ASSESSMENT OF THE OCCURENCE OF VIABLE HELMINTHES OVA IN FAECAL SLUDGE AND PIT DESLUDGING PRACTICES IN NAKURU COUNTY, KENYA

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A thesis submitted to the Graduate School in partial fulfilment for the requirement of a Master of Science degree in Environmental and Occupational Health of Egerton University

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DECLARATION AND RECOMMENDATION

Declaration

This research thesis is my original work and to the best of my knowledge, has not, wholly or in part, been submitted for an award in any other institution.

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Recommendation

This thesis has been submitted for examination with our approval as University Supervisors.

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DEDICATION

To my mother Ms Joyce Wavinya Maingi, my siblings and my family.

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I would first and foremost like to acknowledge the almighty God for the wisdom, good health and protection to enable me reach this far. Secondly, I would like to thank Egerton University for granting me the opportunity. My parents for their continued support throughout my studies and my academic supervisors Prof. Moturi and Dr. Omondi for their informed guidance and mentorship in my studies. Lastly, I would like to acknowledge Bill and Melinda Gates foundation through the Sanitation Research Fund for Africa programme for their financial support in my research and the biological sciences laboratory for offering me the space and equipment support for sample analysis.

ABSTRACT

The use of pit latrines, their eventual fill up and need to desludge them expose humans and the environment to diseases associated with untreated excreta. Based on this, a study was done in Nakuru County to assess prescence of viable parasitic helminthes ova in faecal sludge and pit desludging and disposal practices used. Thirty five pit latrines were sampled and the prescence of parasitic helminthes ova determined at varius pit depths. Pit desludging and disposal practices was also analysed from a sample of 28 practitioners to determine their health safety level. One way analysis of variance (ANOVA) was used to determine significant differences in the occurrence of via ble helminthes ova in relation to pit depth. Where significant differences were found, *Post Hoc* tests (fisher's exact and Tukey) were done to establish the exact depths at which the significant differences occurred. Descriptive statistics were used to describe desludging practices in relation to occupational health challenges amongst those involved and in relation to environmental and public health. Results indicate that among the 128 samples collected, 23% (n=30) were found to bear viable helminthes ova. The ova identified belonged to seven species of helminthes, ie; *Ascaris lumbricoides, Trichuris trichiura, Schistosoma haematobium, schistosoma mansoni, Taenia sp, Enterobius vermicularies and Necator americanus.* A significant difference in the occurrence of total viable helminthes ova versus pit latrine depth was established**.** This meant that some depths had higher concentration of helminthes ova than others. A significant difference in the occurrence of viable *Ascaris* ova versus pit depth was also established meaning that some depths were higher in the concentration of *Ascaris* ova than others. *Ascaris* was the most dominant and persistent helminthes parasite in pit latrine faecal sludge suggesting that pit latrine sludge was still infective upon exposure to exhausters and the public. The fact that faecal sludge mixes up during desludging implies that there is a possibility of exposure from all the different species of helminthic parasites identified regardless of the depth from which one is emptying from. Proper handling, disposal and occupational safety by those desludging pit latrines should be ensured to prevent infections from the various hazards identified.

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LIST OF ABBREVIATIONS AND ACRONYMS

CoK – Constitution of Kenya

DEH – Department of Environmental Health

DFID – Department for International Development of the United Kingdom

DHS – Division of Hygiene and Sanitation

ESH – Environmental Sanitation and Hygiene

ESHWG – Environmental Sanitation and Hygiene Working Group

GoK – Government of Kenya

HLM – High Level Meeting of ministers

JMP – Joint Monitoring Programme of the World Health Organization and the United Nation Children's Fund.

MDGs – Millennium Development Goals

MoH – Ministry of Health

MoPHS – Ministry of Public Health and Sanitation

PPE – Personal Protective Equipment

ROSA – Resource Oriented Sanitation concepts in Africa

VIP – Ventilated Improved Pit latrine

WHO – World Health Organization

WSP – AF – Water and Sanitation Program – Africa region

WSSCC– Water Supply and Sanitation Collaborative Council

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

Use of pit latrines is one of the most common forms of sanitation worldwide despite the fact that approximately 2.6 billion people do not have access to even this basic sanitation facility. Some of the places with the lowest sanitation coverage include Southern Asia and Sub-Saharan Africa of which Kenya is included where two-thirds of the population lack access to improved sanitation facilities (JMP, 2014). The World Health Organization (WHO) estimates show that 80 percent of all sicknesses and diseases are caused by polluted water, unavailability of water and inadequate sanitation (WEDC 1992). Improper disposal of faecal sludge lead to contamination of water sources which is the main way in which water borne diseases are transmitted. The disposal of faecal sludge inappropriately can be considered as a point source of faecal pollution in water and therefore a major environmental health hazard.

Pit latrines are commonly used in developing countries since they have several advantages over other forms of sanitation. Some of these advantages include; simple construction of the facility, low costs in construction and mantainance compared to other forms of sanitation and their acceptability by different communities globally. However, they have limitations that include bad smell, harbouring of flies, and their rapid fill up,that create problem of desludging and disposal of this faeacal sludge. This could easily cause public health risks and the possible contamination of underground and surface water sources. The fact that every pit latrine will eventually fill up and require emptying poses a health hazard. The speed with which pit latrines fill up depends on a number of factors which include; the number of users per day, amount of excreta produced per person per day and the rate of decomposition of excreta. Poor degradation in most pits result in building up of noxious and potentially hazardous material that must eventually be removed at a significant cost and risk to human and environmental health.

In urban areas, space is often a limiting factor when one decides to relocate a filled up pit latrine and thus opt to empty the pit instead. It is this increased demand for pit latrine emptying and disposal practices that forms the need to find safe methods of emptying and disposing of faecal sludge in terms of regulations and methods to be used. Unsafe emptying and disposal of faecal sludge from pit latrines poses a number of health risks that call for the need to identify appropriate technologies and policies in order to safeguard human and environmental health. Human infection with pathogens from the sludge may occur during emptying of faecal sludge where improper desludging procedures are used. Spillage of excreta during pit emptying and transportation may lead to contamination of surrounding ground and surface water that may eventually be consumed by humans.

1.2 Statement of the problem

Use of pit latrines is a common sanitation practice especially in developing countries, this results in concentration of faecal pathogens in these pit latrines that can easily infect other people when these latrines are emptied. Emptying of pit latrines is becoming a common practice especially in urban areas due to limited space for putting up new pit latrines to replace the filled ones. The pathogens present in faecal sludge in these latrines may infect people emptying them or those who may be in contact with the sludge at their disposal points. This calls for the need to understand the existence of pathogens in the faecal sludge and the sludge emptying practices to minimize the exposure of the public and the people exhausting the sludge to health risks associated with these pathogens. Though there is documentation on survival of pathogens in faecal sludge, little is known on the occurences of pathogens at different depths in a pit latrine.

Very few studies have been done to investigate the prevalence of pathogens in faecal sludge in Kenya and the types of pit latrine emptying practices. Nakuru municipality is an appropriate study area because of its rapid urban expansion with large parts of the urban and peri urban areas not served with a sewerage system. They rely on pit latrines and therefore faecal waste emptying and disposal is increasingly being practiced due to lack of space for new pit latrine construction.

1.3 Objectives of the study

1.3.1 Broad objective

To assess the disludging practices and the occurrence of viable helminthes ova in pit latrine faecal sludge in Nakuru County, Kenya.

1.3.2 Specific objectives

1) Assess the practices of faecal sludge emptying, transport and disposal practices I Nakuru County.

2) Assess how sludge handling practices are likely to impact on public, environmental and occupational health exposure in Nakuru County.
3) Identify the parasitic helminthes species present in faecal sludge in Nakuru County.
4) Determine the presence of viable helminthes ova in faecal sludge in pit latrines and their survival at different depths in Nakuru County.

1.4 Research questions

1) What are the sludge emptying, transport and disposal practices in Nakuru County
2) How is faecal handling practices likely to impact on public, environmental and occupational health exposure in Nakuru County?
3) Which species of helminthes are found in faecal sludge within Nakuru County?
4) Are there viable helminthes ova in faecal sludge at different pit latrine depths within Nakuru County?

1.5 Justification

The provision of basic sanitation to all remains a necessary and urgent task in Kenya. The government of Kenya is committed to reducing the back log in sanitation services, and more so through the recently decentralized government where counties have been mandated to act on water and sanitation affairs at the county level. The constitution of Kenya and vision 2030 are some of the policy instruments geared towards improved sanitation in Kenya. This is of significance since according to Water Sanitation Program, it is estimated that poor sanitation costs Kenya an equivalent to U.S $324 million each year. This sum is equivalent to U.S $ 8 per person per year or 0.9% of the national GDP. Majority of Kenyans use pit latrines as their main mode of faecal waste disposal and eventually the pit would need to be emptied especially in urban and Peri urban areas where space is a limiting factor.

The completion of a pit latrine infrastructure does not necessarily mean that enough sanitary conditions are guaranteed, unless it is accompanied by other essential services like proper use, excreta emptying, transport, treatment and disposal to ensure proper and sustainable sanitation. Inadequate information regarding pit emptying and disposal of faecal waste may hinder progress on sanitation programs in Kenya and specifically in Nakuru County and more so those involved in pit latrine emptying and disposal. Knowledge base on the above mentioned aspects will go a long way in ensuring that occupational safety and health of the workers involved in desludging and disposal of faecal sludge is upheld by those responsible through awareness creation.

Documenting the occurrence of viable helminthic ova at different depths in a pit latrine creates a knowledge base and a challenge for further research to come up with better technologies on pit latrine desludging and treatment that would ensure the containment of such parasites during pit desludging and disposal. The data generated from this study would thus be beneficial to key local, national and international actors and institutions involved formally or informally with the provision of adequate sanitation in line with SDGs, vision 2030, OSHA 2007 and the Constitution of Kenya on the need for adequate environmental, public and occupational health and safety as well as sanitation for all. Nakuru County has various sanitation policies but are not clear on how to handle faecal sludge while desludging, transporting and disposing. Proper enforcement on the available policies and laws on sanitation is also lacking.

1.6 Scope of the study

This study was part of a larger research project "scientific understanding of pit latrine processes in Nakuru County, Kenya. The study covered the aspects of sanitation in Nakuru County and especially on desludging and disposal practices of pit latrine contents, biodegradability of pit latrine contents and viability of helminthic ova in relation to pit depth among selected pit latrines in selected locations (Kaptembwa, Free area, Hilton, Njokerio and Jowatho) in relation to health and management of these sanitation systems. Data from the local players in the desludging and disposal of faecal sludge such as the County Government of Nakuru and those involved with exhausting was collected to identify the different methods of desludging and how the faecal sludge is disposed of thereafter and in relation to occupational, environmental and public health exposure.

The analysis of faecal sludge to establish the presence of viable helminthic parasites at different depths within pit vaults was done to establish if there are significant differences in their occurence. Sampling of faecal sludge was done by use of modified calibrated sampler.

1.7 Assumptions and limitations

The successful accomplishment of this study was based on the following assumptions and limitations;

1. There would be cooperation from all stakeholders involved, especially those involved in desludging and disposal of faecal waste.
2. That solid waste will not prevent the penetration of the sampler
3. Information given by the desludgers was correct to the best of their knowledge.
4. The pedestal hole would be wide enough for the sampler to pass through.

1.8 Definition of terms

Environmental sanitation - This refers to the interventions to reduce people's exposure to diseases by providing a clean environment in which to live. It is a measure to break the cycle of diseases and includes the hygienic management and or disposal of human excreta and the control of disease vectors.

Improved sanitation - The availability and use of a pit latrine (simple, VIP,) pour flush latrine, or a connection to a public sewer or a septic tank.

Basic sanitation - This refers to the management of human excreta at household level as used to describe the MDG target on sanitation.

Hygiene - This is the practice of keeping one self and the surrounding environment clean.

Adequate sanitation - Refers to one that provides privacy and separates human excreta from human contact

Onsite sanitation - Refers to the sanitation technologies where the human excreta are disposed permanently on site e.g. ventilated improved pit latrines or septic tank systems with soak away of pit waste.

Desludging – refers to the removal of faecal sludge from a pit latrine vault

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

Provision of adequate sanitation is fundamental to human health and development. According to the World Health Organisation, approximately 2000 children die each day as a result of diarrheal diseases and out of these, 1800 (88%) are as a result of poor drinking water and lack of adequate sanitation as well as poor hygiene. The fact that little effort is made on ensuring the safety of those involved in desludging and disposal of faecal waste leads to occupational hazards and risks. Indiscriminate dumping of human waste has been experienced in the past in many developing countries and the magnitude of the pathogen loads left exposed into the environment due to this dumping need to be documented so as to come up with sound management measures to safeguard environmental and public health as well as occupational health and safety of those exposed.

Before the introduction of the MDGs, there was lack of an internationally agreed upon standard of sanitation that qualified as "improved sanitation". Improved sanitation was then redefined in order to make it possible to measure MDG progress on sanitation. It was redefined as: a sanitation system in which excreta are disposed off in such a way that they reduce the risk of faecal-oral transmission o pathogens to its users and the environment (WHO/UNICEF, JMP, 2000). The classification of various sanitation provision facilities as either improved or unimproved is shown in the table 1.

2.2 Types of sanitation systems

Sanitation systems can be grouped as either onsite or offsite. Onsite sanitation systems are those systems that provide for disposal and storage of faecal waste on the same site where the structure exists and no transportation is needed while the offsite sanitation systems provide for disposal of faecal waste but require transportation of the waste for storage or treatment to a place far from the point of disposal. Some of the onsite sanitation systems include; VIP latrines, simple pit latrines and the pour flush with inbuilt septic tanks. Offsite sanitation systems include the conventional sewerage systems and emergency sanitary systems that require conveyance of the waste when filled up. See table 1;

Table 1: Types of sanitation facilities used in Kenya.

Improved sanitation facilities	Un improved sanitation facilities
• Convectional sewerage • Simple pit latrine • Pour-flush latrine • Septic system • VIP Latrine • Simplified sewerage	Public/shared latrine Bucket latrine Open defecation Open pit latrine

Source JMP 2002

2.3 VIP versus simple pit latrine

VIP latrines have been accepted in Kenya as a better alternative to the simple pit latrine. The difference between a VIP latrine and a simple pit latrine is because it consists of a dignified enclosed brick structure, concrete cover slab and pedestal door for privacy, light exclusion to prevent flies, a pit with a cover, a ventilation pipe with fly screen leading from pit to above the level of the super structure and a hand washing facility. A simple pit latrine does not have this accessories. The continual flow of air removes unpleasant odour and gas is vented through the vent pipe to the atmosphere (Bester and Austin 2000). The fly screen attached at the vent pipe prevents flies from leaving and entering the VIP latrne. Usually flies are attracted to the light coming from the vent pipe and thus become trapped when they fly towards the vent pipe (DWAF, 2003).

2.4 Trends in global sanitation coverage and access

The world remains off track in meeting the MDGs on sanitation target of 75% and it is said to miss the target by more than half a billion people if the current trends prevail. 2.5 billion People were not using improved sanitation by the end of 2011 and open defecation decreased to a little over a billion people which still represents 15% of the global population (JMP 2013). Sanitation coverage is lowest in sub Saharan Africa, Oceania and south Asia where 70%, 64% and 59% of people do not have access to improved sanitation respectively. 1.9 billion people have however gained access to improved sanitation since 1990 globally and 64% of the population use improved sanitation facilities.

In sub-Saharan Africa, 48% of the population use either shared or improved sanitation facilities and an estimated 26% practice open defecation. In southern Asia, the proportion of the population using shared or unimproved facilities is much lower as compared to sub Saharan Africa. This is due to open defecation in which it’s the highest proportion of any other region and almost one third of the 2.5 billion people without improved sanitation live in India (JMP 2013).

2.5 Global sanitation trends in rural versus urban areas.

Sanitation disparities also occur as a result of poverty as well as rural versus urban settlements where those living in rural areas and poor are far less likely to have access to improved sanitation facilities as opposed to the rich and urban population. Of the 2.5 billion people without adequate sanitation, 71% live in rural areas (JMP 2013). The poor are also the likely population to have problems with latrine fill up and disposal after pit emptying. This is because they lack the funds for proper emptying and disposal of that kind of waste.

Most people living in urban areas use improved sanitation facilities compared to less than half of the rural population. The number of people without improved sanitation in urban areas however has grown by 196 million since 1990 to 728 million people as a result of urban growth. Progress has also been made in rural areas since 1990 where 707 million rural dwellers have gained access to improved sanitation. Nine hundred and thirty four million people living in rural areas practice open defecation. In 48 countries designated as least developed (LDCs) by the United Nations, much of the population has benefited from investment in sanitation. In these countries, only 36% of the population uses improved sanitation and one out of four people practice open defecation (JMP 2013)

2.6 Sanitation trends in Kenya

2.6.1 Sanitation overview

Access to sanitation in Kenya continues to be a major challenge. The 2009 country census puts an overall access levels at 65% with rural coverage at 56% and urban at 75%. The joint monitoring programme (JMP 2010) which considers those using shared facilities as lacking access puts the overall coverage at 31%, with rural coverage at 32% and urban at 27%. These figures indicate that over 8 million Kenyans still defecate in the open which results in disease prevalence such as diarrhea, amoeba, typhoid and cholera. Little is known on how pit latrines are desludged and how the sludge is disposed of thus uncertainties exist on the occupational health risks encountered by those doing the practice and those exposed to the sludge.

In Kenya, sanitation coverage is low with the MoPHS estimates indicating that over 45% of the rural population does not have access to basic sanitation. According to JMP reports, Kenya is not on track in achieving the sanitation MDGs. Between 1990 and 2008, the use of improved sanitation facilities in rural Kenya increased marginally from 27% to 32% (UNICEF/WHO JMP, 2010). The 2009 population census reported that in 2009 alone, over 3000 Kenyans suffered from cholera and over 40 people died from the same. The census reported that 74% of households in rural and 62.5% in urban reported pit latrine as the main mode of human waste disposal. Sanitation coverage in 2010 stood at 32% of the population with access to improved sanitation facility (JMP, 2012). The table below shows the percentage of Kenyan population that gained access by 2011;

Table 2: Percentage of Kenyan population with access to sanitation by 2011

	IMPROVED	SHARED	UNIMPROVED	OPEN DEFECATION	POP
RURAL	29	19	35	17	41,610000
NATIONAL	29	26	31	14	
URBAN	31	47	19	3	

Source: JMP 2013.

In Kenya the ventilated improved and simple pit latrines are considered as the most feasible forms of sanitation due to their numerous advantages of construction costs and health improvements a benefit which is explained by the presence of these facilities countrywide. They require no water to dispose faecal waste and thus appropriate in water scarce countries like Kenya. However, most facilities don’t meet the standards expected of VIP latrines but rather just simple pit latrines.

In 2010, Kenya’s water and sanitation expenditure represented 0.86% of the GDP, down from 1.10% in 2008 (Water Aid, 2011). World Health Organization data shows that diarrheal diseases accounted for 16% of under-five mortality in Kenya in 2006 and 7% of deaths overall. This is accelerated by the fact that the sound management of faecal waste and especially from pit latrines and open defecation is lacking. In economic terms, Kenya loses US $ 324 Million annually due to poor sanitation which is approximately KES 27 Billion annually. (HLM 2012, Plan 2008)

2.6.2 Sector policies and strategies

The constitution of Kenya (2010), states that water and sanitation provision are a constitutional right. This right covers, availability, accessibility, quality and use, and the Kenyan government has obligated to respect, protect and fulfill these rights. The key strategies in the sector include the National Environmental sanitation and Hygiene strategy and the water sector strategic plan which are guided by the vision 2030. These strategies have been awarded an increasing budgetary allocations from US$ 124 million budget and US $ 627 million from 2010 – 2015 respectively (HLM, 2012).

2.6.3 Specific country commitments

The water and sanitation sector has developed policies, strategies, concepts and implementation plans in line with the constitution and with specific indicators on improving water and sanitation services in both urban and rural areas. This include the Kenya Health Policy framework (1994-2012), the Water Policy 1999,Water Act 2002, the National Environmental Sanitation and Hygiene Policy 2007, National Water Services Strategy (NWSS 2007-2015) the Water and Sanitation Concept (WSSC), the Pro-poor Implementation Plan (PPIP), Occupational Safety and Health 2007 and the National Health Strategic Plan (NHSSP II).

Both the Sustainable Development Goals (SDGs) number six and vision 2030 identify guaranteed access to water and sanitation as one of the key targets. The Peri urban and rural populations particularly are not favored to these services due to the absence of land ownership, housing density, population mobility and inaccessible terrain. Governance and poor implementation of policies in regard to the sound management of these services could also be an important factor contributing to sanitation provision backlog in Kenya.

The constitution of Kenya states that every individual has a right to accessible and adequate housing as well as reasonable standards of sanitation (section 43(1). Under minorities and marginalized groups section 56 (v), it further stipulates that the government shall take affirmative action to ensure that minorities and marginalized groups have reasonable access to safe clean water and sanitation (Constitution of Kenya, 2010).

The regulations on construction, desludging and disposal of faecal wastes in pit latrines may not be well structured in Kenya and therefore alot of health related risks are eminent due to these practices. Onsite sanitation facilities especially pit latrines are the predominant form of excreta disposal for majority of urban and Peri-urban dwellers in Africa, Asia and other parts of the developing world (Saywell, Strauss et al 2000) and this includes Kenya.

2.7 Pit latrine emptying methods

Various technologies have been developed to empty pit latrines worldwide including Kenya. These include the manual and the mechanical methods.

2.7.1 Manual methods

In Kenya, most of the pit latrine emptying is done manually. Scoops and buckets are used to remove the more fluid type of waste while thicker sludge has to be dug out by hand and shovels. This poses great health risk to the waste handlers as they are directly exposed through contact and inhalling. Usually one would use a bucket tied to a rope and drop it inside the pit then pull it out and empty the bucket until the solid sludge is reached. The squatting slab often needs to be destroyed so that workers can gain access to the sludge increasing costs and inconveniences to the owner (Practical Action 2007). Manual emptying is practised in virtually every area where there are pit latrines e.g. Dar Salaam, Tanzania (Muller and Rijnsburger 1992,) Nairobi, Kenya (Building Partners for Development, 2005), Nam Dinh, Vietnam (Strauss *et al* 2002) and Yichang, china (Muller 1997) which are just some of the examples from literature.

Pit emptying is usually done by a group of two to four men who empty sludge from the pit into containers ranging from 100-200 litres (Macleod 2005). The sludge may then be dumped in nearby drains (Strauss et al, 2002), buried in a nearby pit (Muller and Rijnsburger, 1992) or may be transported for treatment or simply dumped in the closest stream, trench or street (BPD 2005, Bereziat 2009, Onibokun 2009). The methods used depend then on what is most convenient for those doing the practice. Enforcement may be difficult since they work in secret and mostly during the night (Bereziat 2009). A few workers wear protective clothing (Building Partnerships for Development, 2005) while the majority do not and are thus directly exposed to pathogens like the tape worm, round worm, and whip worm (van Vuuren, 2008). Since they are forced to work at night due to the attached stigma, the emptier experiences a higher occupational risk of injury and the likelihood of spillage would also increase during emptying and while transporting the sludge to the disposal site (Practical Action 2007).

2.7.2 Gravitational Flushing

This is prevalent and it's also known as seasonal flushing or gravitational desludging (WSP, 2005).Sludge is left to flow out of a hole made in the bottom/side of the latrine into the surrounding area or nearby stream (Bereziat 2009). This is usually done during the rainy season when the sludge liquefies due to excess water and thus flows out of the pit easily (Building Partnerships for Development, 2009). Natural flushing is a very common method of pit desludging in 55% of the population in Dar es Salaam and it's the third most common method of pit emptying in Kibera, Kenya (WSP 2005).

2.7.3 Mechanical emptying methods

2.7.3.1 Vacuum tankers

This method is regarded as the most technologically advanced option in pit desludging but quite expensive. It is used as the primary way of desludging on-site sanitation facilities in the middle and upper-class societies of the developed world. They are efficient in emptying the pit contents and provide minimal contact with the faecal sludge and thus mostly preferred (Building Partners in Development, 2005). It comprise of a truck with a large vacuum tank attached to a powerful vacuum pump and a large diameter horse for insertion into the pit. Pumps can pull up to three meters of elevation (Pickford and Shaw 1991). Some of the disadvantages include the inability to get into unplanned settlements and also the high operating costs as well as maintenance costs.it is however not feasible to pit latrines due to the assorted solid debris found within pit sludge. (Muller and Rijnsburger, 1992, Bereziat 2009)

2.7.3.2 Mini tankers

These are similar to vacuum tankers but are smaller in size. They include various models i.e. the Micra Vac, Dung Beetle, Maqunieta and the UN-HABITAT vacu tag. The development of these smaller versions of tankers was to enable accessibilities to high density areas like slums where the normal tankers cannot gain access (Issaias 2006). According to Thye 2006, the Vacutug Mark II is the latest and most widely used mini tanker and has been tried in Kibera slum, Kenya (UN-HABITAT 2005). However, its inability to extract low water content sludge and the fact that it relies on external sources of water has limited its viability for large-scale use (WUP 2003).

2.7.3.3 MAPET

MAPET stands for Manual Pit Emptying Technology and was developed and implemented with the financial and institutional help of the Dar es Salaam Sewerage and sanitation Department (DSSD).There exists no evidence of this type of technology in Kenya and when the DSSD was dissolved in 1997, its existence was no more and therefore no evidence of its continuation past the pilot phase (BPD 2005, Practical Action 2007). According to Muller and Rijinsburger, 1992, the MAPET was developed by a Dutch Non Governmental Organisation (WASTE) and was a pilot study in Dar es salaam in the early 1990s.

2.7.3.4 Gulper/MDHP

The London school of Hygiene and Tropical Medicine developed the Gulper together with Steve Sudgen and Oxfam also known as Manual Desludging Hand Pump (MDHP). Similar to other extraction methods, the gulper has difficulties in emptying the very dense sludge found more than a meter below the surface of a pit latrine resulting in need for more operators or more frequent emptying (Thye, 2009). According to a report to the water research commission on tackling the challenges of full pits, the gulper has been tested in Dar es Salaam too and some of the advantages are that it is less expensive as compared to most pit emptying methods($100) and trials made in Dar es salaam, Kampala and Blantyre showed those advantages.

2.8 Pit latrine sludge disposal methods

Faecal sludge treatment and disposal forms the final component in the management of faecal sludge. The following are some of the disposal methods of faecal sludge in use worldwide.

2.8.1 Open dumping

Indiscriminate dumping of faecal sludge over the open environment has been done over the years and it’s simply thrown in the nearest stream, lake, ocean or by the road side. It’s one of the simplest and cheapest methods though pollutes affecting the environment heavily. In most developing countries including Kenya, it is considered unlawful and one risks penalties especially from the local municipal authorities when apprehended. It causes heavy environmental pollution.

2.8.2 Onsite burial

According to Scott and Reed (2006), burial of faecal sludge and covering it with a layer of soil, at least five meters thick is sufficient to prevent transmission of pathogens and allow for the sludge stabilization. However, this depends on the availability of space to dig the hole which should be 30 meters away from the nearest water source. It's most common in the rural areas where space is not a limiting factor unlike the densely populated urban and peri urban areas (Oxfam 2010).

2.8.3 Composting

According to Buckley et al (2008), when sludge is left undistributed for a long duration of time, preferably more than two years, it stabilizes and can be used for soil conditioning. Composting is usually done by transferring faecal sludge into a different pit as in onsite burial or can be left within the pit to allow total decomposition. The sludge can be left to decompose for 2-5 years depending on the size of the pit after which it can be considered safe (Chaggu 2004). According to Still (2002), acceleration of decomposition can be enhanced by continuously adding Kitchen organic wastes or ashes over the course of its use as this enables decomposition to take place in a shorter period of six months.

2.8.4 Bio digesters

Faecal sludge that is in liquid form can be used in bio-digesters for the production of biogas (Bereziat, 2009, WHO 1999). According to WEDC (1999), Human Wastes can also be added to existing animal waste to produce biogas. The bio digesters provide both health and environmental benefits since they replace harmful fossil fuels and biomass (WASTE, 2006). The FAO (1996) also found out that enough biogas can be produced per person per day to satisfy the energy needs of an average individual in less developed countries. This method of disposing faecal sludge is therefore beneficial in terms of energy and promoting agricultural productivity through rich and safe fertilizer while at the same time providing faecal waste disposal solution.

2.8.5 Waste water treatment plants

Faecal sludge can also be deposited in conventional waste water treatment plants which are common in most developing and developed countries. However some of the treatment technologies in these plants are very expensive and are not viable for developing countries due to the high operational costs (Parr et al 2010). A few of this treatment plants are designed to handle concentrated sludge from pit latrines and therefore most of them are unable to fully treat pit latrine wastes (Bereziat 2009)

2.9 Pathogens in excreta

The pathogens excreted in faeces may include: Bacterial species e.g. *Aeromonas spp, Campylobacter jejuni*, pathogenic *E. Coli, Pleisiomonas spp, Shigella spp, Vibrio Cholerae and Yersinia spp.* Viruses; include, Enteric adenovirus 40 and 41, Hepatitits A Virus, Hepatitis E, Polio virus and rotavirus. Protozoic species include *Cryptosporidium pavum, Entamoeba histolytica, Giardia intestinalis and* lastly helminthes which include *Ascaris lumbricoides*, (roundworm), *Taenia solium/saginata* (Tapeworm), *Trichuris trichiura* (Whipworm) the hook worm, *(Necator americanas) and Schistosoma spp* (WHO 2006). According to Schonning and Stenstrom (2004), majority of the above listed pathogens cause gastro-intestinal diseases such as diarrhea, stomach cramps and vomiting. Pit latrine faecal sludge can contain high concentrations of excreted pathogens depending on the health status of those using it. Such pathogens include bacteria, viruses, protozoa and helminthes (WHO 2006).

According to Feachem *et al* 1983, Schonning and Stenstrom 2004 and WHO 2006, any exposure to fresh or untreated faeces constitutes to a human health risk. Survival of pathogens is an important factor in disease transmission especially in faecal sludge. The table below shows survival times for different pathogens in faecal sludge under temperate and tropical conditions.

Table 3: Organism survival periods in faecal sludge.

Organism	Survival time (days) in the wet faecal sludge at ambient temperature	
	Temperate Climate 10 - 15^{0}c	**Tropical Climate 20- 30^{0}c**
Viruses	<100	<20
Salmonellae	<100	<30
Vibrio cholerae	<30	<5
Faecal coliforms	<150	<50
Amoebic cysts	<30	<15
Ascaris eggs	2-3 years	10-12 months
Tapeworm eggs	12 months	6 months
Trematodes	<30	<30

Source; Feachem *et al* 1983 and Strauss 1985

According to a research report to the water research commission on tackling the challenges of full pit latrines,(David Still and Kitty Foxon 2012), an investigation into helminthic and protozoan parasites in pit latrine faecal sludge in South Africa revealed that *Ascaris lumbricoides* was the most prevalent at 60% in all the samples collected followed by *Trichuris trichiura* at 50% then *Taenia* at 11% (PRG 2008)

2.10 Occupational and environmental implications of pit latrine emptying, transport and disposal practices.

According to (Kone and strauss, 2004), only a fraction of the estimated volume of faecal sludge collected and disposed of daily reaches safe disposal sites, the rest is either used unhygienically in agriculture,aquaculture or disposed indiscriminately into lanes,drainage, ditches, estuaries and the sea or onto urban spaces therefore posing a serious health risk. (Klingel *et al* 2002)

As discussed earlier, pit latrine sludge may contain harmful pathogens and parasites that may harm those who come into contact with it. Its thus important that proper procedures should be followed while desludging and disposing faecal sludge amongst those carrying out the job and the nessesity to avoid spillage to prevent exposure to the environment and the public. Although pit latrine sludge may be used for soil fertilization purposes, this can only be allowed under strict conditions after proper treatment has been done to eliminate all the pathogens and parasites.

Disposal into water bodies and open dumping should never occur as this would pollute the water and soil with harmful pathogenic life forms as well as eutrophication of water bodies since its rich in nutrients. Water related diseases may occur if untreated faecal wastes dumped in fresh water bodies whose water is used for drinking and other domestic purposes.

2.11 Conceptual framework

In order to ensure environmental, occupational and public health safety in a locality, proper sanitation practices and knowledge of pathogen survival in faecal sludge is of importance. Proper pit latrine desludging and disposal practices, availability of appropriate sanitation practices and regulations as well as good understanding on pathogen survival profile in faecal sludge should be established. Some of the indirect factors that may affect environmental and public health exposure are physicochemical and sociocultural aspects. The framework below links all this aspects and how they are related to one another for the purposes of this research.

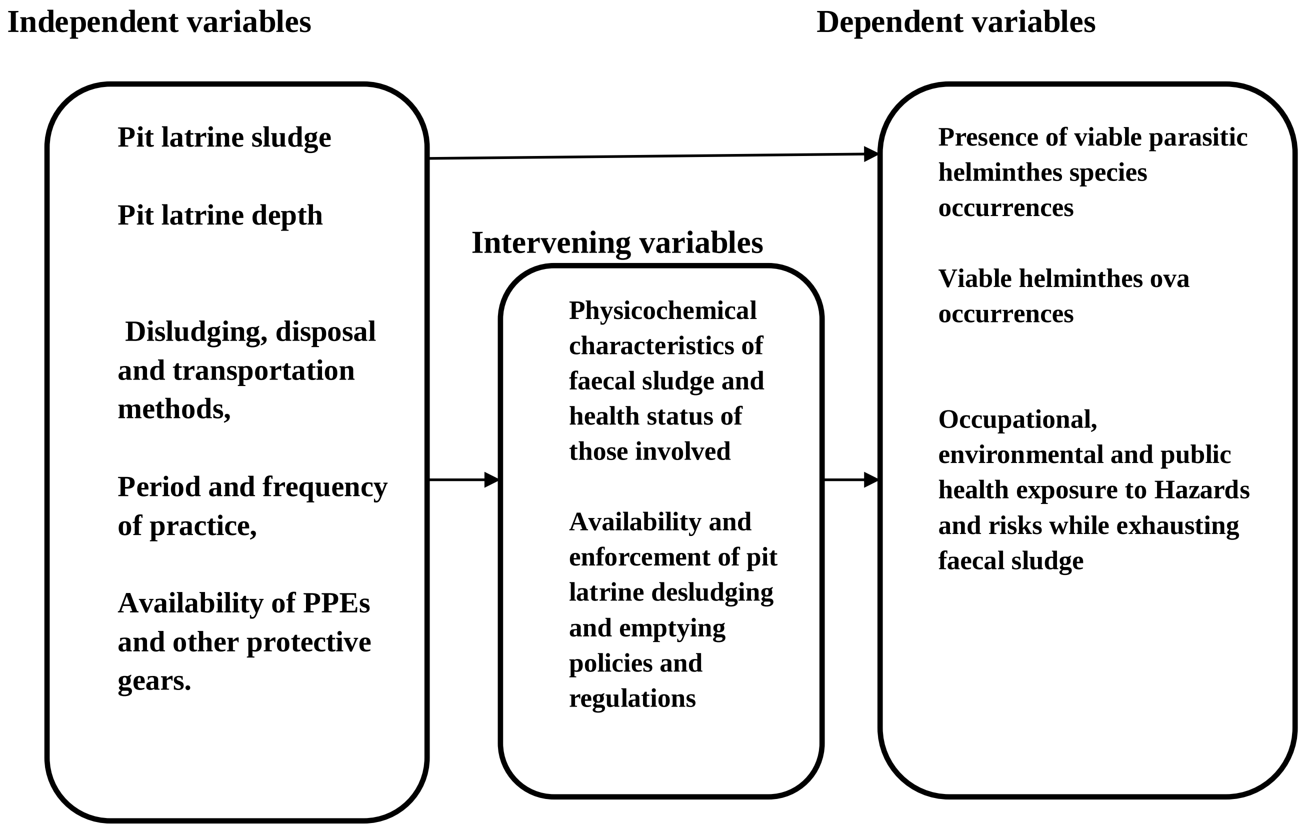


Figure 1: A conceptual framework showing the different variables and their relationships

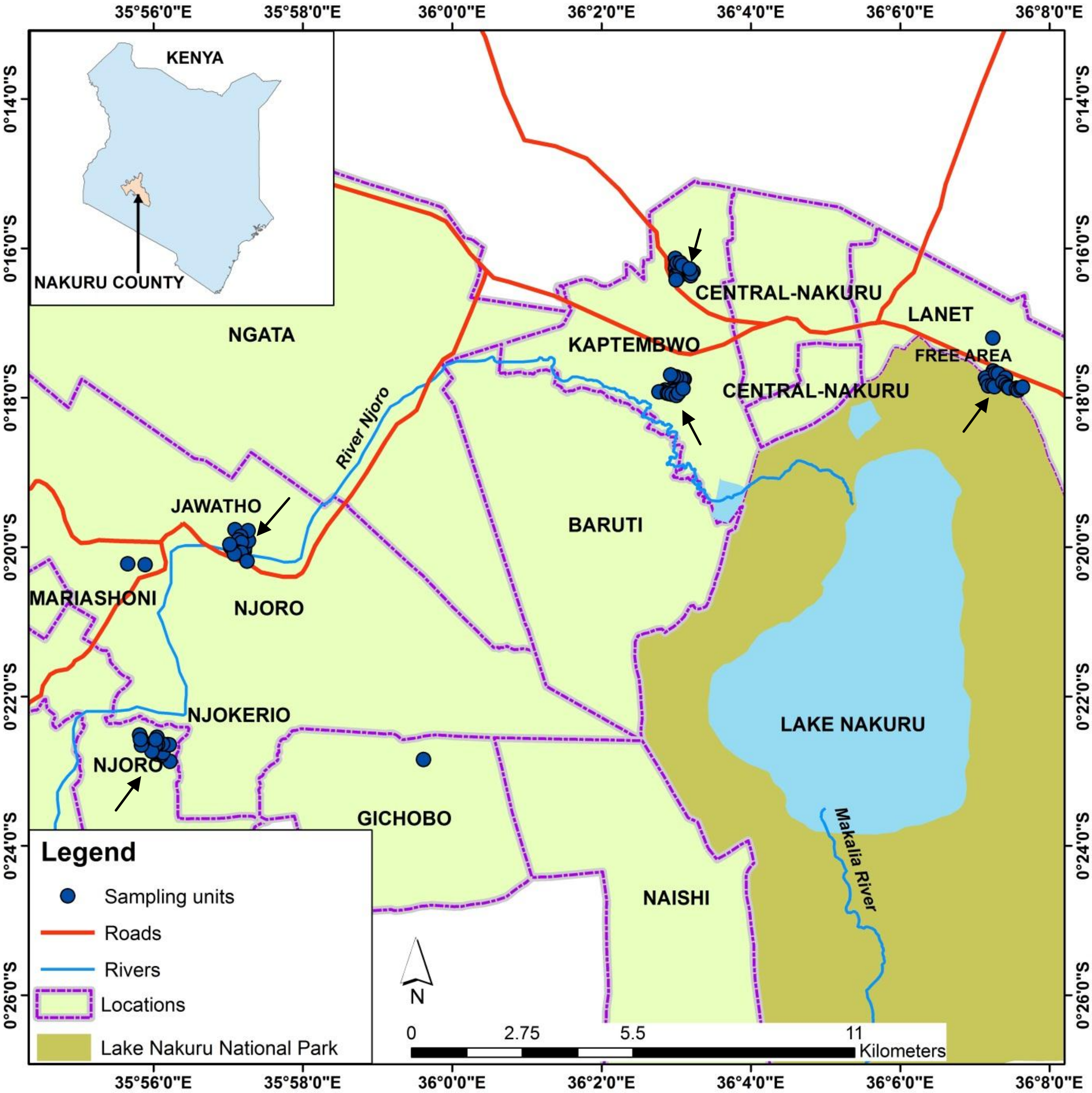
CHAPTER THREE

3.0 METHODOLOGY

3.1 Study area

This study was carried out in Nakuru County, Kenya. Nakuru town is located at a distance of 160 Km North West of Nairobi and lies between the latitudes $0^0 10^1$ and $0^0 20^1$ South and longitude 36^0 and $36^0 10^1$ East. It is situated at an altitude of between 1520 and 1890 meters above sea level within the Great Rift Valley. The study area lies in Agro-ecological zone III. The town of Nakuru is the fourth Largest cosmopolitan town in Kenya (ROSA, 2007), with a predictable weather pattern having temperatures ranging between 10 degrees Celsius during the cold months (July and August) and 28 degrees Celsius during the hot months of January to March. The county receives between 700mm and 1200mm of rainfall annually with average annual rainfall of approximately 800mm with two rainy seasons; April to August (long rains) and October to December constituting the short rainy season.

Until 1985, the town was adequately served with adequate water supply and proper sanitation. However, the provision of clean water and proper sanitation has been facing a downward trend in the region. The main actor involved in water and sanitation in Nakuru is the Nakuru Water and Sanitation Services Company limited (NAWASSCO).



Source; Survey of Kenya Topographical Maps, Scale 1:50,000 using ILRI boundery shape files: GIS Arc GIS 10.2.

3.2 Figure 1 above is a map of the study area showing the various sampling locations and study units.

3.3 Research design

This research adopted a survey research design and lab analysis of sample. A survey on desludging and disposal practices in relation to occupational safety and environmental health/public health exposure and microbial analysis to establish viable parasitic helminthes ova present in faecal sludge at different depths was done. A sample of 35 pit latrines were selected purposively for collection of sludge samples. A complete sample of 28 practitioners on desludging and disposal of faecal sludge was selected for the survey.

3.4 Validity and reliability of research tools

Pre testing of questionnaires was done in a pilot study in Naivasha Sub County which is almost similar to Nakuru in terms of sanitation practices that include pit latrine use. This was to ensure that the quesstionnaires would yield the required outcome. Standard methods of pathogen determination were used to enable comparison of data acquired among similar research work across the world.

3.5 Sample size and sampling procedure

Two sets of sample sizes were worked with in this research.

1. A sample size for those involved in desludging and disposal of faecal sludge and registered with the Nakuru County Government
2. A sample size of pit latrine units for the analysis of faecal sludge for prescence of viable helminthic ova in relation to pit depth.

A complete sample of all the registered service providers on desludging and disposal of faecal sludge was obtained from the Nakuru County Government for the survey on the relationship between desludging and disposal practices and occupational, environmental and public health exposure to hazards. Five service providers were identified and Snow ball networking used to locate them within the municipality upon which each of the service provider had a work force of 1 to 2 people adding up to a sample size of 9 mechanical and 19 manual desludgers and hence a total of 28 practitioners. A sample size of 35 pit latrines was established for helminthic ova determination tests in relation to pit depth and comparison in the occurrence between various helminthes species found in faecal sludge. The sample size was justified by the following explanations and calculations based on sample size calculation in clinical research by Chow et al (2007);

The sample size calculated would mathematically result in a very small margin of error of 1.35 and an estimated population variance from sample households of 6.95 as shown below;-

$$E = Z_{\propto/2} \times \frac{\sigma}{\sqrt{n}}$$

Where $Z_{\propto/2}$ is the critical value, the positive z value represents the vertical boundary of the area of $\propto/2$ in the right tail of a standard normal distribution curve.

σ - is the population's standard deviation.

n - Is the sample size where;

$$n = [\frac{Z_{\propto/2}\sigma}{E}]^2$$

$n = (\frac{1.96 \times 6.95}{1.35})^2$ =101.81 pit latrines.

The sample size proportions was based on the number of households in that particular region as shown below;-

Kaptembwa has 10701 households / fraction sample size = 0.336*100 = a sample size of 34.

Hilton has 3315 households / fraction sample size = 0.159*100 = a sample size of 16.

Free area has 5070 households / fraction sample size = 0.1042*100 = a sample size of 10.

Njokerio has 2579 households / fraction sample size = 0.081*100 = 8.

Jowatho has 10149 households / fraction sample size = 0.319*100 = 32.

However, it was noted that not every household has a pit latrine since most of the people living in the low income areas within Nakuru county rented houses with shared pit latrines. An estimate of three households per pit latrine was then used to adjust the sample size of 100 to 33 as shown below;

Calculated sample size of pit latrines per household/estimate households sharing a pit latrine ie; 101.81/3= 33.93

Seven pit latrines from each of the 5 locations were then selected purposively forming a sample of 35 pit latrines. Samples were taken at 3 or 4 depths depending on the depth of the pit latrine. A total of 128 samples were extracted for analysis at various pit depths and sampling done vertically and directly below the pedestal hole by use of a modified sampler.

3.6 Data sources

The study used both primary and secondary data. Primary data was gathered from relevant respondents especially those involved in sanitation provision services, emptying and disposal of faecal sludge in Nakuru and also through field observation.The sources of secondary data included; official reports, theses and publications in hard and soft copy formats. Some of the primary data was as a result of laboratory analysis on the occurrence of viable helminthes species ova in faecal sludge in relation to pit depth and variation of occurrences versus pit depth.

3.7 Data collection tools and processes

Data on desludging and disposal practices was collected through questionnaires issued to practitioners on desludging and disposal of pit latrine sludge in areas covered by the study units. Information gathered included desludging, transport and disposal practices in regard to health risks exposure among those carrying out the activity and the public as well as the environment.

Faecal samples were collected from pit latrines by use of a modified sampler, kept in an air tight container and placed in a cool box then transferred to the laboratory immediately for analysis. Laboratory analysis was performed to establish viable helminthes parasite ova present in faecal sludge and their occurence at different depths. Floatation method (Bailinger) was used to recover helminthic ova in faecal sludge and establish their occurrence in relation to pit depth.(WHO 2006).

3.8 Data analysis

The computer based statistical package for social sciences (SPSS version 20.0) was used for data analysis to yield descriptive and inferential statistics. Descriptive statistics were used to organize and analyze data on faecal desludging and disposal practices in Nakuru. Kolmogorov-smirnov test and levene’s test were used to test for normality and homogeneity of data and variances. One way analysis of variance (ANOVA) by the aid of Minitab version

16 research tool was used to establish significant differences in the occurrence of viable helminthes ova in relation to depths in the selected pit latrines. Where significant differences were found, a Post Hoc test was conducted (Tukey and Fisher's exact) to establish the exact depth at which the significant differences occurred. Graphs and tables have been used to present data findings especially those from the descriptive statistics. The table below shows a summary of data analysis and the different variables used.

Table 4: Summary of data analysis

Research questions	**Independent variable**	**Dependent variable**	**Statistical analysis tool**
What are the faecal desludging, transport and disposal practices and how are they likely to enhance public, environmental and occupational health exposure?	desludging practices, Period and frequency of practice, Availability, use and type of standard emptying and disposal methods Use and type of PPEs	soil, water pollution etc.)through spillages, dumping, washing etc Exposure to public, occupational injury cases Type of diseases suffered while disludging amongst the practitioners	Descriptive statistics.
Which species of helminthes parasites are found in pit latrine faecal sludge in Nakuru county?	Pit latrine sludge	Helminthes parasite ova species	Descriptive statistics
Are there viable helminthes ova in sludge within Nakuru county and how do they occur in regard to pit latrine depth?	Pit latrine depth	Viable helminthes ova occurrences	One way analysis of variance(ANOVA)

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Pit latrine emptying and disposal practices

4.1.1 Gender and age of pit desludging practitioners

Majority of those involved in desludging and disposal of faecal sludge in Nakuru were male (89.3%,n=25) ,while only (10.7%,n=3) were female. The female gender were involved in managerial duties, records and accounts in organized groups. Most of the desludging practitioners (46.4% n=13) were aged between 30 – 40 years. This could be attributed to the nature and kind of activities involved whereby masculinity and physical energy amog the majority male gender is needed and is also a characteristic of this age bracket especially when carrying out manual desludging.

4.1.2 Experience and ownership of desludging ventures

A large number of those people (64.3%, n=18) involved in the desludging and disposal of faecal waste in Nakuru County have been hired and use semi mechanized and mechanized emptying methods while the remaining portion (35.7%,n=10) were the owners of the desludging ventures and mostly practice manual desludging. In terms of their work experience, majority of them (42% n=12) have an experience of 0 - 5 years in the desludging business followed closely by 39.3%, n=11) having practiced for 6 -10 years and only (17.9%, n=5) having practiced between 11-15 years as shown in Table 5

Table 5: Duration of practice on desludging ventures by the various respondents interviewed.

Duration of practice	Number	Percentage
0 – 5 years	12	42%
6 – 10 years	11	39.3%
11 and above years	5	17.9%

Most of the practitioners don’t carry out desludging of faecal waste for long and many considered it stop gap means of winning their daily bread as they wait for better job openings. This may be good for the practitioners since the duration of exposure to harzards from untreated faecal sludge would be minimal if one serves in the profession for a short period. However, a single exposure may just be enough to make someone infected by pathogens if not well protected.

4.2 Desludging methods, transport and disposal practices

Various methods and practices are employed by practitioners while emptying, transporting and disposing faecal sludge from pit latrines in Nakuru County.

4.2.1 Desludging methods

67.9%, n=19) of the practitioners practice manual desludging methods i.e. bucket and rope techniques while some use semi mechanized methods like the gulper. The rest (32.1%,n=9) reported to use mechanized methods of desludging particularly the exhausters. This means that majority of these practitioners are exposed to the various hazards associated with faecal sludge since they are less equipped in terms of technology and personal protection. Those using the manual way of desludging tend to have minimal personal protective equipment . They may only use gumboots and overalls which may not help much since some of the manual desludgers immerse themselves into the sludge making their use irrelevant. Manual desludging increases chances of body contact with the faecal material thus exposing them to greater risks of infections as opposed to the few who use the mechanized way of desludging. Some parasites like the whip worm are common in faecal sludge and can actually penetrate through the skin hence a threat mostly to the manual desludgers.

The table 6 below shows the number and proportion of people using manual and mechanized desludging techniques respectively;

Table 6: Percentage of practitioners using different desludging methods in Nakuru county

Methods of disludging	Number of those desludging	Percentage
Manual(buckets and rope)	19	67.9%
Mechanized (mainly vacuum exhausters)	9	32.1%

4.2.2 Content removal and frequency of desludging

A majority of those interviewed 75%,(21) said that they were not able to empty all the contents within the pit latrine vault while a few (25% (7) agreed that they empty all the contents from the pit. These were mostly the manual desludgers. Most of the pit desludgers

42.9% (12) empty pits weekly while 32.1% (9) empty pits daily. The others 25% (7) empty pits once per month. The table 7 below shows the frequency of desludging among workers and their percentage proportions;

Table 7: Frequency of pit latrine desludging among practitioners in Nakuru County

Frequency of disludging	Number of respondents	Percentage
Daily	12	42.9%
Weekly	9	32.1%
Monthly	7	25%

The reasons given as to why they found it difficult to empty all the contents was that the sludge at deeper depths was solid and that most of the pit latrines were being used as disposal areas for solid waste like paper bags, diapers, plastics etc. and therefore could not be sucked by a vacuum pump but rather dug out manually. According to Buckley *et al* (2008), a recently deposited sludge found at the top portion of a pit vault is typically high in water and organic content as well as lower in density and therefore easier to desludge. As the sludge compacts over time, it solidifies and can only be removed by digging. Manual. Manual desludgers gave reasons for not emptying all the contents as pit walls being not lined and thus having a high possibility of collapsing upon reaching deeper depths. Another reason was that at very deep depths, pulling out compacted faecal waste was difficult and took a lot of time. The amount of money paid by the latrine owner also determined the depth at which a pit was manually disludged. Costs increased as one disludged deeper into the pit. Since majority are involved in desludging on a daily basis, a large proportion of these desludgers may be exposed to pathogens if not well protected.

4.3 Faecal sludge transport and disposal methods

The main mode of faecal sludge transport in Nakuru County is by exhauster trucks and tractor pulled tankers (75%,n=21), hand pulled carts and wheel barrows (25% n=7). During transport, there have been cases of sludge spillage reported. Majority, (78.6%, n=22) agreed that there has always been a spillage when desludging and transporting faecal sludge while the rest (21.4%, n=6) reported that spillages occurred sometimes but not always and especially during desludging through brocken suction pipes. This may expose the public and those living nearby to harmful pathogens and parasites,especially children who may decide to play on the contaminated ground from which spillage occured. Environmental pollution is also eminent when faecal sludge spills to the ground before treatment. Some of the parasites in faecal sludge thrive very well in soil especially the *Ascaris lumbricoides* , thus posing a health hazard upon contact with human beings and animals and also upon surface runoff to water bodies like rivers and lakes that serve as a source of domestic water.

While most of the practitioners reported disposing faecal sludge at the treatment plant owned by the county government, (35.7%,n=10) said that they use or get orders to supply the sludge for soil conditioning purposes by farm owners. Only a few said they once dug alternative pits for disposal but not anymore due to limited space. Another 46.4%, (n=13) reported that around the areas from which they were desludging, snacks and juices were being served and hence a likely source of food contamination. Evidence based on observation found out that most of the desludging pipes were torn and leaked making the sludge spill on the surrounding while desludging. This exposes people to health risks associated with faecal sludge as well as contaminating the soil and water sources especially during the rainy season. The mode of transport and disposal of faecal sludge determines the safety of the general public, those desludging and the environment. Poor transport of faecal sludge may cause spillage of the sludge while haphazard disposal may spread harmful biological and chemical disease agents. The plates (Plate 1) below are photos showing some of the torn suction pipes and spillage of faecal waste while desludging.

Plate 1: Photos showing worn out and torn suction pipes spilling septage to the environment

The fact that most of those using vaccum exhausters deposit faecal sludge at the sewerage treatment plant owned by the county governmet may affect the performance of the plant since many of the treatment plants are not designed to handle pit latrine sludge and, in addition, adding maintenance and operational costs (Bereziat, 2009). This is evident as two of the treatment plants in Nakuru and Naivasha upon which pit latrine sludge has been deposited over time have brocken down. A lot of solid matter and silt settles to the bottom of these ponds and more often require removal mannually. This increases the maintenance costs as well as exposing those involved in the removal of silt and sediments to faecal related harzards since most of them lack appropriate gear for protection as shown in the plates below;

Plate 2: Unprotected workers removing silt and solid waste from one of the waste water treatment ponds in Nakuru County.

4.3.1 Level of awareness on the risks involved and the use of personal protective gear while desludging

All the interviewed 28 practitioners said that they were aware of the risks involved while desludging faecal waste. Among the risks identified by the practitioners included; disease infection, cuts and pricks from sharp objects and cpllapse of slab into the pit in the case where the slab is unstable or the walls are not lined. However, observations on the use of protective gears and safety while desludging the pits revealed that the practitioners do not take occupational safety seriously. Despite being aware of the risks involved while desludging and disposing faecal sludge, a large proportion of the practitioners did not wear personal protective equipment (PPE) at all times with a smaller proportion reporting to completely wearing none of the PPEs. PPEs include things like overalls, face masks, gumboots, gloves etc, that can help in the prevention of physical contamination while desludging. Only 17.9% of those interviewed admitted to wear PPEs at all times. This therefore led to exposure to the various hazards associated with faecal sludge among the desludging practitioners while on duty.

4.4 Level of training on desludging practices and occupational health and safety

Most of the practtioners, 57.1% (16) have never been trained on pit desludging practices. Those trained 42.9%, (12) have done so informally through on the job training by their colleagues and therefore not professionals in the practice. They therefore lack informed skills on pit latrine desludging practices and hence may contribute towards occupational injuries.

In regard to the training on occupational health and safety, 67.9% (19) have never been trained while 32.1% (9) admitted to having been trained on occupational health and safety. This was because they formed a group under which they organized a workshop for the training in collaboration with non-governmental organizations on water and sanitation in Nakuru, supported by Practical Action/Umande trust. The content of the training was on the need for personal protective equipment, how to wear and remove them after work and the risks involved while desludging faecal waste and thus the need for safety while carrying out such tasks. Despite the training of some of the practitioners, the use of PPEs was still very low and thus exposing the practitioners to occupational risks upon desludging as shown in plate 3 below;

Plate 3: Photos showing desludging practitioners without appropriate PPE

Some of them complained of unfavourable weather conditions and said that wearing of overalls was uncomfortable especially when the weather was sunny. Others said that the owners of the trucks did not provide them with the PPEs but based on observation, some had been provided with protective gears but were ignorant of their use.

4.5 Practices that increase exposure while desludging faecal waste

According to Godfrey (2012) and Mikhael (2011) faecal sludge practitioners are likely to consume alcohol before, during or after desludging. In this research, 46.4% admitted to drinking alcohol before or after desludging pit latrines. However, a majority reported that they never took any alcohol whatsoever before or after desludging faecal waste. Those who did said that by taking alcohol, they were more courageous to undertake faecal desludging while others only took alcohol after job for relaxation and pleasure. Some took only hard liquor after desludging due to the wrong perception that it kills harmful parasites ingested while desludging faecal waste. However, taking of alcohol especially during or before desludging may increase the risk of injury and exposure to faecal sludge due to poor judgement.

4.6 Cleaning of tools and wearing of protective gears

All the practitioners admitted to clean themselves and their tools and vehicles of trade after desludging faecal waste. However, only 35.7% (10) wore any kind of protective gear while doing so. The rest 64.3% (18) did not wear any form of protective gear thereby exposing themselves to the various risks and hazards involved.

4.7 Deworming, vaccination and injuries experienced while desludging faecal sludge

None of the participating practitioners had been dewormed for the last six months before the research was undertaken while only (3.6% n=1) had been vaccinated against tetanus. Tetanus vaccination is very important especially to the desludging practitioners who are exposed to various injuries from sharp objects while on duty. The fact that most of them are not vaccinated increases their chances of getting tetanus when cut or pricked by sharp objects since most of the practitioners (92.9%,n=26) had experienced some form of injury in the course of duty. This included; cuts, pricks, falls, bruises and broken arms and legs especially after falls or collapsing of pit walls. A small percentage (7.1%, n=2) reported that some of their colleagues had died while emptying pit latrines within the county. The reasons given were; suffocation by toxic fumes and collapsing of pit latrine walls while at work. This were mainly the manual desludgers since they have to enter into the pit to desludge. Toxic fumes may erupt while desludging faecal waste from pit latrines and this directly affects the desludger directly upon inhalation and therefore causing harm.

4.8 Availability of first aid kits, firefighting equipment and insurance

Majority of the practitioners (85.7%,n=24) lacked first aid kits while only 14.3%, (n=4) had these kits. However, even those with the first aid kits lacked the basic knowledge on the medical procedures for first aid in case of emergencies while others were not stocked. A few exhauster Lorries (10.7%, n=3) had been installed with firefighting equipment. However, it was noted that none of those found was functioning. This meant that they were less equipped in the event of an accident, injuries or even fire for those operating the exhausters. The plate below (Plate 4) shows some of the unstocked first aid kits and non functional fire extinguisher found in the vehicles of these practitioners.

Plate 4: Photos of non functioning fire fighting equipment and empty first aid kits

4.9 Helminthes parasite species in pit latrine faecal sludge

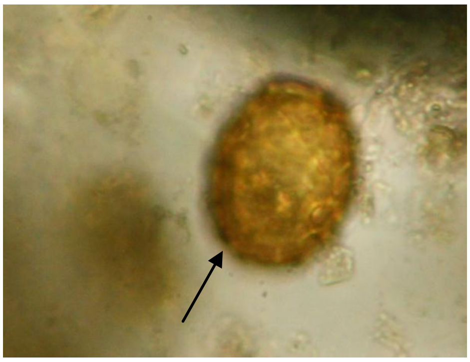
Out of the 35 pit latrines sampled, 34% (12) were found to contain faecal sludge that had viable helminthes ova. Out of the total samples (N =128) collected, 23%, (n=30) were found to contain viable helminthes ova. Human excreta and lack of adequate personal and domestic hygiene have been implicated in the transmission of many infectious diseases including cholera, typhoid, hepatitis, polio,cryptosporidiosis, Ascariasis and schistosomiasis. The WHO estimates that 2.2 million people die annually from dirrhoeal diseases and that 10% of the population of the developing world are severely infected with intestinal worms related to improper waste and excreta management, (Murray and Lopez, 1996)

In this study,seven helminthes species were identified. These include; *Ascaris lumbricoides*, S*chistosoma haematobium, S. mansoni, Enterobius vermicularis, Necator americanus, Trichuris trichiura and Taenia sp.* Their percentage occurrence in the investigated pit latrines is given in the Table 8 below;

Table 8: Occurrence of helminthic species ova in pit latrine sludge found in Nakuru

Helminthes species	No of occurrences	Prevalence (%)
Ascaris lumbricoides	27	67.5
Necator americanus	6	15
Trichuris trichiura	3	7.5
Enterobius vermicularis	1	2.5
Schistosoma haematobium	1	2.5
Schistosoma mansoni	1	2.5
Taenia sp	1	2.5

The highest occurences as shown in the table above were those of the *Ascaris lumbriocoides* followed by *Necator americanus* and *Trichuris trichiura.* Only single occurences were observed for the other helminthes species. Pit latrine faecal sludge can contain high concentrations of pathogens depending on the health status of those using it. Such pathogens include bacteria, viruses, protozoa and helminthes (WHO 2006). (David S and Kitty F, 2012), found that the ova of *Ascaris* was the most prevalent at 60% followed by *Trichuris* at 50% then *Taenia* at 11%in an investigation into helminthic and protozoan parasites in pit latrine faecal sludge in South Africa (PRG 2008). This study gave almost similar results where Ascaris occurred in (67.5% n=27) of the total samples followed by hookworm at (15% n=6), then *Trichuris* at (7.5% n= 3) of the total samples analyzed. *Taenia spp*, *Schistosoma haematobium*, *Schistosoma mansoni* and *Enterobius vemicularies* were found to be least at (2.5% n=1) of the total samples analyzed. Below are the photos (plate 5) of some of the ova identified through microscopy from the samples analysed.



a) *Ascaris* ova x40

b) *Schistosoma haematobium* ova x40

c) *Trichuris trichiura* species ova x40

d) *Schistosoma mansoni* ova x40

Plate 5: Photos of some of the helminthes parasite's ova identified in pit latrine faecal sludge from the study area

4.9.1 The occurrence of total viable helminthes parasite ova across pit latrine depths.

Majority of helminthes ova were found near the surface (0-1 meters) as opposed to the other depths respectively. *Ascaris lumbricoides* ova was the most common occurring across all the depths and across all the pit latrines sampled (Figure 2). After conducting a one way analysis of variance, there was a significant difference in the occurrence of total viable helminthes ova versus pit depth ($F=10.86$, $\rho = 0.00$) and upon conducting a post hoc test, a statistical difference was found to occur between the top layer and all the other depths respectively and not within the 1 meter, 2 meters and 3 meters . This was due to the diverse occurrence of various helminthes species at the top layer where all the seven species identified were present. Another fact is that the faecal sludge at the top was relatively fresh and of recent deposition compared to the other depths and therefore many parasites including the short lived ones are likely to be present before they die off by the time of sample collection. The fact that Ascaris ova was found to occur in large numbers near the surface sludge could also have led to the significant difference in the occurrence of these parasite ova between the top layer and all the other depths respectively. The figure below shows a representation in the occurrence of total helminthes ova present in faecal sludge in relation to pit latrine depth;

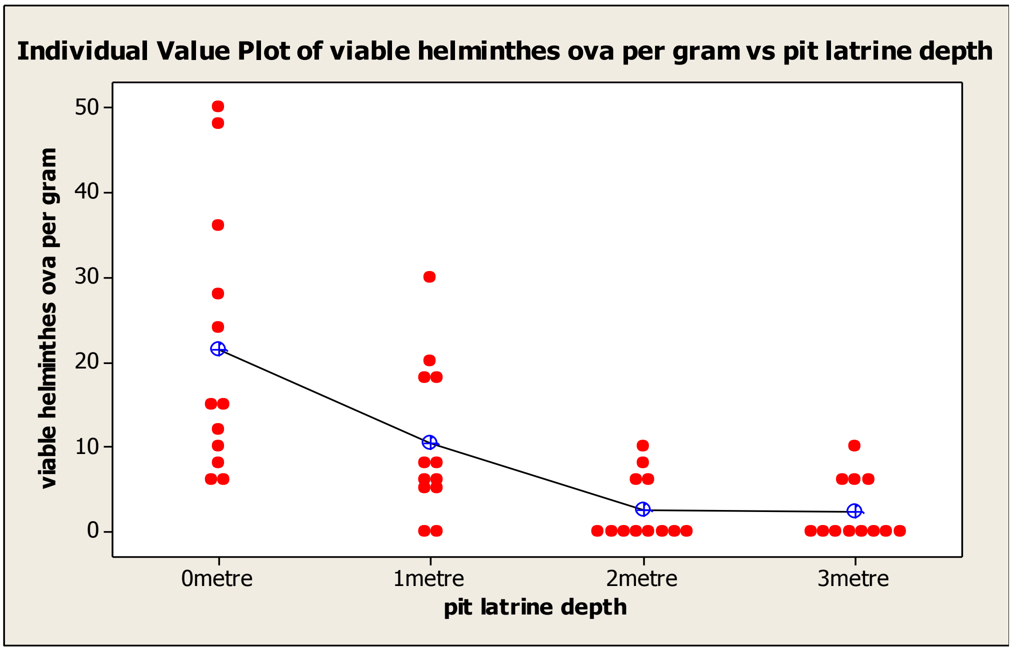


Figure 2: Trends in the occurrence of viable helminthes ova versus pit depth in the various sampling sites

From the figure above on the occurrence of viable helmithes ova versus pit depth, the highest occurences per pit latrines sampled occurred at the top and gradually reduced as samples were taken lower down the pit latrine depth. Signicant differences occurred only between the top layer and all the other depths respectively but not within the second(1m), third(2m) and fourth depths(3m) and therefore the top most layer was concluded to be the most hazardous upon exposure to desludgers and the public.

4.9.2 The occurrence of Ascaris ova in pit latrine faecal sludge versus depth

Ascaris lumbricoides ova occurred at all the four sampled depths of a pit latrine right from the top to the bottom. The mean occurences are shown in (Table 9) below,

Table 9: The number of *A. lumbricoides* ova at different pit depths

Pit depth	N	Mean ova counts	SD
0 meter	9	21.000	14.335
1 meter	10	11.000	7.832
2 meters	4	7.500	1.915
3 meters	4	7.000	2.000

The Ascaris has been referred to as a bio marker in the establishment of pathogen free faecal sludge since it's the hardiest and most persistent helminthes parasite and thus its elimination would render the sludge safe for disposal or reuse (Jimenez 2007). In this particular research *Ascaris* was found to occur in all depths and even dominated at depths of 2 meters and 3 meters respectively. Its presense means that faecal sludge is still infective and thus unsafe upon exposure to human. The fact that the sludge mostly spills on the ground while disludging and that most practitioners don't wear PPEs exposes the public and the practitioners to these harmful parasites. When the contaminated soil is washed through surface run off, it may also contaminate sources of water for domestic use hence enhancing exposure to the various hazards identified.

4.9.3 level of significance on occurences observed.

A p-value of 0.049 was established by one way and therefore a significant difference in the occurrence of viable *Ascaris* ova versus pit latrine depth. A Post hoc test to establish the exact level of significance (fisher's exact test) found that significant differences exist between the occurrence of viable *Ascaris* ova at the top and occurrences in all the other depths but not between the depths of 1m, 2m and 3m, this meant that there was a high load of Ascaris ova at the top of pit latrine sludges in Nakuru county as opposed to the other depths within the pit latrine and since this is the most disludged part of the pit latrine by manual disludgers exposes them more to the various parasites identified.

4.9.4 Viable *Ascaris* ova per gram of faecal sludge versus pit latrine depth

Viable Ascaris ova was found to occur in large numbers at the top and gradually reducing as you go deeper in a pit latrine as shown in the figure below;

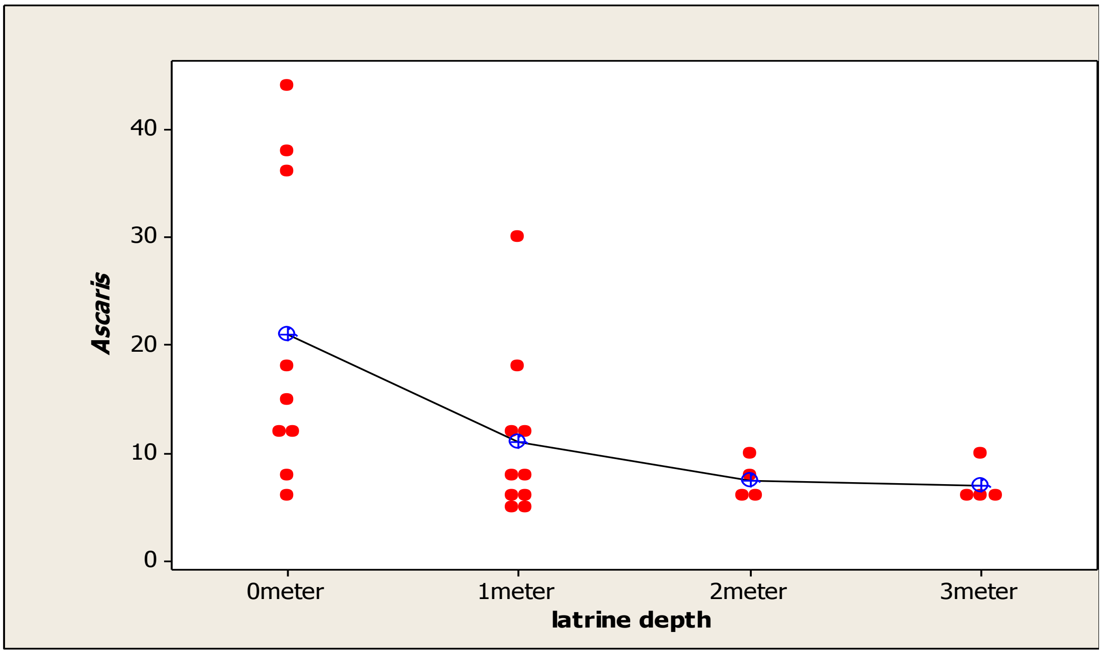


Figure 3: Viable *ascaris* ova per gram of faecal sludge versus pit latrine depth

The figure above illustrates mean proportions of *Ascaris spp* identified versus pit latrine depth. *Ascaris lumbricoides* occurred in all the four depths sampled meaning that sludge from such depths was still hazardous upon exposure to the environment and humans.

Upon conducting a one way analysis of variance, a significant difference was also found in the occurrence of viable *Ascaris* ova versus pit latrine depth (F=3.04, ρ= 0.049). The *A. lumbricoides* ova have a thick cell wall that makes them resistant to adverse environmental conditions and therefore a long life span and thus of an interest (Fripp, 2004). The difference occurred between the top layer (0 meters) and all the other depths respectively but not within 1m, 2 m and 3m. This again can be explained by the fact that the faecal samples at the top where deposited recently and therefore a large number of viable *Ascaris* and other helminthes species ova could be present as opposed to the other depths where there has been a retention time and thus gradual die off. These findings are different from the ones reported by Foxon and Still (2012) on the occurrence of viable Ascaris ova in VIP waste at 3 depths in S. Africa where there was no significant difference in the number of viable *Ascaris* ova in regard to pit latrine depth. This could be due to the fact that the depths in Kenya were at intervals of 1 meter while those of S. Africa were at intervals of 0.5 meter and thus not comparable since we took samples far much deeper in a pit latrine.

The figure below shows mean occurences of various helminthes species identified in faecal sludge ;

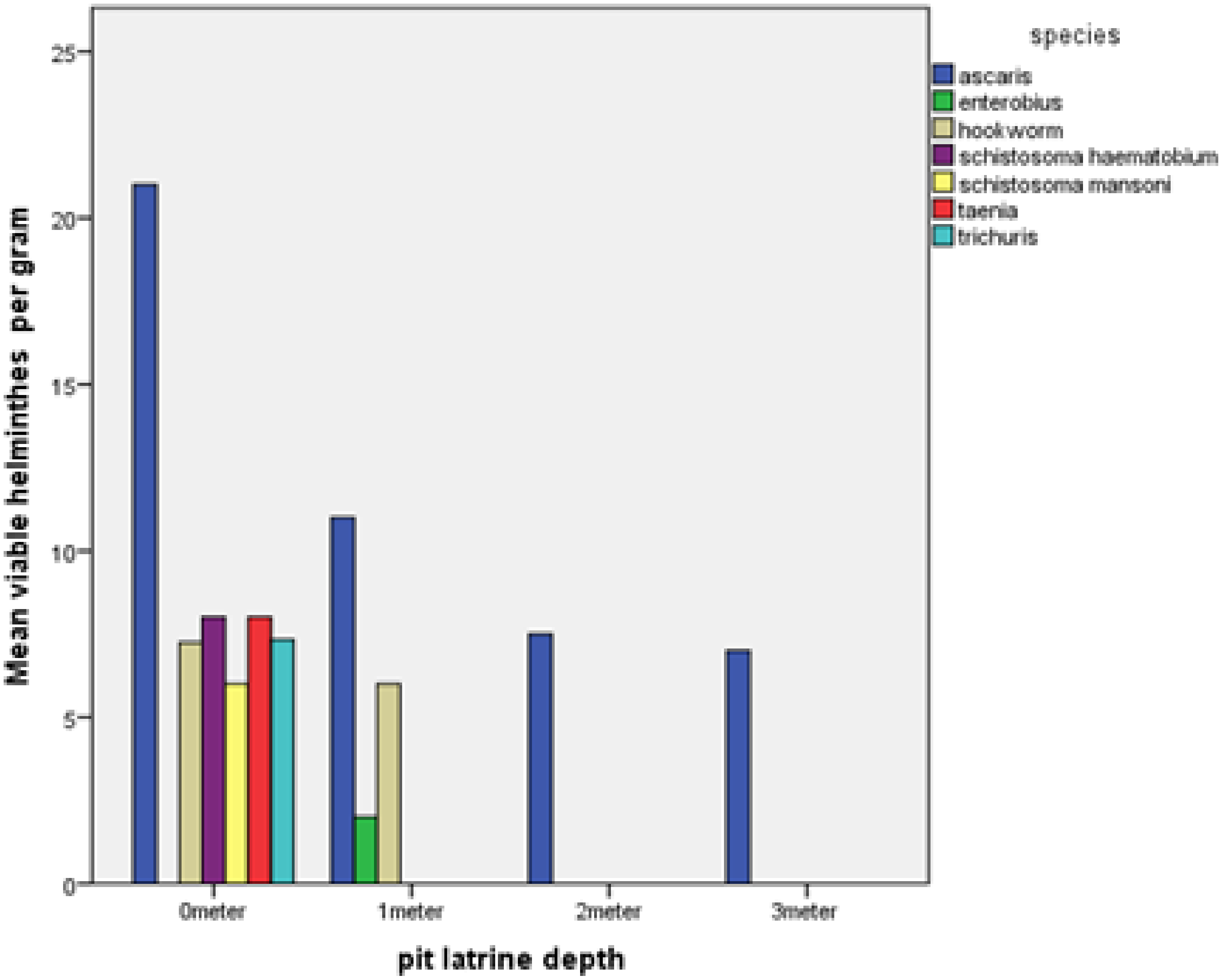


Figure 4: Mean proportions of the occurrence of various helminthes species identified versus pit latrine depth.

As presented, most of the helminthes species identified occurred at the top and one meter respectively with only the *Ascaris lumbricoides* occurring in all the depths from which sludge was sampled. This explains the hardy and persistent nature of the Ascaris lumbricoides in the environment and faecal sludge. The reduction in the concentration of the other parasites as one goes deeper explains their die off rates in regard to time and therefore with enough retention time,faecal sludge can be safe from these parasites as they die off over time.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Majority of the desludging practitioners in Nakuru Sub County use manual desludging methods upon which increased exposure to hazards related to faecal sludge may occur. This includes exposure from contact and inhalation of infested fumes since most of them have been found to not wear the appropriate PPEs at all times when desludging pit latrines.

Pit latrine faecal sludge in Nakuru County was found to contain numerous helminthic parasite species ova which include; *Ascaris lumbricoides, Taenia sp, Schistosoma haematobium, Schistosoma mansoni, Trichuris trichiura, Necator sp* and *Enterobius vermicularis*. These ova could potentially infect those desludging the pit latrines and the public and the environment upon exposure due to poor disludging and disposal practices. *Ascaris lumbricoides* was found to be the most occurring among the different species identified.

More viable helminthes parasite ova and of different species were found at the top most part of faecal sludge in pit latrines than deeper below. This therefore was potentially the most risky upon exposure during desludging and in instances where the pit latrines were literally full and still on use.

Ascaris lumbricoides was the most occurring across all depths and existed even at depths of 3 meters in pit latrines and therefore making faecal sludge at such depths still infective.

5.2 Recommendations

Creation of awareness on the risks and hazards associated with exposure to faecal sludge as well as the need for wearing personal protective gear while desludging should be done among the desludgers since most of them seemed ignorant and careless and lacked the appropriate protective gears while desludging.

Alternative methods of treatment and use of pit latrine faecal sludge should be encouraged and funded by the concerned actors to ensure that maximum benefits are gained by using faecal sludge as a resource and not waste. This will save the sewerage treatment plants from breakdowns since this sludge will not be deposited in those plants and thus save costs as well as creating job opportunities and extra income to those involved.

Research should be done on how to effectively eliminate helminthes parasites from the sludge and therefore can be re used in agriculture instead of being thrown away as waste. Treatment of faecal sludge from helminthes parasites which are the most persistent will render it fit for soil conditioning and a source of nutrients for plants.

Pit latrine sludge regardless of the depth from which it has been extracted should be treated with utmost care since this research has found out that even at deeper depths, viable helminthes ova especially those from *Ascaris lumbricoides* are still present and hence the need for further treatment before disposal. Its however recommendable that pit latrine sludge should be left for sometime when a pit is full before desludging as this would increase the die off rates of the parasites present.

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APPENDICES

APPENDIX 1: RESEARCH TOOLS

QUESTIONNAIRE FOR DISLUDGING AND DISPOSAL PRACTICES

I am Jayson Maingi from Egerton University and am conducting a research on the assessment of pit latrine sludge and disludging practices in Nakuru County. As part of the data collection process, we are conducting a survey in areas and people that are being considered for participation in the project. Information given will be kept private and confidential and will be used for purposes of this research only.

AREA …………………………………………………………………..

NAME OF THE COMPANY (optional) …………………………………

1. Gender male [ ] female [ ]

2. Age 20-30 [ ] 30-40 [ ] 40-50 [ ] over 50years [ ]
3. Are you an employee or the owner of the disludging venture?
   Owner [ ]
   Employee [ ]
4. For how long have you practiced disludging?

   0-5 years [ ] 6-10 years [ ] 10-15 years [ ] 16-20 years [ ] Over 20 years [ ]

5. How often do you disludge pits

   Daily [ ] Weekly [ ] Monthly [ ] other (explain)…………………..........................

6. What methods of disludging does your business offer?
   Exhauster [ ]
   Buckets and rope/spades (manual) [ ]
   Gravitational flow [ ]
   Other (explain)
   ……………………………………………………………………………..
7. Do you understand the dangers involved while disludging faecal waste?

YES [ ]   NO [ ]

8. Have you been trained on pit latrine disludging practices before?

   YES [ ]   NO [ ]

9. If yes, where have you trained at and what was the content all about?

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

OCCUPATIONAL HEALTH RELATED ISSUES

10. Do you wear any protective gears when doing your job?

    YES [ ]   NO [ ]

11. If yes, which ones do you wear?

    Hand gloves [ ]

    Face masks [ ]

    Gum boots [ ]

    Overalls [ ]

    Other (explain)

    ………………………………………………………………………………

12. Do you wear them?

    All the time [ ]

    Sometimes [ ]

    Never [ ]

13. If never or sometimes, what are the reasons for not wearing at all times when disludging

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

14. Do you clean yourself after disludging?

    YES [ ]

    NO [ ]

15. If yes what do you use to clean yourself?

    Water only [ ]

    Soap and water [ ]

    Anti-bacterial disinfectant [ ]

Other (explain)

……………………………………………………………………………….

16. Have you suffered from any diarrheal disease in the past six months?

YES [ ]

NO [ ]

17. If yes, which one?

Typhoid [ ] Cholera [ ] Dysentery [ ] other (explain)

……………………………….

18. Do you attribute these diseases to the nature of your work?

YES [ ] NO [ ]

19. Have you experienced any accidents or injuries in the process of pit disludging?

YES [ ] NO [ ]

20. If yes, which ones?

Cuts from sharp objects [ ]

Collapse of the pit walls [ ]

Drowning in sludge [ ]

Collision while transporting to disposal sites [ ]

Other (explain)

………………………………………………………………………………..

21. Any deaths experienced during disludging? YES [ ] NO [ ]

22. If yes, what was the reason for the death………………………….......................................

…………………………………………………………………………………………

……

DISPOSAL PRACTICES

23. How do you transport the disludged waste to the point of disposal?

By truck (exhauster) [ ]

Wheel barrow [ ]

Hand pull cart [ ]

Donkey pulled cart [ ]

Tractor [ ]

24. Are there any spillages while transporting the sludge?

YES [ ]   NO [ ]

25. Do you take faecal sludge to the municipal treatment plant?

    YES [ ]   NO [ ]

26. If yes, how much does the municipal charge you for disposing waste at their treatment plant?

    ....

27. Do you find the fee affordable?

    YES [ ]   NO [ ]

28. If no, do you then always take the sludge to the plant?

    YES [ ]   NO [ ]

29. If no, then how do you dispose of your sludge after pit emptying if not at the municipal plant?

    Nearby stream/river [ ]

    Buried on the ground [ ]

    Dumped by the roadside [ ]

    To the open dumpsite [ ]

    In the nearby bushes/forest [ ]

    Other

    (explain)…………………………………………………………………………

APPENDIX II

EGERTON UNIVERSITY

STANDARD OPERATING PROCEDURES FOR COLLECTION AND DISPOSAL OF FAECAL SAMPLES

Introduction

Faecal sludge can host a variety of potentially hazardous pathogenic life forms and thus classified as biologically hazardous waste. This waste cannot therefore be disposed of as normal waste thus suitable precautions should be taken when handling such wastes samples.

Principle

- Sample collection and disposal should be done with utmost care to avoid contamination.
- Samples after collection should be named according to their source and the sequence of samples obtained from that source.
- A photo record of the sample is taken to allow later correlation of measured sample properties to its initial visual appearance.

Safety precautions

The following precautions should be followed;-

- Always use appropriate personal protective equipment e.g. gloves, lab coat, closed shoes and face protection while collecting and disposing faecal samples.
- Wear face goggles when collecting and disposing faecal sludge to avoid contact in case of splash back.
- Clean all soiled equipment thoroughly after use and with 70% ethanol spray for those items to be taken out of the laboratory.
- Dispose used gloves in appropriate waste bins after cleaning, disposal, and sample handling is complete.
- Dispose samples in regard to local regulatory guidelines on disposal of biohazards. (NEMA).
- Wash hands thoroughly with soap after handling such samples and disinfect.

Extra care should be taken from those samples collected from public latrine vaults as those may contain sharps and thus can't be handled directly with gloved hands but rather with a spoon or a spatula.

Maintenance of 'clean' and 'dirty' work areas.

Where excreta samples are collected or processed after collection should be considered a dirty area. 'Clean 'zones should therefore be designated for items that will be taken out of the laboratory and sampling sites e.g. cameras and GPS gadgets.

- Sample boxes and equipment used to handle samples should only be placed on wipe clean surfaces – plastic or metal top work benches or trays.
- Items to be taken out of the laboratory e.g. cameras, paper forms for recording and GPS should be kept on a clean tray or on a segregated clean area of the work bench.
- Clean items should be handled whilst wearing clean gloves

Materials and equipment

- Permanent marker
- Camera
- Metal/plastic spoons for scrapping faeces into disposal bags and bins.
- Wipe clean trays
- 70% ethanol for disinfection of equipment and spills.
- Pro forma sheets for recording sampled data and a biro pen.

Procedure for disposal

All excreta samples should be disposed of under the NEMAs guidelines. However, the following general procedures will follow;-

- Clean all benches with 70% ethanol after working on them.
- Clean all containers and equipment used with water and dish washing detergent and disinfected with ethanol.
- Designated disposal containers should be set up on which appropriate treatment and disposal of waste will follow.
- Name all the waste collection bins appropriately for proper identification.

Sample naming procedure

- Each field location is assigned a digit location number.
- Each sampling point within that location is assigned an alphabetical letter.
- Sample number should follow this format;
  (Location number (e.g. 01) – sample point letter (e.g. A) – sample number from that sampling point e.g. sample 4, i.e. 01A004.

Receipt of samples

- Assign a name to a sample and write on the container with a permanent marker and store the samples in a cold box while at the field and in the cold room within the laboratory.
- Record sample names and dates and times collected and transferred to storage in the sample data base.

Photo records

- Two persons to carry the procedure, one to handle the samples while the other handles clean items like cameras and GPS in the field.
- Use 70% ethanol spray (sparingly) to disinfect camera and other objects that are not to be kept in the laboratory.
- Dispose of dirty gloves and wash hands according to standard procedure before transferring the camera to office to retrieve the taken photos.