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TRANSFORMATION TOWARDS SUSTAINABLE AND RESILIENT WASH SERVICES

Alternative low-cost latrine option for rural and peri-urban communities

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The aim of the study was to develop a low-cost latrine that is suitable for use in the rural and peri-urban areas. The study assessed the key capital cost components of three commonly used on-site latrine technologies in Ghana (Ventilated Improved Pit, Traditional pour flush toilet, and Biofil toilet) which was used as basics for the design of a new low-cost latrine option. The study was conducted using field survey and field test. The results of the study revealed that, majority of latrine installation cost comes from pit lining, followed by pit excavation, cover slab, with pipe materials bearing the least cost. It was also found that installing the newly developed toilet technology saves 64 %, 62% and 83% of the cost of the Pour Flush toilet, VIP and Biofil toilet respectively.

Introduction

Sanitation is defined as: "the lowest-cost option for securing sustainable access to safe, hygienic and convenient facilities and services for excreta and sullage disposal that provides privacy and dignity while ensuring a clean and healthful living environment both at home and in the neighbourhood of Users" (UN, 2005) Sanitation facilities isolate human excreta from the environment thereby breaking the faecal-oral transmission chain associated with poor sanitation (WHO, 2014)

Improvement in sanitation coverage is a key element to improved health and Studies have shown that 90% sanitation coverage has an impact on community health (Ikin, 1994). Despite the enormous benefits derived from improved sanitation, the majority of the world's population still do not have access to improved latrine systems. After 25years of sanitation promotion during the MDG's period, the Joint Monitoring Project reports that 2.3 billion people of the world's population still lack access to improved sanitation among which 950 million still practice open defecation (WHO/UNICEF, 2015). According to the report, the majority of the people who lack access to improved sanitation live in the developing countries. WHO/UNICEF (2015).

Like other developing countries, access to sanitation services particularly household latrine is a major challenge in Ghana. It is estimated that 85% of the Ghanaian population does not have access to improved sanitation (WHO/UNICEF, 2015). This situation is frightening as 12.2 % of deaths in Ghana are reported to be sanitation and hygiene-related (Aalto et al., 2012). The key factors accounting for the low uptake of household latrines in the country has been attributed to factors such as the extensive use of public toilet, poverty, lack of space, high cost of latrine, operation and maintenance difficulties (Jenkins & Sugden, 2006; Keraita et al, 2013; Obeng et al., 2015). According to (Obeng et al., 2015), the high usage of shared latrines results from the high population densities leading to high demand for rental accommodation, with some landlords changing toilets to living rooms. Boot, (2008) also identified the lack of financial capacity to construct toilet facilities as one of the main challenges that hinder households from owning and sustaining household latrines. Research shows that it is difficult for household who survive on subsistence income to use the limited income earned to secure improved sanitation when they have lived their entire life without them (McConville, 2003; Oduro-Kwarteng et al., 2009). Even when they are aware of the benefits of sanitation, the perceived high cost of installation keeps several households from adopting household latrines (McConville, 2003). Even for those who have the resources to construct household latrine in their homes, the costs of operation and maintenance become a great concern to householders (McConville, 2003). The high cost of latrines particularly has created a barrier to consistent adoption of improved household latrine by the poor in the rural and peri-urban communities.

Looking at current sanitation coverage in Ghana, it is important for that the sanitation sector figure out the best way to deliver improved sanitation services to the poor in the rural and peri-urban communities without compromising public health, environmental health and safety standards. One means by which this can be achieved is by exploring different design modifications which could make latrine affordable for the poor to use. This research aims to develop a low-cost latrine that is suitable for use in the rural and peri-urban areas by making some modifications in some of the existing latrine technologies in Ghana. The study assessed the capital cost (in terms of construction materials) three existing on-site sanitation technologies and hence made some modifications to develop a low-cost option without compromising quality.

Study area

The study was conducted in, Donuaso, is a Peri-Urban community located in the Ejisu-Juabeng Municipality in the Ashanti Region of Ghana. The community is located at latitude 6˚42’0” N and longitude 1˚27’0” W at an elevation of 247 meters above sea level and has a population of 36,409 people. Majority of the people are engaged in Agriculture and other are craft and trade. The most common toilet facility used in the community is public toilet. Many households in the community also use pit latrine and these household latrines are usually shared (GSS, 2014).

Methodology

Three on-site sanitation technologies (Ventilated Improved Pit, (VIP) Pour Flush, and Biofil toilet) were selected for the for the cost assessment and comparison. These technologies were selected because they are the commonly used technologies and the ones being promoted in Rural and Peri-Urban communities by Non-Governmental Organizations (NGOs) and Institutions in sanitation sector of Ghana. In assessing the capital cost and identifying the major material costs component within the on-site latrine installation cost stream, Engineering estimates for the different toilet designs or technologies were developed. The cost information for the input materials and service rendering were obtained from retail shops, wholesale shops, and sanitation service providers. Upon assessing the material costs and Identifying the major cost components, a new or modified toilet technology was designed and built. The new toilet technology was designed taking into consideration the cost of construction and operation of the existing on-site sanitation technologies. In view of this, the technology was designed to reduce cost or to replace some of the cost components within the conventional on-site latrine technologies with low-cost options. Three of the new toilet technology was installed for households to use and the cost of the technology was compared with those of the conventional on-site latrines (pour flush, VIP and Biofil toilet) to ascertain the level of cost reduction. Microsoft Excel was used for the data analysis.

Results and discussions

Cost assessment of on-site sanitation technologies

The Table 1 shows the Engineering estimates of the On-Site latrine technologies that were assessed and the major components that contributed to the overall estimated material cost.

Table 1. Engineering estimates of on-site sanitation technologies

Engineering estimates for toilet technologies						
Volume of pit			4.2m^3			
Area			1.5			
Total depth of pit			2.5			
	POUR FLUSH			VIP		
Item description	**QTY**	**UNITS**	**AMOUNT (GH₵)**	**QTY**	**UNITS**	**AMOUNT (GH₵)**

Pit digging and lining						
Pit Excavations	1		450			450
Concrete bricks (150x225x450mm)	123	No	431	123	No	431
Cement (50Kgs bag)	3	Bags	105	3	Bags	105
Sand	2	m^3	140	2	m^3	140
Subtotal of pit and pit lining			**1126**			**1126**
Cover Slab(Thickness-5-10cm)						
Cement (50Kgs bag)	1	Bag	35	1	Bag	35
Sand	0.5	m^3	20	1	m^3	40
Aggregate	1	m^3	70	1	m^3	70
Wood Board	4	pcs	48	4	pcs	48
Reinforcement (iron rod and binding wire)	8	pcs	128	8	pcs	128
Subtotal of cover slab			**301**			**321**
Pipe Materials and Toilet seat						
PVC Pipes	1	Set	42	1	Set	35
Water-sealed Squatting bowl	1	Set	100			
Subtotal of pipe materials			142			35
TOTAL			**1569**			**1482**
Engineering estimates for Biofil Digester						
Dimension	**60x60x180cm**					
Description of items	QTY		UNITS		AMOUNT (GH₵)	
Excavation	1.2		m^3		250	
Digester	1		set		2500	
Toilet seat and cistern	1		set		250	
Pipe materials (100mm)	20		m		300	
TOTAL					**3300**	

The estimated material costs of the toilet technologies ranged from GH₵ 1482 to GH₵ 3300 with VIP, Pour flush and Boifil digester costing GH₵ 1482, GH₵ 1569 and GH₵ 3300 respectively. The capital cost of the latrine technologies that were assessed excludes the superstructure. The costs of these latrine technologies (VIP Pour Flush and Biofil toilet) confirm the finding of the study conducted by the International Development Enterprise (IDE) where fifteen (15) different toilet technologies were assessed and concluded that the cost of installing the available toilet technologies in Ghana without the superstructure ranges between GH₵1500 to GH₵6500 (IDE, 2016). The key factors that could explains the differences in the costs of the latrine technologies are the differences in the latrine designs, the design requirements and the materials needed for the various designs. For instance, the pour flush latrine requires a water-seal trap to control odour while the VIP requires a sizable vent pipe to adequately control the odour that comes out from the system. According to Ulrich et al., (2016) such special design requirements can have a significant impact on the cost of the latrines.

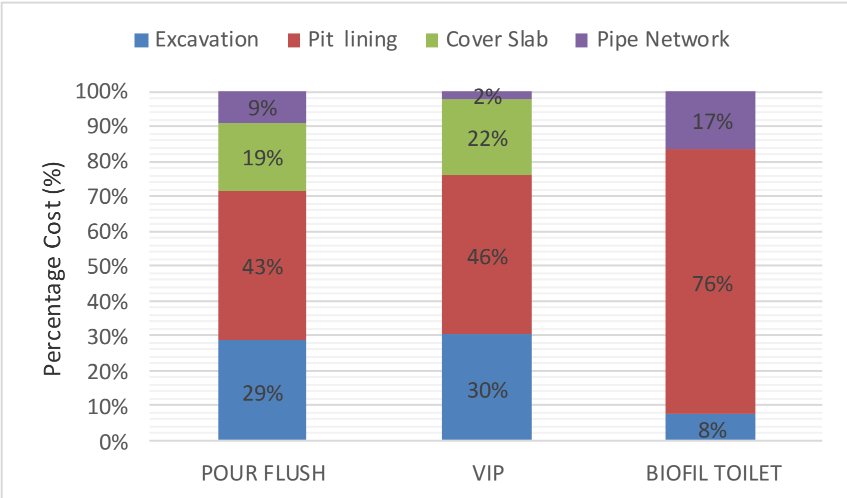

Figure 1. Percentage cost contribution of components to total costs of latrine technologies

Figure 1 shows the major cost components of On-Site latrine technologies and their percentage contribution to the total cost of the technologies. It was found that pit lining accounted for the highest percentage (ranging from 44% to 76%) of the components within the cost stream. The major material input for pit lining was sand, aggregate, cement, and blocks or bricks. A similar project conducted in Mauritania by Ulrich et al., (2015) revealed that the costs of lining material such as cement, bricks and steel accounted for 62-76% of the total cost of latrine installations. According to Ulrich et al., (2016) the prices of these lining materials keep increasing and are responsible for the high cost of latrines. It must, however, be noted that the Biofil toilet has a digester in place of a developed pit. The excavation of pit accounted for about 30% of the total cost of the substructure of On-Site latrines. This cost was, however, dependent on the depth of the pit (IDE, 2016). The cover slab which had the same input materials as the pit lining accounted for about 19% to 22% of the material cost. Depending on the type of toilet technology the cost of pipe materials constituted about 2% to 17% of the total capital cost. The cost of plumbing materials for the Biofil toilet accounted for 17% of the cost of installation while that the Pour flush and the VIP technologies accounted for 9% and 2% respectively.

Description of toilet technology

The New Latrine Technology is a water-dependent On-Site latrine designed to rapidly separate the liquid portion of excreta from the solid part. It employs a porous filter for the solid-liquid separation. To reduce cost without compromising performance the new technology replaces pit excavation, lining and cover slab which are the major cost components of On-Site latrines with two plastic containments of 240ℓ each with porous concrete fitted underneath. The containments are to be used alternatively and are connected to a soakaway using a 1m drain pipe. The key components of the new latrine technology include the containment system, a porous concrete plate, water-sealed pan, vent system, connecting pipes (inlet and outlet pipes) and a soakaway. The plastic barrel serves as excreta containment while the porous concrete separates the liquid portion of flushed excreta from the solid. The vent pipe provides an escape route for odour gases and the water-sealed pan prevents odour in the privy room. The soakaway also reduces the wastewater contaminants load that goes into the environment. The system was designed to ensure nutrients recycling (faecal sludge reuse), minimize water use, reduce the costs and eliminate the difficulties associated with deeper pit excavation. Assuming a faecal sludge accumulation rate of 0.03 m^3 /person/year, each barrel is expected to be full in eight (8) months period when used by ten (10) persons per day.

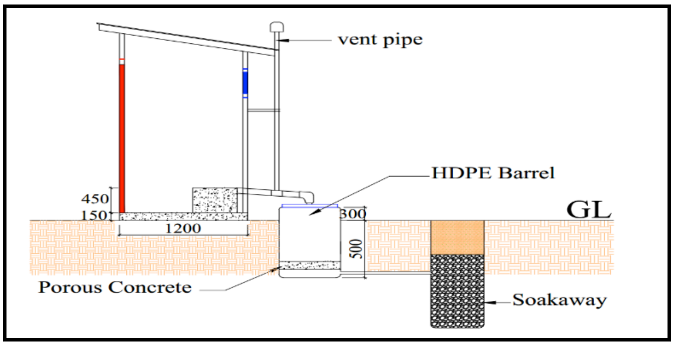

Figure 2. Schematic diagram of the new toilet technology

Maintenance and Feacal Sludge Management
The system does not require any manual or mechanical desludging and transport of faecal sludge to waste treatment plant. The purpose of the two-alternating containments is to ensure that the faecal sludge from the system is reused for agriculture purpose to fertilize soil and ensure nutrient recycling. The contents (faecal sludge) in the full containment is therefore expected to be sanitized with local additives (wood ash and sawdust). Upon switching the excreta containments, the excreta containing barrel is then filled with wood ash and sawdust. The content is then mixed thoroughly and regularly for the period of at least six (6) months. The additives are expected to increase the pH of the sludge, increase the C: N ratio, significantly reduce the pathogen load and bring the faecal sludge to a sanitized level for use as soil fertilizer (Monney & Awuah, 2016). For this reason, the nature of the barrels used were such that they would allow for easy storage, emptying and transport of sanitized faecal sludge to backyard garden or farm.

Comparison between existing latrines and new latrine technology

Table 2. Engineering estimates for new latrine technology

Engineering estimates for new toilet technology			
Components	**QTY(s)**	**UNIT**	**Amount (GHC**
HDPE Barrel	2	No	200
Water-sealed Squatting Bowl	1	No	100
Porous concrete	1	No	15
Cement	1	No	35
Sand	1	No	30
Blocks	8	No	28
Pipe Materials		90	
others			62
Total			**560**

Table 3. Cost comparison between new latrine and the conventional toilet technologies			
Latrine technologies	**Total cost(GHC)**	**New Latrine Cost**	**% Reduction**
Pour flush toilet	1569	560	64%
VIP	1482	560	62%
Biofil Toilet	3300	560	83%

The total cost for the new latrine technology is presented in Table 2. With the new toilet technology majority of the cost components of the substructure were from, the HD-PE barrel (36%), the toilet pan or water-sealed squatting bowl (18%) and the pipe materials (16%). The estimated total material costs for installing the substructure of the new latrine was about GH₵ 560.

Comparatively the capital cost of installing the new latrine technology is cheaper since it saves 64 %, 62% and 83% of the cost of the pour flush toilet, VIP and Biofil toilet respectively. The huge cost difference between the new toilet technology and the other three toilet technologies could be explained by the high cost of pit lining (Pour Flush and VIP) and the digester (in the case of the Biofil Toilet). As shown in Table 1 the cost of lining was GH₵ 676 for both the VIP and the Pour Flush and the Biofil digester cost about GH₵2500 which are all higher than the total cost (GH₵ 560) of the New Toilet Technology (Table 2). Although the cost differences between the total cost of the new technology and the cost of lining for the pour flush and the VIP latrine were not huge, there exists a huge cost difference between total cost of the new technology and the digester cost of the Biofil toilet. Even between the Biofil and the VIP or Pour flush the cost differences are enormous. This could be due to the fact that the Biofil digester is usually installed by the manufacturer at a fixed price of GH₵2500 for only the digester (IDE, 2016). As a result, Biofil toilet users usually do not have control over the cost of the technology.

On the cost involved in operating and maintaining these toilet technologies, the most significant costs associated with the VIP and the pour flush toilet are those incurred for pit emptying. However, these costs are dependent on the emptying method used and the extent to which adequate provision is made for easy transport of faecal sludge. It's been reported that there is no faecal sludge accumulation in the Biofil toilet due to the presence of the worms that feed on the faeces in the digester (Biofilcom). As a result, need no emptying of sludge. Just like the Biofil toilet, the new technology comes with no emptying cost. Faecal sludge generated from the system are to be sanitized and used as compost on farms and household gardens.

Conclusion

Assessing the capital costs of sanitation technologies provide a useful information for households' decision making. The key components that contribute to the overall material cost of on-site sanitation technologies were pit lining, pit excavation, cover slab and pipe materials Installing the new toilet technology save about two-thirds of the costs of the existing latrine technologies.

This study provides an alternative toilet technology for the poor since and adds to the range of potential technologies available to people in the rural and peri-urban areas. It must be noted that even though the system is still in the experimental stage, there are evidence of better service delivery (in terms of odour and insects' nuisance, heat, and groundwater pollution) compared with the VIP and pour-flush and also high user satisfaction.

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