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# Parametric analysis of Sanitation Technologies for Fecal Sludge Management: a case of Eldoret Municipality, Uasin Gishu County, Kenya

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ABSTRACT

Sustainable sanitation is majorly focused on provision of safe, equitable and accessible sanitation for all irrespective of their gender, age and socio-economic status. This study aimed at the key parametric analysis of main sanitation technologies used and outlining urban fecal sludge management using a shit flow diagram. The Excreta flow diagram generated will be used as an advocacy tool for informing key sanitation stakeholders in the town on key parameters for sustainable fecal sludge management along the sanitation service chain. The key parameters focused on entailed the user interface, containment, conveyance, treatment and final disposal/reuse. Furthermore, the regulatory compliance monitoring, health and safety of sanitation provision were considered in the study. The study applied a mixed approach research design whereby qualitative and quantitative techniques were incorporated. Data collection process involved key informant interviews amongst sanitation workers and questionnaire guided interviews with the residents. Results unveiled that 64% of fecal sludge generated from Eldoret municipality was safely managed with 36% unsafely managed. Within the town, current coverage of existing sewer network (offsite sanitation) stands at 40% while 60 % actually rely on onsite sanitation. Study results further indicated a population of about 3% still practice open defecation. Comparing with high income areas, this study noted considerable coverage of sewer network within areas where low income communities occupied. Additionally, sanitation facilities were less accessible in these low income areas including Langas, Munyaka, Huruma and Mwanzo. There is dire concern on gender exclusivity of available sanitation facilities because of poor hygiene making it unsafe for use by women and children within the town. This study recommends increasing the coverage of sewer network in the town owing to higher water table in most areas around the town and its subsequent contribution to ground water contamination, and thus public health complication. In addition, this study recommends that regulatory authorities ought to oversee policies regarding safe fecal sludge disposal by improving access in order to reduce open defecation.

## Introduction

This paper describes the parametric analysis of sanitation technologies for fecal sludge management in Eldoret town. The key parameters on focus in the study were the sanitation technologies being used from the user interface, containment,

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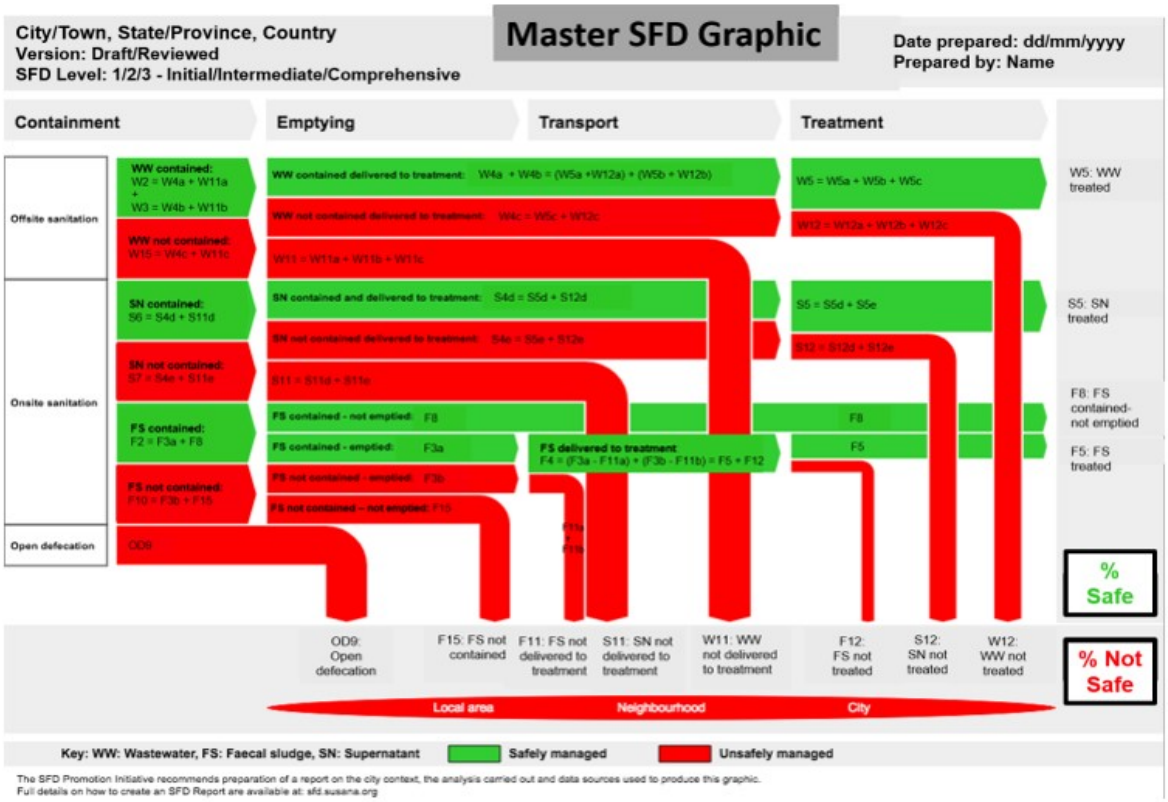


**Figure 1:** *Master SFD Graphic illustration. Source; https://sfd.susana.org/knowledge/the-sfd-*

emptying, Conveyance/transport, treatment and final disposal/end use. The research was based on the adoption of the Shit Flow Diagram (SFD) approach to identify the priority areas to be acted upon in ensuring city wide inclusive sanitation for the urban sanitation (Rohilla, 2020). The SFD guides on the fate of fecal sludge by determining the proportion of fecal sludge managed to unmanaged fecal sludge along the sanitation service chain technologies. The model derived from fecal sludge analysis will provide an insight on the state of sanitation service delivery through assessment. This paper employs a two-step approach by the use of diagnostic tools (SFD) to identify the sanitation problems and the decision support tools (sustainable sanitation strategies) as solution to the main aspects of sanitation service delivery contributing to improper disposal of fecal sludge (Blackett & Hawkins, 2016).

Urban sanitation is a challenge to most communities residing in cities and towns across the globe. This was the basis of an initiative by Bill and Melinda Gates Foundation's city wide inclusive sanitation initiative for eight cities across the sub-Saharan Africa and South-east Asia(Athena et al., 2021). The approach is centered on equitable sanitation service provision through a Monitoring, Learning and Evidence (MLE) program for the women, young girls and low income communities in the cities. The initiative was very key in this research given that critical information on the fec al sludge management technologies had to be collected for analysis to determine the main areas for focus in improving sanitation service in Eldoret municipality. The urban population growth usually outpaces the provision of sanitation services. This depicts the need to avoid replicating the sanitation interventions which were applied and are effective in the developed world to the developing and third world countries(Emory University et al., 2020). The government and other development agencies require a paradigm shift which would require the raising of awareness, building capacity and encouraging complementary interventions for managing fecal sludge in the urban areas (Nansubuga et al., 2016).

Water Sanitation Program (WSP) of the World Bank developed a new tool in 2012-2013 to assess the excreta flow through a city by its context and outcomes. The goal was to give a detailed revelation of management of excreta throughout sanitation service chain. Through the World Bank, WSP was able to conduct the studies in 12 cities (Eawag-Sandec, 2015). In 2014 Shit flow diagram (SFD) promotion initiative funded by Bill & Melinda Gates Foundation a group of institutions dealing with excreta management convened to prepare rolling out of the second phase of the SFD method and approach. Tools for the production of SFDs have been updated and improved through sharing and promotion with potential users (Susana, 2015). The sustainable sanitation solutions for the urban community lacking sanitation facilities should be devised to provide hygienic, affordable toilet systems which are alternative to classical conventional sewage systems which may not be applicable within the low income, congested informal settlements which are becoming common in most of the growing cities in the African continent (David, 2014). It is a challenge to solve sanitation problems in informal settlements because of widespread community problems such as poverty, unemployment and community support (Tlhabanelo, Malebo Philemon, 2011). The urban sanitation problems should be focused on proper waste removal system, proper social infrastructures and water supply to ensure a multidimensional problem solving approach(Andersson et al., 2016).

The prevailing sanitation provision problems in Eldoret municipality can be mitigated through parametric analysis of available sanitation technologies along the sanitation service chain through determination of main sanitation technologies used within the town to outline the urban fecal sludge management with a shit flow diagram. The study aimed at addressing main gaps in the citywide urban sanitation delivery. These gaps were targeted by ensuring inclusive sanitation delivery especially amongst the low income communities through focus on the onsite sanitation technologies. Promoting partnership among institutions is vital to foster the advancement of incentives, leveraging synergistic roles, and financing sanitation. The government will establish regulatory frameworks pertaining to fecal sludge management (FSM) that aim to promote responsible handling and appropriate disposal of fecal sludge throughout the entire sanitation service process. (Blackett et al., 2016). The figure below illustrates how an SFD is outlined with its main features.

## Methodology

The study involved a quantitative research design whereby a survey was conducted on the communities to ascertain the numeric description on their views and opinions on the fecal sludge management techniques and the sanitation technologies they use. A narrative method of qualitative research was used in understanding the sanitation service chain as explained by sanitation professionals and community members in cumulative efforts of managing fecal sludge generated in Eldoret town municipality. This was executed by conducting key informant interviews with the sanitation service providers to collect individual stories from members identified from a predetermined sample (Creswell & David, 2018). The key informants for this research included sanitation workers (Public health officers, environmental scientists & workers from ELDOWAS). Community leaders were also involved in the study, especially the nyumba kumi representatives, village heads and chiefs. Persons living within the municipality were randomly selected in their households and focus was given to household heads and property caretakers. Other key sanitation stakeholders such as the private investors in sanitation operating as vacuum truck owners, drivers and other pit emptiers were also included in the study.

Purposeful sampling was used to identify the key informants from people working in WASH related sectors of Uasin Gishu County Government and ELDOWAS. The key informants were engaged using a checklist to identify the coverage of sewer netwoks and the main sanitation technologies in

the municipality. A sample size of 400 was used in selection of random samples across ten wards in the municipality. The main sample was distributed across the ten wards (Huruma, Kamukunji/ Industrial area, Kapyemit, Kidiwa/Kapsuswa, Kapsoya, Kimumu/munyaka, Kipkenyo/Kipkarren, Langas, Pioneer/Elgon view and Race course) to provide for 40 samples from each of the wards in the municipality. The random samples were randomly selected from individuals who are residents in the wards especially the household heads and property caretakers. An open-ended questionnaire was used to conduct interviews with the residents on their sanitation technologies. Field observations and focused group discussions were also conducted with the residents across the municipality.

The data collected was analyzed using the Electron application SFD generator software to determine the management of the waste water and fecal sludge from the user interface, containment, emptying, transport and treatment of both the onsite and offsite sanitation systems. The resulting output from the SFD generator tool outline the SFD graphic indicating the safely managed fecal sludge and the unsafely managed. The data collected from the questionnaires was entered in Statistical Package for the Social Sciences (SPSS) (IBM SPSS Statistics 29) software for analysis.

## Results and Discussion

*Sanitation Technologies*

The research sought to find out the main sanitation technologies used. The data from the respondents showed that majority of the subjects were having access to toilets (50%). The remaining 47% were using pit latrines while those practicing open defecation were 3%. Eldoret Water and Sanitation Company (ELDOWAS) has greatly improved in increasing the sewer connection to most parts of the municipality and this has encouraged most households to prefer a toilet which is connected directly to the sewer line to avoid the costs of containment emptying treatment and final disposal even in the low income areas. There is a larger part of Racecourse, Annex and Kipkenyo not covered by the sewer lines connection but since they are high income areas, the property owners have opted to use toilets connected to a well lined septic tank which is emptied by vacuum trucks which dispose to the centralized sewer.

| User Interface | No. of Households | % |
|---|---|---|
| Pit latrine | 178 | 47.0% |
| Flush Toilet | 200 | 50.0% |
| Open defecation | 22 | 3.0% |
| **Total** | **400** | **100%** |

**Table 1:** *The main sanitation technologies used in Eldoret Municipality*

*Containment*

It was found out that the sewer line connection for Eldoret municipality is at 40% with a dense network concentrated in the areas of Langas, Huruma, Kapsoya, Kumukunji, Pioneer and Elgonview areas. The people using septic tanks were found to be 13.3%, fully lined tanks 4.5%, unlined pits, 22.3%, partially lined pits 12.8% and lined pits at 7.2%. Results showed that the water table in some areas such as Langas, Kapsoya and Kamukunji was very high hence predisposed to ground water contamination. Further, connection of sewer lines has been greatly improved in this

| Containment | No. of Households | % |
|---|---|---|
| Lined pit | 29 | 7.25% |
| Partially lined pit | 58 | 14.5% |
| Unlined pit | 82 | 20.5% |
| Septic Tank | 53 | 13.25% |
| Fully lined tank | 18 | 4.5% |
| Connected directly to sewer lines | 160 | 40.0% |
| **Totals** | **400** | **100%** |

**Table 2:** *Containment methods used in Eldoret municipality*

areas to prevent use of onsite containment technologies such as septic tanks and pits.

*Emptying*

Majority of the areas were seen connected to centralized sewer connection whilst the rest of the areas mainly rely on onsite methods of vacuum trucks, manual emptying by humans (8.8%), motorized emptying using generator pumps (11.8%), connecting their containment systems to open storm sewer drains (8.0%) or not emptying and covering with topsoil when full (12.5%).

| Emptying | No. of Households | % |
|---|---|---|
| Manual Emptying | 35 | 8.75% |
| Motorized emptying | 49 | 12.25% |
| Vacuum trucks | 74 | 18.5% |
| Connected to open storm sewer | 32 | 8.0% |
| Connected to centralized/conventional sewer | 160 | 40.0% |
| Not emptied/ covered with top soil when full | 50 | 12.5% |
| **Totals** | **400** | **100%** |

**Table 3:** *Emptying techniques employed*

*Transportation*

Most of the fecal sludge emptied were transported to the sewer treatment plants of Huruma and Kipkenyo. This was attributed to the fact that Huruma sewer treatment plant is centrally located in the municipality and therefore proximal to most of the urban settlements.

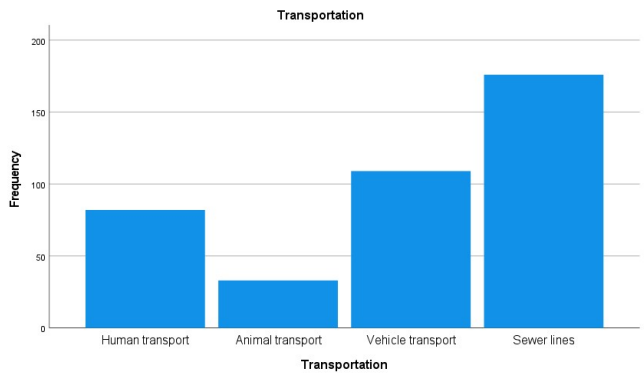


**Figure 2:** *Transportation of fecal sludge*

*Treatment*

Sewer treatment plants accounted for 71.3 % of the total treated fecal sludge. Treatment ponds which were acting as decentralized treatment plants under the private sector covered 8.5% while the composting which was common for the people using pit latrines were 20.3%. This depicted that most of the fecal sludge emptied and conveyed from their containments were delivered to sewer treatment plants.

| Treatment Method | No. of Households | % |
|---|---|---|
| Composting | 81 | 20.25% |
| Treatment ponds | 34 | 8.5% |
| Centralized sewers | 285 | 71.25% |
| **Totals** | **400** | **100%** |

**Table 4:** *Treatment methods employed*

*Final disposal/ End use*

The final disposal of the fecal sludge was mainly through channeling of treated sludge into the river from the sewer treatment plant (71.3 %). Other fecal sludge delivered to treatment plants finally ended up being used for farming and forestry especially at Kipkenyo Treatment plant. In summary the use of composted fecal sludge across the municipality was found to be 15.5 % for farming and 13.3% for forestry.

| Final Disposal | No. of Households | % |
|---|---|---|
| Channeled to open storm water drains/open ground/Rivers | 285 | 71.25% |
| Farming | 62 | 15.5% |
| Forestry | 53 | 13.25% |
| **Totals** | **400** | **100%** |

**Table 4:** *Final disposal of the faecal sludge*

*Outline of the urban fecal sludge management by shit flow diagram for Eldoret municipality.*

As urban populations continue to grow, many cities, particularly in Africa, that currently rely on onsite sanitation for safe waste storage will require

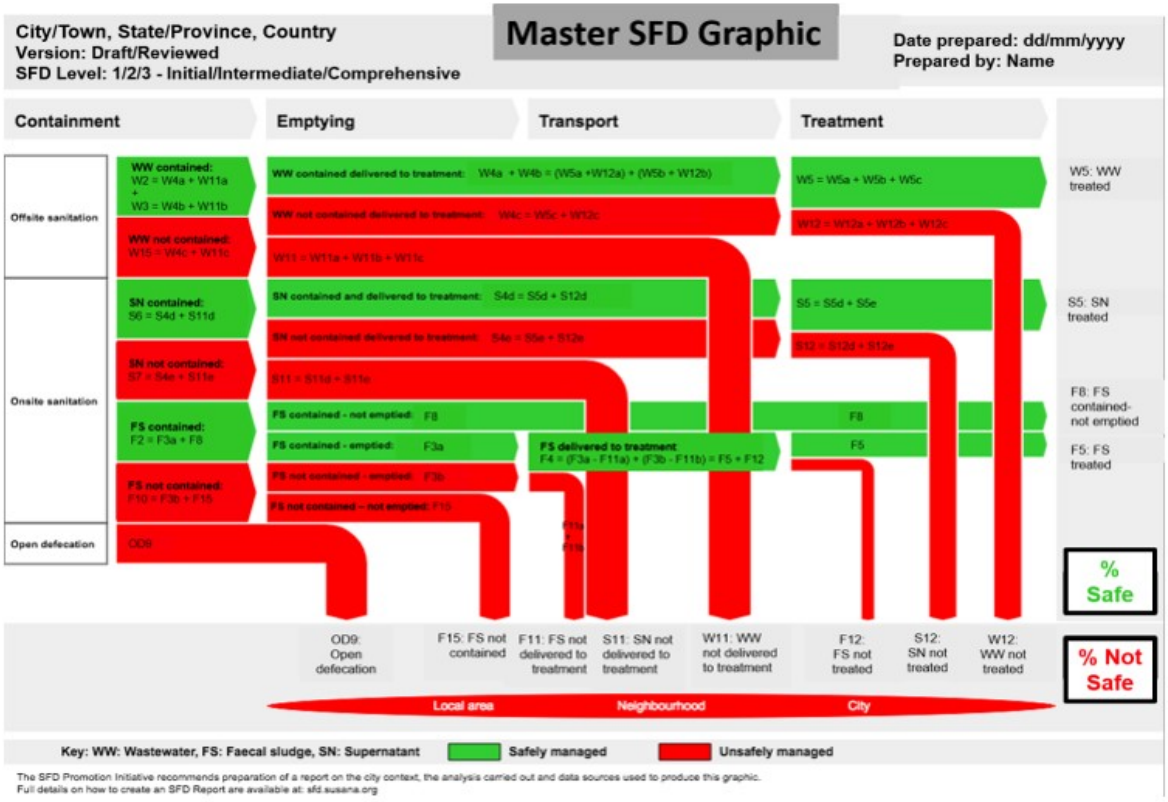


**Table :** *Graphic Illustration of Fecal sludge management in Eldoret Municipality*

new strategies. In certain Asian cities, containment systems that release waste into open drains are prevalent, posing a significant public health hazard(Panesar et al., 2020). The widespread dumping of excreta further exacerbates the problem, and there is a dearth of reliable data on the extent and effectiveness of treatment measures (Arndt et al., 1979). The production process of the SFD faces challenges due to limited data availability and inadequate technical expertise in cities. Ambiguity regarding terminology and the status of infrastructure often adds to the uncertainty. The establishment of formal definitions for the SFD preparation process has proven beneficial in overcoming capacity limitations in cities (Martínez, 2016). The SFD serves as a valuable tool for obtaining an accurate overview of a city's sanitation situation. This paper provides evidence of the pressing need to enhance management and monitoring of urban sanitation worldwide and emphasizes the role of the SFD as a crucial planning instrument (Peal et al., 2020).

*SFD Graphic Illustration of Fecal sludge management in Eldoret Municipality.*

The use of an SFD as a promotion initiative in the provision of urban sanitation has been mainly aimed at the comprehensive understanding of excreta management along the sanitation service chain in assessing the context and outcomes of fecal sludge management (Moorgas, 2020). The SFD for Eldoret is a provision for an opportunity to understand the sanitation value chain and the terms used in description of the various sanitation technologies currently used by people living in the municipality. The information shared from the SFD generated is essential in capacity building for planning and advocacy of FSM services(Chhajed-Picha & Narayanan, 2021). The information collected from household surveys across the municipality helped in understanding the local problems relating to onsite systems which lacked capacity on their application by individual households because of resource constraints(Scott et al., 2018). Hence, an SFD can be regarded as a diagnostic and decision support tool in the assessment of city-wide sanitation service delivery.

## Conclusion

Sustainable sanitation is a collective effort from the community, government and private sectors in ensuring adequate sanitation infrastructure. The government policy makers should prioritize investments in water sanitation and hygiene since it is very crucial in safeguarding public health by prevention of waterborne and sanitation related diseases. The sanitation provision should be based on sustainability according to the users, this is because the conventional sewers may not always be a solution especially to those people residing in congested and unplanned areas. Onsite sanitation should be encouraged with a behavior change strategy to ensure people use fecal sludge for sustainable disposal/end use practices such as farming and forestry.

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