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Assessment of Waste Water Management in a Low-Cost Housing Settlement: The Case of Emali Town, Makueni County, Kenya

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Abstract

Averagely 80% of world's wastewater is released into the environment without adequate treatment. Effective management of wastewater is therefore essential to mitigate pollution and recover valuable resources such as water energy and nutrients. Despite the rapid population growth of Emali Town in Makueni County, Kenya, no concrete wastewater management system exists at the moment. The purpose of the study was to investigate wastewater management in a low-cost housing settlement in Emali Town. The study used survey research design. The target population for this study was the 11,000 residents of Emali town and a study sample size of 297 was selected using simple random sampling technique. Data was collected using a semi-structured questionnaire. The reported per capita was use in the study area was approximately 60 liters, three-quarters of which ends up as wastewater effluent, mainly directly to the effluent. The study found that 65.2% of households in Emali Town lacked access to a centralized sewerage system and that only 20% of households were connected to a wastewater collecting system. Insufficient wastewater management was the main cause of the town's declining water quality. The majority of the respondents (88.1%) indicated that they do not know the key existing policy and regulatory frameworks on wastewater management. The finding of the study indicate that implementation of decentralized waste water management system would enhance water management in low cost hosing systems therefore offering cost-effective solution to environmental pollution. The study recommends that in order to guarantee that wastewater generated is safely directed to a suitable disposal site sustainably, policies and institutional frameworks should be in place with the mandate that owners of any premises, whether temporary or permanent, residential or industrial, be connected to a wastewater collection system.

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Keywords: *Wastewater Management; Low-Cost Housing; Sanitation Infrastructure; Environmental Pollution; Emali Town.*

1.0 Introduction

Wastewater management is a critical indicator of environmental sustainability and public health. Averagely 80% of the world's wastewater is released into the environment without adequate treatment (WHO & UN-Habitat 2024). Effective management of wastewater is therefore essential to mitigate pollution and recover valuable resources such as water energy and nutrients. Furthermore, proper wastewater management helps prevent waterborne diseases, protects aquatic ecosystems and ensures sustainable water use.

Globally, wastewater management remains one of the most significant environmental and public health challenges of the 21st century. It is deeply intertwined with the achievement of the global Sustainable Development Goal (SDG) 6.3. It is estimated that out of all wastewater generated worldwide, 95% mainly from developing countries is discharged into the ecosystem without any form of treatment (United Nations, 2023). Recent data from the United Nations Statistics Division indicates that while progress has been made, only 56% of domestic wastewater is safely treated before discharge. The disheartening fact about this is that this figure has remained largely stagnant since 2020 (United Nations, 2025). It is further evidence that averagely 3.4 billion people currently lack access to safely managed sanitation services (WHO, 2024).

In Sub-Saharan Africa, wastewater management is characterized by a profound systemic divergence between two conflicting but complementary factors; rapid demographic expansion and stagnant infrastructural development. Sub-Saharan Africa is currently known for being a tension zone for deteriorating water quality. Existing empirical evidence indicates that less than 10% of generated wastewater undergoes any form of formal treatment before being discharged into the environment (Afolalu et al., 2022). According to the 2024 SDG 6 Data Portal, only 19% of domestic wastewater in Sub-Saharan Africa is safely treated. This highlights a critical deficit in centralized sewerage systems and pervasive reliance on unmonitored onsite sanitation. This overreliance frequently facilitates the cross-contamination of groundwater reservoirs. The management crisis is inflamed by an unprecedented urbanization rate, with the regional population projected to increase by 79% by 2054 (Roy et al., 2025).

In Kenya, wastewater management is governed by two bodies, the Water Resources Authority (WRA) through Water Act (2016) and the National Environment Management Authority (NEMA) through various regulations. These bodies are established in the Kenyan constitution (2010). As of 2024, the national proportion of domestic wastewater that is safely treated stands at a mere 11% to 15% (World Health Organization & UN-Habitat, 2021). Compared to the global average of 56%, this is significantly lower. The Water Services Regulatory Board (WASREB, 2024) reports that while urban coverage is gradually expanding, only 12% of domestic wastewater flows are handled by formal sewerage systems, with the remaining 88% managed through onsite sanitation facilities such as septic tanks (14%) and rudimentary pit latrines (74%). This structural dependency on onsite systems has led to the degradation of over 63% of monitored water bodies, which currently fail to meet national ambient water quality standards (Lema, 2025).

Makueni County embodies the sanitation challenges faced by rapidly urbanizing "satellite" regions in Kenya very well. With an urbanization rate of 11.8%, the county currently lacks any piped

sewerage network or centralized fecal sludge treatment facilities (UN Habitat, 2023). The Makueni Countywide Inclusive Sanitation Strategy (2025-2030) indicates that approximately 46% of the population utilizes unimproved sanitation facilities, while in burgeoning transit hubs like Emali Town, institutional and residential waste is primarily managed through unregulated septic tanks and pit latrines (World Bank, 2019). The lack of adherence to construction codes has resulted in widespread "grey water" discharge directly into open drains and natural waterways, posing a direct threat to the regional aquifer and the health of its 1.04 million residents. This "grey water" discharge accounts for 75% of the total wastewater in town centers (World Bank, 2019).

The crisis of wastewater management in the low-cost housing settlements of in Kenya represents a structural hygiene deficiency of the urban sanitation infrastructure. An overwhelming divergence between rapid demographic growth and stagnant institutional response characterizes it. Despite the global imperative for safely managed sanitation, a staggering 80% of wastewater is discharged into the environment untreated (Afolalu et al., 2022). Developing countries contribute 95% of this untreated wastewater discharge (Abebe et al., 2023). This is a prerequisite to an ecological catastrophe. The situation is increasingly dire in Kenya, as national data indicate that only 12% of the population is served by a centralized sewerage system, leaving the remaining 88% to rely on rudimentary on-site sanitation facilities that are frequently prone to failure (Kilingo et al. 2021).

The absolute absence of a centralized primary sewerage network and the lack of standardized construction codes for decentralized treatment units in low-cost developments contribute to poor wastewater management in this area. Also, a profound disconnect between Makueni County's urban planning departments and national environmental regulators pose a major challenge. This disconnect results in a total absence of fecal sludge management (FSM) oversight. Finally, financial exclusion of low-income residents who cannot afford private exhauster services, coupled with a lack of community-led sanitation governance frameworks contributes majorly to poor wastewater management.

The selection of low-cost housing settlements for this study is necessitated by the acute sanitation "bottlenecks" that characterize these high-density environments. In low-cost estates, the disconnect between housing affordability and infrastructure provision is stark. Research done in peri-urban Kenya shows that over 50% of the residents rate their domestic wastewater systems as "very poor," with many sharing a single pit latrine among 11 to 15 households (KNBS, 2022). These settlements act as a point-source pollution sites where untreated effluent facilitates the transmission of pathogens, contributing to high regional rates of waterborne diseases (UN Habitat, 2023). This study focuses on Emali Town specifically because its low-cost housing sector lacks the financial leverage to access private exhaust services. This creates a hygiene pitfall where environmental degradation and poverty reinforce one another.

In Emali Town, Makueni County, the problem is intensified by its status as a high-density transit hub. Sewerage coverage in the town stands at a critical 0%. Statistics reveal that 75% of domestic wastewater in the town settlements consists of "grey water" which is discharged directly into open surface drains and natural water bodies, leading to the contamination of local aquifers and a failure rate of onsite systems exceeding 60% (Bundi & Njeru, 2018).

The study seeks to close the inadequate empirical data on waste water management in low cost settlement areas in Makueni County. Most studies have been done in Nairobi city and the contextual setting is different given the geographical location and resource allocations. Through this research, a viable context-specific framework for sustainable wastewater management within

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Emali Town's low-cost housing sector is provided. This study is essential because the current trajectory of unregulated discharge is not only an environmental hazard but a fundamental breach to the human right to sanitation. Without solving this, the resident population remains at a permanent risk of recurring waterborne epidemics and irreversible groundwater toxicity. The study evaluated the existing wastewater management practices and systems in the Emali Town, the challenges and environmental impacts of the existing wastewater management systems, and the level of awareness of the local population on the institutional and regulatory policies and regulations on wastewater management.

2.0 Research Methodology

The area of study, Emali town, lies (*Latitude* 2° 5.829'S *and Longitude* 37°28.121'E) along Nairobi-Mombasa highway and its one of the most urbanizing towns and commercial hub in Makueni County (Fig. 1). The town also lies along the Nairobi- Mombasa standard gauge railway and covers an approximate area of 16km^2.The town has a population of about 11,000. Urbanization in the county is rapidly increasing with other towns like Makindu, Wote, Kibwezi, Mtito-Andei and Machinery recording substantial urban population (Makueni Fact sheet, 2012).

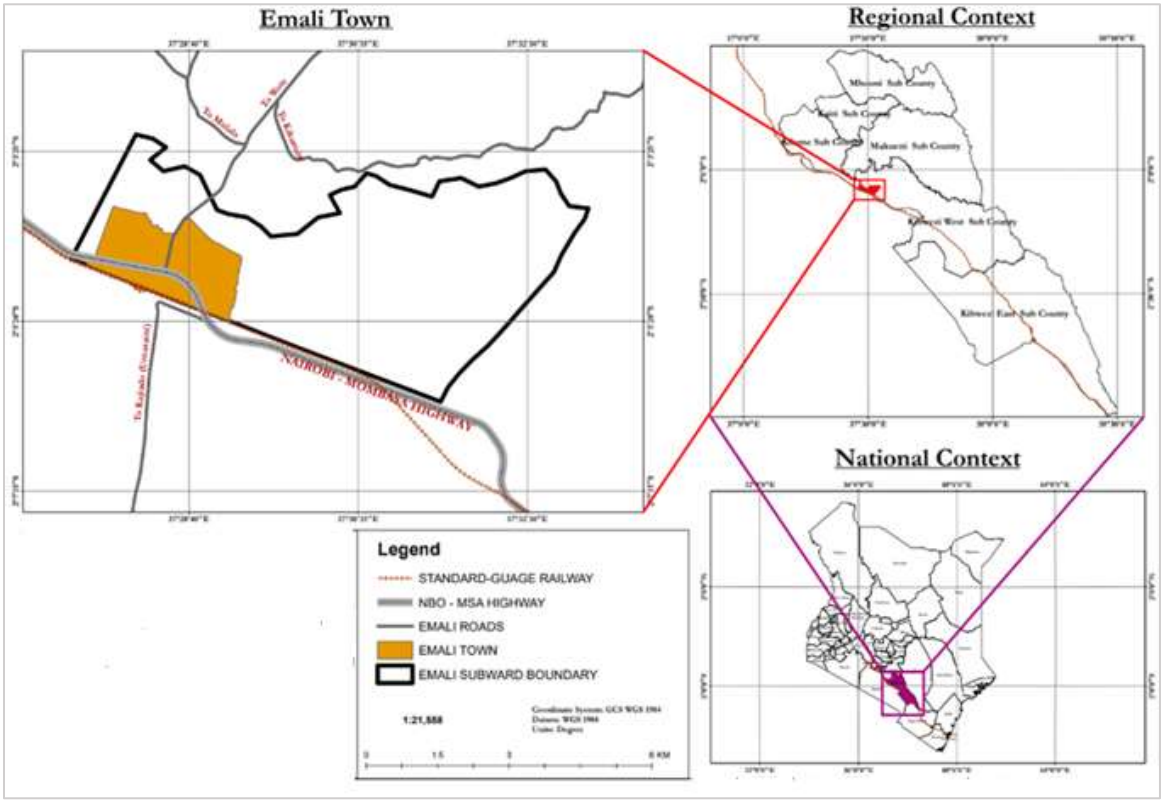

Figure 1: Map of Study Location

Source: GoMC (2025)

The study used survey research design. This is defined as the extraction of information from respondents using a structured questionnaire and interview schedules (Chopra, 2018). According to Orodho (2005), survey concerns describing, recording, analyzing and reporting conditions that exist or have existed. The survey design is relevant to this study as the researcher report on the

environmental impacts of the existing wastewater management systems and the adherence to the existing policies and regulatory frameworks around sanitation and wastewater management. An analysis on the existing national and county government frameworks was done to identify gaps and area of improvement. The survey design collected data from respondents in residential areas, institutions and key informants. The data collected was subsequently analyzed and presented as generalized findings of the area of study.

The target population for this study was 11,000 residents of Emali town according to the 2019 census done by KNBS (2019). The study also targeted the technical staff who serve within the municipality for the focus group discussion. These included; the municipal manager, NEMA official, the Manager Nol Turesh Water and Sewerage Company, County Director of Environment, County Director of Urban Planning and Housing, and County Director of Socio-Economic Planning.

The sample size of the study was determined using the Cochran's formula:

$$n = \frac{z^2 pq}{e^2}$$

The sample size was 297. To select the sample, the study used simple random sampling technique. By doing this, bias was lessened and every member of the study group had an equal chance of being chosen (Mugenda & Mugenda, 2013). The technical people were selected using purposive sampling method.

Qualitative and quantitative data was collected using a semi structured questionnaires. One questionnaire targeted the population while the second one was used to collect data from the key informants. The approved questionnaire was uploaded in google forms for data collection. The data was collected by research assistants who interviewed the respondents and filled the data to the online tool.

Data collected from the field was downloaded for analysis using the Statistical Package for Social Sciences (SPSS) and Microsoft Excel. On qualitative data, thematic analysis was derived from the open-ended questions. The main themes and patterns in the responses were identified and analyzed to determine the adequacy, usefulness and consistency of the information. Quantitative data was analyzed using descriptive statistical tools such as frequencies, percentages and means as described by Mugenda and Mugenda, (2013). The results of data analysis were presented in frequency tables, bar graphs and pie charts. Answering of the research questions was by interpreting the bar graphs and other diagrams produced. Implications from the different data sets were integrated logically to give the required information.

3.0 Results

3.1 Demographic Information

The study sought to establish the socio-demographic characteristics of the study population which included; household headship, education level, employment status, household size, type of housing and period of stay in Emali town. The study findings indicated that 85% of household heads were male, 15% had only completed primary school or had not completed it, 78% had finished secondary school, and 7% had finished post-secondary education. Additionally, the results showed that 19.5% of respondents were engaged in the formal employment, 65.6% were in the informal employed sector, and 14.9% were jobless. In Emali town, house-holds size were often small, with

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73.1% consisting of 3 or less than 3 members and 26.9% having more than three. At the time of the study, 91.1% of people lived in rental housing and 8.9% in their own homes. In terms of length of stay, 64.9% had lived in Emali for more than five years, whereas 35.1% had lived there for less than five years (Table 1).

Table 1: Demographic characteristics

Demographic	Category	Frequency	Percentage
Household headship	Male	202	85
	Female	36	15
Education level	Primary	35	15
	Secondary	186	78
	Post-secondary	17	7
Employment	Formal sector	46	19.5
	Informal sector	156	65.6
	Unemployed	36	14.9
Household size	3 or Less than 3 members	174	73.1
	More than 3 members	64	26.9
Housing	Rented	217	91.1
	Owned	21	8.9
Length of stay	More than 5 years	154	64.9
	Less than 5 years	84	35.1

Source: Field Data (2025)

3.2 Waste Water Management Practices

3.2.1 Sources and Volumes of Wastewater

The best way to manage wastewater is determined by its sources and volume, which also affect the effluent's characteristics. According to the findings of this study, each person in email town consumes an average of 60 litres of water. Majority of this water is used for laundry, bathing and washing utensils. Since there is no proper sewerage system, most of this water is released to the environment. The study established that an average of 45 liters of water consumed daily per person in Emali ends up as effluent in the environment. According to the 2019 census, 11,000 people are living in Emali; since the average amount of wastewater released into the environment is 45 liters per person, the entire population releases 11,000 * 45 = 495,000 liters each day. The study established that in addition to the household waste water, storm water, residential buildings, and commercial spaces are the main sources of wastewater during the rainy season.

3.2.2 Existing Wastewater Management Practices

The study sought to determine the facilities and current waste water management procedures. The study found that 20% of respondents said they were connected to a wastewater collecting system, whereas 80% of respondents said they were not. The municipal manager indicated that the wastewater collection systems in Emali town are open storm drainages, and closed drainages.

The study findings indicated that 80.7% of the respondents use pit latrine while 19.3% have septic tanks. In the aspect of septic tanks construction, 78.9% of respondents did not know when septic tank was constructed. Up to 100% of septic tanks are installed outside of residential buildings, and 90.7% of non-fabricated septic tank types are composed of masonry (58.3%) and concrete (41.7%).

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Even though 98.5% of septic tanks had suction and air holes, all respondents (100%) said they have never emptied a sewage tank since it was constructed. Considering that 90.9% of respondents said the built-in septic tank was not impermeable, this suggests that neglecting the tank could cause it to fail to meet criteria and contaminate the groundwater and soil.

The majority of stormwater is discharged into the environment as a result of drainage line obstruction. Furthermore, despite the existence of wastewater collection systems, the issues of wastewater penetration and exfiltration persist, resulting in environmental damage and system capacity surpassing expectations, respectively. Poor drainage systems are the main cause of wastewater exfiltration, which is visible during rainy seasons when streets flood. During dry seasons, solid waste is dumped into drainage systems, which eventually become blocked and pollute the environment. Exfiltration is sometimes brought on by inadequate sewer system maintenance, which causes wastewater to seep from damaged wastewater pipes.

3.2.3 Conditions of the Existing Wastewater Management Practices

Over 36% of respondents indicated that the condition of the wastewater collection system in Emali town was very bad, 30.4% indicated the situation was bad, 27.5% indicated it was good while only 5.8% indicated it was very good (Figure 2).

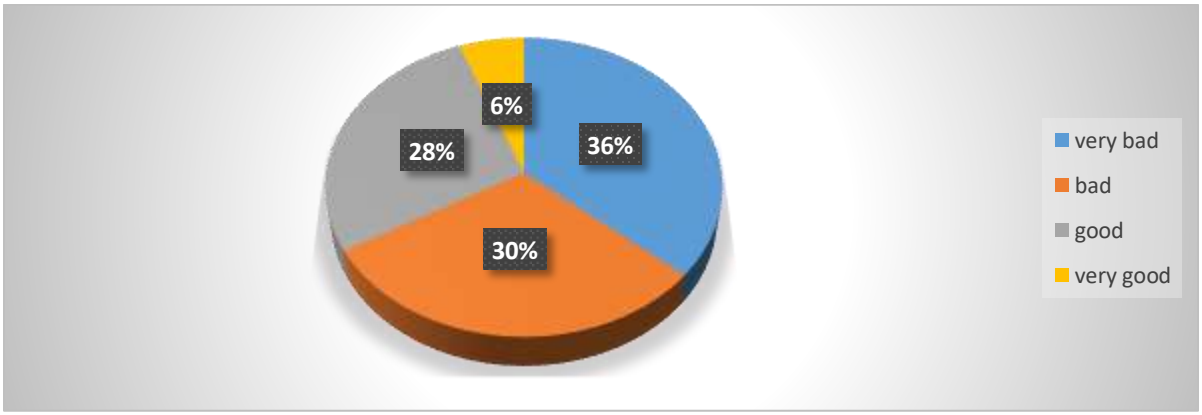

Figure 2: Conditions of the Existing Wastewater Management Practices

Source: Field Data (2025)

3.3 Environmental Impacts of Existing Wastewater Management Practices

The study made the following observations on the impacts of existing waste water management practices in Emali town. The waste water discharged to the surface from the residential areas and the storm water during rain season resulted to algae growth in the area where the water accumulates. This is a potential for toxins being released to the air causing health effects. The waste water discharged through dilapidated sewerage systems was found to overflow from the drainage system leading to stench smells and posing health risks to humans and livestock. The study also observed that the waste water discharged also contained feacal sludge which is released to the water bodies. This caused water contamination and the potential development of waterborne diseases.

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3.4 Knowledge of Existing Policy and Regulating Frameworks and institutions on Waste Water Management

The study sought to determine the level of awareness on existing policies, standards and regulatory frameworks and whether they influence wastewater management. The study further established the level of awareness national regulatory and standardization institutions on waste water management.

3.4.1 Knowledge of Existing Policy, Standards and Regulatory Frameworks

Majority of the respondents (88.1%) indicated that they do not know the existing policy and regulatory frameworks on wastewater management (Table 2).

Table 2: Knowledge of existing policy and regulatory frameworks

Awareness	Frequency	Percentage
Have Knowledge	28	11.9
No Knowledge	210	88.1

Source: Field Data (2025)

The study further sought to determine which of the existing policies, standards and regulatory frameworks were known by the respondents. Table 3 shows that majority (60.9%) were not aware of any of the named policies, standards and regulatory frameworks. 40.7% of the respondents reported that they were are of the 2019 Makueni County Water Policy, 33.9% reported that they were aware of the Environment Bill and 26.9% reported that they were aware of the Makuani Countywide Inclusive Sanitation Strategy. The respondents were generally no familier with most of the national policies and regulations with only 2.9% and 5.9% reporting that they were aware of the Sustainable Waste Management Act (2022) and Water Act (2016) respectively (Table 3).

Table 3: Awareness of Specific Policies, Standards and Regulatory Frameworks

Policies, Standards and Regulation Frameworks	Percentage
Sustainable Waste Management Act (2022)	2.90
National Sanitation Management Policy 2024-2030	4.70
Environmental Management and Coordination Act (EMCA)	8.90
National Environment Policy 2024	5.60
Water Act 2016	5.90
The Makueni County Water Act 2020	17.90
The Makueni Countywide Inclusive Sanitation Strategy	26.90
Environmental Bill	33.90
Makueni County Water Policy 2019	40.70
None of the Above	60.90

Source: Field Data (2025)

3.4.2 Knowledge of Regulatory and Standardization Institutions

The study sought to understand if the respondents have knowledge on regulatory and standardization institutions in Makueni County and Kenya in regard to wastewater management. The study found out that majority of the respondents did not have knowledge on the existing

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regulatory and standardization institutions in the county and country (Table 4). 35% of the respondents reported that they were aware of county government department of water and environment, 31% reported they were aware of NEMA while only 9% reported that they knew Kenya Bureau of Standards (KEBS). In general, only 2% reported that they knew all the three regulatory and standardization institutions on water.

Table 4: Knowledge on Regulatory and Standardization Institutions

Institution	Frequency	Percentage
NEMA	102	31
KEBS	21	9
County Government department of water and environment	83	35
All the above	5	2

Source: Field Data (2025)

3.5 Challenges Hindering Proper Management of Wastewater

The key informants reported that the challenges that hindered proper waste management in Emali town included: waste water management being capital-intensive, with the majority of residents not having the financial capacity to implement the necessary interventions; lack of skilled personnel to develop waste water management plants; lack of proper disposal methods of sludge from the wastewater treatment facilities. The other challenge that was highlighted was the poor maintenance of available treatment plants which leads to breakdown of the plants.

3.6 Efforts to Improve Wastewater Management

The key informants interviewed, who are responsible for water and wastewater management at county and national level, reported that efforts that were being undertaken to ensure proper waste water management in Emali town included doing campaigns that advocate for proper management of wastewater while highlighting the risks that are associated with poor management of waste water; undertaking training on the operation of water treatment plants. Training of skilled personnel was reported to enhance smooth operation of the plants and also led to increased efficiency of the water treatment process. The other strategy that was reported was that indicated that the county had made efforts to ensuring that the wastewater treatment plants are well maintained in order prevent breakdown of the treatment facilities.

The key informants indicated that the following can be done to revert the negative effects associated improper wastewater management on the environment: 1. coming up with proper disposal methods of sludge to prevent environmental pollution; 2. Increase surveillance and treatment of water-borne diseases; 3. Enhanced sensitization of the local population on the importance of waste water management; and 4. Training more staff on wastewater management in order to equip them with the know-how of waste management and also enlighten them on the benefits associated with proper wastewater management.

4.0 Discussion

4.1 Waste Water Management Practices

The current study found that in Emali town, the conditions of the existing wastewater management practices are not adequate. This can be attributed to lack of wastewater collection and treatment systems, with only 20% of households being connected to onsite wastewater collection systems.

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The rest of the households either use pit latrines, with the most of the grey wastewater released to the environment, resulting environmental pollution. The study also found that most of the storm wastewater collection pipes were dilapidated and frequently busted leading to spilling of the wastewater to the land. The wastewater collection systems was also found to be prone to blockages causing wastewater overflow. These findings agree with the findings of Bundi & Njeru (2018) who reported that in Kenya, the waste water management systems are dilapidated and the rate of urbanization has constrained the capacity of existing wastewater management practices. In urban areas, only less than half of the waste water is safely collected and treated before being released to the environment (Lema, 2025).

4.2 Environmental Impacts of Existing Waste Water Management Practices

Rapid, uncontrolled population increase and a lack of proper waste management system greatly contribute to environmental degradation in Emali town. 65.2% of households in the town lack access to a onsite sewerage system, which is a major cause of the town's declining water quality since most of the wastewater is released directly in to the environment, through open drains (Kenya National Bureau of Statistics, 2019). According to a report by the United Nations (2023), around 80% of the urban wastewater is channeled to the environment untreated. Globally, untreated wastewater affects nearly 30 million hectares of agricultural land exposing approximately 885 million consumers to harmful biological and chemical contaminants (Kilingo et al., 2021). Wastewater in slums causes severe public health crises by introducing pathogens into living environments, directly causing high rates of waterborne diseases like cholera, typhoid, and diarrhea. Due to poor infrastructure and open sewage, residents suffer from chronic gastrointestinal infections, malnutrition, and parasitic worms (Roy et al., 2025).

4.3 Knowledge of Existing Policy and Regulating Frameworks and institutions on Waste Water Management

The study found out that majority of the respondents are not aware of the existing legal and regulatory frameworks governing waste water management both at county and national level. The respondents were also not aware of the institutions responsible for regulatory and standardization of wastewater management. Reviewing pertinent policies and legal frameworks in Kenya reveals that while most of them have public participation components, some policies have not taken an integrated approach to the management of the various environmental sectors, particularly in sanitation. This agrees with report by Benard, et al. (2024) on several policy papers, including Sessional Paper No. 3 of 2004, National Housing Policy, Sessional Paper No. 3 of 2009, National Land Policy, Kenya Health Policy 2012, Environment Policy of 2013, Environment Sanitation and Health strategy (2016- 2030), and National Urban Development Policy of 2016.

The findings of the present study confirm that improper management of waste water compromise local water sources such as wells and rivers which indicate a significant failure in enforcement and compliance. This means that proper enforcement and regulation of wastewater management practices is important. The findings of study also highlights that proper wastewater management is important not only for environmental protection but also enhancement of public health. Implementation of decentralized waste water management system would enhance water management in low cost hosing systems therefore offering cost-effective solution to environmental pollution.

4.4 Recommendations

In order to improve wastewater management in Emali Town, it is recommended that the Makueni County government should develop wastewater collection and treatment facilities with adequate capacity to connect all the households in Emali Town. In addition, the county government should come up with strategies to sensitize the local population on proper wastewater management and the existing policies and regulations for effective enforcement. The study recommends that further studies be done to establish the challenges that hinder implementation of waste water management in Makueni County. Further studies should also be done to establish the incentives and tradeoff between urbanization and environmental sustainability and water quality.

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