INSTITUTIONALISED COLLECTION FOR RURAL ON-SITE SANITATION

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ABSTRACT

A previous survey has indicated general dissatisfaction with urine diversion toilets. As part of the strategy to address this issue, the beneficial reuse of the urine is being investigated. A scoping trial for the collection of urine from rural houses (300) served with urine diverting toilets is described. The experience gained on the storage of urine, the methods of collection and transport are described. This information is used to provide first cut estimates of urine collection (R 7.26 / kℓ). The design of a future pilot study to provide information necessary to optimise the collection of urine is described.

1 INTRODUCTION

EThekwini Municipality is the municipality with the highest number of urine diversion toilets. A source-separated waste technology without the use of water is seen as a solution in areas where the provision of sewerage is not feasible because of distance, topography and affordability. The realisation that urine is a resource rather than a waste product has prompted researchers to investigate extracting nutrients from urine (Etter et al., 2013). A suitable collection system for urine harvesting is necessary. The collection of urine from urine diversion toilets (UD toilets) within the rural areas of eThekwini is a complex task because of the low density, hilly topography and poor vehicle access. This paper reviews the lessons learned from a urine collection scoping project that was undertaken as part of an international study and make recommendations for a future pilot study.

2 Challenges experienced in rural areas with the provision of sanitation services

Adequate sanitary facilities and sanitation services are lacking in most developing regions. The 2013 WHO – UNICEF Joint Monitoring Programme report (WHO-UNICEF, 2013) states that 2.5 billion people do not have access to adequate sanitation. To ensure the provision of the essential services in South Africa, the government policy reinforces the entitlement of all to a basic sanitation service that is affordable, effective and acceptable (DWA, 2012). The adoption of the free basic services policy that was implemented in 2001 was to address the affordability to services for poorer communities (DWAF, 2002).

In Durban the aspiration is to flush toilets. Early work by (Duncker, 2007) and (Duncker et al., 2005) indicated that the poor population in South Africa aspire to flush toilets. In a 2012 study of UD toilet users (Mkhize et al., 2014) it was observed that a significant number of participating householders did not regard the UD toilet as a permanent sanitation service but rather preferred a flushing toilet. This level of service is not technically feasible or financially viable. Communities in rural settings are least suited for the conventional flushing technologies due to communal land ownership, inaccessible terrain, mobile population and housing densities. (Gounden et al., 2006). Sanitation technologies that do not require the expense of water to dispose of urine and faeces were considered a solution. Ventilated Improved Pit latrines (VIP) are a possible dry on-site sanitation solution however in 2003 (Gounden et al., 2006) eThekwini Municipality standardised on the urine diversion toilet (UD) for dry on-site sanitation for poor citizens because of the difficulty experienced in emptying full VIP pits.

WHY UD TOILETS?

Approximately 80 000 UD toilets have been installed and are still being rolled out in the rural parts of the municipality (IDP, 2013 – 2014). The urine diversion toilet was favoured by the municipality because it allowed safe onsite disposal of waste without any intervention from the municipality. Urine diversion toilets were the preferred option based on the principle that the toilet can only be sustainable if the householder was responsible to sustain it (Gounden et al., 2006). This meant that the capital cost for the construction of these toilets was the only cost borne by the municipality. Recent observations (Mkhize et al., 2014) have indicated that householders are not maintaining their toilets and municipal intervention is required. In addition, the perception that urine and faeces are waste products is slowly changing. Research has identified that valuable nutrients can be recovered from urine (Grau et al., 2012).

HOW TO COLLECT URINE?

Prior to the collection of urine, areas with sufficient functioning toilets had to be identified and urine collection tanks installed. (Rossboth, 2013). In a study undertaken to investigate the economic aspects of recovering nutrients from urine, two collection schemes were implemented. One group received an incentive to bring their urine to a local collection tank (incentivised collection), while in the second scheme workers from the municipality went from household to household at intervals to collect the urine (institutional collection).

Incentivised collection

This research is under investigation by other members of the VUNA research team (Vuna, 2014) and is not the focus of this paper.

Institutional collection

The second approach is an institutionalised method which requires the input of municipal workers to drive around collecting urine from individual urine diversion toilets. Although this method is labour intensive, control measures ensure that the maximum urine is collected. Compared to the incentive approach, EWS does not pay households, but pays their own workers (or possibly in the future an external service provider) to collect the urine. Direct costs for the institutionalised approach include the transportation costs from the household to the treatment facility. Indirect costs refer the management of the collection teams and optimization of the transportation. The institutional collection removes the need for individual householders to come in close contact with urine with the concomitant health concerns.

For the Institutional Collection study, three rural areas (Ehlanzeni, Umnini and Ntshongweni) were chosen within the eThekwini Municipality and 100 UD toilets were selected in each area. They received regular institutional collection from the individual households.

From the beginning of the project (May 2012), the collection has undergone a continuous learning process. It started as a very random and ad-hoc process. From the 4 ℓ urine collection tanks which were initially installed the collection teams were only able to collect about 100 ℓ in a day. A collection team consists of a driver, two to four collectors and one community facilitator. Subsequently, the collection team's performance has improved considerably and currently the volume is 500 to 700 ℓ per day. Three factors have triggered these improvements: (a) the urine collection tank volume was increased from 4 to 20 ℓ; (b) increased use of the urinals and toilets by the households; and (c) the collection teams have learned which households actually use the UD toilets and routes have been improved. These changes have impacted on the estimated costs. Our cost estimation (2014) for the instutionalised collection suggest about R 2 132 per household per year and R 2.00 per litre of urine. These are unacceptably high costs. Therefore, we formulated some recommendations for improvements to the institutionalised collection.

3 RECOMMENDATIONS

IMPROVEMENTS IN THE INSTITUTIONALIZED APPROACH

We observed that collectors go to the UD toilets, remove the tank, carry it back to the bakkie, empty it, bring the tank back to the UD toilets and return to the bakkie. The return distance by foot could be up to 100 m. The collector has to walk from the bakkie to the UD toilet and back twice. It is suggested that tanks should be exchanged, instead of getting collected, emptied, and brought back to the household. Exchanging the tank would need only two additional tanks on the bakkie (for two collection teams per bakkie).

We also observed that with the increase in the urine production (people use the UD toilets more frequently) tanks are heavier (up to 40 kg for a newly designed tank) and more difficult for one person to handle. Therefore it is suggested that two persons carrying one tank as it is hypothesised that this will be more effective. The weight is equally shared and a carrying tool can be used. Two people can chat, which makes longer walks more interesting. Collection would be also less exhausting over the day. There is also a higher self-control, if two people work as a team. A carrying tool would make it possible to carry the tank with stretched arm at the knee level which means the tanks are above the grass and road bumps.

We recognized that the collector has to lift the full tank from the ground to the loading area of the bakkie. Then from the loading area to the highest level of the transportation tank. Missing lids from the urine collection tanks means that urine splashes over the collectors. Thus, we suggest that each bakkie should be equipped with mechanised handling equipment for transferring the urine from the urine collection tanks to the transportation tank. This will also speed up the collection cycle time and makes the whole job much less exhausting and cleaner. The existing bakkie is not designed to stop, allow people to alight and then continue onward. Collectors have to open the door, get out of the vehicle to start the collection after every stop. Therefore, we recommend that the bakkie should be designed in a way that collectors can quickly alight and rejoin the vehicle.

We recognise that there is a trade-off between a higher number of collection teams (collectors) and more complex collection coordination. More complex coordination means that in case of more collection teams, they would face longer walking distances and more waiting time (until the last team returns to the bakkie). More collection teams would require more space on the bakkie. Nevertheless, it is hypothesised that each bakkie should have two collection teams consisting of two collectors. Through two collection teams, EWS can better optimize driving and walking distances.

We also observed that each collection team needs time to prepare the collection rounds. They have to prepare the paper work and write down the volumes collected at each household. For a large-scale collection, even more information might be needed. Automatic information recording avoids manual paperwork. Monitoring the collection team becomes possible. Using a mobile phone makes the job more prestigious. The suggestion would be that each bakkie should be equipped with a smart phone and a dedicated app for information processing. We recommend an automatic information recording. Until now, each UD tank has an identification number (ID), but the existing IDs are not used in the information processing. There is no control on whether the collection team actually serves a specific UD toilet or not. The IDs should be used in the future information processing. Difficulties associated with the exchange of tanks needs to be addressed in the data system.

Finally, we observed that the existing 1 000 ℓ transportation tank on the bakkie is an improvement over transporting individual urine storage tanks. Up to now, the 1 000 ℓ tank is sufficient for the collection. However, if the urine production increases, collection efficiency improves, and more UD toilets are emptied per day, the 1 000 ℓ tank will be insufficient. We recommend a bigger bakkie (up to 3 000 ℓ). While these recommendations are rather quick-wins and could pay off very quickly, we also learned that more a conceptual approach is necessary to optimize the institutionalised collection.

CONCEPTUALISATION OF THE INSTITUTIONALISED COLLECTION

Our concept for optimizing the institutionalised collection considers four variables: location of the collection teams; urine production rate; accessibility of UD toilets; and the collection frequency.

Location of the collection teams: Currently the collection is located in Springfield. Driving distances to the collection areas are between 40 and 60 kms. It means that the collection team is losing time by driving to the collection areas. The team can only collect for about 4 h over an 8 h working day. Of course, security issues might restrict the base station for the bakkies from being in the community. However, the decentralisation of the bakkie is strongly recommended. Wastewater treatment plants or other municipal depots adjacent to the rural areas could be potential base stations. For an optimised instutionalised collection such locations are necessary.

Urine production: Urine production has a strong impact on the instutionalised collection. It influences the volume, which needs to be transported. For calculation purposes, it was assumed that the average weekly production rate is 5 ℓ . This production rate is in line with what was observed in the scoping phase. If the urine production rate increases, the frequency of the collection will increase. In addition, urine production rate might differ from household to household. It might be necessary to classify the UD toilets into different classes (zero to low urine production rate, medium urine production rate, and high urine production rate).

Accessibility of UD toilets: Because the UD toilets are located in the rural areas, the accessibility varies considerably. The road system consists of major roads (gravel), secondary roads (sand), and tertiary roads (track). Accessibility describes the distance between the UD toilet itself and the nearest road. Geographical Information System (GIS) software is used to specify the class of the roads, tracks and paths and classify the UD toilets in terms of the location and distance from roads. Accessibility from the road can be classified into A, B, and C. Class A UD toilets are easily accessible. It means that the collection distance from the vehicle is up to 50 m from the major road. Class B means that the UD toilets are less accessible. The bakkie has to turn off the major road and drive 50 and 100 m up a secondary road. The walking distance will remain less than 50 m. Class C UD toilets are much more difficult to access (walking distances of more than 50 m over undulating terrain. In Cliffdale there are 507 UD toilets which consist of 247 in Class A, 159 in Class B, and 100 in Class C. In Ntshongweni there are 2 257 UD toilets which consist of 1375 in Class A, 574 in Class B, and 335 in Class C = 335.

Collectors have to walk and drive for more than 100 m from the major road. Each class requires different collection times. It has been estimated that the urine from UD toilets in Class A can be collected in 3 min, those in Class B in 6 min and those in Class C require 10 min. These times are estimated based on observations and a time motion study. Of course, the times might depend on the experiences. After a few collection rounds and learning in the collection team, these time estimations should be feasible. Critical points for achieving the collection time are the supportive tools and actions for the collection teams.

Collection frequency: Collection frequency depends on the urine production rate. Because the urine production rate is relatively low, the frequency should be initially only once a month or every second week. This frequency should be similar for all Classes (A, B, and C). A monthly emptying service should be established as a basic service. When the production rate increases, the frequency will be increased accordingly. If production rate rises above 15 ℓ per household and week, Class A toilet should be emptied once week, class B every second week. Class C should be emptied once a month.

COST ESTIMATIONS FOR AN OPTIMISED INSTITUTIONALIZED APPROACH

Considering the factors mentioned above, we estimated the first cut cost scenarios for the logistics. We assumed that:- the collection team is localised, a urine production rate of 15 ℓ per week, and a collection frequency of once a month. We also used the specified accessibility of UD toilets in Cliffdale and Ntshongweni. Our estimations yielded following results:

Cliffdale: one vehicle with two collection teams (1 driver and four collectors) would need approximately 3 days (22.5 h) for the collection, collection costs would be about R 6 900 (R 2 300 per day). The annual cost would be R 82 800 per year or R 163 per year per household

Ntshongweni: one vehicle with two collection teams (1 driver and four collectors) would need approximately 11 days (90 h) for the collection, collection costs would be about R 25 300 (R 2 300 per day). The annual cost would be R 303 600 per year or R 134 per year per household.

The total volume of urine collected in a year would be 2 155 kℓ at a cost of R 7.26 /kℓ

These values are rough cost estimations which will be validated through a second six-month pilot in the same area but investigating different scenarios.

PILOT STUDY FOR VALIDATING THE COST ESTIMATIONS FOR AN INSTITUTIONALISED COLLECTION

We are currently preparing for a pilot project in the Ntshongweni area. We will implement the lessons that were learnt from the previous study. It will cover more UD toilets and will run over a period of six-months. We will put the tank ID on the house and track them using a smart phone which will also be used for data collection at the bakkie. We also use a vehicle fitted with a C-Track® device and a GPS system to monitor the driving distances and record the urine collected from each household. The double-cab vehicle will allow two collection teams with at least four collectors.

We divided the UD toilets into three groups: Test Group, Best Practice Group and Control Group. The Test Group consists of 150 UD toilets, the Best Practice Group has 50 UD toilets and the Control Group has 100 UD toilets. The collection strategy for the Control Group will remain constant. The Best Practice Group consists only of Class A UD toilets. We expect that these UD toilets will give us a cost benchmark for minimal logistic costs. Over all three groups, we start with a collection services at every second week for 20 ℓ tanks. In the Test Group and Best Practice Group, we introduce four different parameter variations:-

- addition of a second 20 ℓ tank at each UD to increase the UD tank capacity from 20 to 40 ℓ.
- using an algorithm to predict the urine volume. The collection schedule will be varied according to the actual urine production rate.
- increasing the collection frequency to once a week for all Class A UD toilets and keeping it at two weeks for Class B and Class C.
- increasing the collection frequency for all UD toilets to once a week.

Through testing these parameter variations, we expect to gain the information necessary to determine the most cost efficient configuration of tank size, urine volume, and collection frequency. During this process, issues such as vehicle size, intermediate storage tanks and additional household urine collection tanks will be solved while validating the cost estimations.

4 CONCLUSION

This paper presents insights into the concept of urine collection which is the first step for any nutrient recovery strategy. However there is limited knowledge on the actual costs and the logistic configuration. We have presented some initial insights from a scoping study. We concentrated on the institutionalised collection and estimated the collection costs. We formulated some quick-wins and recommendations for improving the institutionalised collection and reducing the collection costs. We also developed a conceptual framework for estimating the costs. Some first-cut cost predictions are presented. To validate these cost predictions, we describe the procedure for a future pilot study.

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