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Alternatives in ecological sanitation: a comparison of systems in Uganda

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Ecological Sanitation (Eco-San) systems are designed to recover nutrients and organic matter from human urine and faeces. Eco-San systems, especially Urine-Diverting Dry Toilets (UDDTs), have been promoted in Uganda since 1997. However, uptake remains low, and pit latrines continue to be the most common sanitation technology in the country. This paper provides a general comparison of pit latrines, UDDTs, and an alternative Eco-San option known as the sawdust bucket system. The comparison accounts for several factors related to installation, operation, user comfort, and technical issues. The two Eco-San systems were found to provide benefits beyond those of pit latrines, and the bucket system was the most favourable of the three. However, each Eco-San system has distinct advantages in different contexts, and it is recommended that multiple Eco-San options be promoted. Given freedom of choice, consumers can select the option most appropriate for their specific contexts and needs.

Introduction

Ecological Sanitation (Eco-San) systems are designed to recover nutrients and organic matter from human urine and faeces for use as agricultural amendments (Esrey et al., 2001). Wider implementation of these systems could help to address concerning trends in countries such as Uganda, where declining soil fertility is jeopardizing the nutritional security of a rapidly growing population (NEMA, 2010).

In Uganda, promotion of Eco-San systems began in 1997 in the southwestern region. Composting toilet designs that mix urine and faeces were the first types of systems to be introduced. However, in part because these systems resembled normal pit latrines, users did not add the materials necessary to provide adequate conditions for composting, and the units failed. Subsequent projects focused on promoting urine-diverting dry toilets (UDDTs), which separate urine from faeces and treat the fecal fraction through dry, high pH conditions. These facilities have characteristics, such as faecal collection vaults and urine diversion devices, that distinguish them from pit latrines. Wood ash is added to faecal vaults after use to raise pH and reduce moisture. These facilities were operated with greater success (Niwagaba and Asiimwe, 2005).

However, uptake of Eco-San systems in Uganda remains low. It is estimated that they are being used by 0.4% of the population (Uganda Bureau of Statistics and ICF International, Inc., 2012). This low level may be due, in part, to the relatively high cost of UDDT facilities (Uddin et al., 2011). Although initial attempts to promote more affordable composting designs were unsuccessful, these types of systems might still function as an alternative in certain contexts, especially if similarities with pit latrines can be minimized.

The sawdust bucket system, also known as "bucket and chuck it," provides a composting option easily distinguished from pit latrines. This system collects both urine and faeces in a bucket placed beneath a toilet seat or squat hole. After use, sawdust is added to absorb moisture and control odours. When the bucket is full, it is removed, and the contents are deposited in an outdoor compost pile, where the excreta are mixed with other organic materials to decompose (Jenkins, 2005). The bucket system is shown in Photograph 1, with the associated compost pile shown in Photograph 2.

The objective of this study was to compare pit latrines, UDDTs, and bucket systems, in an effort to identify advantages and disadvantages of each option. This study focuses on circumstances found in Uganda, but findings may also be applicable to other countries in sub-Saharan Africa and around the world.

Photograph 1. The indoor bucket system

Photograph 2. The outdoor compost pile

Methodology

A previous study performed by the authors had assessed the experiences of UDDT users in Rukungiri Municipality, a town of approximately 29,000 residents located in southwestern Uganda. Due to local soil conditions and limited space, a number of UDDTs had been installed in the town, but limited training and monitoring had resulted in a number of operational challenges (Kamuteera et al., 2013). Results from the previous study's user surveys, along with the personal experiences of the authors and a review of relevant literature, were used to identify advantages and disadvantages of UDDT systems. One of the author's experiences operating his own bucket system, along with another review of relevant literature, provided a basis from which to identify advantages and disadvantages of the bucket system. To provide a point of comparison with more conventional systems, a similar process incorporating personal experiences and literature review was used with respect to pit latrines, the sanitation systems most commonly used throughout Uganda. Results for each type of system were compared, and key themes were isolated to distinguish the contexts in which promotion of each type of Eco-San system might be most appropriate.

Findings

An overall comparison of pit latrines, UDDTs, and bucket systems is displayed in Table 1. A total of fourteen characteristics were divided into four groups, and, each type of facility was given a numerical score of 1, 2, or 3 for every characteristic. Lower scores were given to the facility or facilities that were judged to be better, in the Ugandan context, with regard to the characteristic in question.

Installation needs

With regard to installation needs, lower scores were given to the facilities whose characteristics enabled them to be installed in the greatest number of possible settings. Because the bucket system only requires a user-fabricated seat, a bucket placed beneath the seat, and an enclosure for the compost pile, this system was estimated to have an installation cost of only 300,000 Ugandan shillings ($105). In contrast, due to additional structural requirements, the UDDT was more expensive, with an installation cost estimated at 2,400,000 shillings ($840). Pit latrine costs can vary depending on soil conditions and the materials used, but their construction costs often fall below those of the UDDT (Uddin et al., 2011). Therefore, the bucket system received the lowest score, since it would be available to people with a broad range of income levels.

With regard to space requirements, the common practice in Uganda involves relocating to a new pit when the previous latrine has filled. Especially in areas with limited space, the need to dig new pits can become a problem (Langergraber and Muellegger, 2005). UDDTs are permanent structures that never need to be relocated, while the bucket system only requires enough space for the bucket and an outdoor compost pile. However, while the bucket system requires the smallest overall land area, it should be noted that the need for a compost pile could limit its use in urban environments. UDDTs can be constructed as attachments to existing households (Drangert, 2003), suggesting that these facilities may be more suitable in urban settings.

Finally, soil conditions often determine whether or not pit latrine construction is a feasible option, due to the difficulties involved in digging pits in areas with high water tables, rocky soils, or loose soils (Niwagaba and Asiimwe, 2005). In this respect, the two types of Eco-San systems are equally superior, since they can both be constructed and used anywhere, regardless of soil conditions.

Table 1. Comparison of Toilet Facility Characteristics

Characteristics	Pit Latrine		UDDT		Bucket System	
	Score	**Rationale**	**Score**	**Rationale**	**Score**	**Rationale**
Installation Needs						
Installation cost	2	Inexpensive where soil conditions are appropriate	3	Additional structural components result in greater costs	1	Inexpensive, uses self-made or low-cost components
Space requirement	3	Multiple pits over time	2	Permanent structure	1	Bucket and compost pile
Local soil conditions	3	Difficulty in wet, rocky, loose soils	1	Can be constructed anywhere	1	Can be used anywhere
Operational Needs						
Training requirements	1	None	3	Training on ash addition, urine diversion, emptying	3	Training on sawdust addition, composting
Urine diversion	1	Not required	3	Required	1	Not required
Desiccant Material Needed	1	None	2	Wood ash; produced in the kitchen	3	Sawdust; obtained elsewhere
Frequency of Emptying	1	Never emptied	2	Once every 6 - 12 months	3	Approximately once a week
User Comfort						
Adaptability	2	Superstructure materials can be changed	2	Superstructure materials can be changed	1	Bucket and seat highly adaptable to personal needs
Portability	2	Superstructure can be relocated	3	Permanent structure	1	Bucket can be taken anywhere
Presence of odors and flies	3	Pits are odorous and attract flies	1	Minimal if operated correctly	1	Minimal if operated correctly
Possible toilet location	3	Outside the home	2	Outside or attached to house	1	Inside the home
Technical Issues						
Potential Nutrient Recovery	3	Nutrients are buried in deep pits	1	Urine diversion prevents loss of N	2	Some N lost during composting
Pathogen Treatment	3	Limited treatment through extended storage	1	High pH and low moisture content reduce pathogens	2	High temperatures not likely at household level
Possible Contamination of Water	2	Some chance of groundwater contamination	1	Products are contained in sealed vaults until treated	2	Possible leaching into storm runoff
Combined Score	**30**		**27**		**23**	

(Scores: 1 = good, 2 = moderate, 3 = poor)

Operational needs

With regard to operational requirements, better scores were given to the facilities that placed the fewest operational burdens on users. For any type of Eco-San system, users must receive considerable training on specific procedures, such as desiccant addition, urine diversion, and the composting process. In contrast, pit latrine use requires little training, especially since these facilities are ubiquitous throughout the country.

The UDDT's need for urine diversion adds difficulty, since users must ensure that urine and faeces each enter the appropriate opening. Incorrect use could result in high moisture levels in fecal vaults or blockage of urine pipes. The bucket system does not face these issues. However, due to increased moisture from the urine, a greater desiccant volume is likely to be needed in the bucket system. Additionally, since firewood is commonly used for cooking, most households produce at least some of the wood ash needed for UDDT operation. However, the amount of ash produced is often not adequate, and an additional supply may need to be procured from an outside source (Kamuteera et al., 2013). For the bucket system, most or all of the sawdust that is added would likely need to be obtained from an outside source.

The bucket system requires frequent emptying, placing an additional burden on the user. Each week, the filled bucket must be carried to the outdoor compost pile, and the bucket's contents must be mixed into the compost. The UDDT also needs to be emptied periodically, although the emptying is much less frequent. While the bucket system is assumed to be the least convenient in this respect, it is possible that the increased frequency of emptying could enable responsible users to fall into a pattern of correct use more easily.

User comfort

User comfort characteristics focused on the flexibility and aesthetic environment of each facility. Because the bucket system incorporates simple components that are either purchased inexpensively or fabricated by the user, it is easily adapted to suit diverse needs. Bucket size, seat height, and seat configuration can be adjusted to accommodate children, elderly users, or disabled persons. The system is also highly portable. If, for example, a user moves to a new house, the bucket system can simply be taken along, whereas pit latrines and UDDTs could not make the trip. New facilities would need to be constructed at the new location.

Concerning the aesthetic environment, both the bucket system and the UDDT can provide an environment where odours and flies are absent, assuming they are operated correctly and desiccants are added regularly. In contrast, wet and odorous materials in latrine pits attract large numbers of flies, often making pit latrine use an unpleasant experience (Esrey et al., 2001). Bucket systems can also be located inside the home, meaning that users do not need to venture outside to relieve themselves. This concern is especially relevant at night and during rainstorms. The UDDT provides an intermediate option between the bucket system and the pit latrine, in that the UDDT can be installed as an attachment on an existing structure (Drangert, 2003).

Technical issues

This category concentrated on issues regarding the potential for nutrient recovery, levels of pathogen reduction, and the possible contamination of water resources associated with each system. By diverting and storing urine in a sealed container, the UDDT prevents ammonia loss and produces a nitrogen-rich fertilizer. High levels of organic matter and other nutrients are present in the fecal fraction. The separation of these two streams results in the greatest overall nutrient recovery. In contrast, significant amounts of nitrogen can be lost during composting (Jonsson et al., 2004), while pit latrines bury all of these materials indefinitely.

With respect to pathogen reduction, correct operation of UDDTs results in high pH and low moisture levels, which have been shown to significantly reduce concentrations of many fecal pathogens after several months (WHO, 2006). While it must be acknowledged that these conditions are not always achieved, pathogen reduction during composting is even more difficult to accomplish. High temperature is the major mechanism of pathogen reduction in the composting process, but attaining a temperature of 42°C, reported to inactivate pathogens after six months of storage, is unlikely (Mehl et al., 2011). A number of factors, including pH, moisture content, and carbon to nitrogen ratio, must be maintained at certain levels simultaneously, making high temperature composting extremely difficult to achieve for many users.

UDDTs also protect water resources from possible contamination. Because urine and faeces are stored in closed containers and compartments, they do not come into contact with groundwater or stormwater runoff. Similarly, the bucket system provides complete protection when materials are being collected in the bucket, but some potential for contamination of runoff is present in the compost pile, since pathogens, nutrients, and organic matter could leach into runoff during a rainfall event. Pit latrines also open possible routes for the contamination of groundwater. In many situations, pit walls allow liquids to percolate into the surrounding soil (Bhagwan et al., 2008), where nutrients, pathogens and other dissolved or suspended material may eventually reach the water table (Gajurel and Wendland, 2004), especially if latrines are not properly sited.

When all characteristics from all groups were taken into account, both types of Eco-San systems had lower combined scores than the pit latrine, with the bucket system having the lowest overall score. From a very general standpoint, these results suggest that the bucket system is the most appropriate and widely applicable sanitation option among the three possibilities that were compared.

Discussion of social acceptability

While these Eco-San systems have many favourable characteristics, their acceptance is not guaranteed. Altering sanitation practices is a complex form of behaviour change, one that may take decades to fully accomplish (Jenkins and Sugden, 2006). For example, when a proposal to build one of Rukungiri's first UDDTs was introduced, it was met with significant resistance. The conventional wisdom was that sanitation systems needed to be located far from habitation and that deep pits were more hygienic. The proposed

UDDT went against both of these notions. However, the project moved forward, and the facility's success led to the installation of more UDDTs, which have been operated with varying degrees of success. Many users viewed these systems as appropriate options for Rukungiri (Kamuteera et al., 2013).

The bucket system has also been met with strong resistance by key members of the Rukungiri community. Some resistance is due to the fact that bucket latrines have been used elsewhere in the country. Sawdust addition was not incorporated into these systems, and, understandably they are thought to be extremely unpleasant. Despite these difficulties, local promotion efforts have led some residents to install and use bucket systems that do incorporate sawdust addition. The system's affordability and adaptability compare favourably with other options, making the system appealing. In some cases, the agriculturally valuable products remain unused. However, with continuing education and increased exposure to these systems, uncertainties are likely to fade, and reuse may eventually occur.

Recommendations and lessons learnt

Contextual appropriateness

The comparison shown in Table 1 provides a general perspective on the relative merits of each system considered in this paper. The bucket system was given the lowest overall score, but it may not be appropriate in all circumstances. The different Eco-San systems each have distinct advantages. UDDTs, for example, might be more suitable in an urban setting that does not allow for an outdoor compost pile, or for a farmer who grows crops requiring high levels of nitrogen, since a UDDT would provide a nitrogen-rich urine fertilizer. Bucket systems may be more appropriate in settings where compost can be produced and would be put to use. Although a system may appear to be better in a general sense, the local context must always be taken into account before promoting a given system.

The importance of education

It is widely recognized that education is a key component in the implementation of Eco-San systems (Kamuteera et al., 2013). Without it, facility operation is much less likely to succeed. In addition to general education regarding the operation of Eco-San systems and their benefits, it is also important to avoid a sole focus on one type of Eco-San system. Information on the different Eco-San options that are available should also be presented to stakeholders. Initially, people may view Eco-San facilities as rigid systems with many user responsibilities. It might be possible to change this perception by showcasing a number of different possibilities, emphasizing their contextual benefits, and showing how facilities can be adapted to suit user needs. For example, the author is familiar with a UDDT that has been adapted to function more like the bucket system, with combined urine and feces collection and transfer of collected material to a compost pile. The owners of this facility identified the advantages of each type of system that were most important to them, and they developed a single system that combined those benefits.

Consumer choice

Education that focuses on the various options available within the overall Eco-San framework naturally leads to the importance of consumer choice. Often, organizations or agencies may promote one type of system that is deemed to be the best, which can result in limited opportunities for individuals to choose the facility that is most appropriate for them. Even in a single community, residents live in different settings and have a variety of needs. Ensuring that these residents have the freedom to choose from multiple sanitation options, including Eco-San systems such as the UDDT and bucket system, could help to increase the overall uptake of Eco-San facilities in Uganda and improve the likelihood that households are using contextually appropriate systems.

Conclusions

A general comparison of UDDTs, bucket systems, and pit latrines revealed that, when a variety of characteristics are considered, the two Eco-San systems provide benefits beyond those of pit latrines. The bucket system was found to be the most favourable of the three, due in part to its affordability and adaptability. However, while this system performed best in general, it should not be promoted as the only Eco-San option or the option that is always best. Each type of system has its own distinct set of advantages and is likely to function more effectively in certain contexts. Therefore, it is important to educate the public regarding all of the options that are available to them, emphasizing the contextual benefits of each and how

each could be adapted to suit personal needs. In the end, complete freedom of choice should be given to informed consumers. As the advantages of the different Eco-San systems become more well-known through increased exposure, overall uptake of these more sustainable systems is likely to increase.

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Notes

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