Innovative Approach for the Management of Faecal Sludge Accumulated in Ventilated Improved Pit Latrine: A Case Study of eThekwini Municipality in Durban South Africa

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Abstract-
The provision of sustainable sanitation service to all South Africans has become one of the government national priorities. This is because the government recognizes that all citizens of the country has the right to basic sanitation that is affordable, appropriate, socially acceptable and sustainable in the long run. Ventilated Improved Pit latrines (VIP) has been considered to be the minimum acceptable level of sanitation service. However, the provision of appropriate sanitation service in the form of VIP latrines to all goes beyond building the toilets, plans should be put in place by municipalities are for adequate operation and maintenance of the toilets before and when the toilets reaches their capacity. Major challenges faced by many of this municipalities which is also common in many developing countries is that, this on-site sanitation systems eventually becomes full to their capacity and if there is no long-term maintenance plan in place, this system becomes unusable and eventually leaves the household without an effective basic sanitation system again. This paper present innovative approaches that have been considered for the operation and maintenance of Ventilated Improved Pit latrine in and around eThekwini Municipality in Durban, South Africa.

Key words: VIP latrines; Faecal sludge; sludge accumulation; sustainable sanitation; operation

1. Introduction
Ventilated Improved Pit (VIP) latrines are a modern version of the traditional pit latrine with the advantage of substantially reducing the strong odours and large number of flies usually common to the traditional pit latrines (Mara, 1996; Bakare, 2014). They comprise of a pit, cover slab and pedestal, and a superstructure which has a ventilation pipe with fly screen attached to it (Buckley et al, 2008; Bakare, 2014). This on-site sanitation system has been implemented widely across the country. However, two important factors were not taken into consideration; how should accumulated sludge be managed when the pit becomes full and how to turn sludge accumulated in pits over the years into a valuable resource without any adverse impacts on the environment. A variety of programmes are been put in place by many municipalities around the country to provide innovative approaches to deal with the sludge accumulating in this sanitation systems, major emphases are only placed on addressing the current backlogs while little thought is placed on measures to deal with the accumulated sludge when this onsite sanitation systems will reach their full capacity.

Thus, this paper provides innovative approaches that have been considered to deal with the operation and maintenance of this onsite sanitation systems that have been recommended by the South African Government as the minimum acceptable level of sanitation service to all.
2. Current Practice and Problems in Faecal Sludge Management

Water and Sanitation services provided in South Africa are managed under 154 Water Services Authorities (WSAs), this may be through district municipalities and/or local municipalities or metropolitan municipalities. The Durban metropolitan is managed by the eThekwini municipality. eThekwini municipality is situated in the KwaZulu-Natal province of South Africa and is the local authority for the city of Durban. It is the third largest municipality in the country and is located on the eastern seaboard of the country incorporating Umkomaas in the south, Tongaat in the north and ends at Cato ridge in the west. The population of eThekwini municipality is estimated at about 3 million people and the land mass is said to be approximately 2 297 square kilometers. In adhering to the South African Government Strategic Framework for water services which indicated that ventilated improved pit latrine should be the minimum recommended form of sanitation service for all, eThekwini Municipality have actively been providing many with this form of onsite sanitation and over the years quite a number of this sanitation system have been installed. This form of sanitation system is only capable of holding the fecal material for a particular period of time before it reaches the full capacity. Many of this sanitation system within and around the eThekwini Municipality have actually reached their full capacity, the major problems being faced are (i) identifying an appropriate method that can be used to exhume the sludge that have accumulated in the pits over the years and (ii) identifying an appropriate route for the disposal of accumulated sludge exhumed from these pits. The method adopted for emptying of the pits as well as the disposal route considered is greatly affected by the nature materials found in the pits.

2.1 What is in the pit?

It has been observed in many of the VIP latrines investigated previously within and around the boundaries of eThekwini municipality that depending on the habits cultivated by the users of the pits, it is prone to find various forms of materials added to the pits in addition to feces. Materials that have been found in pit latrines across the eThekwini municipalities ranges from newspapers, magazines, broken glass, bottles, rags, plastic bags, and other form of household waste materials (Bakare, 2014; Buckley et al, 2008; Still, 2002). Thus in order to be able to determine the composition of the material in a pit, it will require physically observing what is in the pit or exhume the contents of the pit, this is as a result of what the owners dumps in the pit as many household make use of the pit beyond serving their basic sanitation needs (Bakare, 2014; Bakare et al, 2012; Mara, 1984). Figure 1 below is images of typical contents of pit latrines from different locations within the eThekwini municipality in Durban with different user habits.
2.2 Methods for Exhuming Pit latrine Sludge content

The removal of accumulated sludge content in pit latrines is very important when these pits are full. Although depending on the availability of space, when the pit becomes full, it can be covered while another one can be built to replace the full pit. The reason why it is important to exhume the accumulated sludge when the pit becomes full, is because full pits pose significant risks to the surrounding ground and surface water as well as to it raises health concerns. There are a number of reasons why the rates of sludge accumulation in pit latrines increases at a significant rate, this could be due to the number of people that are making use of the pit, user habits and local environmental conditions in the area in which the pit is constructed. According to Bakare (2014), depending on the user habits, the contents of the pit will vary in terms of the materials discarded into the pit in addition to faecal matter. These wide varieties of materials that are usually found in pits have a detrimental effect on the efficiency of the degradation processes taking place in the pit and also makes pit emptying significantly more difficult. Sludge contents in ventilated improved pit latrines can be exhumed manually or mechanically. eThekwini municipality found that mechanical evacuation of pit latrine contents using suction tankers, vacuum tankers, and hand pumps are not sustainable in the long term. Mechanical equipment/machinery used for pit emptying is expensive, vulnerable to failure and accessibility to pit location by this machinery might be restricted or become impossible due to lack of good roads, the type of terrain and if the area is densely populated. The municipality has considered manual pit emptying to be the most viable and cost effective method for the evacuation of pit latrine content. Manual pit emptying involves people digging out the content in a pit latrine by making use of long shovels, spades, forks, buckets, skips and other hand tools. The major problem with this pit emptying option is that it exposes the workers to a number of health-related issues if not properly managed, particularly infection by various helminthes species, and the work might be unpleasant. Over the years mechanical devices for pit emptying have been developed aimed at reducing the disadvantages encountered from manual pit emptying. These mechanical devices are either semi-mechanized or fully mechanized (Bakare, 2014). One such device is the MAPET system which is more of a hand pump requiring manpower to build up the vacuum. The major challenge with the use of this system is that because of the typical nature of materials found in pit latrine as well as the thickness of the sludge, it become necessary to add significant amount of water into the pit to soften the pit content before the MAPET can be used to exhume the pit sludge content. It may be required when significant amount of water is added that the content of the pit be adequately mixed and if possible debris should be removed from the pit before the MAPET equipment can be used to empty the pit (Bakare, 2014).
Regardless of which pit emptying technique is used, factors such as the nature of the pit contents, the accessibility to the pit as well as costs of emptying should be taken into consideration. The nature of the materials found in pit latrines usually makes it a difficult task to empty the pit because material found in the pit are usually in a partially compacted or solidified form. It has been documented that mechanical pit emptying equipment are prone to failure, since when a pit comprises mostly extraneous material, the suction pipes and valve can become blocked which could damage the equipment and in such cases the most viable pit emptying technique is to manually dig out the pit content. Another major factor that influences what pit emptying techniques to be considered is whether the pit to be emptied is easily accessible, this is because there might be no good road for the vacuum tankers and also where the pit are situated are usually densely compacted and populated.

3. Sludge Management Options
Depending on the feasibility of reusing sludge from pit latrines, sludge may be added to the inflow to the town sewage works or buried on-site. In eThekwini municipality, the water and sanitation department have considered a wide range of options for the management of pit sludge content that have accumulated over the years when the pit reaches full capacity. The options that have been considered include:
- Transport to waste water treatment works
- Addition of Pit Additives
- Agroforestry
- Further dewatering and treatment/ processing to produce agricultural fertilizers

3.1 Transport to wastewater treatment plants
It has been documented by the study conducted by Bakare, (2014) that the transportation of exhumed pit latrine contents to wastewater treatment works is not a viable options and that this option resulted to a detrimental impact on the treatment works selected for this feasibility study. This option was considered on an assumption that the amount of pit latrine contents exhumed during the emptying process is relatively insignificant compared to the volume of wastewater flows into the treatment works. What makes this option not viable is the fact that when pit content are exhumed and collected in skips, there is a need to transport the content to the nearest treatment works which is usually quite a distance from where the sludge was collected. Also on arrival at the treatment works, the content are usually not dumped directly into the treatment works but requires the content be washed through customized screens at the treatment works using large volume of water. Apart from all the mentioned constraints above, it was observed that the treatment works used for this feasibility study was significantly impacted by a shock increase in the organic, solid and nitrogen loads in the treatment works which impeded the process and overall performance of the treatment works considered, some of which had serious problems with solid handlings and nitrification.

3.2 Addition of pit additives
Another option considered by the municipality was making use of pit latrine additives to enhance the biological degradation and activities taking place in the pit. It is usually presume that this additives which may be chemical, microbial or enzymatic in nature is capable to reduce the rate at which sludge accumulates in the pit as well as extend the life span of the pit latrine. According to the study conducted Bakare et al, (2015), the use of pit latrine additives usually
do not have any significant effect on the rate at which sludge build up in the pit and there is no
evidence that the addition of pit latrine additives is capable of extending the life span of the pit. Both the laboratory and field trials conducted did not provide any evidence that the use of pit additives have any effect on the contents in the pits as claimed by the manufacturers. A number of reasons as to why the pit additives used in the study proved ineffective were identified. Apart from the reasons identified, the main reason why to date no pit additives have shown any
effectiveness in reducing sludge accumulation rate and/or sludge volumes in pit latrines can
attributed to the fact that the amount of microbes added to the pit as a result of using pit latrine
additives is usually insignificant when compared to the amount of microbes already present in
the pit that are naturally degrading the feacal sludge content in the pit.

3.3 Entrenchment of Pit latrine sludge content
In order to adequately protect the health of the public, the eThekwini municipality considers
that it is highly essential to identify an appropriate disposal route that will safeguard any form
of contacts with the public. This is because of the fact that when pit content is disposed off
appropriately it can lead to public health menace and also become a barrier to sustainable
development and a huge strain on financial resources. Therefore any disposal route of pit latrine
content considered should be well designed, sited and managed properly to protect any risk to
the environment and to the public. This is because VIP latrine sludge contains highly infectious
pathogenic organisms and organic pollutants. In a feasibility study conducted by Bakare,
(2014), entrenchment of pit latrine sludge content have proven to be a beneficial option. In the
pilot study conducted, the following were observed:

• Changes in the composition of the sludge exhumed from the pit before entrenching
  compared to the sludge exhumed from the trenches at varying time interval was
  observed. The composition of the sludge exhumed directly from the pit in terms of the
  parameters measured (moisture, volatile solids, chemical oxygen demand, and aerobic
  biodegradability) was significantly reduced when compared to the sludge that was
  entrenched over time. This reduction was observed to be statistically significant for all
  parameters measured.

• Groundwater contamination around the entrenchment site was monitor for three years.
  However it was observed that there was no profound groundwater contamination for the
  entire duration of monitoring. It was concluded that monitoring of groundwater quality
  at the entrenchment site would have to be for a significant number of years to be sure
  that there will be no occurrence of pollution plume. However no pollution plumes was
  observed in the three years of monitoring and there was no indication that this will occur,

• Trees planted above or next to entrenched pit latrine sludge content had good growth
  characteristics compared to trees planted just in the soil without entrenched pit content.
  Thus enhanced growth of trees observed was attributed to a variety of possible
  mechanisms including the release of nitrogen and nutrients from the entrenched sludge
  as fertilizer and improved soil water retention characteristics.

• Exhumed pit contents was found to contain a very load of pathogens in the form Ascaris
  ova as well as Taenia and Trichuris ova, thus indicating that the pit content used in the
  study was extremely hazardous to public health. However, entrenched sludge that was
exhumed at various time interval after the trees were planted still contains many of the helminth ova but it was observed that there was a significant reduction in the fraction of those ova that are potentially infective. The study therefore concluded that when pit contents are buried in trenches for agroforestry, there is the possibility that the pathogens contained will be significantly reduce to a level that risk associated will minimal over a period of time.

4. Conclusion
In terms of the South African water services Act of 1997 and the Health Act of 1977, local authorities are responsible for the provision of adequate, affordable and sustainable facilities to manage faecal waste from on-site sanitation. ETehkwini municipality has embarked on an extensive sanitation programme to provide free basic sanitation services including a pit emptying service once every five years to every household. The ventilated improved double pit latrine has been chosen as the minimum standard and for various reasons and after testing a number of pit emptying methods in different location and topographies, the municipality has chosen manual pit emptying as the most suitable and effective method for pit evacuation. The main issue at present is finding an appropriate disposal route which is applicable to the local environmental conditions for sludge evacuated from pit latrines. Although the municipality has proposed various disposal options, research is still in progress to create a management/decision support matrix to determine the appropriate and sustainable disposal route.

This paper has considered three potential disposal routes, burial on site, disposal to landfill, disposal to wastewater treatment plants and entrenchment in conjunction with agroforestry. While burial on site (where possible) appears to be the most economical option, perceived health concerns have caused some objections to this disposal route. It is not yet clear whether disposal to landfill is a feasible option or not. However, this route is likely to be expensive. Finally it has been found that disposal to wastewater treatment plant can have a significant detrimental effect on the plant due to the high solids, nitrogen and COD load of the VIP contents. A promising option is entrenchment of VIP sludge in conjunction with agroforestry.

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