that wastes that are not properly managed, especially excreta waste, are a serious health hazard and could lead to the spreading of diseases and releases a bad odor. The bad odor affects the people settled next to the disposal pits, which clearly show that the pits have serious effects to people settled around or next to them.

The majority of the respondents of both prisons argued that people, especially those who are located closer to the prisons, are not happy about the bad odors from the excreta disposal. Residents close to the prisons have complained that the place is smelly and dirty, which they are against very much.

Health effects of poor disposal of human waste management

The aim of this question was to find out whether people or/and environment inside or around the selected prisons are affected by any infectious diseases or nuisances. From the research findings, the following were identified as

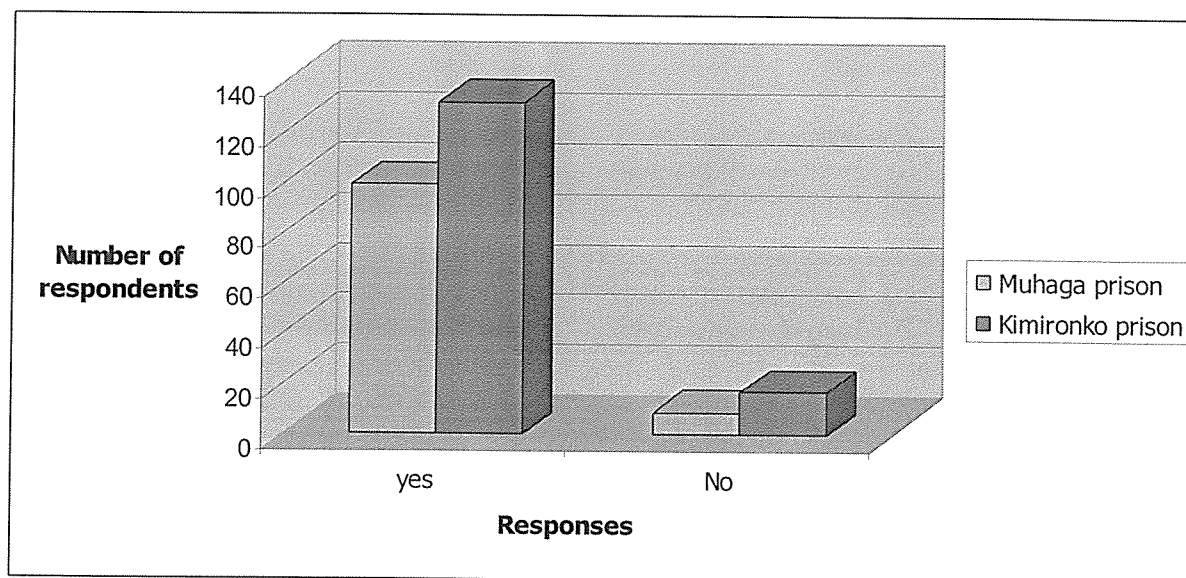


Figure 8: Ratings to know if the prisoners suffer from human waste disposal of Kimironko prison (n=149) and Muhanga (n=108)

The results shows that the large majority of respondents Muhanga Central Prison (91.5%) and Kimironko Central prison (88.6%) agreed that prisoners suffer from different infectious diseases associated with improper human waste management. Only 8.3% of respondents of Muhanga and 11.4% of Kimironko said they are infectious diseases caused by human waste management.

According to the (WHO, 2004), improper human excreta have been implicated in the transmission of many infectious diseases. It is now recognized that only its prevention, largely through improved sanitation and hygiene, will reduce the harms and death toll any further.

It is noteworthy that human waste management in selected prisons, as well as in other prisons calls for preferential options that provide the acceptable waste disposal and other basic hygiene services.

The large quantity of human waste brought to the disposal sites is not well treated, that is why respondents have been asked to list the infectious diseases or/and environmental nuisances that are the mostly to harm life inside or outside of the prisons. People are so scared of an outbreak of infectious diseases that can occur at anytime.

Table 7 below presents a list of the most frequent infectious diseases and environmental nuisances in selected prisons.

Table 7: Reported number of human waste related infectious diseases and environmental nuisances in selected prisons

	Muhanga prison		Kimironko prison	
Infectious disease	Frequency	%	Frequency	%
Diarrhea	59	54.6	64	43
Typhoid	22	20.4	38	25
Cholera	3	2.8	10	7
Dysentery	24	22.2	37	25
Total	108	100	149	100
Env'tal nuisances	Frequency	%	Frequency	%
Drinking water pollution	34	31.5	25	17
Food chain contamination	35	32.5	54	36
Flies and insects	33	30.5	56	37.6
Soil and air pollution	6	5.5	14	9.4
Total	108	100	149	100

The vast majority of respondents (54.6%) in Muhanga prison and (43%) reported the diarrhea as the disease that mostly causes health damage in prisoners.

Some respondents (22.2%) and (20.4%) of Muhanga prison as well as (25%) of respondents of Kimironko prison mentioned also the dysentery and typhoid as second diseases that are suffered in selected prisons.

Only 3% respondents of Muhanga Prisons and 7% respondents of kimironko regarded Cholera as one of diseases that sometimes affect life in selected prisons to a low level though.

Human waste disposal has an adverse impact on the environment. According to a significant number of respondents of Muhanga prison (32.5%) and (36%) of Kimironko prison, the germs in the excreta contaminate easily food chain, while 31.5% of respondents of Muhanga and (36%) said failure to dispose human waste lead to pollution of surface water, drinking or washing water. Although, the number of respondents who said faeces are unhygienic, smelly and attract flies, is almost high in both prisons, (30.5%) in Muhanga Prison and (37.6%) in Kimirinko Prison.

A small number of respondents (5.5%) in Muhanga and (9.4%) in kimironko prison replied that there are some aspects of soil pollution and air pollution further to pesticides used to control smelly, flies and other insects related to improper human feces.

According to (Who, 2005) various diarrheal and other diseases are spread via fecal-oral routes, and these routes are far more heavily traveled where water supplies and sanitary conditions are inadequate. This information concurs with KIST report (<http://www.ashdenawards.org/>, retrieved on 7th March 2011, 18:22:52 GMT), which stated that Rwanda's troubled past has led to a huge increase in the prison population. Severe overcrowding has put overwhelming pressure on the prison infrastructure, especially the sanitation system, leading to health and environmental problems.

Thus, where a large number of people sharing inappropriate excreta disposal systems, eating food from the same source, there is a greater risk of the spread of diseases such as diarrhoea, food poisoning, typhoid, cholera, hepatitis A, and other communicable diseases, (WHO, 2007).

Given the importance of diarrhea and other diseases or nuisances mentioned above, it seems fair to say that human feces remains the world's most hazardous

pollutant, and that related water and sanitation inadequacies still constitute one of the world's most serious environmental health problems.

The figure 12 gives clearly responses given when respondents were asked if communities around the selected prisons have ever complained of any nuisances related to improper feces disposal facilities.

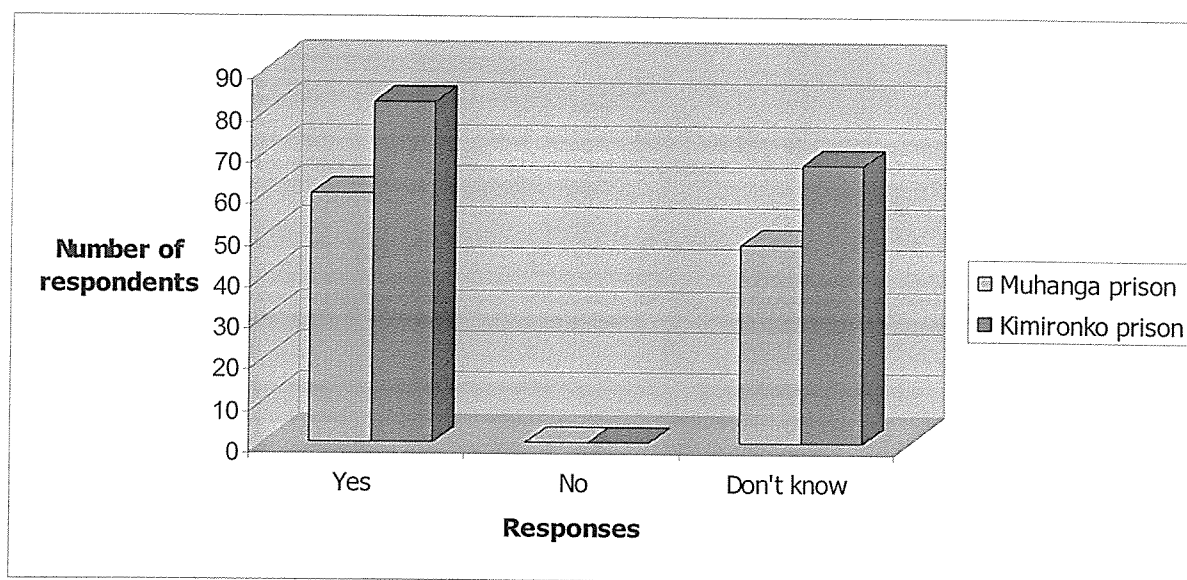


Figure 9: Responses to know if communities around the disposal facilities have complained of any nuisances

The respondents in Muhanga prisons (55.5%) and (55%) in Kimironko prison replied positively, there are complaints from people living around prisons about nuisances related to bad human waste disposal.

None of respondents replied no to the question. Then, almost the half of the respondents namely 44% of Muhanga and 45% of Kimironko said they do not know about any complaints that should have made by communities around the prisons.

For the respondents who said yes to the question, stated the most nuisances that people complain about is foul odors from human waste disposal pits of the prisons.

Human excreta when not well disposed are considered “unhealthy” as well as “smelly”. However, in selected prisons there are almost no data available concerning the public health effects of odor because there have been no studies investigating the impact of malodorous gases on human health rather than the responses or outcomes elicited from the presence of malodorous air in general.

Moreover, respondents confirmed that people always complain about the problems which are typically interrelated: flies or other insects that contribute to the spread of human waste related diseases like diarrhea, typhoid, dysentery, etc. From the researcher observation, it is obvious that all flies and insects seen around the disposal pits contribute in contaminating food and water transmitting infectious diseases inside or around the selected prisons.

The major health burden arising from food contamination is almost certainly its contribution to the diarrheas and dysenteries that figure so highly in the morbidity and mortality especially of children in communities around the disposal pits (WHO, 2007). The researcher has noticed that for the selected prisons or other prisons of the country, with very little access to basic sanitation, increasing the effectiveness of management of excreta has the biggest health implications and the biggest challenge.

According to (WHO/UNICEF, 2000), methane (CH_4) and nitrous oxide (N_2O) are greenhouse gases (GHG) that have a stronger air pollution effect than carbon dioxide. Methane and nitrous oxide are formed when organic materials – such as excreta (or wastewater, wastewater sludge) decompose in anaerobic (or almost anaerobic) conditions. So that is why some respondents have agreed that excreta in selected prisons are all possible sources of these greenhouse gases, depending on how they are managed. Thus, improving access to sanitation and improving management of the collected excreta, in selected prisons can substantially reduce greenhouse gas emissions, excreta related diseases or other environmental nuisances seen above.

Strategies to improve human waste management

Safe excreta strategies have become a yardstick of socio-cultural development of a nation. Improved strategies of human waste disposal, results in improvement of health, reduced child mortality/morbidity, improved water quality, environment and economic growth of a country.

The purpose of safe excreta strategies is to contain human excreta at the moment of defecation so that it is not free to spread throughout the environment.

In this section, 43 administrative staffs were interviewed to give their opinions about the current human waste management technologies in the selected prisons and what is being done to improve them.

In the first sub question all 43 respondents agreed that the current human disposal technologies in selected prisons have to be improved, even though it seems very difficult to be achieved considering the big number of prisoners incarcerated. There is no way that the number of toilets can be augmented inside the prisons, the only way to overcome the issue is to reduce the number of prisoners by transferring some in other prisons that are being built in the country.

Nevertheless, According to the second sub questions asking whether they are alternatives that are being planned and/or implemented to improve human waste management in selected prisons, respondents interviewed agreed that the safe disposal of human excreta in selected prisons is essential for prisoners and public health protection.

The major views gathered from respondents about alternatives to be undertaken to improve human waste management in selected prisons to save the human environment and lead to adequate sanitation were summarized in the figure below.

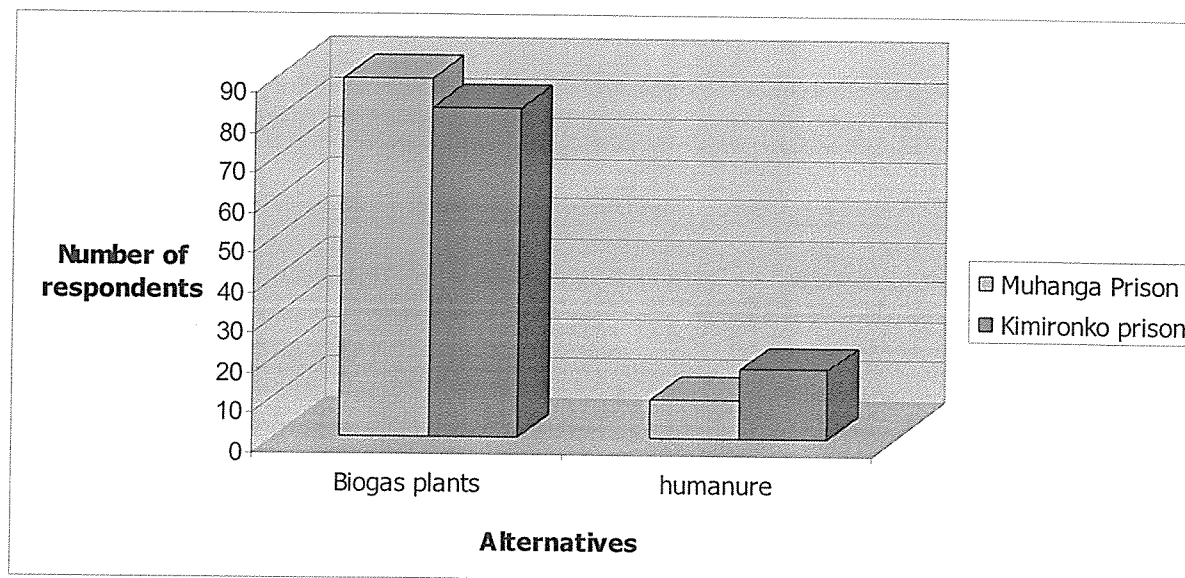


Figure 10: Alternatives to improve the human waste management technologies in selected prisons (n=43)

A small number of respondents (10%) of Muhanga Prison and (17.4%) of Kimironko Prison, claimed that humanure process which involves a compost toilet is the other alternative to dispose human waste in selected prisons.

The purposes for composting humanure include preventing water pollution, recycling human excrement to prevent fecal contamination of the environment, and recovering soil nutrients for the purpose of growing food.

Humanure is safe for humans to use on crops as long as it has been composted properly. This means that thermophilic decomposition of the humanure must heat it sufficiently to remove or destroy harmful pathogens, or enough time must have elapsed since fresh manure was added that biological activity has killed most pathogens, (<http://www.compostingtoilet.org/>, retrieved on 22nd June, 2011 12:23:45 GMT).

It is important to note that in selected prisons respondents are aware of the fertilizer value of human faeces. But the respondents argued that using human excreta as fertilizer is "unhealthy" as well as "smelly". This information tally with (<http://www.compost-bin.org/humanure-handbook/>, retrieved on 22nd June, 2011, 21:09:38 GMT) which state that using human waste as fertilizer is repulsive and unacceptable because they can attract flies,

From the results shown in the figure 17, over 90% of respondents in Muhanga prisons and 82% in Kimironko prisons indicated that biogas plants is the most preferred alternative to dispose such huge quantity of human waste efficiently. It is important to take into account the selected prisons put emphasis on biogas considered as ECOSAN, well appreciated as the long-term and cost effective strategy for excreta disposal.

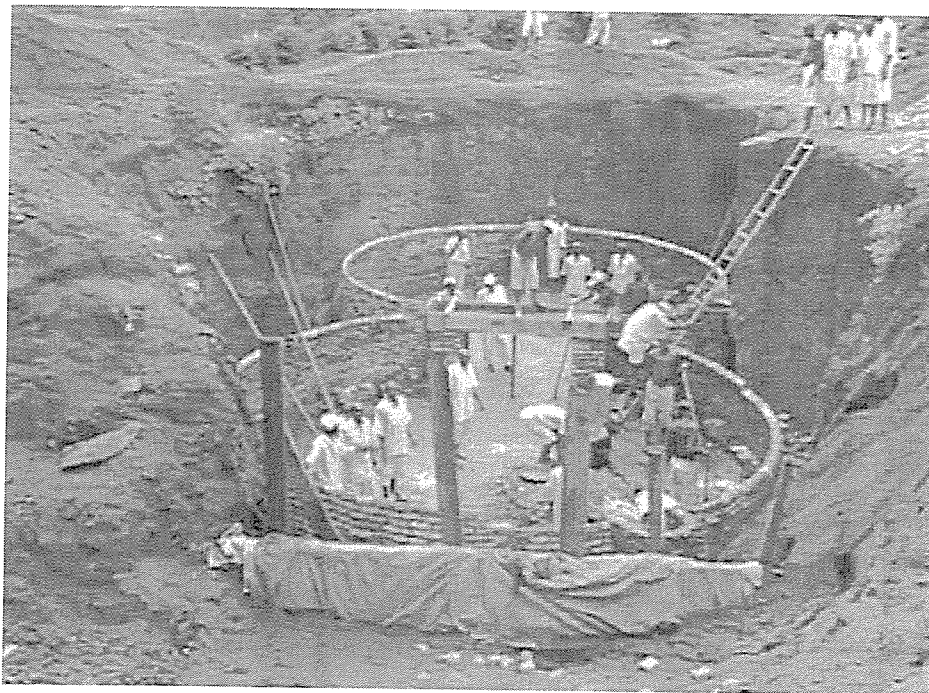


Plate 2: Biogas plants that are being constructed at Kimironko central prison

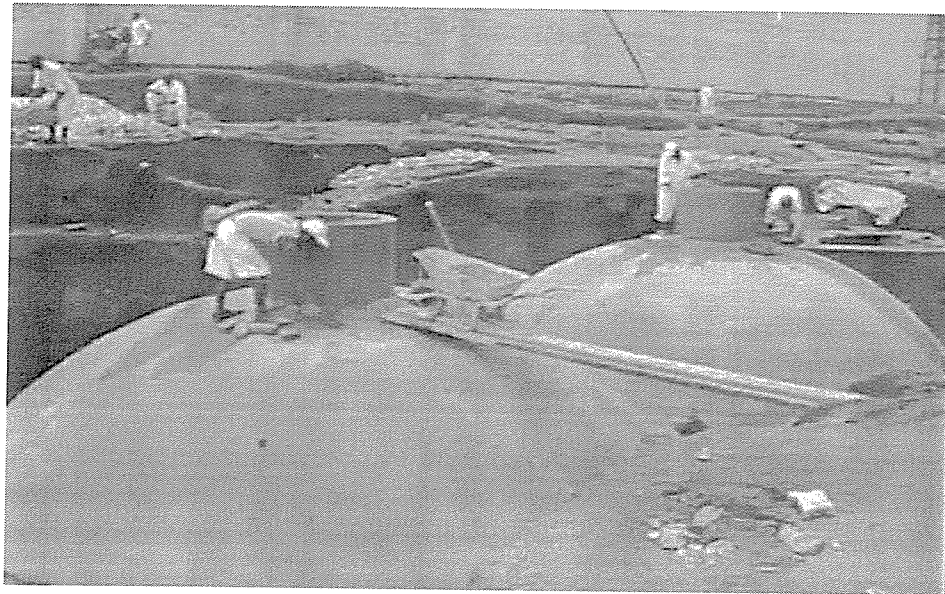


Plate 3: Biogas plants construction almost finished at Muhanga Central prison

According to respondents, human waste disposal from such concentrated groups of prisoners is a major health hazard for both the prison and the surrounding area and also the prisons use fuel wood for cooking, putting great pressure on local wood supplies.



Plate 4: Wood to be used in Kimironko Central prison (deforestation)

Biogas has been found as a hygienic and affordable way of disposal of human wastes from disposal pits, generating biogas should be used for different purposes like cooking and lighting.

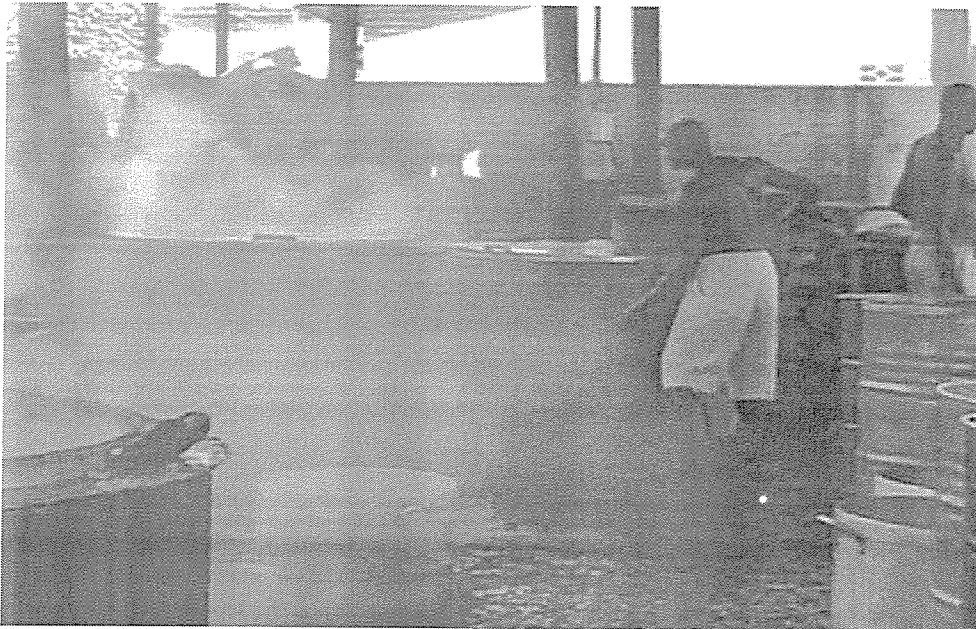


Plate 5: Prisoners cooking with fuel wood at Muhanga Central prison

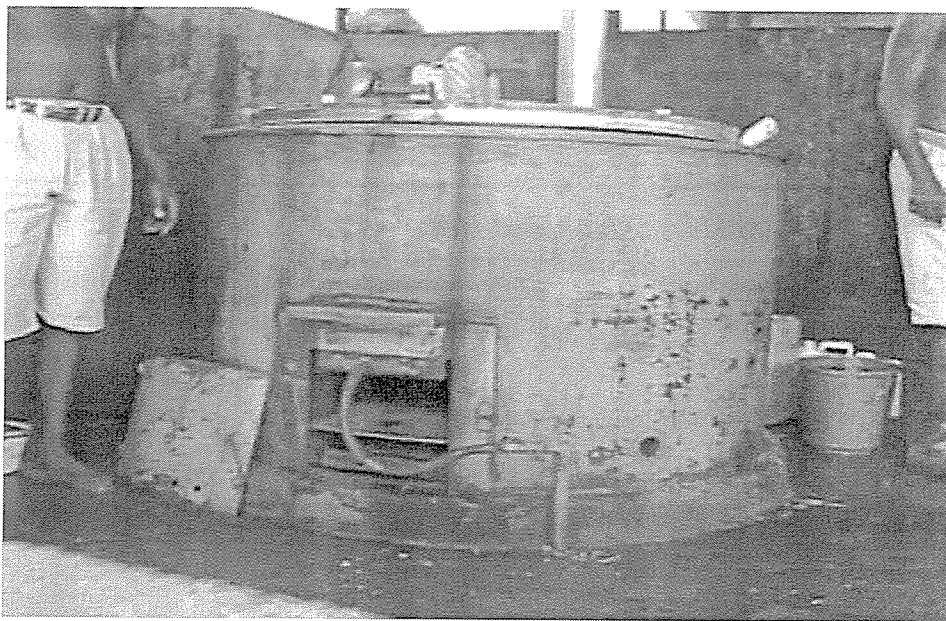


Plate 6: Prisoners cooking with biogas at Cyangugu Central prison

A biogas plant is the name often given to an anaerobic digester that treats farm wastes, human wastes or energy crops. According to Richards and Cummings, (1991), the composition of biogas varies depending upon the origin of the anaerobic digestion process. Advanced human waste treatment technologies can produce biogas with 55–75% CH₄, or higher using in situ purification techniques.

The overcrowded prisons means that energy consumption is higher, and the amount of waste produced is greater as well. The selected prisons intend to get approximately one-half of their fuel for the prison by converting human feces into biofuel. Converting human waste to biogas will improve three areas of the Rwandan prison situation. Firstly, it will save the Rwandan government nearly \$1 million a year that it is usually spent on wood for fuel. Secondly, it will reduce the amount of waste being dumped along the hills finishing in rivers and streams. Thirdly, once the waste is processed, it will serve as an odor-free fertilizer for the grounds.

A director of Kimironko prison confided that the program has been so successful in one prison of western Province near the Democratic Republic of the Congo where there are now biogas facilities and they produce nearly half the necessary electricity to power the prisons.



Plate 7: Biogas plants at Cyangugu Central Prison (no more excreta disposal pits problems)

The process requires putting a given amount of human or animal waste into a “digester,” which ferments it using bacteria to release methane gas that can be captured and then burned as fuel. Attached is a “compensating chamber” that replenishes the supply of bacteria to keep the operation self-sustaining. A 100m³ biogas plant can store 20m³ of gas, but may generate up to 50m³ per day, so it is important that the gas is consumed regularly. The biogas plants will be purchased for the prisons by the Ministry of Internal Security. The cost of a 500m³ plant is about 50 million Rwandan francs (£50,000). A system of phased payments is used, with the final 5% paid only after 6 months of satisfactory operation. The initial reason for using biogas systems was to improve the sanitation in prisons, reducing health risks and smell for both prisoners and the neighbouring residents. Large institutions put enormous demands on fuel wood for cooking, and can cause local deforestation even in a generally well-wooded country like Rwanda. The prisons of 5,000 people consumes about 25 m³ (approximately 10 tonnes) of fuel wood per day. Using all the biogas from their sewage system can save about half of this fuel wood. The overall prison population that will be served by biogas plants is about 15,000 people, so the annual fuel wood saving is about 13,500 m³.

CHAPTER FIVE

FINDINGS, CONCLUSION AND RECOMMENDATIONS

The present study was undertaken to assess the situation of human waste management in selected prisons of Kimironko and Muhanga, two of large prisons of Rwanda. Firstly, this research aimed to establish the status of human waste management in selected prisons. Secondly it was investigate health effects of improper disposal of human waste in selected prisons. Thirdly, it was to explore strategies to improve human waste disposal in selected prisons.

Findings

This chapter provides a summary of the findings of the study especially of the empirical analysis presented in chapter 4.

The results were unanimous that Human waste management in selected prisons is not sustainable from Public health viewpoints and does not protect the environment”.

According to the findings of this study, the demographic characteristics indicated that out of 108, 52% of respondents of the Muhanga central prison were middle aged (30 to 39 years of age) and for Kimironko central prison over 45% of 149 respondents were 40 to 49 years aged.

However, in selected prisons there is a reasonable representation in gender distribution with more male than women according to whether human waste transportation via prisons housing to disposal pits need male force meaning that 91.7% of the respondents in Muhanga and 96% of respondents in Kimironko Prison were male. Regarding to the number of years of stay of the respondents in selected prisons (n=257), the majority 63% have stayed in selected prisons between or more 13 years and have been involved in human waste management services.

To establish the status of human waste management in selected prisons, it was important to know, the respondents perceptions about the quality of human waste

disposal in selected prisons, the types of human waste excreta used in selected prisons (number available and) number in use), using chi square to analyze whether common disposal pits of selected prisons are problems to life of prisons or community around and evaluating to what extent the problems cited are serious.

The majority of respondents said that the human waste is poorly managed, namely 68% in Muhanga Central Prison and 39.5% in Kimironko Central Prison. On one hand, a significant number of respondents (32%) of Kimironko Central prison said that the human waste was satisfactorily disposed, while on the other hand (20.4%) in Muhanga Central Prison said the human waste was very poorly disposed, meaning that human excreta disposal in Muhanga central prison is worrying.

Besides, given the large number of prisoners living in selected prisons, this study revealed the insufficiency of excreta disposal systems.

Respondents of both prisons said that many buckets are used by prisoners to dispose human waste, because they are common systems used by prisoners, as they cannot move as they need to defecate or to urinate.

The study indicated also they are a small number of other systems used for excreta disposal like latrines with open pit, public latrines, ventilated improved pit latrines usually used by administrative staffs, prison guards or other prisoners in prison services, and this study shows also they are two big common pits for each prison where all human waste are transported and disposed.

When evaluating the human waste management problems in selected prisons above half of respondents in both prisons said that lack of service quality (cause of the prison overpopulation), foul odor and lack of planning (short, medium and long term) are very serious problems in human waste management of the selected prisons, while a significant number showed Lack of hygiene awareness and economic standards are not a big problems in human waste management of the selected problems. On top of that, malodorous odors were highly indicated as a major problem ever complained inside and

around the selected prisons. On top of that, malodorous odors were highly indicated as a major problem ever complained inside and around the selected prisons.

On the second objective the findings portrayed that over 80% of respondents in selected prisons said that prisoners suffer from different infectious diseases related to improper human waste management.

A significant number of the respondents indicated the diarrhea as the illness most suffered in both prisons, and the least number was for Cholera

Slightly above 30% of respondents of both selected prisons indicated that drinking water, good chain contamination and flies they are severe environmental nuisances, while soil pollution were regarded as a small environmental nuisance.

Over 50% of the respondents of both prisons said that community around complain about the improper human waste management. The rest of respondents said they do not know about those complaints. The results showed that the most complaints were against foul odors and flies coming from the disposal pits.

On the third objectives, the findings revealed that biogas plant is a favored strategy to ensure the sustainable human waste management, with proper benefits ahead like providing the energy for lightening and cooking, reducing pressure on local wood supplies. Biogas is considered like ECOSAN a sustainable closed-loop system that treats human excreta as a resource, not as a waste product. Excreta are processed until they are free of disease organisms. Great care has to be taken to ensure that digested effluent is safe to be used for agricultural purposes. It is important to note that when the research was conducted biogas plants were being put in the place.

Humanure as compost toilet was shown also as another response to poor human waste management but not at preferred position.

Discussion

The study aimed at achieving the following specific objectives:

To establish the status of human waste management in selected prisons, investigate health effects of improper disposal of human waste in selected prisons and establish ways employed to improve human waste disposal in selected prisons

The study was carried out in selected prisons namely Muhanga Central prison and Kimirinko Central prison .The period considered was 1999-2009, and the study limited itself to the human waste management.

Over 50% of respondents in both prisons asked in this study said that human waste management in selected prisons is not well disposed because of the prisons are overcrowded. Through this study it has been observed that prisoners use buckets to defecate and urinate after the excreta are transported out of the prisons to the disposal pits. It has been found that both selected prisons do not have sufficient excreta disposal systems such as toilets, public toilets, latrines.

These findings agree with Sabin (2010) who said that the prison overpopulation in Rwanda has created a situation of large amounts of human waste that the prison cannot adequately process.

This study showed that disposal pits of both selected prisons are the source of many health problems such as infectious diseases (diarrhea, typhoid, cholera, dysentery) and environmental nuisances (food chain contamination, drinking water pollution flies and insects, soil and air pollution) that affect people in and around the prisons. According to the respondents people around the prisons complain mostly about the foul odors.

Our findings concur with Sabin, (2010) who observed that excreta disposal from such concentrated groups of people is a major health hazard for both the prison and surrounding area because human waste leak out the disposal pits into the natural water bodies providing drinking water or water to wash.

According to Howard et al., (2003), the lack of clean excreta disposal may be a direct cause of contamination of groundwater sources, contamination of food chain, poor hygiene and sanitation at personal, household and community levels.

In this study, a number of respondents in selected prisons (50%) said that diarrhea is the most infectious diseases that affect prisoners. This have been already confirmed by the report of WHO, (2005) saying that in all infectious diseases, diarrhoeal diseases from improper human waste management kills 1.8 million of people each year and ranks as the third leading cause of both mortality and morbidity (after respiratory and HIV/AIDS).

Through different analysis demonstrated in this research, the respondents (over 90%) observed that biogas plant is the priority alternative that can manage sustainably human waste management in selected prisons seen the amount of human waste to be disposed.

SNV/MININFRA report, (2005), remarked that using biogas digesters to manage human waste is not a new idea in Rwanda; it has been applied before and with great success.

The first prison biogas plant started operation in 2001, and has run with no problems since then, (Anne, 2005).

But also, it is obvious that the overcrowded prisons mean that energy consumption is higher. Converting human waste to biogas will improve not only the human waste management of the selected prisons but also will reduce the amount fuel wood used by the selected prisons.

A director of Kimironko central prison confided after a trip made in Cyangugu Central prison one prison of western Province near Democratic Republic of the Congo, it was observed that biogas program has been successful where after cooking, it even produces nearly a half the necessary electricity to power the prison.

As a small number of respondents (15%) said compost toilet is can be an other option to improve human waste management, but not preferred by the administrative staffs of the selected prisons.

Human faeces have been always considered as valuable nutrient source in a number of countries. For example in China, in Japan, in korea but also in some countries of Africa and south America nutrients faeces have been utilized in agriculture (Steineck et al. 1999).

Nevertheless, Linden, (1997) observed that composting human waste is very difficult and when it is not properly composted it can cause many problems such as infectious diseases (diarrhea, cholera, typhoid) or environmental nuisances (food chain contamination, drinking water pollution, air and soil pollution).

Two alternatives compared, biogas has more benefits than human waste composting such as saving money, saving cooking time, improving hygienic conditions, producing high-quality fertilizer, enabling electricity production and reducing air and water pollution.

CONCLUSION

This research concluded that a sizeable proportion of the human waste produced by the selected prisons finds its way in big disposal pits of the prisons, and is poorly managed. From this research it was observed that lack quality, foul odors and lack of planning are the problems that affect human waste management in selected prisons and need to be improved.

The study described the infectious diseases such as diarrhea, typhoid cholera, dysentery and environmental nuisances such as drinking water pollution, food chain contamination, flies and insects, soil and air pollution, that affect people inside and around the selected prisons, and need special prevention and treatments.

Biogas plant has been recognized by the vast majority of administrative staffs of both prisons, as a sustainable solution to alleviate the sanitation crises and very important to improving human and environmental health within this country.

The compost toilet (humanure) was given as the second choice for improving human waste management in selected prisons, even though people perceptions were negative on using excreta as fertilizer.

Human waste management remains an essential service that aims to protect public health and the environment, and in some cases the respondents had high expectations that human waste management would be improved as new and viable strategies are being installed.

RECOMMENDATIONS

It is of great significance to change human waste management in order to ensure the success of health and sanitation of people in the prisons and community surrounding.

- ✓ There is a need to provide adequate land space for the treatment and final disposal of human waste collected from the prisons environments. Boundaries should then be created around these sites and monitored to prevent people from settling near the facilities.
- ✓ Provide incentives to community-based health sanitation promotion activities by non-governmental organizations.
- ✓ Involving relevant stakeholders and government commitment in producing and implementing the integrated plan for human waste management, collection and disposal.
- ✓ An integrated approach to human waste management will have to take into account community- and regional-specific issues and needs and formulate an integrated and appropriate set of solutions unique to each context.
- ✓ Education and training programs must be developed to monitoring and controlling biogas plant as a new and sustainable strategy that is being implemented.

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APPENDIX A: BUDGET

Budget line/ wording	Amount per period (\$)	Period in months	Total amount (\$)
Communication	40	6	240
Travel	40	6	240
Photocopying and binding	30	6	180
Secretarial services	10	6	60
Equipment and stationary	30	6	180
Subsistence	50	6	300
Data analysis	10	3	30
Miscellaneous	20	6	120
TOTAL			1350
One thousand three hundred and fifty US Dollars			

APPENDIX B: QUESTIONNAIRE

Questionnaire to the prisoners' chiefs and prison staffs

Dear respondent I'm Patrick René MWIMANZI a student of school of engineering and applied sciences, Kampala International University pursuing Master of Science in Environmental Management and Development. I'm carrying out research "*Human waste management in selected prisons in Rwanda*". I kindly request you to respond honestly to each statement by ticking in the tables/boxes or writing in the spaces provided where appropriate. Your responses will be completely confidential and used for purpose of this research only. Your cooperation in filling this questionnaire is for great importance.

How to complete this questionnaire

- ✓ Persons completing this questionnaire should be administrative staff of the prison or technicians (prisoners) dealing with sanitation and human waste management of the prison
- ✓ Should you wish to add a comment on this research, please add it in the space provided
- ✓ Place an "X" in front of where you wish to select your response to that question unless detailed answer is provided

Section A: Bio-data

1. Age: 15-19... 20-24... 25-29... 30-34... 35-39... 40-44...
45-49... 50-54... 55-59... 60+....

2. Sex: Male..... Female.....

3. Length of stay in the prison

1-4 5-8.... 9-12.... 13-16.... 17-20.....

Section B: The human waste status in the prisons

4. (a)How would you describe the quality of human waste disposal in this prison?

- Very satisfactory []
- Satisfactory []
- Poor []
- Very poor []

(b) If satisfactory or poor, what are you dissatisfied with?

.....
.....

5. What types of excreta disposal or management systems do you use in this prison?

Excreta disposal systems	No available	No in use

6. Is the common excreta disposal pits a problem on the prison life or community around?

YES NO

(Explain briefly)

.....
.....

7. (a) Use the following scale to evaluate each of the following human waste management problems (Tick)

1. Very Serious

2. Serious

3. No problem

Problem	Very serious	serious	no problem
Foul odour			
Economic standards			
Lack of service quality (cause of The prison overpopulation)			
Lack of hygiene awareness			
Lack of planning (short, medium and long term plan)			

(b) Explain briefly the most problem related to the human waste management ever complained in this prison or around.....

.....

Section B: Health effects of poor disposal of human waste

8. (a) Are aware of any infectious diseases or environmental nuisances associated with human waste disposal sites of the prison?

- Yes [] List the infectious diseases and environmental nuisances that most affect this prisons?
- No []

9. Have communities around the disposal facilities complained of any nuisances?

- Yes [] what have they complained about?
- No []

II. Interview: only for prison staffs

Strategies (or ways) to improve human waste management in selected prisons

1. Do you think the current technologies of human waste disposal in this prison have to be improved?

- Yes []
- No []

2. Give different alternatives of how the current human waste disposal strategies are intended to be improved in this prison

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

3. What do you do to achieve your suggestions in question 2?

.....

4. If you wish to provide additional comments or ask a question regarding this research, please use the space below:

.....
.....

5. If you would like the feedback on this research, please write your email address in the space below

.....

Thank you for your time and assistance

CURRICULUM VITAE

Patrick René MWIMANZI

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PROFESSIONAL PROFILE

- *Always seeking to learn and grow and recognition emotionally mature and confident*
- *A versatile and results-oriented with high personal integrity, and able to relate to and create trust in all.*
- *Highly articulate, confident and persuasive team-builder, able to motivate and communicate to achieve exceptional performances.*
- *Dependable and reliable in supporting and enabling team effort to produce genuine long-term sustainable development.*
- *Enjoy being part of a successful and productive team and thrives in highly pressurised and challenging working environments*
- *Can Work well with others, motivate and encourage high integrity, diligent and conscientious*

REFERENCES

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I certify that the information provided above is real.

Patrick René MWIMANZI

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