Waterlines, 40:1, 73–88
<http://dx.doi.org/10.3362/1756-3488.20-00003>

Improving management of manually emptied pit latrine waste in Nairobi's urban informal settlements

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Abstract: *Sanergy has offered reliable, non-sewered sanitation services in Nairobi, Kenya through the implementation of container-based, urine-diverting dry toilets. However, there remains a large volume of untreated faecal waste in urban informal settlements due to poorly managed pit latrines. With limited space in the settlements to bury old pits and dig new ones, management of faecal sludge requires manual pit emptying and safe discharge. Sanergy piloted the Mtaa Fresh project in the settlement of Mukuru Kwa Njenga, establishing a waste transfer station where manual pit emptiers could safely and reliably dispose of pit latrine contents. The most important factors in the successful implementation of this station were, first, the relationship established between Sanergy and the pit emptiers and, second, Sanergy's commitment to iterating as new insights emerged. The relationship with the emptiers impacted the location, design, and adoption of the site, and aided in the formalization of a pit emptiers' community-based organization. The commitment to iterating enabled Sanergy to respond to learnings gained from the emptiers. Additional factors that ensured the success of Mtaa Fresh included the implementation of full-time staff, security when the site is closed, support from local authorities, and an expansion to improve management of faecal sludge and trash. Improvements trialled during the expansion aim to minimize operation and maintenance costs, but sustainability will still rely on government support and external funding.*

Keywords: pit sludge, urban slums, environmental impact, pit emptiers, faecal sludge management, transfer station

More than 85 per cent of Kenya's urban poor lack access to basic sanitation, and more than 50 per cent lack access to improved sanitation (Ministry of Health, 2016; WHO and UNICEF, 2017). Among this population, it is estimated that up to 80 per cent of Kenyans use pit latrines (Ministry of Health, 2016; Kamau and

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Njiru, 2018), the most common form of sanitation for urban poor in sub-Saharan Africa (Banerjee et al., 2008; Thye et al., 2011; Katukiza et al., 2012; Jenkins et al., 2015; Peal et al., 2015; Nakagiri et al., 2016).

Improved sanitation facilities are those which hygienically separate faecal sludge from the users (UNICEF and WHO, 2008). Though many types of pit latrines are considered improved sanitation services, poor management and inadequate faecal sludge disposal may result in the reclassification of many pits as unimproved (UNICEF and WHO, 2008; Graham and Polizzotto, 2013). Unfortunately, managing pit latrine sludge poses serious challenges as pits are frequently difficult to reach and are often poorly constructed. Overflow of latrines into the environment is common as full latrines are frequently left to flood out in lieu of being emptied (Jenkins et al., 2015; Nakagiri et al., 2016). Improper management of sludge from these pits can severely impact the health of users, the community, and the environment by spreading disease and contaminating groundwater and drinking water sources (Graham and Polizzotto, 2013). These health issues are exacerbated in urban informal settlements where population density, poor access to services, and low incomes already impact the community (Klingel et al., 2002; Collender, 2011).

Pit latrines can be safely and sustainably managed with proper containment, collection, treatment, and safe reuse or disposal (Katukiza et al., 2012). While burying of pit latrines is considered safe disposal, space to dig new pits is becoming increasingly limited particularly in urban informal settlements (Isunju et al., 2011; Peal et al., 2015). Most settlements struggle with safely managed sanitation because municipal services for residents in urban slums are insufficient, and proper transport, treatment, and management of faecal sludge are often neglected in sanitation planning (Klingel et al., 2002; Isunju et al., 2011; Peal et al., 2015; Nakagiri et al., 2016; Mansour et al., 2017). With continued reliance on pit latrines and increasing populations in urban informal settlements, there is a demand for improved management of pit latrine sludge.

Sanergy's Mtaa Fresh Project in Mukuru Kwa Njenga

Sanergy, an organization launched in 2011, operates in 11 of Nairobi's informal settlements by providing safe, non-sewered sanitation products and services. Sanergy and its Kenyan operating subsidiary, Fresh Life, established their brand through the introduction of Fresh Life Toilets: container-based, urine-diverting dry toilets franchised to local entrepreneurs, landlords, schools, and other community institutions. Faecal matter from these toilets is safely collected, transported out of the community, and sustainably converted into organic fertilizer and animal feed. By the end of 2019, Fresh Life Toilets were serving approximately 120,000 people every day (Sanergy, no date).

While Fresh Life Toilets are an effective sanitation service ensuring safe management from collection to reuse, a large volume of faecal sludge is left untreated in communities due to poorly managed pit latrines. In 2017, a shit flow diagram (SFD) of Nairobi was developed by government stakeholders, the African Population and Health Research Centre, and Sanergy to represent faecal

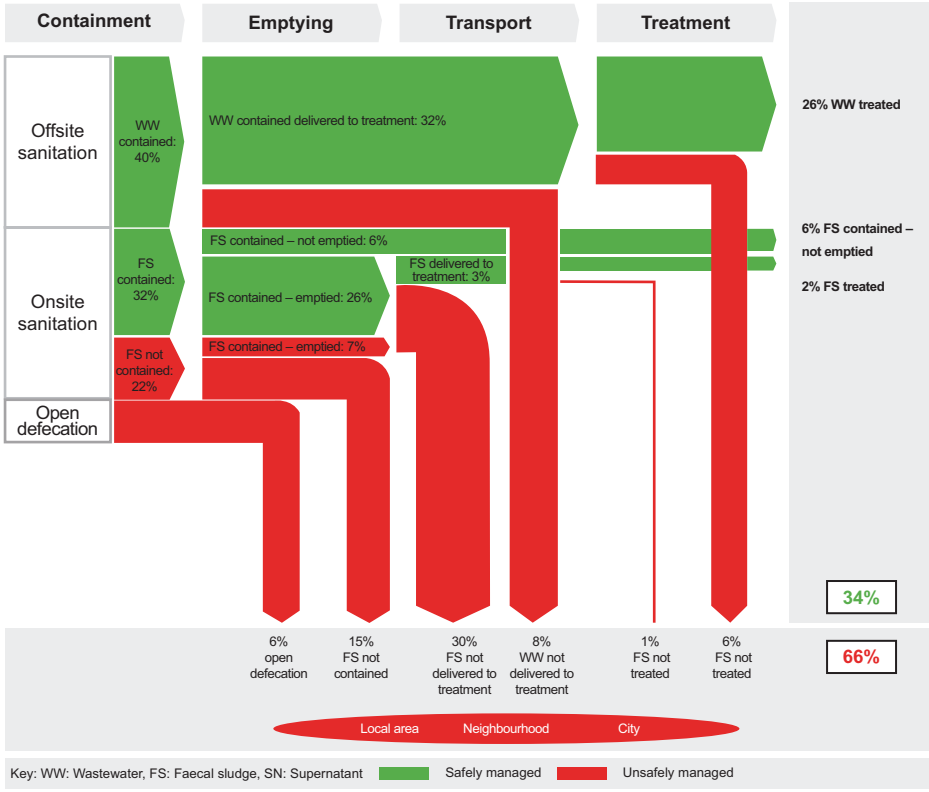

Figure 1 2017 shit flow diagram for Nairobi, Kenya; 30 per cent of faecal sludge from onsite sanitation services never reaches treatment facilities
Source: Adapted from Dewhurst, 2018

sludge and wastewater management within the city (Dewhurst, 2018). The SFD (Figure 1) showed that sustainable sanitation coverage in the city was low, and only 34 per cent of human waste was safely managed. Additionally, the SFD identified a large gap in the safe management of faecal sludge from onsite sanitation services, including pit latrines, which rarely reaches treatment facilities (Peal et al., 2015; Dewhurst, 2018).

There are over 150 informal settlements in Nairobi which are home to approximately 60–70 per cent of all residents in the city (Mukuru Situational Analysis, 2017; Kamau and Njiru, 2018). Mukuru Kwa Njenga, one settlement where Sanergy operates, has a population exceeding 113,000 people over 274 acres (111 ha) (Mukuru Situational Analysis, 2017). On average, 547 people share one public toilet while only 1 per cent of residents have access to private in-home toilets (Mukuru Situational Analysis, 2017).

Pit latrines in Mukuru Kwa Njenga fill up quickly because of the high population density, and space to build new pit latrines is not available. Because the pits are often inaccessible by exhauster trucks or other forms of improved collection and transport,

Photo 1 Ambulances used by manual pit emptiers to transport latrine contents. Placing the barrels on modified handcarts warps the barrel shape. Lids no longer fit, and emptiers use tarps to contain the contents of the barrel

emptiers are hired to manually remove the sludge using buckets and scoops. The emptiers subsequently transport the sludge through the slum in 'ambulances': 200-L barrels in modified handcarts (Photo 1). No legal discharge locations are available in the area, therefore local government officials, known as chiefs, unofficially designate specific locations and hours for dumping into the environment to minimize both hazards to the community and penalties for the emptiers. This is not mandated through any legal framework: though the government would normally designate disposal sites (Republic of Kenya, 1999), this is not true in Mukuru Kwa Njenga where land tenure issues exist from partial private ownership in the 1980s (Mukuru Situational Analysis, 2017).

Though manual pit emptying is considered illegal by many local authorities (Mansour et al., 2017), it is commonly accepted as a necessity in settlements where there are no viable alternatives. There are few laws or regulations governing non-sewered sanitation systems in Kenya, and many of those are not applicable to the sprawling informal settlements growing on the fringes of major cities (Mansour et al., 2017). Though past legal frameworks did not include onsite sanitation,

recent policies such as the Kenya Environmental Sanitation and Hygiene Policy 2016–2030 recognized the need for utilities to support emptying and encouraged public-private partnerships for improved sanitation delivery (Ministry of Health, 2016). However, appropriate guidelines for pit emptying are preliminary, and emphasis is still placed on the adoption of technologies such as urine-diverting toilets rather than on improving pit emptying practices (Ministry of Health, 2016; Mansour et al., 2017).

Driven by a commitment to improve the safe management of faecal sludge in the community, Sanergy piloted the Mtaa Fresh or 'Fresh Neighbourhood' project. The project aimed to redirect pit sludge into the safe sanitation value chain at the intersection of pit latrine emptying and sludge discharge, drawing on previous work by Water and Sanitation for the Urban Poor (WSUP) to support safe manual emptying in Kisumu, Kenya (WSUP, 2018). This began as a single intervention to provide a waste transfer station where pit emptiers could dispose of faecal sludge safely and sustainably rather than discharging into the environment. Through an iterative learning process, Mtaa Fresh became a multi-pronged approach to safely managing all waste within Mukuru Kwa Njenga including formalizing and organizing the pit emptiers and creating a subscription model through which landlords could pay to have their pit latrines emptied on a regular basis. This case study outlines the steps taken in this project (Figure 2), key learnings, and recommendations for practitioners hoping to establish a transfer station.

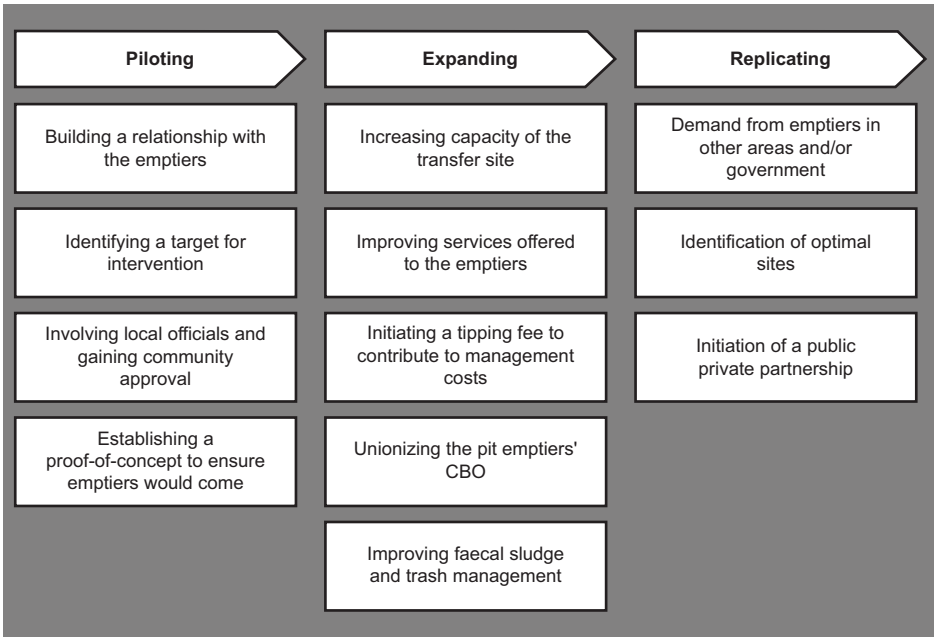

Figure 2 The steps taken in each stage of the Mtaa Fresh project

Piloting Mtaa Fresh

Building a relationship with the pit emptiers

Sanergy piloted the Mtaa Fresh project using a human-centred design approach. The first step was engaging the pit emptiers in Mukuru Kwa Njenga to identify their current methods and processes and to understand the existing gaps. The head emptier of Riara, one of the many neighbourhoods in the area, was identified and consulted on pit emptier behaviours, tipping methods, dumping sites, and general preferences:

- The emptiers worked in teams with lead emptiers, established areas of operation, and specific hours during which they collected and dumped the untreated faecal sludge.
- The emptiers dumped the sludge in rivers or nearby ditches, locations which were unofficially condoned by the local chiefs and community leaders.
- Payment from landlords varied based on factors such as the difficulty in reaching and emptying the pit, the distance from the pit to the dumping site, and the volume of sludge removed.

Manual pit emptiers were at risk of many hazards, including risk of assault and other physical injury. They were also frequently subject to arrest and paid bribes to local authorities or youth groups for dumping the faecal sludge. Emptiers would often drink alcohol or take other substances while working and developed a reputation for unreliability. Little or no protective equipment was worn during emptying, and health and hygiene behaviours were not regularly practised leading to high rates of exposure to raw faecal waste.

In listening to the pit emptiers and observing their processes, Sanergy began to understand their needs and motivations which were not met in the current system. This relationship contributed greatly to the design and maintenance of the transfer station where they could consistently and safely dispose of pit sludge.

Connecting with local government and the community

After discussions with the pit emptiers, Sanergy approached local officials regarding the Mtaa Fresh project. Sanergy proposed the idea of a transfer station as a safe alternative for emptiers to discharge the pit latrine contents, a solution which the chief and the community supported. Additionally, Sanergy met with the public health officer and environmental office of Mukuru Kwa Njenga where Sanergy's idea for a transfer station was readily accepted. Consultation with the National Environment Management Authority (NEMA) of Kenya was unnecessary at this stage.

Developing a proof-of-concept

In 2017, a pilot site was constructed as a minimum viable product to determine if the emptiers would use the service. Sanergy selected an initial site in the Riara neighbourhood of Mukuru Kwa Njenga (Figure 3) to meet criteria determined through engagement with the emptiers. The site was designed to require as little

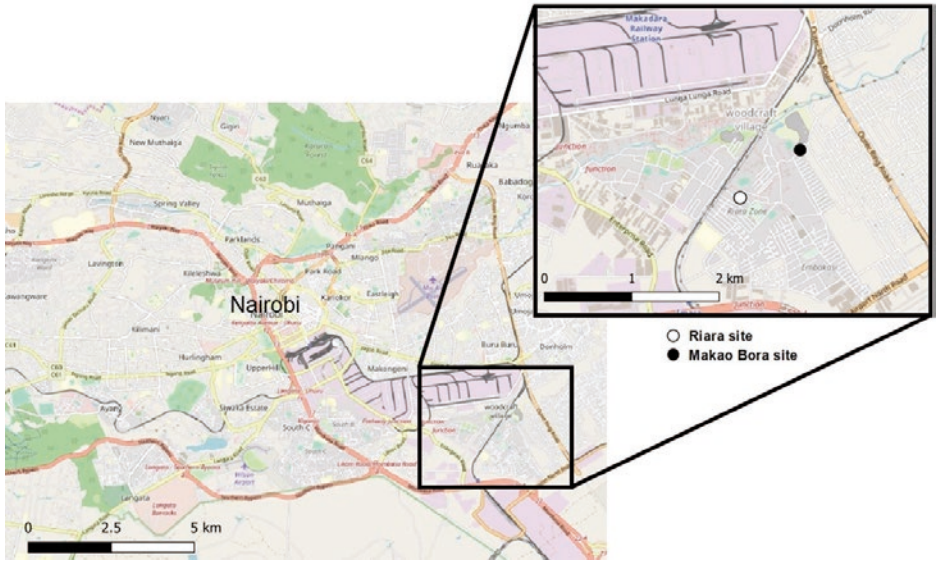

Figure 3 Locations of the Mtaa Fresh project in Mukuru Kwa Njenga

behaviour change from the emptiers as possible: a spherical 2,000-L plastic holding tank (1.49 m high, 1.6 m dia.) was sunk below ground to ensure that emptiers could dispose of the pit sludge with their current equipment and tipping methods, and the site was open from 6 p.m. to 6 a.m. to accommodate what were thought to be the emptiers' working hours. The site was free to use.

In the first 3 months, Sanergy was approached by additional pit emptying teams to use the site, and eight emptiers were recruited who consistently used the service. Throughout 2017, this number grew such that the pilot was serving 20 emptiers and receiving approximately 4,000 L of sludge every day. Sanergy staff were at the site daily to respond to the emptiers' needs; this customer-service relationship was an important factor in the success of the pilot. Furthermore, this site was essential in demonstrating to stakeholders the viability of the project, providing Sanergy with the credibility needed to scale the work.

A key learning of this pilot was that emptier input in the design did not ensure use of the site. The following are several findings that affected the operation of the site:

- Though some emptier teams worked at night, most did not. The original hours of operation greatly impacted use of the site.
- Though an exhauster company was consulted before site selection to confirm accessibility, the exhauster trucks struggled to access the site to empty the holding tank. This affected the reliability of the site as emptiers could not dump on occasion due to a full holding tank.
- The faecal sludge received at the site contained a large volume of trash which caused the holding tank to fill quickly and complicated tank emptying.

Through continuous improvement and quick corrective actions (e.g. changing the hours, providing a hose for the exhauster truck), the site operated successfully for one year.

Expanding and improving Mtaa Fresh

Increasing capacity and improving services

As use of the Riara transfer station increased, the pit emptiers began asking for a site with more capacity. Due to the emptiers' willingness to use the service and the potential for impact, Sanergy agreed to the investment. In 2018, Sanergy opened the site of Makao Bora (Figure 3) which was selected for its proximity to the emptiers' working areas and to the largest condoned dumping location. The new transfer station was designed to meet the emptiers' needs identified during the Riara pilot – convenience, reliability, and predictability – and to address the challenge of limited tank capacity. The site had an existing 28,000-L underground concrete holding tank (5.7 m by 2.7 m, 2.4 m high) which provided easy access for exhauster trucks. Amenities for pit emptiers were also introduced at the site, including a washing station for equipment and hands, a shower stall, and a gumboot cleaning pool.

Pit emptiers arriving at the site tip their ambulances to discharge the faecal sludge into the holding tank, rinse their equipment, and return to the pit latrine. The emptiers repeat this process until they have exhausted the number of barrels requested by the landlord. Once finished, the emptiers clean all their equipment at the transfer station and pay a tipping fee to the site attendants, discussed in the next section.

The sludge discharged from the ambulances passes through a double-mesh screen to capture trash before settling in the holding tank (Photo 2). The upper layer of sludge in the tank is removed approximately five times per week by exhauster truck which takes it to the Ruai Sewage Treatment Plant. Once a month, the settled solids are removed from the bottom of the tank by shovel and disposed of as hazardous waste. Trash captured by the screen is collected and stored until a garbage disposal company collects it for incineration. The transfer station operates Monday to Saturday with set daytime hours and full-time staff to aid the emptiers, manage the collected trash, maintain cleanliness of the site, and empty the holding tank. Cameras are also onsite and security staff work at night to maintain safety and ensure no trespassing occurs when the site is closed.

To date, over 4 million L of pit sludge have been safely transported and contained at Mtaa Fresh, reducing environmental contamination in the community. In 2020, NEMA approved the Mtaa Fresh site, and work has begun with NEMA, Nairobi Water and Sewerage Company, and Nairobi Metropolitan Services for further expansion and formalization. Monthly operation and maintenance costs exceed US$5,000.

Initiating a fee-for-service model

To garner support, use of the Makao Bora site was free for the first month. Sanergy then proposed a payment plan to the emptiers of KES 200 (approximately $2) per day to contribute to management costs of the site; however, this was refused by emptiers

Photo 2 Pit emptiers tipping their ambulances into the holding tank through the double-mesh screen while the transfer station operator collects faecal sludge for a laboratory study. Transfer station operators use water to flush any spills back into the holding tank

working less frequently than others who would have to pay a higher per-barrel rate. Subsequently, a 'tipping fee' of KES 30 per barrel ($0.30) was established. After 8 months, this fee was negotiated with the emptiers and increased to KES 50 ($0.50) per barrel.

Based on average waste received and related operational expenses, Sanergy would need to charge a per-barrel rate of over KES 400 ($4) to break even. This cost is not feasible for the emptiers as landlords pay them an average of KES 400 per barrel of sludge removed from the pit latrine, a price which depends on factors such as the distance from the pit to the closest ambulance parking or to the transfer station. Rather than increasing fees for the emptiers, focus is being placed on helping the emptiers increase revenue and reducing operational costs at the transfer station (outlined in the following sections).

The pit emptiers' willingness to pay for the service of discharging their ambulances at the transfer station was one of the most telling discoveries from the Mtaa Fresh project. The implementation of a tipping fee was possible as the emptiers were accustomed to paying bribes for illegal dumping, and because the new site offered value that aligned with the needs identified in the pilot. Setting a regular price per barrel shifted the emptiers' existing payment behaviour from occasional, but unpredictable bribes to a consistent, predictable price per barrel. By charging a fee to use the transfer station, Sanergy was able to manage the sludge more economically and afford more

amenities for the emptiers. Providing these additional services along with a safe location to discharge made paying the tipping fee a worthwhile expense.

Unionizing a community-based organization of pit emptiers

Through interactions with the pit emptiers, Sanergy learned that there was a community-based organization (CBO) of six emptiers. Sanergy and the local government provided support to this CBO to expand and improve the organization thereby legitimizing the profession. The emptiers drafted their own constitution and regulations for membership, barring drinking alcohol while working and establishing guidelines on hygiene behaviours. The CBO also required identifiable clothing while emptying to limit confrontations with the authorities, and Sanergy provided personal protective equipment to members of the CBO: branded coveralls, gloves, gumboots, and dust masks (Photo 3).

Past reviews of pit emptying in Kibera highlighted the emptiers' desire to have their work and the associated hazards acknowledged by the community (Eales, 2005). The symbiotic relationship between Sanergy and the CBO did that, providing the CBO with legitimacy in the eyes of the community and the government. The formalization of the CBO made the emptiers more disciplined which increased demand for their service, increased their earnings, and stopped arbitrary arrests by the local police. Out of 40 known emptiers in Mukuru Kwa Njenga, 26 agreed to the formalized CBO while the remaining 14 either changed professions or moved to another neighbourhood.

Photo 3 The pit emptiers on the day the CBO was formalized and personal protective equipment was distributed

Improving management and treatment

As of late 2019, expansion at Makao Bora began to improve management of the site and treatment of the sludge and trash, thereby minimizing operational costs and maintaining a cost-effective fee for the emptiers. Goals for the expansion include:

- providing space for the emptiers to store equipment at the site;
- cleaning and drying the collected trash to reduce the cost of disposal; and
- dewatering the faecal sludge and reducing the cost of emptying the holding tank.

Along with site improvements, additional work is being done to establish the pit emptiers' CBO as a self-sufficient entity capable of managing the service for landlords through scheduling without assistance from Sanergy.

The original site was designed solely as a holding and transfer facility; however, the expansion allows room for initial treatment of the faecal sludge through dewatering. Preliminary work is under way to test filtration through permeable membranes and mechanical dewatering based on similar faecal sludge treatment projects such as Sanivation's current work in Naivasha, Kenya (Sanivation, no date), and Pivot Works' past project in Kigali, Rwanda (Stringel, 2017). This dewatered sludge can then be included in Sanergy's existing transport, treatment, and reuse process, and the effluent can be disposed of in the sewer for co-treatment with wastewater, reducing costs from emptying the holding tank via exhauster truck.

Faecal sludge characteristics, particularly total solids (TS) content, can impact the success of transfer stations. Sludge with high TS (low water content) cannot be easily pumped or removed by exhauster trucks, while sludge with low TS (high water content) yields larger volumes to transport and manage. Average and median values of various faecal sludge characteristics are listed in Table 1, including TS, chemical oxygen demand (COD), ammonia content (NH_3^+), pH, and electrical conductivity (EC). To incorporate the faecal sludge into Sanergy's existing process, the sludge must be dewatered such that the TS content increases from a median of 2.2 per cent to approximately 25 per cent. Reducing the moisture content to these values can reduce the sludge volume by up to one-twelfth (Ingallinella et al., 2002), minimizing the cost of transporting the sludge to Sanergy's production facility.

Table 1 Characterization of fresh faecal sludge from pit latrines and settled sludge from the holding tank

	TS (%)		*COD (mg/g TS)*		*NH_3^+ (mg/g TS)*		*pH*		*EC (mS)*	
	Avg.	*Med.*	*Avg.*	*Med.*	*Avg.*	*Med.*	*Avg.*	*Med.*	*Avg.*	*Med.*
Pit latrines	3.07 ± 2.11	2.19	896 ± 347	907	167 ± 93.1	170.6	7.60 ± 0.43	7.65	22.2 ± 5.59	24.0
Holding tank	9.43 ± 2.69	10.0	901 ± 369	813	64.2 ± 39.6	54.1	7.58 ± 0.38	7.56	15.2 ± 3.30	15.7

To dewater the faecal sludge at Mtaa Fresh, trash management needs to be improved. A past study estimated that only 30 per cent of households in Africa have access to proper trash collection (Banerjee et al., 2008), which results in large amounts of garbage in pit latrines such as rags, bottles, and other solids. This trash prevents sludge removal by exhauster truck and makes treatment through Sanergy's existing process chain impossible. Future treatment of sludge requires it to be clear of all inorganic solids, therefore innovative solutions are necessary to remove the trash. Trash captured in faecal sludge must be incinerated which is priced according to weight; therefore processes to wash and dry the trash are currently being initiated to reduce the weight of the trash and enable disposal through alternative methods which will ultimately reduce the cost of operations.

Replicating the model

Results from the first years of the Mtaa Fresh project demonstrate a demand for transfer stations where emptiers can safely discharge pit sludge. Currently, the site only serves residents of Mukuru Kwa Njenga; however, there are requests from the Kenyan government and emptiers in other areas to install similar sites in other Nairobi informal settlements such as Kibera, Huruma, Mukuru Kwa Reuben, Kawangware, and Korogocho. Emptiers recognize that using these safe sites increases the financial stability, safety, and legitimacy of their work, and communities understand the benefit of reducing the amount of untreated pit sludge discharged into the environment.

In 2019, Sanergy received commitment from Kenya's Ministry of Water, Sanitation, and Irrigation to support replication of Mtaa Fresh in the settlements of Kibera and Huruma through a formal public–private partnership with the county government. This process was delayed due to the onset of COVID-19 and the transition of Nairobi's service delivery responsibilities to the national government through the newly created Nairobi Metropolitan Services (NMS). As of August 2020, NMS officials have conducted site visits to Mtaa Fresh and are engaged in discussions on a restructured memorandum of understanding and contract to support replication. The goal of these partnerships is to receive partial cost coverage for operation and maintenance of the two additional sites.

Current and future work are in line with upcoming regulations, including the Africa Sanitation Policy Guidelines (AMCOW, 2020) and similar work in development by the Eastern and Southern Africa Water and Sanitation (ESAWAS) Regulators Association (ESAWAS, no date). These guidelines emphasize not only the need for recognition of non-sewered sanitation and faecal sludge management in policy, but also the need for improvements across the entire sanitation value chain of containment, collection, treatment, and safe reuse or disposal.

Recommendations for global practitioners

There is both a need and a demand for improved management of pit sludge in urban settlements throughout sub-Saharan Africa that are heavily reliant on pit latrines (Banerjee et al., 2008; Jenkins et al., 2015; Peal et al., 2015; Chunga et al., 2016;

Nakagiri et al., 2017). Lack of space for new pits, poor emptying practices, and unsafe sludge disposal are major issues that can be partly rectified by establishing transfer stations in these areas. The provision of additional transfer stations affords an opportunity to capture more sludge for conversion while protecting an already disadvantaged community from exposure to pathogens from untreated faecal sludge.

Based on Sanergy's experience with the Mtaa Fresh project, the following are recommendations for the successful implementation of transfer stations:

- *Build a relationship with the local experts – the pit emptiers!* The emptiers are the experts in faecal sludge in their communities. Building trust with them is paramount in establishing a usable and sustainable transfer station that can be easily adopted into the emptiers' pre-existing process with minimal behaviour change. Through Mtaa Fresh, the emptiers were treated as paying customers with Sanergy staff available at site to provide customer support. Furthermore, the emptiers' expertise allowed Sanergy to save both time and money in researching, designing, and testing solutions. This relationship was hugely important in obtaining support from local authorities, and it has proved so fruitful that emptiers in other neighbourhoods are demanding Sanergy's services. Building this relationship can take time, and beginning this process needs to be the first step in such a project.
- *Identify a site location that ensures maximum adoption and adherence.* Typically, transfer station locations are chosen to minimize the cost of transporting the sludge from the collection site to the treatment site (Bovea et al., 2007); however, this does not account for user accessibility or community acceptance. Transfer sites can benefit pit emptiers by reducing the distance they need to travel to dispose of the sludge, which allows them to empty more and increase their income (Thye et al., 2011). Understanding this context and being able to provide an attractive and reliable disposal site for the emptiers can be one of the most important factors in successful implementation (Klingel et al., 2002; Ogwueleka, 2009). Given that illegally discharging sludge is 'free', it is important to choose a location that emptiers are likely to adopt readily and view as a benefit. Best practice involves selecting a site that is already used for disposal or near such a place so that emptiers do not need to change routes, as Sanergy did with the Makao Bora location. Furthermore, a location should be chosen to take advantage of easy access to water and power, two factors which can be difficult to find in informal settlements, as well as easy access for exhauster trucks if this is needed to maintain operations of the site. Another factor to consider in identifying a location is community acceptance, which can impact the success of the transfer station. The location should not negatively affect the community by being too close to restaurants, hotels, or similar businesses.
- *Design the transfer station using a human-centred design approach.* Use of the site and any treatment methods implemented should be designed with emptying practices in mind to ensure adoption. If pit emptiers must alter too many of their current practices immediately, they may be less inclined to

use the service. Furthermore, designs should consider the water table in the area and any other faecal sludge characteristics that might affect discharge, storage, and treatment. Finally, a human-centred design technique of rapid prototyping should be employed using low-cost, low-infrastructure pilots prior to scaling whenever possible.

- *Maintain proper operations and management of the transfer station.* Another key factor in ensuring the sustainability of a transfer station is to ensure proper operations and management (Klingel et al., 2002). This includes consistent and reliable exhaustion of the holding tank, if needed, to ensure that pit emptiers always have access to the site to discharge during hours of operations. Full-time staff and security are encouraged, especially if valuable items are to be stored at the site. If a tipping fee is required to cover related operational costs, then it should be negotiated with the emptiers, and focus should be on mitigating high costs and obtaining external funding as opposed to raising the fee. High fees may either prevent emptiers from using the site or make the process too expensive for landlords to afford. Several pricing structures were attempted in the Mtaa Fresh project, and a per-barrel rate had the most positive feedback from emptiers.
- *Garner government support.* Support from the government and local authorities is necessary when attempting to establish a transfer station. Though research is progressing on better trash and water management to decrease operational costs, sustainability will rely predominantly on government subsidies or external funding.

Acknowledgements

Sanergy would like to acknowledge the Government of Kenya; the Ministry of Water, Sanitation, and Irrigation; the Ministry of Public Health; and local government. Thank you to Dr Nicola Greene of OPERO Services Ltd for initial project design, and to the many Sanergy staff for their hard work throughout the years. Sanergy would also like to acknowledge Barbara J. Ward and Linda Strande of Eawag for their support in this project.

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