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Developing an Infrastructure Intervention for Solid Waste Exclusion in Pit Latrine Faecal Sludge

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Abstract:- Pit latrine emptying is an important maintenance practice meant to increase a toilet's lifespan. However, the presence of solid waste in faecal sludge pose a great challenge during pit emptying, faecal sludge treatment and processing. Recent studies have demonstrated that solid wastes cause pits to fill up at a faster rate, destruct faecal sludge decomposition, and cause damage to emptying devices by blocking machine parts, and in some cases breaking them. When such occurs, emptying devices are usually withdrawn to manually remove the trapped debris, causing a loss of valuable time and reductions in daily revenue. One way of averting the adverse effects of solid wastes in pit latrines is by preventing them from mixing with faecal sludge in the pit. Therefore, the study aimed to design, develop and test an infrastructure intervention that would exclude solid waste from pit latrine faecal sludge. The study used a quantitative approach in which experimental methods were used to collect primary data. The methodology included the design, fabrication, and installation of a solid waste screening unit on a pit latrine. The screening unit was positioned directly below the squat hole to intercept solid waste while allowing excreta to pass through it. The unit was tested on a pit latrine that was used by 20 individuals over a period of 120 days, after which mass measurements of the intercepted solid wastes were done. The data obtained was analysed using Microsoft Excel 2016 version. It was found that the screening unit was capable of intercepting 88.2±0.6 % of the solid waste that entered the toilet through the squat hole. This confirmed that although behavioral, and education interventions have been conducted, there was little change in behavior towards the dumping of solid wastes in pit latrines. The study also showed that installing solid waste screening systems in future pit latrines can be one way of preventing solid wastes from mixing with pit latrine faecal sludge. These findings suggest that incorporating solid waste screening systems into future pit latrines could effectively prevent solid waste from mixing with faecal sludge. This intervention promises to complement existing behavioral and educational interventions prevalent in many developing countries. The study's application and findings promise improvements in faecal sludge management during pit emptying, treatment, and processing, thereby enhancing public health outcomes.

Keywords:- *Infrastructure Intervention, Solid Waste, Exclusion, Pit Latrine, Faecal Sludge*

I. INTRODUCTION

Pit latrines play an important role in providing access to cost effective sanitation particularly in countries with limited access to centralised sewage systems. They have played a critical function in improving public health by preventing open defecation, a practice which can lead to the outbreak of waterborne diseases and environmental pollutants. In Sub-Saharan Africa, between 65 to 100 percent of the urban populations rely on pit latrines for the containment of human waste (Strande et al., 2014). However, while they provide basic sanitation services, pit latrines are not without their challenges. They have a short life span such that they become unusable after a few years of use.

Pit latrines fill up as faecal sludge and other wastes accumulate. One of the most pressing challenges contributing to rapid fill up rates is the presence of solid wastes (SW) within the faecal sludge. Solid wastes occur as a result of human activities during the course of using the latrines. The SW comprises mainly of non-biodegradable items consisting of plastics, paper, hygiene products, etc., and these pose numerous challenges on the latrine lifespan, the environment, and public health.

SW speed up filling rates, leading to a shorter lifespan for the latrine. Rapid fill up rates require frequent pit emptying or construction of new latrines, each of which may be costly and financially challenging for people in low-income settings. Solid waste in pit latrine faecal sludge can also introduce harmful pathogens and contaminants into the surrounding soil and groundwater, posing great environmental and public health risks. The contamination can affect nearby communities that rely on groundwater for drinking as well as damage nearby ecosystems. The unsanitary conditions such as foul odours, and the presence of rodents, cockroaches, etc., tend to diminish the overall quality of life for those living in the vicinity of the latrine (Grolle et al., 2018).

Solid waste accumulation makes pit emptying a very challenging procedure. This is because extra effort is required to separate and discard non-biodegradable materials. This may result into an increase in pit emptying fees, making sanitation services much more expensive for households. Furthermore, solid wastes can lead to inefficiencies in treatment processes, and resource recovery technologies such as composting, anaerobic digestion, etc. Faecal sludge from pit latrines has the capability to be a used in energy production and agricultural use when properly treated. However, such efforts can be averted by the presence of solid waste (Grolle et al., 2018; Jenkins et al., 2015; Strande et al., 2014).

To cope with the problem of SW, it is vital to develop strategies and technologies aimed at minimising the accumulation of solid wastes, enhancing the efficiency of pit emptying, and promoting the practice of sustainable sanitation. Several strategies and technologies can be explored in this endeavor and they include: (1) Developing innovative pit latrine designs that facilitate the separation of solid waste from liquid waste. This could involve the incorporation of screens, filters, or settling chambers within the latrine structure to capture and retain solid waste whilst allowing liquid waste to infiltrate into the floor; (2) Raising awareness and educating pit latrine users on proper disposal of non-biodegradable items. This can substantially lessen the dumping of solid waste into the pits. Behavior change that can turn individuals into responsible users; (3) Retrofitting pit latrines with solid waste exclusion mechanisms. This can be a practical method to cope with the problem. These retrofits might involve including retrofit kits that include solid waste separation technology into older latrine systems; (4) Implementing faecal sludge treatment technologies such anaerobic digestion and composting at community level. This can assist manage and process faecal sludge more efficiently (Quarshie et al., 2021; Tembo et al., 2016); (5) Promoting the usage of biodegradable sanitary products can reduce the dumping of non-biodegradable substances into pit latrines. Products that emphasise environmental friendliness can be developed and strongly advertised by manufacturers and other stakeholders (Strande et al., 2014); (6) Exploring waste-to-electricity options, such as biogas manufacturing from faecal sludge, can provide a dual benefit of waste control and power generation at the same time as minimising the impact of solid waste (Quarshie et al., 2021); and (7) Governments can play a crucial position in addressing strong waste exclusion in pit latrines by growing and implementing policies that inspire responsible sanitation practices, waste disposal, and the improvement of suitable infrastructure (Still & Foxon, 2012).

In an effort to address the problem of solid waste in pit latrines, the study explored the development of an infrastructure intervention for solid waste exclusion in pit latrine faecal sludge to mitigate their adverse effects.

A. Statement of the Problem

The presence of solid waste in pit latrines has been identified as a significant factor leading to rapid pit filling, consequently shortening the lifespan of these sanitation facilities. This issue presents a substantial challenge for latrine owners, particularly those in low-income communities, as it necessitates frequent pit emptying or construction of new pits, both of which are financially burdensome alternatives (Radford et al., 2015; Zuma et al., 2015). Moreover, the presence of solid waste in faecal sludge serves as a breeding ground for pathogenic organisms such as bacteria, viruses, and parasites, posing severe environmental and public health risks. The contamination of soil and groundwater, which may impact neighboring communities dependent on groundwater for drinking and nearby ecosystems, underscores the urgency of addressing this issue (Strande et al., 2014).

The process of pit emptying is further complicated by the presence of solid wastes, as additional efforts are required to separate them from the faecal sludge. This complication results in labor-intensive and costly pit emptying procedures. Additionally, materials like plastics and fabrics often clog pumps, pipes, and other equipment at treatment facilities, hampering the overall treatment process. Consequently, pit emptying expenses escalate, rendering sanitation services less accessible to communities and potentially fostering unsanitary practices such as open defecation (Gudda et al., 2019).

Furthermore, the presence of solid waste renders faecal sludge unsuitable for resource recovery and reuse, hindering valuable resource recovery processes such as composting and anaerobic digestion. These techniques, which hold significant benefits for agriculture and energy production, are severely impeded by the presence of solid waste (Tembo et al., 2014). As a result, communities and the country at large miss out on potential benefits from resource recovery.

Addressing the multifaceted challenges posed by solid waste in pit latrine faecal sludge demands a comprehensive approach. While strategies like behavior change and community education have been attempted in the past, it is imperative to develop measures aimed at preventing solid wastes from contaminating faecal sludge in the first place. Therefore, the objective of this study was to devise an infrastructure intervention to effectively exclude solid waste from pit latrine faecal sludge, thereby mitigating the associated environmental, health, and economic consequences.

B. Study Aim and Objectives

The study aimed to design, develop, and test an infrastructure intervention that would exclude solid waste from pit latrine faecal sludge. The aim of the study was broken down into the following specific objectives:

- To characterise the common types of solid wastes found in our pits
- To design and install an infrastructure intervention for solid waste exclusion in pit latrine faecal sludge.

- To evaluate the effectiveness of the intervention in excluding solid waste from pit latrine faecal sludge.

II. LITERATURE REVIEW

A. Theoretical Framework

Solid waste in pit latrine faecal sludge is still a challenge today as it was in times past. Numerous interventions have been formulated and tested by different researchers in a bid to reduce or eradicate solid waste. A review of literature has shown that the interventions can be grouped into three main categories, namely, behavioral, infrastructure, and educational.

Studies on behavioral interventions looked at approaches to changing people's behavior to prevent solid waste from entering pit latrines. One approach was to encourage users to dispose of their waste in proper containers, such as dustbins or waste pits, rather than throwing it into the pit latrine. A study conducted in a rural part of Kenya by Onyango et al. (2015) found that providing users with designated waste disposal areas near the pit latrine and educating them on proper waste disposal practices led to a significant reduction in solid waste entering the pit latrine. Similarly, a study conducted in urban Ghana by Awunyo-Akaba et al. (2017) found that community sensitisation and awareness-raising campaigns, as well as the provision of designated waste disposal areas, led to a reduction in solid waste entering the pit latrine.

Another behavioral intervention involved the use of incentives to encourage users to properly dispose of their waste. A study conducted in rural Bangladesh by Islam et al. (2020) found that providing users with small monetary incentives for proper waste disposal significantly reduced the amount of solid waste entering the pit latrine. However, the authors noted that the long-term sustainability of this approach needed further investigation. In instances where behavioral approaches did not produce desired outcomes, infrastructural interventions were attempted.

Infrastructure interventions involved modifying the pit latrine or its surrounding environment to prevent solid waste from entering. This approach included such interventions as installing a simple wire mesh or grate over the pit latrine to prevent solid waste from entering, to providing users with a separate pit for waste disposal. A study conducted in rural Malawi by Gunda et al. (2016) found that installing a wire mesh over the pit latrine led to a significant reduction in solid waste entering the pit latrine. However, the authors noted that the wire mesh needed to be cleaned regularly to prevent blockages. In a study conducted in rural Uganda by Ssemugabo et al. (2017) it was found that providing users with a separate waste disposal pit reduced the amount of solid waste entering the pit latrine. The authors suggested that this approach could be particularly effective in areas where waste management systems are lacking.

As a way of supplementing both behavioral and infrastructure interventions, some researchers explored educational interventions to prevent indiscriminate disposal of solid waste in pit latrines. Educational interventions involved providing users with information and knowledge on proper waste disposal practices. One such approach was the use of participatory methods, such as community-led total sanitation (CLTS), to raise awareness and mobilise communities to take action against destructive practices when it came to using pit latrines. A study conducted in rural Ethiopia by Teshager et al. (2018) found that using CLTS and community mobilisation led to a significant reduction in solid waste entering the pit latrine. The authors noted that this approach was effective in promoting behavior change and community ownership of the intervention.

Another educational intervention used behavior change communication (BCC) strategies to promote proper waste disposal practices. A study conducted in urban Tanzania by Mushi et al. (2020) found that using BCC strategies, such as community meetings and door-to-door visits, led to a substantial reduction in solid waste entering the pit latrine. The authors suggested that this approach could be effective in promoting sustained behavior change.

It can be seen from the aforementioned studies that combining behaviour, infrastructure, and educational interventions can help to make people stop dumping solid waste in pit latrines. Although the findings of the studies are significant, several limitations can be noticed in their interpretation of their conclusions.

Firstly, the settings in which the studies were conducted were specific to the given environment such as rural or urban areas. Such environments cannot be generalised to other settings. As an example, the infrastructure approaches used in the rural communities of Malawi may not be applicable in urban cities with different environmental settings.

Secondly, much of the studies relied on self-reported data, which may be subjective and not having adequately indicated the quantities of solid wastes that may have entered toilet systems Awunyo-Akaba et al. (2017).

Thirdly, some of the studies did not consider possible repercussions, and whether the interventions could be sustained in the long-term. For instance, although giving money as an incentive encouraged people to dispose of solid waste in a proper way, it was unclear whether the approach was sustainable in the long term or produced unintended consequences, such as creating a reliance on external incentives (Islam et al., 2020),

Finally, the studies did not provide adequate descriptions, as well as components of the interventions such that it is challenging to replicate the interventions in other settings. For example, in a study by Onyango et al. (2015), information was limited on the design and implementation of educational programs that were carried out, as well as the waste disposal areas used.

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In conclusion, keeping solid waste from entering pit latrines is a major public health and environmental issue in many low-income and rural communities. From the review of related literature on the subject, it is evident that behavioural, infrastructure, and educational interventions can be beneficial in addressing this issue. However, further research is need to identify interventions that are more effective and sustainable in the long term, and applicable to different settings. It was from this background that this study aimed to develop and test an infrastructure intervention that would exclude solid waste from pit latrine faecal sludge.

B. Empirical Review of Literature

➢ *Pit Latrines as Onsite Sanitation Systems*

Humans produce different types of waste that require proper handling. Different sanitation systems are in use to contain human excreta. The systems are classified as either onsite or offsite depending on whether the waste produced is to stored and treated where it is being produced, or conveyed away to far-off facilities for treatment and eventual disposal (Strande et al., 2014). One of the most widely adopted form of onsite sanitation systems is the pit latrine (Nakagiri et al., 2015; Tembo et al., 2019).

A simple pit latrine is essentially a hole dug in the ground to which people dispose of human excreta. Its cross-section can be in the shape of a square, rectangle, or circular, and lined with bricks, old metal drums, concrete, etc. The lining helps to prevent the pit from collapsing especially in areas where the soil structure is weak. The latrine slab covers the pit, bears the users' weight, and provides a base for the construction of the superstructure. Sawn timber, concrete, rammed earth, bamboo, etc., are examples of materials used to build slabs. A squat hole of about 25 cm in diameter is provided in the slab through which excreta drops into the pit (Rottier & Ince, 2003: Nakagiri et al., 2015).

The superstructure is a cubicle built above the slab to provide privacy and protection from the weather elements (Buckley et al, 2008). It can be made of bricks, or a wooden frame covered with plastic sheets, thatched grass, or any locally available material. Provisions for a lockable door and window are made in the structure for security and to improve air ventilation. In some instances, the superstructure divides into two cubicles: one to act as a bathroom, and the other as a toilet. If the bath water drains into the pit, then the toilet is classified as a 'wet toilet' (Rottier & Ince, 2003). Figure 1 shows the main components of a simple pit latrine.

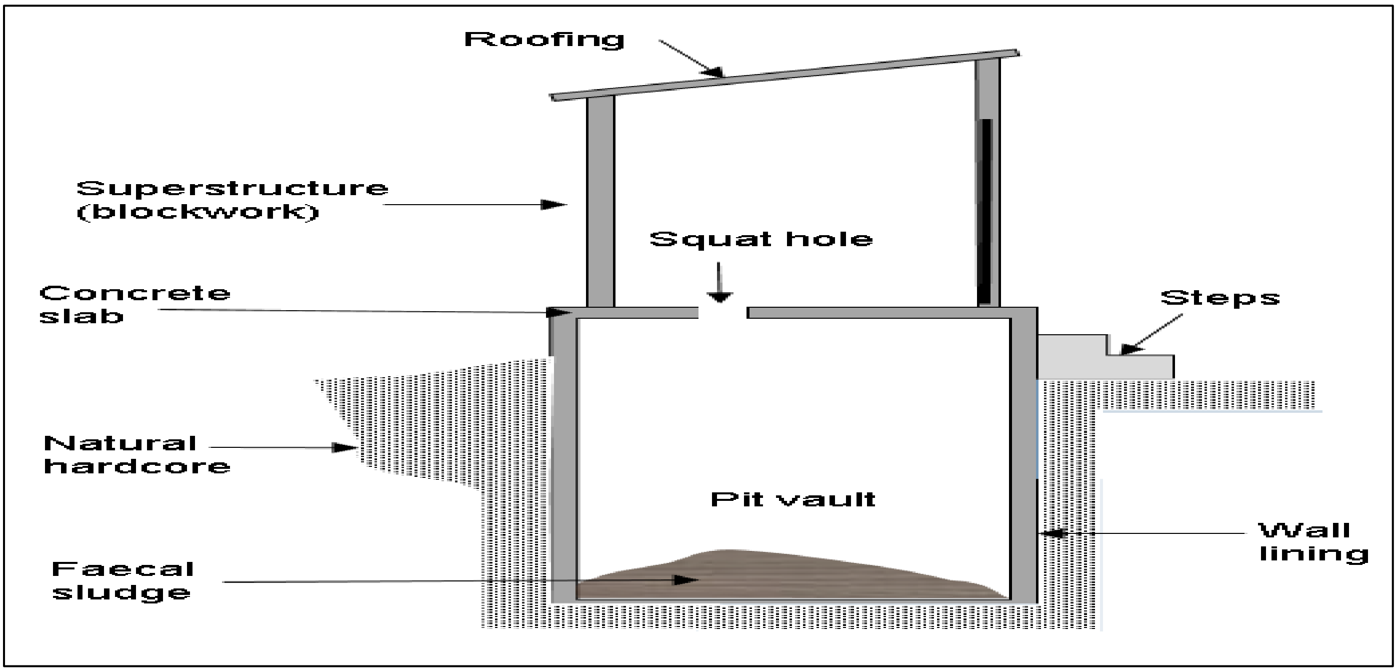

Fig 1: Components of a Simple Pit Latrine

➢ *Design Considerations for a Simple Pit Latrine*

When designing a pit latrine, the location and size of the pit are critical factors to consider. Strande et al. (2014) and Sowmya and Raj (2019) emphasised the importance of constructing pit latrines in areas that are well-drained and far away from water sources to prevent contamination. Strande et al. recommended a distance of at least 30 metres, while Sowmya and Raj suggested a minimum distance of 15 metres. Additionally, the bottom of the pit must be situated about two metres above the water table during the wet season, according to Strande et al.

It is also advisable that a pit latrine be located far enough away from residential areas to avoid issues with foul odours but still be accessible to all, including people with disabilities. Tembo et al. (2019) found that the distance of the pit latrine from the household and accessibility were significant factors that influenced the use of pit latrines in rural Zambia. Also, efforts must be made to prevent flies from breeding and feeding in the pit. This can be achieved by keeping the toilet clean and ensuring that the squat hole is closed when not in use. In this way, diarrheal disease that comes as a result of flies depositing germs on food can be prevented (Strande et al., 2014).

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➢ *Determination of Pit Size*

According to the World Health Organization (WHO, 2018), the minimum size of a pit latrine should be based on the number of people who will be using it and the estimated amount of excreta produced. The recommended volume of the pit should allow for at least one year of use before it needs to be emptied. The WHO recommends the following pit sizes for various numbers of users:

- 1 to 10 users: 0.75 to 1 cubic meter
- 11 to 20 users: 1 to 1.5 cubic meters
- 21 to 30 users: 1.5 to 2.25 cubic meters
- 31 to 40 users: 2.25 to 3 cubic meters
- 41 to 50 users: 3 to 3.75 cubic meters

It is important to note that these are minimum recommendations, and in areas with high water tables or rocky soils, larger pits may be required to ensure safe and effective use. Additionally, the pits should be located at a safe distance from any wells or other sources of drinking water to prevent contamination. In instance where it is vital to calculate the actual volume for faecal sludge accumulation, (1) can be used (Rottier and Ince, 2003). Mathematically,

$$V = R \times P \times N \qquad (1)$$

In (1), V is the approximate volume of the pit in cubic metres, R is the faecal sludge (FS) accumulation rate in cubic metres per person per year, P is the anticipated number of users, and N is the design life of the pit latrine in years, respectively.

Of all the variables in the Equation, information about FS accumulation rates may seem difficult to find because the rates vary depending on factors such as diet, type of anal cleansing materials, and environmental and technical factors (Strande et al., 2014). However, some studies came up with some estimated values. Some of the FS accumulation rates proposed by Rottier and Ince, (2003) are depicted in Table 1.

Table 1: Approximate FS Accumulation Rates (Litres/ Person/ Year

Pit latrine type	**Anal Cleansing Materials**	
	Water	**Solid materials**
Wet pit	40	60
Dry pit	60	90

Source: Rottier and Ince, (2003)

When estimating the pit that has to be excavated, two additional factors must be considered:

- The pit should be taken out of service when the sludge level in the pit reaches 0.5 metres below the slab; and
- If the pit is lined, the space taken by the lining need to be accounted for (Rottier & Ince, 2003).

WHO guidelines provide a faster estimate of pit size in a given situation. However, there is no harm in using the Equation proposed by Rottier and Ince. The solution obtained from the calculations can always be compared against WHO guidelines.

➢ *Pit Latrine Waste Composition*

Faecal sludge, also known as human excreta, is a mixture of faeces, urine, water, and other materials such as toilet paper and cleaning agents. It may also contain pathogens such as bacteria, viruses, and parasites that can cause disease if not properly handled and disposed of. The exact composition of human faecal sludge varies depending on factors such as diet, water consumption, and the presence of other materials in the toilet, but it typically contains high levels of organic matter, nitrogen, and phosphorus (Velkushanova et al., 2021).

According to Velkushanova et al. the amount and characteristics of faecal sludge generated and collected vary depending on individual activities and storage conditions, and different types of sludge are not comparable due to differences in treatment processes. Velkushanova et al. proposed approximate ranges of faecal sludge categories based on total solids (TS), including liquid faecal sludge (TS<5%), slurry faecal sludge (TS 5-15%), semi-solid faecal sludge (TS 15-25%), and solid faecal sludge (TS <25%). These categories can influence appropriate analysis techniques, sample preparation, and design and management decisions.

Faecal sludge may also contain chemicals such as those used in cleaning materials, and additives. Although additives are usually intentionally added to faecal sludge to reduce odours or increase decomposition, there is insufficient proof that supports their efficacy. On the contrary, data suggests that additives might have negative consequences, such as stifling biodegradation and accumulating unwanted gases and odours in pit latrines (Grolle et al., 2018).

The solid waste in faecal sludge includes both toilet paper and other materials that may have been flushed down the toilet, as well as any other solid waste that may have entered the pit latrine, such as food scraps or plastic bags. The composition of solid waste in faecal sludge can vary widely depending on factors such as the type of toilet used, the diet of the user, and the presence of other waste materials in the pit latrine. Proper treatment and disposal of solid waste in faecal sludge are crucial for protecting public health and the environment.

➢ *Causes and Impacts of Solid Waste in Pit Latrines*

Solid waste dumping in pit latrines is a common practice in many areas across the world. There are several reasons why people may resort to this method of waste disposal. Adjei et al. (2018) identified lack of proper waste management facilities as one of the main reasons why people resort to dumping solid waste in pit latrines in peri-urban areas of Ghana. Kabwe et al. (2016) in Dar Es Salaam, Tanzania found that the convenience of pit latrines being located in close proximity to households was a major factor

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in their use for solid waste disposal. In some cases, cultural practices also play a role, where certain types of waste are traditionally disposed of in pit latrines (Zhang et al., 2019). For example, a study by Gyasi et al. (2021) revealed that it was taboo to dispose of menstrual products in a way that would expose them to the public's view.

Additionally, lack of awareness about the negative impact of solid waste dumping on the environment and human health is another contributing factor (WHO, 2018). Finally, in some areas, laws or regulations may exist to prevent this type of waste dumping, but a lack of enforcement can lead to continued dumping (Olawuyi et al., 2020). All of these factors contribute to the widespread practice of solid waste dumping in pit latrines. Solid waste dumping in pit latrines can have negative impacts on the functioning and safety of the pit, as well as on the health of surrounding communities. Improper disposal of solid waste in pit latrines can result in the accumulation of solid waste at the bottom of the pit, reducing the volume of the pit and decreasing its ability to effectively treat and contain faecal sludge (Adjei et al., 2018), can increase the amount of total solids in faecal sludge, which can make it more difficult to treat and dispose of the sludge safely (Zhang et al., 2019). In addition, solid wastes contribute to the formation of solid sludge plugs in the pit, which can prevent the proper functioning of the pit and lead to overflowing and contamination of surrounding areas (Kabwe et al., 2016). Finally, WHO (2018) notes that solid waste in pit latrines can also lead to the release of harmful gases such as methane and carbon dioxide, which can pose health risks to people working in or living near the pit.

Overall, these impacts demonstrate the importance of proper waste management practices in the treatment and management of faecal sludge. Separating solid waste from faecal sludge and disposing of it in a safe and appropriate manner can help mitigate these impacts and ensure the effective functioning and safety of pit latrines.

➢ *Tackling Solid Waste in Faecal Sludge During Pit Emptying*

Latrines have been found to contain a variety of solid waste, including plastic bags, broken glass, cloth, needles, sanitary towels, clothing, newspapers, and anal cleansing supplies (Brouckaert et al., 2013; Tembo et al., 2019. The enormous range of shapes, sizes, and other properties of solid waste has made the design of a single mechanical method to handle such variations very difficult. Some attempts, however, have been made to deal with the problem of solid waste in pit latrines during pit emptying.

Sisco et al. (2017) conducted a study to compare the effectiveness of two approaches for removing solid waste during pit emptying. The first approach involved removing waste and sludge simultaneously using an excavator that had been modified with two cutting heads. The second approach required manual removal of waste before sludge removal, using modified "fishing" tools. While simultaneous removal of waste and sludge seemed like a good idea, it required an additional high-energy macerating unit to break down the waste, which would complicate the process because it had to fit through a small hole. The second approach, which relied on manual tools, was considered untidy, unclean, and potentially hazardous to workers and the public.

Rogers et al. (2017) developed a new waste management approach for faecal sludge emptying that used a mechanical screw auger and a vacuum system to separate solid waste from the sludge. The technology has been successful in India and Malawi, and it would lead to several benefits, such as enabling pit emptiers to earn an income, reducing household costs, and improving downstream processes like composting.

On the other hand, modifying the squat pan, such as with the SATO pan technology, can decrease waste disposal in pit latrines. The SATO pan offers a seal against flies and prevents odours from escaping, but it has some drawbacks. Solid waste with diameters smaller than the pan's hole can still pass through, and the seal against odour and pathogen transmission can be broken if the flap is damaged. Accessing and replacing the damaged flap is challenging, and the pan requires water to operate, which can be scarce in peri-urban areas. Flies feeding on pans with excreta residue can pose a risk to public health.

It can be noted that mechanical technologies offer an attractive solution to pit latrine emptying challenges. However, their effectiveness and sustainability depend on operator training, maintenance, availability of spare parts, and compatibility. Finding sustainable and effective solutions for solid waste removal remains a significant challenge, requiring locally appropriate, affordable, and easy-to-maintain technologies and practices, and the involvement of local communities, private sector actors, and governments.

➢ *Solid Waste Screening using Mesh Screens*

The use of mesh screens in pit latrines is a simple yet effective method for preventing the entry of solid waste into the pit. These screens are typically made of wire mesh or similar materials and are installed at the top of the pit, either directly below the squat hole, or in a separate compartment. Mesh screens work by allowing only liquid waste and small particles to pass through, while trapping larger solid waste materials. This prevents the accumulation of solid waste at the bottom of the pit, reducing the risk of blockages, overflows, and contamination of surrounding areas. Mesh screens also help to maintain the volume of the pit, ensuring that it can effectively treat and contain faecal sludge.

Studies have demonstrated the effectiveness of mesh screens in improving the performance and safety of pit latrines. For example, a study by Sow et al. (2017) found that the use of mesh screens in pit latrines in rural Senegal led to a significant reduction in the amount of solid waste in the pit and improved the quality of the faecal sludge. Another study by Fabry et al. (2017) found that the use of mesh screens in pit latrines in Madagascar reduced the occurrence of blockages and overflows, leading to improved hygiene and reduced health risks for local communities.

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Overall, the use of mesh screens in pit latrines can be a highly effective method for preventing the entry of solid waste and improving the performance and safety of these sanitation facilities. As such, their use should be encouraged as part of efforts to improve sanitation and hygiene in communities where pit latrines are commonly used.

- *Determining the Effectiveness of a Mesh Screen*

Mesh screens are created by interweaving, crimping, or welding wires of uniform cross-section to form openings of specific shapes and sizes. The selection of wire material depends on the environmental conditions in which the mesh will be used. For instance, plain carbon steel wire is used for general-purpose screening, while stainless steel wires are suitable for corrosive environments.

The available space per unit area of the screen is a crucial design parameter for meshes, which is determined by the area between the wires forming the opening. The percentage of clear space on the screen can be calculated based on the size of the openings, the diameter of the round sections of wires (d_w), the dimensions of the openings, and the areas of the openings.

Suppose that the mesh has square openings with wires having round sections of diameters d_1 and d_2, and dimensions L_1 and L_2. Supposing further that the areas of its openings range from A_1 to A_N, the percentage of the screen that is clear space can be represented as:

$$A_0=[L_1L_2/(L_1+d_1)(L_2+d_2)]\times100 \quad (2)$$

For square openings, $L_1 = L_2 = L$, (2) reduces to (3):

$$A_0=[L_A/(L_A+d_W)]^2\times100 \quad (3)$$

The effective aperture will be smaller and equal to the projection of the real screen aperture when the screens are positioned at an angle θ to the horizontal. After that, the available area will be changed to:

$$\text{Available area} = A_o \cos\theta \quad (4)$$

The effectiveness of mesh screens in keeping out solid waste from pit latrine faecal sludge can be calculated by measuring the amount of solid waste retained by the screen and the amount that passed through it and fell to the bottom of the pit. To calculate the effectiveness in solid waste retention, the amount of solid waste retained on the screen is divided by the sum of the amounts of solid wastes on the screen and in the pit. The resulting value can then be multiplied by 100 to obtain the percentage effectiveness in solid waste retention of the screen. For example, if the amount of solid waste retained on the screen is 500 grams and that in the pit was 200 cubic meters, the percentage effectiveness would be 71.43%. This indicates that the mesh screen was able to retain solid waste from entering the pit by 71.43%. It's important to note that other factors, such as the frequency of pit emptying and the size and design of the mesh screens, can also affect the effectiveness of the screens.

III. MATERIALS AND METHODS

The study aimed to develop and test an infrastructure intervention that would intercept solid waste thrown in pit latrines. The main steps taken included the design and fabrication of a solid waste screening unit, followed by the design and construction of a tailor-made pit latrine on which the screening unit was installed. The pit latrine was used over a period of four months after which the screening unit was removed and all materials that it intercepted were collected, cleaned and analysed. A quantitative analysis of material flow through the screening unit was then done.

A. Research Design

The study used a quantitative approach in which experimental methods were used to collect primary data. Secondary data was gathered through the review of literature that was deemed relevant to the study.

B. Study Area

The study was conducted in John Laing township in Lusaka, Zambia (Fig.2). John Laing is a high-density, low-income township that lies within a 7-kilometre radius of Lusaka's central business district (CBD). It was named after a white miner, Mr. John Laing who owned the Dealer Stone Mining company that sold crushed stones for cement production in Chilanga. John Laing was purposely selected because it was one of the largest high-density townships where pit latrines are in high use. Its existing sanitation conditions provided an environment that was representative of field conditions that prevailed in other high-density areas in Lusaka and other parts of Zambia.

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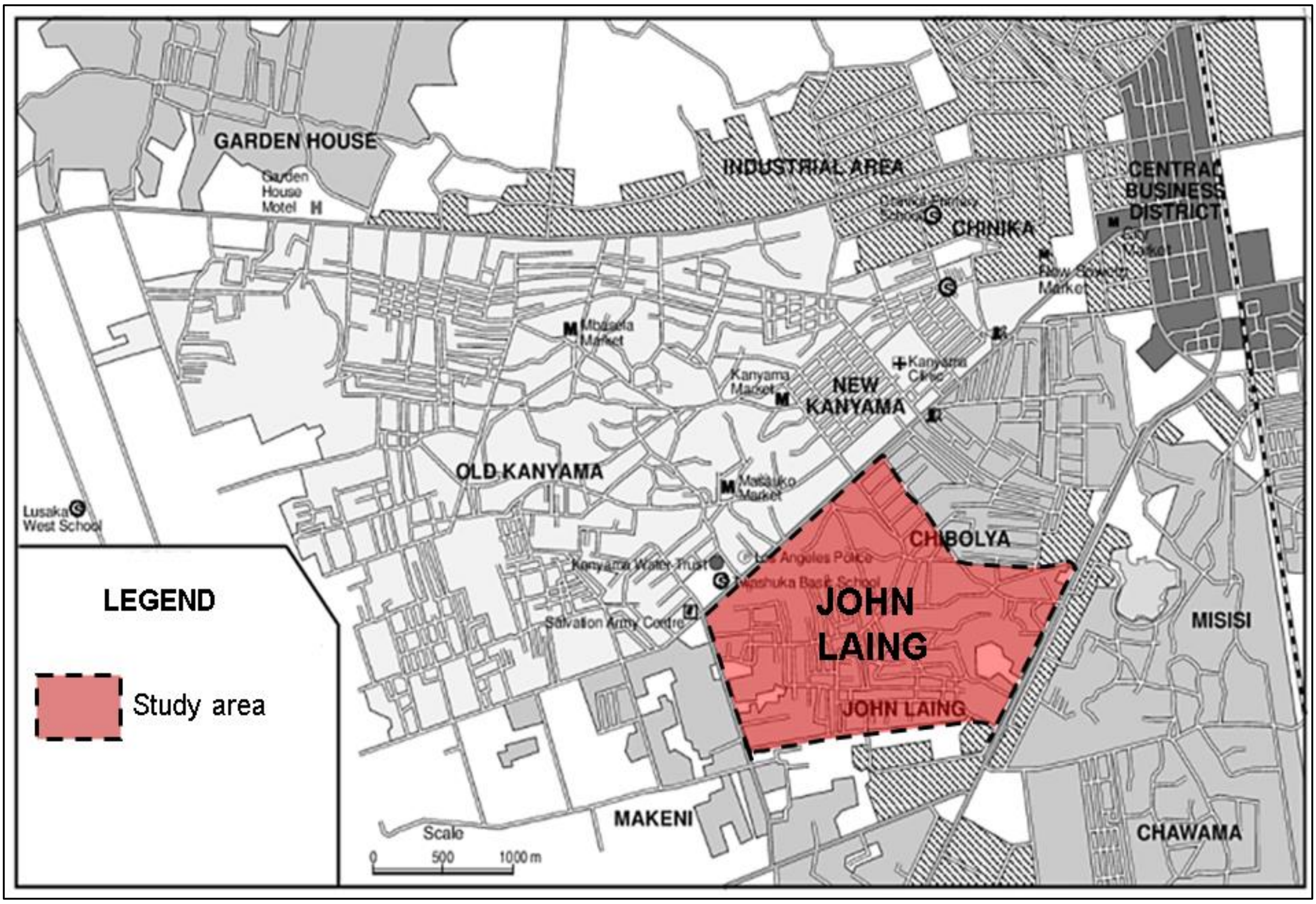

Fig 2: Map of the Study Location
(Source: Adapted from Phiri, 2015)

➢ *Selection of the Study Site*

The tailor-made pit latrine used in the study was constructed on a block of flats belonging to Mr. Emmanuel Katonda, located on Plot No. C17/035 in an area called locally identified as ‘Chitimukulu’. This property was purposely identified as suitable because it met the required number of toilet users earmarked by the study. The property had four semi-detached flats having two rooms each. Construction of the pit latrine commenced after obtaining a written consent from the property owner.

C. Study Population and Sample Size Determine

The study population was made up of the households of John Laing township, while the sample size consisted of households residing in the study area. Then, one property was purposely selected based on the following criteria:

- The property was to have at least a total of 20 individual that used the same toilet. This number was arrived at on the premise that 20 individuals would produce adequate waste within the allowable period that the study was to be conducted.
- The property was to have available space within its boundaries for the construction of a new toilet.
- The existing toilet should be near the end of its useful life. This was used as a basis to convince the property owner to have a toilet built for them.
- The property owner and tenants were to be willingness to participate in the study in form of using the built toilet.

Identification of the property that met the set criteria was done through field observation and consultations with the residents within the study area.

D. Procedure for Data Collection and Analysis

The study collected quantitative data through experimental methods. A quantitative analysis of the data was done using Microsoft Excel 2016. This software package was purposely selected because it could simply and automatically turn data into statistical charts, percentages, and mathematical manipulations that could be handled using the package's built-in functions.

E. Procedure for the Design of the Screening Unit

The first phase of the study was the design and fabrication of the solid waste screening unit. This was firstly done because the design of the toilet on which it was installed depended on it. Figure 3 shows the plan and cross section view of the toilet and how the unit was installed.

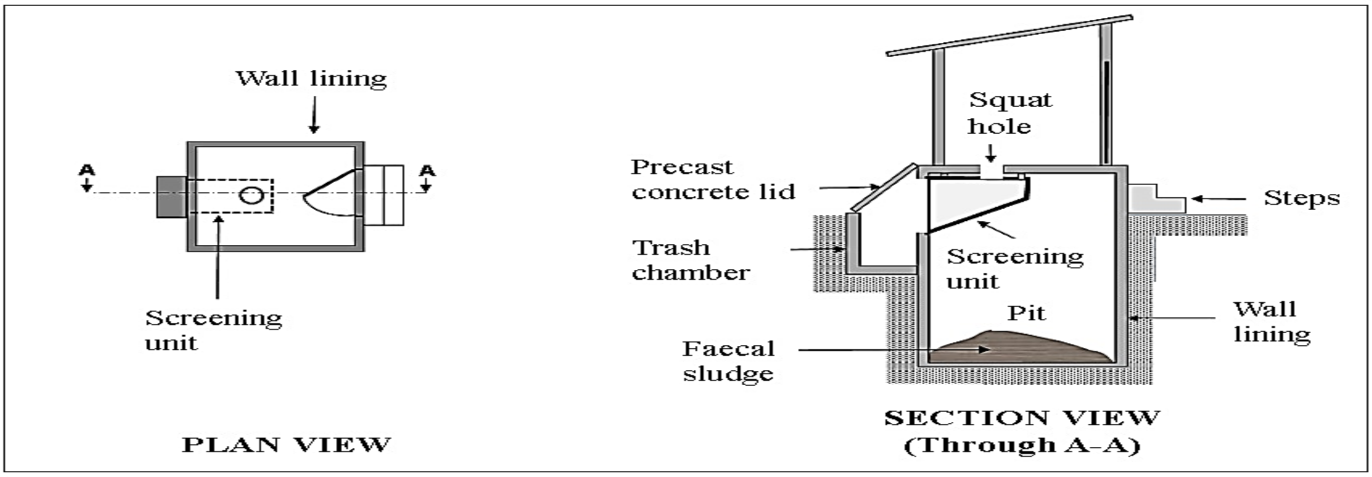

Fig 3: Position of Screening Unit

➢ *Description of the Screening Unit*

Figure 4 shows the main components of the screening unit. It was made up of the main frame, side covers, and the base cover.

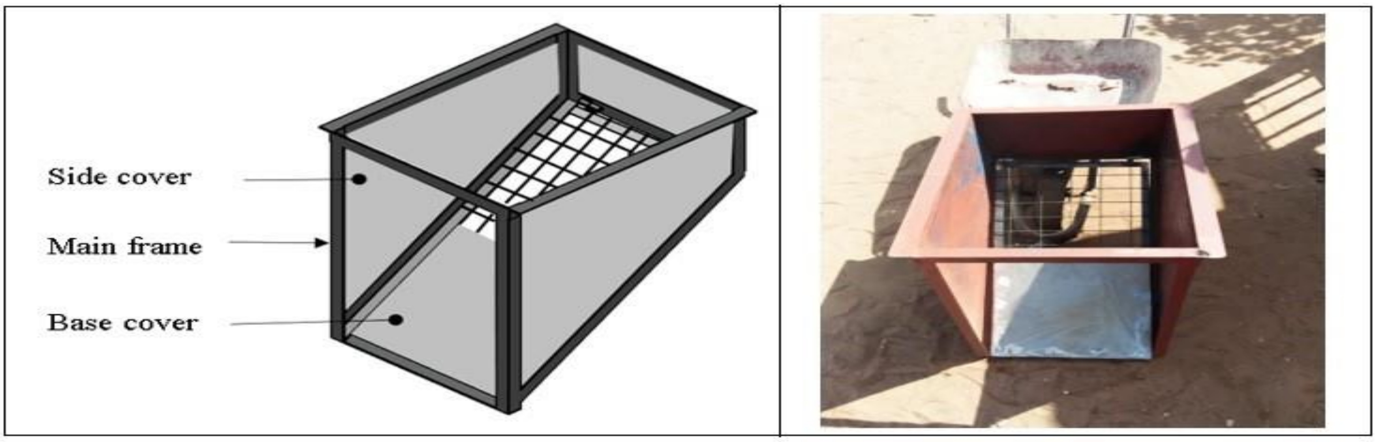

Fig 4: Left-Isometric Drawing; Right-Fabricated Screening Unit

- *The Main Frame*

The skeletal framework of the screening unit is as depicted in Figure 5. Its purpose was to provide structural stability and support other components. Arc welding was used to connect the 30 x 30 x 3 mm mild steel angle bars that made up the structure. Hinges, for connecting the base cover were welded on its top section. To prevent rust formation and corrosion, the frame was sprayed with two coats of red oxide paint. Weight and strength were considered important design parameters that influenced the frame's rigidity, while affordability and local availability guided the criteria for the selection of materials used.

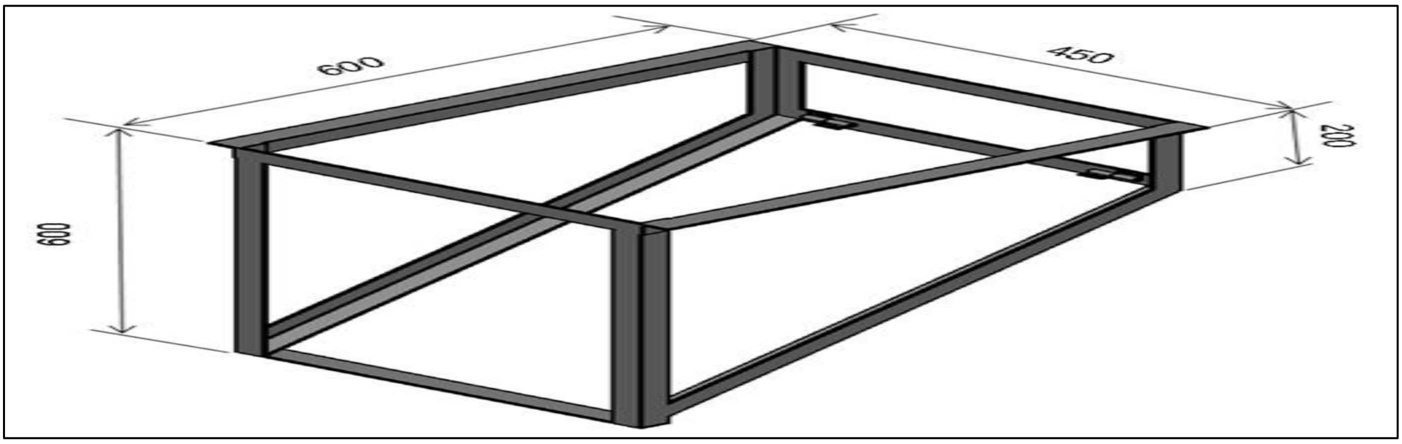

Fig 5: Main Frame of Screening Unit

- *The Side Covers*

The unit's sides were protected by the side covers. They served the purpose of preventing materials from entering the pit from the frame's sides. The main design factors were weight, strength, and durability. Mild steel sheets that were three millimeters thick were employed. Oil paint was applied to make them more durable.

- *The Base Cover*

Figure 6 shows the side and front views of the base cover. It was made from 32 x 3 mm flat bars. A flat metal sheet covered its lower half, while the upper half had the wire mesh. The mesh was fitted to the base cover by folding the mesh ends around the frame. This made it easy to have the mesh removed or replaced whenever there was need.

Mesh aperture size and angle of inclination were considered important design factors. A mesh with rectangular openings was selected to ensure that the effective aperture and open area projected towards the direction of material flow were not going to be significantly reduced after the mesh was inclined. Additionally, this type of mesh was chosen because, compared to the other forms, it was lighter, more resilient, and could have pieces cut from it without losing shape (WireCrafters, 2022).

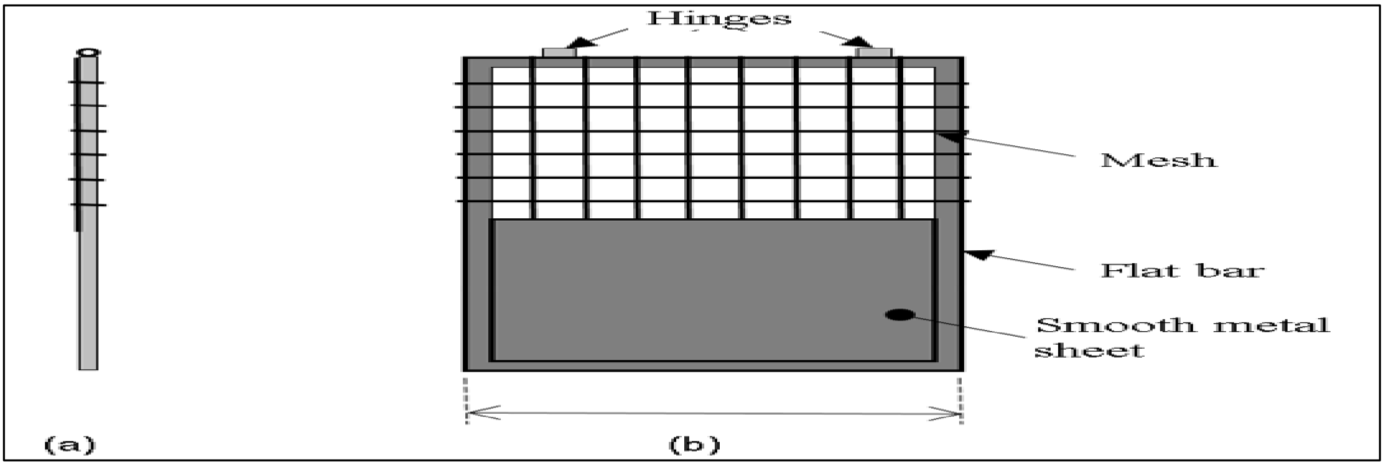

Fig 6: (a) Side View; (b) Front View of Base Cover

- *Determination of Mesh Aperture Size*

With reference to Figure 7, the effective area Ae, facing the direction of material flow was calculated using the equation

$$Ae = Ao \cos \theta \quad (5)$$

A_o was the open area before the inclination (Figure 3-7(a)), equal to the product of the opening's dimensions L_1 and L_2. The effective length, Le perpendicular to material flow was

$$Le = L_1.\cos \theta \quad (6)$$

Hence, the effective area, Ae was expressed as

$$Ae = Le \times L2 \quad (7)$$

It was assumed that the effective area, Ae should be a 4 x 4 cm square because it was adequate to pass feaces 4.0 cm in diameter (Rekstis, 2021). Rekstis reported this diameter as that of type 2 feaces on the Bristol Stool scale, and the study used it as a guide to determine the required effective area for the passage of faeces.

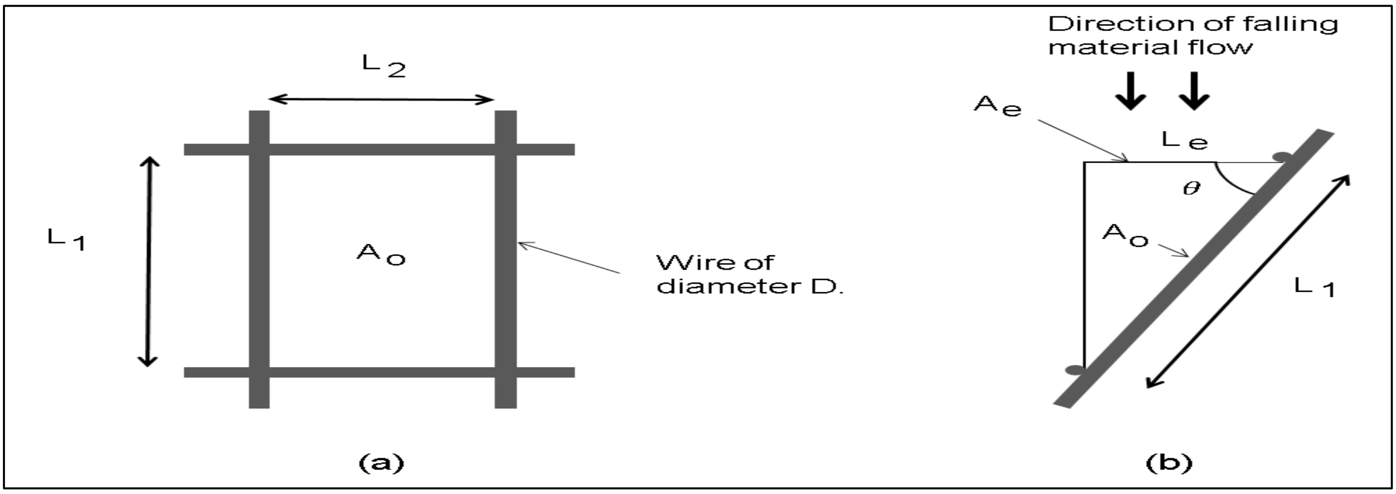

Fig 7: Mesh Opening (a) Before Inclination; (b) After Inclination

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The screen was able to be inclined between 0 and 35 degrees with respect to the horizontal. It was observed that increasing the inclination angle would cause oversize materials to easily roll off the screen, but would also significantly diminish the effective area of the mesh openings.

F. *Procedure for the Design and Construction of the Tailor-Made Pit Latrine*

The second phase of the study was the design and construction of the pit latrine on which the fabricated screening unit was installed. The design involved determining pit size and shape so that it fitted within the space available on the study site. The design also included the addition of the trash chamber to the rear end of the toilet.

➢ *Determining the Size of the Pit*

The volume for sludge accumulation was determined using the equation proposed by Rottier and Ince (2003):

$$V = R \times N \times Y \quad (8)$$

Where:
V = volume of the sludge to be produced (in m^3).
R = faecal sludge accumulation rate (m^3/person/year).
N = the number of toilet users.
Y = the design life of the pit (in years).

Equation (8) was applied under the assumptions that the pit was the "dry type", with a faecal sludge accumulation rate of 90 litres per person per year. In the final estimates for the pit volume, a depth of half a meter below ground level was added to the sludge accumulation volume. This depth was added as a safety precaution against feacal sludge overflow. The pit was supposed to be decommissioned as soon as the sludge reached this elevation (Rottier & Ince, 2003). Additionally, the slab was raised to a height of one meter above the ground to make room for the screening unit.

➢ *Construction of the Trash Chamber*

The trash chamber was built as a separate compartment on the rear side of the toilet as shown in Fig. 8. It was slightly raised above the ground level to prevent flooding during the rainy season. Its top was covered with a precast concrete lid to prevent unauthorised access, while the sides and bottom were plastered to make them waterproof.

Fig 8: L-R: Construction of the Trash Chamber

➢ *Installation of the Screening Unit on the Pit Latrine*

The screening unit was placed inside the pit through the opening behind the toilet. It was positioned below the squat hole and supported on two 40 x 40 mm angle bars suspended underneath the slab (Fig. 9). The angle bars were welded onto rods that were anchored in the slab's concrete. The screening unit slid in and out on the two angle bars, similar to the way a table drawer function.

Fig 9: Angle Bar Supports Beneath the Slab

G. Procedure for the Collection of Solid Wastes from the Toilet

The third and final phase of the study involved the removal of solid waste that had collected in both the trash chamber (TC) and the pit over the four-months period. The collected solid waste was to be washed, dried, sorted into categories, and weighed. The Kanyama Water Trust, a pit emptying enterprise operating in the study area, were engaged at this stage.

➢ *The Following Highlights the Sequence of Events that Took Place During this Stage:*

- The trash chamber's concrete lid was removed to create access to the chamber itself and the pit. Tools used included a pick and shovel.
- Disinfectant chemicals were then sprayed in the trash chamber, the pit and the surrounding area to sanitise the place.
- The screening unit was pulled out from under the toilet's slab and its contents were removed with a shovel, and placed in a bucket marked "TC". Workers ensured to wear sanitary gloves, face masks, and other PPE while doing this.
- Using a shovel, the contents of the trash chamber were removed and added to the bucket. A lid was then placed on the bucket to prevent foul odours and flies.
- Finally, the contents of the pit were collected using long scooping tools. They were placed in a separate bucket that was marked "PIT".

Fig 10: L-R, Opening and Removing Solid Waste from the Trash Chamber

At the end of the exercise, the Kanyama Water Trust team disinfected the place and mended the access hole at the rear of the toilet (Fig. 10 & 11).

Fig 11: Mending of the Access Hole at the End of Collecting Solid Waste

➢ *Procedure for the Cleaning and Sorting of the Solid Waste*

The cleaning, drying, and the sorting of the solid waste into categories was conducted at the Natural Resources Development College (NRDC), Department of Agricultural Engineering. This place was purposely selected due to the presence of a bio-digester at the Agricultural Engineering Department previous used by students to conduct research. It provided a place to hygienically dispose of the wastewater from the cleaning process.

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- *The Activities Involved During the Cleaning, Drying, and Categorisation of the Solid Waste Were as Follows:*

- The solid waste pieces in the bucket labelled TC were separated from each other using wire hooks based on their appearance as either fabric, plastic, paper, bottles, etc.
- Each piece was repeatedly washed and rinsed in clean water until all excreta was removed off them.
- The cleaned pieces were laid on a flat concrete floor inside a well-ventilated enclosure and left to dry for two weeks.
- At the end of the drying period, the waste was placed into categories comprising fabrics, plastics, bottles, paper, and others. Trace amounts of hair, cotton strands, etc., were also grouped under a category named Others.

The sequence of activities highlighted above was also followed during the cleaning, drying and categorisation of the solid waste that was collected from the pit.

- *Procedure for the Quantification of the Solid Waste Categories*

The mass of each solid waste category was measured using an electronic scale and recorded in a log book. The total mass M_t of all categories was computed by summing up the dry masses of the waste categories from both the trash chamber and pit using the Equation 3-5.

$$M_{total} = M_1 + M_2 + M_3 + \cdots M_n \quad (9)$$

Where:
M_1 ,M_2 , M_3 , … M_n., are dry masses of categories 1, 2, 3, up to the *n*th category.

The masses of categories were calculated as percentages of the total mass of collected solid waste using the equation

$$\text{Percent proportion} = \frac{\text{Mass of category}}{M_{total}} \times 100 \quad (10)$$

The results obtained were entered in Microsoft Excel and manipulated to generate graphs and charts for easy representation.

- *Determining the Effectiveness of the Screening System*

A mass balance of the solid wastes over the screen was carried out to determine the effectiveness of the screening system. It was taken as a measure of the quantity of the solid waste captured by the screening unit, expressed as a percentage of the total quantity of solid wastes that collected in both the trash chamber and pit latrine. Mathematically,

$$M_{iSW} = M_{PV} + M_{TC} \quad (11)$$

Where:

M_{iSW} = mass of SWs that entered the pit (in g)
M_{PV} = mass of SWs in the pit (in g)
M_{TC} = mass of SWs that collected in the trash chamber (in g)

Since the solid waste was accumulated over a period of 120 days, the terms of Equation 3-3 converted to mass flow rates. The measurements were carried out on a dry basis. The overall efficiency of the screening system was then calculated as,

$$\text{Percentage effectiveness} = \frac{M_{TC}}{M_{PV}+M_{TC}} \times 100 \quad (12)$$

IV. PRESENTATION OF FINDINGS, ANALYSIS AND INTERPRETATION

As indicated, the study aimed to design, develop, and test an infrastructure intervention for the exclusion of solid waste in pit latrine faecal sludge. The study collected quantitative data using experiment methods. Data analysis and presentation was done using Microsoft Excel 2016. The sections that follow discuss the results in relation to the study objectives.

A. *Background Information of Study Participants*

The study participants were those that used the toilet during the course of the study. Information concerning their age and gender was collected because it was essential in order to explain any subsequent trends that would be observed from other collected data. The gender distribution of the participants is as shown in Table 2. clearly, there were more females compared to males.

Table 2: Age Distribution of the Toilet Users

Age	Frequency	Percent
Below 12 years	3	15%
13 to 19 years	8	40%
Over 20 years	9	45%
TOTAL	20	100%

Source: Designed by Author

From a total of 20 individuals, 45% were over the age of 20 years, 40% between 13 and 19, and 15% were below the age of 12 years. Teenagers and those above 20 years represented 85% of the toilet users.

Table 3 represents the gender distribution of the participants. Females accounted for 80% of the users, with the remaining 20% being male.

Table 3: Gender Distribution of the Toilet Users

Gender	Frequency	Percent
Male	4	20%
Female	16	80%
TOTAL	20	100%

Source: Designed by Author

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B. Design of the Pit Latrine

Figure 12 shows some photos of the pit latrine during the construction phase. The sides of the excavated pit were lined bottom to top with 6-inch concrete block and plastered. The first three courses of the lining had opening left in them to allow liquids to infiltrate in the surround soil.

Fig 12: Stages of the Pit Latrine's Construction

➢ *Determining the Volume for FS Accumulation*

Table 4 gives a summary of the calculations used to determine the volume for faecal sludge accumulation. Using 90 litres per person per year as the faecal sludge accumulation rate for 20 users over a design period of one year, the volume for faecal sludge accumulation was found to be 1.80 cubic metres (Rottier & Ince, 2003).

Table 4: Sludge Accumulation Volume

Parameter Description	Value
Per capita faecal sludge accumulation rate, R (m^3/person/year)	0.09
Number of toilet users, N	20
Design life of the pit (in years), Y	1
Volume for sludge accumulation, (m^3)	1.80

Source: Rottier & Ince (2003)

➢ *Volume of the Excavated Pit*

Table 5 represents how the overall dimensions of the pit to be excavated were arrived at. Based on the space available at the study site, a square pit measuring 1.4 by 1.4 metres was excavated to a depth of 1.5 metres. This depth was initially calculated as 1.488 metres using the volume for faecal sludge accumulation reported in Table 4 but rounded up to 1.50 meters. To this was added a 0.5 metres allowance below slab level against faecal sludge overflow (Rottier & Ince, 2003). Consequently, the depth increased to 2.0 metres.

The pit's total excavated volume was then found to be 3.92 cubic meters. After the pit's sides were lined with 6-inch concrete blocks, the interior volume was found to be 2.42 cubic metres.

To provide space for the installation of the screening unit, the toilet slab was raised above ground level by 0.6 metres.

Table 5: Size of the Excavated Pit

Pit Dimensions	External (M)	Wall Lining (M)	Internal (M)
Length	1.4	0.3	1.40
Width	1.4	0.3	0.30
Depth	2.0	-	1.10
Volume	3.92		2.42

Source: Designed by Author

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C. SW Composition from the Trash Chamber and Pit Latrine Vault

Solid waste composition values were determined from the dry mass measurements of the solid wastes collected from the trash chamber and pit latrine vault. An electronic balance, with an uncertainty of ±0.1 grams was used as shown in Figure 13. Appropriate rules regarding uncertainties in measurements were followed to arrive at final values of all calculations.

Fig 13: Mass Measurement of SW using an Electronic Balance

➢ *Composition of SW from the Trash Chamber*

Figure 14 shows a summary of the percent compositions of the different solid waste materials that were collected from the trash chamber. According to the results, fabrics were the most dominant type of waste, with a composition of 72.42±0.06%, followed by paper at 10.6±0.4% paper, plastics at 7.6±0.6%, bottles at 7.2±0.6%, and others at 2.3±2.0%.

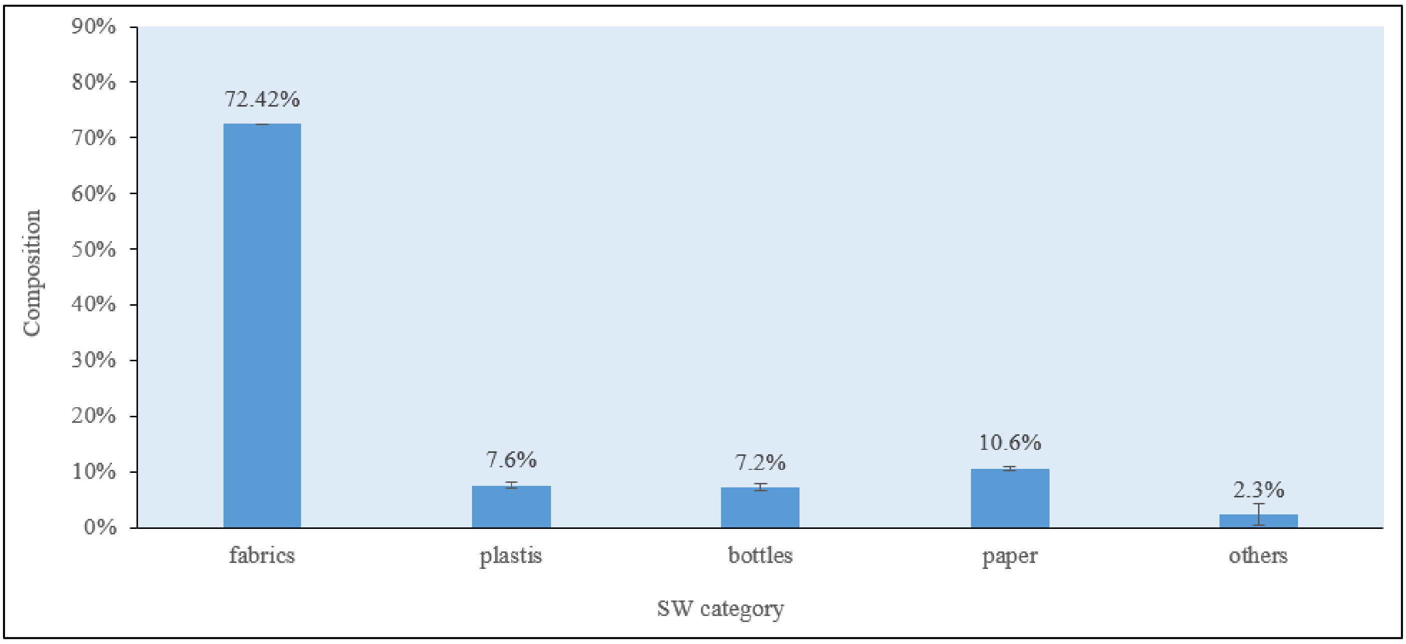

Fig 14: Screening Unit Solid Waste Composition

➢ *Composition of SW from the Pit Latrine Vault*

Figure 15 represents the percent composition of the solid waste items that were collected from the pit latrine vault. The results showed that 61.1±0.5% of the solid waste was paper waste. Plastics came in second, making up 16.8±2.0% of the waste, followed by others and fabrics, which made up 11.2±2.9% and 10.9±3.0%, respectively.

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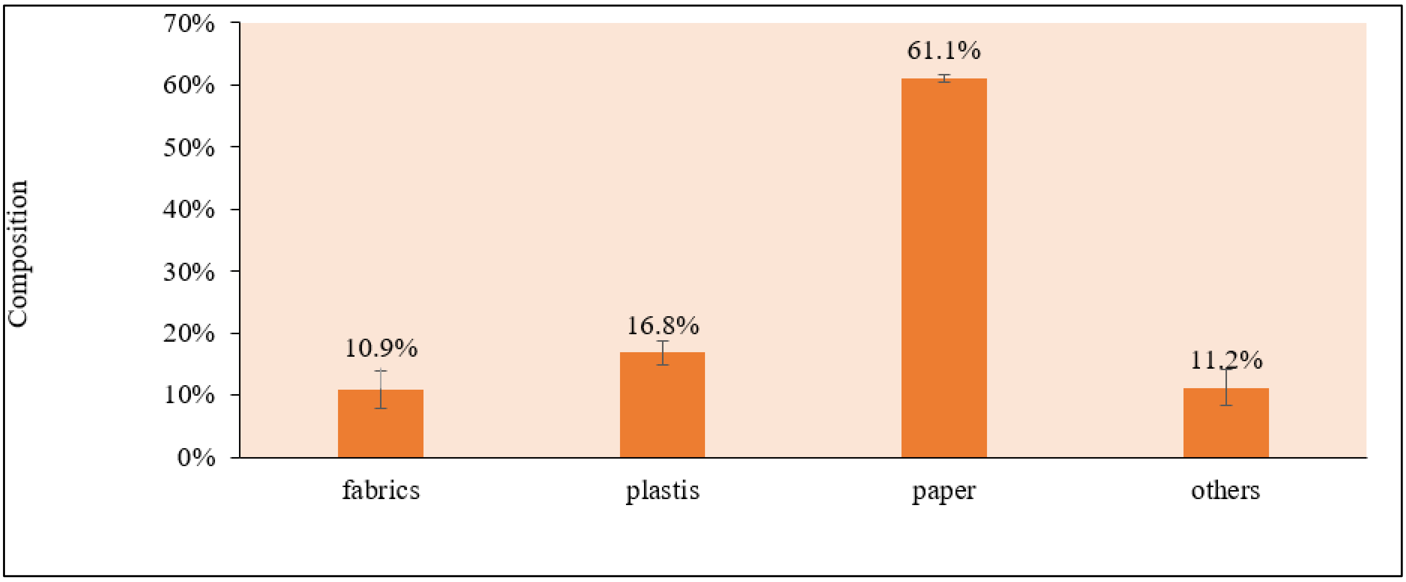

Fig 15: Pit Vault Solid Waste Composition

➢ *Comparison of the Quantities of SW from the Trash Chamber and Pit Vault*

Figure 16 shows a comparison of the proportions of the different solid waste categories found in the trash chamber and the pit, expressed as percentages of the sum of each category.

It is clear from the results that fabrics were more predominant in the trash chamber, standing at 98%, followed plastics at 77%, paper at 56%, and 60% as other minor wastes.

The proportion of bottles in the trash chamber is shown as 100% because there were no bottles that entered the pit. As a result, there was zero percent bottles in the pit.

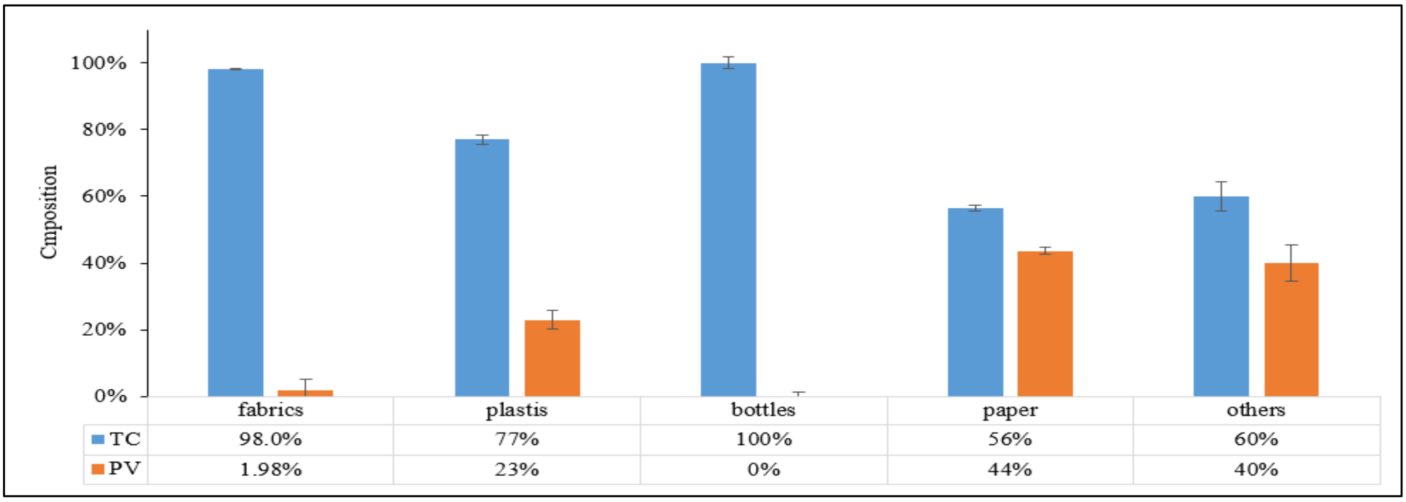

Fig 16: Comparison of SW from Trash Chamber and Pit

➢ *Determination of the Effectiveness of the Screening Unit*

The effectiveness of the screening system was taken as the measure of the amount of the solid waste that got intercepted by the screening unit, expressed as a percentage of the total mass of solid wastes that collected in both the trash chamber (TC) and pit latrine vault (PV). Table 6 gives a summary of the analysis.

Table 6: Composition of Solid Waste Category

	Mass of SWs (in grams±0.1g)					**Total (grams)**	**Proportion (%)**
	Fabrics	**Plastics**	**Bottles**	**Paper**	**Others**		
TC	163.6	17.1	16.2	23.9	5.1	225.9±0.5	88.17±0.6
PV	3.3	5.1	0.0	18.5	3.4	30.3±0.4	11.83±2
SUM	166.9	22.2	16.2	42.4	8.5	256.2±0.9	100%

Source: Designed by Author

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From Table 6, the screening unit was found to be 88.2±0.6 % effective. The 11.83 % proportion represented the quantity of solid wastes that managed to go through the screening unit and collected in the pit latrine vault.

V. SUMMARY, CONCLUSIONS AND RECOMMENDATION

A. Summary of Findings

The high percentage of fabric waste included items such as used facemasks, shower caps, undergarments, and fragments of "chitenge" cloth. After further physical inspections of the fragments of “chitenge” pieces, it was discovered that they were comparable in size and shape. This revelation suggested that they could have had a common use. The fact that 80% of the users were female (Table 3) it was likely that they used them as menstrual pads. The “chitenge” pieces must have provided a cheaper alternative to conventional menstrual pads. The need for secrecy when it came to menstruation must have compelled the female users to dispose of them in the pit latrine because it provided some level of privacy.

The observation on high fabrics content was consistent with the findings of Gyasi et al. (2021), in which gender or sex of users was reported as one of the underpinning factors that influenced the disposal of solid waste in pit latrines. Their study reviewed that toilets in which women were the majority users were more prone to be laden with solid wastes, especially menstrual products. This was because the latrines provided a perfect place for women to conceal menstrual hygiene items that would ordinarily not be disposed of in a regular trash bin. The study reasoned that privacy concerns and fear of having their menstrual products used in rituals played a significant role in influencing women behavior when it came to sanitation.

Similarly, in a study by Tembo et al (2019) on faecal sludge characterization, high fabrics (textiles) content of 54.4 ± 13.3% was reported. Of all the toilets sampled during their study, fabrics were the majority per latrine compared to all the other wastes. The study attributed the high fabrics compositions to socio-cultural perceptions and socioeconomic conditions prevalent among pit latrine users. For example, the stigmatization of menstruation in the majority of Zambian cultures such that pads and other menstrual products are to be disposed of in a way that ensures maximum discretion is one of the leading causes of solid waste in pit latrines. Additionally, the study stated that the absence of functional solid waste management systems in peri-urban areas, and the lack of sensitisation on good hygiene practices all contributed to the disposal of solid waste in pit latrines.

From the results, plastics had the second highest percentage composition next to fabric waste. This was somewhat anticipated and is consistent with the findings of other studies (Gyasi et al., 2021; Tembo et al., 2019;). The trend is like this because plastics are extensively used in packaging, hygienic products and everyday items. Some of the plastics could have been used as wrapping materials for pubic hair, which cannot orderly be disposed of in regular trash bins. The presence of plastics simply signified that there was still limited awareness among toilet users of the adverse impacts of indiscriminate dumping of plastics in pit latrines among toilet users. It also suggested that more still had to be done in terms of community sensitisation on sound sanitation practices in the pit latrine.

Paper had the third highest percent composition after plastics. This was to be expected because, as an anal cleansing material, it is often disposed of in pit latrines after use (Zuma et al., 2015). Tissue was the main material found besides newspaper and other types of paper. A bit of soft cardboard was also found. The presence of a variety of paper types other than the normal tissue paper suggested that the choice of using non-tissue paper was mostly economical seeing that the users came from a low-income community.

The composition of the bottles included small empty lotion bottles such as those for Vaseline Blue Seal and Glycerin Lotion, and a few disposable drink bottles. Since the toilet was also used as a bathroom, these would have been thrown in it as people bathed. Some people would have applied lotion before leaving the bathroom and so, threw any bottles that ran out of lotion. In terms of solid waste prevention, the system showed a 100% prevention rate of bottles reaching the pit vault.

Lastly, the category labelled “Others” consisted of materials that was either so small size or number such that they could not be categorised as distinct items. These included items such as razor blades, gum, strands of hair, and broken pieces of soap that easily slip away into the pit latrine.

B. Conclusion

The aim of the study was to design, develop and test an infrastructure intervention for the exclusion of solid waste in pit latrine faecal sludge. This was accomplished. The solid waste screening system was designed, fabricated, and installed on a tailor-made pit latrine. The pit latrine was used for a period of 120 days after which a quantitative analysis of material flow across the screening unit was done using experimental methods. The results showed the system was 88.2±0.6 % effective in retaining solid wastes. This showed that there was a significant proportion of solid waste intercepted by the screening unit, with fabrics accounting for the majority of the solid waste content. These findings make it clear that in the absence of such a system, these wastes would have found themselves mingled with faecal sludge, negatively impacting pit emptying and other subsequent processes at treatment facilities, disposal sites, and energy recovery processes. Although the intervention has no impact on existing pit latrines, its application can go a long way in mitigating the effects of solid waste in pit latrine faecal sludge in newly constructed toilets.

C. Recommendation

The major limitation of the study was that it would not be conducted on a good number of pit latrines. This was due to limited monetary resources required to construct new toilets as it was not possible to incorporate the system on existing toilet structures. One way of overcoming the limitation is by allowing the study to be conducted by a group of three or more students, who would commit to construct a toilet each. Results from all the toilets can then be analysed collectively.

Although the system is meant to trap solid wastes, it does not encourage people to throw trash in toilets. Otherwise, the mesh would be overloaded and crush under the weight of trapped debris. For the system to work effectively, there is need to intensify measures meant to improve pit latrine sanitation. User education through community sensitizations concerning good sanitation practices must be supported as much as possible. It is further recommended that construction of pit latrines be regulated to ensure the incorporation of a solid waste screening units. Overall, there is need to improve solid waste management services in peri-urban areas to encourage people to appropriately dispose of their waste. To ensure that such actions are implemented successfully, a responsive regulatory structure is ultimately necessary.

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