INFLUENCE OF SOCIAL ECONOMIC FACTORS AND TECHNOLOGICAL SUITABILITY ON FAECAL EMPTYING, CONVEYANCE AND DISPOSAL: A CASE OF MERU SLUMS, KENYA

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DECLARATION

I hereby declare that this is my original work and has never been submitted for an award to any university or institution of higher learning.

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DEDICATION

I dedicate this work to my son Mark Silvanus Owuor, family members, colleagues and Meru University fraternity for their inspiration and overwhelming support throughout the research period.

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ABBREVIATION AND ACRONYMS

FS	Faecal sludge
FSM	Faecal Sludge Management
KNBS	Kenya National Bureau of Statistics
L.M.I.C	Low and Middle Income Countries
MIRERC	Meru University of Science & Technology Institutional Research Ethics Review Committee
MoH	Ministry of Health
MUST	Meru University of Science and Technology
NACOSTI	National Commission for Science, Technology and Innovation
PHO	Public Health Officer
SD	Standard Deviation
SDGs	Sustainable Development Goals
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
WASH	Water, Sanitation and Health
WHO	World Health Organization

DEFINITION OF TERMS

Conveyance	Transportation of faecal sludge from containments to designated treatment or disposal site
Disposal	Hygienic treatment faecal waste
Emptying	Removal of accumulated faecal sludge from sanitation facilities
Faecal sludge	Partially digested and undigested solids originating from storage and treatment facilities of human excreta.
Faecal sludge management	Handling of faecal sludge contained in on-site sanitation systems such as pit latrine and septic tanks.
On-site sanitation	Are sanitation facilities such as septic tanks and pit latrines where containments are located within the household premises mainly for treatment of human waste deposits.
Pit emptiers	Deposit sanitation workers involved in the practice of faecal removal from pits
Pit emptying	Removal of accumulated sludge from pits using hand tools or mechanical options such as vacuum pumps
Pit Latrines	A type of toilet consisting of a hole in the ground that collect human urine and faeces
Toilet	A structure used for urination and defecation consisting of a user interface connected to containment.
Sanitation	Is the provision of facilities and services for the safe disposal of human urine and faeces

ABSTRACT

Safe management of faecal waste is one of the Sustainable Development Goals (SDGs) which envisions safe sanitation for all. However, although efforts to improve sanitation conditions in slums have been made, faecal emptying, conveyance and disposal still remain a challenge endangering the health of the public. The increasing number of slum dwellers accessing on-site sanitation systems has overwhelmed on-site sanitation infrastructure compromising faecal handling mechanisms in cities and towns. This study examined the influence of socioeconomic factors and technological suitability on faecal emptying, conveyance and disposal in on-site sanitation facilities in Meru slums. The specific objectives were; to examine the influence of social factors on faecal emptying, conveyance and disposal in on-site sanitation facilities; to establish the influence of economic factors on faecal emptying, conveyance and disposal in on-site sanitation facilities and to assess technological suitability of faecal emptying, conveyance and disposal in on-site sanitation facilities in Meru slums. A convergent design with a mixed methods approach was adopted. Quantitative data was collected using structured questionnaires from a sample of 228 household heads selected using cluster and proportionate simple random sampling techniques. Correlation and regression analysis was carried out to ascertain the association between emptying, conveyance and disposal of faecal waste and the economic factors. Qualitative data was gathered using focus group discussions and analyzed thematically. It was established that all the three variables, that is social factors (r=0.595, p-value=0.000), economic factors (r=0.539, p-value=0.0000) and technological suitability (r=0.270, p-value=0.000) had a significant positive association with faecal emptying, conveyance, and disposal. It was further found that, social factors, economic factors, and technological suitability explained 35.4%, 29.0%, and 7.3% respectively of the changes in faecal emptying, conveyance, and disposal Lastly, a unit change in social factors, economic factors, and technological suitability, resulted in a change of 0.454, 0.615, 0.177 respectively in faecal emptying, conveyance, and disposal. All the three factors put together contributed in a change of 41.6% in faecal emptying, conveyance, and disposal. Findings showed that only 31% of slum dwellers emptied latrine pits and that manual emptying was more common (84%) than mechanical emptying because of its cost efficiency, reliability and the effectiveness in handling all nature of materials contained in pits. Increased cost constrained faecal emptying, conveyance, and disposal (r=0.499, p-value=0.000). Residents who were able to pay for faecal handling services were more likely to practice hygienic faecal emptying, conveyance, and disposal (r=0.524, p-value=0.000). Low level of income for majority of slum dwellers influenced the design of the latrines adopted. Emptying faeces from poorly designed pit latrines was more expensive due to operators' safety concerns. The study concluded that the inability to meet the costs associated with faecal emptying, conveyance and disposal services facilitated poor sanitation status in slums. There is need to sensitize the slum community on the benefits of practicing safe management of faecal waste. Besides, development of government policies to regulate pricing and increase the capacity of mechanical handling of faeces could be essential.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Safe emptying, conveyance and disposal of the accumulated excreta from sanitation facilities constitute an essential part of hygienic Faecal Sludge Management (FSM). Safely managed faecal waste is one of the agenda in the Sustainable Development Goals (SDGs) which envisions safe sanitation for all (United Nations, 2015). However, management of faecal waste has been a challenge due to increase in population in unplanned urban areas. Globally, 3.6 billion people lack access to safely managed sanitation systems and 38% of the urban population access sanitation facilities which do not completely separate them from faecal contact (WHO/UNICEF, 2020). Access to unsafe sanitation could predispose the population to the risk of contracting helminthes infection and polio as well as diarrheal diseases such as dysentery and cholera which is responsible for 88% of children mortalities in sub-Saharan Africa (Demissie *et al.*, 2021). The health of residents in urban areas would be in danger unless accumulated faecal waste is appropriately managed which the focus of this study was.

Sustainable sanitation in urban areas is pegged on operational, reliable and safe faecal sludge management system for quality health and environmental protection from pathogenic contamination. Globally, cities and towns have been dependent on sewerage systems for removal of faecal waste from the point of generation to designated treatment and disposal facilities. However, while cities and towns continue to experience high population growth, majority of the inhabitants globally estimated to be 2.7 billion have been forced to depend

on on-site sanitation technologies (Gensch *et al.*, 2018) due to the inflexible and high resource demanding nature of conventional sewerage systems which can no longer contain large volumes of faecal waste generated in urban areas. In Cambodia, a study by Harper *et al.* (2020) reported that alternative options to sewerage systems include on-site sanitation systems such as pit latrines, pour flush toilets, septic tanks and urine diverting toilets where excreta is managed at the point of collection. However, little attention is given to the ways of emptying, conveyance and disposal of human waste that accumulate in the systems. There is need for a paradigm shift in the ways of managing accumulated faecal waste in urban areas which this study sought to address.

Overdependence of the urban population on on-site sanitation systems has alleviated the burden of excreta management in towns and cities due to the ability of the technology to contain and treat the waste at the point of generation. However, the technology is plagued with various disadvantages emanating from sanitation facilities design, access to filled pits, operation and maintenance of emptying technologies. In India, a study by Prasad and Ray (2019) found out that the use of trucks for emptying toilets required between $25 to $80. The study showed that high toilet emptying fee encouraged disposal of faeces in open drains which exposed the population to helminthes infections. Similarly, in Sub-Saharan Africa a study by Peal et al. (2020) that estimated excreta management in urban areas indicted that 14% of contents in pits and septic tanks remain unemptied resulting to overflow of sludge to the environment. Failure to empty filled up sanitation facilities could result in spillage of untreated sludge which contain diarrheal related pathogens. Emptying of on-site sanitation systems could remain in limbo unless suitable and economically viable emptying options are available.

Developing countries, Kenya included have put in place interventions towards improvement and sustainability of safe and hygienic faecal sludge management in urban areas. However, management of the accumulating excreta in on-site containments still remain unaddressed with even more deteriorating conditions in unplanned and informal urban settlement with poor sanitation infrastructure and high population densities. Studies for instance by Gitonga et al. (2021), Peletz et al. (2020) and Mugendi et al. (2023) found out that urban areas in Kenya are lagging behind in safe and hygienic storage, emptying treatment and disposal of accumulated faecal waste from non-sewered sanitation technologies. Failure to adopt socially and economically viable FSM interventions in urban areas could result to faecal contamination of the soil and water sources exposing the urban population to endemic sanitation diseases such as cholera and typhoid. The effect of environmental contamination with faecal waste could be detrimental in informal settlement with poor sanitation design high toilet user capacity and filling rates. There is need for a paradigm shift in the ways of emptying, conveyance and disposal of accumulated faecal waste in urban areas which this study sought to address.

Excreta accumulation in towns and cities could be attributed to overdependence of slum dwellers on on-site sanitation facilities which have generated demand for frequent emptying to allow for access and continuous use of the facilities. Nevertheless, safety in emptying, conveyance and disposal of accumulated faecal waste has been compromised by: high population density in unplanned urban areas; poor management of accumulated faecal sludge; lack of socially and economically viable servicing technologies; limited space for servicing on-site sanitation facilities; poor quality of materials deposited in pits; poor on-site sanitation designs and the safety of pit emptying practice. Given that the factors could be

context specific, there however exist limited documentation on the effect of social economic factors on faecal emptying conveyance and disposal in informal settlements. It will therefore be necessary to examine the influence of social economic factors on emptying, conveyance and disposal in on-site sanitation technologies in low income urban areas of Meru.

1.2 Problem Statement

The global call to accelerate sanitation coverage and access across nations has culminated to substantial studies on classification of on-site sanitation systems with regards to system types and their suitability. However, linkage of these facilities to complement the sanitation service chain through hygienic, safe and improved faecal sludge containment, emptying and disposal has not been adequately traversed. The Sustainable Development Goals (SDG) agenda 6.2 guarantees every citizen access to adequate sanitation facilities with safe disposal and treatment of human excreta (United Nations, 2015). However, as towns and cities continue to grow, the existing convectional sewers cannot be the only dependent solution for dense urban areas experiencing rapid population growth due to infrastructure insufficiency and inadequate institutional and budgeting capacities (Reymond *et al.*, 2016). Onsite sanitation remain to be the only practical and preferred sanitation option for urban areas experiencing high population growth with most of the households opting for leaching pits, septic containment and pit latrines as solution to their sanitation needs (Andersson *et al.*, 2016).

Universal access to sustainable sanitation is considered the most important yet challenging Sustainable Development Goal (SDG) due to the environmental, technical and social complexity in providing safe, equitable and affordable sanitation to all citizens (Delaire *et al.*, 2020). Studies for instance by Shivendra and Ramaraju (2015) and Harada *et al.* (2016),

Chunga *et al.* (2016) found out that on-site sanitation technologies, despite being a promising solution to the poor urban population they present a challenge of excreta accumulation. This therefore requires social and economically viable solution in addressing faecal emptying, conveyance and disposal in on-site sanitation facilities. Researchers like Bancalari and Martinez (2018) impute the challenge of faecal sludge management in low-income urban areas to the shortcomings of on-site sanitation systems on their design and maintenance cost. There is limited documentation on impeding factors to onsite sanitation emptying, faecal conveyance and disposal. This study sought to examine the influence of social economic factors on faecal emptying, conveyance and disposal in on-site sanitation technologies in low- income urban areas.

1.3 Objectives

This section outlines the general and specific objectives for the study

1.3.1 General Objective

The main objective for this study was to examine the influence of social economic factors and technological suitability on faecal emptying, conveyance and disposal in Meru slums.

1.3.2 Specific Objectives

a) To examine the influence of social factors on faecal emptying, conveyance and disposal in Meru slums.
b) To establish the influence of economic factors on faecal emptying, conveyance and disposal in Meru slums.
c) To examine the influence of technological suitability on faecal emptying, conveyance and disposal in Meru slums.

1.4 **Research Questions**

The study was guided by the following questions:

a) What is the influence of social factors on faecal emptying, conveyance and disposal in Meru slums?
b) What is the influence of economic factors on faecal emptying, conveyance and disposal in Meru slums?
c) How does technological suitability influence faecal emptying, conveyance and disposal in Meru slums?

1.5 **Justification of the Study**

High population densities, unplanned settlements and overdependence on on-site sanitation technologies are the leading cause of excreta accumulation crisis in urban slums. With limited space for faecal emptying, conveyance and disposal in slums there is need for establishment of a socially and economically viable ways in managing the accumulated excreta failure to which would expose the urban population to the high risk of contracting sanitation related illnesses such as cholera and typhoid. The study findings will have a significant knowledge on social economic factors on faecal emptying, conveyance and disposal in on-site sanitation facilities in slum set up. The findings of this study could inform the government and sanitation implementers on sustainable intervention for realization of safe and hygienic faecal waste management practices.

The study could provide specific insights to non-governmental organizations (NGOs) venturing into faecal waste emptying, conveyance and disposal in low-income urban settlements with a principle focus of mitigating environmental contamination and

improvement of faecal waste disposal. The research captures a wide scope on faecal emptying, conveyance and disposal in on-site sanitation facilities which could help in generating substantial data useful in monitoring and evaluating social economical faecal sludge management indicators. Further, the study findings will be used by future researchers as a source of secondary information as they conduct their future studies.

1.6 **Limitations of the Study**

Some of the participants were illiterate to a point of not being able to understand questionnaires written in English. In such a case, the researcher translated the questions verbally into common understandable language such as Kiswahili. As well, the researcher encounter language barrier from interviewees who preferred local languages as such, an interpreter fluent in the local language was engaged.

1.7 **Delimitation of the Study**

The study was delimited to the slums of Meru and therefore urban, peri- urban and rural areas were not targeted. The focus of the study was also on slum residents using on-site sanitation technologies therefore users of other sanitation option including sewerage networks were excluded from the study.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature on faecal emptying, conveyance and disposal in on-site sanitation facilities, influence of social and economic factors on faecal emptying, conveyance and disposal as well as suitability of technologies on faecal emptying, conveyance and disposal in on-site sanitation facilities. The chapter also presents the theoretical and conceptual framework for the study.

2.2 Faecal Emptying, Conveyance and Disposal in On-site Sanitation Facilities

Onsite sanitation facilities are promising sanitation solutions for 2.7 billion people globally (Gensch, 2018). Faeces from these facilities require safe emptying, transportation and hygienic disposal to avoid exposure of the population to diarrheal-causing pathogens (Peal *et al.*, 2020). However, according to Gensch (2018) little attention is given to the ways of emptying, conveyance and disposal of faecal waste that accumulate in the facilities. In India, a study by Prasad and Ray (2019) found out that due to limited disposal sites, faeces were poorly disposed into storm water open drains. Poor disposal of faecal waste in open drains was also noted by Peal *et al.* (2020) in Sub-Saharan Africa where 14% of contents in filled up pits and septic tanks remained unemptied and overflowing to the environment. Improper handling of faeces especially in informal settlements could result in environmental contamination and the risk of interacting with helminthes. It would be necessary to enforce sanitation practices conforming to hygienic emptying, conveyance and disposal of faecal waste in order to transform informal settlements into healthy areas.

Filled up toilets can either be abandoned for new ones or emptied for reuse in response to the challenge of excreta accumulation in densely populated urban areas (Namata *et al.,* 2015). However, construction of new facilities in densely populated informal settlements could be a challenge owing to the high cost of acquiring land to provide an extra space for construction of new toilet. A study by Chunga *et al.* (2016) that examined sanitation technologies in Malawi found out that property owners were 1.8 times more likely to empty filled up toilet pits than constructing new ones due to the high cost of purchasing land for construction of new facilities.

Conveyance of accumulated faecal waste away from the point of generation in slum areas to designated disposal site is key in managing large volumes of accumulating fresh faecal waste (Lerebours *et al.,* 2021). However, if inappropriately handled could result to environmental pollution due to its high concentration of pathogens such helminthes, protozoa, bacteria and viruses. In Uganda a study by Namata *et al.* (2015) that analyzed sanitation technologies in urban areas found out that space was a limiting factor to hygienic management of accumulated faecal waste in urban setting. Similarly in Kenya, a study by Kocbek *et al.* (2020) that explored treatment of faecal sludge in slum toilet found out that the challenge of inadequate land space for emptying and conveyance of faecal sludge resulted to high expenditure on faecal emptying and transportation. The study also link the high cost of operation and maintenance of faecal sludge management service to unhygienic disposal possibilities which may predispose the public to sanitation hazards such as outbreak of diarrheal diseases. Failure to reinforce policies on hygienic emptying and conveyance methods could result to environmental pollution with sanitation related pathogens such as bacteria and virus which could cause a negative effect on the health of the public.

Intensive use of on-site sanitation technologies in urban areas provoke the need for designating faecal waste disposal sites that guarantee hygienic treatment of faecal waste. Nevertheless, indiscriminate disposal of untreated faecal waste could predispose the population to the risk of contracting sanitation related illnesses such as typhoid and cholera. However, although pit emptying was embraced in Malawi, a study by Semiyaga *et al.* (2015) established that due to inadequate faecal disposal sites in slums, faecal waste was discharged into water courses, surrounding environment and agricultural fields. Disposal of faeces in the environment could not only contribute to ground water contamination but also compromise residents' safety. An investigation into factors influencing faecal emptying, conveyance and disposal in slum on-site sanitation facilities could inform adoption of socially and economically viable faecal handling options.

2.3 Social Factors and Faecal Emptying, Disposal and Conveyance

Effective emptying of toilets requires that the facilities are accessible to allow movement of trucks to emptying and disposal sites. However, the nature of low income urban settlements limit safe and hygienic faecal waste management practice in accessing filled up sanitation containments aggravating the burden of excreta accumulation in cities and towns. As a result of high user rates in slum toilets, often the toilets require frequent emptying, however, a study by Doe *et al.* (2020) in Ghana and Malawi found out that congested slum settlements constrained accessibility to disposal areas. The study pointed out that 24.3% of the toilets remained unemptied due to poor road network. Similarly in Uganda, a study by Nantongo (2022) that explored pit latrine emptying found out that 51.18% of the slum toilets were inaccessible which affected faecal sludge emptying by mechanized means. Movement of

emptying vehicles could be compromised by impassable access routes to onsite sanitation facilities.

Highly populated settlements such as urban areas experience high filling rates of their on-site sanitation facilities due to high user capacity on the toilets. Nevertheless, unsustainable faecal sludge management practices could result to generation of unpleasant odour in the environment as a result of uncontrolled degradation of organic matter (Kocbek *et al.*, 2020). Offensive odour emanating from decomposing faecal matter may attract sanitation disease vectors such as flies and cause respiratory infections to the public. Similarly, in Ghana a study by Senanu *et al.* (2021) that analyzed faecal sludge odour control found out that insect nuisance and odour were a common challenge of on-site sanitation facilities due to poor faecal emptying conveyance and disposal in low sanitation coverage regions. Unless socially viable faecal sludge management practices are put in place residents in poor sanitation coverage areas will continue to spend the income on preventable diseases such as respiratory related infection, dysentery, and diarrheal.

Where mechanical emptying is not viable, the substitute option would be manual emptying where faeces from pit latrines are scooped using hand tools like shovels and buckets. However, manual pit emptying, though affordable, has been associated with endangering the lives of pit operators due to its unsafe nature. In India, a study by Tyagi (2017) that examined the challenges of manual emptiers established that 22,000 manual pit operators died annually as their health, dignity, living conditions and safety were neglected. Exposure of sanitation workers to health hazards associated with manual pit emptying could result in fatal calamities related to injuries or even loss of life. Apart from the risks associated with manual pit emptying, handling of faeces in some communities is considered unclean. A

study by Zaqout *et al.* (2020) in Bangladesh found out that manual pit emptiers were considered unclean and faced issues of social stigma. The study established that manual pit emptiers were regarded as dirty and were not allowed to participate in community activities. Unless policies on regulatory frameworks for faecal sludge management are instituted, emptying, conveyance and disposal of faeces in the often marginalized slums could face a persistent dilemma.

Faecal sludge management is dependent on space for construction of new toilets, motorized access to facilities and for faecal disposal. However, space in urban areas could be a challenge due to the high cost of acquiring land for construction of new facilities as well as demolishing of uncontrolled settlements to pave way for trucks to empty sanitation systems. In Uganda, a study by Namata *et al.* (2015) that examined sanitation technologies in urban areas established that the only applicable options for managing filled up toilets were either abandoning them for new ones or empting for subsequent use. However, the study indicated that when space for constructing new sanitation facilities was limited, emptying was the only practical alternative. In Malawi, a study by Chunga *et al.* (2016) that explored choices for sanitation technologies reported that property owners preferred latrine emptying 1.8 times more than construction of new toilets as a result of limited toilet re-construction space. Similarly, Capone *et al.* (2020) found out that high latrine user load exacerbated pit latrines emptying frequency and to avoid frequent desludging, residents considered huge-sized pits. Construction of huge-sized pits could be expensive especially to poor urban residents. Traditionally, covering of filled up latrines for the construction of new ones was a common way of managing human faeces. However, this practice could be unsustainable in urban

areas due to increasing population and high cost of limited land to construct new pit latrines. There is need to examine the influence of space in emptying sanitation technologies.

Pit latrines are installed for faecal sludge containment but not for disposal of household waste and trash. However, in Malawi a study by Chiposa *et al.* (2017) reported that 90% of urban dwellers using on-site sanitation facilities used the facilities for disposal of domestic waste such as stones, glasses and clothes. Disposal of undesirable materials in toilets was also reported in Zambia by Tembo *et al.* (2019) where total solid content in faecal sludge constituted 54.4 % textile, 3.1% metal, 2.2% glass and 17.9% plastics. Disposal of non-biodegradable materials in pits could not only increase pit filling rates but also affect the efficiency of emptying toilets. In Kenya, a study by Gudda *et al.* (2019) established that toilet fill up rates was high and the use of vacuum trucks was impractical due to the risk of blockage by materials in pits such as polythene, cardboards, clothes, diapers, glass and plastic bottles. Unless slum residents are enlightened on proper disposal of household waste, poor quality materials deposited in pits could continue limiting faecal emptying in on-site sanitation facilities.

In developing countries high population density pose a significant challenge in hygienic emptying, conveyance and disposal of faecal waste. Although, research findings indicate a strong relation between high population density and inadequate sanitation infrastructure in low-income urban areas (Bair *et al*., 2015), a number of studies demonstrate a correlation between toilet capacity and high population. For instance, in Uganda a study by Fuhrimann *et al*. (2016) reported a high pit latrine user rate of 650 individual sharing one toilet per day. High pit latrine user capacity in slums could overwhelm the existing on-site sanitation facilities. Similarly, in Indonesia, a study by Odagiri *et al.* (2021) that assessed on-site

sanitation emptying services reported that densely population areas registered higher rates of emptying septic tanks while low population density quartiles reported low incidences of emptying household facilities. High population densities could be a challenge in faecal waste emptying, conveyance and disposal. Failure to put in place effective excreta management service in low-income urban settlements could result to contamination of soils and surface water which accelerate the spread of pediatric enteric infections.

Improvement of faecal waste emptying, conveyance and disposal from on-site sanitation facilities is dependent on the level of awareness of the population on the impact faecal waste management practices on their health and environment. After analyzing household motivation and drivers for on-site sanitation improvement among 4407 households in Malawi Mpanang'ombe *et al.* (2021) concluded that informal urban dwellers lacked awareness and understanding of the actual drivers for on-site sanitation improvement and that safe and hygienic emptying of pits was less of a motivation to safe management of excreta in informal settlement. Similarly, a study by Odagiri *et al.* (2021) found out that in India household members had a common perception that an ideal septic tank is one which is never to be emptied. In addition, the study also highlighted that household members who adopted uncontained septic tanks lacked awareness on the potential environmental and health risks of poor sanitation designs. There was need to explore how the low-income urban population handle emptying, conveyance and disposal of faecal waste and the significance of increasing the volume of safely managed faecal waste in slums.

2.4 Economic Factors and Faecal Emptying, Disposal and Conveyance

Faecal emptying, conveyance and disposal is a practice associated with payment of servicing fees for effective management of accumulated waste in on-site sanitation systems. However,

operational cost could be influenced by the type of sanitation design and quality of material deposited in pits informing the emptying technology to be adopted. While analyzing socio-economic characteristics of low-income urban population in Malawi, Chunga *et al.* (2016) found out that 93% of respondents owned unimproved on-site sanitation facilities. Unimproved sanitation facilities could limit mechanized emptying options since the facilities do not have provisions for emptying leaving the poor urban population with the option of manual pit emptying. Although operation cost defines household choices of managing the accumulated excreta nevertheless, Jenkins *et al.* (2015) and Simiyu, Chumo and Mberu (2021) found out that unimproved sanitation facilities elicited high cost of operation which was inclusive of the cost of emptying the pit and the maintenance cost of repairing the concrete slab demolished during emptying process estimated to be $35- $57. Unless the poor urban population adopt improved sanitation facilities operational cost of faecal emptying, conveyance and disposal could be unaffordable resulting to unhygienic disposal of faecal waste in slums which could have a negative effect on the slum population

Economic status of individuals calibrated as a combination of a person's level of education, occupation and income influence households choices of sanitation facilities and emptying technologies. However, the practice of hygienic emptying, conveyance and disposal of faecal waste in low-income urban areas is facing numerous challenges affiliated to the ability and willingness to pay for sanitation services. A study by Chunga *et al.* (2016) that analyzed socio- economic characteristics of population in Malawi on access to sanitation facilities found out that 93% of respondents earning a low income of K 10,000- K40,000 owned unimproved sanitation facilities since they could not afford to pay for improved sanitation facilities construction materials. Nevertheless, researchers like Holm *et al.* (2015)

reported that besides the type of sanitation facilities adopted by household owners, the study reported that in Zambia 50% of the respondents were willing to pay for on-site sanitation service. Furthermore, reseachers like Orner and Mihelcic (2018) found out that whereas mechanized pit emptying remain to be the most hygienic option of faecal waste management manual pit emptying practice was common among poor urban dwellers despite the associated health and environmental risk. There is need for economically viable faecal emptying, conveyance and disposal choices that will ensure sanitation efforts in low income settlements geared towards safe and hygienic collection and disposal of faecal waste do not shoot beyond the range that on-site sanitation facilities slum owners and users are able to pay.

On-site sanitation infrastructure is predominantly installed to guarantee safe containment of faecal waste preventing human contact with excreta and environmental protection from pathogenic contamination (McConville *et al.,* 2022). However, in poor urban settlements poorly designed on-site sanitation systems could be a limitation to hygienic faecal sludge management interventions. In Uganda a study by Zzwa *et al.* (2016) reported that sanitation system with no brick linning support in the substructure reported high filling rates and were prone to collapse. The study also found out that poor toilet designs which do not feature manholes for accessing pits during emptying influenced accumulation of faecal waste in pits and abandonment of filled toilets. Poor designs of on-site sanitation facilities could limit hygienic and safe pit emptying services in low-income urban areas as a result elevating the burden of faecal sludge accumulation in cities and towns.

High demand for on-site sanitation facilities in low-income urban areas has resulted in ratification of onsite sanitation emptying services as an alternative to management of

accumulated faecal sludge (Awere *et al.*, 2020). However, researchers like Tembo *et al.* (2019) found out that the use of pit latrine for domestic waste disposal site of material such as clothes, broken glasses and plastics influenced the filling rate of toilets resulting to high frequency of emptying sanitation facilities. A study by Parikh, Forte *et al.* (2016) while accessing the necessity of faecal sludge management services in Sierra Leone found out that most of the low- income urban household desludged their toilets more frequently with an equal spilt on manual and mechanized pit emptying technologies. Similarly a study by Jenkins *et al*. (2015) that explored the demand and pit latrine emptying behaviors in Tanzania reported that pit emptying frequencies were high during rainy season as a result of poorly constructed on-site sanitation systems that flood and in some scenarios overflow in the environment. High frequency of emptying toilets could be influenced by high user capacity, poor sanitation design and poor quality of material deposited in the pits. Unless the poor urban population embrace hygienic faecal emptying practice high frequency of toilet empty could result to contamination of soils and water sources with sanitation related pathogens which may cause an outbreak of diarrheal diseases to the urban population.

Management of accumulating faecal waste in low –income urban areas is dependent on space availability for emptying, conveyance and disposal of faecal waste. However, as urban areas continue to develop the value of land is appreciating at a high rate ruling out the probability of the poor urban population to acquire extra land for faecal management when toilets get filled up. In India, a study by Prasad and Ray, 2019 found out that emptying of a full pit was estimated to be $25 to $80 however, urban dwellers who consider putting up new facilities pay 10 time more than the cost of servicing existing toilets. Limited land space often rule out the option of excavation and new toilet construction among poor urban

household owners. Researchers like Chunga *et al.* (2016) highlight high population density in informal settlement as the leading cause of excreta accumulation. Poor urban settlements are characterized by closely confined household set up and often vacuum trucks cannot find their way through narrow streets and this requires either demolishing of the settlement to pave way for trucks or adoption of manual emptying practice. In Malawi a study by Chipeta, Holm, Kamanula and Mtonga (2017) found out that sanitation facilities in unplanned poor urban settlement were inaccessible compelling the poor urban household owners to rely on manual pit emptying for management of faecal waste. Limited access to pits for emptying could be a leading cause of unhygienic and unsafe manual pit emptying practices that predispose the poor urban population to the risk of diarrheal infection.

2.5 Technological Suitability and Faecal Emptying, Disposal and Conveyance

Hygienic servicing uses equipment capable of limiting direct human exposure to excreta. The commonly used servicing options include manual emptying which involves simple hand tools like shovels and buckets to scoop faeces from pits and motorized emptying where excreta is sucked using vacuum pumps into tanks mounted on trucks. Access to affordable faecal management options and services is becoming dire owing to the differing financial implication of each option as towns and cities continue to densify. In India, a study by Prasad and Ray (2019) found out that the high toilet servicing fee of $25 to $80 imposed by the service providers encouraged the poor urban population to dispose faeces in open drains. Similarly in Malawi, among the barriers to toilet servicing included cost constrains which compelled residents to unhygienically dispose of untreated excreta into the environment (Chunga *et al.*, 2016). Untreated excreta have a pollution effect to the environment and could expose residents to diseases. As towns gear towards achieving hygienic servicing

sanitation systems, it is vital that a balance between money, the flow of human excreta and labour is attained. This study therefore sought to find out the influence of operation cost in actualizing faecal sludge management (FSM) practice in urban areas.

The unpredictable nature of on-site sanitation facilities in poor urban settlement informs the need for a suitable faecal emptying, conveyance and disposal technologies that address the challenges of on-site sanitation facilities. Nevertheless, both mechanical and manual pit emptying technologies present their limitation ways of faecal waste management. A study by Thye *et al.* (2011) that analyzed servicing technologies in developing countries found out that vacuum tankers had the ability to exhauste sludge from deep pits with maximum height of 2 to 3 meters hence their suitability in emptying deep pits and septic tanks in urban areas. However, poor quality of material deposits in pits including plastics, glass, stones, metals and cloths compromise the effectiveness of vacuum pumps in handling faecal sludge by blocking and damaging the pumps (Chiposa *et al.*, 2017). Beyond the cost of emptying services, availability and the ability of pit emptying technologies to remove the accumulated pit content is a vital determinant of the type of pit emptying technological options in urban areas (Jenkins *et al.*, 2015). Therefore the inability of vacuum pumps to effectively deal with the challenge of urban pit contents could limit mechanized pit emptying service provision in urban areas for fear of high cost of operation and maintenance of machines. Nevertheless use of vacuum tankers has demonstrated high level of efficiency in emptying of on-site containments in comparison to manual emptying technologies. A study by Greene *et al.* (2021) that explored faecal sludge management practices in Low Middle Income Countries (LMICs) found out that mechanized pit emptying technologies accelerated speed and

enhanced the safety of emptying process which was significant in upholding safe and hygienic faecal sludge management practices across the supply chain.

Guarantee of safety to users and pit operators is key in establishing a hygienic and sustainable faecal sludge management practice. However, pit emptying practices has deprived pit operators of their health and dignity due to the unhygienic nature of the practice. A study by Capone *et al.* (2020) that explored pit latrine emptying practices in Mozambique found out that manual pit emptying technologies was discouraged and pronounced illegal in most developed and developing countries due to its unhygienic nature where excreta is inevitably spilled in the environment during pit emptying process. Manual pit emptying technology could expose the faecal handlers to the risk of helminthes infection owing to the pathogenic state of faecal sludge which may contain helminthes species such as *Taenia spp, Ascaris and Trichuris* (Hawkins & Muxímpua, 2015). Manual pit emptying operators have often been exposed to the risk of injury health complication and loss of life to on-site containments dipper than 1.5 meters which require pit emptiers to enter the pits. Where on-site pit are an alternative for disposal of domestic waste glass and metal may cause injury to the pit emptyiers as they exhausted the pits (Tembo *et al.*, 2019).

In Tanzania, a study by Jenkins *et al.* (2015) that explored pit latrine emptying technologies found out that the process of manual empting of filled pits takes between 2 to 7 days and for poor sanitation design which require destroying of slab during emptying the hole is left open, at this point access to sanitation facility is limited and the users were also predisposed to the risk of injury and falling into pits. Unless the population adopts socially and economically viable servicing technologies, faecal waste emptying, conveyance and disposal

in slums could be a source of soil and ground water contamination. There was need to explore suitability of emptying technologies in servicing on-site sanitation technologies.

2.6 Theoretical Framework

The study was guided by the theory of Integrated Behavioral Model for Water, Sanitation, and Hygiene (IBM-WASH) interventions.

2.6.1 Integrated Behavioral Model for Water, Sanitation and Hygiene (IBM-WASH) Intervention

Integrated Behavioral Model for Water, Sanitation, and Hygiene (IBM-WASH) interventions is a theoretical model developed by Dreibelbis *et al.* (2013) to interpret water sanitation and hygiene interventions in their underlying behaviors. The model recognize the three ambits of water, sanitation and hygiene related behavior's including psychosocial, contextual and technological factors in five isolate proportions of behavior: structural, community, interpersonal, habitual and individual.

The contextual ambit encompasses determinants attributed to the individual's environment and setting that has an influence on a person's behavior in adoption of sanitation technologies. The psychosocial ambit includes the psychological behavioral and social determinants that influence technology uptake and behavioral outcomes. The technological ambit comprises attributes of a product or technology that affect the adoption and use of the product.

For the five aggregate levels, the social level refers to the vast institutional, organizational or cultural factors influencing individual behavior in the three ambits. The community level refers to the social and physical environment that an individual inhabits along with the

institutions that molds an individual experiences. The Interpersonal/ Household level exhibit interaction between people. Factors such as household wealth, norms and household responsibilities are included at this level. The individual level represents sociodemographic factors like gender, age, cognitive factors and attitude to technology and products. Habitual is the final level of the model that focus on the individual with an assumption that individual's behavior are repeated and a continuation of the process yield behavioral outcomes that influence adoption of Water, Sanitation and Hygiene (WASH) related products.

The Integrated Behavioral Model for Water, Sanitation, and Hygiene (IBM-WASH) interventions theoretical model was preferred for the study by reason of its ability to construe behavior in diverse context at the societal, community and household level unlike other models that describe behavior specific at individual level. The three interacting ambits of the Integrated Behavioral Model for Water, Sanitation, and Hygiene (IBM-WASH) interventions models are entrenched on the notion of reciprocal determinism elaborated in the social cognitive theory. The psychosocial ambits describe behavioral, psychosocial and social factors that are susceptible to the intervention. The contextual ambit describes characteristics of environment, the individual and setting that go beyond the compass of behavioral intervention. Technological ambits explore practices and behaviors affiliated to Water Sanitation and Hygiene (WASH) technologies in extension the model elaborated sustainability in the use and maintenance of sanitation facilities.

2.7 Conceptual Framework

The study focused on conceptualized relationship between socio-economic factors and servicing of onsite sanitation facilities in urban areas. The framework presents a perceive

relationship between suitability of servicing technologies, social and economic factors as the independent variable and servicing of on-site sanitation technologies as the dependent variable. The framework also highlights government policy, subsidization of servicing cost, advocacy, training and budget allocation as the moderating factors in the study. Below is a conceptual framework highlighting moderating variables and illustrating the relationship between independent and dependent variables.

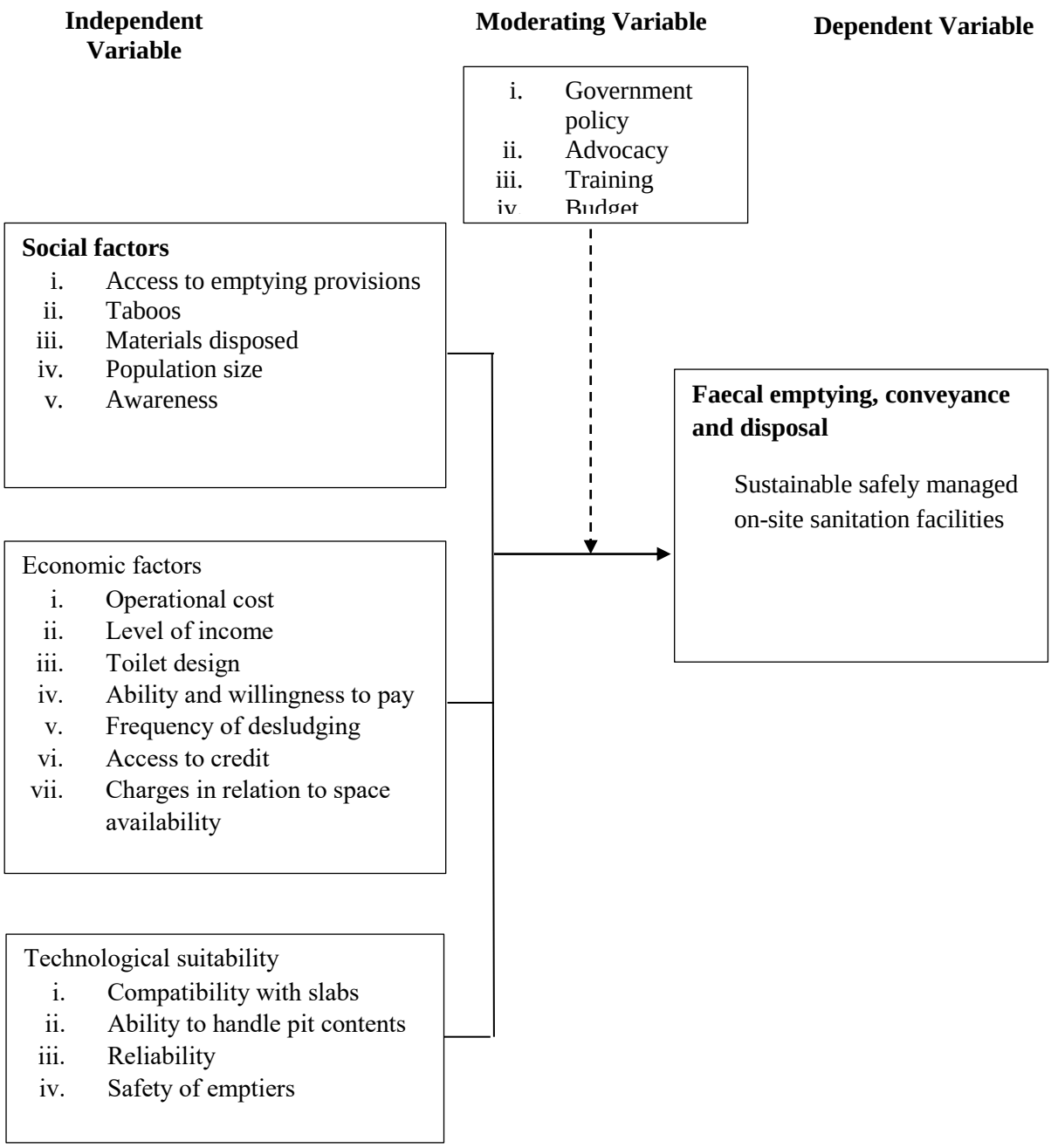

Figure 2.1 Conceptual Framework

CHAPTER THREE

3.0 METHODOLOGY

3.1 Introduction

This chapter presents the methods that were adopted in the study. It outlines the study design, study location, target population, sample size determination, sampling techniques, and methods of collecting and analyzing data. As well, the validity and reliability of data collection instruments is explained.

3.2 Research Design

This study adopted a convergent mixed method research design which enabled simultaneous gathering of both qualitative and quantitative data. Convergent mixed method was preferred due to its ability to generate insights and obtain in-depth information and knowledge of the problem which qualitative or quantitative research tools cannot produce on their own (Talwar *et al.,* 2021). Convergent mixed methods design was adopted by nature of its reliability and flexibility in enhancing innovative research approaches in examining contemporary health challenges in communities (Moseholm & Fetters, 2017). Integration of quantitative and qualitative research methodology significantly enhanced the quality of obtained data in the study.

3.3 Study Area

The study was carried out in the 3 slums of Meru which include Mjini, Majengo and Shauri Yako. The study area is located in the Eastern region of Kenya in Imenti North Sub- County boardering Laikipia County to the West, Tharaka-Nithi County to the East, Nyeri County to the South West and Isiolo County to the North (Ombuya *et al.,* 2022). The study area is

characterized by high population density, unplanned semi-permanent settlements with narrow pathways, poor sanitation facilities designs with no provision for accumulated faecal waste access for desludging. Manual pit emptying is the most common form of removing faecal waste from the toilets and often excreta is realized in open drains and the environment as a result of unhygienic faecal emptying, conveyance and disposal in on-site sanitation facilities.

3.4 Study Population

The total population for the slums is 2,591 people and total number of households is 569 (KNBS, 2019). The study targeted household heads from households within the slums since they were likely to possess in depth desired information concerning sanitation for their households.

Table 3.1 Distribution of Household per Slum

Slum	Total Population	No. of Households
Mjini	351	169
Majengo	1540	250
Shauri Yako	700	150
Total	**2591**	**569**

KNBS (2019) census data

Further, the study targeted seven (7) pit operators as they were the people involved in maintenance of the sewerage systems as well as emptying pit latrines and (5) household heads as Focus Group Discussion (FGD) participants. Also targeted was a Public Health Officer (PHO) as a Key Informant Interview (KII) participant since he had knowledge and experience on urban community sanitation issues. The target population is as shown in Table 3.2.

Table 3.2 Target Population

	FGD & KII	Total Population
Household heads		569
Focus group discussion participants		
Pit Operators	7	
Household heads	5	
Key Informant Interview		
Public Health Office	1	
Total	**13**	**569**

3.5 Inclusion and Exclusion Criteria

The study included household heads 18 years and above, residing in the three slums of Meru who were willing to participate in the study. Slum residents who were not willing to take part in the study were exempted from the study. Non-slum residents were not targeted.

3.6 Sample Size Determination

The sample size was calculated using Yamane's (1967) formula as illustrated.

$$n = \frac{N}{1+Ne^2} = \frac{569}{1+577*0.05^2} \approx 235 \qquad (3.1)$$

Where n is the size of sample

N is the size of the target population size

e is the error term, taken at 5%

The sample size for the study was therefore 235, which was proportionately distributed among the different strata. That is, the household heads, the pit operators, and public health officer. The distribution is shown in Table 3.3.

Table 3.3 Sample Distribution

	Target Population	Sample Size
Household heads	569	235
Focus group discussion participants		
Pit Operators	7	7
Household heads	5	5
Key Informant Interview		
Public Health Officer	1	1
Total	**582**	**248**

3.7 Sampling Techniques

The study employed cluster sampling technique to classify the area into its three clusters of its respective slums namely Mjini, Majengo and Shauri Yako. Simple random technique was employed in selecting household heads from the households within the clusters. The technique ensured that each person stands an equal chance of being selected. Given the unequal distribution of households per strata, the researcher obtained participants from every cluster by dividing the product of population per stratum and the total sample by the total number of households as illustrated in Table 3.4.

Table 3.4 Cluster Distribution

Strata	Households	Sample per stratum
Mjini	169	70
Majengo	250	103
Shauri Yako	150	62
Total	**569**	**235**

Purposive sampling technique was used to select the eight (12) focus group discussion interviewees who included seven (7) pit operators, (5) household heads. The focus group

participants were considered for the study because they were believed to possess specific knowledge, experience and skills on sanitation issues for the slums. The Public Health Officer (PHO) was targeted for the Key Informant Interview (KII).

3.8 Data Collection

Quantitative data was collected using structured questionnaires which were distributed to household head at the household level. Structured questionnaires reduce the thinking load of respondents (Theodore, 2020). Questionnaires were structured to capture information on demographic, social, economic factors and technological suitability of household respondents. Observation checklist was also used alongside questionnaires for validation of emptying, conveyance and disposal practices.

Interview guides were prepared to collect data from focus group discussion members, who in this case were pit operators and household heads.

3.8.1 Pilot Study

It was necessary to pre-test the research instruments before the actual study. According to Hilton (2017), pilot studies reveal weaknesses of research instruments at an earlier stage before the actual study. Researchers like Grum *et al.* (2017) suggested that pre-testing is conducted using 10% of the sample. Questionnaires were distributed among 24 participants during the pilot study which was conducted in Nkubu slums. The validity and reliability of the instruments was then tested.

3.8.2 Validity of Research Instruments

Validity of data collection instruments is defined as the degree to which the interpretations of study results are acceptable (Mohajan, 2017). Validation of data collection instruments is

key in mitigating error in data collection instrument. Validity of the instruments was obtained through a pilot study. Responses from the pilot study were captured to warrant content validity. Content validity determination should involve an expert in the study topic. The researcher consulted 4 sanitation experts and 2 supervisors who were well grounded in sanitation and data analysis to ascertain the validity of research instruments. The instruments were found to be able to measure what they were designed for and could represent the true findings desired for the study.

3.8.3 Reliability of Research Instruments

The researcher used Cronbach's Alpha test to ascertain the reliability of data collection instrument and result presented in Table 3.5

Table 3.5 Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No. of Items
.841	.858	18

A coefficient of 0.858 was found, and according to Mugenda (2008), a coefficient of more than 0.8 is considered good, hence the variables were taken as reliable. To ascertain reliability of data collecting tools triangulation was also adopted to demonstrate the consistency and accuracy of structured study questions where the study questions were administered in different perspectives with the aim of getting a common answer.

3.9 Data Analysis

Quantitative data was analyzed in descriptive and inferential statistics using Statistical Package for Social Sciences (SPSS version .20.0). The descriptive statistics were presented

inform of frequencies, percentages, means and standard deviation and was presented in bar graphs and tables. Correlation and regression analysis was also done to show relationship between variables. Qualitative data from focus group discussion was analyzed thematically and results were presented verbatim.

3.10 Ethical Considerations

Permission to carry out the study was sought from Meru University of Science and Technology (MUST) Institutional Research Ethics Review Committee (MIRERC). Further the researcher sought ethical approval from the National Commission for Science, Technology and Innovation (NACOSTI). The researcher also obtained permission from relevant authorities like the Ministry of Health (MoH). Participation of the respondents in the study was on voluntary basis and the respondents were required to sign a consent form before participating in the study. The study ensured anonymity of respondents to uphold confidentiality of information provided by the participants.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1. Introduction

This chapter presents the results of the data analysis, which was done with a view of achieving the research objective. It begins with the rate of return of the questionnaires, then presents the demographic data of the respondents, and finally the results of the descriptive and inferential analysis carried out on the association between social economic factors and technological suitability on faecal emptying, conveyance and disposal.

4.2. Questionnaire Response Rate

The researcher issued a total of 235 structured questionnaires to the household heads out of which 228 returned fully filled making the return rate to be 97%. The full return rate was achieved because the researcher self-administered the questionnaires and provided clear explanations to the respondents about the research objectives which made the participants to complete the questionnaires accurately.

4.3. Demographic Information

This section presents respondents' background data such as age, gender, education level, and religion and employment status. It was necessary to establish participants' background characteristics because faecal emptying, conveyance and disposal could be dependent on the demographic parameters. By studying the patterns and trends of households the findings could provide insights into social economic and technological suitability factors influencing emptying, conveyance and disposal of faeces at the household level.

4.3.1. Age of Respondents

Information regarding the age of the respondents was collected and the findings were as shown in Table 4.1.

Table 4. 1 Age of Respondents

	Frequency	Percent
18 - 30 years	36	15.8
31 - 40 years	65	28.5
41 - 50 years	80	35.1
Above 50 years	47	20.6
Total	**228**	**100.0**

From the findings, most (35.1%) respondents were in the age between 41 – 50 years, followed by 28.5% who were aged between 31-40 years while 20.6% of participants aged above 50 years. Household heads between 18 and 30 years were only 15.8%. The findings showed that majority of the households were headed by people aged above 30 years which was the age of active childbearing and establishment of families as confirmed in America by Lundberg *et al.* (2016).

4.3.2. Gender of Respondents

Data on the gender of the respondents was collected and the results were as shown in Table 4.2.

Table 4. 2 Gender of Respondents

	Frequency	Percent
Male	127	55.7
Female	101	44.3
Total	**228**	**100.0**

From the findings, majority of the households were headed by males (55.7%). The findings suggested that male respondents dominated in household headship which showed that they were the primary decision makers and oversaw resource allocation and family wellbeing. Women household head (44.3%) could have influence sanitation decision making at the household level to address the needs of women and children in regard to hygienic faecal waste management. The results were similar to those reported in India by Ashraf *et al.* (2022) who found out that while the demand for toilets was mostly driven by women, failure to involve women in decision making on the type of toilets to be adopted at the household lead to construction of toilets in far distances that made women to strain while accessing sanitation services particularly at night. Failure to involve women in household sanitation decisions could facilitate poor excreta disposal practices due to the adoption of gender non-neutral sanitation facilities.

4.3.3. Education Level of Respondents

Information regarding the highest education level attained by the respondents was collected and the findings were as shown outlined in Table 4.3.

Table 4. 3: Education Level of Respondents

	Frequency	**Percent**
Not been to school	19	8.3
Primary school	116	50.9
Secondary school	70	30.7
Post-secondary school	23	10.1
Total	**228**	**100.0**

The results in Table 4.3 revealed that more than 90% of participants had obtained at least elementary education and only 8.3% had never been to school. The implication of the

findings was that majority of the participants were literate and could have been aware of the essence of proper emptying, conveyance and disposal of faeces in relation to prevention sanitation-related diseases. These findings were similar to the findings in Indonesia by Agestika *et al*. (2022) who confirmed the importance of formal education attainment towards peoples' practices of excreta management. Literacy level could have an effect on respondents' sanitation choices, in addition, management of sanitation facilities as well as promote safe emptying and transportation of sludge to designated site. The findings also implied that respondents in the study area could be able to make informed choices in regard to hygienic faecal emptying conveyance and disposal since they could be aware of the impact of poor faecal waste management to the health of the public.

4.3.4. Religion of Respondents

Table 4.4 shows the responses obtained on participants' religion.

Table 4.4: Religion of Respondents

	Frequency	**Percent**
Christian	87	38.2
Hindu	0	0
Muslim	141	61.8
No religion	0	0
Total	**228**	**100.0**

Results in Table 4.4 show that Islam was the predominant religion (61.8%) while Christians accounted for only 38.2% of the participants. Religious practices have a significant effect on the adoption of different types of anal cleansing material (Kalumbi *et al.*, 2020) which could

affect the quality of materials deposited in latrine pits and the type of toilets adopted. The findings were supported in the focus group discussion where a member said:

> *"We Muslims construct toilets that are friendly to use, those that can support the use of water for anal cleansing."*

4.3.5. Respondents' Level of Income

The level of income for respondents was sought in Kenya shillings and the results were as outlined in Table. 4.5.

Table 4.5: Level of income in Kenya shillings (Ksh)

	Frequency	**Percent**
Above 40,000	35	15.4
26,000- 40,000	1	0.4
11,000- 25,000	78	34.2
Below 10,000	114	50.0
Total	**228**	**100.0**

Results as indicated in Table 4.5 show that 50% of the participants earned below KSh. 10,000, followed by 34.2% whose income was KSh. 11,000- 25,000, then 15.4% who earned above KSh. 40,000 while the least (0.4%) earned KSh. 26,000-40,000. This was associated with the fact that emptying a pit latrine manually would cost KSh 6,000 and mechanical emptying which was approximated at KSh 15,000 (Peletz *et al., 2020*). When compared with the average household level of income the available faecal emptying services are deemed unaffordable. Findings suggested that half of the residents earned below KSh. 10,000 followed by 34% who earned KSh. 11,000- 25,000, such earnings cannot be relied upon to pay for the cost associated with faecal emptying, conveyance and disposal. The high

rate of unemployment among household heads has been associated with type of sanitation facility design adopted and the ability to pay for sanitation services such as pit emptying as confirmed in Malawi by Chunga *et al.* (2016).

4.3.6. Respondents' Household size

Table 4.6 shows the responses obtained on participants' household size.

Table 4.6: Household size

	Frequency	**Percent**
0-4	42	18.4
5-9	126	55.3
10-14	47	20.6
Above 15	13	5.7
Total	**228**	**100.0**

The findings in Table 4.6 show that many (55.3%) of the household had a population of 5-9 followed by 20.6% who had 10-14 members, 18.4% who had 0-4 members while only 5.7% had a population size of above 15 members. The findings implied that the slum population had an average household size of 5-9 members suggesting an average user capacity on the available sanitation facilities in the study area. The findings suggest that household members in the study area had young families and the implication of this could be household members could strain in accessing available toilet services. Strained access to sanitation facilities due to high user capacity could disadvantage mostly women and children due to longer duration taken by women and children in accessing sanitation services this could lead to unhygienic sanitation practices. The fact that most of the households constituted more than five members suggested that household especially women could have used the toilet for disposal

of waste such as dippers in pit resulting to high filling rate of toilets which is associated with high cost and complication of emptying toilets. The findings were similar to those reported in Zambia by Tembo *et al.* (2019) who found out that households dumped solid material such as plastics and textiles which compromised the efficiency of emptying toilets. Nevertheless, the 20.6% of the study population having high population size could be exposed to the risk of unhygienic disposal of faecal waste due to limited access toilet facilities. Unhygienic disposal of faecal waste in the soils could expose the slum population to the risk of diarrheal diseases such as cholera.

4.4. Descriptive Statistics

In this section, descriptive statistics for the dependent variable (faecal emptying, conveyance and disposal) and the independent variables (social and economic factors and technological suitability) are presented in percentages, frequencies, mean and standard deviation.

Introduction, Faecal Emptying, Conveyance, and Disposal

The study sought to establish the options and practices of faecal emptying which involved manual and mechanized empting, conveyance which included transportation of faecal waste from on-site sanitation facilities and disposal of faecal waste in designated disposal sites.

4.4.1. Faecal Emptying

The researcher assessed the type sanitation facilities, toilet slab, superstructure anal cleansing methods, emptying frequency and methods.

i. Type of Toilet

The researcher examined the type and status of sanitation facilities available in the study area to ascertain the feasibility of emptying and the findings were as shown in Table 4.7 and figure 4.1 respectively.

Table 4.7: Toilet facility used by Households

	Frequency	**Percent**
Basic pit latrine (Ordinary latrine)	191	83.8
Flush toilet	17	7.5
VIP (Toilet with a ventilation pipe)	20	8.8
Total	**228**	**100.0**

Findings in Table 4.7 show that basic pit latrines were the most adopted sanitation facilities at 83.8%. Other sanitation solutions included Ventilated Improved Pit (VIP) latrines (8.8%) and flush toilets (7.5%). The widespread adoption of basic pit latrines could be attributed to the fact that the cost of construction and maintenance is low and the slum dwellers could not afford other sanitation options. The high cost of constructing toilets in slums could result to sharing of sanitation facilities within the study area which could have resulted to high filling rates of toilets in slums. The results were similar to the findings in Ethiopia by Novotný *et al*. (2022) who reported the predominant use of basic pit latrines due to the low cost associated with construction of such facilities. The use of flush toilets was adopted by few (7.5%) because it required water for maintenance which was often scarce in the slums thus low consideration of the solution in the study area. Such toilets belong to the landlords who have the privilege of adequate water supply at the household level. The findings were supported by findings from the focus group discussions where a member argued that:

"In my area most of us use pit latrines, the other type of toilets are very expensive to build and maintain so most of us dig pits and construct simple structures. There are some people who have money and water in their households so they use the flush toilets. Water in the homestead is only available in few households that belong to the landlords"

ii. Status of Pit Latrine

The status of toilets was assessed to check the presence of odour, flies, provision of manholes for emptying, height of pit contents from the slab and open defecation cases as demonstrated in Figure 4.1.

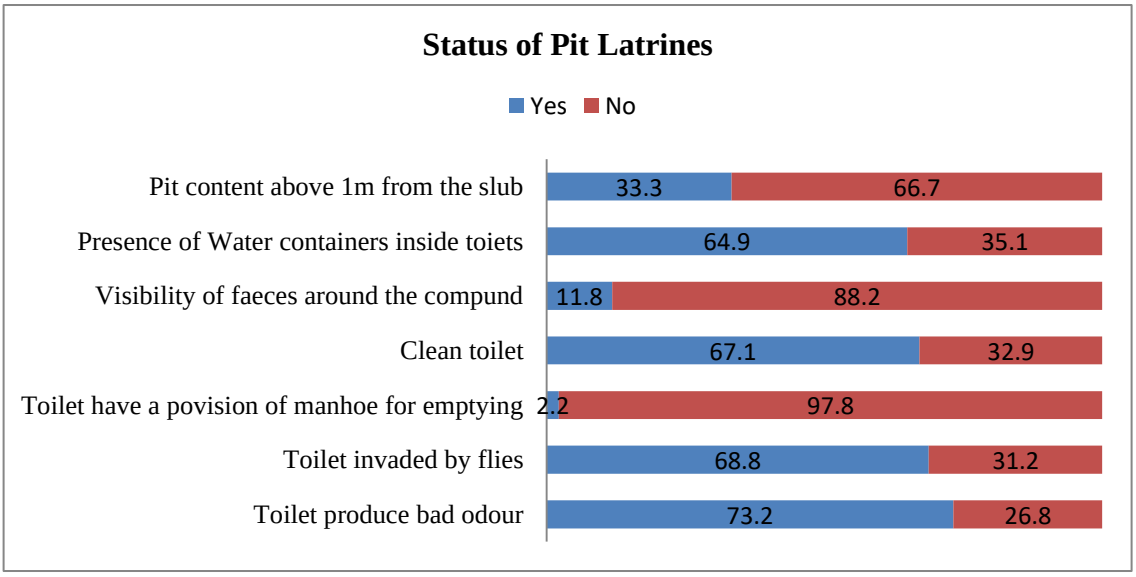

Figure 4. 1 Latrine status

As shown in figure 4.1 it was established that majority (73.2%) of the toilets had bad odour and that 68.8% were inhabited by flies. The high prevalence of odor and flies in toilets indicated that majority of the toilets were not regularly cleaned which could be attributed to inadequate water supply in the study area. The presence of flies in the slum toilets could

predispose the slum population to sanitation related diseases such as diarrhea transmitted by disease vectors such as flies. Almost all (97.8%) latrines provided in the slums lacked provision of open aperture on the slab for emptying and 33.3% of the latrines had pit content above one meter from the slab. Presence of toilets with pit content visible above one meter suggested that some of the toilets (33.3%) were full and alternatives such as emptying of pits or burying of the toilets could be a solution to the challenge of accumulating excreta in the slums. Similar observations were made in Malawi by Chunga *et al.* (2016) who established that urban dwellers used toilets characterized by odour and flies in toilets because they could not afford costs associated with emptying of toilets. Results also suggested that toilets provided in the slums could not be easily emptied because of absence of utility access holes for emptying which could be associated to limited access to pit contents and collapsing of the pits during emptying. The fact that toilets could not be easily accessible for emptying was also supported in the focus group discussions as follows:

> *"It is essential that the latrines to be emptied are constructed to allow for access of the pit by pit emptying service providers. It can be difficult to remove the pit contents from latrines that lack removal holes."*

The result show that 64.9% of the toilets had water storage containers implying that respondents in the study area were Muslim anal washers and that they preferred the use of water as opposed to the use of other materials for anal cleaning. The findings were confirmed in Panama by Naughton *et al.* (2018) who reported that Muslims used water for anal cleansing. The findings that some households (12%), although few, had human faeces around the compounds could be attributed to avoidance of the available toilets due to their unmaintained status resulting to unfriendly toilets infested with flies, odour and visible pit

content that discourage the slum population from using the toilets. Poorly maintained toilets as a contributing factor to open defecation was reported by Busienei *et al.* (2019) in a similar study conducted in Kenya.

iii. Type of Toilet Slab

Further, the status of toilets was also evaluated to check the material used in construction of toilets slabs as illustrated in Figure 4.2.

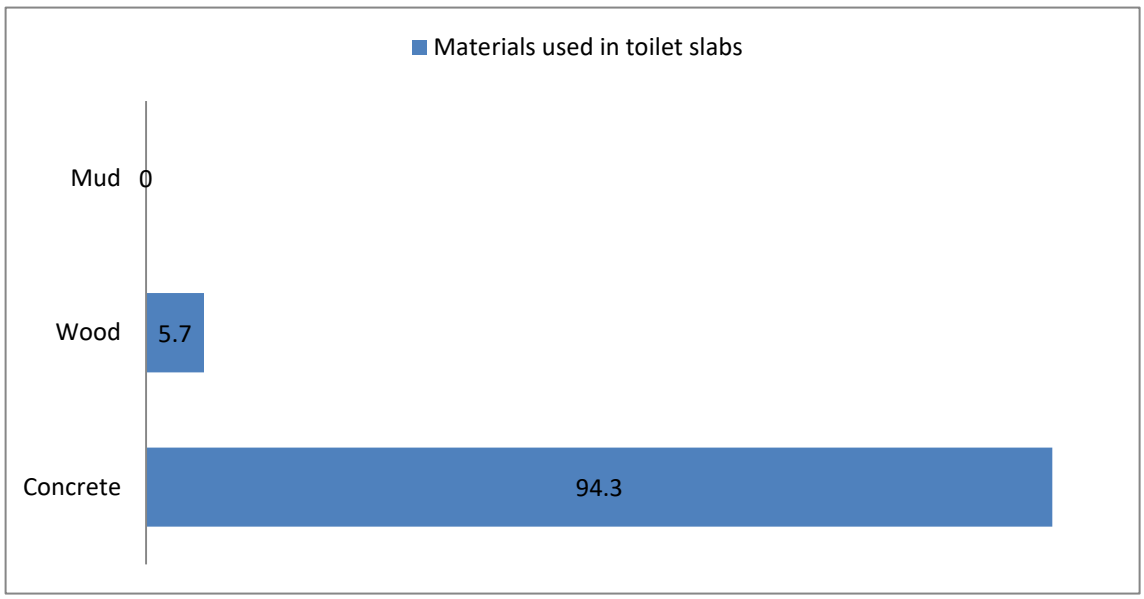

Figure 4. 2 Materials used in toilet slabs

Findings in figure 4.2 showed that majority (94.3%) of the toilets had slabs made of concrete while only 5.7% of the slabs were made of wood. The fact that majority of the respondents adopted toilets made of concrete slabs suggested that participants in the study areas were aware of the benefits of using concrete slabs which guaranteed easy cleaning and minimum maintenance of the toilet in regard to prevention from sanitation related infections such as diarrhea. However, despite the awareness on the benefits of concrete slabs participants were not informed on the ideal design of an improved toilet slab that featured an open aparture for

emptying of pit contents as revealed in figure 4.1 where 97.8% of latrines in the slums lacked provision of open aperture on the slab for emptying. The results were similar to the findings in India by Odagiri *et al.* (2021) who found out that households were not well informed on the implication of the type of toilet designs they used. Failure of households to adopt sanitation facilities that allow for hygienic emptying of faecal waste could limit emptying of pit contents when toilets fill up promoting the breeding of flies in field up toilets which could result to interaction of the slum population with faecal waste. Interaction of the slum population with faecal waste could result to the outbreak of diarrheal diseases such as cholera.

iv. Type of Superstructure

The status of toilets in the study area was also assessed to check the materials used in construction of toilet superstructures as illustrated in Figure 4.3.

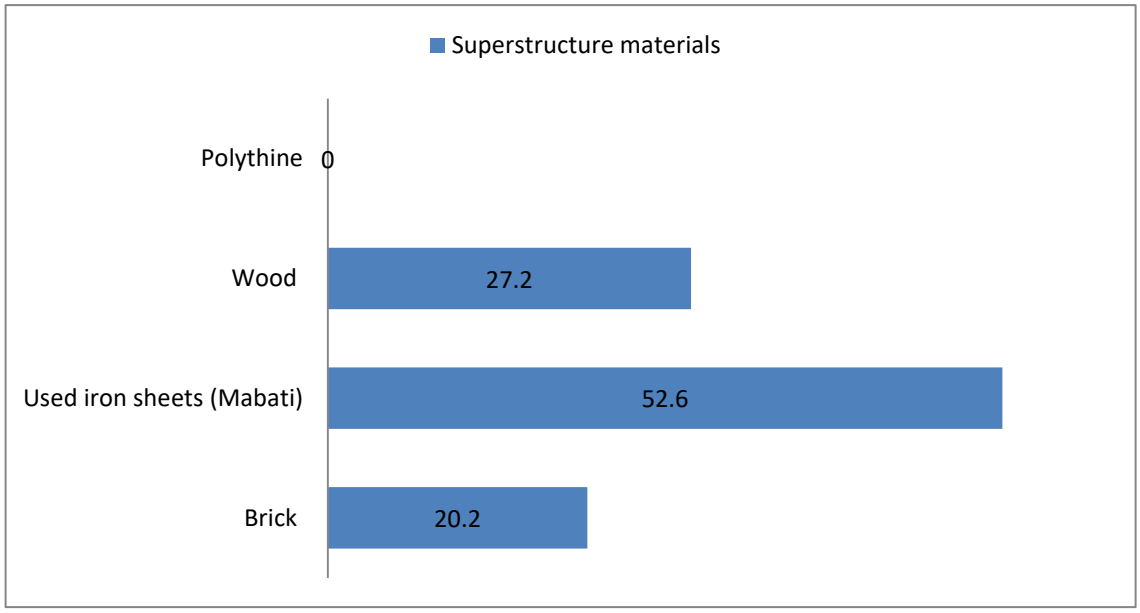

Figure 4. 3 Superstucture materials

As shown in figure 4.3 it was revealed that majority (52.6%) of the toilets' superstructures

were made of used iron sheets (mabati) and 27.2% had superstructures made of wood while only 20.2% were constructed using bricks. The use of poor quality materials such as used iron sheet and wood by the slum population for construction of toilets superstructures suggested that the slum population could not meet the cost of constructing improved sanitation facilities which guaranteed safety of users and minimal contacts of users with human excreta. The results were confirmed in Malawi by Chunga *et al.* (2016) who reported that the wide adoption of unimproved on-site sanitation facilities in urban settlements was as a result of low income earned by household. Failure of slum residents to meet the cost of sanitation services could limit their ability to pay for faecal emptying conveyance and disposal service as a result elevating the burden of accumulated excreta in unplanned low-income urban settlements.

v. Faecal Emptying Frequency

Table 4.8: Have you ever emptied your toilet

	Frequency	**Percent**
No	158	69.3
Yes	70	30.7
Total	**228**	**100.0**

The respondents were asked to indicate whether they had emptied their toilets. The results in table 4.8 show that only 30.7% of the respondents had emptied their toilets before. This could imply that either their toilets are new and yet to fill-up for those who indicated no, or they resort to digging another toilet or even share with others once theirs is filled up.

The findings suggest that majority of the population do not empty their toilets when they fill up except for the few who consider pit emptying as a solution to the challenge of

accumulated excreta in te slums. The findings contradicted those of Chunga *et al.* (2016) in Malawi who found out that property owners preferred latrine emptying 1.8 times more than construction of new toilets. The contradiction could be linked to the cultural values of the community which discourages exposure and handling of faecal waste by the community.

The findings also reveal that though pit emptying is not a common practice a section of the population embrace pit emptying this could be attributed to the limited space to construct new facilities and the high cost of purchasing construction materials. The results were echoed by findings from the focus group discussion where participants reported that;

> *"Most of us do not empty toilets when they fill up, although I once saw people removing faecal waste from the toilet it is a very rear practice. The community around cover the filled up pits and dig new pits for construction of new sanitation facilities."*

The practice of emptying faecal waste from filled up pits could have facilitated resource recovery form the sanitation value chain which guarantees value addition for faecal waste for reuse into agricultural field as organic manure.

vi. Pit Emptying Methods

For those who had emptied their toilets, the research sought to establish the method used in emptying, the findings are indicated in table 4.9.

Table 4. 9: How was the toilet emptied

	Frequency	**Percent**
Manually (using buckets)	59	84.3
Use of trucks (vehicles)	11	15.7
Total	**70**	**100.0**

Table 4.9 shows that majority of the respondents (84.3%) manually emptied their toilets by use of buckets. Manual emptying of pits involves the use of buckets, ropes and shove where pit emptiers get into the pit and scope fresh faecal waste and transfer the waste to a separate pit dug next to the toilet for disposal of faecal waste from the toilet. The practice of manual pit emptying of pits is associated with spillage of faecal waste on the ground with could contaminate the soils and wter channels with faecal waste. The findings implied that for the population practicing pit emptying majority adopted the manual emptying option. This could be attributed to the affordable nature of manual pit emptying compared to the use of exhausters which is considered expensive by the slum dwellers.

Predominant use of buckets in emptying pits was echoed by Greene *et al.* (2021) in Sub Saharan Africa who reported that more than 50% of low and middle income urban dwellers use non- mechanized emptying options in the removal of accumulated excreta in on-site sanitation facilities. The use of non- mechanized pit emptying options could have an effect on faecal emptying conveyance and disposal due to the leakages and spillage of faecal waste associated with the practice. Spillage of faeces on the ground could contaminate the environment with faecal waste predisposing the population to sanitation related illnesses such as cholera and typhoid.

vii. Anal Cleansing Methods

The study sought to determine the cleansing method preferred by the respondents for toilet use. The results are shown in table 4.10.

Table 4.10: Which anal cleansing method do you prefer for toilet use

	Tissue	Water	Leaves	Piece of Cloth
Yes	82(36.0%)	151(66.2%)	37(16.2%)	1(0.4%)
No	146(64.0%)	77(33.8%)	191(83.8%)	227(99.6%)
Total	**228(100.0%)**	**228(100.0%)**	**228(100.0%)**	**228(100.0%)**

Table 4.10 shows that the most preferred cleansing method was water (66.2%) while the least preferred was piece of cloth (0.4%). This can be attributed to the fact that respondents struggled to carry water using container for anal cleansing. Limited access to water in the study area could result to pathogenic contamination of water with container stored in the toilet predisposing slum dweller to the risk of diarrheal infections. The findings suggest that majority of the population in the slum area use water for anal cleansing. This could be attributed to the high number of Muslims in the study area who embrace the use of water for anal cleansing as part of their culture. Since Christianity does not impose religious barriers to sanitation the use of other anal cleansing materials such as tissue and leaves could be attributed to the population of Christian faith. Adequate supply of water in the study area also promoted the use of water for anal cleansing. The use of non-biodegradable materials such as pieces of cloths for anal cleansing could have an effect on the quality of material deposited in pit which could limit mechanised emptying practices.

Respondents were also asked to indicate whether household members dumped waste such as broken glasses, plastics, textile, diaper and sanitary pads in toilet pits. The result is indicated in table 4.11.

Table 4.11: Do household members dump waste such as broken glasses, plastics, textile, diaper and sanitary pads in toilet pits

	Frequency	Percent
No	49	21.5
Yes	179	78.5
Total	**228**	**100.0**

The results in table 4.11 show that majority of the respondents (78.5%) used their pit toilets as dump sites for broken glasses, plastics, textiles, diapers, and sanitary pads. This dumping usually makes the process of emptying pit toilets difficult. The findings imply that the population did not have enough knowledge on the effect of dumping domestic waste other than faeces in pits. Dumping of household waste in pits could have an effect on the emptying mechanism which may result to breakdown of mechanical emptying machines as well as injury to manual pit operators. The findings were in line with those of Tyagi (2017) in India who reported that manual pit operators suffered severe injuries as a result of interaction with hazardous materials deposited in pits.

The study also sought to determine the materials deposited in the pit toilets, since this has an association with the emptying process. The findings are presented in table 4.12.

Table 4.12: Material Deposited in Toilet Pits

Material	Frequency	Percentage
Glasses	37	16.2
Plastics	13	5.7
Diapers and Sanitary Pads	144	63.2
Metal Pieces	34	14.9

The most common material deposited in the pit toilets was found to be diapers and sanitary pads (63.2%), this could be due to the fact that diapers contain faeces and sanitary pads

contain menses which culturally are considered unclean hence buried in the pit toilet. The study findings suggest that the study population practices indiscriminate disposal of waste in the toilets which could damage exhauster pumps during emptying and result to high toilet filling rates. Besides the effect of damage to vacuum pumps during emptying, plastics, metal pieces and glasses could also predispose manual pit operators to the risk of injury during emptying. The findings were similar to those of Tembo *et al.* (2019) in Zambia who found out that faecal sludge contained textiles, metals, glass and plastics.

Participants were given statements on faecal emptying in a five-point likert scale to indicate their degree of agreement regarding faecal emptying as shown in Table 4.13.

Table 4.13: Faecal Emptying

	Strongly Agree	**Agree**	**Not Sure**	**Disagree**	**Strongly Disagree**	**Mean**	**Std. Dev**
Emptying of on-site sanitation facilities is easy	0(0.0%)	59(25.9%)	10(4.4%)	137(60.1%)	22(9.6%)	2.46	0.982
On-site sanitation facilities are frequently emptied	0(0.0%)	28(12.3%)	9(3.9%)	172(75.4%)	19(8.3%)	2.20	0.754
The current method of emptying the on-site sanitation facility is good	0(0.0%)	10(4.4%)	18(7.9%)	161(70.6)	39(17.1%)	1.92	0.615

When asked whether emptying of on-site sanitation facilities including pits and septic tanks was easy, majority (60.1%) disagreed and 9.6% strongly disagreed with the statement while only 25.9% agreed that emptying of on-site sanitation facilities was easy. A mean of 2.46 (Standard Deviation, SD= 0.982) showed that participants generally disagreed with the statement. The results implied that the process of emptying the toilets available in slums was challenging which could have facilitated inadequate emptying of the latrines. On-site

sanitation facilities with weak slabs that do not provide an access hole for emptying pit contents could limit hygienic management faecal waste in onsite sanitation facilities. The results were similar to findings in Kenya by Simiyu *et al.* (2021) who reported that poor sanitation designs limit mechanized faecal emptying. Poor toilet design could compel slum dwellers to opt for manual pit emptying services which could predispose the urban population to the risk of helminthes infection due to the unhygienic nature of the process which does not guarantee safety of the users and the environment.

Respondents were requested to rate the frequency of latrine emptying. Results showed that 75.4% disagreed and 8.3% strongly disagreed while only 12.3% agreed that the on-site sanitation facilities available in slums were frequently emptied. A mean of 2.20 (SD= 0.754) suggested that toilets were not frequently emptied.

It can be deduced from the findings that toilet facilities in the slums were rarely emptied when they filled up and that the emptying methods available were least preferred. The findings were confirmed in Sub-Saharan Africa, Kenya included by Peal *et al* (2020) who reported that faecal waste in on-site sanitation facilities remain unemptied resulting to overflow of the faecal waste to the environment. Findings from the focus group discussions also revealed that residence were willing to use emptied and well managed toilets but toilet emptying could result in spillage of faeces in the compound which could cause contamination even to the neighboring households as reported by a focus group discussion respondent who argued that:

> *"Nobody wishes for a filled up toilet since the process of emptying will bring you problems with the neighbours because of the smell and also spillage of*

faecal waste during removal from pits. No matter how they try to do it the smell is usually bad and people complain a lot about it."

Failure to address the challenge of excreta accumulation in low-income urban areas could result to contamination of water sources with sanitation pathogens such as *Salmonela typhi* and *Vibrio cholera* exposing the slum population to the risk of diarrheal diseases through ingestion of pathogens in untreated water and contaminated fruits and vegetables.

To understand how respondents deemed the available emptying options, respondents were to indicate whether the current method of emptying onsite sanitation facilities was good. At a mean of 1.92 (SD= 0.165), participants disagreed. The findings suggested that the available methods of emptying filled up toilets in the study area was ineffective and could not handle the nature of pit contents in the slums. The results were similar to the findings in Malawi by Chiposa *et al.* (2017) who found out that vaccum pumps suffered blockage and damage as a result of pit contents containing dangerous materials such as metal pieces, textile and plastics. Unless technologically viable pit emptying technologies are used, pit contents in the slums could remain unemptied exposing the low-income urban population to the risk of sanitation related outbreaks such as polio as a result of interaction with fresh faecal matter.

4.4.2. Faecal Conveyance

To find out whether conveyance of waste from on-site sanitation facilities to disposal sites using mechanized and manual options was efficient, participants were to indicate their degree of agreement to several statements and findings as indicated in Table 4.14.

Table 4.14: Faecal Conveyance

	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree	Mean	Std. Dev
Manual conveyance of waste from on-site sanitation facilities to disposal site is usually done efficiently	0(0.0%)	13(5.7%)	29(12.7%)	168(73.7%)	18(7.9%)	2.23	0.671
Mechanized conveyance process is effective	1(0.4%)	13(5.7%)	36(15.8%)	164(71.9%)	14(6.1%)	2.29	0.838
Mechanized conveyance process usually results in spillage and leakage	7(3.1%)	52(22.8%)	47(20.6%)	120(52.6%)	2(0.9%)	2.07	0.797
I am satisfied with the current mechanized method of waste conveyance from the on-site sanitation facility to the disposal site	0(0.0%)	25(11.0%)	48(21.1%)	142(62.3%)	13(5.7%)	2.21	0.710

Results in Table 4.14 show that majority (73.7%) of the respondents reported that manual conveyance of faecal waste from on-site sanitation facilities was inefficiently done and only 5.7% reported efficient conveyance of faeces. Findings from the study suggested that manual transportation of faecal waste from onsite sanitation facilities to designated disposal site using buckets was deemed ineffective due to long duration taken in transportation of faecal waste and spillage of faecal content on the ground. Unhygienic disposal of faecal waste in open drains could result to contamination of soils and water sources with diarrheal related pathogen exposing the community to the risk of cholera outbreak. Similar findings were reported in Tanzania by Jenkins *et al.* (2015) who reported that manual emptying and conveyance of faecal waste was considered ineffective because of the long duration it took

to clear the pit content and its unsafe nature to the environment. Longer contact of pit operators with faecal waste could endanger the health of pit operators through exposure to respiratory infections and exposure of the public to the risk of helminths infection emanating from faecal contaminated soils.

Regarding the effectiveness of mechanized conveyance process, majority (71.9%) disagreed and 6.1% strongly disagreed that faecal waste was effectively conveyed (mean=2.29, SD= 0.838). The findings implied that although the mechanized transportation of faecal waste from on-site sanitation technologies is considered hygienic, still the process faced challenges around leakage of waste from the trucks contaminating the soils with sanitation pathogen like *Vibrio cholerae* which is a potential cause of diarrheal infection resulting from ingestion of diarrheal pathogens in vegetables and fruits obtained from faecal contaminated soils. The results were contrary to the findings in Low and Middle Income Countries (LMICs) by Green *et al.* (2021) who found out that mechanized emptying and transportation of faecal waste was effective and accelerated speed and enhanced safety of the operators and the environment. At a mean of 2.07, SD=0.797, manual conveyance process was reported to result in spillage or leakage of faeces to the environment. The findings suggested that the practice of manual transportation of faecal waste was unhygienic due to contamination of soils with faeces. The results were confirmed in Mozambique by Capone *et al.* (2020) who reported that pit emptying technology was discouraged due to its unhygienic nature and the risk of exposure of pit operators to infections from fresh human faeces with high pathogenic content. Unhygienic faecal waste management practices like manual transportation of faecal waste using buckets could expose the slum population to the risk of diarrheal outbreaks which my result to lose of lives.

Emptying faecal waste from pits is dependent on hygienic transportation and disposal of the waste to designated sites for environmental protection from sanitation related pathogens such as helminthes. However the process of transportation of faecal waste in slums involves the use of buckets and wheelbarrows to pits dug for disposal of emptied faecal waste. When asked to indicate whether they were satisfied with the faecal conveyance method used, many (62.3%) disagreed and 5.7% strongly disagreed with the statement at a cumulative mean of 2.21, SD=0.710. The findings suggested that slum dwellers were not satisfied with the conveyance process in regard to hygienic handling of faecal waste. The findings were in line with those in Kenya by Kocbek *et al.* (2020) who found out that faecal waste conveyance from slum toilets was compromised due to limited disposal site and the high cost incurred in emptying and transportation of faecal waste.

4.4.3. Faecal Disposal

To establish whether the disposal process from on-site sanitation facilities was efficient and hygienic, participants were to indicate their degree of agreement to several statements and findings were as illustrated in Table 4.15.

Table 4. 15: Faecal Disposal

	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree	Mean	Std. Dev
Vacuum trucks dispose faecal waste in a hygienic way	17(7.5%)	156(68.4%)	39(17.1%)	2(0.9%)	14(6.1%)	2.30	0.865
The disposal process using trucks rarely result in bad odour	25(11.0%)	136(59.6%)	41(18.0%)	5(2.2%)	21(9.2%)	2.39	1.029
I am satisfied with current method of faecal waste disposal from the on-site sanitation facility	17(7.5%)	149(65.4%)	37(16.2%)	4(1.8%)	21(9.2%)	2.40	0.990

When asked whether the disposal of faecal waste was done in a hygienic way, majority (68.4%) agreed and 7.5% strongly agreed with the statement while only 6.1% strongly disagreed. A mean of 2.30 (SD=0.865) showed that respondents generally agreed with the statement that faecal waste disposal was done in a hygienic way. The results suggested that the process of faecal waste disposal in the study area was done in a hygienic manner which guaranteed protection of the environment from faecal waste contamination. Disposal of faecal waste into sewer stabilizing pond by emptying trucks facilitate hygienic management of accumulated excreta which acts as a barrier to transmission of excreta related diseases. The use of vacuum trucks for emptying and transportation of faecal waste from on-site sanitation technologies guarantees safe and hygienic disposal of pit content since the vacuum trucks are sealed preventing leakages and spillage of faecal waste into the environment. The results were similar to the findings in Low and Middle Income Countries (LMICs) by Green *et al.* (2021) who found out that the use of vacuum trucks for emptying, transportation and disposal of faecal waste from on-site sanitation facilities was safe and

hygienic to both the user and the environment. Hygienic disposal of accumulated faecal waste in low-income urban settlements could encourage safe management of human excreta cutting out all the possible route of sanitation related infections to slum dwellers.

To rate the general perception of the respondents on the disposal process participants were asked to indicate whether the disposal process result in bad odour. At a mean of 2.39 (SD=1.029) participants disagreed that the disposal process rarely resulted in bad odour. The findings suggested that the faecal waste disposal sites were located far away from the study area and that respondent did not experience nuisance challenges in regard to odour emanating from the sewer stabilizing ponds. Location of designated disposal sites far from the slums could encourage unhygienic disposal of faecal waste into open drains and water bodies as a measure to bring down the cost of faecal waste disposal. Unhygienic disposal of faecal waste in open drains and water sources could expose the slum population to the risk of Schistosomiasis and Filariasis infection. Findings from the focus group discussions revealed that slum dwellers were willing to adopt hygienic faecal waste disposal options nevertheless the use of manual pit emptying options encouraged poor disposal of faecal waste in the environment which could compromise the safety of residence in slum areas.

> *"The problem with the use of buckets in emptying toilets is the spillage of human waste in the compound. It is not good for our health. Where the waste is also dumped is usually dirty and full of flies."*

The findings were confirmed in India by Prasad and Ray (2019) who found out that faecal waste was poorly disposed in to the environment as a result of limited disposal sites and the use of unhygienic pit emptying technologies.

Respondents were further requested to indicate how they regarded the methods of faecal waste disposal from on-site sanitation technologies. Results showed that 65.4% agreed and 7.5% strongly agreed while only 9.2% strongly disagreed that they were satisfied with the current method of faecal waste disposal. The findings suggested that the slum dwellers deemed the current method of mechanized faecal waste disposal in sewer stabilizing ponds ineffective in separation of the public from faecal contact which often accelerates the prevalence of intestinal infection. The results were similar to the findings in Sub-Saharan Africa by Semiyaga *et al.* (2015) who found out that ineffective disposal technologies contribute to discharge of faecal waste in water courses and agricultural fields. Poor disposal of faecal waste in the environment could contribute to ground water contamination compromising residents' safety.

4.4.4. Summary on Faecal Emptying, Conveyance and Disposal

The descriptive outcome of faecal emptying, conveyance, and disposal statistics was summarised in terms of mean and standard deviation, and the finding presented in Table 4.16.

Table 4. 16: Descriptive Statistics for Faecal Emptying, Conveyance, and Disposal

	N	Minimum	Maximum	Mean	Std. Deviation
Faecal Emptying	228	1.00	5.00	2.19	.772
Faecal Conveyance	228	1.00	5.00	2.20	.816
Faecal Disposal	228	1.00	5.00	2.23	.591

The results in table 4.16 show that concerning faecal emptying majority of the respondents disagreed at a mean of 2.19, SD=0.772 that emptying of on-site sanitation facilities was easy and that the available pit emptying methods were not effective in addressing the challenge of

excreta accumulation. At a mean of 2.20, SD=0.816 participants disagreed that the manual and mechanised conveyance process was effective and that they were satisfied with the entire process of faecal conveyance from on-site sanitation facilities to designated disposal sites in sewer stabilizing ponds. On faecal disposal majority of the respondents agreed that vacuum trucks disposed off faecal waste in a hygienic way and that they were satisfied with the available faecal waste disposal services.

4.5. Influence of Social Factors on Faecal Emptying, Conveyance, and Disposal

The study sought to examine the influence of social factors such as accessibility, cultural practices and taboos, quality of materials disposed in pits, population and literacy level on faecal emptying, conveyance, and disposal.

4.5.1. Influence of Presence of Access Provisions to Toilets on Faecal Emptying, Conveyance, and Disposal

The researcher sought to examine whether access provisions to toilets influenced faecal emptying, conveyance, and disposal. Participants were given statements in a five-point likert scale to indicate their level of agreement to the statements and results were as presented in Table 4.17.

Table 4.17: Presence of access provisions to toilets and Faecal Emptying, Conveyance, and Disposal

	Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree	Mean	Std. Dev
The toilets provided are easily accessible to pit emptier/exhausters	47(20.6%)	113(49.6%)	52(22.8%)	16(7.0%)	0(0.0%)	2.23	.722
Vacuum trucks cannot easily access toilets for emptying	56(24.6%)	131(57.5%)	36(15.8%)	5(2.2%)	0(0.0%)	2.16	.491
Toilets can easily be emptied because they have access manholes for emptying	29(12.7%)	126(55.3%)	42(18.4%)	20(8.8%)	11(4.8%)	2.52	.746

Effective emptying of toilets requires access provisions to toilets such as paths or roads to accommodate movement of trucks to emptying and disposal sites. When asked whether pit emptiers could easily access toilets in the slums, majority (49.6%) disagreed and 20.6% strongly disagreed with that the toilets were easily accessible while only 7.0% agreed. A mean of 2.23 (SD=0.722) showed that participants generally disagreed with the statement. The findings suggested that toilets in the study area were unreachable when emptiers needed to empty toilets because of poor location mostly in the backyard where accessibility was limited. A respondent from the focus group discussion said that:

> *"Sometimes the households are located close to each other and removing faeces from toilets in such areas become challenging because there are no clear paths."*

Inaccessible toilets in slums could result to higher cost of emptying pits due to demolition of properties and toilets to pave way for access to sanitation facilities. The findings were

confirmed in Ghana and Malawi by Doe *et al.* (2020) who reported that congestion in slum areas constrained accessibility of on-site sanitation systems to faecal emptying service. Unless toilets in slums are accessible to pit emptiers, the challenge of excreta accumulation in toilets could result in unhygienic faecal disposal or defecation in the open due to filled up toilets. Unhygienic practices such as defecating in the open could contaminate the fields and ground water with faecal waste hence elevating the burden of sanitation diseases in the slums.

To understand how respondents perceived access of toilets by vacuum trucks, respondents were to indicate whether the toilets could easily be accessed by vacuum trucks. At a mean of 2.16 (SD=0.491) participants generally disagreed. The findings revealed that on-site sanitation facilities in the study area were not easily accessible to exhausters operators for emptying. Inaccessible sanitation facilities limiting emptying of pit contents could elevate the burden of excreta accumulation in slums associated with contamination of soils and water sources which could lead to exposure of the urban population to excreta related diseases such as diarrhea. The results of the study in Meru slums agreed with the findings obtained in Uganda by Nantongo (2022) who reported that toilets in slums were rarely emptied because paths to the toilets were too narrow for access by vacuum trucks for emptying. Failure of slum residents to adopt mechanized emptying and transportation of faecal waste from onsite sanitation facilities to disposal sites resulted in consideration of other emptying options like buckets which contaminated water sources as reported by a focus group discussion participant who said:

"When my toilet filled up, it was emptied using buckets. The one who emptied threw the contents inside the nearby river. I could not drink the water because it contained faeces."

Participants were asked to indicate whether their toilets had access manholes which could facilitate easy emptying. Majority (55.3%) of the participants agreed and 12.7% of the participants strongly agreed that toilets with access manholes could easily be emptied. A mean of 2.52, SD=0.746 suggested a general disagreement to the statement. The findings implied that the available toilets were mostly not emptied because of absence of manholes to support emptying. It was reported in the focus group discussion that lack of access manholes to facilitate emptying resulted in demolition of walls and slabs to facilitate emptying. A focus group discussion participant said that:

"One day I had to break toilet slab and wall to fix the sanction pipe in a toilet that was constructed without the holes we mostly use for emptying."

Existence of toilet facilities which had no emptying provisions to facilitate easy emptying of accumulated faecal waste was also reported in Tanzania by Jekins *et al.* (2015).

Unimproved sanitation facilities which do not consider provision of manholes for emptying could result to adoption of unhygienic practices like use of manual pit emptying options to address the challenge of excreta accumulation in slum areas. Unhygienic pit emptying characterized by spillage of faecal waste to the environment during emptying could endanger the health of slum dwellers as a result of nuisance which may attract sanitation disease vectors such as flies and result to respiratory infection to the slum residence.

4.5.2. Influence of Taboos on Faecal Emptying, Conveyance, and Disposal

Respondents were asked to indicate their level of agreement to statements given in a five-point likert scale to establish whether taboos influence faecal emptying, conveyance and disposal. Results were as shown in Table 4.18.

Table 4. 18: Taboos

	Strongly Disagree	**Disagree**	**Moderate**	**Agree**	**Strongly Agree**	**Mean**	**Std. Dev**
There are taboos discouraging handling of faeces	36(15.8%)	52(22.8%)	77(33.8%)	43(18.9%)	20(8.8%)	2.78	.927
Defecating in the open is considered unclean in the community	20(8.8%)	56(24.6%)	31(13.6%)	96(42.1%)	25(11.0%)	2.89	.719
Faecal handling is considered unclean	16(7.0%)	52(22.8%)	47(20.6%)	100(43.9%)	13(5.7%)	2.55	.864

The practice of faecal handling is considered indecent in different cultural contexts with some communities labeling those who engage in the practice as unclean. Findings showed that majority (22.8%) of the respondent reported that there were no taboos discouraging handling of faeces and only 18.9% reported there were taboos discouraging faecal handling. The findings showed that majority of the slum dwellers believe that handling of faeces was considered a taboo in their culture. Taboos limiting handling of faeces could restrict pit emptying efforts in slums. Besides, pit operators could suffer discrimination since they are considered unclean as revealed in the focus group discussion;

> *"My neighbours say that the work I do is shameful and sometimes they don't shake my hand fearing that I'm not clean."*

Another respondent said;

> *"In our culture, there is a strong belief that emptying faecal waste should not be done openly or in public. There are specific designated areas or structures for this purpose. It is considered disrespectful and taboo to openly defecate or dispose of faecal matter in an improper manner."*

The results of the study agree with the findings obtained by Zaqout *et al.* (2020) in Bangladesh who reported that manual handling of faeces was considered as an undignified practice hence culturally unacceptable. The findings confirmed that handling of faeces was considered a taboo and residents who engage themselves in the practice of pit emptying were viewed as unclean. Such believes could discourage slum residents from engaging in excreta related activities due to the fear of stigmatization and community isolation. Inadequate pit emptying services could result to filled up pits which remain unattended exposing the urban population to the risk of diarrhea outbreak which may escalate during rainy season when faecal waste overflow from filled up pits.

Regarding the perception of the respondents on open defecation, many (42.1%) agreed and 11.0% strongly agreed that the community considered defecation in the open unclean (mean=2.89, SD=0.719). the findings implied that defecating in the open was discouraged in Meru slums due to the cultural believes which deterred slum residents from defecating in the open. The findings were confirmed in Kenya by Kasiva (2023) who found out that positive cultural beliefs positively influence the adoption and use of toilets for hygienic management of faecal waste. Findings from the focus group discussions also revealed similar findings as reported by one of the respondent who said that:

"Our cultural belief insists on depositing human waste in the ground where it cannot be visible by other people. Defecating in the open is prohibited and considered a taboo and individual who practices such behaviours are considered to be mentally unstable."

This kind of cultural belief could confine community members into hygienic use of toilets and faecal waste management practices limiting contamination of soils and ground water with faecal waste and lowering the burden of sanitation illnesses in slums.

At a mean of 2.55, SD=0.864, respondents generally perceived faecal handling as unclean. The result suggested that the community in the slums of Meru believed that faecal handling was culturally unacceptable besides, members engaged in pit empting and transportation of faecal waste from on-site sanitation facilities to disposal sites were unclean hence should be avoided. The results were similar to the findings in India by Prasad and Ray (2019) who reported that manual faecal handlers were deemed unclean because their work was culturally unacceptable. Unfriendly cultural practices and taboos preventing emptying of pits and transportation of faecal waste from toilets to disposal sites could results to abandonment of filled up toilets whose pit content may overflow during rainy seasons contaminating surface and ground water leading to the outbreak of sanitation infection such as salmonellosis which is detrimental to the health of slum dwellers especially to children.

4.5.3. Influence of Materials Disposed in Pits on Faecal Emptying, Conveyance, and Disposal

The researcher desired to find out whether materials disposed in pits influence faecal emptying, conveyance and disposal. Respondent were required to indicate their degree of agreement to the statement and findings were as shown in Table 4.19.

Table 4. 19: Materials disposed in pits

	Strongly Disagree	**Disagree**	**Moderate**	**Agree**	**Strongly Agree**	**Mean**	**Std. Dev**
Toilets are used for disposal of household waste	0(0.0%)	5(2.2%)	56(24.6%)	131(57.5%)	36(15.8%)	3.41	.696
Dangerous materials such as broken glasses , pieces of metal and plastics are dumped in toilets	0(0.0%)	16(7.0%)	47(20.6%)	113(49.6%)	52(22.8%)	3.66	.617
Diaper and sanitary towels are thrown in the toilet after usage	0(0.0%)	0(0.0%)	28(12.3%)	129(56.6%)	71(31.1%)	4.43	.428

Pit latrines are installed for containment of faecal waste limiting human contact from faecal waste and not for disposal of household waste and trash. When asked whether households dispose other waste rather than faeces in the toilets, many (57.5%) agreed and 15.8% strongly agreed with the statement while only 2.2% disagreed. A mean of 3.41, SD=696 showed that participants generally agreed with the statement. The finding showed that residents in the study area dump household waste in toilet pits. The results were similar to the finding in Malawi by Chiposa *et al.* (2017) who found out that toilet were used for disposal of household domestic waste. The results were also supported by findings in the focused group discussion where a participant reported that:

"We use the toilet for dumping waste that my cause injuries to children if left open in the compound, it is safe if items such as broken glass, used pharmaceutical bootless and sharp metal pieces are through in the toilet."

Disposal of poor quality materials such as textiles stones and metals could damage vacuum pumps while handling such waste affecting the efficiency of pit emptying.

Respondents were asked if they dumped materials such as broken glasses and plastics in toilets. Results showed that 49.6% agreed and 22.8% strongly agreed while only 7% disagreed that toilets were used for disposal of household domestic waste. The findings suggested that respondents dumped hazardous materials such as metal pieces and broken glasses. The results were similar to the findings in Zambia by Tembo *et al.* (2019) who found out that solid content in faecal waste constituted textile, glasses, metals and plastics. Hazardous material such as metal pieces could suffocate suction pumps resulting to blockage and damage to the pumps. In addition, manual pit emptiers could be at risk injury from such materials but emptying of filled up pits. Injury of pit emptiers and damaged pumps could mean filled up toilets in the slums remain unattended hence overflowing of faecal sludge from on-site sanitation facilities to the environment contaminating the soils, water and field with faecal waste which could stir an outbreak sanitation diseases such as Cholera.

A mean of 3.66, SD=0.617 suggested that toilets were used for disposal of household waste. At a mean of 4.43, SD=0.428, respondents agreed that sanitary towels and diapers were disposed in pits. The finding suggested that residents in the study area practiced indiscriminate disposed waste such as used sanitary towels and diapers in the pits. Disposal of non-decomposing materials such as diapers and sanitary towels which are considered

non-biodegradable could influence the filling rates of toilets in the study area. The results were confirmed in Kenya by Gudda *et al.* (2019) who reported a higher filling rate in toilets where poor quality materials such as diapers were dumped. The findings were also confirmed by findings from the focused group discussion where a respondent reported that:

> *"Aaah, diapers and sanitary towels swell after absorbing water filling most of the volume in the pit hence the toilets fills up within a short time. I had to install a squat pan to control the challenge of tenants dumping diapers in the toilet."*

High filling rates of toilets in slums could mean a higher expenditure on pit emptying and transportation of faecal waste from filled up on-sites sanitation facilities to disposal sites to the slum residents. Higher expenditure on emptying conveyance and disposal of faecal waste from to the low-income slum residents could limit hygienic pit emptying and transportation of faecal waste from filled up on-sites sanitation facilities to disposal sites exposing the slum residents to life threatening disease from sanitation pathogens such as poliovirus.

4.5.4. Influence of Population size on Faecal Emptying, Conveyance, and Disposal

The study also examined the influence of population size on faecal emptying, conveyance and disposal. The findings were as presented in Table 4.20.

Table 4. 20: Population size

	Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree	Mean	Std. Dev
Large populations size result in high user capacity of toilets, leading to high emptying frequencies	16(7.0%)	52(22.8%)	56(24.6%)	78(34.2%)	26(11.4%)	2.81	.869
Population growth necessitates continuous monitoring and adjustment of toilet emptying schedules	4(1.8%)	15(6.6%)	59(25.9%)	121(53.0%)	29(12.7%)	3.02	.973

Population size presents a significant challenge in hygienic management of faecal waste from on-site sanitation facilities in low income urban settlements. Regarding the influence of population on faecal emptying, majority (34.2%) agreed and 11.4% strongly agreed that large population size result in high user capacity of toilets and inadequate emptying many (34.2%) agreed and 11.4% strongly agreed while only 22.8% disagreed with the statement that population density influence user capacity of toilets and emptying frequencies (mean=2.81, SD=0.869). The findings suggested that high user capacity in slums results to overuse of the existing sanitation facilities resulting in filled up toilets in unplanned settlements. The results were similar to the findings in Uganda by Fuhrimann *et al.* (2016) who reported that high pit latrine user rate was as a result of high population size dependent on insufficient sanitation infrastructure. The challenge of excreta accumulation in densely populated low-income urban areas could accelerate unless socially viable pit emptying, conveyance and disposal services are adopted to address the challenge of frequently filled up toilets which require emptying.

When asked whether population growth necessitates continuous monitoring and adjustment of toilet emptying schedules, majority (53.0%) agreed and 12.7% strongly agreed with the statement while only 6.6% disagreed with the statement. A mean of 3.02, SD=0.973 showed that participants generally agreed with the statement. The findings revealed that overpopulation burdens on-site sanitation infrastructure as a result of high user capacity which could influence the filling rates of toilets. The results of the study were confirmed in Uganda by Odagiri *et al.* (2021) who found out that high population density areas were associated with higher filling rates of on-site sanitation facilities. High population densities could require owners of the sanitation facilities to invest more on emptying or construction of new sanitation facilities since they are the only available options in addressing the challenge of accumulated excreta in low income urban settlements. Failure to establish effective excreta management services in densely populated low-income urban settlement could result to contamination of soils and surface water which accelerate the spread of pediatric enteric infections such as Shigellosis.

4.5.5. Influence of Awareness and Faecal Emptying, Conveyance, and Disposal

The researcher sought to examine whether awareness influenced faecal emptying, conveyance, and disposal. Respondents were given statements in a five-point likert scale to indicate their level of agreement to the statements and results were as presented in Table 4.21.

Table 4. 21: Awareness

	Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree	Mean	Std. Dev
Access to education and awareness campaigns has a considerable influence on the behavior of individuals in relation to faecal management in on-site sanitation facilities	16(7.0%)	42(18.4%)	57(25.0%)	100(43.9%)	13(5.7%)	2.68	.784
Adequate literacy skills contribute to better awareness of hygiene practices in toilet maintenance	19(8.3%)	22(9.7%)	48(21.1%)	119(52.2%)	20(8.8%)	2.86	.939

Improvement of hygienic faecal waste management practice is dependent on the level of understanding of the population on the impact of poor faecal waste management practices on their health and surrounding environment. When asked whether access to education and awareness campaigns had a considerable influence on the behavior of individuals, majority (43.9%) agreed and 5.7% strongly agreed with the statement while only 18.4% disagreed with the statement that access to education and awareness campaigns had a considerable influence on the behavior of individuals in regard to faecal management in on-site sanitation facilities. A mean of 2.68, SD=0.784 showed that participants agreed with the statement. Findings suggested that respondents understood the importance of public knowledge on emptying pits and transportation of faecal waste from on-site sanitation facilities to disposal sites in regard to their health and prevention against diseases emanating from poor management of faecal waste. The results contradicted the findings in Malawi by

Mpanang'ombe *et al.* (2021) who found out that informal urban dwellers lacked the understanding of the actual drivers for hygienic faecal waste management. Awareness on the impact of available sanitation option in regard to faecal emptying, conveyance and disposal could inform hygienic choices of slum residence in addressing the challenge of excreta accumulation in pits.

At a mean of 2.86, SD=0.939 adequate literacy skills were reported to contribute to better awareness of hygiene practices in toilet maintenance. The findings revealed that the study population was not well informed on the consequences of the hygienic practices embraced in regards to handling of accumulated faecal waste in pits. the results were similar to the findings in India by Odagiri et al. (2021) who found out that household members had common perception regarding sanitation matters which were insufficient in addressing general sanitation cahallenges.This shows that the level of literacy of an individual influence their choices with regard to faecal emptying, conveyance, and disposal.

From the descriptive analysis as well as the qualitative analysis, it can be indirectly inferred that social factors influence faecal emptying, conveyance, and disposal.

4.5.6. Summary on the Influence of Social Factors on Faecal Emptying, Conveyance, and Disposal

The descriptive outcome was summarised in terms of mean and standard deviation, and the finding presented in Table 4.22.

Table 4. 22: Summary of Mean and Standard Deviation for Social Factors

	N	Minimum	Maximum	Mean	Std. Deviation
Access to emptying provisions	228	1.00	5.00	2.29	.648
Taboos	228	1.00	5.00	2.71	.968
Materials disposed	228	1.00	5.00	3.86	.481
Populations size	228	1.00	5.00	2.87	.747
Awareness	228	1.00	5.00	2.73	.662

The results in Table 4.17 show that on access to emptying provisions to on-site sanitation facilities in the study area majority of the respondents disagreed at a mean of 2.29, SD=0.648 that toilets in Meru slums were easily accessible for emptying suggesting that poor sanitation designs and unplanned settlements in the study area deterred hygienic efforts towards management of accumulated excreta in toilets. At a mean of 2.71, SD=968 participants disagreed that there existed taboos discouraging the slum residents from handling faeces suggesting that faecal sludge management interventions could be adopted for management of accumulated excreta in the slums since pit operators were not vulnerable to discrimination. On materials disposed in pits majority of the respondents agreed at a mean of 3.86, SD=0.481implying that toilets in the study areas were used for disposal of household waste and dangerous materials such as broken glasses and plastics which could damage vacuum pumps during emptying of pits. At a mean of 2.87, SD=0.747 participants agreed that population size influenced toilet usage and the filling rate of toilets in Meru slums implying that toilets with high user capacity rate were prone to high filling rate which required the owner to spend more on pit emptying services. On awareness respondents agreed at a mean of 2.73, SD=0.662 that knowledge and awareness on hygiene and safety of

slum residents in regard to faecal emptying conveyance and disposal is key in influencing the adoption of improved sanitation facilities and hygienic faecal waste management options among slum dwellers.

4.6. Influence of Economic Factors on Faecal Emptying, Conveyance and Disposal

The study sought to examine the influence of economic factors including operational cost, toilet design, frequency of desludging, access to credit, charges in relation to space availability, level of income and ability and willingness to pay on pit emptying options, transportation of faecal waste from on-site sanitation systems and disposal into designated sites.

4.6.1 Influence of Operational Cost on Faecal Emptying, Conveyance and Disposal

Respondents were given statements on operational cost in a five-point likert scale to indicate their level of agreement to the influence of economic factors on faecal emptying, conveyance and disposals as displayed in Table 4.23.

Table 4. 23: Operational Cost

	Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree	Mean	Std. Dev
The availability and affordability of pit emptying services can influence faecal emptying, conveyance and disposal.	16(7.0%)	22(9.6%)	27(11.8%)	120(52.6%)	43(18.9%)	3.49	.849
The availability and affordability of construction materials can influence the design of on-site sanitation facilities.	0(0.0%)	6(2.6%)	10(4.4%)	185(81.1%)	27(11.8%)	4.28	.412
The overall cost of emptying, transporting and disposal of faeces is affordable.	57(25.0%)	112(49.1%)	19(8.3%)	29(12.7%)	11(4.8%)	2.21	.976

Effective management of accumulated excreta in low-income urban settlements requires adoption of sanitation viable practices in emptying and transportation of faecal waste from on-site sanitation facilities to disposal site. However, the operational cost of managing faecal waste in slums could influence hygienic management of faecal waste in slums. When asked whether availability and affordability of pit emptying services could influence faecal emptying, conveyance and disposal, majority (52.6%) agreed and 18.9% strongly agreed while only 9.6% disagreed with the statement that availability and affordability of pit emptying services could influence faecal emptying, conveyance and disposal. A mean of 3.49, SD=0.849 showed that respondents generally agreed with the statement. The findings suggested that slum dwellers had limited options in regard to hygienic and cost effective

faecal waste management services which could have discouraged effective emptying and transportation of faecal waste from on-site sanitation facilities to disposal sites. The results were similar to the findings in Kenya by Kocbek et al (2020) who found out that limited faecal management option in slums elicited higher expenditure on faecal emptying conveyance and disposal. High expenditure on sanitation services such as empting of filled up pits could result to unhygienic disposal of faecal waste in open drains among slum residents exposing the urban population to the risk of diarrheal infections.

Respondents were asked whether the availability and affordability of construction materials can influence the design of on-site sanitation facilities. Results showed that majority (81.1%) agreed and 11.8% strongly agreed while only 2.6% disagreed to the statement that availability and affordability of construction materials can influence the design of on-site sanitation facilities. A mean of 4.28, SD=0.412 suggested that respondents generally agreed with the statement. Findings from the study suggested that the use of toilet without lining and provision of emptying manholes was as a result of the high cost of toilet construction material which could not be met by slum residents. The results were similar to the findings in Malawi by Chunga *et al.* (2016) who establish a direct relationship between poor sanitation designs and low-income urban dwellers. These results were also reported in the focus group discussion where a participant said:

> *"For pit emptying services we even accept instalment payment, however, a down payment must be made before we begin emptying. Most of our clients are poor and you can tell from the type of sanitation facilities they own. Most household prefer us to exhausters since our services are relatively*

affordable so when their toilets fill up we usually respond and do a good job for them."

Poor sanitation design could limit the adoption of mechanized pit emptying options such as the use of vacuum truck compelling slum residents to adopt unhygienic faecal waste management practices such as the use bucket for emptying pits. Unhygienic pit emptying practice associated with spillage of faecal waste to the soils and water source could trigger the outbreak of diarrheal diseases such as cholera endangering the health of low-income urban dwellers.

To understand how participants deemed faecal emptying, conveyance and disposal services, participants were to indicate whether the overall cost of emptying, transporting and disposal of faeces is affordable. At a mean of 2.21, SD=0.976 participants generally disagreed. The findings implied that the general cost of managing the accumulated excreta from on-site sanitation facilities to disposal sites was unaffordable to slum residents. The results were similar to the findings in Africa, Kenya included by Orner and Mihelcic (2018) who established that although mechanized pit emptying remained the most hygienic option of faecal waste management, low-income urban dwellers considered manual pit emptying practice, which was cheaper despite the associated health and environmental risk.

4.6.2 Influence of Toilet Design on Faecal Emptying, Conveyance and Disposal

The researcher sought to examine whether the design of toilets influenced faecal emptying, conveyance and disposal. Respondents were required to rate the statement and findings were presented as shown in Table 4.24.

Table 4. 24: Toilet Design

	Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree	Mean	Std. Dev
I would prefer building a toilet with utility access hole for emptying	86(37.7%)	109(47.8%)	29(12.7%)	4(1.8%)	0(0.0%)	1.76	.427
Toilet pit is lined	20(8.8%)	56(24.6%)	31(13.6%)	96(42.1%)	25(11.0%)	2.89	.711

The pathogenic nature of faecal waste require the use of hygienic faecal waste management interventions such as improved toilet design to guarantee safety of the environment and the public from infections caused by sanitation pathogens such as helminthes. Poor design of toilets in slums could affect efforts put in place to address the challenge of excreta accumulation in slums. When asked whether they would prefer building a toilet with utility access hole for emptying, majority (47.8%) disagreed and 37.7% strongly disagreed while only 1.8% agreed with the statement that they would prefer building a toilet with utility access hole for emptying. A mean of 1.76, SD=0.427 showed that respondents generally disagreed with the statement. Results implied that majority of residents in the slums used sanitation facilities which did not guarantee safe emptying, conveyance or disposal of faecal waste. The findings were confirmed in Malawi by Chunga *et al.* (2016) who reported that majority of low-income urban dwellers adopted poor sanitation designs due to their inability to meet the cost of improved sanitation designs. Similar findings were also reported from the focus group discussion findings where a participant said that:

"Very few households used good toilets but the toilets constructed by others could require demolishing of the slab for mechanized empting. The poor cannot save for construction of better toilets because they needed to cater for basic family needs. We charge extra money to empty toilets without provision for emptying."

Participants were asked whether the available toilets in the slums were lined. Results showed that 42.1% agreed and 11.0% strongly agreed while only 24.6% disagreed to the statement that toilet pits were lined. A mean of 2.89, SD=0.711 suggested that respondents generally disagreed with the statement. The findings implied that respondents used toilets that were not reinforced with brick walls in the substructure. The results were similar to the findings in Uganda by Zzwa *et al.* (2016) who found that poor sanitation designs without brick lining support in the substructure were associated with high filling rate and prone to collapse. Poor sanitation designs associated with high filling rates could result to abandonment of filled up toilets by slum residents and increased practice of open defecation due to the unaffordable nature of pit emptying services. Unhygienic faecal disposal practices such as open defecation could result to interaction of the public with sanitation related pathogens such as helminthes which could have a negative effect on the heath of slum residents.

4.6.3 Influence of Frequency of Desludging on Faecal Emptying, Conveyance and Disposal

Respondents were given statements on frequency of desludging in a five-point likert scale to indicate their level of agreement to the influence of economic factors on faecal emptying, conveyance and disposals as displayed in Table 4.25.

Table 4. 25: Frequency of Desludging

	Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree	Mean	Std. Dev
In this community, people would consider burying a toilet than emptying a toilet	0(0.0%)	5(2.2%)	36(15.8%)	151(66.2%)	36(15.8%)	3.41	.602
When faced with a filled up toilet, I would prefer digging a new pit than emptying the filled pit.	7(3.1%)	31(13.6%)	8(3.5%)	161(70.6%)	21(9.2%)	3.47	.782

The wide adoption of on-site sanitation facilities in low-income urban areas has presented the challenges of excreta accumulation in pits. Management of the challenge involves emptying of faecal waste from pits to designated disposal sites nevertheless, high frequency of emptying latrines could influence hygienic management of accumulated faecal waste in pits since slum dwellers could incur a higher expenditure on sanitation budget. When asked whether in the study area people would consider burying toilets than emptying, majority (66.2%) agreed and 15.8% strongly agreed while only 2.2% disagreed with the statement that community members would consider burying toilets than emptying. A mean of 3.41, SD=0.602 showed that respondents generally agreed with the statement. The findings suggested that toilets in the study area were not frequently emptied. The study findings indicate that toilets in the study area were not frequently emptied since most of the slum dwellers preferred burying of filled up toilets as opposed to emptying the facilities. The results in the study contradicted with the findings in Malawi by Chunga *et al.* (2016) who found out that property owners preferred latrine emptying 1.8 times more than construction of new toilets. The findings suggest that the decisions on whether to empty or construct a

new toilet was dependent on the available hygienic faecal sludge management interventions as revealed by the findings from the discussions in the focus groups.

> *"Majority of us have thought of emptying the toilets when they fill up, however when I think of the use of buckets to empty the pits and the amount of bad smell that comes with the work I would rather plan on digging a new toilet and forget about the old one."*

The results suggest that the available methods of managing the accumulated faecal waste in the slums are not hygienic and viable hence the population prefer construction of new toilets as a solution to filled up toilets.

To understand how participants would react to the challenge of excreta accumulation in toilets, participants were to indicate whether they would prefer digging a new pit than emptying the filled pit when faced with a filled up toilet. At a mean of 3.47, SD=0.782 participants generally agreed. The findings suggested that slum dwellers were not well informed of the benefits and the cost implication of hygienic faecal emptying, conveyance and disposal practice in comparison to the preferred practice of burying filled up toilets as a solution to excreta accumulation crisis in slums. The results were similar to the findings in India by Odagiri *et al.* (2021) who found out that household members had limited knowledge and awareness on household sanitation need and choices in regard to the environmental and health impact of the available faecal waste management options. The finding suggested that low-income urban dwellers could be spending more on the purchase of toilet construction materials which relatively unaffordable in response to the challenge of frequently filled up toilets in slums. Adoption of low cost emptying of pits and

transportation of faecal waste from on-site sanitation facilities to disposal site could save the slum dwellers of time and the high cost of constructing new toilets.

4.6.4 Influence of Access to Credit on Faecal Emptying, Conveyance and Disposal

Participants were given several statements on access to credit in a five-point likert scale to indicate their level of agreement to the influence of economic factors on faecal emptying, conveyance and disposals as displayed in Table 4.26.

Table 4. 26: Access to Credit

	Strongly Disagree	**Disagree**	**Moderate**	**Agree**	**Strongly Agree**	**Mean**	**Std. Dev**
There is a possibility of borrowing money to build toilets in the community	51(22.4%)	131(57.5%)	11(4.8%)	20(8.8%)	9(3.9%)	2.52	.716
CDF and other NGOs have funded building of some toilets in the slums	4(1.8%)	15(6.6%)	9(3.9%)	171(75.0%)	29(12.7%)	4.01	.691

Hygienic management of faecal waste adopt sanitation practices that completely separates the urban population from human excreta, however, payment of faecal emptying, conveyance and disposal service could be influenced by the ability of low-income urban dwellers to access loans. When asked whether they could borrow money for construction of toilets, majority (57.5%) disagreed and 22.4% strongly disagreed while only 8.8% disagreed with the statement that there was a possibility of borrowing money for construction of toilets in the community. A mean of 2.52, SD=0.716 showed that respondents generally disagreed with the statement. The findings implied that slum dwellers had no access to sanitation financing options due to lack of savings, limited collateral and failure to meet the minimum requirements for loan acquisition which could have resulted to the poor hygienic practices in

low-income urban areas. The results were similar to the findings in India by Augsburg *et al.* (2022) who established that access to credit for toilet construction had a direct relationship with uptake of sanitation services. Access to credit could promote hygienic faecal emptying, conveyance and disposal in slums since slum residents could be able to borrow and pay for faecal waste management service.

Respondents were asked whether CDF and other NGOs have funded building of some toilets in the slums. Results showed that 75.0%) agreed and 12.7% strongly agreed while only 6.6% disagreed to the statement that CDF and other NGOs have funded building of some toilets in the slums. A mean of 4.01, SD=0.691 suggested that respondents generally agreed with the statement. The findings suggested that CDF and NGOs played a significant role in supporting sanitation programs in the slums aimed at moving the slum residents up the sanitation ladder. The results were similar to the findings in the Global South, Kenya included by Welie *et al.* (2018) who reported that NGOs had a significant influence on the transformation of poor sanitation conditions in informal settlements to sustainable sanitation that offer dignity to humanity. The findings were also reported by a focus group discussion respondent who said that:

> *"Well-wishers in collaboration with the county government have supported construction of public toilets to allow for access to sanitation services to the less privileged."*

Active participation of the government and NGOs in low-income urban settlement could improve the uptake of improved sanitation designs to facilitate hygienic management of

faecal waste through the sanitation chain through awareness creation and reinforcement of sanitation policies on faecal waste management.

4.6.5 Influence of Charges in Relation to Space Availability on Faecal Emptying, Conveyance and Disposal

The study sought to examine whether charges in relation to space availability influenced faecal emptying, conveyance, and disposal. Respondents were given statements in a five-point likert scale to indicate their level of agreement to the statements and results were as presented in Table 4.27.

Table 4. 27: Charges in Relation to Space Availability

	Strongly Disagree	**Disagree**	**Moderate**	**Agree**	**Strongly Agree**	**Mean**	**Std. Dev**
Narrow paths in our community makes it difficult for pit emptier to access toilets	2(0.9%)	11(4.8%)	15(6.6%)	180(78.9%)	20(8.8%)	4.18	.599
Providing ample space in toilets is necessary for maintaining sanitation and hygiene during the emptying, conveyance, and disposal process.	0(0.0%)	0(0.0%)	5(2.2%)	199(87.3%)	24(10.5%)	4.86	.310

Sustainable faecal waste management interventions are dependent on space for hygienic emptying, conveyance and disposal of faecal waste. However, space in unplanned low-income urban settlement could be a limiting factor to hygienic management of accumulated faecal waste. When asked whether narrow paths made access to toilets difficult, majority (78.9%) agreed and 8.8% strongly agreed while only 4.8% disagreed with the statement that narrow paths in the community makes it difficult for pit emptier to access toilets. A mean of

4.18, SD=0.599 showed that respondents generally disagreed with the statement. Findings suggested that toilets in the study area were not easly accessible for emptying due to the nature of unplanned urban settlements which retained narrow paths limiting hygienic faecal management practices such as the use of vacuum trucks for emptying pits. The results were similar to the findings in Ghana and Malawi by Doe *et al.* (2020) who found out that congested slum settlement limited accessibility to filled up sanitation facilities. Narrow paths in the study area could compromise the movement of emptying vehicles leaving the slum residents with manual pit emptying option as the only viable alternative for emptying the toilets. The practice of manual pit emptying is associated with contamination of the environment with faeces compromising resident's health and safety.

Participants were asked whether provision of ample space in toilets was necessary for maintaining sanitation and hygiene during the emptying, conveyance, and disposal of faecal waste. Results showed that majority (87.3%) agreed and 10.5% strongly agreed to the statement that adequate space in toilets was necessary for maintaining sanitation and hygiene during the emptying, conveyance, and disposal of faecal waste. At a mean of 4.86, SD=0.310 respondents generally agreed with the statement. It was revealed in the focus group discussion that emptying of faeces from toilets was limited by poor accessibility and absence of space for disposal of faeces. Results implied that majority of residents in the slums used sanitation facilities which did not guarantee safe emptying, conveyance or disposal of faecal waste. As urban areas continue to develop the appreciating value of land rules out the probability of poor urban population to acquire extra land for faecal management when toilets fill up. Participants also reported a high cost of emptying toilets

which did not because of the occupational health risks associated with dealing with faulty structures. Focus group discussion participants said that:

> *"Sometimes back I was called to empty filled up pits but the space to the toilets was very limited. I really struggled to locate a disposal site around the household. I remember I was once forced to dig an adjacent pit for seepage of the waste from the filled up pit to the new one because it was the only alternative. The limited space could not allow for use of buckets to empty the toilet. The waste could have spilled to the neighbouring compound resulting in a lot of misunderstandings."*

Poorly designed toilets with minimal space for accessing faecal waste during desludging could contribute to frequent demolishing of the slab to pave way for emptying procedures which could weaken the structure and could mean a high cost of servicing the toilets. The fact that space influenced faecal emptying, conveyance and disposal was also confirmed by Chipeta *et al.* (2017) in Malawi and by Zzwa *et al.* (2016) in Uganda.

4.6.6 Influence of Level of Income on Faecal Emptying, Conveyance and Disposal

The study also examined the influence of level of income on faecal emptying, conveyance and disposal. The findings were as presented in Table 4.28.

Table 4. 28: Level of Income

	Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree	Mean	Std. Dev
My level of income does not influence the choice of sanitation option available	83(36.4%)	112(49.1%)	1(0.4%)	31(13.6%)	1(0.4%)	1.82	.604
In this community, household type of toilet is determined by the level of income	0(0.0%)	0(0.0%)	4(1.8%)	119(52.2%)	105(46.1%)	4.89	.292

On-site sanitation owners are dependent on their economic status a combination of individual's occupation and income to inform their choices in regard to emptying of sanitation facilities and transportation of faecal waste from the facilities to designated disposal sites. Nevertheless, the practice of hygienic management of accumulating excreta in low-income settlements has been slowed down due to low income levels of slum residents. When asked whether individual's level of income had no influence on the available sanitation option, majority (49.1%) disagreed and 36.4% strongly disagreed while only 13.6% agreed with the statement that narrow level of income had no influence on the available sanitation options. A mean of 1.82, SD=0.604 showed that respondents generally disagreed with the statement. The findings suggested that residents' income levels had an influence on the choice of sanitation options available in the slums. The results were similar to findings in Africa, Kenya included by Orner and Mihelic (2018) who found out that poor urban dwellers preferred manual pit emptying practice for the management of faecal waste despite the associated health and environmental risk due to its affordable nature. Unhygienic and unsafe manual pit emptying practices could result to contamination of soils with faeces

containing diarrheal related pathogens such *Vibrio cholerae* which could infect the slum residents.

Participants were asked whether household type of toilet was determined by household level of income. Results showed that majority (52.2%) agreed and 46.1% strongly agreed to the statement that household level of income influenced the adoption of toilet design in the community. At a mean of 4.89, SD=0.292 respondents generally agreed with the statement. The findings implied that the sanitation status in slums was poor owing to the residents' inability to afford improved sanitation facilities. These results were also reported in the focus group discussion where a participant said:

> *"For pit emptying services we even accept instalment payment, however, a down payment must be made before we begin emptying. Most of our clients are poor and you can tell from the type of sanitation facilities they own. Most household prefer us to exhausters since our services are relatively affordable so when their toilets fill up we usually respond and do a good job for them."*

The results were confirmed in Malawi by Chunga *et al.* (2016) who reported that low income earners owned unimproved sanitation facilities. Adoption of unimproved sanitation facilities could result to contamination of the slum area with sanitation pathogens as a result of filled up toilets which remain unattended.

4.6.7 Influence of Ability and Willingness to Pay on Faecal Emptying, Conveyance and Disposal

The researcher desired to find out whether ability and willingness to pay for sanitation services influence faecal emptying, conveyance and disposal. Respondent were required to indicate their degree of agreement to the statement and findings were as shown in Table 4.29.

Table 4.29: Ability and Willingness to Pay

	Strongly Disagree	**Disagree**	**Moderate**	**Agree**	**Strongly Agree**	**Mean**	**Std. Dev**
I am willing to pay for emptying of my toilet	3(1.3%)	31(13.6%)	11(4.8%)	161(70.6%)	22(9.6%)	3.62	.547
I cannot afford to pay for construction of a new toilet	5(2.2%)	43(18.9%)	16(7.0%)	122(53.5%)	42(18.4%)	3.89	.618

Emptying of pits and transportation of faecal waste from on-site sanitation facilities to disposal site is associated with payment of servicing fee for effective management of the waste. However ability and willingness to pay for the service may deter hygienic faecal management interventions in low-income urban settlements. When asked whether they were willing to pay for emptying of toilets, majority (70.6%) agreed and 9.6% strongly agreed while only 13.6% disagreed with the statement that they were willing to pay for emptying of toilets. At a mean of 3.62, SD=0.547 participants generally agreed with the statement. The findings suggested that residents in the study area were willing to pay for pit emptying and transportation of the faecal waste from onsite sanitation facilities to designated disposal sites. The results were confirmed in Zambia by Holm *et al.* (2015) who found out that

household were willing to pay for on-site sanitation service. Findings from the discussions in the focus group also supported the study findings as indicated by respondents who said that;

> *"For pit emptying services we even accept installment payment, however, a down payment must be made before we begin emptying. Most of our clients are poor and you can tell from the type of sanitation facilities they own. Most household prefer us to exhausters since our services are relatively affordable so when their toilets fill up we usually respond and do a good job for them."*

The findings signaled that residents in Meru slums were mostly willing to pay for emptying services in response to the challenge of excreta accumulation in slums.

To understand how participants deemed the payment for sanitation services, participants were to indicate whether they could afford to pay for construction of a new toilet. At a mean of 3.89, SD=0.618 participants generally agreed. The findings implied that although respondents were willing to pay for on-site faecal waste management services, their ability to pay for the services were compromised as a result of their low income levels. The findings concurred with those of Orner and Mihelcic (2018) who found out that whereas mechanized pit emptying remained the most hygienic option of faecal waste management, manual pit emptying practice, which was cheaper, was common among low-income urban dwellers despite the associated health and environmental risk.

4.6.8 Summary on the Influence of Economic Factors on Faecal Emptying, Conveyance, and Disposal

Table 4.30 presents the summary of the descriptive statistics outcome in terms of mean and standard deviation.

Table 4. 30: Summary of Mean and Standard Deviation for Economic Factors

	N	Minimum	Maximum	Mean	Std. Deviation
Operational Cost	228	1.00	5.00	3.33	.593
Toilet Design	228	1.00	5.00	2.33	.725
Frequency of Desludging	228	1.00	5.00	3.44	.782
Access to Credit	228	1.00	5.00	3.27	.614
Charges in Relation to Space	228	1.00	5.00	4.52	.413
Level of Income	228	1.00	5.00	3.36	.569
Ability and Willingness and to pay	228	1.00	5.00	3.76	.427

The findings in Table 4.30 illustrate the average score responses on the influence of economic factors on faecal emptying, conveyance and disposal. In exception of the toilet design indicator with a mean of 2.33, SD=0.725 the rest of the factors had a mean of more than three implying that participants confirmed that the factors influenced faecal emptying, conveyance and disposal from on-site sanitation facilities. At the highest mean of 4.52, SD=0.413 participants agreed that charges in relation to space influenced faecal emptying, conveyance and disposal from on-site sanitation facilities, followed by ability and willingness to pay for sanitation services which had a mean of 3.76, SD=0.427, frequency of

desludging (mean=3.44, SD=0.782), level of income (mean=3.36, SD=0.569), operational cost (mean=3.33, SD=0.593) and access to credit (mean=3.27, SD=0.614)

4.7. Influence of Technological Suitability on Faecal Emptying, Conveyance, and Disposal

The study sought to examine the influence of technological suitability including compatibility with slabs, reliability, safety of emptiers and ability to handle pit contents on pit emptying options, transportation of faecal waste from on-site sanitation systems and disposal into designated sites.

4.7.1 Influence of Compatibility with Slabs on Faecal Emptying, Conveyance, and Disposal

Respondents were given several statements on compatibility with slab in a five-point likert scale to indicate their level of agreement to the influence of technological suitability on faecal emptying, conveyance and disposals as displayed in Table 4.31.

Table 4.31: Influence of Compatibility with Slabs on Faecal Emptying, Conveyance, and Disposal

	Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree	Mean	Std. Dev
The technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities is compatible with existing infrastructure and services, such as transportation networks and waste management facilities	22(9.6%)	77(33.8%)	56(24.6%)	52(22.8%)	21(9.2%)	2.67	.516
The technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities is environmentally sustainable and minimize negative impacts on the surrounding ecosystem	36(15.8%)	113(49.6%)	47(20.6%)	26(11.4%)	6(2.6%)	2.43	.629

Accumulated excreta in on-site sanitation facilities require practical solution in the process of emptying from filled up toilets, transportation of pit content from the facilities to designated disposal sites. When asked whether the technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities is compatible with existing infrastructure and services, many (33.8%) disagreed and 9.6% strongly disagreed while only 22.8% agreed with the statement. A mean of 2.67, SD=5.16 showed that respondents generally disagreed that the technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities is compatible with existing infrastructure and services, such as

transportation networks and waste management facilities. The results suggested that faecal emptying, conveyance, and disposal technology in the study area faced challenges in accessing faecal waste in pits due to the presence of toilets without lined substructure, weak slabs which could easily collapse and lack of manholes for emptying. The findings were confirmed in Uganda by Zzwa *et al* (2016) who reported that poor toilet designs influenced accumulation of faecal waste in pits and abandonment of filled toilets. Failure to address the challenge of excreta accumulation in low income urban areas could result to contamination of soils and water source with faecal waste from overflow of pit contents especially during rainy seasons. Contamination of soils and water with faecal waste could expose the urban population to the diarrheal related pathogens such as *Vibrio cholera*.

Regarding the environmental sustainability of faecal emptying, conveyance, and disposal technology, many (49.6%) disagreed and 15.8% strongly disagreed that the technology used was environmentally sustainable and minimize negative impacts on the surrounding ecosystem (mean=2.43, SD=0.629). The findings implied that narrow paths ways in unplanned settlement in the slum area limiting access to filled up toilets compelling the slum residents to adopt unhygienic practices such as the use of buckets for emptying toilets. The results were similar to the findings in Malawi by Chipeta *et al.* (2017) who established that mechanized faecal emptying technologies such as truck exhauster could not access filled up toilets due to poor road networks in unplanned urban settlement. Finding from the focused group discussions also supported the findings as reported by one of the respondents who said that:

"Community members can no longer ignore the challenge of filled up toilets, we have to embrace the practice of toilet emptying and transportation of pit content to disposal sites. However, it is essential for the emptying trucks used to be able to move in narrow paths in the slums. If the trucks require adjustment to address the challenges linked to faecal emptying it is important for the service providers to consider that."

The results suggested that although the slums present numerous challenges in regard to management of accumulated faecal waste it is vital that mechanized pit emptying options adjust to find their way through narrow pathways in the unplanned urban settlements. Failure of mechanized pit emptying options to access filled up pits in the slums due to narrow roads could result to adoption of unhygienic faecal management practices such as disposal of faecal waste into open drains resulting to contamination of water sources with helminthes species such as *Trichuris* and *Ascaris* which could have a negative health impact on the health of slum dwellers.

4.7.2 Influence of Reliability on Faecal Emptying, Conveyance, and Disposal

Respondents were asked to rate the statements gives in a five-point likert scale to reveal whether reliability influenced faecal emptying, conveyance and disposal. Results were as shown in Table 4.32.

Table 4. 32: Influence of Reliability on Faecal Emptying, Conveyance, and Disposal

	Strongly Disagree	**Disagree**	**Moderate**	**Agree**	**Strongly Agree**	**Mean**	**Std. Dev**
The technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities is reliable	67(29.4%)	89(39.0%)	47(20.6%)	16(7.0%)	9(3.9%)	2.18	.758
The technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities minimizes the risk of system failures or breakdowns	53(23.2%)	78(34.2%)	56(24.6%)	28(12.3%)	13(5.7%)	2.58	.817

Hygienic management of faecal waste is dependent on reliable mechanized emptying which guarantees continuous movement of pit content from on-site sanitation facilities to disposal site. When respondent were asked to rate the reliability of faecal emptying, conveyance, and disposal technologies majority (39%) disagreed and 29.4% strongly disagreed that the technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities was reliable and only 7% of the respondents agreed that the technology was reliable. The findings revealed that the technologies used for faecal emptying, conveyance, and disposal in the study area were unreliable due to the damage on suction pumps caused by unfriendly materials like plastics, textiles and pieces of metal dumped in pits. The results were similar to the findings in Tanzania by Jenkins et al. (2015) who reported that the availability and reliability of emptying technologies is vital in accelerating adoption of safe and hygienic faecal emptying, conveyance and disposal methods. Lack of technologically viable faecal emptying, conveyance and disposal methods could be a barrier to hygienic faecal

management practice compelling residents in slum areas to unhygienically dispose-off untreated excreta into the environment. Untreated excreta could contain diarrheal related pathogens exposing residents to diseases such as dysentery and cholera.

Respondents were also requested to rate the technical capacity of faecal emptying, conveyance, and disposal technology in regard to system failures and breakdown. Results showed that 34.2% disagreed and 23.2% strongly disagreed while only 12.3% agreed that the technology used minimizes the risk of system failures or breakdowns. A mean of 2.58, SD=0.817 suggested that faecal emptying, conveyance, and disposal technologies were prone breakdown due to system failures elevating the burden of accumulated excreta in slum areas due to the increased number of unattended filled up toilets. The inability to deal with the large volume of faecal waste by mechanical emptying service providers could result to unhygienic disposal of fresh faecal waste in open drains and storm water by slum residence in response to the challenge of filled up toilets. Disposal of fresh faecal waste in open drains could endanger the lives of slum children who could contract polio as well as diarrheal diseases. The results were similar to the findings in Sub-Saharan Africa, Kenya included by Peal *et al*. (2020) who reported that contents in on-site sanitation facilities in Sub- Sahran Africa remain unemptied resulting to overflow of faecal waste to the environment.

4.7.3 Influence of Safety of Emptiers on Faecal Emptying, Conveyance, and Disposal

Respondents were given statements on safety of emptiers in a five-point likert scale to indicate their level of agreement to the influence of technological suitability on faecal emptying, conveyance and disposals as displayed in Table 4.33

Table 4.33: Influence of Safety of Emptiers on Faecal Emptying, Conveyance, and Disposal

	Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree	Mean	Std. Dev
The technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities is safe and hygienic for users and service providers	43(18.9%)	111(48.7%)	53(23.2%)	19(8.3%)	2(0.9%)	1.91	.661
The technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities is user-friendly and considerate of cultural and social norms	27(11.8%)	136(59.6%)	44(19.3%)	20(8.8%)	1(0.4%)	2.26	.617

It is essential that pit emptying and transportation services of faecal waste from on-site sanitation facilities to designated disposal site are deemed safe and culturally acceptable to users in regard to adoption and sustainability of the technology. When participants were asked about the safety of faecal emptying, conveyance, and disposal technology in the slums, majority (48.7%) disagreed and 18.9% strongly disagreed that the technology was safe and hygienic for users and service providers (mean=1.91, SD=0.661). The findings suggested that pit emptying and transportation services of faecal waste from filled up on-site sanitation facilities exposed operators to the risk of injury and infection of sanitation related disease such as cholera since their health and lives remain at stake while they offer solutions to the challenge of excreta accumulation in pits. The results were confirmed by findings in Zambia by Tembo *et al.* (2019) who found out that manual pit emptying operators were

exposed to the risk of injury, health complication and loss of life to on-site containments dipper than 1.5 meters.

At a mean of 2.26, SD=0.617, the technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities was reported not friendly to users and inconsiderate of the cultural and social norms. Findings implied that the process of emptying, transporting and disposal of faecal waste from onsite sanitation systems in Meru slums was contrary to the practice of burying faecal matter in the ground to prevent its visibility and exposure to the environment as revealed from the focus group discussion where a respondent said that:

> *"Although the process of emptying toilets using backets leaves the compound filled with faecal waste and attract flies the use of vacuum trucks also contaminates the environment with faecal waste though in the faecal waste spillage is minimal still it's unacceptable to expose human waste on open ground since we are likely to get sick from diarrheal diseases."*

The findings were confirmed in Mozambique by Capone *et al.* (2019) who found out that manual pit emptying technologies were considered unhygienic due to the inevitable spillage of excreta in the environment during pit emptying process. Unsafe and unhygienic pit emptying technologies could expose the faecal handlers and the public to the risk of helminthes infection owing to the pathogenic state of faecal sludge.

4.7.4 Influence of Ability to Handle Pit Contents on Faecal Emptying, Conveyance, and Disposal

The researcher sought to examine whether ability to handle pit contents influenced faecal emptying, conveyance and disposal. Respondents were require to rate the statement and findings were presented in Table 4.34.

Table 4. 34: Influence of Ability to Handle Pit Contents on Faecal Emptying, Conveyance, and Disposal

	Strongly Disagree	**Disagree**	**Moderate**	**Agree**	**Strongly Agree**	**Mean**	**Std. Dev**
The technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities is adaptable to different types of waste, including solid and liquid waste	74(32.5%)	61(26.8%)	81(35.5%)	12(5.3%)	0(0.0%)	2.41	.869

Pit emptying and transportation services of faecal waste from filled up on-site sanitation facilities to disposal site require a reliable faecal management technologies in address the challenge of indiscriminate disposal of household waste in pits. When asked to indicate whether faecal emptying, conveyance, and disposal technology was adaptable to different types of waste, including solid and liquid waste from on-site sanitation facilities, majority (32.5%) strongly disagreed and 26.8% disagreed with the statement at a cumulative mean of 2.41, SD=0.869. The findings from the study revealed that the technology adopted in the slums of Meru was limited in addressing the challenge of pit contents in the toilets in regard to faecal emptying, conveyance and disposal. The results were similar to the findings Malawi by Chiposa *et al.* (2017) who found out that poor quality of material deposits in pits

including plastics, glass, stones, metals and cloths compromise the effectiveness of vacuum pumps in handling faecal sludge by blocking and damaging the pumps. Findings from the focus group discussions also revealed that pit operators impose high fees on emptying of pits due to the challenge of indiscriminate disposal of waste in pits.

> *"Manual pit emptying is the most preferred in the community since the use of buckets ensure removal of all pit content regardless of it nature. The problem with the track exhausters is that they charge a lot of money and their machines cannot remove all the pit content in pits. They usually refuse to exhaust pits for fear that people dump dangerous materials in the pits which could break their pumps."*

The results suggest that for efficiency in regards to pit emptying the population in the study area resolved to manual pit emptying which was affordable despite its unhygienic and unsafe nature to both pit operators and the environment. The results were similar to the findings in India by Prasad and Ray (2019) who reported that high toilet emptying fee encouraged disposal of faeces in open drains which exposed the population to helminthes infections.

From the quantitative and qualitative data analysis, it can be indirectly inferred that technological suitability influences faecal emptying, conveyance, and disposal in Meru slums.

4.7.5 Summary on the Influence of Technological Suitability on Faecal Emptying, Conveyance, and Disposal

Table 4.35. presents the summary of the outcome of the descriptive statistics in terms of mean and standard deviation.

Table 4.35: Summary of Mean and Standard Deviation for Technological Suitability

	N	Minimum	Maximum	Mean	Std. Deviation
Compatibility with Slabs	228	1.00	5.00	2.55	.728
Reliability	228	1.00	5.00	2.38	.694
Safety of Pit Emptiers	228	1.00	5.00	2.09	.811
Ability to Handle Pit Contents	228	1.00	5.00	2.41	.869

The results in Table 4.35 show that on compatibility with slabs with a mean of 2.55, the respondents disagreed, showing that faecal emptying, conveyance, and disposal technology in the study area faced challenges in accessing faecal waste in pits due to the presence of toilets without lined substructure, weak slabs which could easily collapse and lack of manholes for emptying. On reliability, with a mean of 2.38, respondents disagreed, this shows that the technical capacity of the people tasked with the role of faecal emptying, conveyance, and disposal was low and unreliable due to the damage on suction pumps caused by unfriendly materials like plastics, textiles and pieces of metal dumped in pits which left most of pumps disfunctional. On safety of pit emptiers, with a mean of 2.09, respondents disagreed, implying that respondents considered that pit emptying and transportation services of faecal waste from filled up on-site sanitation facilities exposed operators to the risk of injury and infection of sanitation related disease such as cholera since

their health and lives remain at stake while they offer solutions to the challenge of excreta accumulation in pits. Lastly, on ability to handle pit contents, with a mean of 2.41, respondents disagreed, this indicated that the process of faecal emptying, conveyance, and disposal services were limited in addressing the challenge of pit contents in the toilets compelling slum residents to resolve to manual pit emptying practices which were hygienic and exposed the slum residents to the risk of contracting sanitation related illnesses such as cholera.

4.8. Inferential Analysis

This section presents associations in terms of correlation and regression of the variables. This will help in providing answers to the research questions. Correlations between the indicators of the dependent variable and those of the independent variables is analyzed in the first subsection, looks while the next section will consider the regressions of the dependent variable on each of the independent variables so as to determine their individual contributions on the changes in the dependent variable.

4.8.1. Correlation Analysis

To ascertain the association strength between indicators of the independent variables and the indicators of the dependent variables, Pearson correlation coefficient was computed and the findings presented in the subsections that follows.

i. Correlation of Social Factors and Faecal Emptying, Conveyance, and Disposal

To provide a partial answer to the first objective of the research, a correlation analysis of Pearson nature was sought so as to establish the strength of association between the

indicators of social factors and those of faecal emptying, conveyance, and disposal. The findings are presented in Table 4.36.

Table 4.36: Correlation of Social Factors Indicators and Faecal Emptying, Conveyance, and Disposal Indicators

			Faecal Emptying, Conveyance, and Disposal		
			Emptying	Conveyance	Disposal
SOCIAL FACTORS	Access to emptying provisions	Pearson Correlation	.406**	.246**	.226**
		Sig. (2-tailed)	.000	.000	.001
		N	228	228	228
	Awareness	Pearson Correlation	.268**	.271**	.396**
		Sig. (2-tailed)	.000	.000	.000
		N	228	228	228
	Taboos	Pearson Correlation	-.506**	.439**	.509**
		Sig. (2-tailed)	.000	.000	.000
		N	228	228	228
	Material disposed in pit	Pearson Correlation	-.761**	-.149**	-.332**
		Sig. (2-tailed)	.000	.000	.000
		N	228	228	228
	Population size	Pearson Correlation	-.256**	.014	.059
		Sig. (2-tailed)	.000	.053	.112
		N	228	228	228

Social factors was conceptualized in terms of access to emptying provisions, awareness, population size, material disposed in pits and taboos, while the dependent variable which is faecal emptying, conveyance, and disposal was conceptualized in terms of emptying,

conveyance, and disposal. The findings in Table 4.36 show that the access to emptying provisions has a moderate positive (0.406,0.000) association that is significant with emptying, the association between emptying and both conveyance and disposal was significant but weak, as indicated by correlation of 0.246 and 0.226 respectively. Secondly, the association between awareness and disposal was moderate positive (0.396,0.000), while the association between both emptying and conveyance was weak positive and significant, with coefficients of 0.268 and 0.271 respectively. Taboos has a negative association (-0.506) with faecal emptying and a moderate positive association that is significant with conveyance and disposal, as shown by correlation coefficients of 0.439, and 0.509 respectively. Material deposited in the pit has a very strong significant negative association (-0.761) with faecal emptying, a very weak significant negative association (-0.149) with faecal conveyance, and a weak significant inverse nexus (-0.332) with faecal disposal. Population size was only significantly associated with faecal emptying (-0.256) in a negative way, it was not significantly associated with faecal conveyance and faecal disposal.

The first objective of the study, however, sought to establish the influence of social factors on faecal emptying, conveyance, and disposal. To partially achieve this, a correlation coefficient was generated and the findings presented in Table 4.37.

Table 4.37: Correlation Analysis of Social Factors and Faecal Emptying, Conveyance, and Disposal

		Faecal Emptying, Conveyance, and Disposal
Social Factors	Pearson Correlation	0.595*
	Sig. (2-tailed)	0.000
	N	228

The findings in Table 4.37 show that a strong significant positive correlation exists between social factors and faecal emptying, conveyance, and disposal. Hence it is inferred that improvement in social factors results in improvement in faecal emptying, conveyance, and disposal.

ii. Correlation of Economic Factors and Faecal Emptying, Conveyance, and Disposal

To partially answer the second research question, the study sought to determine the strength and direction of association between economic factors and faecal emptying, conveyance, and disposal. This was done by first finding the association between indicators of economic factors and indicators of faecal emptying, conveyance, and disposal. The findings are shown in Table 4.38.

Table 4.38: Correlation between Economic Factors Indicators and Faecal Emptying, Conveyance, and Disposal

			FAECAL EMPTYING, CONVEYANCE, AND DISPOSAL		
			Emptying	Conveyance	Disposal
ECONOMIC FACTORS	Operational cost	Pearson Correlation	.499**	.330**	.370**
		Sig. (2-tailed)	.000	.000	.000
		N	228	228	228
	Access to credit	Pearson Correlation	.179**	.096**	.009
		Sig. (2-tailed)	.007	.047	.891
		N	228	228	228
	Toilet design	Pearson Correlation	.627**	.283	.158
		Sig. (2-tailed)	.000	.099	.129
		N	228	228	228
	Frequency of desludging	Pearson Correlation	.044	.003	.015
		Sig. (2-tailed)	.092	.193	.081
		N	228	228	228
	Charges in relation to space availability	Pearson Correlation	.747**	.129**	.028**
		Sig. (2-tailed)	.000	.009	.032
		N	228	228	228
	Level of Income	Pearson Correlation	.679**	.491**	.372**
		Sig. (2-tailed)	.002	.001	.012
		N	228	228	228
	Ability and willingness to pay	Pearson Correlation	.447**	.291**	.508**
		Sig. (2-tailed)	.000	.000	.000
		N	228	228	228

Economic factors was conceptualized in terms of operational cost, access to credit, ability and willingness to pay, level of income, toilet design, frequency of desludging and charges in relation to space availability while the dependent variable which is faecal emptying, conveyance, and disposal was conceptualized in terms of emptying, conveyance, and disposal. The findings in Table 4.38 show that operational cost had a moderate positive significant association with all the indicators of the dependent variable, that is, faecal emptying, conveyance, and disposal, with coefficients 0.499, 0.330, and 0.370 respectively. Access to credit on the other hand, was only significantly associated with emptying, in a weak positive way (0.179,0.007) and faecal conveyance, positively too (0.96,0.047). The correlation between access to credit and disposal was not significant. The association between toilet design and faecal emptying (0.627,0.000), was the only significant one, this strongly positive association shows that the way a toilet is designed is key during the emptying process. The design of a toilet was not correlated with faecal conveyance and faecal disposal. Frequency of desludging did not have a significant association with any of the indicators of the dependent variable. Charges in relation to space had the greatest association with faecal emptying (0.747), and it was weakly correlated with both faecal conveyance (0.129) and faecal emptying (0.028). Level of income had a strong positive association that was significant (0.679) with faecal emptying, while it was moderately associated with faecal conveyance (0.491) and faecal disposal (0.372). Lastly, ability and willingness to pay, had a significant positive association with faecal emptying (0.447,0.000), faecal conveyance (0.291,0.000), and faecal disposal (0.508), which was the greatest.

Since the second objective sought to assess the influence of economic factors on faecal emptying, conveyance, and disposal, a correlation coefficient between economic factors and human faecal management was generated and the result presented in Table 4.39.

Table 4.39: Correlation between Economic Factors and Faecal Emptying, Conveyance, and Disposal

		Faecal Emptying, Conveyance, and Disposal
Economic Factors	Pearson Correlation	0.539*
	Sig. (2-tailed)	0.000
	N	228

Table 4.39 shows the result of the correlational analysis based on the Karl Pearson technique to establish the connection between economic factors and faecal emptying, conveyance, and disposal. The findings reveal the existence of a moderate significant correlation (0.539) that is positive between the two variables. The p-value of 0.000 < 0.05 indicates that the computed coefficient of correlation is significant, implying that improvement in the economic factors is positively associated with a rise in the faecal emptying, conveyance, and disposal.

iii. Correlation of Technological Factors and Faecal Emptying, Conveyance, and Disposal

To partially answer the third research question, the study sought to determine the strength and direction of association between technological factors and faecal emptying, conveyance, and disposal. This was done by first finding the association between indicators of status of faecal management facilities and indicators of human faecal management. The findings are shown in Table 4.40.

Table 4.40: Correlation between Technological Factors Indicators and Faecal Emptying, Conveyance, and Disposal

			FAECAL EMPTYING, CONVEYANCE, AND DISPOSAL		
			Emptying	**Conveyance**	**Disposal**
TECHNOLOGICAL FACTORS	Compatibility with slabs	Pearson Correlation	.347**	.228**	.279**
		Sig. (2-tailed)	.000	.001	.000
		N	228	228	228
	Safety of emptiers	Pearson Correlation	.063	.116	.181**
		Sig. (2-tailed)	.347	.080	.006
		N	228	228	228
	Ability to handle pit content	Pearson Correlation	.066	.055	.151*
		Sig. (2-tailed)	.325	.406	.022
		N	228	228	228
	Reliability	Pearson Correlation	.649**	.728**	.791**
		Sig. (2-tailed)	.000	.001	.000
		N	228	228	228

Technological factors was conceptualized in terms of compatibility with slabs, safety of emptiers, reliability and ability to handle pit contents, while the dependent variable which is faecal emptying, conveyance, and disposal was conceptualized in terms of emptying, conveyance, and disposal. The findings in Table 4.40 indicate that compatibility with slab had a significant moderate positive association with emptying (0.347,0.000), while it had a weak positive significant association with both conveyance (0.228,0.001) and disposal (0.279,0.000). Safety of emptiers on the flipside was only significantly associated with disposal (0.181,0.006). Ability to handle pit content was also only significantly associated

weakly with disposal (0.151,0.022). Lastly, reliability, had a strong positive significant association with faecal emptying (0.649,0.000), faecal conveyance (0.728,0.001), and faecal disposal (0.791,0.000).

Since the third objective sought to establish the influence of technological factors on faecal emptying, conveyance, and disposal, a correlation coefficient between technological factors and faecal emptying, conveyance, and disposal, was generated and the result presented in Table 4.41.

Table 4.41: Correlation between Technological Factors on Faecal Emptying, Conveyance, and Disposal.

		Faecal Emptying, Conveyance, and Disposal
Technological Factors	Pearson Correlation	0.270*
	Sig. (2-tailed)	0.000
	N	228

Table 4.41 shows the outcome of the correlational analysis based on the Karl Pearson technique to examine the connection between technological factors and faecal emptying, conveyance, and disposal. The findings reveal the presence of a weak significant correlation (0.270) that is positive between the two variables. The p-value of $0.000 < 0.05$ indicates that the computed coefficient of correlation is significant, implying that improvement in the technological factors is positively associated with improvement in faecal emptying, conveyance, and disposal.

4.8.2. Regression Analysis

To further answer the research questions, the study sought to establish the contribution of the independent variable on the dependent variable, in addition to establishing the prediction power of the dependent variables. This was done by use of regression analysis as follows.

i. Regression of Social Factors on Faecal Emptying, Conveyance, and Disposal.

To assess the influence of the indicators of social factors on the indicators of faecal emptying, conveyance, and disposal, several linear regression analyses were conducted and the findings summarized in Table 4.42.

Table 4.42: Regression of Social Factors Indicators on Faecal Emptying, Conveyance, and Disposal Indicators

			Emptying	Conveyance	Disposal
Social Factors	Access to emptying provisions	Beta	0.137	0.053	0.044
		p-value	0.000	0.098	0.118
		R^2	0.165	0.061	0.051
	Taboos	Beta	0.182	0.171	0.207
		p-value	0.014	0.000	0.000
		R^2	0.256	0.193	0.259
	Material disposed	Beta	-0.486	-0.063	-0.095
		p-value	0.000	0.162	0.047
		R^2	0.579	0.022	0.110
	Population size	Beta	0.059	0.009	0.058
		p-value	0.078	0.169	0.417
		R^2	0.066	0.000	0.003
	Awareness	Beta	0.067	0.069	0.138
		p-value	0.028	0.081	0.052
		R^2	0.072	0.073	0.157

The findings in Table 4.42 give the beta coefficients, that is, the contribution of each indicator of social factors on the indicators of faecal emptying, conveyance, and disposal. Access to emptying provisions has a positive significant contribution on faecal emptying only (0.137). Taboos significantly contribute positively to faecal emptying (0.182), faecal conveyance (0.171), and faecal disposal (0.207). Materials deposited in pit toilet has a significant negative contribution on both faecal emptying (-0.486) and faecal disposal (-0.095), the contribution to faecal conveyance is however insignificant (-0.063,0.162). Population size has no significant contribution on any of the three. Awareness, significantly contributes to faecal emptying in a positive way (0.067,0.028) but had no significant contribution on faecal conveyance (0.069,0.081) and faecal disposal (0.138,0.052).

Based on the value of the coefficient of determination (R^2), access to emptying provisions had the greatest explanatory power (16.5%) on faecal emptying, Taboos had the greatest explanatory power (25.9%) on faecal disposal, material deposited in toilet pit had the greatest explanatory power (57.9%) on faecal emptying, population size explained 6.6% of the variation in faecal emptying, and awareness explained 15.7% of changes in faecal disposal.

To answer the first research question, where the study sought to determine the overall contribution of social factors on faecal emptying, conveyance, and disposal, an overall regression analysis was done and are shown in Table 4.43.

Table 4.43: Regression Coefficient of Social Factors and Faecal Emptying, Conveyance, and Disposal.

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.401	0.152		6.091	0.000
	Social Factors	0.454	0.097	0.417	27.693	0.000

a. Dependent Variable: Faecal Emptying, Conveyance, and Disposal

The simple linear regression results in Table 4.43 demonstrate that social factors significantly influence faecal emptying, conveyance, and disposal. The coefficient of the constant term ($\beta_0 = 0.401, p = 0.000 < 0.05$) and social factors ($\beta_1 = 0.454, p = 0.000 < 0.05$) are both statistically significant. Therefore, the model of regression for human faecal management on social factors is given by

$$Y = 0.401 + 0.454X \quad (4.1)$$

indicating that for each change of one unit in social factors, faecal emptying, conveyance, and disposal is marginally transformed by 0.454 units. It was therefore, concluded that social factors and faecal emptying, conveyance, and disposal have a positive linearly association.

Regarding the proportion of change in faecal emptying, conveyance, and disposal that can be accounted for by social factors. A model summary from the regression was generated and presented in Table 4.44.

Table 4. 44: Model Summary of Social Factors and Faecal Emptying, Conveyance, and Disposal.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.595[a]	0.354	0.349	0.017	0.348	456.897	1	226	0.000

a. Predictors: (Constant), Social Factors

Based on the outcome of the analysis which is displayed in table 4.44, social factors as a predictor variable explains 35.4% of the change in faecal emptying, conveyance, and disposal. Since the conveyed p-value is 0.000 which falls below 0.05 significance level, it is then concluded that the value is significant. The remaining 64.9% of the change in faecal emptying, conveyance, and disposal can be attributed to other variables.

ii. Regression of Economic Factors on Faecal Emptying, Conveyance, and Disposal.

To determine the influence of the indicators of economic factors on the indicators of faecal emptying, conveyance, and disposal, several linear regression analyses were conducted and the findings summarized in Table 4.45.

Table 4.45: Regression of Economic Factors Indicators on Faecal Emptying, Conveyance, and Disposal Indicators

			Emptying	**Conveyance**	**Disposal**
Economic Factors	Operational cost	Beta	0.124	0.098	0.197
		p-value	0.038	0.029	0.002
		R^2	0.137	0.109	0.242
	Access to credit	Beta	0.027	0.008	0.007
		p-value	0.006	0.117	0.318
		R^2	0.032	0.009	0.000
	Toilet design	Beta	0.321	0.069	0.017
		p-value	0.000	0.057	0.074
		R^2	0.393	0.080	0.025
	Frequency of desludging	Beta	0.004	0.007	0.004
		p-value	0.181	0.169	0.189

	R^2	0.002	0.000	0.000
Charges in relation to Space	Beta	0.524	0.007	0.012
	p-value	0.000	0.096	0.361
	R^2	0.558	0.017	0.000
Level of Income	Beta	0.397	0.229	0.097
	p-value	0.002	0.001	0.021
	R^2	0.461	0.241	0.138
Ability and willingness	Beta	0.176	0.063	0.191
	p-value	0.017	0.104	0.010
	R^2	0.200	0.085	0.258

The findings in table 4.45 give the beta coefficients, that is, the contribution of each indicator of economic factors on the indicators of faecal emptying, conveyance, and disposal. Operational cost had the greatest significant contribution on faecal disposal (0.197), access to credit was a significant contributor to faecal emptying only (0.027), toilet design contributed significantly to faecal emptying only (0.321), frequency of desludging did not have a significant contribution on any of the variables, charges in relation to space had a significant contribution on faecal emptying only (0.524), and lastly level of income significantly contributed to faecal emptying (0.397), faecal conveyance (0.229), and faecal disposal (0.097), the contribution was greatest on faecal emptying, and lastly, ability and willingness to pay had significant positive contributions on faecal emptying (0.176) and faecal disposal (0.191), it however did not have significant contribution on faecal conveyance as indicated by the p-value of the beta coefficient being greater than 0.05 (0.063,0.104>0.05).

Based on the value of the coefficient of determination (R^2), operational cost had the greatest explanatory power (24.2%) on faecal disposal, access to credit had the greatest explanatory power (3.2%) on faecal emptying, toilet design had the greatest explanatory power (39.3%) on faecal emptying, charges in relation to space explained 55.8% of the variation in faecal

emptying, and level of income explained 46.1% of changes in faecal emptying, frequency of desludging has no explanatory power on faecal emptying, conveyance, and disposal. Lastly, ability and willingness to pay significantly explained 20.0% of variations in faecal emptying and 25.8% of variations in faecal disposal.

To answer the second research question, where the study sought to determine the overall contribution of economic factors on faecal emptying, conveyance, and disposal. An overall regression analysis was done and are shown in Table 4.46.

Table 4.46: Regression Coefficient of Economic Factors and Faecal Emptying, Conveyance, and Disposal.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.596	0.228		7.003	0.000
	Economic Factors	0.615	0.227	0.597	25.998	0.001

a. Dependent Variable: Faecal Emptying, Conveyance, and Disposal

The simple linear regression results in Table 4.46 demonstrate that economic factors significantly influence faecal emptying, conveyance, and disposal. The coefficient of the constant term ($\beta_0 = 0.596, p = 0.000 < 0.05$) and economic factors ($\beta_1 = 0.615, p = 0.000 < 0.05$) are both statistically significant. Therefore, the model of regression for faecal emptying, conveyance, and disposal on economic factors is given by

$$Y = 0.596 + 0.615X \quad (4.2)$$

indicating that for each change of one unit in economic factors, faecal emptying, conveyance, and disposal is marginally transformed by 0.615 units. It was therefore,

concluded that economic factors and faecal emptying, conveyance, and disposal have a positive linearly association.

Regarding the proportion of change in faecal emptying, conveyance, and disposal that can be accounted for by economic factors. A model summary from the regression was generated and presented in table 4.47.

Table 4.47: Model Summary of Economic Factors and Faecal Emptying, Conveyance, and Disposal.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.539[a]	0.290	0.283	0.009	0.282	615.897	1	226	0.000

a. Predictors: (Constant), Economic Factors

Based on the outcome of the analysis which is displayed in Table 4.47, economic factors as a predictor variable explains 29.0% of the change in faecal emptying, conveyance, and disposal. Since the conveyed p-value is 0.000 which falls below 0.05 significance level, it is then concluded that the value is significant. The remaining 71.0% of the changes in faecal emptying, conveyance, and disposal can be attributed to other variables.

iii. Regression of Technological Suitability on Faecal Emptying, Conveyance, and Disposal.

To assess the influence of the indicators of technological suitability on the indicators of faecal emptying, conveyance, and disposal, several linear regression analyses were conducted and the findings summarized in Table 4.48.

Table 4.48: Regression of Technological Suitability Indicators on Faecal Emptying, Conveyance, and Disposal Indicators

			Emptying	Conveyance	Disposal
Technological suitability	Compatibility with slabs	Beta	0.114	0.044	0.071
		p-value	0.002	0.017	0.002
		R^2	0.120	0.052	0.078
	Safety of emptiers	Beta	0.007	0.011	0.022
		p-value	0.068	0.210	0.047
		R^2	0.004	0.013	0.033
	Ability to handle pit content	Beta	0.003	0.003	0.019
		p-value	0.218	0.331	0.042
		R^2	0.004	0.003	0.023
	Reliability	Beta	0.399	0.497	0.562
		p-value	0.000	0.000	0.000
		R^2	0.421	0.530	0.626

The findings in Table 4.48 give the beta coefficients, that is, the contribution of each indicator of economic factors on the indicators of faecal emptying, conveyance, and disposal. Compatibility with slabs had the greatest significant contribution on faecal emptying (0.120), ability to handle pit contents was a significant contributor to faecal disposal only (0.019), and reliability contributed significantly to all but the greatest contribution was on faecal disposal (0.562), lastly, safety of emptiers contributed significantly to faecal disposal (0.022).

Based on the value of the coefficient of determination (R^2), compatibility with slab had the greatest explanatory power (12.0%) on faecal emptying, safety of emptiers had the greatest explanatory power (3.3%) on faecal disposal, ability to handle pit contents had the greatest explanatory power (2.3%) on faecal disposal, and lastly, reliability explained greater variations in faecal disposal (62.6%0 as compared to faecal conveyance (53.0%) and faecal emptying (42.1%).

To answer the third research question, where the study sought to determine the overall contribution of technological suitability on faecal emptying, conveyance and disposal. An overall regression analysis was done and are shown in Table 4.49.

Table 4.49: Regression Coefficient of Technological Suitability and Faecal Emptying, Conveyance, and Disposal.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.611	0.009		5.982	0.005
	Technological Suitability	0.177	0.106	0.168	27.116	0.000

a. Dependent Variable: Faecal Emptying, Conveyance, and Disposal

The simple linear regression results in Table 4.49 demonstrate that technological suitability significantly influences faecal emptying, conveyance, and disposal. The coefficient of the constant term ($\beta_0 = 0.611, p = 0.000 < 0.05$) and technological suitability ($\beta_1 = 0.177, p = 0.000 < 0.05$) are both statistically significant. Therefore, the model of regression for faecal emptying, conveyance, and disposal on economic factors is given by

$$Y = 0.611 + 0.177X \quad (4.3)$$

indicating that for each change of one unit in technological suitability, faecal emptying, conveyance, and disposal is marginally transformed by 0.177 units. It was therefore, concluded that technological suitability and faecal emptying, conveyance, and disposal have a positive linearly association.

Regarding the proportion of change in faecal emptying, conveyance, and disposal that can be accounted for by technological suitability. A model summary from the regression was generated and presented in Table 4.50.

Table 4.50: Model Summary of Economic Factors and Faecal Emptying, Conveyance, and Disposal.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.270[a]	0.073	0.071	0.011	0.073	573.332	1	226	0.000

a. Predictors: (Constant), Technological Suitability

Based on the outcome of the analysis which is displayed in Table 4.50 technological suitability as a predictor variable explains 7.3% of the change in faecal emptying, conveyance, and disposal. Since the conveyed p-value is 0.000 which falls below 0.05 significance level, it is then concluded that the value is significant. The remaining 92.7% of the changes in faecal emptying, conveyance, and disposal can be attributed to other variables. These findings are in line with the findings of Tembo *et al.*, (2019) who argued that technology plays a big part in the emptying and disposal of human waste.

CHAPTER FIVE

5.0 CONCLUSION, RECOMMENDATIONS AND PUBLICATION

5.1. Introduction

The chapter presents conclusions and recommendations based on the research objectives as follows: On social factors which measured accessibility to emptying provisions, taboos on faecal handling, materials disposed in pits, population size and awareness. Economic factors were measured operational cost, household level of income, toilet design, household ability and willingness to pay, frequency of desludging pit latrines, access to credit for sanitation services and charges in relation to space availability. The objective to assess technological suitability was measured by examination of compatibility with slabs for emptying, ability and reliability to handle pit contents manually or mechanically and safety of pit emptiers depending on the choice of technology.

5.2.Conclusion

The study concluded that the unhygienic status of toilets in the study area evident by toilets with pit contents above one meter from the slab, odour from the pits and flies infested toilets suggested that toilets in the study area were poorly maintained contributed to the adoption of unfriendly toilets among slum dwellers. Unfriendly toilets could deprive users specifically women, children the elderly and the physical challenged members of the community who are most vulnerable in regard to poor sanitation conditions of their basic need of access to decent sanitation which accommodate their sanitation needs. As well poor sanitation practices which do not address the challenge of accumulated excreta in pit toilets could expose the slum community to the risk of interacting with excreta through sanitation disease

vectors like flies a potential source of sanitation disease outbreaks such as cholera. The results were similar to the finding in Malawi by Chunga *et al.* (2016) who reported that low-income urban dwellers used toilets characterized by odour and flies due to irregular maintenance of sanitation facilities overwhelmed by the challenge of accumulated excreta in pits.

From the study findings it can be concluded that social factors like materials disposed in pits, access to emptying provisions in toilets and population size influenced faecal emptying, conveyance and disposal. The type of materials disposed in toilets could result in high filling rate of toilet pits with limited provisions for emptying leaving the slum dwellers with inadequate accessing to toilet facilities. The results were confirmed in Malawi by Chiposa *et al.* (2017) who reported constrained emptying of faeces from toilets which were used for disposal of household domestic waste. Emptying of toilets is dependent on the accessibility of pit contents through pathways to sanitation facilities and provisions on the slab to pave way for either manual removal of accumulated faecal waste from pits or sanction of pit contents through the use of vacuum pumps. However, the study findings revealed that on-site sanitation facilities were not easily accessible for both manual pit emptiers and exhausters due to narrow paths that deterred movement of vacuum trucks for emptying. The findings were confirmed in Uganda by Nantongo (2022) who reported that hygienic emptying of toilets in slums through mechanized options was limited due to the inaccessibility of filled up toilets.

Findings from the study concluded that social factors such as the size of population influenced faecal emptying, conveyance and disposal from on-site sanitation facilities. Large population size could result in overcrowding in toilets hence a high user capacity among the

available on-site sanitation facility which may result to high filling rate of the available toilets in the study area. Overpopulation burden in unplanned urban settlements could result to unhygienic faecal waste management practices such as manual emptying of pits and disposal of faecal waste in water source and open drains due to the high filling rates of toilets which could require toilet owners to frequently empty their toilets. The results of the study were similar to the findings in Uganda by Odagiri *et al.* (2021) who found out that high user capacity on sanitation infrastructure was associated with high filling rate of on-site sanitation facilities. Release of untreated faecal waste in open drains could results to contamination of water sources with sanitation pathogens such as polio viruses associated with life threatening sanitation epidemic such as poliomyelitis which could result to paralysis among under five years children in slum areas.

Further, the study concluded that economic factors such as level of income, charges in relation to space availability and operational cost influenced faecal emptying, conveyance and disposal in Meru slums. The level of income of an individual could define faecal emptying conveyance and disposal determinants such as type of toilets and emptying technology. Low income levels among slum dwellers contributed to the adoption of poor toilet designs which limit access to pit contents to allow for emptying of filled up toilets. Similar findings were reported in Malawi by Chunga *et al.* (2016) who found out that low-income household adopted unimproved sanitation designs which constrained hygienic empting. Hygienic faecal waste management is dependent on space however, the use of sanitation facilities which do not guarantee safe emptying conveyance and disposal of faecal waste could result to frequent demolishing of the slab which could compromise the durability of toilets. Demolishing of sanitation facilities during emptying could increase the

cost of servicing toilets which could ultimately succumb to collapse as a result of structural weaknesses. The influence of charges in relation to space availability on faecal waste management in toilets was confirmed by Chipeta *et al.* (2017) in Malawi.

The study findings concluded that economic factors such as operational cost influenced faecal emptying, conveyance and disposal from on-site sanitation facilities. Operational cost equates to the total amount incurred in the process of emptying and transportation of faecal waste from onsite sanitation facilities to designated disposal sites. Findings from the study revealed that poor sanitation designs adopted by households was associated with high operational cost making the overall cost of faecal management in slums unaffordable to residents. The results were similar to the findings in Tanzania by Jenkins et al. (2015) who reported that operational cost in regard to faecal emptying, conveyance and disposal was generally high among household owners using unimproved sanitation facilities. Failure of slum dwellers to meet the cost of emptying, conveyance and disposal of faecal waste from their toilets could results to the use of unhygienic faecal waste management practices such as release of faecal waste in open drains and run-offs especially during rainy seasons which could result to the outbreak of diarrheal infections such as typhoid.

From the study findings it can be concluded that technological suitability factors like the ability to handle pit contents, compatibility with slabs and safety of emptiers influenced faecal emptying, conveyance and disposal from on-site sanitation facilities. The use of toilets for disposal of hazardous household waste such as plastic, glasses and metal pieces could limit the use of mechanized emptying technologies for emptying of on-site sanitation facilities for fear of damage to vacuum pumps. The results were confirmed in India by Prasad and Ray (2019) who reported that high toilet emptying fee imposed by sanitation

service providers limited low-income earners from using mechanized faecal emptying options. The wide adoption of unimproved sanitation facilities in slums without provision of manholes for emptying could strain emptying interventions towards managements of accumulated faecal waste in slum toilets. Emptying of toilets require provision of access aperture for removal of pit contents failure to which could result in demolishing of the toilet slabs to provide adequate space for sanction pipes. The results were similar to the findings in Uganda by Zzwa *et al* (2016) who reported that poor toilet designs which could not provide ecess to pit contents influenced accumulation of faecal waste in pits limiting hygienic faecal emptying

Further, the study findings concluded that safety of emptiers influenced faecal emptying, conveyance and disposal from on-site sanitation facilities. From the study findings, the most commonly adopted faecal emptying, conveyance and disposal technology in the study area which was manual emptying was considered unsafe due to the unhygienic status of the practice which encourages manual handling of raw faecal waste. Human contact with raw faeces could expose pit operators to the risk of interaction with sanitation pathogen and injury from hazardous material such as broken glasses and metal pieces. The fact that faecal emptying, conveyance and disposal technologies compromised the health and safety of pit operators was confirmed in Zambia by Tembo *et. al* (2019).

5.3. Recommendations

The study generally sought to establish the influence of social economic factors and technological suitability factors on human faecal management. The variables considered were social factors, economic factors, and technological suitability. All the variables

indicated a positive significant association with human faecal management. Based on these findings, the following recommendations are made;

Given the findings that majority of slum dwellers used basic pit latrine, the study recommends partnership between the county governments, non-governmental organizations the community and all sanitation implementers. The collaboration will support uplifting of the communities up the sanitation ladder and ensure communities use toilets that guarantee safe management of faecal waste in relation to emptying conveyance and disposal

Sensitizing communities on the need for hygienic management of faecal waste to create inform community on sanitation choices on faecal emptying, conveyance and disposal. The use of toilets for dumping of household waste necessitates the need for educating the slum residents on the effect of such practices in regard to faecal emptying.

The government should adopt innovative interventions to subsidize faecal emptying conveyance and disposal fee to promote hygienic sanitation practices while addressing the challenge of accumulated faecal waste in low-income urban areas

5.4. Suggestions for Further Studies

The study findings established that social factors accounted for 35.4% and economic factors 29.0% while technological suitability factor explained 7.3% influence of faecal emptying, conveyance and disposal in the study area. The remaining 28.3% of the changes in faecal emptying, conveyance, and disposal can be attributed to other factors which are not examined in this study. There is need for future researchers to examine faecal emptying conveyance and disposal alongside demographic, economic and suitability of technologies.

Further studies should be carried out in other low income urban slums to establish other factors influencing faecal waste management from onsite sanitation technologies such as ecosan toilets since the study focused on faecal waste management in Meru slums.

5.5. Publication

Owuor, S. M., Mukiri , K. L. ., Mburugu, K. N. ., & Eliud, G. K. . (2024). The influence of economic factors on feacal emptying, conveyance and disposal: : a case of Meru Slums, Kenya. *African Journal of Science, Technology and Social Sciences*, *2*(2), SS 74–88. https://doi.org/10.58506/ajstss.v2i2.177

REFFERENCES

Afifi, S., Alnahhal, S., & Abdelall, S. (2015). Developing an integrated sustainable sanitation system for urban areas: Gaza strip case study. *Procedia CIRP*, *26*, 767-774.).

Agestika, L., Sintawardani, N., Hamidah, U., Nyambe, S., & Yamauchi, T. (2022). Pattern of child faeces management and disposable diaper usage among under-fives in an Urban Slum of Bandung, Indonesia. *Journal of Water, Sanitation and Hygiene for Development*, *12*(1), 32-40.

Ahmed, M., Abedin, J., Alam, K. F., Al Mamun, A., Paul, R. C., Rahman, M., & Gurley, E. S. (2018). Incidence of acute diarrhea-associated death among children< 5 years of age in Bangladesh, 2010–12. The American journal of tropical medicine and hygiene, 98(1), 281.

Anand, C. K., & Apul, D. S. (2014). Composting toilets as a sustainable alternative to urban sanitation–A review. *Waste management*, *34*(2), 329-343.

Andersson, K., Dickin, S., & Rosemarin, A. (2016). Towards "sustainable" sanitation: challenges and opportunities in urban areas. Sustainability, 8(12), 1289.

Asenahabi, B. M. (2019). Basics of research design: A guide to selecting appropriate research design. *International Journal of Contemporary Applied Researches*, *6*(5), 76-89.

Ashraf, S., Kuang, J., Das, U., Shpenev, A., Thulin, E., & Bicchieri, C. (2022). Social beliefs and women's role in sanitation decision making in Bihar, India: An exploratory mixed method study. *Plos one*, *17*(1), e0262643.

Augsburg, B., Caeyers, B., Giunti, S., Malde, B., & Smets, S. (2022). *Sanitation and credit constraints: The role of labelled microcredit in India's Swacch Bharat Mission subsidy scheme* (No. W22/09). IFS Working paper.

Awere, E., Peter, A. O., Panin, A. O., & Alessandra, B. (2020). Characterization of faecal sludge from Pit Latrines to guide management solutions in Cape Coast, Ghana. *Journal of Geography, Environment and Earth Science International*, *24*(1), 1-13.

Bair, R. A., Ozcan, O. O., Calabria, J. L., Dick, G. H., & Yeh, D. H. (2015). Feasibility of anaerobic membrane bioreactors (AnMBR) for onsite sanitation and resource recovery (nutrients, energy and water) in urban slums. *Water Science and Technology*, *72*(9), 1543-1551.

Bakir, H., Hadi, M., & Jurdi, M. (2017). Towards a renewed public health regulatory and surveillance role in water, sanitation and hygiene. Eastern Mediterranean Health Journal, 23(8), 525-526.

Bancalari, A., & Martinez, S. (2018). Exposure to sewage from on-site sanitation and child health: a spatial analysis of linkages and externalities in peri-urban Bolivia. *Journal of Water, Sanitation and Hygiene for Development*, *8*(1), 90-99.

Berendes, D. M., Sumner, T. A., & Brown, J. M. (2017). Safely managed sanitation for all means faecal sludge management for at least 1.8 billion people in low and middle income countries. *Environmental science & technology*, *51*(5), 3074-3083.

Busienei, P. J., Ogendi, G. M., & Mokua, M. A. (2019). Latrine structure, design, and conditions, and the practice of open defecation in Lodwar Town, Turkana County,

Kenya: a quantitative methods research. Environmental Health Insights, 13, 1178630219887960.

Capone, D., Buxton, H., Cumming, O., Dreibelbis, R., Knee, J., Nalá, R., ... & Brown, J. (2020). Impact of an intervention to improve pit latrine emptying practices in low income urban neighborhoods of Maputo, Mozambique. *International journal of hygiene and environmental health*, *226*, 113480.

Capone, D., Buxton, H., Cumming, O., Dreibelbis, R., Knee, J., Nalá, R., ... & Brown, J. (2020). Impact of an intervention to improve pit latrine emptying practices in low income urban neighborhoods of Maputo, Mozambique. *International journal of hygiene and environmental health*, *226*, 113480.

Chandana, N., & Rao, B. (2022). A critical review on sludge management from onsite sanitation systems: A knowledge to be revised in the current situation. *Environmental Research*, *203*, 111812.

Chipeta, W. C., Holm, R. H., Kamanula, J. F., & Mtonga, W. E. (2017). Designing local solutions for emptying pit latrines in low-income urban settlements (Malawi). *Physics and chemistry of the Earth, parts A/B/C*, *100*, 336-342.

Chiposa, R., Holm, R. H., Munthali, C., Chidya, R. C., & de los Reyes III, F. L. (2017). Characterization of pit latrines to support the design and selection of emptying tools in peri-urban Mzuzu, Malawi. *Journal of Water, Sanitation and Hygiene for Development*, *7*(1), 151-155.

Chunga, R. M., Ensink, J. H., Jenkins, M. W., & Brown, J. (2016). Adopt or adapt: sanitation technology choices in urbanizing Malawi. PloS one, 11(8), e0161262.

Dasgupta, S., Agarwal, N., & Mukherjee, A. (2021). Moving up the On-Site Sanitation ladder in urban India through better systems and standards. Journal of Environmental Management, 280, 111656.

Delaire, C., Peletz, R., Haji, S., Kones, J., Samuel, E., Easthope-Frazer, A., ... & Khush, R. (2020). How much will safe sanitation for all cost? Evidence from five cities. Environmental Science & Technology, 55(1), 767-777.

Demissie GD, Yeshaw Y, Aleminew W, Akalu Y (2021) Diarrhea and associated factors among under five children in sub-Saharan Africa: Evidence from demographic and health surveys of 34 sub-Saharan countries. PLoS ONE 16(9): e0257522. https://doi.org/10.1371/journal.pone.0257522

Doe, B., Peprah, C., & Chidziwisano, J. R. (2020). Sustainability of slum upgrading interventions: Perception of low-income households in Malawi and Ghana. *Cities*, *107*, 102946.

Foggitt, E., Cawood, S., Evans, B., & Acheampong, P. (2019). Experiences of shared sanitation–towards a better understanding of access, exclusion and 'toilet mobility'in low-income urban areas. Journal of Water, Sanitation and Hygiene for Development, 9(3), 581-590.

Fuhrimann, S., Winkler, M. S., Stalder, M., Niwagaba, C. B., Babu, M., Kabatereine, N. B & Nauta, M. (2016). Disease burden due to gastrointestinal pathogens in a wastewater system in Kampala, Uganda. *Microbial Risk Analysis*, *4*, 16-28.

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). Compendium of Sanitation Technologies in Emergencies–German WASH Network.

Gitonga, F. K., Kanyepi, T., & Tanyanyiwa, V. I. (2021). Fecal Sludge Management for Sustainable Cities: Glimpses from Kenya. In *Clean Water and Sanitation* (pp. 1-13). Cham: Springer International Publishing.

Greed, C. (2016). Taking women's bodily functions into account in urban planning and policy: public toilets and menstruation. *TPR: Town Planning Review*, *87*(5).

Greene, N., Hennessy, S., Rogers, T. W., Tsai, J., & Francis III, L. (2021). The role of emptying services in provision of safely managed sanitation: A classification and quantification of the needs of LMICs. *Journal of environmental management*, *290*, 112612.

Grum, T., Seifu, A., Abay, M., Angesom, T., & Tsegay, L. (2017). Determinants of pre-eclampsia/Eclampsia among women attending delivery Services in Selected Public Hospitals of Addis Ababa, Ethiopia: a case control study. *BMC pregnancy and childbirth*, *17*(1), 1-7.

Gudda, F. O., Moturi, W. N., Oduor, O. S., Muchiri, E. W., & Ensink, J. (2019). Pit latrine fill-up rates: variation determinants and public health implications in informal settlements, Nakuru-Kenya. *BMC Public Health*, *19*(1), 1-13.

Harada, H., Strande, L., & Fujii, S. (2016). Challenges and opportunities of faecal sludge management for global sanitation. Towards future earth: challenges and progress of global environmental studies. Kaisei Publishing, Tokyo, 81-100.

Harper, J., Bielefeldt, A., Javernick-Will, A., Veasna, T., & Nicoletti, C. (2020). Context and intentions: practical associations for fecal sludge management in rural low-income Cambodia. *Journal of Water, Sanitation and Hygiene for Development*, *10*(2), 191-201.

Hawkins, P., & Muxímpua, O. (2015). Developing business models for faecal sludge management in Maputo. *Washington, DC: World Bank*.

Heshmati, A., & Rashidghalam, M. (2020). Measurement and analysis of urban infrastructure and its effects on urbanization in China. *Journal of Infrastructure Systems*, *26*(1), 04019030.

Hilton, C. E. (2017). The importance of pretesting questionnaires: a field research example of cognitive pretesting the Exercise referral Quality of Life Scale (ER-QLS). *International Journal of Social Research Methodology*, *20*(1), 21-34.

Holm, R., Tembo, J. M., & Thole, B. (2015). A comparative study of faecal sludge management in Malawi and Zambia: Status, challenges and opportunities in pit latrine emptying. *African Journal of Environmental Science and Technology*, *9*(11), 783-792.

Huang, D., Liu, X., Jiang, S., Wang, H., Wang, J., & Zhang, Y. (2018). Current state and future perspectives of sewer networks in urban China. *Frontiers of environmental science & engineering*, *12*(3), 1-16.

Jangam, C., & Pujari, P. (2019). Impact of on-site sanitation systems on groundwater sources in a coastal aquifer in Chennai, India. *Environmental Science and Pollution Research*, *26*(3), 2079-2088.

Jenkins, M. W., Cumming, O., & Cairncross, S. (2015). Pit latrine emptying behavior and demand for sanitation services in Dar Es Salaam, Tanzania. *International journal of environmental research and public health*, *12*(3), 2588-2611.

Kalumbi, L. R., Thaulo, C., MacPherson, E. E., & Morse, T. (2020). Perspectives and practices on water, sanitation, and hygiene from a fishing community along Lake

Malombe, Southern Malawi. *International Journal of Environmental Research and Public Health*, *17*(18), 6703.

Kasiva, E. G. (2023). *Influence of Social Cultural Factors and Latrine Status on Adoption of Sanitation Practices in Rural Areas a Case of Nzaui Sub-County, Makueni County, Kenya* (Doctoral dissertation, Meru University of Science and Technology).

Kenya, National Bureau of Statistics (KNBS). (2019). Kenya Population and Density Census. *Vol III*

Khalid, A. (2018). Human excreta: a resource or a taboo? Assessing the socio-cultural barriers, acceptability, and reuse of human excreta as a resource in Kakul Village District Abbottabad, Northwestern Pakistan. Journal of Water, Sanitation and Hygiene for Development, 8(1), 71-80.

Kocbek, E., Garcia, H. A., Hooijmans, C. M., Mijatović, I., Lah, B., & Brdjanovic, D. (2020). Microwave treatment of municipal sewage sludge: Evaluation of the drying performance and energy demand of a pilot-scale microwave drying system. *Science of the Total Environment*, *742*, 140541.

Leigland, J., Trémolet, S., & Ikeda, J. (2016). Achieving Universal Access to Water and Sanitation by 2030.

Lerebours, A., Scott, R., Sansom, K., & Kayaga, S. (2021). Regulating sanitation services in sub-saharan africa: An overview of the regulation of emptying and transport of faecal sludge in 20 cities and its implementation. *Utilities Policy*, *73*, 101315.

Lundberg, S., Pollak, R. A., & Stearns, J. (2016). Family inequality: Diverging patterns in marriage, cohabitation, and childbearing. *Journal of Economic perspectives*, *30*(2), 79-102.

Mallory, A., Omoga, L., Kiogora, D., Riungu, J., Kagendi, D., & Parker, A. (2021). Understanding the role of informal pit emptiers in sanitation in Nairobi through case studies in Mukuru and Kibera settlements. *Journal of Water, Sanitation and Hygiene for Development*, *11*(1), 51-59.

McConville, J. R., Kvarnström, E., Ahlström, M., & Niwagaba, C. B. (2022). Possibilities for changing to resource recovery in Kampala's on-site sanitation regime. *Resources, Conservation and Recycling*, *181*, 106275.

Mikhael, G., Robbins, D. M., Ramsay, J. E., & Mbéguéré, in *Faecal Sludge Management: Systematic Approach for Implementation and Operation*, ed. L. Strande, M. Ronteltap and D. Brdjanovic, IWA Publishing, London, United Kingdom, 1st edn., 2014, pp. 67–96

Mohajan, H. K. (2017). Two criteria for good measurements in research: Validity and reliability. *Annals of Spiru Haret University. Economic Series*, *17*(4), 59-82.

Moseholm, E., & Fetters, M. D. (2017). Conceptual models to guide integration during analysis in convergent mixed methods studies. *Methodological Innovations*, *10*(2), 2059799117703118.

Mpanang'ombe, W., Bray, B., & Tilley, E. (2021). Pit emptying subsidy vouchers: a two-phased targeting and structuring experiment in Blantyre, Malawi. *International Journal of Urban Sustainable Development*, *13*(3), 448-463.

Mugendi, C., Kagendo, D., & Kubai, P. (2023). The influence of resource planning practices in faecal sludge management system in Embu County. *African Journal of Science, Technology and Social Sciences*, *2*(2), 89-97.

Mukherjee, A. G., Wanjari, U. R., Chakraborty, R., Renu, K., Vellingiri, B., George, A., ... & Gopalakrishnan, A. V. (2021). A review on modern and smart technologies for efficient waste disposal and management. *Journal of Environmental Management*, *297*, 113347.

Murtaza M., Ghafoor A., Qadir G., Owens M. A., Aziz M. H. & Zia S. 2010 Disposal and use of sewage on agricultural lands In Pakistan: a review. Pedosphere 20, 23–34.

Namata, T., Kagurusi, P. T., & Berhanu, A. (2015). Smart technologies for urban and peri-urban communities: Amref Health Africa's experience in promoting water borne/pour flush toilets in northern Uganda. Water, Sanitation and Hygiene Services Beyond.

Nantongo, H. B. (2022). *Pit latrine emptying in Katanga slum, Uganda* (Doctoral dissertation, Makerere University).

Naughton, C. C., Akers, P., Yoder, D., Baer, R., & Mihelcic, J. R. (2018). Can sanitation technology play a role in user perceptions of resource recovery? An evaluation of composting latrine use in developing world communities in Panama. *Environmental Science & Technology*, *52*(20), 11803-11812.

Novotný, J., & Mamo, B. G. (2022). Household-level sanitation in Ethiopia and its influencing factors: a systematic review. *BMC Public Health*, *22*(1), 1448.

Öberg, G., Metson, G. S., Kuwayama, Y., & A Conrad, S. (2020). Conventional sewer systems are too time-consuming, costly and inflexible to meet the challenges of the 21st century. *Sustainability*, *12*(16), 6518.

Odagiri, M., Thomas, A., Listyasari, M., Mills, F., Bain, R. E., Muhammad, Z., & Willetts, J. (2021). Safely managed on-site sanitation: A national assessment of sanitation

services and potential faecal exposure in Indonesia. *International journal of environmental research and public health*, *18*(15), 8204.

Ombuya, J., Gachoka, K., & Mutea, N. (2022). Evaluation of antimicrobial susceptibility of Escherichia coli isolated from contaminated areas of Majengo slum in Meru County, Kenya. *F1000Research*, *11*(1133), 1133.

Oppiah-Mensah, J. (2019). faecal sludge disposal and health implications in Ejura-Sekyedumase municipality (Doctoral dissertation, UCC).

Orner, K. D., & Mihelcic, J. R. (2018). A review of sanitation technologies to achieve multiple sustainable development goals that promote resource recovery. *Environmental Science: Water Research & Technology*, *4*(1), 16-32.

Osumanu, I. K., Kosoe, E. A., & Ategeeng, F. (2019). Determinants of open defecation in the Wa municipality of Ghana: empirical findings highlighting sociocultural and economic dynamics among households. *Journal of environmental and public health*, *2019*.

Othman, Z., & Buys, L. (2016). Towards more culturally inclusive domestic toilet facilities in Australia. *Frontiers of Architectural Research*, *5*(3), 383-391.

Owolabi, T. A., Mohandes, S. R., & Zayed, T. (2022). Investigating the impact of sewer overflow on the environment: A comprehensive literature review paper. *Journal of Environmental Management*, *301*, 113810.

Parikh, P., da Cunha Forte, J., Parkinson, J., & Boot, N. (2016). Assessing demand for faecal sludge management (FSM) services in Freetown. *waterlines*, 336-356.

Peal A., Evans B., Blackett I., Hawkins P. & Heymans C. 2014a Faecal sludge management: a comparative analysis of 12 cities. Journal of Water, Sanitation and Hygiene for Development 4 (4), 563–575.

Peletz, R., Feng, A., MacLeod, C., Vernon, D., Wang, T., Kones, J., ... & Khush, R. (2020). Expanding safe fecal sludge management in Kisumu, Kenya: an experimental comparison of latrine pit-emptying services. *Journal of Water, Sanitation and Hygiene for Development*, *10*(4), 744-755.

Portiolli, G. F., Rogers, T. W., Beckwith, W., Tsai, J., Wilson, N., & Francis, L. (2021). Development of trash exclusion for mechanized pit latrine emptying. *Environmental Science: Water Research & Technology*, *7*(10), 1714-1722.

Prasad, C. S., & Ray, I. (2019). When the pits fill up:(in) visible flows of waste in urban India. Journal of Water, Sanitation and Hygiene for Development, 9(2), 338-347.

Reference: Odagiri, M., Thomas, A., Listyasari, M., Mills, F., Bain, R. E., Muhammad, Z., & Willetts, J. (2021). Safely managed on-site sanitation: A national assessment of sanitation services and potential faecal exposure in Indonesia. *International journal of environmental research and public health*, *18*(15), 8204.

Reymond, P., Renggli, S., & Lüthi, C. (2016). Towards sustainable sanitation in an urbanising world. Sustainable urbanization, 115-134.

Robb, K., Null, C., Teunis, P., Armah, G., and Moe, C. (2017). Assessment of faecal exposure pathways in low-income urban neighborhoods in Accra, Ghana: rationale, design, methods, and key findings of the SaniPath study. *Am. J. Trop. Med. Hyg.* 97, 1020–1032. doi: 10.4269/ajtmh

Sagoe, G., Danquah, F. S., Amofa-Sarkodie, E. S., Appiah-Effah, E., Ekumah, E., Mensah, E. K., & Karikari, K. S. (2019). GIS-aided optimisation of faecal sludge management in developing countries: The case of the Greater Accra Metropolitan Area, Ghana. *Heliyon*, *5*(9), e02505

Seal, D., Bown, R. T., & Parker, A. H. (2018). Penetrometer tests on 109 pit latrines in Kibera, Nairobi, Kenya. *Water SA*, *44*(3), 459-463.

Semiyaga, S., Okure, M. A., Niwagaba, C. B., Katukiza, A. Y., & Kansiime, F. (2015). Decentralized options for faecal sludge management in urban slum areas of Sub-Saharan Africa: A review of technologies, practices and end-uses. *Resources, Conservation and Recycling*, *104*, 109-11

Senanu, B. M., Boakye, P., Oduro-Kwarteng, S., Sewu, D. D., Awuah, E., Obeng, P. A., & Afful, K. (2021). Inhibition of ammonia and hydrogen sulphide as faecal sludge odour control in dry sanitation toilet facilities using plant waste materials. *Scientific reports*, *11*(1), 1-13.

Shivendra, B. T., & Ramaraju, H. K. (2015). Impact of onsite sanitation system on groundwater in different geological settings of peri urban areas. Aquatic Procedia, 4, 1162-1172.

Simiyu, S. (2017). Preference for and characteristics of an appropriate sanitation technology for the slums of Kisumu, Kenya. *International journal of urban sustainable development*, *9*(3), 300-312.

Simiyu, S., Chumo, I., & Mberu, B. (2021). Faecal sludge management in low income settlements: case study of nakuru, kenya. *Frontiers in Public Health*, *9*, 750309.

Sisco, T., Rogers, T., Beckwith, W., Chipeta, W., Holm, R., Buckley, C. A., & de los Reyes III, F. L. (2017). Trash removal methods for improved mechanical emptying of pit latrines using a screw auger. *Journal of water, sanitation and hygiene for development*, *7*(1), 85-91.

Stevens, L., Islam, R., Morcrette, A., De La Brosse, N., & Mamun, A. A. (2015). Faecal sludge management in Faridpur, Bangladesh: scaling up through service level agreements.

Talwar, S., Dhir, A., Scuotto, V., & Kaur, P. (2021). Barriers and paradoxical recommendation behaviour in online to offline (O2O) services. A convergent mixed-method study. *Journal of Business Research, 131*, 25-39.

Tembo.M. J, Matanda, R., Banda, N. I., Mwanaumo, E., Nyirenda, E., Mambwel, M., & Nyambe, A. I. (2019). Pit latrine faecal sludge solid waste quantification and characterization to inform the design of treatment facilities in peri-urban areas: a case study of Kanyama. *African journal of environmental science and technology*, *13*(7), 260-272.

Theodore, N. (2020). Using questionnaires to survey hidden populations. *Researching the City: A Guide for Students*, 74.

Tyagi A. J. (2017). Predicament of sanitation workers in Swachh Bharat. Tehelka Magazine. http://www.tehelka.com/2017/10/predicament-of-sanitation-workers-in-swachh-bharat/

United Nations (UN) (2021). World Urbanization Prospects. https://statisticstimes.com/demographics/worldurbanpopulation.php#:~:text=As%20of%202021%2C%204.46%20billion,billion%20people%20to%20urban%20areas

United Nations (UN) General Assembly. (2015). Transforming our world: the 2030 agenda for sustainable development. https://www.refworld.org/docid/57b6e3e44.html.

UNICEF & WHO. (2017). Progress on Drinking Water Sanitation and Hygiene

Vakili, M. M., & Jahangiri, N. (2018). Content validity and reliability of the measurement tools in educational, behavioral, and health sciences research. *Journal of Medical Education Development*, *10*(28), 106-118.

van Welie, M. J., & Romijn, H. A. (2018). NGOs fostering transitions towards sustainable urban sanitation in low-income countries: Insights from Transition Management and Development Studies. *Environmental Science & Policy*, *84*, 250-260.

Varpio, L., Paradis, E., Uijtdehaage, S., & Young, M. (2020). The distinctions between theory, theoretical framework, and conceptual framework. *Academic Medicine*, *95*(7), 989-994.

Wasonga, J., Okowa, M., & Kioli, F. (2016). Sociocultural determinants to adoption of safe water, sanitation, and hygiene practices in Nyakach, Kisumu County, Kenya: a descriptive qualitative study. *Journal of Anthropology*, *2016*.

Younas, A., & Sundus, A. (2018). Experiences of and satisfaction with care provided by male nurses: A convergent mixed-method study of patients in medical surgical units. *Journal of advanced nursing*, *74*(11), 2640-2653.

Zaqout, M., Cawood, S., Evans, B. E., & Barrington, D. J. (2020). Sustainable sanitation jobs: prospects for enhancing the livelihoods of pit-emptiers in Bangladesh. *Third World Quarterly*, *42*(2), 329-347.

Zziwa, A., Nabulime, M. N., Kiggundu, N., Kambugu, R., Katimbo, A., & Komakech, A. J. (2016). A critical analysis of physiochemical properties influencing pit latrine

emptying and feacal sludge disposal in Kampala Slums, Uganda. *African Journal of Environmental Science and Technology*, *10*(10), 316-328.

APPENDICES

Appendix I: Consent Form

Research Questionnaire for a study on the Influence of Social Economic Factors and Technological suitability on Faecal Emptying, Conveyance and Disposal: A Case Of Meru Slums, Kenya

I am a student from Meru University of Science and Technology undertaking Masters of Science in Sanitation. This questionnaire will be used to assist me in data collection for a study on the Influence of Social Economic Factors and Technological suitability on Faecal Emptying, Conveyance and Disposal: A Case Of Meru Slums, Kenya. The questionnaire will be used for academic purpose only and responses will be treated with outmost confidentiality since the respondents will remain anonymous.

If you agree to participate in this interview kindly, sign below.

Sign ……

Appendix II: Household Questionnaire

Instructions

Please mark where appropriate to provide the information required.

SECTION A: DEMOGRAPHIC INFORMATION

1. What is your gender? Male [ ] Female [ ]
2. What is your age bracket? 18-30 [ ] 31-40 [ ] 41-55 [ ] Above 55 [ ]
3. What is your religion?
   a) Christian [ ] b) Muslim [ ] c) Hindu [ ] d) Others [ ]
4. What is your level of income?
   a) Below 10,000 [ ] b) 11,000- 25,000 [ ] c) 26,000- 40,000 [ ] d) Above 40,000 [ ]
5. What level of education did you attain?
   a) Primary school [ ] b) Secondary [ ] c) Post-secondary school[ ] d) Not been to school[ ]
6. What is your household size?
   b) 0-4] b) 5-9 [ ] c) 10-14[ ] d) Above 15 [ ]

SECTION B: FAECAL EMPTYING, CONVEYANCE AND DISPOSAL IN ON-SITE SANITATION FACILITIES.

7. Which type of Toilet do you use
   a) Basic pit latrine (Ordinary toilet) [ ] b) VIP (Toilet with a ventilation pipe) [ ] c) Flush toilet [ ]
8. Have you ever emptied your toilet?
   a) Yes [ ] b) No [ ]
9. If Yes, How was the toilet emptied?
   a) Manually (using buckets) [ ] b) Use of trucks (vehicles) [ ] c) Not emptied [ ]
10. Which cleansing method do you prefer for toilet use?
    a) Tissue [ ] b) Water [ ] c) Leaves [ ] d) Piece of cloth [ ]
11. Do household members dump waste such as broken glasses, plastics, textile, diaper and sanitary pads in toilet pits? a)Yes [ ] b) No [ ]
12. If Yes, which among the following waste do members of the household dump in the pit?
    a)Glasses [ ] b) Plastics [ ] c) Diaper and sanitary pad [ ] d) Metal pieces [ ]

Kindly tick the box that appropriately covers your level of agreement with the given statement.

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Emptying of on-site sanitation facilities is easy					
On-site sanitation facilities are frequently emptied					
The current method of emptying the on-site sanitation facility is good					
Manual conveyance of waste from on-site sanitation facilities to disposal site is usually done efficiently					
Mechanized conveyance process is effective					
Mechanized conveyance process usually results in spillage and leakage					
I am satisfied with the current mechanized method of waste conveyance from the on-site sanitation facility to the disposal site					
Vacuum trucks dispose faecal waste in a hygienic way					
The disposal process using trucks rarely result in bad odour					
I am satisfied with current method of faecal waste disposal from the on-site sanitation facility					

SECTION C: SOCIAL FACTORS

Kindly tick the box that appropriately covers your level of agreement with the given statement.

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The toilets provided are easily accessible to pit emptier/exhausters					
Vacuum trucks cannot easily access toilets for emptying					
Toilets can easily be emptied because they have access manholes for emptying					
There are taboos discouraging handling of faeces					
Defecating in the open is considered unclean in the community					
Faecal handling is considered unclean					

Toilets are used for disposal of household waste					
Dangerous materials such as broken glasses , pieces of metal and plastics are dumped in toilets					
Diaper and sanitary towels are thrown in the toilet after usage					
Large populations result in high user capacity of toilets, leading to high emptying frequencies					
Population growth necessitates continuous monitoring and adjustment of toilet emptying schedules					
Access to education and awareness campaigns has a considerable influence on the behavior of individuals in relation to faecal management in on-site sanitation facilities					
Adequate literacy skills contribute to better awareness of hygiene practices in toilet maintenance					

SECTION D: ECONOMIC FACTORS

Kindly tick the box that appropriately covers your level of agreement with the given statement.

Statement	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
The availability and affordability of pit emptying services can influence faecal emptying, conveyance and disposal.					
The availability and affordability of construction materials can influence the design of on-site sanitation facilities.					
The overall cost of emptying, transporting and disposal of faeces is affordable.					
I would prefer building a toilet with utility access hole for emptying					
Toilet pit is lined					
In this community, people would consider burying a toilet than emptying a toilet					
When faced with a filled up toilet, I would prefer digging a new pit than emptying the filled pit.					
There is a possibility of borrowing money to build toilets in the community					
CDF and other NGOs have funded building of some toilets in the slums					
Narrow paths in our community makes it difficult for pit emptier to access toilets					
Providing ample space in toilets is necessary for maintaining sanitation and hygiene during the emptying, conveyance, and disposal process.					
My level of income does not influence the choice of sanitation option available					
In this community, household type of toilet is determined by the level of income					

I am willing to pay for emptying of my toilet					
I cannot afford to pay for construction of a new toilet					

SECTION E: TECHNOLOGICAL SUITABILITY

Kindly tick the box that appropriately covers your level of agreement with the given statement.

Statement	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
The technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities is compatible with existing infrastructure and services, such as transportation networks and waste management facilities					
The technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities is environmentally sustainable and minimize negative impacts on the surrounding ecosystem					
The technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities is reliable					
The technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities minimizes the risk of system failures or breakdowns					
The technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities is safe and hygienic for users and service providers					
The technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities is user-friendly and considerate of cultural and social norms					
The technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities is adaptable to different types of waste, including solid and liquid waste					

Appendix III: Focus Group Discussion

This section seeks to collect information on the influence of technological suitability on faecal emptying, conveyance, and disposal in on-site sanitation facilities. This will be done through focus group discussions involving; pit operators and household heads.

Introduce yourself as the moderator of the discussion and ask the respondents to introduce themselves. Then begin asking questions:

1. How has technology affected the design and construction of on-site sanitation facilities, particularly with regards to faecal emptying, conveyance, and disposal?
2. What are the current challenges facing on-site sanitation facilities in terms of technological suitability for faecal emptying, conveyance, and disposal?
3. How do factors such as cost, availability of materials, and cultural beliefs influence the technological suitability of on-site sanitation facilities?
4. Do you consider the technology in use to be effective when it comes to faecal emptying, conveyance, and disposal? Give reasons for your response
5. Is the technology being used scalable to meet the demands of the growing population? Is it user-friendly and sustainable?
6. Is the technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities adaptable to different types of waste, including solid and liquid waste?
7. What role do government policies and regulations play in promoting the use of technology in on-site sanitation facilities?

Appendix IV: Key Informant Interview

This section seeks to collect information on the influence of technological suitability on faecal emptying, conveyance, and disposal in on-site sanitation facilities. This will be done through Key Informant Interview to a public health officer.

Introduce yourself and ask the respondents to introduce herself. Then begin asking questions:

1. What are the current challenges facing on-site sanitation facilities in informal settlements in regard to Faecal Sludge Management (FSM)?
2. What is the effect of the toilet designs in slums with regards to faecal emptying, conveyance, and disposal?
3. How do factors such as cost, availability of materials, and cultural beliefs influence the technological suitability of on-site sanitation facilities?
4. In the context of slum setting, how do factors such as cost, availability of materials, and cultural beliefs influence the overall management of faecal waste in the area?
5. Do you consider the technology in use to be effective when it comes to faecal emptying, conveyance, and disposal? Give reasons for your response

Appendix V: Observation Checklist

The checklist is designed to obtain data on the condition of household sanitation facilities. Permission to evaluate the sanitation facilities should be obtained from the respondent before recording the observations to ascertain their consent. Kindly, record by ticking the boxes where appropriate.

1. Is there visibility of human faeces around the compound?

Yes [ ] No [ ]

2. Is the toilet clean?

Yes [ ] No [ ]

3. Which material is the toilet slab made of?

   a) Concrete [ ] b) wood [ ] c) Mad [ ]

4. What material is the superstructure made of?

   a) Bricks [ ] b) Mabati [ ] c) wood [ ] d) Polythine or textile [ ]

5. Does the toilet have a provision of manhole for emptying?

Yes [ ] No [ ]

6. Is the toilet invaded with flies?

Yes [ ] No [ ]

7. Does the toilet produce a bad odour?

Yes [ ] No [ ]

8. Is the pit content above one meter from the slab?

Yes [ ] No [ ]

9. Is there a water container inside the toilet?

Yes [ ] No [ ]

Appendix VI: Research Permit

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Appendix VII: Journal Article Publication

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The Influence of economic factors on feacal emptying, conveyance and disposal: a case of Meru Slums, Kenya

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ABSTRACT

Safe management of faecal waste is one of the Sustainable Development Goals (SDGs) which envisions safe sanitation for all. However, although efforts to improve sanitation conditions in slums have been made, faecal emptying, conveyance and disposal still remain a challenge endangering the health of the public. The study examined the influence of economic factors on faecal emptying, conveyance and disposal in on-site sanitation facilities in Meru slums. A convergent design with a mixed methods approach was adopted. Quantitative data was collected using structured questionnaires from a sample of 228 household heads selected using cluster and proportionate simple random sampling techniques. Correlation and regression analysis was carried out to ascertain the association between emptying, conveyance and disposal of faecal waste and the economic factors. Qualitative data was gathered using focus group discussion participants with eight (8) who included four (4) pit operators, 3 household heads and 1 Public Health Officer (PHO) and results analyzed thematically. Findings showed that only 31% of slum dwellers emptied latrine pits and that manual emptying was more common (84%) than mechanical emptying because of its cost efficiency, reliability and the effectiveness in handling plastics, glasses, metal pieces, diapers and sanitary pads contained in pits. Increased cost constrained faecal emptying, conveyance, and disposal (r=0.499, p-value=0.000). Residents who were able to pay for faecal handling services were more likely to practice hygienic faecal emptying, conveyance, and disposal (r=0.524, p-value=0.000). Low level of income for majority of slum dwellers influenced the design of the latrines adopted. Emptying faeces from poorly designed pit latrines was more expensive due to operators' safety concerns. The study concluded that the inability to meet the costs associated with faecal emptying, conveyance and disposal services facilitated poor sanitation status in slums. There is need to sensitize the slum community on the benefits of practicing safe management of faecal waste. The study recommended development of government policies to regulate mechanical emptying conveyance and disposal of faecal matter.

Introduction

Safe emptying, conveyance and disposal of the accumulated excreta from sanitation facilities constitute an essential part of hygienic faecal sludge management (Öberg *et al.*, 2020). Safely managed faecal waste is one of the agenda in the Sustainable Development Goals (SDGs) which envisions safe sanitation for all (United Nations,

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