

**ASSESSMENT OF SOCIETAL NORMS, HEALTH EFFECTS,
AND COPING STRATEGIES INFLUENCING RAW SEWAGE
DISPOSAL IN WATER SOURCES OF MUKURU SLUMS,
NAIROBI, KENYA**

NASIRUMBI MARY AUDREY

**A Thesis Submitted in Partial Fulfillment of Requirements for Conferment of the
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Technology**

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other Institution.

EG407/201440/21

Signed:Date:

Nasirumbi Mary Audrey

DECLARATION BY SUPERVISORS

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

Signed:Date:

Dr. Patrick Kinyua Kubai, Ph.D.

Meru University of Science and Technology, Kenya

Signed:Date:

Dr. Dorothy Kithinji Kagendo, Ph.D.

Chuka University, Kenya

DEDICATION

Special dedication to my parents, Mr. Francis Okumu and Mrs. Winfred Wabwire, for their constant motivation, prayers, and unwavering support throughout this journey. I also dedicate this work to my loving siblings; Vionne, Junior, Laura, my best friends; Austin, Sharon, Yvonne, Beffy, Faith, and my manager at Kenya Red Cross Society, whose encouragement has been invaluable. My heartfelt gratitude goes to my two supervisors Dr. Patrick Kinyua Kubai and Dr. Dorothy Kagendo Kithinji, whose guidance, patience, and mentorship greatly shaped this work.

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ABBREVIATIONS, SYMBOLS, AND ACRONYMS

CHA	Community Health Assistant
CHEW	Community Health Extension Worker
CHP	Community Health Promoters
FGDs	Focused Group Discussions
HCW	Health Care Worker
HHs	Household Heads
JMP	Joint Monitoring Programme
KAP	Knowledge, Attitude, and Practices
KESHP	Kenya Environmental Sanitation and Hygiene Policy
KII	Key Informant Interviews
LMICs	Low and Middle-Income Countries
MPC	Mukuru Promotion Centre
NGO	Non -Governmental Organization
PHOs	Public Health Officers
SDG	Sustainable Development Goals
SPSS	Statistical Packages for Social Sciences
SRI	Sanitation Research Institute
UNEP	United Nations Environmental Programme
UNICEF	United Nations Children Funds
USAID	United States Agency for International Development
WASH	Water Sanitation and Hygiene
WHO	World Health Organization

OPERATIONAL DEFINITION OF TERMS

Coping strategies	Various methods and practices individuals and communities adopt to manage and mitigate the challenges associated with inadequate sanitation
Health effects	These are changes in the well-being of humans due to exposure to particular sources.
Proteobacteria	Is a wide variety of pathogens such as Escherichia, salmonella, vibrio, helicobacters and other free-living bacteria like pseudomonas.
Raw Sewage	Is any untreated sanitary waste consisting of human feces, urine and water.
Societal norms	These are shared standards of acceptable behavior by groups which include informal understandings that govern behavior of society including rules and laws
Water sources	This includes surface waters such as rivers, lakes and stream and underground sources like aquifer

ABSTRACT

Globally, approximately 1.7 billion people lack basic sanitation, with 494 million practicing open defecation, and dire situation in slums. However, despite national sanitation policies and global efforts, over two million tons of sewage are released into water sources annually, particularly in slum areas like Mukuru, Nairobi, Kenya. This study assessed societal norms, health effects, and coping strategies influencing raw sewage disposal in water sources of Mukuru slums, Nairobi, Kenya. Specifically, the study examined societal norms influencing behaviour, the perceived health risks from exposure to sewage-contaminated water, and coping strategies employed by residents. The study employed a descriptive cross-sectional design, integrating both quantitative and qualitative methodologies. Stratified random sampling was used to select 246 household heads for quantitative data collection via structured questionnaire. For qualitative data, purposive sampling guided the selection of participants for Focus Group Discussions and interviews. Quantitative data were analysed using SPSS version 25, with both descriptive statistics and Chi-square tests applied. Qualitative findings were thematically analyzed and summarized in narrative form. Descriptive findings revealed that 96.1% of respondents reported raw sewage disposal into water sources, and 87.7% had observed such actions within their community. Societal norms played a significant role, with 85.1% indicating belief in proper sewage disposal, 43.8% highlighting the importance of communication and coordination, and 46.4% acknowledging social network influence. Regarding health impacts, 93.4% of households reported diarrhea cases, 92.3% experienced respiratory symptoms, 85.1% noted anxiety, and 83.8% identified skin infections among residents. In terms of coping strategies, 49.4% used pour-flush toilets, while 76.2% lacked knowledge of proper disposal systems. Relocation (43.5%), passive waiting (42.9%), and negligence (79.1%) were common coping mechanisms in the face of persistent sanitation challenges. Chi-square tests revealed statistically significant associations (χ^2 , $p < .05$) between societal norms—such as beliefs, household initiative, community communication—and raw sewage disposal behaviour. Similarly, significant relationships were found between raw sewage exposure and skin-related conditions. Furthermore, coping strategies such as household relocation, inaction, and lack of sanitation investment were strongly associated with unsafe disposal practices. The study concludes that raw sewage disposal in Mukuru is not only a matter of infrastructural inadequacy but also deeply influenced by entrenched societal norms, perceived health vulnerabilities, and adaptive coping behaviors. Addressing this issue requires holistic, community-centered interventions that integrate behaviour change, health education, and locally sustainable sanitation technologies. The findings offer a foundation for targeted policymaking and further research in similar urban informal settlements.

CHAPTER ONE: INTRODUCTION

1.0 Introduction

This chapter captured the background information, the problem statement, justification of the study, research questions, study objectives, limitation of the study and delimitation of the study.

1.1 Background of Raw Sewage Disposal in Water Sources

Globally, billions of people still lack access to essential water and sanitation services, with an estimated 2.2 billion people lacking safely managed drinking water and 3.5 billion lacking safely managed sanitation services (World Health Organization & United Nations Children's Fund [WHO & UNICEF], 2023). One-third of the world's population depends on onsite fecal sludge disposal, containment, and transportation before offsite treatment (Junglen *et al.*, 2020). However, management of effluent is a challenge, especially, untreated municipal sewage a point and harmful source of water ecosystem contamination due to the bulk production of organic matter (Collins *et al.*, 2018).

The World Health Organization (WHO, 2021) estimates that nearly 80% of wastewater globally is discharged into the environment untreated, leading to widespread contamination of rivers, lakes, and oceans. Much of the literature has focused on technical solutions, such as infrastructure deficits and centralized treatment systems (Mateo-Sagasta *et al.*, 2021), with less attention paid to the underlying human behaviors, social norms, and adaptive practices that sustain unsafe sewage disposal.

Globally, rivers in highly populated regions such as the Ganges in South Asia and the Citarum in Indonesia have been cited as case studies of severe raw sewage pollution (Mateo-Sagasta *et al.*, 2021). According to Qadri *et al.*, (2020) two million tons of sewage is

discharged into water sources worldwide for example 97% from Venezuela, 75% from Turkey, 71% in European countries 80% in Latin Countries, and 68% in Asia mainly due to technological development. In the United Kingdom, rivers, storm water and drains are short- and long-term channels of sewage discharge systems into the sea (Frances, 2022).

In Sub-Saharan Africa, studies indicate that less than 10% of generated wastewater in the region undergoes adequate treatment (Peal *et al.*, 2020). In many cities across the region, centralized sewerage systems are either non-existent or grossly insufficient. Urban dwellers depend on pit latrines, septic tanks, and makeshift drains, which often overflow during rainy seasons, channeling raw sewage into nearby rivers and wetlands. Lema (2024) documents how major rivers in the region including the Tana, Kafue, Ruaha, and Mara are affected by seasonal influxes of untreated sewage, especially in informal settlements and slum areas. In Abuja Nigeria, Kado district during emptying of septic tanks for sewage disposal, Lake Jabi serves as a receiver while some neighbors dispose of untreated sewage to the open drains when raining (Abubakar,2017). Studies by K'oreje *et al.* (2020) and Shehu *et al.* (2023) have documented high levels of pollutants in African urban rivers, but they tend to focus on quantifying chemical and microbial contamination. There is limited research that interrogates the social and cultural factors.

The use of raw or partially treated sewage in urban agriculture has become a common practice in African cities. While this mitigates water scarcity and supplies essential nutrients to crops, it also poses serious health risks due to contamination with heavy metals, pathogens, and pharmaceutical residues. Njuguna *et al.* (2017) report that in many peri-urban areas, such as those surrounding Nairobi and Kampala, vegetables irrigated with untreated wastewater contain harmful concentrations of lead, cadmium, and other heavy

metals. Such practices not only threaten consumer health but also lead to the accumulation of contaminants in soils and aquifers, compromising long-term agricultural productivity.

In Kenya, the growth of industries, factories, manufacturing plants, residential areas and unplanned informal settlements, has resulted to increased disposal of waste overwhelming sewage treatment plants and septic tanks (Omina et al, 2021; Mansour et al., 2017). According to the Kenya Ministry of Water, Sanitation, and Irrigation, Kenya (2021) only 26% of the country's urban population is connected to sewer systems, and of that, a smaller fraction benefits from functional treatment. In Nairobi alone, over 500 million liters of wastewater are generated daily, much of which flows untreated into the Nairobi River, contributing to high levels of contamination (Chebii et al., 2024). While studies by Muriuki *et al.* (2020) and Tanui *et al.* (2025) have shown the environmental and toxicological risks of untreated sewage entering Nairobi's rivers, they seldom explore the lived experiences and everyday decisions made by slum residents regarding waste disposal. This reveals a crucial research gap in understanding the interplay between societal norms, household constraints, and the urban sanitation crisis.

These drastic changes have resulted to development of dumpsites near rivers and direct discharge of untreated sewage into water sources such as rivers. A tremendous effect of water borne outbreak of diseases such as diarrhea, typhoid, cholera, scabies, and alteration of aquatic life such as zooplankton, fish crabs thus depriving their survival due to decreased oxygen caused by increased algae growth (Xie et al., 2022; Aghae et al., 2021; Igbokwe et al., 2015). However, most data are aggregated at national or county levels, overlooking context-specific health experiences in informal settlements. Researchers such as Njuguna *et al.* (2017) and Kiratu *et al.* (2020) have highlighted contamination in urban agriculture, yet

few studies examine how residents themselves perceive and respond to health risks linked to sewage. For example, it remains unclear how people in Mukuru identify and manage health threats like diarrhea, skin diseases, and respiratory infections linked to sewage exposure. This lack of disaggregated, community-level health data inhibits targeted interventions and public health messaging.

Raw sewage has potential health related risks due to the substantial mixtures of metals such as petroleum products, fats, organic matter and microorganisms such as bacteria including *E. coli*, coliform, typhoid, dysentery, schistosomiasis, intestinal nematodes and viruses such as *Vibrio cholerae*, Hepatitis A Virus (Thakur, 2022). Source of drinking water are exposed to contamination from raw sewage overflow, septic tanks, leaking sewer lines, application of fecal sludge on land and untreated waste water (Qayoom *et al.*, 2020). Health risks result from consumption or ingestion of contaminated water or food and inhalation of contaminated water droplet.

It is evident that the Waste Water Treatment plants remain relevant in sewage treatment with minimal justification of sudden disposal or raw sewage in the water sources (Kim *et al.*, 2019). Importantly, Ngong River which crosses a populated city of Nairobi and serves as a central point of exposure to both human, domestic and industrial generated waste, forms part of the second largest river in Kenya which serves multiple counties in Kenya including Kitui, Kilifi, Makueni along the river chain and forming the upper part of Athi River (Ngatia *et al.*, 2023). Studies in Kenya have largely overlooked everyday forms of resilience. Ngeno *et al.* (2023) and Njuguna *et al.* (2017) have called for more inclusive sanitation planning, but few studies have captured the agency, resourcefulness, and social capital communities leverage

to cope with sewage pollution. Understanding these strategies is vital to designing interventions that are socially and culturally appropriate.

1.2 Problem Statement

A sustainable sanitation system is described as an economical, socially acceptable, technical, institutional and environmentally friendly cutting across the service delivery chain from user interface, storage, emptying, transportation, treatment, disposal, reuse and recovery for a long time (Chambers et al., 2022). Sustainable Development Goal 6 targets accessing equitable and quality sanitation and hygiene for all considering women and children in vulnerable situations (United Nations Department of Economic and Social Affairs [UN-DESA],2020). In a Joint Monitoring study conducted by United Nation Children`s Fund (UNICEF) and World Health Organization (WHO), the global burden of poorly managed sanitation outstretches to 4.5 billion people worldwide. Water bodies have been turned to sewage stream of dead water sources in high populated areas due waste (Mateo-Sagasta *et al.*, 2017).

Technological developments on water and sewerage systems and technologies remain unfulfilled due to pollution of water sources in the world (Bijekar et al., 2022; Tripathy et al., 2025). In the Low and Middle-Income countries, less attention has been given to wastewater contamination of rivers thus predisposing the LMIC at risk of disease transmission as a result impact the developed countries (Xie *et al.*, 2021). This is because of the consequent practices of disposing untreated waste water directly into the rivers, canals, and lakes in LMICs (Xie *et al.*, 2022).

This behavior needs proper monitoring in order to cut the route disease causing microorganism transmission (Xie *et al.*, 2022). Similarly, Ngong river suffers from poor

sewage systems thus causing direct discharge of raw sewage into the water sources (Ngatia *et al.*, 2023).

Despite numerous national policies and global efforts aimed at improving urban sanitation, the direct discharge of raw sewage into water bodies remains a deeply entrenched issue in Kenya's informal settlements. In areas like the Mukuru slums of Nairobi, this problem is driven by a combination of limited infrastructure, rapid population growth, and weak enforcement of environmental regulations (Chebii *et al.*, 2024; Ministry of Water, Sanitation, and Irrigation Kenya, 2021). Residents often rely on informal sanitation methods such as open drains, flying toilets, and unsafe latrines, leading to consistent flow of raw sewage into adjacent water sources, including rivers and open drainage systems (Muriuki *et al.*, 2020). This not only contaminates surface and groundwater but also increases the burden of waterborne diseases, especially among vulnerable populations.

While existing studies have examined the infrastructural and environmental dimensions of sewage disposal (Chebii *et al.*, 2024; Tanui *et al.*, 2025), there is limited understanding of how societal norms, perceptions of health risks, and community coping strategies influence these practices in informal urban settings. Without such context-specific insights, existing interventions risk being technically sound but socially ineffective (Mateo-Sagasta *et al.*, 2021; Lema, 2024). This study is therefore necessary to assess the societal and behavioral drivers of sewage disposal in Mukuru, including how residents understand and respond to health threats, and the strategies they adopt in the absence of formal sanitation infrastructure.

1.3 Justification

Studies have, underscores the severe health and environmental consequences of inadequate sanitation (Gupta *et al.*, 2023) However, improved sanitation can reduce the incidence of

diarrheal diseases by up to 60% (World Health Organization, 2022). In addition, a report by The Lancet (2019) indicated that safe sanitation enhances community dignity and safety, particularly for women and girls. It also boosts economic productivity by reducing healthcare costs and increasing workforce resilience. Therefore, need to understand aspects that might promote discharge of raw sewage in water sources provided an understanding of strategies to prevent and reduce disease transmission, develop interventions that provided insights and best practices that promote sustainable sewage management practices and technique, and help address social inequalities related to access of basic sanitation services.

1.4 Research Questions

- i. What are the societal norms that associated raw sewage disposal in water sources of Mukuru Slums?
- ii. What are the health effects associated with raw sewage disposal in water sources of Mukuru Slums?
- iii. What are the coping strategies directed towards disposal of raw sewage into water sources of Mukuru Slums?

1.5 Objectives of the Study

1.5.1 General objective

To investigate influence of societal norms, perceived health effects, and community coping strategies on raw sewage disposal into water sources within the Mukuru slums of Nairobi.

1.5.2 Specific objectives

- i. To examine the societal norms that influence raw sewage disposal in water sources in Mukuru Slums, Nairobi.

- ii. To assess community perceptions of health risks associated with raw sewage disposal in water sources in Mukuru Slums, Nairobi.
- iii. To assess the influence of coping strategies directed towards disposal of raw sewage in water sources, Mukuru slums, Nairobi.

1.6 Significance of the Study

Societal norms, health effects related to raw sewage disposal in water sources, and coping mechanisms are factors play a vital role in shaping human behavior and decision-making processes. This study provided insights on underlying reasons for this behavior by understanding the root-cause of the raw sewage disposal problem rather than setting up behavior change model and sanitation technologies. Proper interventions were developed towards addressing the societal norms, effects of raw sewage disposal on health and environment and the copying mechanisms. The study's methods and conclusions also provide a foundation for future investigations seeking to develop participatory, behaviorally-informed, and sustainable sanitation solutions. These insights could support the design of innovative interventions and contribute toward addressing the global sanitation crisis in informal urban environments.

1.7 Limitation of the Study

The study relied on self-report data which may be subjected to self-bias. To address this limitation, the research employed triangulation by combining quantitative and qualitative data-gathering techniques, including structured questionnaires, key informant interviews and focused group discussion. Triangulations enable the researcher to double-check the data supplied by respondents, enhancing the data's overall dependability. In addition, respondents

were reassured of their privacy and confidentiality, which prompted them to be candid in their answers.

1.8 Delimitation of the Study

The study specifically targeted Mukuru slums including Mukuru Kwa Njenga, Mukuru Kwa Reuben, and Viwandani within Nairobi County, Kenya. The findings may not directly apply to other informal settlements or regions outside this geographic context due to variations in demographic composition, governance structures, and environmental conditions unique to Mukuru. A mixed-method research design was employed to collect both qualitative and quantitative data concurrently.

While this design facilitated a comprehensive understanding of the issue at a single point in time, it limits the ability to assess longitudinal changes, such as evolving social norms or the long-term effects of sanitation interventions introduced after the study period. Furthermore, the study focused specifically on social norms, health effects, and community coping strategies associated with raw sewage disposal in water sources. It did not include other potentially relevant variables, such as environmental factors (e.g., drainage, flooding), political influences (e.g., policy enforcement), or technical infrastructure (e.g., sanitation hardware systems), which could also influence sanitation behaviors.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter covered the empirical and conceptual reviews, theoretical framework, conceptual framework, summary obtained and research gaps identified. The literature gave a comprehensive existing data on factors which influence the discharge of raw sewage into water sources in slums. The study variables were relative to societal norms, effects of raw sewage disposal on health and the existing sanitation coping strategies related to raw sewage disposal.

2.1 Overview of Raw Sewage Composition

Raw sewage is untreated domestic sewage which comprises of untreated wastewater and blackwater from toilets, sinks, drains, chemicals and sanitary products (Boudjab et al., 2023). Untreated municipal sewage is a leading hazardous source of water contamination, due to its high content of organic substances and nutrients such as nitrogen and phosphorus, which contribute to eutrophication and disrupt aquatic ecosystems (Collins *et al.*, 2018). Furthermore, untreated river water often contains harmful compounds such as polycyclic aromatic hydrocarbons (PAHs), which significantly degrade water quality and harm aquatic life (Syafiuddin & Boopathy, 2021).

The discharge of raw sewage into water sources is commonly linked to the lack of adequate sewerage infrastructure, particularly in rapidly growing informal urban settlements (Ngatia *et al.*, 2023). The continued discharge of untreated sewage exacerbates environmental and public health concerns, especially in densely populated areas like Mukuru Slums. In order to achieve proper sanitation, sewage management must involve the systematic processes of collection, emptying, transportation, treatment, disposal, and reuse (Andrianisa et al., 2022),

however depends on depend on technological, institutional, and social innovations. Despite advances in treatment technologies, many urban informal settlements still face significant challenges due to poor governance, inadequate infrastructure, and cultural norms that influence the persistence of unsafe sewage disposal practices (Sinharoy et al., 2021; Dickson-Gomez et al., 2023; Hakeem et al., 2022). The development of effective sewage management strategies thus requires a comprehensive approach, integrating both technical solutions and community participation.

Disposal of raw sewage into natural water sources leads to a marked shift in microbial populations. Xie et al. (2022) found that nutrient-rich sewage effluent stimulates the growth of Proteobacteria, a class of bacteria associated with elevated ammonia concentrations in polluted aquatic environments. These conditions foster the survival and spread of pathogenic strains including *Vibrio cholerae* (Ogawa-01), *Escherichia coli*, *Salmonella spp.*, *Shigella*, *Haemophilus*, and *Yersinia*, which are responsible for cholera, typhoid, enterotoxigenic illnesses, and plague outbreaks (Aghaee et al., 2021; Igbokwe et al., 2015). The concentration of these microbes is particularly acute in downstream areas near densely populated slums and industrial zones, where exposure risks are heightened. However, existing literature primarily focuses on microbial diversity and disease causation, leaving underexplored the spatial and temporal dynamics of microbial migration from sewage hotspots to broader community water sources.

The influx of nitrogen and phosphorus from untreated sewage accelerates eutrophication, resulting in hypoxic or anoxic water conditions that support the overgrowth of harmful microbial populations (Gobler et al., 2024; Liao et al., 2019). This phenomenon not only depletes dissolved oxygen levels but also creates an environment in which pathogens persist

and proliferate. Suzuki et al. (2019) emphasized that nutrient enrichment in sediments, particularly in urban rivers, acts as a reservoir for *E. coli* and other pathogens. While these studies confirm that eutrophication has microbial implications, few have examined how seasonal changes, hydrological flow, and sediment dynamics influence pathogen resurgence in the post-discharge phase.

Despite the negative effects of raw sewage discharge, several studies suggest that aquatic systems exhibit a degree of natural self-purification. Biological, chemical, and physical processes such as sedimentation, microbial competition, and nutrient assimilation—can gradually reduce microbial counts (Silva et al., 2020; Ago et al., 2024; Xie et al., 2021). However, Liao et al. (2019), Wagner and Zalewski, (2016) and Xu et al. (2025) found that these purifying processes are highly sensitive to seasonal temperature shifts and rainfall variability. Bojarczuk et al. (2018) further noted that although Poland's River Białka showed seasonal self-cleansing, *E. coli* levels remained above permissible thresholds due to runoff and recurring contamination. These findings highlight that self-purification is context-dependent and does not fully offset continuous pollution. The resilience of pathogenic organisms, especially in biofilms or sediment layers, remains insufficiently addressed in urban low-flow rivers.

Beyond microbial threats, raw sewage introduces chemical contaminants such as heavy metals into aquatic ecosystems. Ngatia et al. (2023) reported the presence of cadmium in Nairobi's Ngong River particularly in the Mukuru Kayaba area where concentrations exceeded both WHO and NEMA guidelines. This poses long-term carcinogenic risks through water use, crop irrigation, and food chain accumulation. Silva et al. (2020) noted that while natural attenuation may reduce microbial loads, toxic elements often persist and

bioaccumulate. However, the combined effects of microbial and chemical contaminants especially in environments affected by seasonal flooding or drought remain poorly integrated into public health risk frameworks. There is limited empirical research on how household-level coping strategies and informal sanitation practices intersect with formal governance failures a gap this study explored in detail within the context of Mukuru Slums.

2.2 Association of Social Norms, Health Effects and Coping strategies on Raw Sewage Disposal

This section the literature presents the influence of societal norms, health related and copying strategies reviewed in relation to raw sewage disposal into water sources.

2.2.1 Societal norms on raw sewage disposal practices in water sources

The study of societal norms, which refers to the perceptions and behaviors shaped by community values, plays a crucial role in influencing environmental practices, particularly in water sanitation. Research suggests that the social context in low- and middle-income countries (LMICs) significantly impacts behaviors that curb water contamination (Ferronato et al., 2019).

In a study conducted in Ethiopia by Bamlaku *et al.* (2023) to established latrine utilization factors found out that 88.5% Open Defecation Free (ODF) households and 86.8% for non-Open Defecation Free perceived their susceptibility on diarrheal diseases, 80.7% of showed descriptive norms among ODF households while 60.5% in non-ODF showed injunctive norms. The study established that, positive perception towards sanitation was 3 times more likely to utilize sanitation measures like use of toilets while the perception of latrine use by others was 2.7 times which clearly showed that social norms influenced the decision to utilize the latrine in a non-open defecation frees villages in Ethiopia. A similar study by

Berihun et al. (2025) in Amhara region, Northwest Ethiopia submitted that there was an association between beliefs and expectation on the status of open defecation free which was due to existence of social norms.

Furthermore, a study by Novotny et al. (2017) in Ethiopia to explore role of perceived social norms in rural sanitation, found that set perception on risks or benefits to have influence on sanitation behavior. Additionally, a study by Kuang et al. (2020) in India highlighted the significant role of gendered social norms in sanitation practices. The study revealed that women were more likely than men to face social sanctions for open defecation, illustrating the influence of societal pressures in shaping sanitation behaviors. The findings from both Ethiopia and India demonstrate the powerful role of social norms in driving sanitation behavior, particularly when community expectations and gender roles are factored in. Despite these positive shifts, a notable gap remains in understanding how deeply ingrained cultural and religious norms affect sewage disposal behaviors, particularly in urban slums where formal sanitation infrastructure is often absent.

A study by Doron and Jeffrey (2018) in India, submitted the perceived harmful behavior of littering was influenced by contextual factors of culture and religion such as the norm's purity filth, cleanliness which are complex due to due to taboos and beliefs. In accord, a study conducted by Helferich et al. (2023) littering was described as a descriptive norm because it was perceived as a commonly practiced behavior. In Poland, Piasecki (2019) noted that poor environmental responsibility resulted in households discharging untreated sewage into nearby streams to save costs. Similarly, Kamara et al. (2022) highlighted adoption of sustainable raw sewage disposal in water sources as a WASH component are sometimes hindered due to perception of perceived risk (that behavior will lead to illnesses),

belief benefit (believing there is an actual benefit to engaging in healthful WASH behavior), and personal beliefs, related to one's capacity to modify behavior.

Furthermore, social constructs such as collective efficacy (the ability of the community to make change and belief the collective group will make a change), social norms or traditions, and social identity (how a person wants to be perceived in their social circle/community) are vital in sustainable adoption of WASH options which are usually neglected during designing and delivery by sanitation service providers (Kamara et al., 2022). However, different opinion shows that, while most of peri-urban settings experience poor fecal sludge management, community members are responsible for taking care of their environment and health (Angoua *et al.*, 2018). Despite evidence of collective efficacy, where communities share responsibility for their environment, research has yet to explore how social identity and collective efficacy impact raw sewage disposal behavior in informal urban settings like Mukuru Slums.

Daniel et al. (2021), using a qualitative field study in rural Indonesia, highlight how sanitation behavior is strongly influenced by indigenous belief systems, caste dynamics, and institutional weakness. The study applied the FIETS (Financial, Institutional, Environmental, Technical, Social) framework through 91 semi-structured interviews, revealing that sanitation is shaped as much by social norms and risk perceptions as by infrastructural access. However, it lacks generalizability to dense urban informal contexts.

In a broader desk-based review, Susetyo (2024) emphasized the role of community awareness, technological innovation, and regulatory enforcement in managing waste and environmental sanitation. His findings show that behavioral change, public education, and inter-agency collaboration are crucial but under-deployed tools in managing waste-related

health risks, particularly in areas with poor participation. However, the study's literature-based approach lacked empirical field validation in slum environments.

Empirical studies highlight the complex interplay between structural constraints, institutional dynamics, and community behaviors in shaping sanitation outcomes in underserved urban areas. Ngasala, Masten, and Gasteyer (2022) used a qualitative case study approach incorporating stakeholder interviews and policy reviews to investigate systemic responses to water contamination. Authors findings revealed that fragmented institutional roles, poor inter-agency coordination, and tenure insecurity limited effective sanitation interventions in marginalized areas.

Similarly, Shrestha, Bhattarai, and Acharya (2023) conducted a policy and data-driven analysis using environmental assessments and national WASH indicators to assess disparities in sanitation access across Nepal. They identified persistent gaps in service delivery, particularly in informal settlements, due to political decentralization and limited financing, and called for locally grounded solutions. In contrast, Nelson et al. (2021) adopted a mixed-methods design combining cross-sectional surveys and qualitative interviews to examine the relationship between community participation and infrastructure outcomes. While they found positive associations between participatory engagement and improved WASH services, they noted that such engagement was often restricted to homeowners, excluding tenants and informal residents.

Kirimi, Eliud, and Mburugu (2022) used a mixed-methods approach, combining surveys, focus group discussions, and key informant interviews to examine how cultural beliefs affect latrine adoption in rural Makueni County, Kenya. Their findings revealed that taboos around discussing defecation, as well as symbolic associations of spiritual impurity, inhibited uptake

of sanitation interventions, despite availability. In accord, Mohanty and Dwivedi (2019) utilized ethnographic fieldwork, including participant observation and in-depth interviews in small-town slums of Odisha, India. Mohanty and Dwivedi (2019) concluded that while cultural beliefs about purity and pollution are present, sanitation behaviors are equally shaped by infrastructure, cost, and availability of water. Mentioned studies reveal that cultural influences on sanitation are real however, context-sensitive and mediated by economic and spatial conditions

Studies have underscored the complex role of social networks in shaping sanitation outcomes in informal settlements. Chumo et al. (2023), in a mixed-methods study of five Nairobi slums, argue that bonding and bridging social capital manifested through trust, group participation, and civic engagement enhance sanitation service access and sustainability. Chumo et al. (2023), findings highlight the contributions of women's groups and community-based organizations (CBOs) in organizing clean-up campaigns and promoting hygiene practices. In contrast, Kwiringira et al. (2023) critically examine why existing social networks in Ugandan slums fail to improve sanitation. Their qualitative study reveals that these networks are often fragmented, transactional, and lack community trust, undermining collective sanitation efforts. Nonetheless, the study lacks spatial analysis and does not assess the functional roles of localized actors who mediate sanitation behavior. These gaps provide a clear rationale for the proposed study in Mukuru, which will explore both the presence and the perceived efficacy of social networks and sanitation organizations. Existing literature provides robust insights into the structural and behavioral dimensions that shape sanitation investments in low-income urban settlements. Sinharoy, Pittluck, and Clasen (2019) reviewed policy-level enablers and barriers across informal settlements,

highlighting persistent issues such as tenure insecurity, inadequate institutional coordination, and the exclusion of slums from formal sanitation planning. Their findings emphasize the importance of integrated, rights-based frameworks but do not extend into localized, behavioral perspectives of affected communities.

Alam et al. (2020) added depth to this discourse through a qualitative study in Dhaka's slums, identifying distrust in public infrastructure projects, financial limitations, and logistical constraints as major hurdles to sewerage integration. Their research underscores the potential of community-based organizations (CBOs) in bridging policy and practice but is primarily urban-planning oriented, without quantifying the extent of individual willingness to invest. Delaire et al. (2020) focused on economic feasibility, estimating sanitation service costs across five cities. Their analysis concluded that even low-cost options were largely unaffordable for low-income households without subsidies. While comprehensive, their approach was cost-centric, lacking exploration of psychosocial or contextual factors influencing household decisions. Despite these contributions, a critical research gap persists: few studies offer both quantitative data on willingness to invest and qualitative insights into motivational barriers at the community level.

Narayan, Marks, and Meierhofer (2021) conducted a global systematic review of integrated water, sanitation, and solid waste systems in low- and middle-income countries. Their study highlighted that fragmented institutional responsibilities, weak communication, and poor coordination between agencies often undermine effective service delivery. However, the focus was primarily on macro-level integration and policy design, with limited attention to how localized social norms and behaviors influence practices like raw sewage disposal.

Johannessen et al. (2019) used qualitative case studies and stakeholder engagement in African and Asian cities to demonstrate how social learning especially triple-loop learning involving reflection on shared values can transform urban water governance.

They found that trust, collective reflection, and inclusive communication between community members and institutions were key to effective interventions. Yet, their analysis remained at the level of governance innovation and lacked granular, empirical insights into daily sanitation behaviors driven by community-level cooperation. Simiyu et al. (2017), through a mixed-methods study in Kisumu, Kenya, found that user cooperation and informal management improved the quality of shared sanitation facilities. Their household survey and facility inspections revealed that organized cleaning routines and agreed responsibilities resulted in better hygiene conditions. However, the study did not quantify broader social norms or address sanitation practices beyond toilet management such as raw sewage disposal.

Existing scholarship on waste management in informal settlements consistently reveals a critical gap in regulatory awareness and enforcement. Muheirwe et al. (2023) investigated solid waste regulation in Kampala's Makindye area and found that although national laws existed, 95% of residents lacked awareness, with informal norms rather than policies guiding behavior. Similarly, Showers (2024) assessed waste management in Freetown slums, where 81% of respondents were unfamiliar with segregation laws, and illegal disposal practices were prevalent due to ineffective infrastructure and policy outreach. In South Africa, Vala and Malazaa (2024) examined municipal authorities' implementation of greywater regulation, concluding that fragmented frameworks and low public education had rendered legal instruments ineffective in informal contexts. Complementing these findings,

Simiyu et al. (2019) documented the sanitation conditions in Kenya's Kisumu slums, reporting that limited community engagement and poor legal literacy significantly hindered adoption of safe disposal practices. Across these cases, a consistent pattern emerges: while regulatory frameworks often exist, they are either inaccessible, unknown, or unenforced within marginalized urban spaces.

2.2.2 Health effect from raw sewage disposal in the environment

Arguably, water pollution is the world's most health hazard due to exhaustion of the natural ecosystem, increase in the number of industries that emit industrial effluents into the water sources and rapid population growth in towns and cities (Deb *et al.*, 2021). This has harmfully impacted on the existing rivers degradation and critical ecological damage of global rivers by 20% due to disposal of 90% untreated waste water in the rivers, lakes and reliable marine lands. The study by Deb *et al.* (2021) shows that 80% of the produced waste water is disposed of in the environment without proper and collection treatment. This study concurs report by United Nations Environment Programme (UNEP, 2021) that over 80% of waste water is released into the environment untreated.

A growing body of research underscores the public health burden posed by inadequate sanitation and raw sewage disposal in informal settlements across Africa. Gqomfa, Maphanga, and Shale (2022) examined the impact of informal housing on the water quality of the Diep River in Dunoon, South Africa, using empirical field sampling and microbiological water analysis. Their findings revealed that effluent discharge, open defecation, and insufficient drainage infrastructure contributed to elevated concentrations of *E. coli* and coliform bacteria, particularly during rainy seasons. The study effectively established the link between environmental contamination and downstream waterborne

disease risks, but it did not assess direct health impacts within households. In agreement, Aminu and Udeze (2023) employed a survey-based quantitative approach to examine WASH practices in Lagos slums. They reported high incidences of diarrhea (71.8%) and typhoid (67.5%), primarily linked to unsafe drinking water, shared toilets, and inadequate hygiene behavior. Their logistic regression model confirmed that poor sanitation significantly predicts waterborne disease burden, yet their study lacked environmental sampling to support behavioral data.

Additionally, Ngakane (2021) conducted a cross-sectional survey in Mbekweni slums, South Africa, highlighting community-level health concerns driven by poor sanitation, stagnant wastewater, and erratic waste collection. Residents cited frequent gastrointestinal illnesses, 10% possible TB symptoms and 9% other infections, and blamed inadequate municipal services, revealing a systemic neglect of peri-urban slum populations. The *E. coli* counts detected in the environmental water samples varied from 2300 organisms to 32 million organisms per 100 ml water, indicating extensive sewage contamination. Collectively, mentioned studies illuminate both behavioral and environmental contributors to disease in slums. However, limited offer an integrated approach combining self-reported health data, environmental contamination measures, and seasonal analysis.

Nigusie et al. (2021) conducted a large-scale community-based cross-sectional study in northwest Ethiopia to assess the prevalence and determinants of vector-borne diseases. The e stronger household-level sanitation practices. Although the study identifies key behavioral and environmental drivers, it focuses on rural settings with different sanitation dynamics than dense urban slums.

Complementing this, Palaniyandi (2021) explored the intersection between urban environmental degradation and the persistence of both tropical infectious and non-communicable diseases (NCDs), with particular focus on informal urban settlement. The study utilized a multidisciplinary review methodology, synthesizing satellite-based land use change analysis, public health surveillance data, and case reports from Indian and Southeast Asian megacities. The findings reveal that densely clustered informal settlements with inadequate sanitation systems are epicenters for emerging and re-emerging vector-borne diseases such as chikungunya, filariasis, and Japanese encephalitis. Although the study presents strong regional patterns and environmental predictors, it primarily relies on satellite-level assessments and broader municipal records, offering limited insight into household-level exposure and illness frequency

A study by Zerbo (2022) examined environmental risk factors that influence outbreaks of water and vector-borne diseases in urban areas across Sub-Saharan Africa. The study utilized, multi-country comparative methodology, the research integrated epidemiological data analysis, Geographic Information System (GIS) mapping, and structured expert interviews to identify high-risk zones and the environmental variables contributing to disease transmission. Key findings indicated that unregulated human waste disposal, particularly raw sewage in open drains and natural water bodies, significantly contributed to the spread of vector-borne diseases such as malaria, dengue, and filariasis.

Zerbo (2022) highlighted that climate variability such as increased flooding intensified vector habitats and extended transmission periods. While Zerbo (2022) research provides critical regional insights, it is largely based on national and municipal datasets, lacking localized household-level evidence. Mamidi (2024) echoed these concerns in his study on

Indian slums, noting that while vector risks were clearly linked to improper sewage and solid waste management, community members often lacked disease awareness, with illnesses being misidentified or left untreated. These studies demonstrate a consensus on the role of poor sanitation in exacerbating vector-borne diseases, while also exposing a research gap: the lack of micro-level data from urban informal settlements.

Malnutrition in urban slums is increasingly linked to both environmental and food safety factors. Sanin et al. (2022) conducted an observational study in Dhaka's Bauniabadh slum to assess how domestic and street-level food safety practices affect childhood stunting. Using structured questionnaires, environmental observations, and anthropometric data for 187 school-age children, they found that failure to treat drinking water and frequent consumption of street food were significant predictors of stunting. Alarming, 27% of mothers reported cooking near open sewage, while one-third of food vendors operated near municipal drains or sewers conditions amplifying exposure to fecal pathogens and increasing foodborne illness risks. The authors advocate for integrated WASH-nutrition interventions targeting slum settings. Similarly, Gao et al. (2022) used a cross-sectional survey in rural China and found that inadequate water access severely restricted dietary diversity and increased the risk of stunting and wasting. The study highlights that water scarcity affects not only hygiene but also the quality and preparation of nutritious food.

In Eastern Africa, Judge (2021) used a mixed-methods design combining biomedical and ethnographic data to demonstrate how repeated environmental contamination leads to environmental enteric dysfunction (EED), which impairs nutrient absorption even where food intake appears adequate. Judge (2021) emphasized that addressing undernutrition

requires more than just food provision it necessitates interrupting chronic infection cycles linked to sanitation failures.

Additionally, Momberg et al. (2021), in a systematic review across sub-Saharan Africa, concluded that WASH deficits consistently undermine child growth outcomes. The authors stressed that interventions addressing nutrition without resolving sanitation gaps are insufficient. However, despite growing regional and global evidence, there is limited context-specific research examining how raw sewage disposal practices directly influence nutrition-related illnesses in urban Kenyan slums like Mukuru.

Poopedi, Singh, and Gomba (2023) assessed occupational exposure to respiratory and enteric pathogens among wastewater treatment plant workers in South Africa, highlighting a high prevalence of respiratory symptoms linked to bioaerosols, volatile gases, and microbial agents from untreated sewage. While the study's-controlled setting allowed precise monitoring, it focused exclusively on formal workers with some access to protective equipment. In contrast, informal settlement residents face similar or worse exposure levels without such safeguards, yet remain underrepresented in empirical data. Wafula et al. (2023) expanded the scope by examining indoor air pollutants and respiratory symptoms among residents of Bwaise, an informal settlement in Uganda. Using structured interviews and air quality monitoring, they found elevated Particulate Matter (PM) 2.5 and PM10 levels and an 84.6% prevalence of respiratory symptoms.

Similarly, Makgalemane et al. (2024) studied respiratory conditions in children under six in the Melusi informal settlement, linking long-term exposure to poor air quality with significantly elevated risks of wheezing, cough, and itchy eyes. Yet the study emphasized airborne pollutants while overlooking sanitation and sewage factors as determinants of

respiratory health. Collectively, mentioned studies underscore the growing recognition of environmental respiratory hazards in informal settlements. However, they lack integration of both air and sewage-based exposure pathways in the same populations

The relationship between inadequate sanitation and its effects on mental and physical well-being has been widely explored in various global contexts, including urban slums. Goode et al. (2025) in Baltimore, Maryland, found that sanitary sewer overflows (SSOs) and basement backups caused by aging infrastructure contributed significantly to residents' mental health issues, particularly anxiety and stress. Their findings revealed that 65% of respondents reported anxiety symptoms, further linking the stress of dealing with untreated sewage to both mental health distress and physical health symptoms like nausea and fatigue. These findings underscore the need for community-driven research in understanding the mental health impacts of poor sanitation infrastructure.

Similarly, Kimutai et al. (2023) found that poor sanitation is strongly correlated with psychosocial stress, especially in low-income urban environments, with depression and anxiety being the most common mental health outcomes. They highlighted the importance of improving sanitation infrastructure to mitigate the psychological burden faced by individuals living in such environments, a view shared by Sclar et al. (2018), who identified privacy and safety as key attributes influencing mental well-being in sanitation-deficient areas. Their findings revealed that the stigma and stress associated with poor sanitation negatively impacted both social and mental health.

Ross et al. (2021), study in Maputo, Mozambique, emphasized the psychosocial stressors resulting from sanitation insecurity, particularly in informal settlements, linking the lack of privacy, safety, and dignity to increased anxiety and social isolation. This is crucial for

understanding the deep connection between environmental factors and mental health in underdeveloped settings. Despite these critical findings, a significant gap remains in understanding how sanitation impacts mental health specifically in slum communities like Mukuru, where systemic poverty, poor infrastructure, and lack of access to proper sanitation create a unique psychosocial landscape.

Darling et al. (2023) conducted a systematic review and meta-analysis on the microbiological and chemical contaminants in drinking water in rural Appalachia, particularly focusing on *E. coli*, arsenic, and lead. The study found that *E. coli* was present in 10.6% of water samples, with arsenic and lead detected at concentrations of 0.010 mg/L and 0.009 mg/L, respectively. Health outcomes associated with water contamination included gastrointestinal issues and cardiovascular diseases. However, the authors pointed out that despite the high number of studies, they could not draw definitive conclusions about the state of water quality or its direct health impacts in Appalachia.

Similarly, Meng (2022) conducted an initial study focusing on the urban water crisis in Jackson, Mississippi, USA, analyzing its impact on public health diseases, particularly looking at geographic and racial health inequities. Meng's (2022) findings highlighted the direct link between water contamination, particularly heavy metals (like lead and arsenic), and the increasing rates of chronic diseases such as cardiovascular diseases and diabetes. These health impacts were found to disproportionately affect certain communities, especially marginalized African American populations in urban settings. The study noted that polluted water sources lead to long-term exposure to toxins, causing systemic inflammation and aggravating pre-existing conditions. The studies by Meng (2022), and Darling et al. (2023) provide valuable insights into the health impacts of inadequate water,

sanitation, and hygiene, but Mukuru's unique socio-economic and environmental context requires further investigation to inform effective public health interventions.

The impact of water pollution on public health has been extensively studied in various contexts, revealing alarming correlations between contaminated water and skin diseases. Trisnaini et al. (2025) conducted an analytical study in Indralaya, South Sumatra, and found significant associations between environmental factors, such as water quality and waste disposal practices, and the prevalence of skin diseases. The study emphasized that poor sanitation and the use of river water for daily needs contributed to higher rates of dermatitis and other skin infections. Adegoke, Amoah, and Stenström (2018) further highlighted that exposure to untreated wastewater in agricultural settings led to skin infections and intestinal diseases, especially in areas where sanitation infrastructure was inadequate. They underscored the necessity of sanitation safety plans (SSPs) to mitigate health risks, particularly for vulnerable populations.

Khan et al. (2018) focused on the Swat Valley, Pakistan, identifying fecal contamination in drinking water sources as a major contributor to waterborne diseases such as diarrhea and skin infections. They reported a direct correlation between the high levels of fecal coliforms in drinking water and increased health risks, particularly for children and elderly populations. This finding mirrors the skin-related diseases reported in communities with poor waste disposal and water treatment systems, similar to those observed in informal settlements like Mukuru. Mustafa and Hassan (2024) reviewed studies on water contamination and health risks, linking contaminated water to diseases like diarrhea and skin conditions. They emphasized the need for improved water quality and better sanitation practices to reduce these health risks.

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In accord, Okaka and Odhiambo (2019) examined the perception of flood risk and health impacts in Mombasa's informal settlements. The study found significant health impacts, including malaria, diarrhea, and skin infections, but it did not specifically address how sanitation-related skin diseases are exacerbated by flooding in urban slums. The findings from mentioned studies underscore the critical gap in research on urban informal settlements

like Mukuru, where water contamination due to raw sewage disposal is a pressing health concern.

2.2.3 Sanitation coping strategies

The Sustainable Development Goal (SDG) 6.2 calls for "adequate and equitable sanitation and hygiene for all" and to "eradicate open defecation " (UN-DESA, 2020). However, little progress has been made in the provision of adequate sanitation in many low- and middle-income countries. Studies by Meili et al. (2022), Simiyu et al. (2021) and Lerebours (2021), have reported in slums on-site sanitation (OSS) systems like pit latrines and septic tanks are prevalent and, the effectiveness of containment varies significantly.

A study was conducted by Meili et al. (2022) to identify quality indicators for sanitation in low-income urban settlements in Kenya, Ghana, and Bangladesh. The study found that in Kisumu (Kenya), 83% of toilets were pit latrines with slabs and 13% were flush systems. Kumasi (Ghana) showed a near-even split between 55% flush and 41% slab latrines, while in Dhaka (Bangladesh), 90% of toilets were pour-flush draining to "elsewhere," with 52% of users unaware of the outflow. This raises serious concerns about environmental safety and health risks, as unknown or unsafe outflows may result in fecal contamination of local water sources.

In the same vein, Ssemugabo et al. (2021) conducted a study Kampala slums, to assess sanitation and hygiene facilities and found that traditional pit latrines were the predominant sanitation facility, used by 67.1% of the population. An additional 26.6% used pit latrines with slabs, while only 3.3% had access to pour-flush or flush toilets. And only 2.5% Ventilated Improved Pit (VIP) latrine. Notably, 86.8% of all sanitation facilities were shared among multiple households, primarily due to space constraints, poverty, and the informal

nature of housing which limits private toilet construction. The authors commented widespread sharing of sanitation facilities increases the risk of fecal contamination, the spread of diarrheal diseases, and poor menstrual hygiene management due to overcrowding, limited cleanliness, and inadequate handwashing infrastructure.

A qualitative study by Simiyu et al. (2021) in low-income settlements in Nakuru, Kenya, to examine fecal sludge management (FSM) along the sanitation value chain., found that majority of residents were relying on pit latrines and toilets connected to septic tanks. However, pit latrines were the predominant sanitation facility, commonly built and financed by plot owners. Due to space constraints and population density, these latrines were typically shared by multiple households and filled rapidly. The study found that, lined pit latrines were being emptied mechanically using the gulper and the Rama while unlined pit latrines were emptied manually mainly because they were prone to caving in during emptying because of poor construction.

Additionally, a study conducted by Sogomo et al. (2024) in informal settlements of Eldoret, Kenya to assess landlord perspectives on faecal sludge emptying and transport and found that 80% of landlords used septic tanks, and 20% used pit latrines. Authors noted that emptying was provided by private individuals using vacuum trucks, with no pricing regulation in place, which may lead to adoption of unsanitary practices. Transportation was conducted to wastewater treatment plants (WWTPs) by licensed. However, delays in service, high costs, foul smells, and groundwater contamination were reported challenges. This indicates reliance on informal, unregulated systems that burden tenants and landlords alike.

Similarly, a study conducted by Lerebours (2021) in urban and slum areas of Kampala to assess the health and safety practices in faecal sludge management (FSM) found that

emptying practices varied significantly by settlement type. In informal areas, poor road infrastructure and non-standardized pit designs necessitated reliance on manual or semi-mechanized tools, such as the gulper. In contrast, formal settlements more frequently accessed mechanized vacuum trucks. The study found that transport was typically conducted using vacuum trucks or tricycles, but many emptiers resorted to illegal dumping of faecal sludge into drainage systems to reduce operational expenses and avoid treatment fees. This highlights serious regulatory and logistical gaps, especially in monitoring sludge movement from source to safe disposal.

The study Okoye et al. (2018) assessed the effects of sewage disposal systems in Riverside Housing Estate, Enugu Metropolis, focusing on centralized and on-site (septic tank) systems. The study found that 80% of households had abandoned the central sewage system, opting for septic tanks due to maintenance challenges. The central system, however, suffered from blockages, leading to water pollution, stagnant water, and air pollution, contributing to diseases like typhoid and malaria. Conversely, the septic tank system, while more hygienic and easier to maintain, faced issues of groundwater contamination due to its proximity to hand-dug wells. The study highlighted the need for proper siting of septic tanks and better maintenance of centralized systems.

Analysis of faecal waste flows in 39 cities in Asia and Africa found that 39% of tanks and pits were connected to open drains or water bodies (Peal et al., 2020). In India, a survey of 3000 households in 10 cities found that 72% of septic tanks discharged effluent to drain (Dasgupta, et al., 2021). In Hanoi, Vietnam, a study of 750 households found that 98% of septic tanks discharge to open channels or old sewer pipes not connected to treatment facilities (Harada et al., 2008). National inspections in Ireland found that 9–13% of on-site

systems discharge directly to streams and drains. Discharge to the surface is also common in rural United States (Mills et al., 2024). These findings are now also reflected in global monitoring of the Sustainable Development Goal (SDG) target 6.2.1 of safely managed sanitation services, which requires that on-site sanitation systems contain excreta so they are not discharged to the surface environment (United Nations Children's Fund, & World Health Organization. (2024). Where local data are unavailable, estimates for safely managed sanitation are based on the assumption that 50% of septic tanks are not contained.

Study by Oluseyi and Nweke (2020) examined sewage management and its implications on public health in Agboyi-Ketu, Lagos, focusing on improper waste disposal, particularly in low-income settlements. The study found that poor sewage management practices, including open defecation and direct discharge into water bodies, were common in the Agboyi-Ketu area. Over 70% of the respondents had septic tanks, but many were in poor condition, leading to the contamination of nearby wells and surface water. These unhygienic practices were linked to health issues, including diarrhea, cholera, hepatitis, and typhoid, which were prevalent in the community. Oluseyi and Nweke (2020) submitted that that improper sewage disposal is often overlooked due to neglect by community health promoters and law enforcement, contributing to significant health hazards. In the same vein, Siamalube and Ehinmitan (2025) addresses the persistent cholera outbreaks in Sub-Saharan Africa (SSA), emphasizing the role of poor sanitation and lack of proper water treatment in exacerbating the disease's spread.

Studies by Abubakar (2017), Oluseyi and Nweke (2020) Bhatkal et al. (2024); Alam et al. (2020) and Kwiringira et al. (2021) have submitted neglect both at the household and institutional level may undermine safe sanitation practices in urban informal settings.

Abubakar (2017) conducted an in-depth empirical investigation into how households in Abuja respond to the inadequacies in municipal sewerage and garbage collection services. The study reveals that a considerable number of residents are compelled to adopt alternative, often informal, strategies due to persistent service failures. Specifically, 62% of respondents utilized informal sewerage services and 55% relied on informal garbage collection. Despite some proactive engagement 68% invested personal resources in sanitation there remained a substantial level of neglect: 22% of respondents admitted to completely ignoring sanitation problems, while 37% practiced “partial neglect,” recognizing issues but taking no formal action, especially when the problems were perceived as distant or communal. The phenomenon of “collective disownership,” where shared infrastructure problems are disregarded unless they directly affect one’s household, points to deep socio-cultural disengagement.

In agreement, Bhatkal et al. (2024) extend the analysis by examining systemic neglect at a structural level. Bhatkal et al. (2024) review showed that in the Global South, particularly in slum settlements, sanitation policies tend to focus narrowly on toilet access while ignoring second- and third-generation challenges such as faecal sludge management and the socio-political marginalization of sanitation workers. In India, for instance, while over 60% of the urban poor lack access to basic sanitation, national programs like the Swachh Bharat Mission have emphasized toilet coverage without addressing safe waste containment and disposal. This results in unsafe practices such as manual emptying by informal, marginalized workers, further entrenching environmental health risks and social inequities in sanitation governance.

A qualitative study by Alam et al. (2020) examined the perceptions and challenges faced by residents in low-income communities (LICs) of Dhaka, Bangladesh, in accessing safely managed sanitation under the Dhaka Sanitation Improvement Project (DSIP). The study found that residents of low-income communities frequently deprioritized sanitation despite high demand, instead channeling limited resources toward more immediate needs such as food, rent, water, and healthcare. Shared, poorly maintained toilets and hazardous alternatives like hanging latrines were widespread, with many households lacking access to sewerage due to unaffordable connection costs and insecure tenure. These findings suggest that sanitation neglect is not due to ignorance but is a rational adaptation to survival pressures and institutional shortcomings.

Similarly, Kwiringira et al. (2021) reveal parallel dynamics in Uganda's urban slums, where residents in Kampala, Gulu, and Mbarara deprioritized sanitation in favor of meeting basic livelihood needs. Although aware of the health risks, participants resorted to coping strategies such as wrap-and-throw defecation or reliance on overcrowded shared facilities. The root causes were found to be structural poverty, tenure

Studies by Simiyu et al. (2017) and Chumo et al. (2023) have submitted that economic constraints and weak institutional mechanisms may perpetuate the neglect of safe sanitation practices particularly fecal sludge disposal in informal settlements. In Kisumu, Kenya, Simiyu et al. (2017) found that households spend less than \$1 monthly on sanitation, as immediate priorities such as food and rent take precedence.

This economic reality drives residents toward unsafe sanitation options, including shared pit latrines and illegal dumping. High desludging costs, coupled with irregular income flows, particularly among tenants, discourage regular toilet maintenance. Landlords, on their part,

often prioritize rental space over sanitation investment, further compounding the problem. Security, and poor public service delivery rather than attitudinal. Chumo et al. (2023) affirm these dynamics by emphasizing how low-income tenants and landlords in informal areas routinely neglect sanitation due to limited resources and poor social accountability structures. With landlords shifting desludging responsibilities to tenants and tenants lacking the capacity to act, safe disposal becomes a low priority. Moreover, the lack of collective community pressure or advocacy further entrenches neglect

Studies by Syafruddin and Adi (2019); Ebaid and Helmi (2024) and Webb et al. (2017) have highlighted the impact of relocation on residents' health and well-being in response to inadequate living conditions. Syafruddin and Adi (2019) utilized a qualitative approach to examine the mental and health impacts of relocation in Kampung Pulo, Indonesia. The study findings revealed significant improvements in health conditions post-relocation due to better access to sanitation, healthcare, and safe living environments. These changes were attributed to improvements in water quality, and sanitation facilities.

Similarly, Ebaid and Helmi (2024) applied a mixed-methods approach to explore the relocation of households in Ain El-Sira, Egypt, driven by unsafe living conditions due to poor sanitation and waste management. The study showed that relocation led to enhanced sanitation infrastructure and better health outcomes, highlighting that better-designed slum improvement strategies can significantly enhance residents' quality of life. Additionally, Webb et al. (2017) investigated the impact of relocation on depressive symptoms in public housing residents in Charlotte, NC, using pre- and post-relocation surveys.

They found significant improvements in mental health when residents relocated to less-distressed neighborhoods, with better perceptions of safety and social support. While the

studies by Syafruddin and Adi (2019), Ebaid and Helmi (2024), and Webb et al. (2017) provide valuable insights into the health and well-being outcomes of relocation, Mukuru presents a unique case that warrants focused research.

Past studies have reported reliance of external actors might be significant factor in access to improve sanitation in slums context (Aboagye & Doe ,2022; Simiyu et al. (2021). A mixed-method approach by Aboagye and Doe (2022) in Ghana evaluate how subsidized sanitation services are provided in slum areas in Ghana. Findings suggest that subsidized sanitation services are a critical coping strategy for slum households that cannot afford proper waste disposal system.

Similarly, Choge, (2021) conducted qualitative study in Nairobi to explore the role of domestic private sector actors in faecal sludge management. The findings highlight a growing reliance on private actors to fill the sanitation gap in areas where government services are non-existent. In agreement, Simiyu et al. (2021) examined fecal sludge management practices in low-income settlements in Nakuru, Kenya, using qualitative methods such as interviews and observations with community members and manual emptiers. The research found that on-site sanitation facilities, predominantly shared among multiple households, were the norm due to high costs and space constraints. These facilities were often unclean and filled up quickly, necessitating frequent emptying by manual workers who relied on both mechanized and manual methods. Households depended heavily on external factors including private emptiers, municipal authorities, and NGOs for emptying, transportation, and treatment of fecal sludge.

However, the study highlighted persistent challenges such as negative community perceptions, high costs of services, and logistical barriers in the value chain. The authors

concluded that sustainable sanitation requires coordinated involvement of state and non-state actors, but noted a gap in quantitative data and the need for more robust, context-specific research

According to a global comprehensive report by UN-Habitat (2023) on sanitation and wastewater management in cities, emphasized on the integration of slum upgrading into city-wide strategic planning. The report highlighted that poor households in slums heavily depend on local governments and NGOs for sanitation services. These external actors often provide temporary or inadequate solutions, including basic waste disposal and sanitation infrastructure. However, the report emphasizes that financial mechanisms to support these efforts remain insufficient, hindering the long-term sustainability of sanitation systems in slums.

However, a study Maharaj and Maharaj (2022) to review sanitation challenges in developing countries, particularly in informal urban settlements, and submitted that, while external actors, including NGOs and international agencies, have played vital roles in providing sanitation services, their efforts often face significant obstacles due to inadequate coordination with local governments. Maharaj, and Maharaj (2022) noted Key challenges including insufficient funding, lack of political will, and fragmented service delivery systems. The authors also emphasize that without clear policies integrating local governance structures and community involvement, sustainable sanitation solutions are difficult to achieve.

Similarly, Scott et al. (2019) examined the integration of urban services, such as water and sanitation, in informal settlements. The study underscored the importance of coordinated efforts between local governments and external actors, stressing that successful sanitation

outcomes depend on robust local government leadership, which is often lacking in urban poor areas. These studies indicate a significant gap in the integration of local governance structures with external aid, particularly in slums like Mukuru, where political and financial challenges impede long-term sustainability. Further research is needed to understand how these external support systems can be more effectively coordinated with local governance to create sustainable sanitation solutions in Mukuru and other similar informal settlements.

2.3 Theoretical Framework

The study was guided by three interrelated theoretical frameworks: the RANAS model, the Exit-Voice-Loyalty-Neglect (EVLN) framework, and the Theory of Normative Social Behavior (TNSB). These models provide a robust lens for understanding the societal, behavioral, and coping mechanisms that influence raw sewage disposal in informal urban settings.

2.3.1 RANAS model

The RANAS model (Risk, Attitude, Norm, Ability, and Self-regulation) developed by Contzen, and Mosler (2012) is a psychological framework designed to assess and influence behavior in water, sanitation, and hygiene (WASH) settings. It emphasizes that behavior change is not solely a function of knowledge but is determined by how individuals perceive health risks, their personal and social attitudes, the influence of social norms, their confidence and capacity to act, and their ability to self-monitor and sustain behavior over time.

The model has been widely applied in both urban and humanitarian settings to influence WASH behaviors. For instance, Mashudi et al. (2020) used the RANAS framework to assess community behavior change in maintaining drinking water quality in Indonesia and found

that the model significantly supported behavioral shifts toward safer practices. Similarly, Rahaman et al. (2022) applied the RANAS model to understand psychosocial drivers of handwashing behavior in the Rohingya refugee camps in Bangladesh. Their findings showed that perceived risk, social norms, and self-efficacy were crucial determinants in influencing sustained hygiene practices. These studies demonstrate the RANAS model's versatility in shaping sanitation-related behaviors across diverse and resource-constrained contexts, reinforcing its relevance for analyzing sewage disposal behavior in Mukuru.

2.3.2 Exit, voice, loyalty and neglect conceptualization

Originally introduced by Hirschman in 1970, the Exit-Voice-Loyalty-Neglect (EVLN) model provides a framework for understanding how individuals and communities respond to dissatisfaction with public service delivery (Vantilborgh, 2015). Over time, this model has been adapted and applied to various contexts, including sanitation and urban infrastructure in informal settlements. It outlines four primary coping responses. Exit refers to the act of physically or symbolically withdrawing from a failing system, such as relocating from a poorly serviced area. Voice involves expressing dissatisfaction and seeking reform, such as through community advocacy or engagement with local authorities. Loyalty describes the tendency of individuals to remain committed to a dysfunctional system out of hope or trust that conditions will improve over time. Finally, Neglect represents passive resignation, where individuals withdraw effort and accept poor conditions without protest or action.

Recent research by Abubakar (2017) applied the EVLN model in Abuja, Nigeria, to explain how urban slum residents cope with sanitation failures. His findings revealed that neglect and informal coping strategies, such as illegal dumping and bypassing official channels, were dominant in areas where formal infrastructure was either unaffordable or entirely

absent. These behaviors reflected a form of passive withdrawal and informal resilience, often exacerbated by institutional disengagement. Supporting this, Owuri and Sanusi (2021) conducted a literature-based study on water scarcity and household adaptation strategies, emphasizing that in the face of inadequate service provision, households often resort to self-managed or improvised solutions that mirror the Exit and Neglect dimensions of the EVLN framework. Their review further highlighted that these responses are not merely functional but deeply embedded in socio-economic constraints and trust deficits between communities and state institutions. In the context of Mukuru, these insights are critical to understanding how sanitation-related dissatisfaction manifests in adaptive behaviors that may either resist or reinforce unsafe sewage disposal practices.

2.3.3 Theory of normative social behavior

The Theory of Normative Social Behavior (TNSB), formulated by Rimal and Real (2005), builds on social cognitive theory by distinguishing between descriptive norms (what people do) and injunctive norms (what people believe others expect of them). The theory suggests that social norms influence behavior more strongly when moderated by outcome expectations (e.g., benefits of following the norm), group identity, and norm strength (Rimal & Yilma, 2022)

This framework is particularly relevant in slum contexts where behavior is often shaped more by what is commonly observed than by formal rules. More recently, Amon-Tanoh et al. (2021) conducted a cluster-randomized controlled trial in urban Côte d'Ivoire and found that social norm-based interventions significantly improved handwashing practices when compared to hardware interventions alone. Amon-Tanoh et al. (2021) findings confirmed that leveraging perceived norms within a community can catalyze meaningful hygiene

behavior change, even in resource-limited urban environments. In the context of Mukuru, TNSB provides insight into the communal and normative influences that perpetuate unsafe disposal practices. It helps explain how behaviors like sewage dumping become “normalized,” even among individuals who are aware of the associated health risks. This theory allows for a deeper exploration of how peer influence and perceived acceptability reinforce environmentally harmful sanitation practices and can inform the development of interventions that target social norm change.

2.4 Summary of Literature Review and Research

The reviewed literature affirms that raw sewage disposal in informal urban settlements poses significant environmental and public health risks, particularly through microbial contamination and disease transmission (Xie et al., 2022; Ngatia et al., 2023). Numerous studies have examined the chemical and microbial composition of sewage-contaminated water bodies (Gobler et al., 2024; Silva et al., 2020), as well as the technical limitations of wastewater infrastructure in low- and middle-income countries (Peal et al., 2020; Dasgupta et al., 2021). While these studies provide valuable insights into the environmental consequences of poor sanitation, several gaps remain in understanding the social, behavioral, and experiential aspects of sewage disposal.

First, there is limited exploration of societal norms and cultural perceptions that influence sanitation behaviors in urban slums. Most research has focused on rural or peri-urban contexts, often emphasizing open defecation rather than the direct disposal of sewage into water sources (Berihun et al., 2025; Kuang et al., 2020). The influence of religious taboos, social identity, and collective efficacy on urban sanitation practices remains under-investigated (Kamara et al., 2022; Kirimi et al., 2022). In areas like Mukuru, where informal

rules often supersede formal regulation, these cultural dimensions may significantly shape sanitation decisions.

Second, household-level coping strategies are rarely addressed in depth. While some studies highlight infrastructural or institutional deficits, there is insufficient attention to how residents adapt when formal systems fail through passive neglect, illegal dumping, or risky alternatives like manual emptying (Simiyu et al., 2021; Abubakar, 2017). These informal practices are widespread but understudied, even though they represent critical points for policy intervention and community-based innovation.

Third, although the health consequences of sewage exposure such as diarrhea, skin diseases, and respiratory infections are well documented (Gqomfa et al., 2022; Makgalemane et al., 2024), few studies explore how communities perceive and emotionally respond to these risks. Mental health impacts, including anxiety and stress from sanitation insecurity, are emerging concerns but remain poorly documented in African urban slum contexts (Goode et al., 2025; Kimutai et al., 2023). Understanding these perceptions is vital for designing effective health education and public engagement strategies.

A significant disconnect persists between national sanitation policies and the realities of slum dwellers. Much of the existing literature emphasizes engineering solutions, with limited incorporation of behavioral models or participatory planning (Narayan et al., 2021; Johannessen et al., 2019). Even when policy frameworks exist, awareness and enforcement are often lacking at the community level (Muheirwe et al., 2023; Showers, 2024), resulting in implementation gaps that perpetuate unsafe practices. The gaps in the coping strategies toward sanitation were identified in collection of fecal matter in the slums, with minimal

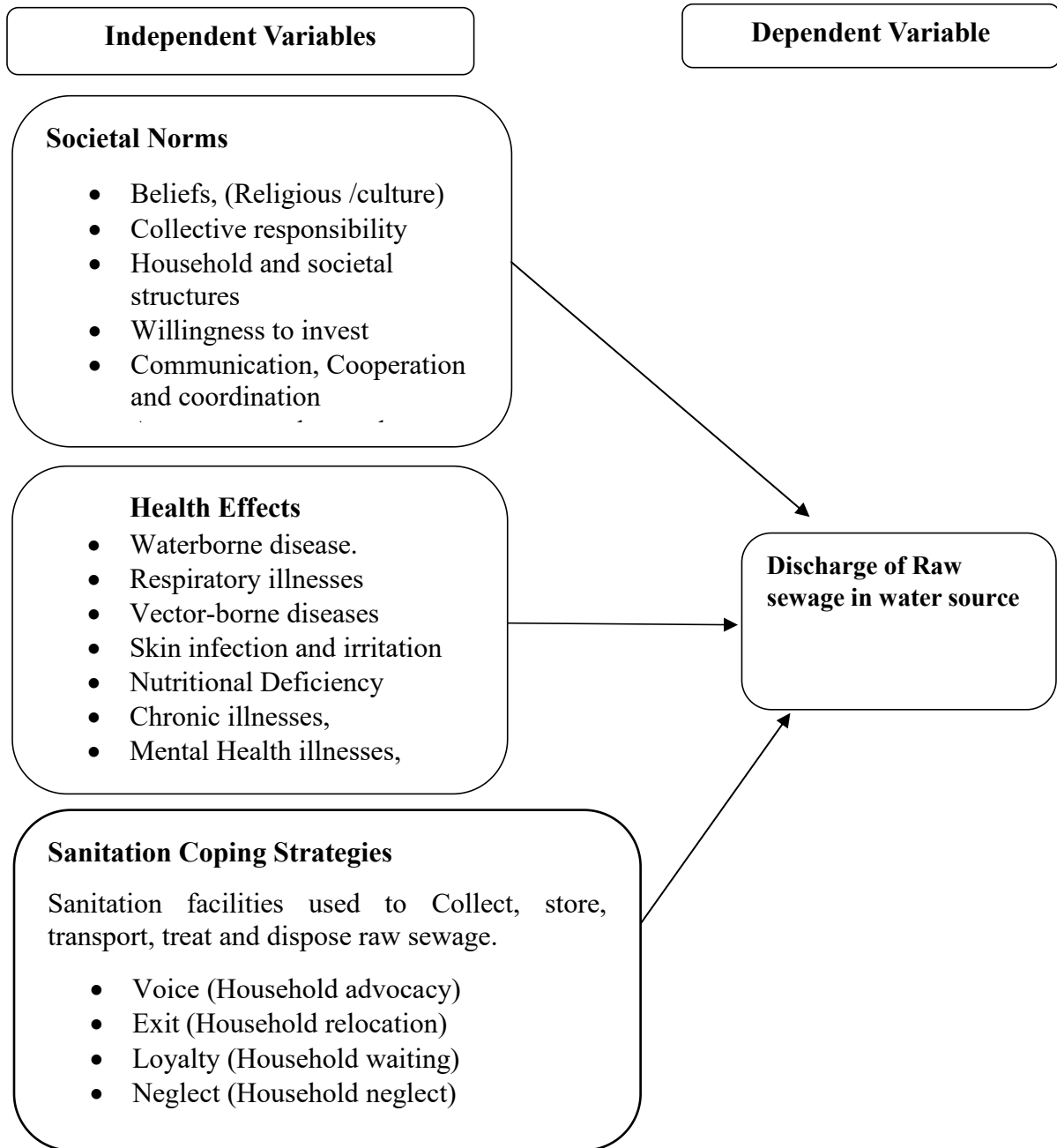
mentions on the coping strategies of the emptying of the filled pit latrines, overwhelmed treatment plants, and overflowing septic tanks.

2.5 Conceptual Framework

The two variables under study were dependent and independent variables. The dependent variable also known as the influenced variable was the discharge of raw sewage on water sources in Mukuru slums, while the independent variables were (Societal factors, health risks variables and coping strategies) influencing disposal of raw sewage in water sources and the association between the independent variables was analyzed to determine the degree of occurrence of the variables and the impact of the variables in respect to each other.

Figure 2. 1

Conceptual framework



Source: Literature Review, 2024

Table 2. 1*Operationalization of the study variable*

1. To determine the role of societal norms that influence raw sewage disposal in water sources in Mukuru Slums, Nairobi	Societal norms	Beliefs, (Religious /culture) Collective responsibility Household and societal structures Willingness to invest Communication, Cooperation and coordination Awareness on law and regulation	Focused Group Discussion Structured Questionnaire Key Informant scheduled interview	Descriptive, Inferential Statistic-Pearson Chi-Square Test, Content analysis.
2. To identify the health effects associated with	Health effects	Waterborne disease. Respiratory illnesses Vector-borne diseases Skin infection and irritation	Structured questionnaires Focused Group Discussions Key Informant scheduled	Descriptive, Inferential statistic-Pearson Chi-Square Test, content analysis.

discharge of raw sewage into water sources in Mukuru Slums, Nairobi		Nutritional Deficiency Chronic illnesses, Mental Health illnesses	interview	
3. To determine the coping strategies directed towards disposal of raw sewage in Mukuru slums, Nairobi	Coping strategie s	Sanitation facilities used to Collect, store, transport, treat and dispose raw sewage. Exit (Household relocation) Loyalty (Household waiting) Neglect (Household neglect)	Structured questionnaires Focused Group Discussions Key Informant scheduled interview	Descriptive, Inferential statistic-Pearson Chi-Square Test, Content analysis.

Source: Researcher 2023

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

The chapter presents details of the methodological approaches used in the assessment factors influencing the discharge of raw sewage in water sources in Mukuru slums. These included the research design, target population, sample and sampling procedures, method of data collection and research instruments, data analysis techniques, and ethical considerations.

3.1 Study Design

The study adopted a descriptive cross-sectional design combining both quantitative and qualitative methods to assess societal norms, health impacts, and coping strategies influencing raw sewage disposal in Mukuru slums, Nairobi. The cross-sectional approach was selected for its effectiveness in capturing a snapshot of prevailing conditions, perceptions, and behaviors within the population at a specific point in time (Zheng, 2015). This research design was employed in order to answer question directly associating with the responders such as what, who, when, where, and how a certain event or practice existed. The mixed-methods approach enhanced the depth and breadth of the findings by enabling the triangulation of diverse data sources.

3.2 Study Area

The study was conducted in Mukuru slums, located in Nairobi County, Kenya. Mukuru lies approximately 7 km southeast of Nairobi's Central Business District at Latitude: 1.3211° S, Longitude: 36.8865° E (Corburn et al., 2017). It is the second-largest informal settlement in Nairobi, covering approximately 52.5 square kilometers across Embakasi South, Makadara, and Starehe sub-counties (Murumba & Pashayan, 2024). The broader "Mukuru Belt"

comprises Mukuru Kayaba, Mukuru kwa Njenga, Mukuru kwa Reuben, and Viwandani (Murumba & Pashayan, 2024).

According to the Kenya National Bureau of Statistics (KNBS, 2019), Mukuru had an estimated population of 417, 236 residents living in 166, 157 households (Table 3.1). Viwandani accounted for 43,070 persons in 18,472 households; Mukuru kwa Reuben housed 65,691 persons in 26,699 households; Mukuru kwa Njenga, the most densely populated, had 242,941 persons in 97,890 households; and Mukuru Kayaba recorded 65,534 persons in 23,106 households. With an annual growth rate of 6%, the population is projected to reach 682,076 residents by 2030 (Corburn *et al.*, 2017). This growth is driven by Mukuru's position as a hotspot for urban expansion, where population density increased by 186.95 inhabitants per hectare between 2000 and 2020 (Ren *et al.*, 2020).

Since 2017, Mukuru has been designated a Special Planning Area (SPA), enabling slum upgrading initiatives targeting housing, infrastructure, and essential services. The community is divided by key geographical features: the Kenya Railway, which runs between Kwa Reuben and Kwa Njenga, and the Ngong River, which separates Kwa Reuben from Viwandani (Corburn *et al.*, 2017; Mallory *et al.*, 2021).

Despite these efforts, the settlement suffers from inadequate access to safe water, sanitation, secure housing, and other essential services (Chumo *et al.*, 2021; Mallory *et al.*, 2021). Housing structures are primarily temporary, often constructed from corrugated iron sheets, and forced evictions are common (Corburn *et al.*, 2017). Most families live in single-room dwellings, with incomes ranging from \$1.90 to \$3.50/day, lacking financial support or safety nets (Murumba & Pashayan, 2024). The main economic activities include informal trade,

small businesses, scrap metal collection, and waste collection (Corburn *et al.*, 2017). The poorest households earn less than KSh 5,000 per month.

The slum faces a high burden of communicable diseases, including respiratory illnesses, COVID-19, malaria, HIV/AIDS, and waterborne infections (Saunders *et al.*, 2020). Sanitation infrastructure is inadequate; most residents use shared pit latrines, which are often unhygienic (Kariuki *et al.*, 2023). Very few toilets are connected to sewer systems. Manual emptying of pit latrines, which costs between KSh. 300–600 per drum, often results in raw sewage being dumped into Ngong River or onto open grounds (Corburn *et al.*, 2017), posing severe public health risks. Therefore, there is an urgent need to investigate the societal norms, health-related vulnerabilities, and coping strategies that could contribute to the unsafe disposal of raw sewage in the selected area.

Table 3. 1

Sampling Population of Mukuru Slums

Mukuru Villages/Belt	Population	Households
Mukuru Kayaba	65,534	23,106
Mukuru Kwa Njenga	242,941	97,890
Mukuru Kwa Reuben	65,691	26,699
Viwandani	43,070	18,472
Total	417,236	166,167

Source: (Kenya National Bureau of Statistics [KNBS], 2019).

3.3 Target Population

Target population is the total membership of a defined class of people, objects or events” (O’leary, 2010). The study primarily focused on local residents of Mukuru slums,

specifically the 166,167 household heads (KNBS, 2019), as they were the primary decision-makers and directly impacted by sanitation conditions and raw sewage disposal practices.

Additionally, the study included public health officers, manual pit latrine emptiers, religious leaders, and local administration officials. These groups were selected for their unique roles: health officers offer expert perspectives on disease patterns; pit emptiers provide insight into sewage handling practices; religious and community leaders influence societal norms; and local administrators shape policy and enforcement. Their inclusion enriched the data through triangulation and enhanced the study's understanding of behavioral, institutional, and structural factors affecting sanitation in informal settlements.

3.3.1 Inclusion criteria

The study included the household heads who had lived continuously in Mukuru slum for a minimum period of six months prior to data collection, ensuring they had adequate experience with local sanitation conditions. Participants were also required to be 18 years of age or older, qualifying them as adults legally capable of providing consent and managing household affairs. In the absence of the household head, an adult household member (≥ 18 years) who had resided in the household for at least six months and was familiar with household sanitation practices was eligible to participate.

3.3.2 Exclusion criteria

The study excluded household heads who had lived in Mukuru for period less than six months. Additionally, individuals who were under 18 years of age, and those did not consent were excluded.

3.4 Sample Size Determination

The sample size of the study was determined using Fisher's sampling formula (Jung, 2014) coupled Cochran's correction formula (1977). The formula was previously used by Bagaja et al., (2024) to determine sample of 373 households from population of 21, 870 households heads. The procedure was as follows;

The initial sample size (n_0) for an infinite population was computed using the following standard formula by Fisher's sampling formula (Jung, 2014):

Where: n is the sample size for infinite population; e is the desired level of precision/confidence interval/margin error; p is the estimated (Proportion of the population with the desired characteristic) is 80%; q , is the estimated (proportion of the population without the desired characteristic (1-P) is 20%; z is value of the normal curve that cuts off an area α at the tails ($1 - \alpha$ equals the desired confidence level, which is 95%). Which is found in the statistical table 1.96 and (d) is Degree of precision; was taken to be taken to be 0.05%. Since the proportion of the population with the characteristic (P) was that over 80% of waste water is released into the environment untreated globally including African regions in Low Middle-Income Cities, United Nations Environment Programme, (UNEP, 2021)

$$= 3.8416/0.0025 \sim 245.86$$

Since the actual population of interest (households) is finite ($N = 166,167$), Cochran's modified formula (1977) for finite populations was applied to adjust the initial estimate:

$$n=246/ (1+(24/230,860)) =245.60$$

$$n=246$$

Therefore, the sample size of the study was 246 households. Also, the study participants in Focus Group Discussions were selected up to the point of thematic saturation, consistent with qualitative research best practices (Hennink & Kaiser, 2022).

3.5 Sampling Technique

The study adopted stratified random sampling and purposive samplings technique to selected the participants. The study area, Mukuru slums in Nairobi County, was purposively selected due to its acute sanitation challenges, high population density, and the widespread discharge of untreated sewage into nearby rivers and open drain. Existing studies have documented the area's chronic exposure to raw sewage, public health risks, and limited access to formal sanitation systems (Kariuki et al., 2023; Chebii et al., 2024)

The study employed a stratified random sampling technique to select households from the study area. Mukuru slums were stratified into four administrative units: Mukuru Kayaba, Mukuru kwa Njenga, Mukuru kwa Reuben, and Viwandani, based on geographical and demographic distinctions (Murumba & Pashayan, 2024). From each stratum, the sample size was proportionally allocated based on the total number of households, as outlined in Table 3.2. Within each stratum, simple random sampling was conducted, and households were selected using a computer-generated random number to ensure objectivity and eliminate selection bias. This approach provided each household an equal and independent chance of inclusion, enhancing the overall representativeness of the sample (Etikan, & Bala, 2017).

In addition to household surveys, purposive sampling was used to select participants for qualitative data collection, including key informant interviews (KIIs) and focus group discussions (FGDs). Key informants were selected based on their expertise, community roles, and involvement in sanitation-related activities. These included public health officers,

local administrators, religious leaders, and manual pit latrine emptiers individuals considered knowledgeable and capable of providing in-depth insights into sanitation norms, behaviors, and governance challenges within Mukuru. For FGDs, 8–12 participants were purposively selected per group, ensuring representation from different demographic categories such as gender, age, religion, and neighborhood location. This approach allowed for rich, contextualized understanding of community coping strategies and sanitation perceptions, which complemented and deepened the quantitative findings (Creswell & Clark, 2017).

Table 3. 2

Sampling frame for quantitative data

Mukuru Village/Belt	Households (KNBS, 2019)	Proportional Size (n = 246)	Sample Percentage (%)
Mukuru	23,106	34	13.8%
Kayaba			
Mukuru Kwa Njenga	97,890	145	59.0%
Mukuru Kwa Reuben	26,699	39	15.9%
Viwandani	18,472	27	11.0%
Total	166,167	246	100%

Source: Kenya Bureau of Statistics, 2019

3.6 Data Collection Instruments

The study collected both primary and secondary data using a number of methods so as to generate quantitative and qualitative data. Quantitative data was collected from the respondents using a structured questionnaire. A questionnaire has the ability to collect a large amount of information in a reasonably quick span of time (Kothari, 2008). The questionnaire consisted of close ended questions within four sections including demographic information, indicators of societal norms, health effects, and coping strategies related to discharge of raw sewage into water sources (appendix II). Qualitative data was collected using key informant interview guide (appendix IV) and Focused group discussion guides (appendix III). Secondary data for the study was collected from library materials, journals, and various internet search engines.

3.7 Pre-testing of Research Instruments

Before administering the research instruments to the respondents, pre-testing was done so as to help in determining the validity and reliability of the research tools to ensure that the questions are applicable and clearly understandable. According to Mugenda and Mugenda (2003), 10% of the actual is adequate for pilot study. The pre-testing was conducted in Kibera slums using 25 respondents (10% of 249) since it has similar characteristics to the study area. The findings were used to identify and rectify errors in the questionnaire and determine the duration of the survey that was noted to be 20-25 minutes.

3.7.1 Validity of the research instruments

Validity determines the accuracy at which results correspond to real properties and variations in physical or social setups (Heale & Twycross, 2015). Content validity for testing the accuracy of the information was employed by presenting the results to my supervisors from

Sanitation Research Institute (SRI) and the board of examiners for review and for data validation at Meru University of Science and Technology.

3.7.2 Reliability of the research instruments

This research utilized the test re-test technique, where researcher subjected the same participants to the same trials on two separate instances to test whether the scores for one test were similar or closer to the previous test. Data obtained was entered and analyzed using SPSS to be determined Cronbach's alpha value. Results yielded a Cronbach's alpha of 0.756 which was slightly above 0.7 indicating that the instruments were reliable (Suruci & Maslakci, 2020).

3.8 Data Collection Technique

Prior to data collection, the researcher obtained an introductory letter from Meru University of Science and Technology (MUST) (Appendix V), followed by a research permit from the Kenya National Commission for Science, Technology and Innovation (NACOSTI) under License No. NACOSTI/P/23/30258. Additional approvals were secured from the relevant county authorities, local administration, the Department of Health, and the Ministry of Education to facilitate ethical community entry, ensure administrative compliance, and enhance safety and cooperation during fieldwork.

The study population consisted of household heads within Mukuru slums. In cases where the household head was unavailable after two follow-up visits within 48 hours, a responsible adult household member aged 18 years or older who had lived in the household for at least six months and was knowledgeable about the household's sanitation practices was considered eligible for participation.

To support data collection efforts, the study recruited three enumerators with at least a diploma in Public Health and prior experience in community-based research. These enumerators were trained for three days prior to fieldwork. The training covered essential aspects such as research ethics, obtaining informed consent, accurate administration of questionnaires, and the use of digital data collection tools specifically the Kobo-Collect application. This training ensured uniformity in data collection procedures and reinforced ethical and technical competencies among the field team.

Quantitative data were collected through face-to-face interviews using a structured questionnaire programmed into the Kobo-Collect mobile platform. Simple random sampling was employed to select households from each of the four strata, The first household in each stratum was selected using a computer-generated random number. Respondents were first informed about the study's objectives and ethical safeguards before being asked to provide informed consent. In instances where a selected household declined participation, the non-response was recorded anonymously and a replacement household was randomly drawn from the remaining sampling list in that stratum to maintain representativeness and avoid sampling bias. Interviews were conducted in the respondent's preferred language either English or Swahili to ensure clarity and comfort. Responses were recorded digitally in real time, ensuring data integrity and minimizing the risk of entry errors or information loss.

For qualitative data, the principal researcher conducted key informant interviews and focused group discussions (FGDs), all of which were audio-recorded with participant consent and supplemented by field notes capturing non-verbal cues and environmental context.

3.9 Data Processing, Analysis and Presentations

The quantitative data were thoroughly examined to ensure completeness, accuracy, and consistency before being assigned numerical codes for analysis using the Statistical Package for Social Science (SPSS) version 25. The data were analyzed using both descriptive and inferential statistical methods. Descriptive statistics such as frequencies, percentages, and means were used to summarize demographic variables and the main indicators related to societal norms, health outcomes, and coping strategies concerning raw sewage disposal. These findings were presented in tables, charts, and graphs for ease of interpretation and visual clarity. To assess potential associations between categorical variables, and raw sewage disposal practices, the Chi-square (χ^2) test of independence was utilized. The test was conducted at a 95% confidence level, and a p-value less than 0.05 ($p < 0.05$) was considered statistically significant, and findings were be presented cross tabulations tables.

The use of the Chi-square test was guided by several statistical assumptions to ensure the validity of results. The data were required to be in the form of frequencies for categorical variables, to be mutually exclusive, observations were assumed to be independent, and each cell in the contingency table had an expected frequency of five or more.

Qualitative data was analyzed to complement the quantitative findings for the three objectives as articulated by the respondents. Qualitative data collected through key informants were subjected to manual content thematic analysis and themes developed were presented with verbatim.

3.10 Ethical Considerations

The study sought ethical approval from National Commission for Science, Technology and Innovation (NACOSTI), license number NACOSTI/P/23/29089, County/local government,

department of research for acceptability in the field for data collection and accountability. The ethical approval was further sought from NACOSTI, County/local government, department of research for acceptability in the field for data collection and accountability. This allowed community entry by the researcher and for security purposes. Adherence to the data protection act was followed to the later to avoid data loss.

The research assured the respondents of their confidentiality and ensure anonymity of the respondents through coding. For a sustainable engagement, the respondents were informed about the objectives of the study for consent, with questions of comfortability in the study with dignity and no biasness.

The study followed an introductory part on the survey tool to inform the respondent the title, objective, and expectation with consent part of continuity with the research. With the use of digital tools such as the KoBo-Collect platform, all survey responses were collected electronically and securely transmitted to a password-protected cloud server. Enumerators' devices were configured with data encryption and secure login protocols to prevent unauthorized access during the data collection phase. Once uploaded, data were downloaded for cleaning and analysis on a secure local computer with up-to-date antivirus protection and limited user access. Furthermore, all audio recordings were stored on encrypted storage drives and renamed using coded identifiers.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter provides comprehensive findings on the factors influencing discharge of raw sewage in water sources, Mukuru slums, Nairobi. The analysis encompasses a presentation of findings employing descriptive statistics, conveyed through systematically designed tables and charts. Additionally, the chapter explores into the determinants influencing the discharge of raw sewage in water sources and related health effects.

4.1 Response Rate

The study targeted 246 households for quantitative data collection, only 235 questionnaires were fully completed and successfully submitted through the Kobo Collect digital platform, representing a response rate of 95.5%. (Table 4.1). The high response rate could be due to engagement of local authorities, promoted community trust and acceptance of the research. According to Mugenda and Mugenda (2003), a response rate of 65% or higher is considered sufficient for meaningful analysis and interpretation in social science research. In addition to the survey, the study conducted four Key Informant Interviews (KIIs); included two manual pit latrine emptiers, and two public health officers. The qualitative component also included three Focus Group Discussions (FGDs), each comprised of at least eight participants including: at least two Community Health Volunteers (CHVs), at least two Religious Leaders (representing both Christian and Muslim faiths), One Chief or assistant chief and at least three Village elders (both male and female).

Table 4. 1*Response rate*

Mukuru Village/Belt	Households Sample size	Failed respond	Households' response	Percentage of respondent
Mukuru Kayaba	34	1	33	13.4
Mukuru Kwa Njenga	145	5	140	56.9
Mukuru Kwa Reuben	39	2	37	15.0
Viwandani	27	2	25	10.2
Total	246	9	235	95.5%

Source: Researcher, 2024

4.2 Demographics Characteristics of Respondents

The respondents were required to indicate; Gender, Age category, Religion, Marital status, level of education and household size. The findings as in Table 4.2 revealed that 50.6% of respondents were male, while 49.4% were female, indicating a nearly equal gender distribution. These respondents are predominantly rural-urban migrants who have relocated to Nairobi in search of employment opportunities, often settling in informal housing due to affordability. Such migration patterns contribute to the demographic expansion and pressure on sanitation infrastructure in slums.

As shown in Table 4.2 the largest proportion of respondents (53.2%) fell within the 18–35 age group, followed by 34.9% aged 36–50 years, and 11.9% aged 51 years and above. More individuals within ages 18-35 signified that majority of persons in the slum area are youths.

The high concentration of youth reflects broader urban trends where young adults migrate to informal settlements in search of livelihoods. However, as observed in interviews and focus group discussions, many of these youths engage in manual pit latrine emptying when employment opportunities are limited. One public health officer noted,

“Many young men, when they don’t find jobs, turn to pit latrine work for income—it’s risky, but it pays quickly.”

This behavior is often exacerbated by the lack of designated faecal sludge disposal sites, leading to raw sewage being dumped into rivers or drains. Similar findings have been reported by Mallory *et al.* (2021) in in slums of Nairobi. The study found that informal pit emptying was often the last resort for unemployed youth in informal settlements like Mukuru and Kibera. The study highlighted that, in the absence of proper infrastructure, pit emptiers are forced to resort to hazardous and environmentally damaging methods of waste disposal.

Religious affiliation showed that 75.3% of respondents identified as Christian, followed by 24.3% Muslim, and 0.4% other affiliations. The findings showed composition of religious affiliations, which may differ in teaching and values influencing sanitation behaviors. The differences in religious practices or potential social divides between Christians and Muslims in the community might create challenges in implementing cohesive waste management strategies, as indicated in Focused group Discussion by one of the participants;

“Based on some of sanitation facilities in the slum (Urinary Diverting Dry Toilet), they are hindered from using them, if this is the only option around..., faeces can easily get to the environment.”

The findings support conclusions made by Tsekleves *et al.* (2022) that religious beliefs influence sanitation practices in Sub-Saharan Africa, emphasizing the need for community-led approaches.

The study found that majority 71.1% of the respondents were married while 14.9% were single parents. with 11.1% and 3.0% reported to be divorced and widowed respectively. The married participants, may have larger households to manage. This could mean a greater responsibility for managing waste and ensuring proper sanitation, which might increase the likelihood of engaging in informal or substandard sewage disposal methods. As one female CHV noted during an FGD:

“Most married women here carry the burden of keeping the family safe from diarrhea or cholera—yet there’s no toilet or drainage nearby”.

The findings disagree with studies by Kipngeno *et al.* (2024) in Nakuru Slums and Kariuki *et al.* (2023) in Nairobi slums. The studies submitted that married couples were more likely to have improved sanitation practices due to shared responsibilities in managing household waste, whereas single parents faced greater challenges due to financial and time constraints. Regarding educational attainment, 40.9% of respondents had completed secondary education, 37.9% had primary education, 10.2% had tertiary education, and 11.1% had no formal education. Education plays a pivotal role in sanitation awareness and behavior. Participants with higher education levels were more likely to understand the risks of poor sanitation and advocate for hygienic practices. Conversely, those with limited education reported lower access to information and reliance on unsafe disposal practices. One CHV in Mukuru Reuben shared, *“Some families still pour waste into the river because they don’t know the risks—it’s what they saw others do.”*

As shown in Table 4.2, the average household size was found to be 3.90 members (SD = 1.678), indicating small-to-medium family units. This average aligns with typical urban slum households, where space constraints and income limitations affect family size. Larger households generate more waste, which often exceeds the capacity of shared latrines or septic systems. As a result, families may resort to more frequent emptying or unsafe discharge especially due to financial constraints. This was highlighted in FGDs, where a village elder from Viwandani noted, “Some families are too many for one toilet, so they either share with neighbors or pour it into the river when it gets too full.”

Table 4. 2

Demographic Findings (N=235)

Variable	Frequency(N=235)	Percent (%)
Gender		
Female	116	49.4
Male	119	50.6
Age bracket in years		
18-35	125	53.2
36-50	82	34.9
51 & above	28	11.9
Religion		
Christian	177	75.3
Muslim	57	24.3
Other	1	0.4
Marital status		

Married	167	71.1
Single-Never married	35	14.9
Widowed	7	3.0
Level of Education		
No education	26	11.1
Primary education	89	37.9
Secondary education	96	40.9
Tertiary education	24	10.2
Household size	235	Mean (3.90, Sd=1.678)

Source: Researcher, 2024

4.3 Raw Sewage Disposal Practices in Mukuru Slums

The study investigated whether respondents had witnessed any instance disposal of excreta/raw sewage in the nearby water sources next to their household and findings were presented in Table 4.3. The findings revealed that a substantial majority 87.7% (n=206) of respondents had witnessed raw sewage being discharged into rivers, open drains, or other water bodies adjacent to their households. Only 12.3% (n=29) reported not having observed such practices.

The high frequency of reported incidents strongly suggests that these acts are not isolated events, but rather a common response to systemic infrastructure failure. During focus group discussions, this sentiment was widely echoed. One female CHV from Mukuru Kwa Njenga shared,

“Sometimes you wake up and the whole pathway is flooded with sewage—it flows from a burst latrine or someone’s trench that empties straight into the river.”

Further interviews revealed that the problem is particularly acute at night when pit emptiers resort to discharging waste into rivers to avoid public scrutiny or arrest. A manual pit latrine emptier admitted during a key informant interview,

“Where do you expect us to take it? The disposal site is too far and expensive. We’re not proud of it, but the system gives us no option.”

The situation is further exacerbated by the geographic proximity of households to water bodies, particularly the river that cuts across Mukuru slums. According to multiple participants in FGDs, landlords and tenants residing close to the river often find it easier and cheaper to discharge raw sewage directly into the water source, bypassing the need for transport or treatment. One village elder explained,

“Those who live near the river just open the pipe—it’s faster than paying someone to carry it or digging a pit.”

Compounding the issue is the fact that many households reported having pour-flush toilets without any corresponding storage infrastructure, such as septic tanks, or conveyance systems like sewer lines. This disconnection along the sanitation chain means that even where facilities exist, proper containment and treatment are missing. A public health officer noted,

“People have toilets, but the waste just runs into the open. They don’t know what happens after it leaves the toilet.”

The findings are consistent with research by Corburn et al. (2017) who noted that in Nairobi’s informal settlements, raw sewage disposal into open water sources is a persistent

problem rooted in inadequate infrastructure, informal waste management practices, and a general lack of institutional support.

Table 4. 3

Disposal of excreta into water sources

Disposal of excreta into water sources	Frequency(N=235)	Percent (%)
No	29	12.3
Yes	206	87.7
Total	235	100.0

Source: Researcher, 2024

The study further established disposal point, as shown **Figure 4.1**. the majority 96.1%(n=198) identified tributaries or rivers, 57.8%(n=119) open drains, 28.2%(n=58) recorded environment and only 0.5%(n=1) said other sites. A Public Health Officer emphasized the shortcomings in current practices, stating;

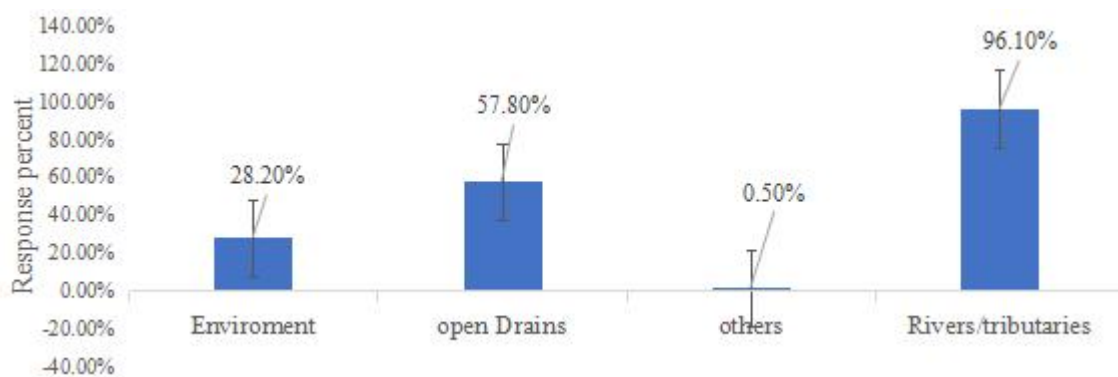
"Most existing sanitation systems are dysfunctional, leading to blockages and raw sewage discharge into water sources.

The disposal practices in the water sources were attributed to the pressure from the community around that most of the household close to the water sources had pipes dug underground connected to the river and tributaries passing across. The congestion of the slums and the influx in population that resulted to destruction of the existing sanitation facilities attributed to releasing the sewage at night to reduce the cost of implications. The behaviour of neglecting the situation by the household with minimal efforts to address the bad practices resulted to being a norm and a practice commonly used by the households around the river and pen drains.

The findings support existing studies by Oluseyi and Nweke (2020), Dasgupta, et al., (2021), and Mills et al., (2024), which consistently documents that informal settlements often resort to unsafe sewage disposal due to the absence of adequate containment, conveyance, or treatment systems. Mills et al., (2024), Submitted that in Ireland found that 9–13% of on-site systems discharge directly to streams and drain.

Figure 4. 1

Disposal sites of raw sewage



Source: Researcher, 2024

4.4 Societal Norms influencing Raw Sewage Disposal

The study assessed how societal norms influence raw sewage disposal practices in the Mukuru slums by examining community beliefs, household roles, cultural expectations, existing social networks, willingness to invest in sanitation, communication patterns, and awareness of legal frameworks governing waste management.

4.4.1 Influence of belief beliefs on raw sewage disposal

The respondents were tasked to identify their level of agreements with statements associated with beliefs on raw sewage disposal on five-point Likert’s scale, and results was tabulated in Table 4.4. The findings in Table 4.4, revealed that majority, 85.1% strongly agreed and 14.9% agreed that it is important to dispose of raw sewage properly his discrepancy suggests

that while harmful effects are recognized, behavior is often influenced by other overriding constraints.

During FGD, this nuance was evident. One Participant explained,

“Most of us know it’s wrong to pour sewage into the river, but when you have nowhere else to take it, you just do what others are doing.” Another participant noted, *“We talk about protecting God’s creation, but when toilets are full and you have children, you act out of desperation.”*

These sentiments reflect broader patterns observed in comparable settings. For instance, a study by Bamlaku *et al.* (2023) in Ethiopia found that while communities were aware of the environmental and health consequences of improper waste disposal, prevailing norms and infrastructure gaps led to behavior that contradicted those beliefs.

As Shown in Table 4.4, when respondents were asked to indicate their level of agreement with the statement that disposing of raw sewage into water sources is harmful to the environment. The results showed that 85.1% strongly agreed, 14.0% agreed, while only 0.8% (1 each) disagreed or strongly disagreed, and none remained neutral. These findings suggest high awareness among residents about the environmental risks associated with improper sewage disposal. Similarly, Novotny *et al.* (2017) emphasized that social norms around perceived risks significantly influence sanitation outcomes in informal settlements.

Respondents were asked whether community pressure influenced their behavior regarding raw sewage disposal. As shown in Table 4.4 combined 84.7% either strongly agreed (46.4%) or agreed (38.3%), while 12.8% disagreed or strongly disagreed, and 2.6% remained neutral. These findings suggest that a significant majority of residents perceive community pressure as a factor affecting sanitation practices. Manual pit latrine emptiers mentioned that they

often face pressure from residents to dispose of waste quickly and cheaply, even if it means dumping it in nearby water sources. One emptier stated:

"People want the waste gone fast and they don't want to pay a lot, so sometimes we are forced to dump it where we shouldn't."

Similar results were reported from FGD, that in densely populated areas, what neighbors think matters. One member noted

"If people around you use the river, it becomes normal—even if it's wrong."

Conversely, others felt social shame motivated compliance when sanitation campaigns were active. The findings align with study by Helferich et al. (2023) described littering as a descriptive norm because it was perceived as a commonly practiced behavior.

The study explored the extent to which a sense of collective responsibility influences residents' decisions regarding raw sewage disposal. As in Table 4.4 only 31.9% agreed or strongly agreed, while 62.1% (Disagree: 43.4%, Strongly Disagree: 18.7%) rejected the idea. This reflects a worrying breakdown in community cohesion regarding environmental sanitation. This could be attributed to factors such as a lack of trust in community-led initiatives, a perception that sanitation is an individual rather than a shared problem, or a belief that the government or external organizations should be solely responsible for providing sanitation services. Public health officers noted that many residents prioritize their immediate needs over the collective good when it comes to sanitation. One officer explained:

"People are struggling to survive day to day. They don't always think about the impact of their actions on the wider community."

During FGDs, some religious leaders and village elders expressed frustration with the lack of community cooperation on sanitation issues. This finding supports Susetyo (2024)

emphasizing that effective sanitation systems require behavioral change, stakeholder trust, and strong community buy-in.

Table 4. 4

Beliefs associated with raw sewage disposal

Level of agreement with statement	Frequency (N=235)	Percent (100%)
Important to dispose raw sewage properly		
Strongly Agree	200	85.1
Agree	35	14.9
Neutral	0	0
Disagree	0	0
Strong Disagree	0	0
Harmful in water sources		
Strongly Agree	200	85.1
Agree	33	14.0
Neutral	0	0.0
Disagree	1	0.4
Strong Disagree	1	0.4
Community pressure influence		
Strongly Agree	109	46.4
Agree	90	38.3
Neutral	6	2.6
Disagree	12	5.1
Strong Disagree	18	7.7

Collective responsibility

Strongly Agree	44	18.7
Agree	31	13.2
Neutral	14	6.0
Disagree	102	43.4
Strong Disagree	44	18.7

Source: Researcher, 2024

4.4.2 Influence of household efforts in addressing raw sewage disposal

The study assessed whether households have taken any steps to address the improper disposal of raw sewage in water sources and findings were demonstrated in Table 4.5. The findings shows that 32.8% of respondents indicated that someone in their household has addressed the improper disposal of raw sewage in water sources, while 67.2% indicated that no one in their household has taken such action. This low rate of household initiative suggests a general reluctance or inability to take individual action, possibly due to lack of awareness about effective solutions, a lack of resources or capacity to implement changes, or a sense of helplessness in the face of larger systemic challenge. Public health officers noted that many residents are aware of the problem but lack the means to address it effectively.

One officer explained:

"People know that it's wrong to dump sewage in the river, but they don't have anywhere else to put it. They need affordable and accessible alternatives."

From FGDs, it emerged that many residents felt powerless due to lack of resources, space, or legal support. One participant said,

“I rent here. I can’t build anything or change the toilet—I have to wait for the landlord.”

Another respondent opined that,

“we want to improve things, but we need help. We need toilets, we need drainage, and we need a way to dispose of waste safely.”

These findings align closely with Ngasala et al. (2022) emphasized the failure of fragmented governance systems to empower local households, while Shrestha et al. (2023) identified similar gaps between sanitation policy and actual service delivery in marginalized settings. Nelson et al. (2021) found that participation only leads to change when it is supported by inclusive, well-structured engagement and institutional backing.

Table 4. 5

Household efforts in addressing raw sewage disposal

Household addressing disposal practices	Frequency	Percent (%)
No	158	67.2
Yes	77	32.8
Total	235	100.0

Source: Researcher, 2024

4.4.3 Cultural influence in raw sewage disposal

The study assessed whether existing religious or cultural beliefs influence the discharge of raw sewage into water sources in Mukuru slums, and findings tabulated in Table 4.6. The findings showed that, only a small proportion 3.4% of respondents acknowledged the existence of religious or cultural beliefs that influence the discharge of raw sewage into water sources, while 96.6% indicated that there are no such beliefs. Most of the respondents

do not overtly attribute their behaviors to cultural or religious norms, possibly due to secularization of sanitation practices.

These findings were echoed in Focused Group Discussion, that religious and cultural beliefs generally promote cleanliness and hygiene, they do not specifically address sewage disposal practices.

“Most religions emphasize the importance of cleanliness, but they don't provide specific guidance on how to dispose of sewage in an urban slum.”

However, some participants raised concerns on certain sanitation practices since may conflict with beliefs about ritual cleanliness. A participant in FGD reported that

“... There are religious values by Muslims who are washers, They use water for anal cleansing. Based on some of sanitation facilities in the slum (Urinary Diverting Dry Toilet), they are hindered from using them, if this is the only option around..., faeces can easily get to the environment...”

These findings disagreed with studies by Kirimi et al. (2022), and Mohanty and Dwivedi (2019), all of which highlighted significant cultural or religious influence on sanitation behavior in rural or small-town contexts. However, the Mukuru context reveals that in highly urbanized slum environments, such influences may be diminished or secondary to infrastructural and spatial constraints suggesting that cultural determinants of sanitation are deeply shaped by geographic and socio-economic context.

Table 4. 6

Cultural influence on sewage disposal

Variable	Frequency	Percent (%)
Religious / cultural		
No	227	96.6
Yes	8	3.4
Total	235	100.0

Source: Researcher, 2024

4.4.4 Existing social networks/ organization influence on raw sewage disposal

The assessed the presence and role of social networks or organizations in Mukuru slums that actively promote sanitation and results presented in Table 4.7. The findings showed that 46.4% of respondents indicated that there are existing social networks or organizations in their community that promote sanitation, while 53.6% indicated that there are no such networks or organizations. The results indicate uneven distribution of these networks across different areas within Mukuru, or a lack of visibility or effectiveness of existing organizations.

Public health officers highlighted the role of Community Health Volunteers (CHVs) in promoting sanitation at the household level. One officer explained:

"Our CHVs go door-to-door, educating people about hygiene and sanitation. They are a key link between the community and the health system."

Manual pit latrine emptiers noted that some community-based organizations (CBOs) are involved in waste management and sanitation projects. One emptier stated:

"There are a few groups that organize clean-ups and try to improve sanitation, but they are often underfunded and struggle to make a big impact."

During FGDs, participants identified various types of social networks involved in sanitation. One member reported that.

"We have a women's group that organizes clean-ups and educates people about sanitation. They are very active in our area."

However, some participants in FGD also expressed skepticism about the effectiveness of these networks, citing issues such as corruption, lack of accountability, and limited reach.

One respondent said,

"Sometimes these organizations come and go, but we don't see much change on the ground. We need more sustainable solutions."

The current findings align with Chumo *et al.* (2023) in recognizing the positive influence of women's groups and CBOs in sanitation promotion, yet they also resonate with Kwiringira *et al.* (2023) in revealing community skepticism, funding challenges, and weak institutional linkages

Table 4. 7

Household and Society Structures influence on raw sewage disposal

Social networks	Frequency	Percent (%)
No	126	53.6
Yes	109	46.4
Total	235	100.0

Source: Researcher, 2024

4.4.5 Willingness to invest influence disposal of raw sewage

The study investigated respondents' willingness to use their own resources to improve sanitation services in their residences and demonstrated findings in Table 4.8. The findings revealed that majority 49.4% of respondents were not willing to use their resources in improving sanitation and 12.3% 12.3% of respondents indicated they were less willing to use their resources. However, only 10.6% of respondents were very willing, and 27.7% willing, to invest their resources in improving sanitation. The reluctance may stem from financial constraints, a lack of trust in available sanitation solutions, or a perception that sanitation is the responsibility of the government or other external actors as was reported in FGD. One respondent stated that,

"Many people in Mukuru are struggling to afford basic necessities like food and rent. Sanitation is often a lower priority for them."

Participants discussed various barriers to investing in sanitation, including a lack of secure land tenure, which discourages long-term investments

"Why spend my money if someone else will ruin it, or the government will come and demolish everything?"

These findings are in strong agreement with empirical evidence presented by Sinharoy et al. (2019), Alam et al. (2020), and Delaire et al. (2020), all of whom identified financial hardship, tenure insecurity, and distrust in institutional follow-through as major deterrents to sanitation investment in informal settlements

Table 4. 8

Willingness to invest influence disposal of raw sewage

Willingness to use individual resources	Frequency (N=235)	Percent (%)
Not willing	116	49.4
Less willing	29	12.3
Willing	65	27.7
Very much willing	25	10.6

Source: Researcher, 2024

4.4.6 Influence of communication, Cooperation and coordination on raw sewage disposal

The study investigated the extent to which social norms, including communication, coordination, and cooperation, influence the disposal of raw sewage in water sources in Mukuru slums. Results were demonstrated in Table 4.9. The study found that the majority of respondents agreed that social norms like communication, coordination, and cooperation influence sanitation behavior, with 41.7% strongly agreeing and 43.8% agreeing. However, 11.1% of respondents were neutral, 1.3% of respondents disagreed and 2.1% of respondents strongly disagreed that like communication, coordination, and cooperation influence sanitation behavior. The high percentage of agreement (85.5% combined) indicates that residents recognize the power of social dynamics in shaping sanitation behaviors. This could stem from observing how community discussions, joint efforts, or lack thereof, impact waste management practices. From interviews, the study found that effective communication and coordination are essential for implementing successful sanitation programs.

One officer explained:

"When we communicate clearly with residents about the importance of proper waste disposal and work together to find solutions, we see positive changes in behavior."

During FGDs, participants discussed the challenges of promoting cooperation on sanitation issues, citing issues such as mistrust and lack of leadership. A participant noted: *"It's hard to get people to work together when there's so much mistrust and division in the community"*.

The findings align with study by Bamluka et al. (2023) that found, weaker social norms were associated unsafe sanitation practices. Similarly, the findings of this study strongly align with prior research, particularly studies by Narayan et al. (2021), Gerger Swartling et al. (2019), and Simiyu et al. (2017), which emphasize that collaboration, trust, and communication are key determinants of sanitation success in informal settlements.

Table 4. 9

Communication, cooperation and coordination influence on Raw sewage disposal

Communication, coordination and cooperation	Frequency (N=235)	Percent (%)
Strongly Agree	98	41.7
Agree	103	43.8
Neutral	26	11.1
Disagree	3	1.3
Strong Disagree	5	2.1

Source: Researcher, 2024

4.4.7 Law/regulation awareness influence on raw sewage disposal

The study established the level of awareness among Mukuru slum residents regarding national or local laws and regulations related to proper disposal of raw sewage and findings demonstrated in Table 4.10. A majority of respondents, comprising 58.3% (n=137), reported being unaware of such laws or regulations. This lack of awareness highlighted a potential gap in knowledge regarding legal frameworks designed to govern sewage disposal practices. Conversely, 41.7%(n=98) of respondents, reported awareness of existing laws or regulations. While this proportion represents a minority of respondents, it underscores the presence of some level of knowledge regarding legal requirements for sewage disposal within the community.

This study reinforces a common regional trend, affirming that awareness gaps persist despite the existence of legal frameworks. Muheirwe et al. (2023) and Showers (2024) similarly reported widespread regulatory unawareness, while Vala and Malazaa (2024) highlighted systemic failures in public sensitization. Simiyu et al. (2019) further emphasized low legal literacy as a barrier to sanitation compliance

Table 4. 10

Awareness of laws pertaining raw sewage disposal

Laws/Regulation	Frequency(N=235)	Percent (%)
No	137	58.3
Yes	98	41.7
Total	235	100.0

Source: Researcher, 2024

4.4.8 Test of associations (Chi-Square Test) of Societal norms and discharge of excreta into water sources

The study conducted Pearson Chi-Square Test of Independence at 95% Confidence Interval to assess the relationship between societal norms and raw sewage disposal into water bodies. The findings presented in Table 4.11. The study found statistically significant association between the belief that it is important to dispose of raw sewage properly and actual sewage disposal behavior ($\chi^2 (1, N = 235) = 3.419, p = .046$.) Individuals who strongly agreed with proper disposal were more likely to dispose of sewage safely. As shown in Table 4.11, There was a significant association between collective responsibility and sewage disposal practices ($\chi^2 (4, N = 235) = 26.217, p < .001$) (1)

A significant association was also found between the presence of social networks in the community and sewage disposal practices ($\chi^2 (1, N = 235) = 20.741, p < .001$), indicating that communities with organized social structures were more likely to engage in safer sewage disposal. Furthermore, the association between communication, coordination, and cooperation and sewage disposal was also statistically significant ($\chi^2 (4, N = 235) = 16.680, p = .002$) suggesting that shared dialogue and collaboration within the community played a role in promoting proper sewage management.

On the other hand, no significant associations of; Perceived harmfulness of sewage in water sources ($\chi^2 (3) = 7.571, p = .056$), Religious or cultural beliefs ($\chi^2 (1) = 1.166, p = .280$), Household efforts to address disposal ($\chi^2 (1) = 0.403, p = .526$), Willingness to invest in sanitation improvements ($\chi^2 (3) = 0.985, p = .805$), and sewage disposal practices.

Table 4. 11*Association of Societal Norms and Raw Sewage Disposal*

Societal Norms	Outcome (Raw Sewage)		Statistical analysis		
	Disposal		Chi-square	df	p-value
	Safe	Unsafe			
Important to dispose raw sewage properly			3.419	1	0.046
Strongly agree	28(11.9%)	172(73.2%)			
Agree	1(0.4%)	34(14.5%)			
Harmful to dispose in water sources			7.571	3	0.056
Strongly agree	25(10.6%)	175(74.5%)			
Agree	3(1.3%)	30(12.8%)			
Disagree	1(0.4%)	0%			
Strongly disagree	0	1(0.4%)			
Community pressure influence			–	–	0.000
Collective responsibility			26.217	4	0.000
Strongly agree	15(6.4%)	29(12.3%)			
Agree	3(1.3%)	28(11.9%)			
Neutral	2(0.9%)	12(5.1%)			
Disagree	4(1.7%)	98(41.7%)			

Strongly disagree	5(17.2%)	39(16.6%)			
Religious / cultural beliefs			1.166	1	0.280
No	29(12.3%)	198(84.3%)			
Yes	0	8(3.4%)			
social networks			20.741	1	0.000
Household efforts			0.403	1	0.526
No	21(8.9%)	137(58.3%)			
Yes	8(3.4%)	69(29.4%)			
Willing to invest			0.985	3	0.805
Not willing	15(6.4%)	101(43%)			
Less willing	4(1.7%)	25(10.6%)			
Willing	6(2.6%)	59(25.1%)			
Very much willing	4(1.7%)	21(8.9%)			
Communication, cooperation and Coordination			16.680	4	0.002
Strongly agree	20(8.5%)	78(33.2%)			
Agree	4(1.7%)	99(42.1%)			
Neutral	3(1.3%)	23(9.8%)			
Disagree	0	3(1.3%)			
Strongly disagree	2(0.9%)	3(1.3%)			
Laws/regulation			1.549	1	0.213

No	20(8.5%)	117(49.8%)
Yes	9(3.8%)	89(37.9%)

Chi-square tests or fishers exact used when appropriate; df-degree of freedom

Source: Researcher, 2024

4.5 Health Effects Associated with Disposal of Raw Sewage Disposal into Water Sources

The study established health consequences of raw sewage disposal in Mukuru slums. The study explored community-reported cases of waterborne, vector-borne, nutritional deficiency, respiratory, skin, chronic, and mental health conditions linked to poor sanitation

4.5.1 Waterborne-related illnesses related to raw sewage disposal practices

The study assessed whether households had experienced waterborne illnesses potentially linked to raw sewage disposal into nearby water sources, and the results were presented in Table 4.12. A significant majority, 77.9% reported that someone in their household has suffered from waterborne-related illnesses. Conversely, 22% of respondents, reported no instances of waterborne-related illnesses within their households When asked, how frequent sanitation related waterborne illnesses were reported in your household.

A substantial proportion of respondents, comprising 42.6%, reported these illnesses occurring frequently, while 37.2% of respondents stated that sanitation-related waterborne illnesses occur less frequently in their households. A smaller percentage, representing 19.1% of respondents, reported these illnesses as being the most frequent, and, a negligible 1.1% of respondents reported never experiencing sanitation-related waterborne illnesses in their households. These results reveal a pervasive public health concern in Mukuru, highlighting chronic exposure to environmental contamination.

The study findings echo results from Aminu and Udeze (2023), who found that 72% of Lagos slum residents suffered waterborne diseases, largely due to poor sanitation infrastructure, shared latrines, and unsafe water sources. Their study affirmed that high disease prevalence correlates with the absence of safe WASH practices. Similarly, Ngakane (2021) found widespread gastrointestinal illness in Mbekweni, with 10% of residents reporting symptoms linked to fecal contamination and stagnant water, driven by inadequate municipal services.

Table 4. 12

Waterborne illnesses

Variables	Frequency (N=235)	Percent (%)
Waterborne related illnesses		
No	52	22.1
Yes	183	77.9
If yes Frequency (N=183)		
Frequent	78	42.6
Less Frequent	68	37.2
Most frequent	35	19.1
Never	2	1.1

Source: Researcher, 2024

When asked to specify the types of waterborne illnesses experienced, as shown in Figure 4.2, the majority of respondents (93.4%, n = 171) reported diarrhea. This was followed by typhoid (26.8%, n = 49) and dysentery (17.5%, n = 32), while cholera was mentioned by

8.7% (n = 16) of households. These results confirm that diarrheal diseases remain the most prevalent sanitation-related health outcome in Mukuru, affecting both children and adults.

The high rate of self-reported typhoid and dysentery further underscores the chronic exposure to contaminated water and unhygienic environments. The findings were echoed in focused Group Discussion, where one participant asserted that;

“My kids have had typhoid more than once. We try to boil water, but when it rains and sewage floods the area, there’s nothing you can do.”

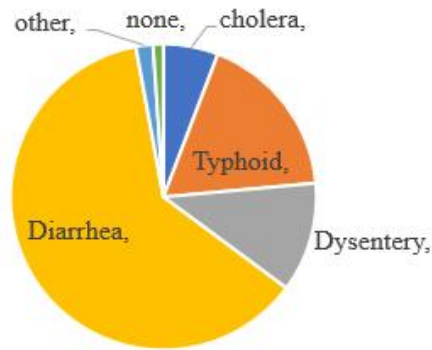
From interviews the study noted sanitation-related cases spike during the rainy season, when open sewage mixes with surface runoff and enters water points or food preparation areas. Public health officer reported that,

“Most of our clinic cases—especially for children—are diarrhea and typhoid. It’s worse when latrines overflow into the pathways.”

The study results confirms that diarrheal disease remains the most prevalent sanitation-related outcome, consistent with findings in Gqomfa et al. (2022), who found high E. coli and coliform levels in the Diep River during rainy seasons due to open sewage and runoff contamination. Their study illustrates how sewage inflow especially during rains elevates microbial hazards in water sources.

Figure 4. 2

Waterborne illness in Mukuru slums



Source: Researcher, 2024

4.5.2 Vector borne illnesses related to raw sewage disposal practices

The study assessed the prevalence of vector-borne diseases among households in Mukuru slums, particularly in relation to the unsanitary disposal of raw sewage into nearby water sources and the resulting environmental conditions. As presented in Table 4.13, an overwhelming 83% of respondents reported that someone in their household had suffered from a sanitation-related vector-borne disease, while only 17% reported no such occurrence. Among the affected, study shows that 27.7%, reported these diseases as being most frequent, indicating a high incidence and recurring health concern. Additionally, 45.6% of respondents stated that vector-borne diseases occur frequently in their households.

Conversely, 24.1% of respondents reported vector-borne diseases as occurring less frequently. And a small proportion, representing 2%, reported never experiencing vector-borne diseases in their households, while an additional 1.0% respondents indicated uncertainty regarding the frequency of such diseases. These findings showed the pervasiveness and intensity of vector exposure in environments burdened by untreated

sewage and stagnant water. Similar patterns were observed in Nigusie et al. (2021), who reported a 18.1% prevalence in rural Ethiopian households and identified poor sanitation, especially floor cleanliness and irregular environmental cleaning, as significant predictors of disease.

Table 4. 13

Vector Borne Diseases

Variables	Frequency (N=235)	Percent (%)
Vector borne illnesses		
No	40	17.0
Yes	195	83.0
If yes frequency (N=195)		
Frequent	89	45.6
I don` t know	2	1.0
Less frequent	47	24.1
Most frequent	54	27.7
Never	3	1.5

Source: Researcher, 2024

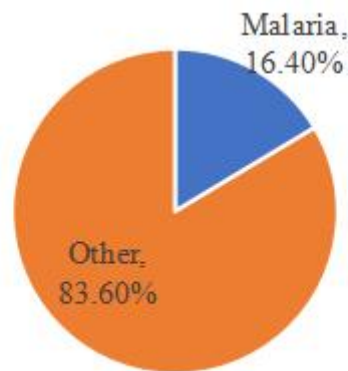
When asked about the specific diseases as illustrated in Figure 4.3, only 16.4% identified malaria, while the majority 83.6% selected “other” illnesses suggesting a wider variety of under-recognized or misdiagnosed vector-borne diseases possibly linked to environmental exposure. These include likely conditions such as filariasis, skin infections due to insect bites, and sand fly-borne illnesses, common in tropical urban slums but poorly documented

by name due to limited diagnostic access, a trend supported by Mamidi (2024), who observed similar confusion and informal care-seeking in Indian slums.

Qualitative evidence from Focus Group Discussions (FGDs) reinforced these patterns. A respondents noted, *“There are so many biting insects during rainy seasons; you hear people complain of swelling legs or strange fevers. We don’t go to hospitals always we just buy medicine or wait.”* Another participant emphasized, *“Stagnant water from overflowing sewage is everywhere. That’s where mosquitoes and flies multiply children are always getting sick”*. These statements reflect lived environmental realities, echoing Zerbo (2022), who found that unregulated waste disposal and climate variability, such as flooding, intensified transmission zones in Sub-Saharan urban areas.

Figure 4. 3

Vector borne illness



Source: Researcher, 2024

4.5.3 Nutrition illnesses related to raw sewage disposal practices.

The study established the sanitation-related nutrition deficiency diseases, and the within households in the Mukuru slums. As shown in Table 4.14, 15.7% of the respondents reported that at least one member in their household had suffered from a nutrition-related deficiency.

Among these cases, the majority 59.5% noted that the conditions occurred less frequently, while 16.2% reported frequent cases, and 10.8% marked the issue as most frequent. Only a small proportion reported never experiencing such conditions, and 2.7% were uncertain. This finding aligns with study by Sanin et al. (2022), who demonstrated that intermittent but repeated exposure to contaminated environments including open sewage elevates the likelihood of nutrient-related deficiencies. The study also noted, over a quarter of mothers cooked near open drains, amplifying risks of pathogen ingestion and subsequent nutritional disruption.

Table 4. 14

Nutrition Deficiency Diseases in Households

Variables	Frequency (N=235)	Percent (%)
Nutrition deficiency diseases		
No	198	84.3
Yes	37	15.7
Frequency (N=37)		
Frequently	6	16.2
I don't know	1	2.7
Less frequently	22	59.5
Most frequently	4	10.8
Never	4	10.8

Source: Researcher, 2024

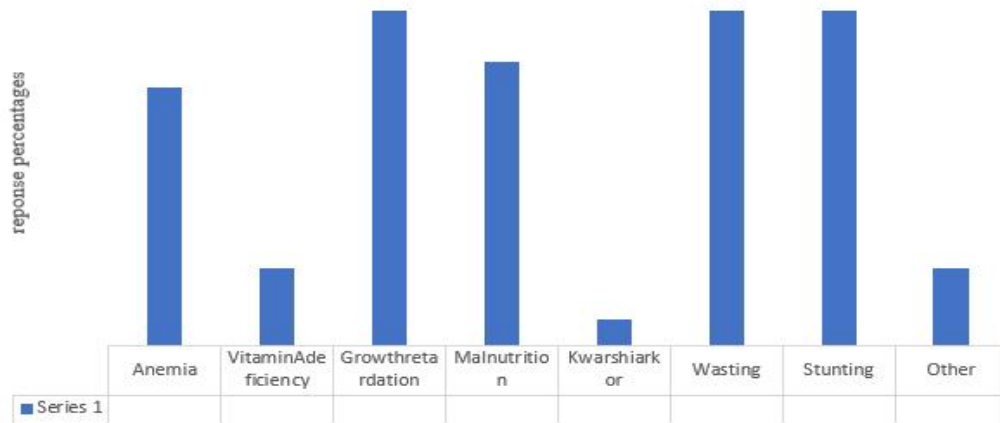
When asked to specify the type of nutrition-related illnesses, results presented in Figure 4.4 revealed that the most commonly reported conditions were stunting (43.3%) and wasting (43.3%), followed by malnutrition (36.7%), and anemia (33.3%). The study results indicates

that that poor sanitation especially raw sewage exposure may be exacerbating undernutrition and growth issues in children, who are the most vulnerable. This is particularly concerning in a setting where food insecurity, environmental contamination, and high disease burdens converge.

Qualitative data from FGDs and key informant interviews reinforced these patterns. A public health officer explained: *“Many children here are underweight, not because there’s no food entirely, but because the frequent diarrheal illnesses prevent nutrient absorption.”* From Focused Group Discussion a respondent shared: *“We see young children with stunted growth and constant gut issues. Families live near open drains full of sewage, so it's easy for infections to spread.”* These narratives mirror the conclusions of Momberg et al. (2021), whose systematic review across sub-Saharan Africa found a consistent link between WASH (Water, Sanitation, and Hygiene) deficiencies and impaired child growth. Momberg et al. (2021), emphasized that nutritional interventions alone are inadequate in the absence of sanitation reform precisely the condition faced in Mukuru. Gao et al. (2022) also reinforce these findings through their study in rural China, where poor water access led to limited dietary diversity and increased wasting

Figure 4. 4

Nutritional deficiencies



Source: Researcher, 2024

4.5.4 Respiratory illnesses related to raw sewage disposal practices

The study established whether respondents or household members had experienced respiratory Infections and the frequency. As shown in Table 4.15 majority 92.3% of respondents reported that at least one household member had suffered from a respiratory illness while, a small proportion of respondents, representing 7.7% reported no instances of respiratory diseases in their households. Among affected, 43.8% reported that such illnesses occurred frequently, 30.4% less frequently, 25.3% most frequently and 0.5% respondent reported that the illness had never recurred.

When asked to specify the respiratory conditions experienced (Figure 4.5), 94.4% cited flu-like symptoms, 78.9% reported whooping cough, while 10.6% indicated other forms of respiratory complications. The high prevalence of flu and cough-like illnesses suggests that exposure to raw sewage, damp conditions, and open drains may be contributing to the transmission of airborne and contact-based respiratory infections, especially in overcrowded housing environments common in informal settlements as noted in Focused Group

discussion. The participant remarked, “*Even when toilets overflow, the smell stays for days. It makes people sick and weak.*” This aligns with Poopedi et al. (2023), who reported high respiratory symptom prevalence among wastewater workers exposed to similar contaminants (e.g., bioaerosols, volatile gases), albeit in a more controlled and occupationally monitored environment. A study by Wafula et al. (2023) in Bwaise settlement in Uganda further supports this pattern; study identified an 84.6% prevalence of respiratory symptoms tied to poor air quality and overcrowding.

Table 4. 15

Respiratory diseases in the Households

Variables	Frequency (N=235)	Percent (%)
Respiratory diseases		
No	18	7.7
Yes	217	92.3
If yes Frequency (N=217)		
Frequent	95	43.8
Less frequent	66	30.4
Most frequent	55	25.3
Never	1	.5

Source: Researcher, 2024

Figure 4. 5

Respiratory ailments



Source: Researcher, 2024

4.5.5 Mental illnesses related to raw sewage disposal practices

The study established whether respondents or household members had experienced mental health issues and the frequency. Findings as in Table 4.16 indicated that nearly half, 48.9% of the respondents reported that someone in their household had suffered from mental health issues. Conversely, a slightly larger proportion of respondents, representing 51.1%, reported no instances of mental health issues within their households. Among those who reported cases, 69.6% described the mental health concerns as less frequent, 17.4% as frequent, and 13.0% as most frequent. When asked to specify the type of mental health conditions experienced (Figure 4.6), the majority 85.1% cited anxiety, 34.2% depression and 30.7% indicated other mental health issues such as stress, panic attacks, and sleep disturbances.

These findings suggest that nearly half of the households experience significant mental distress, much of which appears to be rooted in the psychosocial stressors associated with poor living and sanitation conditions. These experiences were echoed in Focus Group Discussions (FGDs). One participant stated:

“when you see neighbor channeling excreta to open drain and rivers, you’re always worried about disease, the smell, the shame. It becomes too much.”

These findings align with past studies, which highlight the psychological burden of poor sanitation. For example, Goode et al. (2025) in Baltimore found that sanitary sewer overflows (SSOs) were linked to mental health issues such as anxiety and stress, with 65% of respondents reporting anxiety symptoms.

Similarly, Kimutai et al. (2023) identified a strong correlation between poor sanitation and psychosocial stress, particularly in low-income urban areas, where depression and anxiety

were most prevalent. Both studies emphasize the importance of improving sanitation infrastructure to alleviate the psychological burden on residents.

Table 4. 16

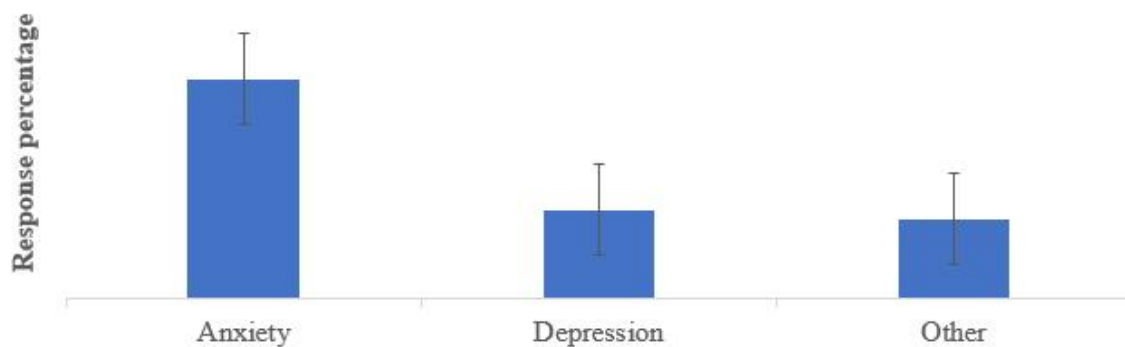
Mental Health Illness

Variables	Frequency (N=235)	Percent (%)
Mental issues		
No	120	51.1
Yes	115	48.9
Frequency (N=115)		
Less frequent	80	69.6
Frequent	20	17.4
Most frequent	15	13.0
Total	115	100.0

Source: Researcher, 2024

Figure 4. 6

Mental health illness



Source: Researcher, 2024

4.5.6 Chronic related to raw sewage disposal practices

The study established whether respondents or household members had experienced chronic health issues and the frequency, findings tabulated in Table 4.17. The study results revealed that a majority 83% of respondents, reported no instances of chronic health issues within their households. Conversely, 17% of respondents reported that someone in their household has suffered from chronic health issues.

Among those affected, 48.8% indicated these conditions occurred less frequently, 36.6% frequently, 4.9% most frequently, and 9.8% reported that they had not recurred. When participants asked to identify such illness as presented in Figure 4.7, the majority 64.9% indicated hypertension, 18.9% diabetes, 4.7% kidney failures and 27.0% reported other chronic conditions. While chronic illnesses are often associated with genetic, lifestyle, or aging factors, poor sanitation and unsafe sewage management may be contributing to the development or worsening of these conditions as was reported in Focused Group Discussion. One respondent asserted that;

“the environment is dirty, there is no privacy, sewage is everywhere... some residents have pressure [hypertension] and the doctor told them stress is a cause.”

Another emphasized by asserting that; *“Some of the elders here have diabetes or high blood pressure. When they live next to overflowing sewage or breathe in that air all day, it makes their condition worse.”*

The findings support Meng (2022) and Darling et al. (2023), studies on the urban water crisis, and its link to chronic health conditions such as cardiovascular diseases and diabetes.

Table 4. 17

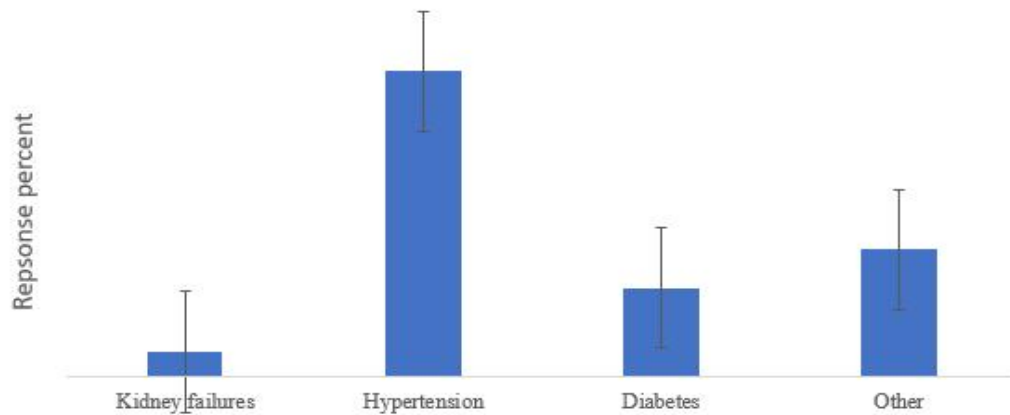
Chronic Health Issues

Variables	Frequency (N=235)	Percent (%)
Chronic health issues		
No	194	82.6
Yes	41	17.4
If yes Frequency (N=41)		
Frequent	15	36.6
Less frequent	20	48.8
Most frequent	2	4.9
Never	4	9.8

Source: Researcher, 2024

Figure 4. 7

Chronic health issues



Source: Researcher, 2024

4.5.7 Skin illnesses related to raw sewage disposal practices

The study established whether respondents or household members had experienced skin illnesses and the frequency, findings tabulated in Table 4.18. The study revealed that a significant majority 68% of respondents reported no instances of sanitation-related skin infections within their households. However, 32% of respondents reported that someone in their household has suffered from sanitation-related skin infections such as scabies and skin rashes, this was a result of exposure to the contaminated water around the household. Among those affected, 40.0% described the infections as occurring less frequently, 36.0% as frequent, and 21.3% as most frequent

When asked to identify illness, as shown in Figure 4.8, the majority 83.8% of respondents cited skin rashes, 33.8% scabies, 1.0% indicated jiggers and 15.4% reported other skin conditions, including boils, fungal infections, and chronic itchiness. The high prevalence of skin rashes and scabies in this study is consistent with the findings of Adegoke, Amoah, and Stenström (2018), who emphasized that exposure to untreated wastewater leads to similar health risks. These results reflect a high level of dermal exposure to infectious agents likely found in fecally contaminated environments. The qualitative insights from focus group discussions (FGDs) strongly supported these findings. One respondent noted that:

“Children play near the drainage or water sources. They walk barefoot and come home with rashes or wounds. Even if you clean them, the next day it’s the same.”

The findings of this study align with the results of (Trisnaini et al. (2025), Mustafa and Hassan (2024) and Okaka and Odhiambo (2019) who similarly identified a significant

correlation between poor sanitation and skin infections in areas with inadequate waste disposal practices.

Table 4. 18

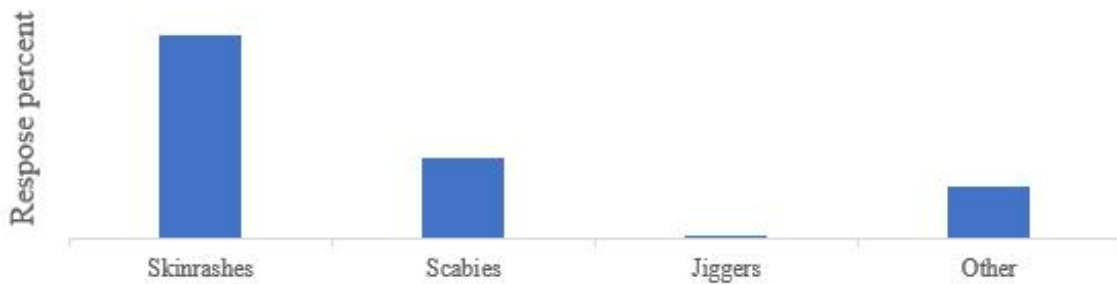
Frequency of skin diseases

Variables	Frequency (N=235)	Percent (%)
Skin infections		
No	160	68.1
Yes	75	31.9
If yes frequency (n=75)		
Frequent	27	36.0
Less frequent	30	40.0
Most frequent	16	21.3
Never	2	2.7

Source: Researcher, 2024

Figure 4. 8

Skin related Issues



Source: Researcher, 2024

4.5.8 Test of associations of health effects and discharge of excreta into water sources

A Chi-Square Test of Independence was conducted at a 95% confidence interval to determine whether there was an association between sanitation illnesses and raw sewage disposal. As shown in Table 4.19, the study found, a statistically significant association between skin infections and disposal of raw sewage, ($\chi^2 (1, N = 235) = 4.075, p = .044$). This suggests that households experiencing skin infections were more likely to be associated with unsafe sewage disposal practices. This could reflect exposure to contaminated environments or direct contact with untreated waste in shared spaces

The bivariate analysis further revealed as in Table 4.19, that there was no statistically significant association between waterborne related illnesses and raw sewage disposal behavior ($\chi^2 (1, N = 235) = 0.572, p = 0.449$). This indicates that the presence of waterborne diseases in a household was not significantly related to whether sewage was disposed of safely or unsafely. Similarly, mental health issues were not significantly associated with sewage disposal behavior ($\chi^2 (1, N = 235) = 0.223, p = .636$), nor were chronic health issues ($\chi^2 (1, N = 235) = 1.159, p = 0.282$).

Table 4. 19*Associations of sanitation illness and discharge of raw sewage into water bodies*

Sanitation illness	Outcome (Raw Sewage Disposal)		Statistical analysis		
	Safe	Unsafe	Chi-square	df	p-value
Waterborne related illnesses			0.572	1	0.449
No	8(3.4%)	44(18.7%)			
Yes	21(8.9%)	162(68.9%)			
Mental health issues			0.223	1	0.636
No	16(6.8%)	104(44.3%)			
Yes	13(5.5%)	102(43.4%)			
Waterborne related illnesses			0.572	1	0.449
No	8(3.4%)	44(18.7%)			
Yes	21(8.9%)	162(68.9%)			
Mental health issues			0.223	1	0.636
No	16(6.8%)	104(44.3%)			
Yes	13(5.5%)	102(43.4%)			
Chronic health issues			1.159	1	0.282
No	26(11.1%)	168(71.5%)			
Yes	3(1.3%)	38(16.2%)			

Skin infections			4.075	1	.044*
No	15(6.4%)	145(61.7%)			
Yes	14(6.0%)	61(26.0%)			

df-degree of freedom *- P<0.05

Source: Researcher, 2024

4.6 Coping Strategies Influencing the Discharge of Raw Sewage into Water Sources

This section explores the sanitation influence coping strategies that is; practice along sanitation service chain including; types of sanitation facilities, methods of waste storage and conveyance, treatment and reuse practices, and household behavioral responses such as relocation or neglect on raw sewage disposal in Mukuru Slums.

4.6.1 Practices along sanitation service chain in Mukuru slums

The study sought to determine the types of sanitation facilities available to residents in Mukuru slums. As shown in Table 4.20, the most commonly used sanitation facility was the pour flush toilet, reported by 49.4% of respondents. This was followed by dry pit latrines (28.5%), and Urinary Diverting Dry Toilets (UDDTs), used by 17.0%. Only a small number of households used communal toilets (1.3%), cistern flush toilets (0.9%), or Urinary Diverting Flush Toilets (UDFTs, 0.9%), while 2.1% had no sanitation facility at all. The dominance of pour flush toilets could be due to perceived hygiene and ease of use, but the absence of proper containment or sewer linkages may still result in environmental discharge as was reported in FGD. A respondent said;

“We don't know where the waste goes after we flush; it probably ends up in the river.”

UDDTs, though promoted for ecological sanitation, had limited uptake potentially due to cultural stigma or lack of user knowledge, as suggested in FGDs. One participant explained,

“These dry toilets are good in theory, but many people don’t know how to maintain them. They smell if not used properly.”

The study further found that, though dry pit latrines were common, constructed with substandard materials and lack secure containment. FGD participant noted,

“The pits are shallow or uncovered. During rains, you see everything flowing on the surface.”

The finding that pour flush toilets are the most commonly used in Mukuru aligns with observations by Meili et al. (2022), who noted a similar prevalence of pour-flush and pit latrine systems in low-income settlements across Kenya, Ghana, and Bangladesh, despite challenges in effluent containment. The limited uptake of UDDTs is also consistent with findings by Ssemugabo et al. (2021), who reported that cultural preferences, inadequate training, and perceived inconvenience hinder adoption of dry sanitation options in urban slums

Table 4. 20*Sanitation collection facilities*

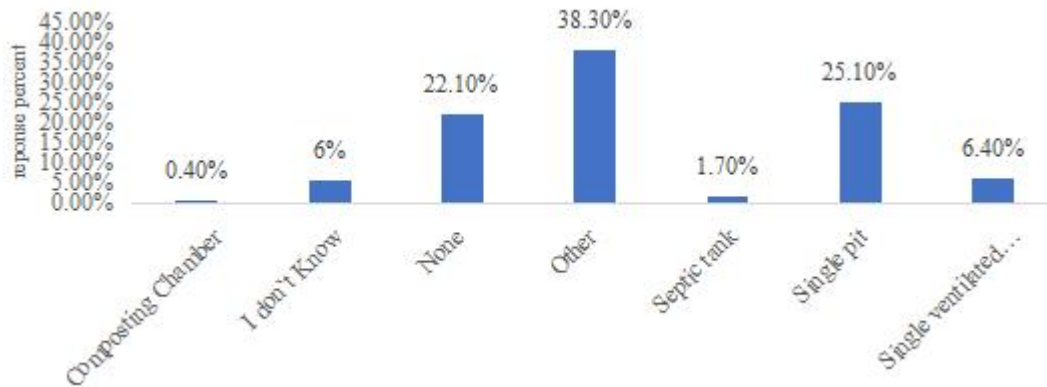
Sanitation Facilities	Frequency (N=235)	Percent (%)
Cistern Flush toilet	2	0.9
Communal Toilets	3	1.3
No facility	5	2.1
Pit latrine-Dry toilet	67	28.5
Pour Flush Toilet	116	49.4
Urinary Diverting Dry Toilet (UDDT)	40	17.0
Urinary Diverting Flush toilet (UDFT)	2	0.9
Total	235	100.0

Source: Researcher, 2024

The study participants were inquired to identify excreta storage systems in Mukuru Slums. As shown in Figure 4.8 most 25.1% of the respondents reported single pits, 6.4% Ventilated Improved latrines (VIP), 1.7% (n=4) septic tank, and 0.4%(n=1) composting chamber. About 38.3%(n=90) asserted other options while 22.1%(n=52) reported none. This finding resonates with Simiyu et al. (2021), who observed that informal settlements like Nakuru predominantly rely on unlined pit latrines and non-standardized containment systems due to space constraints and inadequate infrastructure. However, unlike studies suggesting septic tanks are widely used yet poorly managed in slums (Sogomo et al., 2024; Okoye et al., 2018), the low usage (1.7%) in Mukuru contradicts this trend. This disparity implies that septic tanks may not yet be a dominant option in Mukuru, possibly due to affordability or connection to sewer systems, making their installation impractical or ineffective for most households.

Figure 4. 9

Method used to store sewage/excreta



Source: Researcher, 2024

The respondents were asked how excreta are conveyed to treatment or dumping sites in study area and results shown in Figure 4.9. The study found that majority 25.5% respondents indicated excreta were transported using jerrycan/tank, 15.7% (n=37) reported human-powered emptying, 3.8% (n=9) sewer and 8.1% (n=19) reported other methods. About a third 36.2% (n=85) recorded none as well as 14.0 (n=33) were not of conveyance methods. These findings could be explained by the absence of regulated or mechanized emptying services and highlight the reliance on informal systems, often involving manual pit emptiers who carry the waste to open drains or rivers. As one pit emptier explained in an interview,

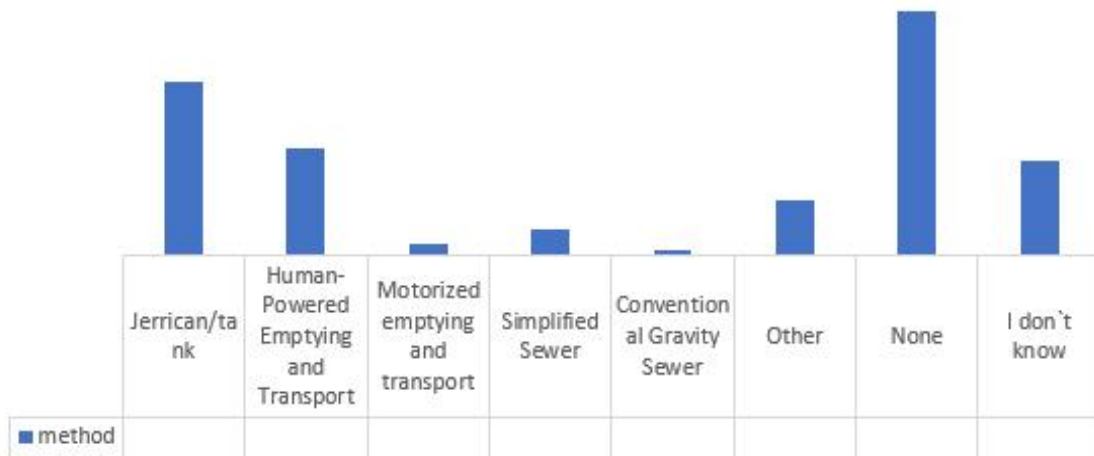
"...We manually empty pit latrines and transport the sewage to storage tanks for further disposal...`... However, poor road infrastructure sometimes leads to spillage into water sources, exacerbating contamination..."

The study results align with Simiyu et al. (2021), who reported that in Nakuru's informal settlements, pit latrines often shared and rapidly filling were commonly emptied using

manual tools due to space and infrastructure constraints. Similarly, Sogomo et al. (2024) found that even where septic tanks were used in Eldoret, faecal sludge was often handled by unregulated private emptiers, leading to environmental risks. Lerebours (2021) also noted that in Kampala, poor road conditions and non-standardized pit designs led to manual emptying and illegal dumping.

Figure 4. 10

Transportation/ Conveying sewage/excreta



Source: Researcher, 2024

The study further assessed whether participants were aware of sewage/sludge excreta treatment methods. As indicated in Table 4.21, a staggering 80.0% of respondents were not aware of any treatment methods, while 12.3% admitted their sludge was not treated at all. Only 2.1% respondents used waste stabilization ponds, and a mere 1.3% used co-composting. The lack of awareness of treatment method among respondents could be due deep-rooted beliefs that is associated with fecal matter. However, limited use of waste stabilization ponds and co-composting may be attributed to a lack of access to these technologies.

This finding highlights a critical gap in awareness and access to faecal sludge treatment methods, echoing Lerebours (2021), who reported that informal settlements in Kampala lacked both infrastructure and public knowledge on safe sludge disposal. Simiyu et al. (2021) similarly found that even when manual or semi-mechanized emptying was practiced in Nakuru, treatment steps were rarely understood or followed. The low uptake of co-composting and stabilization ponds in Mukuru reflects structural limitations, while deep-rooted taboos around fecal matter as noted in studies by Kirimi et al. (2022) may further discourage community engagement with safe treatment practices.

Table 4. 21

Treatment of sewage/ sludge-excreta

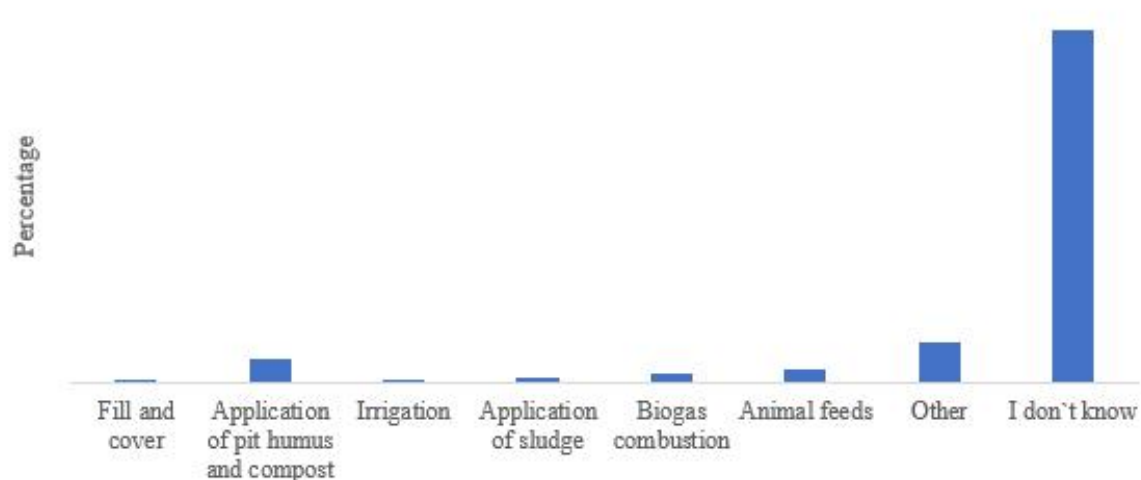
Treatment of sewage/ sludge-excreta	Frequency (N=235)	Percent (%)
Co-composting	3	1.3
I don` t know	188	80.0
None	29	12.3
Other	10	4.3
Waste stabilization ponds	5	2.1
Total	235	100.0

Source: Researcher, 2024

The study also established whether respondents were aware excreta disposal technique and presented in Figure 4.10. The study revealed that most 76.2% (n=179) of respondents were unaware of disposal techniques, however 5.1% (n=12) said application of pit humus compost,3.0% (n=7) animal feed, 2.1% (n=5) biogas combustions, 0.4% (n=1) fill and cover and 0.4% (n=1) irrigations, and 8.5% (n=20) identified other techniques.

Figure 4. 11

Disposal of sewage/excreta



Source: Researcher, 2024

4.6.2 Household relocation influence on raw sewage disposal

The study established whether respondents had relocated to a new plot in your community due to improper disposal of raw sewage. As shown in Table 4.22, 43.8% of the respondents reported that they or someone in their household had relocated to a new plot within the community due to improper disposal of raw sewage, while 56.2% indicated they had not. The results showed that about nearly half of households have taken drastic individual intervention in response to poor sanitation possibly due to fear of sickness.

The relocation is an indication of lack of hope in institutional interventions, prompting voluntary relocation as a coping mechanism as was reported in Focused Group Discussion. A respondent stated;

“Some of us move when the trench near our houses is always full of waste and starts to smell. We try to avoid sickness. But where to go? It's the same problem elsewhere

in the slum.” Another participant added, “some may move because the smell is unbearable, and children may get sick. Some also couldn't sleep at night.”

The study results are in agreement with past studies that show relocation as a common coping response to poor sanitation. Syafruddin and Adi (2019) found that relocation improved health due to better sanitation and water quality in Indonesia. Similarly, Ebaid and Helmi (2024) observed better outcomes in Egypt after relocation from unsafe environments. In Mukuru, nearly half of the respondents reported relocating due to unbearable sewage conditions, mirroring the health-driven motives noted in those studies. However, unlike planned relocations with improved infrastructure seen in previous research, Mukuru’s relocations are informal and often within similarly affected zones, offering little long-term relief.

Table 4. 22

Household relocation influence on raw sewage disposal

Households’ relocation	Frequency	Percent (%)
	(N=235)	
No	132	56.2%
Yes	103	43.8%

Source: Researcher, 2024

4.6.3 Household reliance on external actors’ influence on raw sewage disposal

The study established whether respondents had ever waited for stakeholders to deliver better sanitation services and findings depicted in Table 4.23. As presented in Table 4.23, 34.9% (n = 82) of respondents acknowledged that they had waited for external actors to provide sanitation improvements, while 65.1% (n = 153) indicated they had not. The findings

showed most of the community member were not relying on that external actor to improve their sanitation conditions possibly due to sense of resignation, self-reliance, or disillusionment with past promises as was reported in Focused Group Discussion. One participant commented;

“We've been waiting for years for the government to build proper toilets, but nothing has happened. We're tired of waiting.” Another respondent added, *“People are skeptical because they've seen so many projects come and go without making a real difference.”*

However, over a third of households have chosen to delay taking action on sewage issues while anticipating support from authorities or non-state actors due to mix of hope, dependency, and disempowerment, especially in a context where informal tenure and poverty limit residents' ability to improve facilities themselves as was noted from Interviews. Public health officers stated:

“People here feel that sanitation is the government's responsibility.... Some wait for years without any improvement.”

The study findings partially agree with previous studies. Aboagye and Doe (2022) found that households in slums often rely on subsidized services from external actors as a coping strategy, which supports the observation that some Mukuru residents delay action while expecting help.

Similarly, Simiyu et al. (2021) reported dependence on NGOs, private emptiers, and municipal actors for fecal sludge management in Nakuru, which aligns with the one-third of respondents in this study who admitted to waiting. However, the majority (65.1%) in Mukuru did not rely on external support, showing disagreement with UN-Habitat (2023) and

Maharaj and Maharaj (2022), who highlighted continued dependence on external actors due to limited household capacity. This difference may reflect growing disillusionment, as noted in FGDs, where residents expressed frustration with failed promises and poor coordination echoing Scott et al. (2019), who emphasized that without strong local governance, external support remains unsustainable.

Table 4. 23
Household dependency influence on raw sewage disposal

Households Waiting	Frequency (N=235)	Percent (%)
No	153	65.1%
Yes	82	34.9%

Source: Researcher, 2024

4.6.4 Household neglect influence on raw sewage disposal

The study established whether respondents or any other household member had ever neglected the fact that there is improper during improper sewage/excreta disposal in water sources and findings tabulated in Table.24. The study revealed that majority 79.1% of participants admitted to neglecting improper sewage disposal in water sources while 20.9% declined, underscoring the urgency of interventions and awareness campaigns to promote responsible sanitation practices within the community. This high level of household neglect indicates a serious sanitation challenge, where residents may have become desensitized or resigned to the issue due to prolonged exposure, lack of institutional support, or fear of retaliation from offenders. Participants in FGD also pointed to non-responsive enforcement officers and ineffective reporting systems as factors that discourage action, particularly among Community Health Promoters (CHPs).

This suggests that neglect is not simply a matter of awareness, but is deeply tied to feelings of helplessness and competing priorities such as food and shelter. One participant said, “*The water pipes are destroyed and sold to different plots, and these reports are not actioned on. This causes Community health promoters (CHPs) to neglect some of their roles.*” Another respondent emphasized that, “*...Negligence of the enforcing office bearers causes the CHPs not to report because their reporting is not taken keenly...*”

“*...The youths offending the law by pumping raw sewage into water sources are guarded by police, preventing the CHPs from addressing sanitation...*”

These results are in agreement with studies from other informal settlements. For example, Abubakar (2017) found that 22% of households in Abuja completely ignored sanitation issues, while 37% practiced "partial neglect," especially when the problem did not directly affect them. Similarly, Bhatkal et al. (2024) reported that households often relied on unsafe disposal methods due to limited infrastructure and weak government investment, especially in off-grid areas. Studies by Alam et al. (2020) and Kwiringira et al. (2021) also found that households prioritized survival needs over sanitation, often due to financial barriers and insecure tenure.

Table 4. 24

Household negligence influence on raw sewage disposal

Households neglect	Frequency (N=235)	Percent (%)
No	49	20.9%
Yes	186	79.1%

Source: Researcher, 2024

4.6.5 Test of association between coping strategies and raw sewage disposal

The Pearson Chi-Square Test of Independence was conducted at 95% Confidence Interval to assess the association between coping strategies and raw sewage disposal, as shown in Table 4.25. The findings showed a statistically significant association between household relocation and sewage disposal behavior ($\chi^2 (1, N = 235) = 3.546, p = .044$). This suggests that households that relocated were more likely to dispose of sewage safely compared to those that did not relocate. Similarly, study found a significant relationship between households neglecting improper sewage disposal and unsafe disposal outcomes ($\chi^2 (1, N = 235) = 0.909, p = .030$), an indication household that neglected sewage disposal were more likely to dispose of sewage unsafely compared to those that did not neglect it.

The association between households waiting for stakeholders to improve sanitation services and raw sewage disposal was not statistically significant ($\chi^2 (1, N = 235) = 2.938, p = .087$), indicating that reliance on external actors was not conclusively related to safe or unsafe disposal behaviors.

Table 4. 25

Associations of coping strategies and discharge of raw sewage into water bodies

Coping Strategies	Outcome (Raw Sewage Disposal)		Statistical analysis		
	Safe	Unsafe	Chi-square	df	p-value
Household's relocations			3.546	1	0.044
No	21(8.9%)	111(47.2%)			
Yes	8(3.4%)	95(47.2%)			

Households			2.938	1	0.087
Waiting					
No	23(9.8%)	130(55.3%)			
Yes	6(2.6%)	76(32.3%)			
Households			.909	1	0.030
neglect					
Yes	8(3.4%)	41(17.4%)			
No	21(8.9%)	165(70.2%)			

Source: Researcher, 2024

CHAPTER FIVE: CONCLUSION, RECOMMENDATIONS AND PUBLICATION

5.0 Introduction

This chapter presents a comprehensive summary of findings, the conclusions, recommendation, alongside recommendation for future study and publications. This chapter presents the critical findings from the research conducted in Mukuru slums regarding raw sewage disposal practices in relation to the societal norms, health risks and coping strategies. The research further proposes recommendations to address gaps and future areas of study to provide an actionable route for government, stakeholders, partners, and researchers in enhancing sustainable sanitation systems that are environmentally friendly and climate resilient generally improve public health in urban informal settlements.

5.1 Summary of the Findings

The study in Mukuru slums showed that 96.1% disposed raw sewage into water sources such as rivers and their tributaries while 87.7% witnessed the practice within the households. This study primarily showed that societal norms such as 85.1% beliefs on importance of raw sewage and 85.1% beliefs on harmful impacts of disposing raw sewage in the environment, 46.4% pressure from communities influenced raw sewage disposal, 43.4% disagreeing that collective responsibility among community members had influence on discharge of raw sewage into water sources, 46.4% existence of social networks such as organizations addressed sanitation issues, 41.7% agreeing that communication, cooperation and coordination agreeing had influence on raw sewage disposal, 49.4% communities who were unwilling to invest in sanitation had influence over the discharge of raw sewage.

Consequently, the prevalence of diseases such as 77.9% water-related illnesses, 83.0% vector-borne diseases, 85.1% mental issues, 92.3% respiratory issues, 83.8% skin related

diseases underscored the direct health risks linked to improper sewage disposal. The prevalence of these diseases enabled the communities to understand the dynamic and impacts of their behaviour and how their practices would help improve the sanitation issues in their environment.

Nevertheless, the sanitation facilities utilized such as 49.4% being pour flush toilets, with 1.7% septic tanks while 22.1% indicating lack of storage systems, and 36.2% indicating no transportation system, this disconnects from the collection point allowed disposal into the nearby open drains, water sources and environment, which results to contamination and degradation of the ecosystem. The study finding showed that only 2.1% reached the sewage treatment plant in the waste stabilization ponds, while 80% were unaware of how their waste was treated, similarly to disposal where only 0.9% knew that raw sewage can be recycled to sludge, 5.1% used as humus, 2.1% used for biogas combustion, and a striking 76.2% were not aware of the disposal methods, an important part along the sanitation value chain. of properly disposing raw sewage.

These findings showed the gap along the sanitation value chain and the consumer utilizing these systems. These would result to lack of ownership and mandate to address raw sewage disposal. With 43.8% relocating to new sites and 79.1% neglecting the raw sewage disposal practices in their households, this lack of responsibility greatly influenced the discharge of raw sewage thus overwhelming the environment and sanitation infrastructure. These showed the urgent need to embrace and utilize the societal norms in addressing raw sewage disposal, create awareness on the prevalence of the health risks that would have impact on the need to have sanitary living conditions, and the investment in maintenance and operationalization of sanitation systems along the sanitation value chain in order to properly dispose raw sewage.

The need to engage communities through awareness programmes with accountability, adhere to proper copying strategies, from both communities, government, donors, stakeholders and partners to mitigate the environmental health risks associated with raw sewage disposal and have a climate resilient ecosystem.

5.2 Conclusion

In the first objective, societal norms including beliefs, community pressure, collective responsibility, social networks, religious/cultural practices, willingness to invest, and communication/coordination significantly influenced raw sewage disposal practices in informal settlements.

The study on health-related effects in raw sewage disposal reveals a significant prevalence of various health issues in the community, including water-related illnesses, vector-borne illnesses, respiratory illnesses, and mental health problems. The findings indicate that poor sanitation practices, such as the disposal of untreated sewage into water sources, contribute to the high incidence of these health problems.

The study highlights the direct health risks associated with poor sewage disposal and the connection between sanitation and public health. The accumulation of raw sewage in water sources provides breeding grounds for mosquitoes, leading to vector-borne illnesses, while the bad odor from contaminated water sources can cause respiratory issues. The study also found a statistically significant association between raw sewage disposal and skin infections, emphasizing the need to improve sanitation infrastructure and practices to ensure a safe environment and reduce the prevalence of these health issues.

The study objective three, revealed a significant sanitation issue of raw sewage disposal in the community, particularly near water sources. Since the majority of households (49.4%)

used pour flush toilets, while a significant proportion (2.1%) lack facilities for collecting raw sewage, this lack of proper sanitation infrastructure and practices contributed to the disposal of raw sewage into water sources, which is detrimental to water resources, environment, and posed potential health risk to the community.

Additionally, the findings underscored the lack of awareness about sanitation treatment infrastructure and disposal techniques, leading to the improper disposal of raw sewage into water sources. The study suggested that households that often resorted to relocating to a new plot due to improper sewage disposal, were significantly associated with raw sewage disposal. Furthermore, the findings indicated that many households neglected improper sewage disposal in water sources, that further escalated the raw sewage disposal practice.

5.3 Recommendations

This study recommends that the government, WASH partners, stakeholders to initiate awareness campaigns to Mukuru slums residents to inform them on harmful impacts of disposing raw sewage in water sources and adoption of sanitation systems, strengthened communication and feedback sessions, cooperation in allocation of resources to avoid duplication of resources, coordination to enhances acceptance, ownership and accountability of sanitation projects within the informal settlements.

The Ministry of Health, Ministry of Environment, Water and Sanitation, and WASH partners should engage communities through risk communication and community engagement to address the interlink of health risks on sanitation, thereby motivating communities to adopt raw sewage disposal practices despite the prevalence of health risks.

The government, WASH partners, and stakeholders should engage communities in designing suitable sanitation systems for slum dwellers to promote ownership, maintenance, and

sustainability. This approach will reduce exposure of human excreta to the environment and address relocation issues by fostering community accountability and responsibility.

5.4 Recommendations for Future Studies

Assess long term impact of awareness campaigns on Mukuru slums residents' knowledge, attitudes and practices regarding the harmful impacts of raw sewage disposal practices

Explore best practices and challenges in resource allocation and coordination among line ministries and WASH partners

Track sustainability of designed sanitation systems in Informal settlements.

5.5 Publication

Nasirumbi, A., Kubai, P., & Kagendo, D. (2025). Role of Societal Norms in Raw Sewage Disposal in Water Sources, Mukuru Slums, Nairobi County, Kenya, *African Journal of Science and Technology & Social Sciences* 4(2) 2025 SS 21-31
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REFERENCES

- Aboagye, P. D., & Doe, B. (2022). The place of subsidy: Affordable sanitation service delivery in slums of Kumasi, Ghana. *GeoJournal*, 58, 69-85. <https://link.springer.com/article/10.1007/s12132-022-09470-y>
- Abubakar, I. R. (2017). Household response to inadequate sewerage and garbage collection services in Abuja, Nigeria. *Journal of Environmental and Public Health*, 2017, 5314840. <https://doi.org/10.1155/2017/5314840>
- Adegoke, A. A., Amoah, I. D., & Stenström, T. A. (2018). Epidemiological evidence and health risks associated with agricultural reuse of partially treated and untreated wastewater: A review. *Frontiers in Public Health*, 6, 337. <https://doi.org/10.3389/fpubh.2018.00337>
- Aghaei, B. L., Mirzaei, M. K., Alikhani, M. Y., & Mojtahedi, A. (2021). Sewage and sewage-contaminated environments are the most prominent sources to isolate phages against *Pseudomonas aeruginosa*. *BMC microbiology*, 21, 1-8.
- Ago, M. K., Caasi, R. D., Kege-e, D. S., & Napaldet, J. T. (2024). Self-purification in tropical upland rivers as affected by environmental factors: the case of Balili River in Benguet, Philippines. *International Journal of Phytoremediation*, 26(13), 2234-2249.
- Alam, M. U., Sharior, F., Ferdous, S., Ahsan, A., Ahmed, T., Afrin, A. & Tidwell, J. B. (2020). Strategies to connect low-income communities with the proposed sewerage network of the Dhaka sanitation improvement project, Bangladesh: A qualitative assessment of the perspectives of stakeholders. *International Journal of Environmental Research and Public Health*, 17(19), 7201. <https://doi.org/10.3390/ijerph17197201>

- Alemu, F., Kumie, A., Medhin, G., & Gasana, J. (2018). The role of psychological factors in predicting latrine ownership and consistent latrine use in rural Ethiopia: A cross-sectional study. *BMC Public Health*, 8, 229.
- Allen, G. R., Mahbubur, R., Munirul, A., Zaman, K., & Firdausi, Q. (2020). Can we 'WaSH' infectious diseases out of slums? *International Journal of Infectious Diseases*, 92,2020, Pages 130-132, ISSN 1201-9712. <https://doi.org/10.1016/j.ijid.2020.01.014>.
- Aminu, F. O., & Udeze, E. (2023). Relationship Between Water, Sanitation, Hygiene Practices and the Incidence of Water Borne Diseases Among Urban Slum Households in Lagos State, Nigeria. *Journal of Agriculture, Food, Environment and Social Sciences*. <https://www.jafeas.com/index.php/j1/article/download/59/74>
- Amon-Tanoh, M. A., McCambridge, J., Blon, P. K., Kouamé, H. A., Nguipdop-Djomo, P., Biran, A., & Cousens, S. (2021). Effects of a social norm-based handwashing intervention including handwashing stations, and a handwashing station-only intervention on handwashing with soap in urban Côte d'Ivoire: a cluster randomised controlled trial. *The Lancet Global Health*, 9(12), e1707-e1718.
- Andrianisa, H. A., Ahossouhe, M. S., & Cookey, P. E. (2022). Sanitation services. *Integrated functional sanitation value chain*, 103.
- Angoua, E. L. E., Dongo, K., Templeton, M. R., Zinsstag, J., & Bonfoh, B. (2018). Barriers to access improved water and sanitation in poor peri-urban settlements of Abidjan, Côte d'Ivoire. *PloS One*, 13(8), e0202928.
- Appiah-Ephah, E., Duku, G. A., Azangbego, N. Y., Aggrey, R. K. A., Gyapong-Korsah, B., & Nyarko, K. B. (2019). Ghana's post-MDGs sanitation situation: an overview. *Journal of Water, Sanitation and Hygiene for Development*, 9(3), 397-415.

- Asfaha, K.F., Tesfamichael, F.A., Fisseha, G.K., Misgina, K.H., Weldu, M.G., Welehaweria, N.B., N.B., & Gebregiorgis, Y.S. (2018). Determinants of childhood diarrhea in Medebay Zana District, Northwest Tigray, Ethiopia: A community based unmatched case-control study. *BMC Pediatrics*, *18*(1):1–9. <https://doi.org/10.1186/s12887-018-1098-7>
- Bagaja, O. M., King'ori, I., & Ileri, A. (2024). Socio-Demographic Factors Associated with the Uptake of Community Led Total Sanitation: An Empirical Study among the Residents of Isiolo County, Kenya. *East African Journal of Health and Science*, *7*(1), 80-94.
- Bagnis, S., Boxall, A., Gachanja, A., Fitzsimons, M., Murigi, M., Snape, J., & Comber, S. (2020). Characterization of the Nairobi River catchment impact zone and occurrence of pharmaceuticals: Implications for an impact zone inclusive environmental risk assessment. *Science of The Total Environment*, *703*, 134925.
- Bamlaku Golla, E., Gelgelu, T. B., Deguale Adane, M., Tsegaye Giday, T., Asres, A. W., & Adafrie, T. T. (2023). Latrine utilization and associated factors among rural households in southwest Ethiopia: risk, attitude, norms, ability, and self-regulation behavioral model. *Environmental Health Insights*, *17*, 11786302231163956.
- Berihun, S., Tesfa, H., Dagnaw, T. E., Tsega, T. D., Alemu, A. T., Fenta, E. T., ... & Ayele, W. M. (2025). Exploring barriers for public latrine utilization among selected towns in Awi zone, Amhara region, Northwest Ethiopia, 2023. *BMC Public Health*, *25*(1), 1006.
- Bhatkal, T., Mehta, L., & Sumitra, R. (2024). Neglected second and third generation challenges of urban sanitation: A review of the marginality and exclusion dimensions

- of safely managed sanitation. *PLOS Water*, 3(6), e0000252.
<https://doi.org/10.1371/journal.pwat.0000252>
- Bijekar, S., Padariya, H. D., Yadav, V. K., Gacem, A., Hasan, M. A., Awwad, N. S., ... & Jeon, B. H. (2022). The state of the art and emerging trends in the wastewater treatment in developing nations. *Water*, 14(16), 2537.
- Bojarczuk, A., Jelonkiewicz, Ł., & Lenart-Boroń, A. (2018). The effect of anthropogenic and natural factors on the prevalence of physicochemical parameters of water and bacterial water quality indicators along the river Białka, southern Poland. *Environmental Science and Pollution Research*, 25, 10102–10114.
- Boudjabi, S., Ababsa, N., & Chenchouni, H. (2023). Sewage and sewage treatment. In *The Palgrave handbook of global sustainability* (pp. 719-745). Cham: Springer International Publishing.
- Chambers, K. G., Sheridan, P. M., & Cook, S. M. (2022). Sanitation criteria: a comprehensive review of existing sustainability and resilience evaluation criteria for sanitation systems. *Environmental Science & Technology Letters*, 9(7), 583-591.
- Chebii, F., K'oreje, K., Okoth, M., Lutta, S., Masime, P., & Demeestere, K. (2024). Occurrence and environmental risks of contaminants of emerging concern across the River Athi Basin, Kenya, in dry and wet seasons. *Science of The Total Environment*, 914, 169696.
- Choge, C. (2021). Domestic private sector participation in faecal sludge management. *Loughborough University Repository*. Retrieved from https://repository.lboro.ac.uk/articles/thesis/Domestic_private_sector_participation_in_faecal_sludge_management/16692394/files/30909505.pdf

- Chumo, I., Mberu, B., Sumba, L., Elungata, P., & Beguy, D. (2023). Sanitation services for the urban poor: A social capital approach to sanitation challenges in informal settlements. <https://doi.org/10.1371/journal.pwat.0000086>
- Collins AL, Newell Price JP, Zhang Y, Gooday R, Naden PS, Skirvin D (2018) Assessing the potential impacts of a revised set of on-farm nutrient and sediment ‘basic’ control measures for reducing agricultural diffuse pollution across England. *Scientific Total Environment* 621:1499–1511. <https://doi.org/10.1016/j.scitotenv.2017.10.078>
- Contzen, N., & Mosler, H. J. (2012). The Risks, Attitudes, Norms, Abilities, and Self-regulation (RANAS) approach to systematic behavior change. *Eawag. Available online at: <https://www.eawag.ch/en/department/ess/>*(Retrieved April 20, 2020).
- Corburn, J., Agoe, V., Ruiz Asari, M., Ortiz, J., Patterson, R., Ngau, P., ... & Kano, M. (2017). Situational analysis of Mukuru Kwa Njenga, Kwa Reuben & Viwandani. *Technical paper*.
- Creswell, J. W., & Clark, V. L. P. (2017). *Designing and conducting mixed methods research*. Sage publications.
- Daniel, D., Djohan, D., Machairas, I., Pande, S., Arifin, A., Al Djono, T. P., & Rietveld, L. (2021). Financial, institutional, environmental, technical, and social (FIETS) aspects of water, sanitation, and hygiene conditions in indigenous-rural Indonesia. *BMC Public Health*, 21, 1-15.
- Darling, A., Patton, H., & Rasheduzzaman, M. (2023). Microbiological and chemical drinking water contaminants and associated health outcomes in rural Appalachia, USA: A systematic review and meta-analysis. *Science of The Total Environment*, 888, 164205. <https://www.sciencedirect.com/science/article/pii/S0048969723026578>

- 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.
- Deb, D., Schneider, P., Dudayev, Z., Emon, A., Areng, S. S., & Mozumder, M. M. H. (2021). Perceptions of urban pollution of river dependent rural communities and their impact: A case study in Bangladesh. *Sustainability*, 13(24), 13959.
- 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.
- Dickson-Gomez, J., Nyabigambo, A., Rudd, A., Ssentongo, J., Kiconco, A., & Mayega, R. W. (2023). Water, sanitation, and hygiene challenges in informal settlements in Kampala, Uganda: a qualitative study. *International journal of environmental research and public health*, 20(12), 6181.
- Doron, A., & Jeffrey, R. (2018). *Waste of a Nation: Garbage and Growth in India*. Cambridge, MA: Harvard University Press.
- Ebaid, M. A., & Helmi, M. I. (2024). Strategic relocation and sustainable redevelopment of Ain El-Sira: A comprehensive approach to slum improvement in Egypt. *Results in Engineering*, 23, 102709.
- Etikan, I., & Bala, K. (2017). *Sampling and sampling methods*. *Biometrics & Biostatistics International Journal*, 5(6), 00149. <https://doi.org/10.15406/bbij.2017.05.00149>
- Ferronato, N., & Torretta, V. (2019). Waste mismanagement in developing countries: A review of global issues. *International Journal of Environmental Research and Public Health*, 16, 1060.

- Frances, D, (2022) Elements of Marine Ecology (Fifth Edition), 2022.
<https://www.sciencedirect.com/book/9780081028261/elements-of-marine-ecology>
- Gao, Y., Sheng, J., Mi, X., Zhou, M., Zou, S., & Zhou, H. (2022). Household water access, dietary diversity and nutritional status among preschoolers in poor, rural areas of China. *Nutrients*, 14(3), 458. <https://www.mdpi.com/2072-6643/14/3/458>
- Gobler, C. J., Drinkwater, R. W., Anthony, A., Goleski, J. A., Famularo-Pecora, A. M. E., Wallace, M. K., & Hem, R. (2024). Sewage-and fertilizer-derived nutrients alter the intensity, diversity, and toxicity of harmful cyanobacterial blooms in eutrophic lakes. *Frontiers in Microbiology*, 15, 1464686.
- Goode, M., Abu, J. J., Alves, P. B., Woerner, E. M., Levell-Young, T., Smith-Hams, T., ... & Hendricks, M. D. (2025). A peek at leaks and basement backups: A pilot survey exploring the impacts and outcomes of untreated sewage in homes. *Environmental Research Communications*, 7(4), 045025. <https://doi.org/10.1088/2515-7620/adcb06>
- Gqomfa, B., Maphanga, T., & Shale, K. (2022). The impact of informal settlement on water quality of Diep River in Dunoon. *Sustainable Water Resources Management*. <https://link.springer.com/content/pdf/10.1007/s40899-022-00629-w.pdf>
- Gupta, A., Sengar, M., Manar, M., Bansal, U., Singh, S. K., SENGAR, M., ... & Singh, S. K. (2023). Tracking Water, sanitation, and hygiene practices: waste management and environmental cleaning in the slums of North India. *Cureus*, 15(7).
- Hakeem, V., Takyi, S. A., Asibey, M. O., & Amponsah, O. (2022). From informal settlements to environmentally sustainable communities: Lessons from Kumasi. *SN Social Sciences*, 2(7). <https://doi.org/10.1007/s43545-022-00402-y>

- Harada, H., Dong, N. T., & Matsui, S. (2008). A measure for provisional-and-urgent sanitary improvement in developing countries: septic-tank performance improvement. *Water Science and Technology*, 58(6), 1305-1311.
- Heale, R., & Twycross, A. (2015). Validity and reliability in quantitative studies. *Evidence-based nursing*, 18(3), 66-67.
- Helferich, M., Thøgersen, J., & Bergquist, M. (2023). Direct and mediated impacts of social norms on pro-environmental behavior. *Global Environmental Change*, 80, 102680.
- Hennink, M., & Kaiser, B. N. (2022). Sample sizes for saturation in qualitative research: A systematic review of empirical tests. *Social science & medicine*, 292, 114523. <https://doi.org/10.1177/11786302211043049>
- Igbokwe, H., Bhattacharyya, S., Gradus, S., Khubbar, M., Griswold, D., Navidad, J., ... & Azenabor, A. A. (2015). Preponderance of toxigenic *Escherichia coli* in stool pathogens correlates with toxin detection in accessible drinking-water sources. *Epidemiology & Infection*, 143(3), 494-504.
- Islam, A. (2021) Massive Garbage Dumping Pollutes Old Brahmaputra. Available online: <https://www.thedailystar.net/news/massive-garbage-dumping-pollutes-old-brahmaputra>
- Johannessen, Å., Gerger Swartling, Å., Wamsler, C., Andersson, K., Arran, J. T., Hernández Vivas, D. I., & Stenström, T. A. (2019). Transforming urban water governance through social (triple-loop) learning. *Environmental Policy and Governance*, 29(2), 144-154.
- Judge, M. (2021). Determinants of the cycle of childhood undernutrition and infectious disease in Eastern Africa (PhD thesis). University of Western Australia.

<https://research-repository.uwa.edu.au/en/publications/determinants-of-the-cycle-of-childhood-undernutrition-and-infection>

Jung, S. H. (2014). Stratified Fisher's exact test and its sample size calculation.

Junglen, K., Rhodes-Dicker, L., Ward, B. J., Gitau, E., Mwalugongo, W., Stradley, L., & Thomas, E. (2020). Characterization and prediction of fecal sludge parameters and settling behavior in informal settlements in Nairobi, Kenya. *Sustainability*, *12*(21), 9040.

Kamara, J. K., Galukande, M., Maeda, F., Lu-boga, S., & Renzaho, A. M. N. (2022). Understanding the challenges of improving sanitation and hygiene outcomes in a community-based intervention: A cross-sectional study in rural Tanzania. *International Journal of Environment Research and Public Health*, *14*(6),1-16. <https://doi.org/10.3390/ijerph14060602>.

Kariuki, T. M., Kagendo, D., & Kaimuri, M. (2023). Influence of socio-economic factors on utilization of sanitation facilities by women In Mukuru Kwa Reuben informal settlement In Nairobi County. *African Journal of Science, Technology and Social*

Kenya National Bureau of Statistics (KNBS). (2019). *2019 Kenya Population and Housing Census: Volume II – Distribution of Population by Administrative Units*. KNBS. <https://www.knbs.or.ke/?wpdmpro=2019-kenya-population-and-housing-census-volume-ii-distribution-of-population-by-administrative-units>

Khan, K., Lu, Y., Saeed, M. A., Bilal, H., & Sher, H. (2018). Prevalent fecal contamination in drinking water resources and potential health risks in Swat, Pakistan. *Environmental Pollution Journal*, *45*(3). <https://doi.org/10.1016/j.envpol.2018.05.070>

- Kim I-T, Lee Y-E, Yoo Y-S, Jeong W, Yoon Y-H, Shin D-C, Jeong Y (2019) Development of a combined aerobic–anoxic and methane oxidation bioreactor system using mixed methanotrophs and biogas for wastewater denitrification. *Water* 11(7):1377. <https://doi.org/10.3390/w11071377>
- Kimutai, J. J., Lund, C., Moturi, W. N., & Shewangizaw, S. (2023). Links between water insecurity, inadequate sanitation, and mental health. *PLOS ONE*, 18(4), e0286146. <https://doi.org/10.1371/journal.pone.0286146>
- Kipngeno, A., Kubai, P., & Mutembei, J. (2024). Social-Cultural Factors Influence on Management of Shared Sanitation, in Nakuru Town West Slums.
- Kirimi, L. M., Eliud, G. K., & Mburugu, K. N. (2022). In the cultural mirror: Influence of cultural factors on adoption of sanitation practices in rural Kenya. *African Journal of Social Transformation*. <https://journals.must.ac.ke/index.php/AJSTSS/article/view/19>
- Koech, G. (2022). Simplified sewer system to improve sanitation in Mukuru slums.
- Kola, L., Kohrt, B. A., Hanlon, C., Naslund, J. A., Sikander, S., Balaji, M., ... & Patel, V. (2021). COVID-19 mental health impact and responses in low-income and middle-income countries: reimagining global mental health. *The Lancet Psychiatry*, 8(6), 535-559.
- K'oreje, K. O., Okoth, M., Van Langenhove, H., & Demeestere, K. (2020). Occurrence and treatment of contaminants of emerging concern in the African aquatic environment: Literature review and a look ahead. *Journal of Environmental Management*, 254, 109752. <https://doi.org/10.1016/j.jenvman.2019.109752>
- Kothari, C. R. (2008). *Research methodology: Methods and techniques* (2nd ed.). New Age International Publishers.

- Kuang, J., Ashraf, S., Shpenev, A., Delea, M. G., Das, U., & Bicchieri, C. (2020). Women are more likely to expect social sanctions for open defecation: Evidence from Tamil Nadu India. *Plos one*, *15*(10), e0240477.
- Kwiringira, J. N., Kabumbuli, R., Zakumumpa, H., Mugisha, J., Akugizibwe, M., Ariho, P., & Rujumba, J. (2021). Re-conceptualizing sustainable urban sanitation in Uganda: Why the roots of 'slumification' must be dealt with. *BMC Public Health*, *21*(1), 992. <https://doi.org/10.1186/s12889-021-11029-8>
- Kwiringira, J.N., Rujumba, J., Ariho, P., & Mugisha, J. (2023). *Why slum social networks do not facilitate community development: A sanitation perspective*. *BMC Public Health*, *23*(1). <https://doi.org/10.1186/s12889-023-17176-4>
- Lema, M. W. (2024). Contamination of urban waterways: A mini-review of water pollution in the rivers of East Africa's major cities. *HydroResearch*.
- Lerebours, A. (2021). Regulating emptying and transport services for faecal sludge in Sub-Saharan African cities (Doctoral dissertation, Loughborough University).
- Liao, K., Bai, Y., Huo, Y., Jian, Z., Hu, W., Zhao, C., & Qu, J. (2019). Use of convertible flow cells to simulate the impacts of anthropogenic activities on river biofilm bacterial communities. *Science of the Total Environment*, *653*, 148-156.
- Maharaj, N., & Maharaj, B. (2022). Sanitation challenges and policy options in developing countries: a critical review. *Resource Management, Sustainable Development and Governance: Indian and International Perspectives*, 399-414.
- Makgalemane, M. R., Patrick, S., & Shirinde, J. (2024). Respiratory conditions and health symptoms associated with air pollution amongst children aged six years and below in Melusi Informal Settlement, Tshwane Metropolitan Municipality, South Africa: a

- cross-sectional study. *BMC Public Health*, 24(1), 2038. <https://doi.org/10.1186/s12889-024-19324-w>
- 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.
- Mamidi, S. (2024). Waste management and vector-borne diseases. University of Pittsburgh. <https://d-scholarship.pitt.edu/47230/1/Mamidi%2C%20S.%20MPH%20Essay%202024.pdf>
- Mansour, G., Oyaya, C., & Owor, M. (2017). *Situation analysis of the urban sanitation sector in Kenya*. Water & Sanitation for the Urban Poor (WSUP). <https://wsup.com/wp-content/uploads/2017/09/Situation-analysis-of-the-urban-sanitation-sector-in-Kenya.pdf>
- Mashudi, S., Yusuf, A., & Triyoga, R. S. (2020). Changes in Community Behavior and Keeping the Quality of Drinking Water Based Ranas Models. *Indian Journal of Public Health Research & Development*, 11(1), 1555-1560.
- Mateo-Sagasta, J., Velpuri, N. M., & Orabi, M. O. (2021). Wastewater production, treatment and reuse in MENA. *Water reuse in the Middle East and North Africa*, 15.
- Mateo-Sagasta, J., Zadeh, S. M., Turrall, H., & Burke, J. (2017). Water pollution from agriculture: A global review. Executive Summary. Food and Agriculture Organization of the United Nations Rome and International Water Management Institute.
- Meili, D., Schelbert, V., Alam, M. U., Antwi-Agyei, P., Simiyu, S., Adjei, K. A., ... & Günther, I. (2022). Indicators for sanitation quality in low-income urban settlements:

- Evidence from Kenya, Ghana, and Bangladesh. *Social Indicators Research*, 162, 683–720
- Meng, Q. (2022). Urban water crisis causes significant public health diseases in Jackson, Mississippi, USA: An initial study of geographic and racial health inequities. *Sustainability*, 14(23), 15534. <https://doi.org/10.3390/su142315534>
- Mills, F., Foster, T., Moe, C., Amin, N., Liu, P., Rahman, M., & Willetts, J. (2024). Unsafe containment: Public health risks of septic tanks discharging to drains in Dhaka Bangladesh. *PLOS Water*, 3(12), e0000325.
- Ministry of Water, Sanitation, and Irrigation, Kenya (2021). *Annual status report on water, sanitation and irrigation 2021*. Government of Kenya. <http://www.parliament.go.ke/sites/default/files/2021-09/2021%20Annual%20Status%20Report%20on%20Water%2C%20Sanitation%20and%20Irrigation%20from%20Minitry%20of%20Water.pdf>
- Mohanty, R., & Dwivedi, A. (2019). Culture and sanitation in small towns. *Economic and Political*. https://scifirepo.org/sites/default/files/Culture%20and%20Sanitation%20in%20Small%20Towns_%20An%20Ethnographic%20Study%20of%20Angul%20and%20Dhenkanal%20in%20Odisha.pdf
- Momberg, D. J., Ngandu, B. C., & Myer, L. (2021). Water, sanitation and hygiene (WASH) in sub-Saharan Africa and associations with undernutrition. *Journal of Developmental Origins*. <https://www.cambridge.org/core/journals/journal-of-developmental-origins-of-health-and-disease/article/water-sanitation-and-hygiene-wash-in-subsaharan-africa/4EFCA65F661A89693B564D2B9253776A>

- Muheirwe, F., Kihila, J. M., & Kombe, W. J. (2023). Solid waste management regulation in the informal settlements: A social-ecological context from Kampala city, Uganda. *Frontiers in Sustainability*
<https://www.frontiersin.org/articles/10.3389/frsus.2023.1010046/>
- Muriuki, C. W., Home, P. G., Raude, J. M., Ngumba, E. K., Munala, G. K., Kairigo, P. K., & Tuhkanen, T. A. (2020). Occurrence, distribution, and risk assessment of pharmaceuticals in wastewater and open surface drains of peri-urban areas: Case study of Juja town, Kenya. *Environmental Pollution*, 267, 115503.
- Murumba, R. N., & Pashayan, A. R. (2024). Political trust in the age of coronavirus: experiences in Mukuru, Nairobi, Kenya. *Frontiers in Political Science*, 6, 1331229.
- Mustafa, B. M., & Hassan, N. E. (2024). Water contamination and its effects on human health: A review. *Journal of Geography, Environment and Human Health*, 45(2), 99-110.
- Narayan, A. S., Marks, S. J., Meierhofer, R., Strande, L., Tilley, E., Zurbrügg, C., & Lüthi, C. (2021). Advancements in and integration of water, sanitation, and solid waste for low-and middle-income countries. *Annual review of environment and resources*, 46(1), 193-219.
- Nelson, S., Drabarek, D., Jenkins, A., & Negin, J. (2021). How community participation in water and sanitation interventions impacts health and infrastructure longevity. *BMJ Open*, 11(12), e053320. <https://doi.org/10.1136/bmjopen-2021-053320>
- Ngakane, L. (2021). Health concerns related to housing, sanitation, water access and waste disposal. <https://scholar.sun.ac.za/handle/10019.1/109996>

- Ngasala, T. M., Masten, S. J., & Gasteyer, S. P. (2022). System-wide approaches to mitigate environmental and health impacts of water contamination. *Water Policy*, 24(1), 192–210. <https://doi.org/10.2166/wp.2022.149>
- Ngatia, M., Kithiia, S. M., & Voda, M. (2023). Effects of anthropogenic activities on water quality within Ngong river sub-catchment, Nairobi, Kenya. *Water*, 15(4), 660.
- Ngeno, E., Ongulu, R., Orata, F., Matovu, H., Shikuku, V., Onchiri, R., ... & Ssebugere, P. (2023). Endocrine disrupting chemicals in wastewater treatment plants in Kenya, East Africa: Concentrations, removal efficiency, mass loading rates and ecological impacts. *Environmental Research*, 237, 117076.
- Nigusie, A., Gizaw, Z., Gebrehiwot, M., & Destaw, B. (2021). Vector-borne diseases and associated factors in the rural communities of northwest Ethiopia: A community-based cross-sectional study. *Environmental Health Insights*, 15, 11786302211043049.
- Njuguna, S. M., Yan, X., Gituru, R. W., Wang, Q., & Wang, J. (2017). Assessment of macrophyte, heavy metal, and nutrient concentrations in the water of the Nairobi River, Kenya. *Environmental Monitoring and Assessment*, 189, 454.
- Novotný, J., Kolomazníková, J., & Humňalová, H. (2017). The role of perceived social norms in rural sanitation: an explorative study from infrastructure-restricted settings of South Ethiopia. *International journal of environmental research and public health*, 14(7), 794.
- Okaka, F. O., & Odhiambo, B. D. (2019). Households' perception of flood risk and health impact of exposure to flooding in flood-prone informal settlements in the coastal city of Mombasa. *International Journal of Climate Change Strategies and Management*,

- 11(4), 592-606. <https://www.emerald.com/insight/content/doi/10.1108/IJCCSM-03-2018-0026/full/html>
- Okoye, B., Umeora, C., Ifebi, O., & Onwuzuligbo, C. (2018). Effects of sewage disposal systems on the environment in public housing estates in Enugu Metropolis. *COOU African Journal of Environmental Research*, 1(1), 120-130.
- Oluseyi, T. O., and J. C. Nweke. "Implications of Improper Sewage Management on Public Health: A Case Study of Kosofe Local Government Area, Lagos State." *African Journal of Housing and Sustainable Development* 1.1 (2020).
- Omina, O. L., Tao, W., Feng, W., & Kipkirui, E. (2022). *Inaccessible and unaffordable? The state of water and sanitation services in Nairobi, Kenya. International Journal of Environment and Ecology*, 4(1), 28–36. <https://www.ijee.latticescipub.com/wp-content/uploads/papers/v4i1/A185204010524.pdf>
- Owuri, A., & Sanusi, Y. A. (2021). Water Scarcity Problem and Households' Adaptation Strategies: Evidence from Literature. In *School of Environmental Technology International Conference (SETIC 2020)*.
- Palaniyandi, M. (2021). New emerging and re-emerging tropical infectious and non-communicable diseases in urban settlements. ResearchGate. <https://www.researchgate.net/publication/356028872>
- Peal, A., Evans, B., Ahilan, S., Ban, R., Blackett, I., Hawkins, P., & Veses, O. (2020). Estimating safely managed sanitation in urban areas; lessons learned from a global implementation of excreta-flow diagrams. *Frontiers in Environmental Science*, 8, 1.
- Piasecki, A. (2019). Water and Sewage Management Issues in Rural Poland. *Water*, 11(3), 625. MDPI AG. <http://dx.doi.org/10.3390/w11030625>

- Poopedi, E., Singh, T., & Gomba, A. (2023). Potential exposure to respiratory and enteric bacterial pathogens among wastewater treatment plant workers, South Africa. *International Journal of Environmental Research and Public Health*, 20(5), 4338. <https://www.mdpi.com/1660-4601/20/5/4338>
- Prüss-Ustün, A., Wolf, J., Bartram, J., Clasen, T., et al. (2019). Burden of disease from inadequate water, sanitation and hygiene for selected adverse health outcomes: An updated analysis with a focus on low- and middle-income countries. <https://doi.org/10.1016/j.ijheh.2019.05.003>
- Qadri, R., & Faiq, M. A. (2020). Freshwater pollution: Effects on aquatic life and human health. In *Fresh Water Pollution Dynamics and Remediation* (pp. 15-26). Springer. DOI: 10.1007/978-981-13-8277-2_2
- Qayoom, U., Bhat, S. U., & Ahmad, I. (2020). Efficiency evaluation of sewage treatment technologies: Implications on aquatic ecosystem health. *Journal of Water and Health*, 19(1), 29-46.
- Rahaman, K. S., Ramos, S., Harter, M., & Mosler, H. J. (2022). Psychosocial factors influencing handwashing behaviour and the design of behaviour change interventions for the Rohingya camps in Bangladesh. *Journal of Water, Sanitation and Hygiene for Development*, 12(10), 671-682.
- Ren, H., Guo, W., Zhang, Z., Kisovi, L. M., & Das, P. (2020). Population Density and Spatial Patterns of Informal Settlements in Nairobi, Kenya. *Sustainability*, 12(18), 7717. <https://doi.org/10.3390/su12187717>

- Rimal, R. N., & Real, K. (2005). How behaviors are influenced by perceived norms: A test of the theory of normative social behavior. *Communication Research*, 32(3), 389–414. <https://doi.org/10.1177/0093650205275385>
- Rimal, R. N., & Yilma, H. (2022). Descriptive, injunctive, and collective norms: An expansion of the theory of normative social behavior (TNSB). *Health Communication*, 37(13), 1573-1580.
- Ross, I., Cumming, O., Dreibelbis, R., Adriano, Z., Nala, R., & Greco, G. (2021). How does sanitation influence people's quality of life? Qualitative research in low-income areas of Maputo, Mozambique. *Social Science & Medicine*, 272, 113709. <https://doi.org/10.1016/j.socscimed.2021.113709>
- Sanin, K. I., Haque, A., Nahar, B., Mahfuz, M., Khanam, M., & Ahmed, T. (2022). Food safety practices and stunting among school-age children an observational study finding from an urban slum of Bangladesh. *International journal of environmental research and public health*, 19(13), 8044.
- Saunders, D. (2020). Opinion: Huge slums are at the heart of the pandemic – but not for the reasons you might expect". *The Globe and Mail*.
- Sclar, G. D., Penakalapati, G., Caruso, B. A., Rehfuess, E. A., Garn, J. V., Alexander, K. T., ... & Clasen, T. (2018). Exploring the relationship between sanitation and mental and social well-being: A systematic review and qualitative synthesis. *Social Science & Medicine*, 217, 121-134. <https://doi.org/10.1016/j.socscimed.2018.09.016>
- Scott, R., Scott, P., Hawkins, P., Blackett, I., Cotton, A., & Lerebours, A. (2019). Integrating basic urban services for better sanitation outcomes. *Sustainability*, 11(23), 6706.

- Shehu, P., Rikko, L. S., & Azi, M. B. (2023). Monitoring urban growth and changes in land use and land cover: a strategy for sustainable urban development. *Int. J. Hum. Cap. Urban Manag*, 8(1), 111-126.
- Showers, D. (2024). An assessment of waste management in slum communities in Freetown. <https://www.academia.edu/download/118130630/2290.pdf>
- Shrestha, A., Bhattarai, T. N., & Acharya, G. (2023). Water, sanitation, and hygiene of Nepal: <https://doi.org/10.1021/acsestwater.2c00303>
- Siamalube, B., & Ehinmitan, E. (2025). Unmasking the Neglected Cholera Outbreaks in Sub-Saharan Africa. *International Journal of Public Health*, 69, 1607990.
- Silva, D. C., Queiroz, L. G., Marassi, R. J., Araújo, C. V., Bazzan, T., Cardoso-Silva, S., ... & Pompêo, M. L. (2020). Predicting zebrafish spatial avoidance triggered by discharges of dairy wastewater: An experimental approach based on self-purification in a model river. *Environmental Pollution*, 266, 115325.
- Simiyu, S., Cairncross, S., & Swilling, M. (2019). Understanding living conditions and deprivation in informal settlements of Kisumu, Kenya. *Urban Forum*, 30(2), 157–175. <https://link.springer.com/content/pdf/10.1007/s12132-018-9346-3.pdf>
- Simiyu, S., Chumo, I., & Mberu, B. (2021). Fecal sludge management in low-income settlements: case study of nakuru, kenya. *Frontiers in Public Health*, 9, 750309.
- Simiyu, S., Swilling, M., & Rheingans, R. (2017). Estimating the cost and payment for sanitation in the informal settlements of Kisumu, Kenya: A cross-sectional study. *International Journal of Environmental Research and Public Health*, 14(1), 49. <https://doi.org/10.3390/ijerph14010049>

- Sinharoy, S. S., Pittluck, R., & Clasen, T. (2019). Review of drivers and barriers of water and sanitation policies for urban informal settlements in low-income and middle-income countries. *Utilities policy*, *60*, 100957.
- Sogomo, A. K., Konga, D. K., Ndasaba, F. S., Swara, K. A. A., Shihemi, V. K., Ngetich, W. K., & Kiptum, C. K. (2024). A landlord/lady perspective on emptying and transportation of faecal sludge in informal settlements of Eldoret town, Uasin Gishu County, Kenya. *World Journal of Advanced Engineering Technology and Sciences*, *11*(2), 227–237. Study. *Sustainability*, *15*(4), 3781. <https://www.mdpi.com/2071-1050/15/4/3781>
- Ssemugabo, C., Wafula, S. T., Ndejjo, R., Osuret, J., Musoke, D., & Halage, A. A. (2021). Characteristics of sanitation and hygiene facilities in a slum community in Kampala, Uganda. *International health*, *13*(1), 13-21.
- Sürücü, L., & Maslakci, A. (2020). Validity and reliability in quantitative research. *Business & Management Studies: An International Journal*, *8*(3), 2694-2726.
- Susetyo, B. (2024). Environmental sanitation: Strategies and challenges in waste management. *International Journal of Society Reviews (INJOSER)*, *2*(7).
- Suzuki, Y., Hashimoto, R., Xie, H., Nishimura, E., Nishiyama, M., Nukazawa, K., & Ishii, S. (2019). Growth and antibiotic resistance acquisition of *Escherichia coli* in a river that receives treated sewage effluent. *Science of the Total Environment*, *690*, 696-704.
- Syafiuddin, A., & Boopathy, R. (2021). A review of polycyclic aromatic hydrocarbons and their substitutions in full-scale wastewater treatment plants. *Environmental Quality Management*, *31*(1), 21-37.

- Tanui, I. C., Kandie, F., Krauss, M., Piotrowska, A., Finckh, S., Kiprop, A., ... & Brack, W. (2025). Occurrence and potential risk of steroid hormones in selected surface water and wastewater treatment plants in western Kenya. *Environmental Pollution*, 367, 125623.
- Thakur, R., Onwubu, S. C., Harris, G., & Thakur, S. (2022). Communities of eThekweni Municipality, South Africa, 81–88.
- The Lancet Microbe. (2021). Climate change: Fires, floods, and infectious diseases. *The Lancet Microbe*, 2(9), e415.
- Tripathy, S., Kar, O. P., & Pradhan, A. (2025). Challenges and Innovations in Industrial Wastewater Treatment: Safeguarding Water Resources and Promoting Sustainable Practices. *Water, Air, & Soil Pollution*, 236(2), 1-14.
- Trisnaini, I., Putri, D. A., Pratiningsih, W. A., Wulandari, K. C., Kusuma, L. A. P., Damayanti, K., ... & Miagoni, V. (2025). Analysis of factors associated with the incidence of skin diseases in the community of Indralaya District. *Jurnal Kesehatan*, 84-98
- Tseklevs, E., Fonseca Braga, M., Abonge, C., Santana, M., Pickup, R., Yongabi Anchang, K., & Roy, M. (2022). Community engagement in water, sanitation and hygiene in sub-Saharan Africa: does it WASH?. *Journal of Water, Sanitation and Hygiene for Development*, 12(2), 143-156.
- UN-Habitat. (2023). Sanitation and wastewater management in cities: Emphasizing the integration of slum upgrading into city-wide strategic planning. United Nations Human Settlements Programme.
- https://unhabitat.org/sites/default/files/2023/06/water_report_web.pdf

- United Nations Children's Fund, & World Health Organization. (2024). *Progress on household drinking water, sanitation and hygiene 2000-2022: special focus on gender*. World Health Organization.
- United Nations Department of Economic and Social Affairs (UN-DESA). (2020). *Sustainable Development Goal 6: Ensure availability and sustainable management of water and sanitation for all*. United Nations. <https://sdgs.un.org/goals/goal6>
- United Nations Environment Programme. (2021, August 25). Better sewage treatment critical for human health and ecosystems. UNEP. <https://www.unep.org/news-and-stories/story/better-sewage-treatment-critical-human-health-and-ecosystems>
- Vala, B., & Malazaa, N. (2024). Examining the efficacy of legal frameworks for greywater in informal <https://iwaponline.com/jwh/article-pdf/22/5/842/1426670/jwh0220842.pdf>
- Vantilborgh, T. (2015). Volunteers' reactions to psychological contract fulfillment in terms of exit, voice, loyalty, and neglect behavior. *VOLUNTAS: International Journal of Voluntary and Nonprofit Organizations*, 26, 604-628.
- Wafula, S. T., Nalugya, A., Mendoza, H., Kansime, W. K., Ssekamatte, T., Walekhwa, A. W., & Musoke, D. (2023). Indoor air pollutants and respiratory symptoms among residents of an informal urban settlement in Uganda: A cross-sectional study. *PLoS One*, 18(8), e0290170. <https://doi.org/10.1371/journal.pone.029017>
- Wagner, I., & Zalewski, M. (2016). Temporal changes in the abiotic/biotic drivers of selfpurification in a temperate river. *Ecological Engineering*, 94, 275-285.

- Webb, M. D., Rohe, W. M., Nguyen, M. T., Frescoln, K., Donegan, M., & Han, H. S. (2017). Finding HOPE: Changes in depressive symptomology following relocation from distressed public housing. *Social science & medicine*, *190*, 165-173.
- World Health Organization (WHO) & United Nations Children's Fund (UNICEF). (2023). Progress on household drinking water, sanitation and hygiene 2000–2022: Special focus on gender. WHO and UNICEF. <https://www.unicef.org/reports/progress-on-household-drinking-water-sanitation-and-hygiene-2000-2022>.
- World Health Organization (WHO). (2022). *Sanitation*. <https://www.who.int/news-room/fact-sheets/detail/sanitation>
- Xie, Y., Liu, X., Ni, S. Q., Wei, H., Chen, X., Ismail, S., ... & Lee, T. (2021). Insight into impacts of sewage discharge and river self-purification on microbial dynamics and pathogenicity in river ecosystem.
- Xu, F., Zhang, P., He, Y., Long, H., Zhang, J., Lu, D., & Ren, C. (2025). Seasonal Self-Purification Process of Nutrients Entering Coastal Water from Land-Based Sources in Tieshan Bay, China: Insights from Incubation Experiments. *Journal of Marine Science and Engineering*.
- Zerbo, A. (2022). Environmental risk factors associated with outbreaks of water and vector-borne diseases in urban areas of Sub-Saharan Africa. University of Oviedo. https://digibuo.uniovi.es/dspace/bitstream/handle/10651/66420/TD_AlexandreZerbo.pdf
- Zhang, Y., Wu, J., & Xu, B. (2018). Human health risk assessment of groundwater nitrogen pollution in Jinghui canal irrigation area of the loess region, northwest China. *Environmental Earth Sciences*, *77*, 1-12.

Zheng, M. (2015). Conceptualization of cross-sectional mixed methods studies in health science: a methodological review. *International Journal of Quantitative and Qualitative Research Methods*, 3(2), 66-87.

APPENDICES

Appendix A. Informed Consent Form

Study Title	ASSESSMENT OF SOCIETAL NORMS, HEALTH EFFECTS, AND COPING STRATEGIES INFLUENCING RAW SEWAGE DISPOSAL IN WATER SOURCES OF MUKURU SLUMS, NAIROBI, KENYA
Institution	Meru University of Science and Technology (MUST) School of Engineering and Architecture P.O. Box 972-60200 Meru-Kenya.
Lead Researcher	Nasirumbi Mary Audrey Masters of Science in Sanitation Student, MUST T.+254 (0) 71402204, Email: audreymary04@gmail.com
Supervisors	Dr. Patrick Kinyua Kubai (PhD) Lecturer, School of Health Sciences (SHS) Meru University of Science and Technology Dr. Dorothy Kithinji Kagendo (PhD) Lecturer, Meru University of Science and Technology (SHS) Meru University of Science and Technology

Introduction

My name is Nasirumbi Mary Audrey, Masters of Science Sanitation student, Meru University of Science and Technology (MUST), School of Engineering and Architecture,

department of Civil and Environmental Engineering. I am doing research assessing factors influencing the discharge of raw sewage disposal into water sources in Mukuru Slums Nairobi County. I am going to give you information and invite you to be part of this research. This consent form may contain words that you do not understand, feel free to ask me to explain.

Study Purpose

Disposal of raw sewage of raw sewage in water sources such as rivers and streams lead to exposure of communities to health-related effects such as cholera, diarrheal, infections that impact on the livelihood of communities impacting high cost of disease burdens. This study will explore the factors associated with this practices and impacts.

Procedure

In this study, we will visit, a number of households in the informal settlements of Mukuru slums in Nairobi County, in order to learn from you, where you will be expected to answer questions on issues such as societal norms on raw sewage disposal, health effects and coping strategies directed towards disposal of raw sewage in water sources.

Participant selection

You are being invited to take part in this study because we feel that your experiences and knowledge, especially concerning your household's welfare decisions, are very valuable for this study. We also feel that being at the household level, you understand and are able to make decisions concerning financial matters for your household.

Participation is Voluntary

Participation in this study is entirely voluntary. You will make a choice whether to participate or not. If you choose not to participate, you will not be discriminated against any way and your decision will be respected.

Confidentiality of Information

The research being done in the slums may draw attention and you may be asked questions by other people in the community. Utmost confidentiality will be observed in handling the information given. The information you will give us will only be used for the purpose of this study. Names of the participants will not be produced in analyzed information and raw data will be safely kept under lock and key, only accessible to study team.

Study results

The results of this study will be presented in the thesis. They will be seen by my supervisors, a second marker and external examiner. The thesis may be read by future students on the course. The study may be published in a research journal in future.

Benefits from the study

Participation in this study will not translate into any direct benefits, monetary or otherwise. However, the results from the study may be used by the Ministry of Health, Ministry of Environment, County Government of Nairobi, and other stakeholders to improve sanitation standards in your area.

Risk of Participating

There will be no risk in participating in this study although some questions may involve your personal matters such as finance. Your identity will not be revealed.

Right to Withdraw or refuse

You do not have to take part in this research if you do not wish to do so. While participating in this study you may withdraw from it any time you feel uncomfortable.

Questions

In case, you have any questions, comments or complain regarding the study, kindly contact the investigator or the above address.

Participants Consent

I declare that I have read the above information or it has been read to me. I have the opportunity to ask questions about it and any questions I have been asked have been answered to my satisfaction. I therefore consent voluntary to be a participant in this study.

Signature/Thumbprint of Participant.....Date.....

Appendix B. Structured Questionnaire

This research aims at executing information on societal norms, health effects related with raw sewage disposal and coping strategies influencing the discharge of raw sewage into water sources, in Mukuru slums, Nairobi County. This research is for Academic purpose only and the information herein will be treated in strict confidence.

Tick in the box or fill where appropriate.

Disposal of raw sewage in water sources Survey

Section A: Demographic Characteristics at the household level

1.)_ Indicate your Gender?*

Male	Female	Prefer not to say

2.)_ Which age bracket do you belong?*

18-35 yrs	36-50 yrs	51 yrs & above

3a.)_ Choose your Religion?*

Christian	Muslim	Other

4.)_ What is your marital status?*

Single-Never	Married	Divorced	Widowed
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married			

5.)_What is your level of education?*

No education	Primary education	Secondary education	Tertiary education

6.)_State the number of people in your household?

Section B: Societal Norms Influencing Raw Sewage Disposal in Water Sources

7.a)Do you believe that it is important to dispose raw sewage properly**Using a scale of 1-5,1(Strongly agree, 5 strongly disagree)with the following statements*

Strongly Agree	Agree	Strongly disagree	Disagree	Neutral

7b) Do you believe that disposing of raw sewage into water sources is harmful to the environment? **Using a Likert scale of 1-5,1(Strongly agree, 5 strongly disagree) with the following statements*

Strongly Agree	Agree	Strongly disagree	Disagree	Neutral

7c)_ Do you believe that pressure from your community influences disposal of raw sewage/excreta in water sources?*Using a Likert scale of 1-5,1(Strongly agree, 5 strongly disagree)with the following statements

Strongly Agree	Agree	Strongly disagree	Disagree	Neutral

7d.)_ Do you believe collective responsibility influences disposal of raw sewage/excreta in water sources?*Using a s cale of 1-5,1(Strongly agree, 5 strongly disagree)with the following statements

Strongly Agree	Agree	Strongly disagree	Disagree	Neutral

7e)_ Are there existing religious / cultural beliefs that influence the discharge of raw sewage into water sources?*Using a s cale of 1-5,1(Strongly agree, 5 strongly disagree)with the following statements

Yes	No

10a.)_ Are there existing social networks or organizations in your community that promote sanitation.*

Yes	No

11a.)_Has anyone in your household addressed the improper disposal of raw sewage in water sources from your households*

Yes	No

12.)_Are you willing to use your resources to improve sanitation services in your residence?*

Very much willing	Willing	Less willing	Not willing

13.)_ Do you believe social norms including communication, coordination, and cooperation influences the disposal of raw sewage in water sources?*_Using a Likert scale of 1-5,1(Strongly agree, 5 strongly disagree)with the following statements

Strongly Agree	Agree	Strongly disagree	Disagree	Neutral

14.) Are you aware of national or local laws/regulations in place to ensure proper disposal of raw sewage?*

Yes	No

Section C: Health Effects associated with disposal of raw sewage disposal into water sources

15a.)_Has anyone in your household suffered from waterborne related illnesses*

Yes	No

15b.)_If yes kindly select the type of illness*

Cholera	Polio	Typhoid	Dysentery	Dysentery	Hepatitis	Other	None

15d.)_How frequent are sanitation related waterborne illnesses reported in your household? *If yes, choose one

Most frequent	Frequent	Less Frequent	Never

16a.)_Has anyone in your household suffered from sanitation related vector borne diseases reported in your household? *

Yes	No

16b.)_If yes kindly select the type of illnesses*

Malaria	Lymphatic filariasis/Elemphatiasis	Schistosomiasis/	Bilharzia	Other	None

16c.) How frequent are sanitation related vector borne diseases reported in your household?

*

Most frequent	Frequent	Less Frequent	Never	I don't know

17a.) Has anyone in your household suffered from sanitation related nutrition deficiency diseases? *

Yes	No

17b.) If yes kindly select the type of disease*

Anemia	Vitamin A deficiency	Growth retardation	Malnutrition	Kwashiorkor
Wasting	Stunting	None	I don't know	Other

17d.)_How frequent are sanitation related nutrition deficiencies reported in your household?*

Most frequent	Frequent	Less Frequent	Never	I don't know

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18a.)_Has anyone in your household suffered from respiratory diseases?*

Yes	No

18b.)_If yes kindly select the type of disease*

Flu	Whooping cough	Other	None

18d.)_How frequent are respiratory diseases reported in your household?*

Most frequent	Frequent	Less Frequent	Never	I don't know

19a.)_Has anyone in your household suffered from mental health issues?*

Yes	No

19b.)_If yes kindly select the type of disease*

Anxiety	Depression	None	Other

20a.)_Has anyone in your household suffered from chronic health issues?*

Yes	No
-----	----

20b.)_If yes kindly select the type of disease*

Kidney failures	Hypertension	Diabetes	Liver damage	Other	None

20c.)_Other*20d.)_How frequent are chronic illnesses reported in your household?*

Most frequent	Frequent	Less Frequent	Never	I don't know

21a.)_Has anyone in your household suffered from sanitation related to skin infections?*

Yes	No

21b.)_If yes kindly select the type of disease*

Skin rashes	Scabies	Jiggers	None	Other

21d.)_How frequent are sanitation related skin infection reported in your household?

Most frequent	Frequent	Less Frequent	Never	I don't know

22.)_Have you had financial constraints to cater for cost of health effects resulting from raw sewage disposal in water sources?*

Yes	No

Section D : Coping strategies influencing the discharge of raw sewage into water sources

23a.)_Identify sanitation facility in your household*

Pit latrine-	Communal Toilets	Urinary Diverting Dry Toilet (UDDT)	Flying toilet
Dry toilet Pour Flush Toilet Cistern Flush toilet	Ventilated Improved Pit latrine	No facility	Other

24a.)_Which method do you use to collect and store sewage/ excreta*

Single pit	Single ventilated	Double	Composting	Septic tank
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	Improved Pit	ventilated Improved Pit(VIP)	Chamber	
Biogas Reactor	Anaerobic Filter	Other	None	I don't know

25a.)_Identify ways for transporting/conveying sewage/excreta in your household*

Jerrican/tank	Human Powered Emptying and Transport Motorized emptying and transport	Simplified Sewer	Solid Free Sewer	Conventional Gravity Sewer
Transfer station- underground holding tank		Other	None	I don't know

26a.)_ Identify ways of treating your sewage/ sludge-excreta*

Waste stabilization ponds	Aerated ponds	Free water surface contaminated wetland	Activated sludge	Unplanted Drying Beds
Planted Drying Beds	Co-composting	Biogas reactor	None	I don't know

27.a)_ Identify ways for use/ disposal of sewage/excreta from your household*

Fill and cover	Application of pit humus and compost	Irrigation	Fish pond Water disposal	Surface disposal and storage	Soak pit	Open drains
Application of dehydrated faeces	Application of sludge Biogas combustion	Animal feeds	Other	None	I don't know	

28a.)_ Are there instances in which you witness disposal of excreta/raw sewage in the nearby water sources next to your household?*

Yes	No

I have not witnessed

28b.)_ If yes, where*

Water sources-rivers,	Tributaries	Open drains Environment	Other

29.)_ Has anyone in your household relocated to a new plot in your community due to improper disposal of raw sewage in your area?*

Yes	No

30.)_ Has anyone in your household ever waited for stakeholders to deliver better sanitation services?*

Yes	No

--	--

31.)_ Has anyone in your household neglected the fact that there is improper during improper sewage/excreta disposal in water sources*

Yes

No

Yes	No

Date	time

Appendix C. Focused Group Discussion Questions

Section A: Manual Pit Emptier

1. Do you ever face social stigma due to nature of your work? If yes, how did this interfere with your operation?
2. What social, cultural, religious norms, social support, collective responsibility have hindered you from conducting your duties?
3. How can communication, coordination and cooperation influence proper disposal of raw sewage/excreta in your community
4. What is the health-related effects that you have faced due to the nature of your work? (water borne, vector borne, skin infection, chronic illnesses, mental health issues, nutritional deficiencies)
5. What are some of the methods you use to collect, transport, treat and dispose the raw sewage/excreta in your community?
6. Are their times you disposed raw sewage into the nearby water sources in your area/witnessed the disposal practice?
7. Have you ever faced charges due to improper raw sewage disposal in water sources?
8. What challenges do you face when trying to access, the pit latrines for emptying/urinary diverting toilets?
9. Have you ever tried to address the improper disposal of raw sewage in your community, neglected the situation, or left you area of operation?

Section B: Community Health Promoters

1. What social, cultural, religious norms, social support, collective responsibility have hindered you from conducting your duties?

2. How can communication, coordination and cooperation influence proper disposal of raw sewage/excreta in your community
3. What is the health-related effects that you have faced due to the nature of your work? (water borne, vector borne, skin infection, chronic illnesses, mental health issues, nutritional deficiencies)
4. What are some of the methods you use to collect, transport, treat and dispose the raw sewage/excreta in your community?
5. Are there times you witnessed disposal of raw sewage into the nearby water sources in your area?
6. What are the consequences of the discharge of raw sewage in water sources on the environment and public health?
7. Have you ever tried to address the improper disposal of raw sewage in your community, adapted to the situation, left you area of operation or never bothered?
8. What measures can be taken to prevent the discharge of raw sewage in water sources in your community?
9. What challenges do you face when trying to address proper disposal of raw sewage or excreta in your community?

.....Thank You.....

Appendix D. Key Informant Interview Guide

Section A: Public Health Officers

1. What role do you play to address the disposal of raw sewage disposal in water sources?
2. How does your communication, coordination and cooperation with the community influence proper disposal of raw sewage/excreta?
3. Are there any regulation measure you apply to address the improper disposal of raw sewage in water sources?
4. How does social norms in your community influence the discharge of raw sewage into water sources (Probe, Beliefs, cultural constraints, religion, expectations, norms, collective responsibility and social support)
5. Are you able to associate raw sewage disposal in water sources with any public health /environmental effects?

Kindly Explain

6. What is your opinion on the existing sewage/ excreta collection, disposal, transportation and treatment methods in your location?
7. Are their times you witnessed disposal of raw sewage/excreta into the nearby water sources in your location?
8. How have you tried to address the sanitation issues with your area of operation (collection, transportation, treatment or disposal?)
9. Are their organizations in your area of operation that address the issue of disposal of raw sewage in water source? Kindly explain where they serve the community along the sanitation value chain.

10. In your own opinion, what key areas along the sanitation service delivery chain do you think need more effort to solve the sanitation menace in informal settlements?

(Collection, Transportation, Treatment/Disposal)

Section B: Local Administration-Chiefs/Village Elders

1. What is your role in ensuring proper disposal of raw sewage in your community?
2. How does your communication, coordination and cooperation with the community influence proper disposal of raw sewage/excreta?
3. What are the societal norms, cultural, religious norms, social support, collective responsibility within your location/ villages that hinder you from addressing proper raw sewage disposal?
4. Are there any regulation measure you apply to address the disposal of raw sewage in water sources?
5. Are you able to associate raw sewage disposal in water sources with any public health /environmental effects?

Kindly Explain

6. What is your opinion on the existing sewage/ excreta collection, disposal, transportation and treatment methods in your location?
7. Are there times you witnessed disposal of raw sewage/excreta into the nearby water sources in your location?
8. How have you tried to address the sanitation issues with your area of operation (collection, transportation, treatment or disposal?)
9. In your own opinion, what key areas along the sanitation service delivery chain do you think need more effort to solve the sanitation menace in informal settlements?

(Collection, Transportation, Treatment/Disposal)

.....Thank You.....

Section C: Religious Leaders

1. What is your role in ensuring proper disposal of raw sewage in your community?
2. How does your communication, coordination and cooperation with the community influence proper disposal of raw sewage/excreta?
3. Are there any religious norms, culture that influence or hinder proper disposal of raw sewage in your community?
4. Are their existing sewage disposal/excreta methods accepted by your members?
 - i. Yes. Explain
 - ii. No. Explain
5. Are you able to associate raw sewage disposal in water sources with any public health /environmental effects?
Kindly Explain
6. Is there any association between health-related sanitation illnesses with religion?
7. What is your opinion on the existing sewage/ excreta collection, disposal, transportation and treatment methods in with your religion?
8. Are their times you witnessed disposal of raw sewage/excreta into the nearby water sources in your location?
9. How have you tried to address the sanitation issues with your community?

10. In your own opinion, what key areas along the sanitation service delivery chain do you think need more effort to solve the sanitation menace in informal settlements?

(Collection, Transportation, Treatment/Disposal)

11. What do you recommend as the most effective way to addressing social and religious norms when addressing sewage disposal/excreta disposal

.....Thank You.....

Appendix E. Introductory Letter



MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

P.O. Box 972-60200 – Meru-Kenya.

Cell phone: +254 712 524293, +254 799 529958, +254 799 529959

Website: www.must.ac.ke Email: info@must.ac.ke

SCHOOL OF ENGINEERING AND ARCHITECTURE

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

TO: Whom It may concern

DATE: 24th August, 2023

Dear Sir/Madam,

RE: INTRODUCTORY LETTER FOR NASIRUMBI MARY AUDREY, REG NO. EG407/201440/21

The above-named, is a student in the Department of Civil and Environmental Engineering at Meru University of Science and Technology, pursuing a Master's degree in Sanitation. She has been approved to conduct research on "Assessment of factors influencing discharge of raw sewage in water sources, Mukuru Slums, Nairobi" aimed at completing her studies. This is therefore, to request that you grant her any assistance needed to enable her meet the program requirements for her graduation.

Kindly contact us for any further enquiries.

Thank you

Mirara Simon W.
Chair of Department, Civil and Environmental Engineering
Meru University of Science and Technology

Email: CODcivilengineeing@must.ac.ke
Smirara@must.ac.ke



MUST IS ISO 9001:2015 CERTIFIED

Appendix F. Research Permit from NACOSTI


REPUBLIC OF KENYA
National Commission for Science, Technology and Innovation


NATIONAL COMMISSION FOR
SCIENCE, TECHNOLOGY & INNOVATION

Ref No: 840368 Date of Issue: 06/September/2023

RESEARCH LICENSE



This is to Certify that Miss. MARY AUDREY NASIRUMBI of Meru University of Science and Technology, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Nairobi on the topic: ASSESSMENT OF FACTORS INFLUENCING DISCHARGE OF RAW SEWAGE IN WATER SOURCES, MUKURU SLUMS, NAIROBI COUNTY for the period ending : 06/September/2024.

License No: NACOSTI/P/23/29089

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NATIONAL COMMISSION FOR
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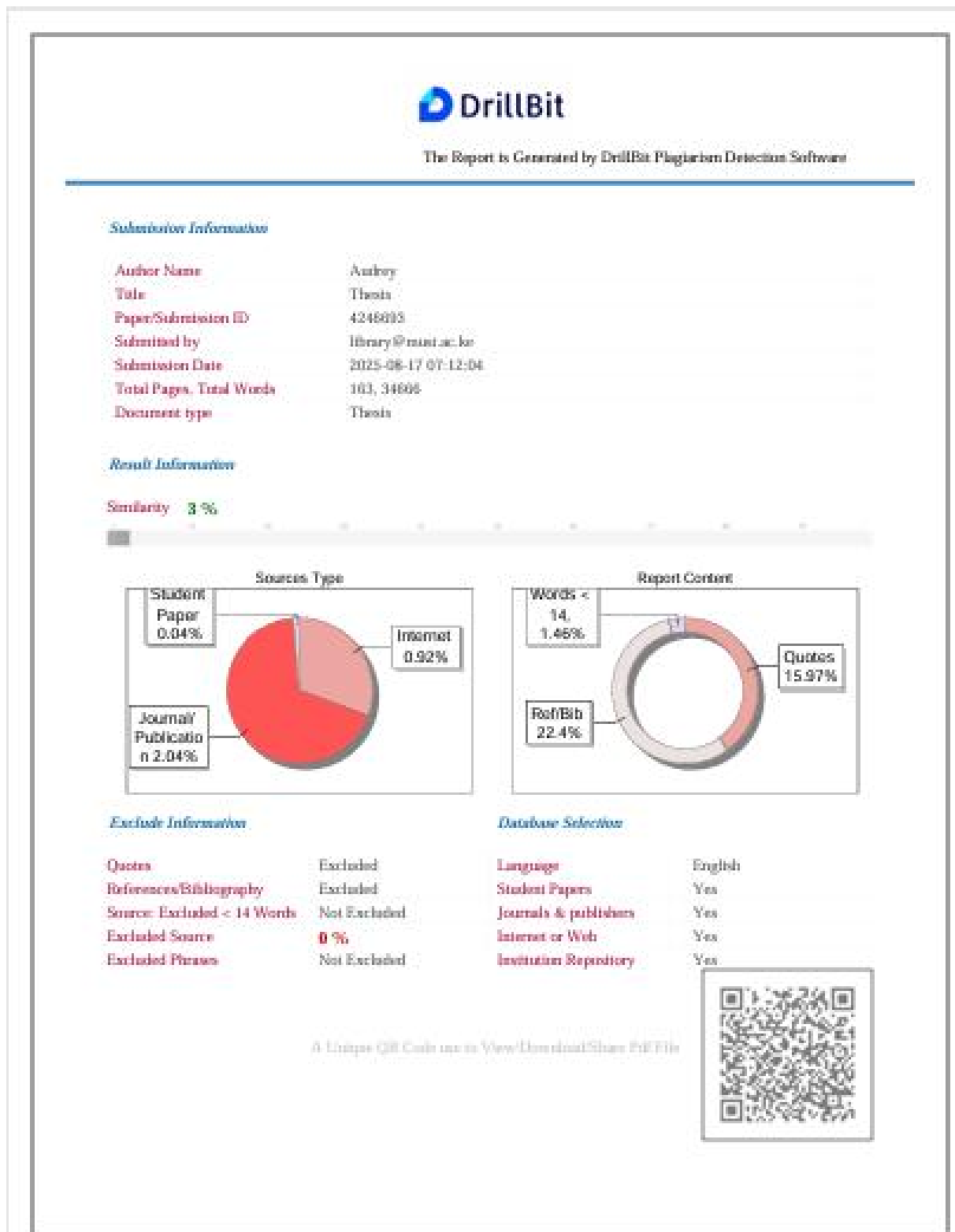
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Appendix G. Permit from County Government



Appendix H. Plagiarism Report



Appendix I: Publication



Role of societal norms in raw sewage disposal in water sources, Mukuru slums, Nairobi County, Kenya

Audrey Nasirumbi^{1*}, Patrick Kubai², Dorothy Kagendo³

¹Meru University of Science and Technology, Meru Kenya

ARTICLE INFO

ABSTRACT

Keywords

Societal norms

Raw sewage disposal

Community engagement

Sanitation

A sustainable sanitation system is economical, socially acceptable, and environmentally friendly. Raw sewage disposal into water sources is a significant environmental and health concern in many informal settlements in Kenya. Inadequate access to proper sanitation facilities leads to water source contamination. Despite the severe environmental and health impacts, there is limited knowledge about the factors influencing these practices. Therefore, this study's specific objectives sought to determine the role of societal norms influencing the discharge of raw sewage into water sources in Mukuru slums, Nairobi, Kenya. A cluster proportionate random sampling was used to identify household heads, while key informants were purposively selected. A quantitative study of 246 household heads was conducted using structured questionnaires and analyzed using the Pearson Chi-Square Test at 95% Confidence Interval. Qualitative data collected through FGDs, and KIs, was transcribed and manually presented in narratives. The study findings revealed that 96.1% of raw sewage was discharged into water sources while 87.7% of the participants witnessed raw sewage disposal practices. Raw sewage disposal had influenced societal norms such as belief that played a role in 85.1% of cases ($p=0.046$). The study concluded that poor societal norms contributed to raw sewage disposal into water sources. The study recommended community to educate her residents on values such as beliefs, collective responsibilities, the presence of social networks, proper communication, cooperation, and coordination to prevent raw sewage disposal in the area and create an enabling environment for all.

Introduction

Raw sewage is untreated domestic sewage that comprises untreated wastewater and blackwater from toilets, sinks, drains, chemicals, and sanitary products (Collins et al., 2018). (Collins et al., 2018). Untreated municipal sewage is a point source and harmful source of water ecosystem contamination due to the bulk production of organic matter (Collins

et al., 2018). Globally, an estimate of 2 million tons of sewage is discharged into water sources in the world with 97% from Venezuela, 75% from Turkey, 71% in European countries 80% in Latin Countries, as well as 68% in Asia, due to technological development, (Qadri et al., 2020). In Abuja Nigeria, Kado district during emptying of septic tanks for sewage disposal, Lake Jabi serves as a receiver while some

*Corresponding author: Nasirumbi Audrey

Email: audreymary04@gmail.com

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