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Evaluation of Sanitation Technologies Across Sanitation Service Chain in Kericho Town, Kenya

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Abstract:- In 2020, over half of the world's population resided in cities, with projections indicating that by 2050, this figure will rise to 70%. Providing adequate sanitation services in urban and peri-urban areas presents significant challenges due to the dense concentration of people, particularly in low- and middle-income countries. Poor sanitation practices in these areas can lead to the spread of diseases with high morbidity and mortality rates. The focus of the study was on Kericho town, Kenya, facing a notable sanitation challenge due to dilapidated sewer system and inadequate sanitation facilities . The aim of this study was to evaluate the safety of sanitation technologies used in Kericho Town. Descriptive study design was adopted. Data collection methods included surveys, interviews, and observations, with a sample size of 409 households. The findings revealed that 66.5% of the population relies on pit latrines with slabs, 13.69% use pour/manual flush systems, 11.49% have ventilated improved pit latrines, 8.07% employ automatic cistern flush, and a minimal 0.24% practice open defecation. 25% of population discharged waste directly into the sewerage system whereby 5% were considered safely managed. Additionally, 4% of waste from user interfaces was discharged directly into open ground or open drains. 2% of population used septic tanks connected to soak pits, whereas 6% of population used septic tanks connected to open ground. Sludge from septic tanks, comprising 20%, was delivered to the WWTP by exhausters for further treatment, of which only 20% underwent treatment, with the remainder released untreated into the environment. 49% of the population used lined pits, while 14% used unlined pits. Approximately 20% of faecal sludge from the pits was exhausted, with only 20% of it considered safely treated, and the remainder released into the environment. Notably, open defecation accounted for less than 1% based on the survey findings. Consequently, the current trend in faecal sludge management in Kericho Town posed potential health hazards to the community unless measures such as rehabilitating the existing wastewater treatment plant are implemented.

Keywords:- *Safely Managed, Sanitation Technologies, Urbanization, Faecal Sludge.*

I. INTRODUCTION

Access to adequate sanitation facilities is essential for public health and environmental sustainability, particularly as urbanization accelerated globally. By 2050 it's estimated that 70% of the world's population will be living in cities with majority in urban and peri-urban areas (WB, 2020). With the majority of the population living in urban and peri-urban, there is pronounced challenges in providing adequate sanitation services due to the high concentration of people (Pickford, 2016).

These challenges are particularly significant in low- and middle-income countries (LMICs), where poor sanitation practices can lead to the spread of diseases that have significant morbidity and mortality rates (WHO, 2015). In developing countries, sanitation improvement is usually neglected leading to loss of lives due to water contamination (Okurut *et al.*, 2015). With the Sustainable Development Goal (SDG) 6 emphasizing the provision of adequate and safe sanitation and hygiene for everyone, particularly focusing on the needs of women, girls, and individuals in vulnerable circumstances (UN, 2015), addressing the issue of inadequate sanitation becomes increasingly challenging. Research findings indicate that in urban areas of developing countries, a range of onsite and offsite sanitation technologies and services prevail, originating from various sources such as residents, housing investors, and governmental or mandated utility providers (Evans *et al.*, 2006). However, international targets require more advanced technologies capable of ensuring safely managed sanitation throughout the entire process, from the toilet to the point of disposal or end-use (WHO/UNICEF, 2017). Consequently, discussions surrounding various sanitation approaches, such as citywide inclusive sanitation (CWIS) (Gambrill *et al.*, 2020; Lüthi *et al.*, 2020), remain prominent in the contemporary sanitation sector.

Effluent discharge, the release of treated or untreated wastewater into the environment, poses significant challenges to ecosystem health and human well-being (Muruganandam *et al.*, 2023). To mitigate the adverse effects of effluent discharge, regulatory standards have been developed globally to establish acceptable levels of pollutants in discharged wastewater. The establishment of regulatory frameworks is a crucial step in managing effluent discharge.

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International organizations such as the World Health Organization (WHO) and the Environmental Protection Agency (EPA) have played pivotal roles in setting global and national standards respectively. The WHO Guidelines for Safe Recreational Water Environments provide comprehensive recommendations for managing effluent discharge to protect public health (WHO, 2019).

In Kenya, it is forbidden for individuals or entities to release wastewater from sewage treatment facilities, industrial processes, or other discharge points into the environment without holding a valid effluent discharge license issued by the National Environment Management Authority (NEMA). NEMA has established water quality standards outlined in the Environmental Management and Coordination (Water Quality) Regulations of 2006 (NEMA, 2006). The third schedule specifically outlines the standards for effluent discharge into the environment including limits for parameters such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS) among others.

However, challenges arise in the effective enforcement of these regulations, as observed in the case of rivers such as Nairobi River, where compliance with these standards has not been consistent. Despite discussions in 2019 about prosecuting polluters of Nairobi River (NEMA, 2019), the water quality in the river has not shown significant improvement (Africanews, 2023). This raises concerns about the practical implementation and enforcement of regulatory measures, highlighting the need for more robust mechanisms to ensure compliance and address ongoing environmental degradation.

Kericho town faces a significant sanitation challenge due to its old dilapidated sewer system with low coverage and the overall management of faecal sludge along the sanitation service chain (CGoK, 2017). To address the challenges in managing faecal matter this study examined the gaps in faecal sludge management throughout the entire sanitation service chain process, from containment to disposal or reuse.

II. METHODOLOGY

➢ *Study Area*

The study was conducted in Kericho Town under the jurisdiction of Kericho Water and Sanitation Company (KEWASCO). Administratively, Kericho Town has 17 sub-locations (Fig) with a total population estimated at above 160,000 with a total of over 40,000 households (KNBS, 2019). Kericho town lies on latitude…xxx and longitude ..xxx

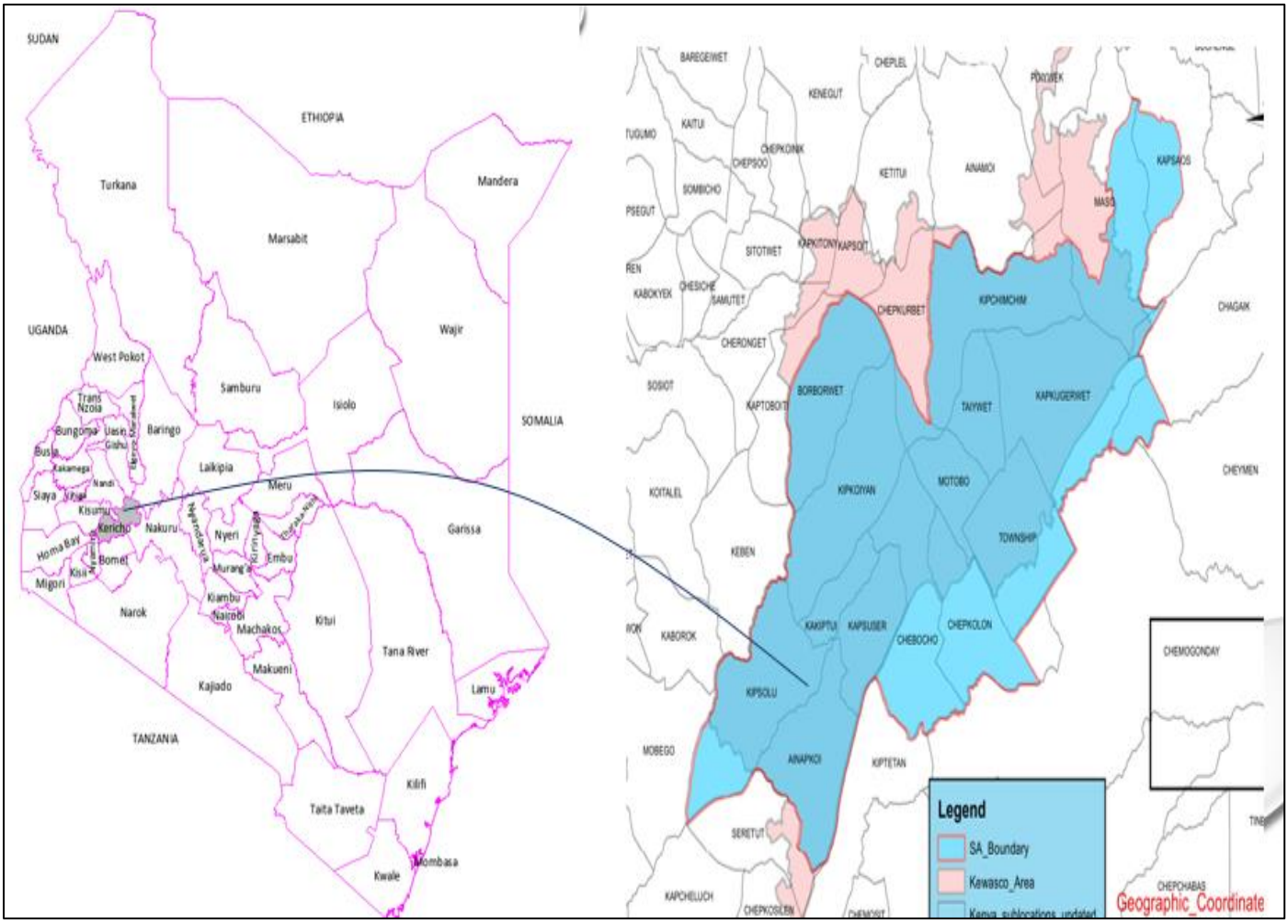

Fig 1 Map of Kericho Town Town (KEWASCO, 2022). Adapted (World Agroforestry Centre, 2018)

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➢ *Study Design*

Descriptive survey research design was adopted, quantitative and qualitative methods to collect information on sanitation along the service chain were employed in addition to convergent mixed methods design where both qualitative and quantitative data was gathered simultaneously.

- *Sampling Procedure*

Purposive Sampling technique was used to select the key informant interviewers (KII). The KII was conducted on technical manager of KEWASCO coded as KII-001, Inspector of WWTP coded as KII-002 as well as Inspector of decentralised treatment facility (DTF) in Kapsoit coded as KII-003 and one representative of vacuum truck operators (VTOs) coded as KII-004. Cluster sampling was employed to gather households' data in the 17 sub-locations. Six trained enumerators carried out surveys at 409 households (households varying according to the population proportion) from 17 sub-locations in Kericho Town. Household units were selected using simple random sampling within the cluster until the n^{th} households was reached in every cluster.

- *The sample size was estimated using the expression given below (Israel, 1992):*

$$n = \frac{N}{[1 + N(e^2)]}$$

Where,

n = the required sample size;

N = Total number of household units;

e = sampling error;

The number of households obtained from the Kenya National Bureau of Statistics (KNBS) (2019) for Kericho town is 38,896 and the projection for 2023 was 42,346

Therefore, at ± 5% precision, sample size of households was n = 409

Field based work involved household surveys, key informant interviews with treatment inspectors of KEWASCO and Exhauster operators, as well as carrying out observations and transect walks.

Before and after the fieldwork, a review of the literature was conducted through reading through the published works and unpublished works which resulted from key informant interviews to learn more about sanitation in Kenya and Kericho. The review aided in perspective-taking and to help to triangulate data and close gaps. Some of the unpublished data encountered during the study was a study done by World Bank as well as laboratory test reports for waste water treatment plant among others as detailed in

Table.

Table 1 Unpublished Reports

	Description of Unpublished Data	Source of Information	Organisation
1.	An Analysis of Sanitation in the Lake Victoria Basin in Kenya (Factsheets on nineteen Settlements- April 2023) Prepared by Lincoln Odeya of World Bank Group	Chief Executive Committee Member for Water, Energy and Environment, Natural Resources & Forests	Kericho County
2.	Laboratory test reports for the period April 2022 to Aprill 2023	Technical Manager	KEWASCO
3.	Sewer Leakage and repair Reports	Technical Manager	KEWASCO
4.	Map of KEWASCo Service Area	Technical Manager	KEWASCO
5.	Job Cards for Sludge delivery to WWTP by exhausters from January 2023 to October 2023	Technical Manager	KEWASCO

➢ *Data Analysis*

This study employed a combination of qualitative and quantitative data analysis methods. Quantitative data analysis involved processing responses gathered from questionnaires distributed to households, whereas qualitative data analysis focused on insights derived from KII , observations and published documents.

Quantitative data analysis utilized the Statistical Package for Social Sciences (SPSS) software version 26, while thematic analysis of the data from the interviews and observations were conducted, with topics such as the types of sanitation systems in use, the number of sanitation systems, and the frequency of emptying the on-site containments, capacity and efficiency of WWTP.

➢ *Ethical Considerations*

Ethical considerations were addressed throughout the fieldwork process. Before initiating any research activities in Kericho Town, a research permit from National Commission for Science and Technology (NACOSTI) and a permit through the county secretary were obtained. Prior to conducting interviews, permission was sought from participants, ensuring their voluntary participation in the data collection process and willingness to respond to questions. It was clearly communicated that the research was conducted solely for research purposes, with no financial compensation provided or expected.

To uphold confidentiality, names of research assistants were only used to protect the anonymity of interviewees. Careful scheduling of appointments within office hours and

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at locations convenient to participants' workplaces was undertaken to minimize any inconvenience. Before the commencement of interviews, participants were briefed on the research topic and objectives. Permission to record the interviews was sought, and for those who agreed, photographs of their facilities were taken.

To secure the collected data, including photos, recordings, and notes, a systematic transfer was carried out from the phone to a personal computer with encryption. These ethical measures were implemented to ensure the integrity of the research process, prioritize participant confidentiality, and adhere to ethical standards

III. RESULTS

Results for the safety of excreta from onsite technologies, whether lined or unlined, excreta disposal by households with children under 3 years of age in Kericho Town and greywater management (see Table 2 and 3)

- *Containment*

The results of containment facilities were operational as shown in

Table.

Table 2 Condition of Toilet Facilities in Kericho Town

Variables	Percent (%)
Toilet category	
On plot (shared/private)	94.4
Off plot (communal/public)	4.6
Sharing toilet	
Yes	32.3
No	67.7
Toilet functionality	
Yes	96.3
No	3.7
Why is not functional?	
Collapsed(fully/partial)	47
Full waiting for emptying	53
Total	**100**
Cleanable slab	
Yes	88.3
No	10.5
Superstructure of the facility	
Brick or other permanent material	68.5
Wood/bamboo/cloth or other semi-permanent material	29.3
No superstructure	0.7
Presence of roof	
Yes	96.1
No	3.2
Privacy	
Yes	94.4
No	4.6
Slab contamination	
Faeces or faeces and urine	9.8
Urine only	17.6
No faeces and no urine	70.4
Toilet location	
Outside housing unit	65.0
Inside housing unit	35.0
Can any member of household use public toilet?	
Yes	17.6
No	80.7
Do you pay to use toilet?	
No	86.8
Yes	11.7
(Yes, per use (public m)	2.4
Yes, monthly payment)	9.3

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The findings for containment methods in Kericho Town, revealed that 49% of pit latrines were lined, while 14% were unlined. In the case of septic tanks, 3% were partially lined, 3% were fully lined with overflows to drain, and 2% were fully lined with a soakaway system. 24.45% were connected to a piped sewer system, while the majority 49.945% ,discharged waste into fully lined pits. Additionally, 14.18% released waste into pits with unlined bottoms or sides, 2.93% discharged into partially lined septic tanks, 3.18% released into fully lined septic tanks with overflow to drains or open ground, and 2.44% were unaware of the destination of their discharge. Furthermore, 1.96% discharged into fully lined septic tanks with soakaways, 0.098% released directly into open ground, and 0.73% discharged directly into open drains or ditches.

Additionally, greywater management in Kericho Town was examined and findings were presented in

Table. Majority of respondent's discharged kitchen waste directly to open ground 27.1% , pipe sewer system 24.9% , others recorded fully lined pit latrine, unlined pit latrine, open drain, fully lined septic tank with overflow to drain/open ground/other, partially-lined septic tank, at (18.1%, 9.8%, 6.8%, 3.2%, 2.9%) respectively and 3.7% of respondents didn't know as illustrated in

Table.

Table 3 Greywater Discharge.

Greywater Discharge	Frequency	Percent
Piped sewer system	102	24.9
Directly to the lake or river	2	0.5
Fully-lined pit latrine	74	18.1
Pit with unlined bottom or sides	40	9.8
Partially-lined septic tank	12	2.9
Fully lined septic tank with overflow to Drain/open ground/other	13	3.2
Don't know	15	3.7
Fully-lined_ septic tank with soak away	12	2.9
Directly to open ground	111	27.1
Directly to an open drain/ditch	28	6.8
Total	**409**	**100.0**

➢ *Emptying*

The Study examined emptying practices of faecal sludge in Kericho Town. As illustrated in

Table, majority of the respondents i.e., 56.7%, had no facilities which ever reached capacity, 14.2% had experienced pit or septic tank filling up and 29.1% of respondents didn't knew status of pit latrine or septic tank they were using.

Table 4 Emptying practices in Kericho Town

Variable	Frequency (n=409)	Percent (%)
Pit or Septic ever Reach Capacity		
Yes	58	14.2
No	232	56.7
Don't know	119	29.1
Total	409	100
Toilet Overflow		
Yes	69	16.9
No	296	72.1
Don't now	46	11.0
Total	409	100

The study investigated pit filling frequency within past 5 years, out of which 58 respondents, 69% registered once, 1% twice, 0.2% thrice and 22.4% had not experience pit filling up within past 5 years. It was observed that average number of years a sanitation facility tool to reach capacity in Kericho Town was 8 years with majority 32.8% being 10 years.

Table. The main reason for toilet overflow in Kericho Town was mainly due unavailability of emptiers as reported

The study found that out 409 of respondents 16.9%, had observed toilet overflow as shown by 34.78% respondents, blockages of pipe/ sewer system 31.88% , overcapacity toilet 13.04% , cost related to emptying 10.14% among others as shown in pie chart Fig.

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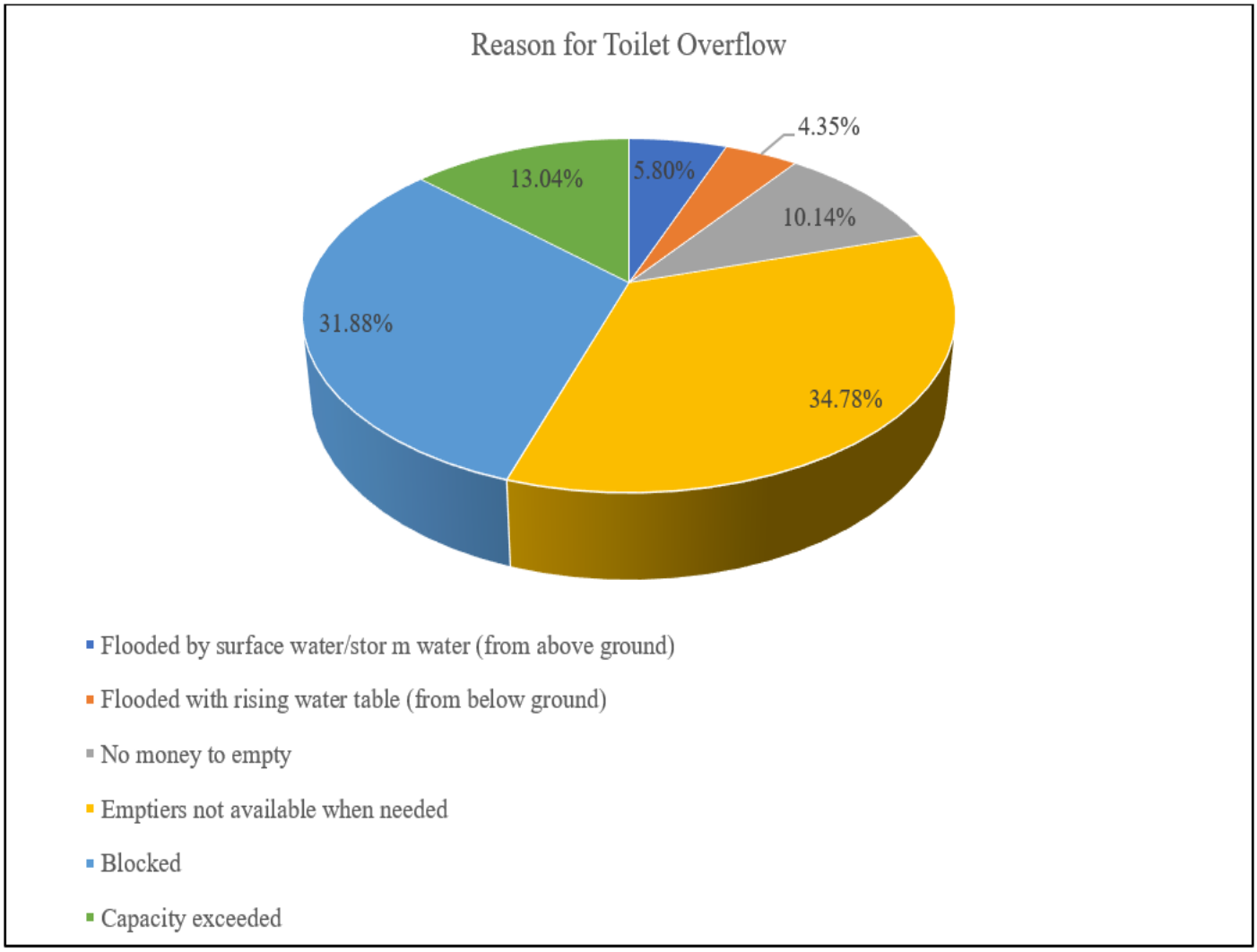

Fig 2 Reason for Toilet Overflow

The study findings showed that 65.5% of household that had experienced pit filling up, they had emptied and reused it, 22.4% had covered and used alternative pit, and only 12.1% had abandoned pit latrine unsealed.

The household survey showed emptying in Kericho Town was mainly conducted by formal utility as per 47.4% of the respondents. Others included; formal providers (company/NGOs), informal providers and member of household/neighbour at 34.2%, 7.9% and 10.5 % respectively, as shown in Table. 68.4% of respondents revealed that emptying was conducted mechanically using tanker as compared to 31.6% using small machine as shown in Table.

The faecal sludge emptied in Kericho Town was reported to have been emptied as follows: 23.7% into pits in the compound and then covered while 76.1% into a tanker, to be transported to the treatment sites as shown in Table .

According to an interview with technical operators of KEWASCO, '*Kericho Town, has six exhausters tasked with the removal of faecal sludge, primarily from septic tanks and occasionally from pit latrines. Among these, only two are currently operational, specifically two units affiliated with Finlays and one associated with AIC Litein Hospital*"

Table 5 Who did the Last Emptying

Who did the last Emptying	Frequency	Percent
Formal provider (utility)	18	47.4
Formal provider (company / NGO)	13	34.2
Informal provider (individual)	3	7.9
Member of household Neighbour	4	10.5
Total	**38**	**100.0**

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Table 6 How was it Emptied

How was it Emptied	Frequency	Percent
Mechanically, using tanker truck	26	68.4
Mechanically, using small machine	12	31.6
Total	**38**	**100.0**

Table 7 Where was it Emptied to

Where was it Emptied to	Frequency	Percent
1. Directly into machine/ tanker	29	23.7
2. Into a pit on the compound that is then covered	9	76.1
Total	**38**	**100.0**

Findings showed that 81.6% of respondents who had pit filling up had paid for emptying services. The average cost of emptying service in Kericho Town was KSh. 3532.26, with maximum being KSh. 7000 and lowest at KSh. 500.

Table 8 Payment for Emptying

Did you pay for the pit to be emptied	Frequency	Percent
1. Yes	31	81.6
2. No	5	13.2
3. Don't know	2	5.3
Total	**38**	**100.0**

The cost was mainly determined using a flat rate as was reported by 74.2% of respondents who paid, while 25.8% was based on volume excavated as shown on

Table. It was noted that payment by majority of respondents, 88.38% was in full amount as compared to 16.12% who paid in instalments. When respondents were asked about fairness of the price majority, 51.61% respondent considered the cost being fair whereas 29.03% recorded to be expensive.

Table 9 Criteria for Payment for Emptying

How was the payment calculated	Frequency	Percent
Flat rate	23	74.2
Cost per volume removed	8	25.8
Total	**31**	**100.0**

The study investigated level of satisfaction with service provider in terms of price, overall service quality, safety and ease of obtaining service in Kericho Town, the findings of which are depicted in
Table.

Table 10 Level of Satisfaction with Service Provider

Level of satisfaction with service provider	Price		Overall Service Quality		Obtaining Service	
	N= 38	Percent (100%)	N= 38	Percent (100%)	N= 38	Percent (100%)
Very Satisfied,	17	44.7	13	34.2	5	13.2
Satisfied,	16	42.1	17	44.7	15	39.5
Dissatisfied	5	13.2	7	18.4	15	39.5
Very Dissatisfied	0	0	1	2.6	3	7.8

As illustrated in
Table majority of respondents who had emptied filled pits/septic tank were satisfied i.e., 86.8% with price of the services, 78.9% with overall service quality and 52.7% with obtaining emptying service.

The researcher observed that, the exhausters at the point of exhaustion to disposal demonstrated a safe emptying process, with no spillage. Additionally, operators adhered to proper personal protective equipment (PPE) usage, ensuring a safe working environment during faecal sludge emptying operations. This suggested a satisfactory level of efficiency and safety in the current faecal sludge management practices in Kericho Town in terms of emptying

The study investigated the challenges faced by the emptiers in street, compound and toilet of Kericho Town while emptying sludge in pit/septic as shown in

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Table (Household survey).

Table 11 Challenges faced by emptiers in Kericho Town

Variable	Frequency(N=27)	Percent (100%)
Street		
Lack of space	13	48.1
Poor Road conditions	6	22.2
Night-time working	1	3.7
Entrance gate too narrow	7	25.9
Total	**27**	**100**
Compound		
Entrance/gate too narrow	13	48.1
Lack of space for equipment once inside	6	22.2
Poor surface conditions	8	29.6
Night-time working	0	0
Total	**27**	**100**
Toilet		
Distance too far for equipment to reach the toilet	10	38.5
Access point too small to get equipment into the pit	9	34.6
Had to break/damage the slab to gain access	3	11.5
Had to remove/ damaged latrine pans or seat	2	7.7
Collapsed pit	2	7.7
Total	**27**	**100**

Similar findings were reported by emptiers in Kericho Town (KII-04),*"At present, we are facing a significant challenge due to unexpected vehicle breakdowns. Unfortunately, four of our vehicles are currently out of commission, and this has had a considerable impact on our operational capacity. As a result, we're now compelled to conduct approximately 8 trips in a single day, which is quite demanding given the circumstances. In addition, it's important to note, though, that our machines have limitations. We can only pump waste from depths of up to 20 feet, so if a pit or tank is deeper than that we only exhaust 20 feet"*

- *Conveyance/Transport*

In Kericho Town, the transportation of excreta involves conveying wastewater to treatment plants through sewer systems or by emptying from containment units, and then transporting it to these facilities by exhausters. According to Technical service manager of KEWASCO, "*The existing sewer network in the Central Business District (CBD) of Kericho spans approximately 12 kilometres and primarily functions as a gravity system, with sewer lines ranging from OD 315mm to OD 160mm in diameter. The Sewerage System serve approximately 12,000 people through 2,262 piped sewer connections. The remainder of the Town's population relies on on-site wastewater disposal methods, primarily Pit Latrines and Septic Tanks. The Kericho water and sanitation company has vacuum trucks to transport the waste from the septic tanks to the waste stabilization ponds*"

The study examined the proportion of wastewater and sludge safely transported to treatment plants, based on job cards obtained at KEWASCO from January to October 2023. On the sewer job card data, the proportion of wastewater in sewer system, which was delivered to centralised treatment plants was considered and coming up with the proportion based on the sewer data provided on leakages. The work descriptions which were handled during the months on the sewer were, unblocking, increase of pipe diameter, provision of manhole covers and old lines which need replacements. Since the sewer delivered approximately 450 cubic metres per day the average blockage period observed from KEWASCO's data was 55.57 minutes (approx. 1 hour) from the data. This therefore meant 55.57 minutes was the time the sewer takes to spill over, assuming a flow rate of 18.75 cubic per hour. Hence the efficiency of sewer to transport was 95.8%. The proportion of septic tanks from which faecal sludge was emptied was reported by KEWASCO during KII as 100%, Proportion of faecal sludge emptied also 100% and, which is delivered to treatment plants was 100% as there were no leakages along the way during transportation of Exhausters

Wastewater was conveyed to treatment plants either through sewer systems or by being emptied from containment units, and it was then transported to these facilities by exhausters. In Kericho Town, there were 9 exhausters tasked with the removal of faecal sludge , primarily from septic tanks and occasionally from pit latrines. Among these, only 2 out of 6 belonging to KEWASCO were operational, 2 trucks affiliated with Finlays Company Limited and 1 belonged to AIC Litein Hospital. It's noteworthy that within Kericho Town, there were no manual pit emptiers. This was due to

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licensing restrictions by KEWASCO. There was a sewer system within the Central Business District (CBD) which transported sewer to Waste Water Treatment Plant (WWTP).

➢ *Treatment and Disposal of Sludge in Kericho Town*

For the households with septic tanks, the emptied sludge by exhausters was treated in Kericho WWTP and DTF at Kapsoit. According DTF Inspector *"Primary treatment was done in septic tank, which are never emptied. Off-site treatment of FS is infrequent in rural areas. The limited capacity and resources of many low-income countries make it challenging to establish and sustain adequate faecal sludge treatment facilities outside major urban settlements."*

In addition, Kericho Town has Waste Water Treatment Plant (WWTP) made up of 2 trickling filters (1 functioning) and 2 secondary clarifiers and The Decentralised Treatment Facility (DTF) at Kapsoit. According to Technical operators of KEWASCO, "*Waste Water Treatment Plant manages a daily influx of approximately 450 cubic meters of wastewater. Additionally, the facility receives an average of 66 cubic meters of faecal sludge on a daily basis from septic tanks and pit latrines within the town and from hospitals and neighbouring tea estates. The Decentralised Treatment Facility (DTF) at Kapsoit has a daily treatment capacity of 50 cubic meters, and based on the deliveries, it has not surpassed this capacity on a daily basis*."

Further to KEWASCO testing the samples daily, samples were also taken to the government laboratory in Kisumu City on a monthly basis. The laboratory results by the government chemist were also shared by Technical Manager from April 2022 to April 2023 as summarized in the

Table.

Table 12 Standards for Effluent Discharge into the Environment compared with Kericho WWTP effluents

Parameter	Tolerance Limit	Apr-23	Mar-23	Feb-23	Jan-23	Oct-22	Sep-22	Aug-22	Jul-22	Jun-22	May-22	Apr-22
pH	6.5-8.5	7.55	7.36	7.41	7.56	7.38	7.19	7.28	7.43	7.38	7.41	7.33
Colour in Hazen Units (H.U)	<15	0.124	1.77	1.06	2.17	1.02	1.23	1.84	2.33	1.28	5.22	4.02
Biochemical Oxygen Demand (BOD 5days at 20°C) (mg/l)	<30	337	118	133	112	108	149	103	95	81	77	69
Chemical Oxygen Demand (CD (mg/l)	<50	514	339	231	199	176	222	248	202	161	118	102
Total Suspended Solids, (mg/l)	<30	0.72	0.72	0.72	0.88	1.11	1.04	0.33	0.23	0.10	0.11	0.03
Total Dissolved solids (mg/l)	<1200	165	235	217	173	211	201	170	205	184	202	164
Total Nitrogen (ppm)	<2	2.31	1.27	0.68	0.717	1.08	1.14	1.07	1.32	0.71	1.074	1.224
Total Phosphorus (mg/l)	<2	0.61	0.66	0.75	1.02	0.12	0.08	0.078	0.12	0.02	0.01	0.02
Oils, Greases and Fats	ND	0	0	0	0	0	0	0	0	0	0	0
Total coliforms (counts /100 ml)	<30	187	143	189	210	193	207	177	113	88	115	103
E.coli (Counts / 100 ml)	ND	11	17	14	17	47	55	43	16	11	9	12

Key

	Adhering to the standards
	Not as per the standards
ND	Not Detectable
"<"	the result is below the limit of detection.

IV. DISCUSSION

➢ *Sanitation Technologies in Kericho Town*

The majority of people in Kericho Town (66.5%) utilized pit latrines with slabs, while smaller percentages relied on pour/manual flush systems (13.69%), ventilated improved pit latrines (11.49%), and automatic cistern flush (8.07%). A minimal percentage (0.24%) resorted to no facilities. This could be attributed to various factors such affordability, ease of construction, and cultural norms. Pit latrines are often the most accessible and cost-effective sanitation option for many households, particularly in areas where access to piped water and sewage systems may be limited. These findings align with previous research conducted by Nakagair *et al*. (2015), Ssemugabo *et al*. (2020) and Gitonga *et al*. (2021) who also observed similar trends in sanitation preferences and practices.

The majority of respondents (96.3%) reported functional sanitation facilities of which 80.7% were situated outside housing units. Most facilities (88.3%) had slabs that were easy to clean. The majority of facilities (68.5%) were constructed using brick or other permanent materials, probably due to availability of low-cost materials. The research also indicated that nearly all facilities (96.1%) were equipped with roofs, and 94.4% had doors providing privacy, which was important for maintaining hygiene and safety. Consistent findings were reported by Ssemugabo *et al*.(2020) in Ethiopia, they found that more than 90% of facilities had doors and roofs, and majority of the sanitary facilities were functional but not improved and lacked hand-washing facilities, and households led by students and those who owned their houses were more likely to own improved sanitation facilities.

The distinction between the majority of sub-locations in Kericho Town relying on pit latrines with slabs(66.5%), and the township having flushing toilets, underscores urban-rural disparities in sanitation infrastructure. The mention of flushing toilets being more common in the township due to

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the availability of the sewerage system indicates the influence of urban infrastructure on sanitation choices. Consistent findings were reported by Chaudhuri *et al.* (2017) in a study conducted in India on WASH facilities disparities between urban and rural areas. They mentioned that overall, spatial heterogeneity in rural-urban inequality presents a daunting challenge for authorities, urging for spatially optimized policy reforms instead of enacting nationwide uniform policy measures.

- *Safety of Excreta along the Sanitation Service Chain*

This study investigated the containment methods in Kericho Town. The findings showed that 49% of pit latrines were lined, whereas 14% were unlined. In the case of septic tanks, 3% were partially lined, 3% were fully lined with overflows to drain, and 2% were fully lined with a soakaway system.

Septic tanks are recommended by the Kenya Environmental Sanitation and Hygiene Policy (KESHP) as an improved sanitation facility, but they are less preferred due to a lack of awareness about proper faecal containment and cost. Kimuli *et al.* (2016) and Rotowa *et al.* (2016) reported similar findings in Naivasha, Kenya and Akure, Nigeria respectively. They found that majority of the containment were unlined pit latrines and leaking septic tanks. Also, a World Bank analysis on Lake Victoria Basin Lake-wide Inclusive Sanitation (LWIS) conducted in April 2023, covering 19 towns including Kericho, reveals that 8.8% of the town's sanitation relies on septic tanks, 13.5% on ventilated improved pit latrines (VIPs), 62% on unlined pits, 9.1% on lined pits, and 1.3% of the population has no sanitation facilities (Odeya, 2023).

Faecal sludge emptying in study area involves both mechanical and manual method, but mechanical method predominates as was reported by 68.4% of respondents. This is explained by the availability of emptying services at relatively affordable cost, an estimate of KSh. 3532.26. Lack of space, poor road conditions, and inaccessibility of toilets was reported by respondents as challenges associated with emptying, thereby promoting manual emptying practices. As supported by Gitonga *et al*.(2021), recorded that in Kenya availability of space and funds for constructing new toilet determine whether a full pit latrine will be emptied or abandoned.

It is crucial to highlight that key water quality parameters such as BOD, COD, total coliforms and *E. Coli* had consistently failed to meet the stipulated standards as per NEMA (2006) which builds to study done by UN on over 80% of sewage is discharged without treatment. This can lead to outbreak of diseases as it occurred in Porto Pim Beach (Brandão *et al.*, 2020).

V. CONCLUSION

A quarter of the population discharged waste into sewer systems, which ultimately is not treated safely. Approximately 8% of the population that uses septic tanks for containment finds their sludge ending up in the same wastewater treatment plant. Despite efforts to contain open defecation, challenges persist due to dilapidated infrastructure and an inefficient wastewater treatment plant.

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The authors declare no conflicts of interest associated with this publication.

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