MANAGEMENT OF FAECAL SLUDGE FROM A MOBILE COMMUNAL SANITATION FACILITY – A CASE STUDY OF THE MOBISAN

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ABSTRACT

Sanitation technologies are designed to contain, treat or dispose human excreta in such a way that it does not impact on the human health or the environment. Substantial volume of excreta (including urine and faeces) are deposited in the sanitation system daily; and should be management accordingly in order to prevent health risks and environmental pollution.

The MobiSan facility is a urine diversion toilet designed to contain separately urine and faeces. Faeces collected in the collection vault are drying by the wind effect and addition of saw dust. After a period of 6 to 9 months, dried faeces contained in the vault is assumed to be sanitised, thus safely handled and reused.

Against this background, this study aims at investigating the management of human excreta produced by the MobiSan facility before, during and after withdrawal from the containment vaults. This was achieved through the monitoring of the MobiSan facility for a period of 6 months focusing on the daily operation, turning of faeces in the vault and monitoring of the drying and sanitisation process.

Results suggest that the management of the faecal sludge prior and during the sanitisation process was found to be in line with the management practices of the technology while that of the final faecal sludge extracted from the MobiSan was found to be inadequate and not complying with established practices. It is therefore recommended that the faecal sludge produced by the MobiSan should be further analysed to determine its treatability and alternative management options and practices. Unless these issues are taken into consideration, the management of faecal sludge produced by the MobiSan will remain a hazard for both human and the general environment.

Key words: MOBISAN, FAECAL SLUDGE, MOBILE COMMUNAL SANITATION, MANAGEMENT.

INTRODUCTION

Sanitation is an extremely complex issue that impacts on the daily life of every human being particularly in developing countries including South Africa where the level of service is lacking (Austin and Duncker, 2002). The latest human settlement report on the sanitation backlog suggests that 16 Million people living in SA in 2012 do not have access to Basic Sanitation facilities; or have no access to sanitation facilities whatsoever (The presidency department) despite the Government effort to provide adequate sanitation services to previously disadvantaged communities. The achievement of the millennium development goals (MDGs) for water and sanitation remain a chimera in view of current sanitation backlog.

Sanitation technologies are designed to contain, treat or dispose human excreta in such a way that it does not impact on the human health or the environment. Substantial volume of excreta (including urine and faeces) are deposited in the sanitation system daily; and should be management accordingly in order to prevent health risks and environmental pollution. Recent years have witnessed the launch of several initiatives by investing in the development and implementation of alternatives (non-waterborne) sanitation including dry and communal mobile sanitation systems.

<u>The peri-urban sanitation dilemma in South Africa</u>

Informal settlements remain eyesores across major cities in South Africa. They consist of non-conventional housing built without complying with legal building procedures. These settlements are usually built at the edge of the cities where land is cheap and neglected (Moser and Satterthwaite, 2008; Mahanga, 2002). However, these informal settlements are often better located than the housing developments to which the government seeks to relocate them. The urban poor usually use salvaged materials like wood, tins, corrugated iron and others to build these settlements.

Broadly, these crude dwellings mostly lack proper indoor infrastructures, such as water supply, sanitation, drainage, waste disposal and proper road access. This is compounded by high density of inhabitants, a largely transient population, poor physical site conditions and health conditions to name few. Urban households regularly live in these awful conditions which increased the spread of contagious diseases (Cairncross et al., 1990; Hardoy and Satterthwaite, 1990).

According to the UN (2005), South Africa suffers unequal income distribution, with about 34% of its population living below the poverty line. This inequality is reflected in the provision of basic services including water and sanitation. These basic services are not always available in informal settlements as these are considered as illegal and neglected as such. It is clear that the South African government as many others has failed to ensure that rapid urban growth has been supplemented with investments in services, mainly in the indigents' areas (Cairncross et al., 1990). The result is an increase in the number of households living in informal settlements without suitable infrastructures.

In South Africa (as in most developing countries) the most commonly used sanitation technologies are waterborne sewerage at one end of the scale and pit toilets at the other (Austin, et al., 2005). Alternatives (considered as intermediate to waterborne sanitation) such as septic tank, VIP, Urine diversion, pour flush etc. have unfortunately acquired the status of poor man solutions to the sanitation problem. This view has tarnished the image of any sanitation technology that is not waterborne (Austin and Van Vuuren, 2001). The provision of alternative sanitation technologies is a challenging exercise that requires a holistic approach to ensure user buy-in.

<u>Challenges for providing alternative sanitation technologies to informal settlements</u>

The legacy from the apartheid is still apparent and this is reflected on the current service delivery inequality. This is compounded by unequal discrepancies in wealth between rich and poor which reflect also on the level of service provision. In addition to this those living in peri-urban areas (including informal settlements) want nothing less than similar service to those living in formal areas despite various constraints that limit the provision of such services. Further, various informal settlements dwellers believe that the use of alternative sanitation implies second class, waterborne sanitation can be provided at low cost, waterborne sanitation is robust and less sensitive and on-site sanitation systems are unhealthy and contribute to the pollution of water resources etc.

Furthermore, the current legislation does not promote the provision and use of alternative sanitation despite the failure of sewered waterborne sanitation systems. Bearing this in mind, there is a need for new approaches and technologies that support alternative sanitation systems; one of these being user awareness and education.

Need for alternative sanitation systems

During the last decade urban areas in South Africa have experienced a huge increase in the number of informal settlements. Urban areas are growing rapidly as they are perceived as a potential area of income and the only way to take advantage of the limited developments in the country (Mels et al., 2008). South African urban population living in informal settlements is growing over the years. Challenges such as over urbanisation, absence of affordable housing, lack of urban policy, the legacy of apartheid planning and lack of service delivery and poor channels for communication with the local community have contributed to the wave of service protests.

The most preferred sanitation system (waterborne) has failed; as inadequately maintained sewer reticulation systems in urban and peri-urban environment (where available) have caused variable environmental impacts. Winblad (1996) indicated that the sanitation approaches based on flush toilets, sewers and central treatment plant cannot solve the sanitation problem. Conventional sanitation options may be suited to certain situations but in other circumstances where both water and space are scarce there may be clear need for alternative sanitation system (Dudley, 1996). In response to these issues several alternative sanitation systems including the MobiSan have been successfully implemented while other have been problematic mainly due to poor design and construction practices or due to social issues such as users buy-in, water supply levels, reliability, etc. (Austin & Van Vuuren, 2001).

The MobiSan concept

The MobiSan (mobile sanitation) facility is one of these various alternatives that were developed and implemented. MobiSan is independent from sewer networks, is able to deal with higher toilet rates thus higher densities and it fits in most unsuitable locations. It provides easiness to implement in poor accessible as well as in privately owned settlements. Finally the added value of its mobility facilitates the fast and easy insertion, transfer or replacement in case of an emergency situation, a settlement's relocation or failure of the system.

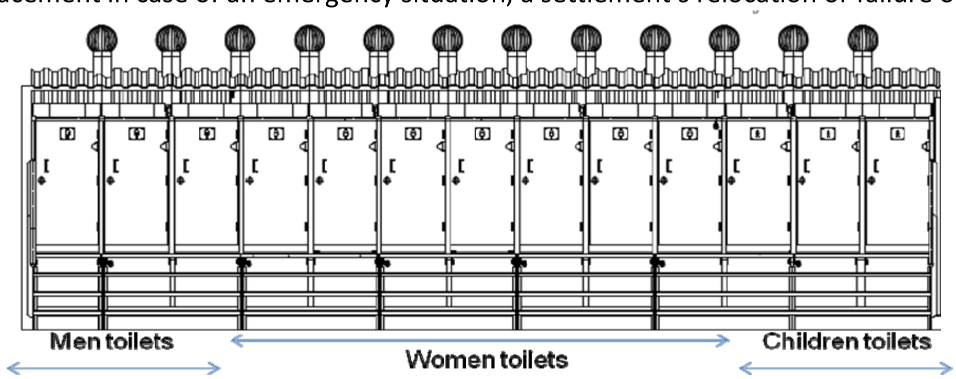

Figure 1: The MobiSan facility – cubicle division (courtesy: Landustrie, 2009)

The MobiSan system is based on urine diversion and faecal matter composting and dehydration. It consists of a 20-feet ship container equipped with 13 toilets and 13 urinals as well as hand washing facilities. Urine and faecal matter are collected in separate storage tanks for potential reuse (on/off-site the settlement) (Mels et al., 2008). The faeces are contained in one chamber until that one is full, then, a dividing wall is opened and using a mixing device, the content is manually transported to a second chamber using a mechanical mixing device that is installed all along the tank. Besides transportation the mixing device contributes to the aeration and homogenization of the contained faeces. A gearbox is incorporated into the mixing device to reduce the requested strength to be generated when mixing the content of the faeces chamber.

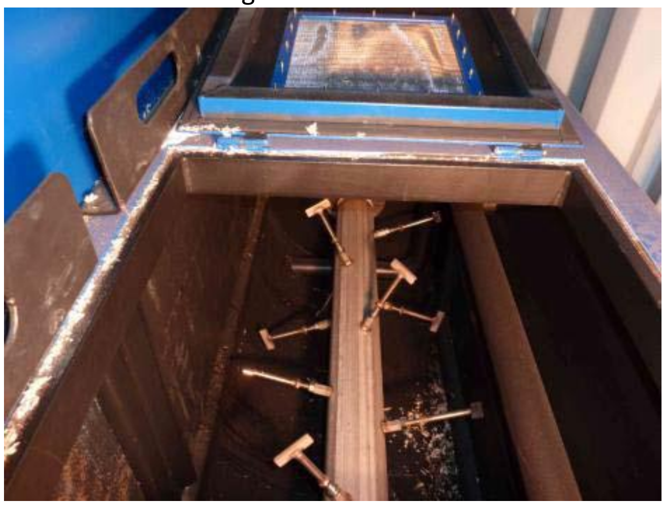

Figure 2: Faeces chamber (with separation channel – Mels et al., 2008)

The wind driven ventilators create a positive extraction that contributes to increase the natural airflow getting in the MobiSan through the toilet bowls and getting out through the ventilation pipes to the atmosphere. Such a positive extraction keeps any offensive odour away from the cubicle. In addition, it catches as much moisture as possible in the way from the faeces tank to the ventilation pipes encouraging to the dehydration process. Faeces collected in the collection vault are drying by the wind effect and addition of saw dust. After a period of 6 to 9 months, dried faeces contained in the vault is assumed to be sanitised, thus safely handled and reused. However, given the large volume of faecal sludge and urine produced by the MobiSan, adequate management practice is required in order to ensure that the handling, reuse or disposal comply with the general standards and restrictions.

This paper presents results of an investigation of the management of the faecal sludge produced by the MobiSan with the view to explore potential for improvement. The analysis of the sludge was only used as an indication of the readiness of the treated faecal sludge for potential application or further treatment.

METHODS

Data required for the purpose of this study was obtained through a daily operational control and weekly monitoring of the MobiSan facility for a period of 6 months. The daily operation consisted of turning of faeces in the vault, adding saw dust to enhance the dehydration process and controlling odour while the monitoring process consisted of analysis the daily report provided by the caretaker, collecting and analysing samples for moisture content (MC), pH, temperature, volatile suspended solid (VSS), total solids (TS), faecal coliform (FC) and helminth ova (HO) as well as potassium (K), total nitrogen (TN) and total phosphorous (TP) and determining the stability of faecal sludge.

Collected samples were taken to the laboratory and analysed using available standard methods applicable in South Africa. The analysis of sample was mainly to determine the fertilising and microbiological quality of sanitised faeces in order to determine whether it complies with standards for reuse or disposal (and general restrictions). The moisture content was analysed to determine the stability of the sludge and as an indicator that determine additional management actions.

After a period of 6 months (during which faeces was expected to be sanitised), final samples were collected and analysed for the same parameters indicated above prior to decide on the withdrawal and disposal of the sanitised faecal sludge. In addition to the collection and analysis of samples, the handling and disposal of the faecal sludge were monitored. The monitoring process consisted of observing the way withdrawn faecal sludge is managed in terms of the handling, transportation, reused and disposal.

RESULTS

The analysis of the faecal sludge from the MobiSan shows the following results (table 1). The temperature was found to be varying between 31 and 36°C which were attributed to the fermentation process that occurred during the sanitisation of faeces in the vault. The MC was found to be between 36 and 42%; the value obtained are above the range (of <20%) as suggested by Dudley (1996). The rapid dehydration observed enhanced the pathogen destruction as suggested by the results presented in table 1. It was also observed a reduction of smell and breeding of flies.

Figure 3: The quality of faecal sludge from the different toilets of the MobiSan

Table 1: Results of analysis

Parameter	Results*		
	Sample 1 (Male)	Sample 2 (Female)	Sample 3 (Children)
Temperature (°C)	31	32	36
pH	7.2	7.1	7.8
MC (%)	36	38	42
VSS (%)	21.8	76.4	92.6
TS (%)	23.51	23.48	24.29
N (mg/kg dry mass)	59669	60059	62123
P (mg/kg dry mass)	14194	18695	16352
K (mg/kg dry mass)	14075	14058	14096
FC (CFU/g dry)	850	785	963
HO (viable ova/g dry)	12	16	24

* Samples were collected from 3 different vaults.

Results obtained show that the properties of the faecal sludge from the MobiSan is heterogenic (figure 3). The temperature, pH and MC (parameters that increase the die off of micro-organisms) were found to be out of the recommendable ranges.

Since the properties of the faecal sludge were found in line with those reported in the literatures the next phase of the study was to investigate the management of the faecal sludge produced by the MobiSan. The large volume of sludge withdrawn from the facility was collected using spade and rakes and packed into plastic bags. The handling of the faecal sludge was found to be not conforming with hygienic practices as workers were exposed to the faeces despite being considered sanitised.

DISCUSSION

The study highlights some of the factors which contribute to the management of the faecal sludge produced by the MobiSan. The results show that the quality faecal sludge produced by the MobiSan is heterogenic. The faecal sludge from male, female and children vaults was different in terms of the properties out of the range suggested in the literature. The physical quality of faecal sludge was attributed to the certain factors such as the misuse, disposal of nightsoil despite adequate management of the facility. The fertilising and microbiological quality was found in line with those suggested in the literature.

The rapid pathogen destruction was believed to be enhanced by the adequate dehydration process. The natural air flow getting to the faeces tank follows the same pattern as the wind speed does, the airflow within the faeces tank and ventilation pipes is not high. If the wind speed increases, the natural air flow entering the faeces tank will increase but generally remains low. Since the MobiSan was positioned at the boundary of the settlement (with no houses around), the wind was expected to be adequate, thus favouring the dehydration process.

With regard to the moisture content, the literature suggests that the relative Humidity (rH%) is higher when the temperatures get lower and vice versa. It was be observed that the air flowing out of the faeces tank through the ventilation pipe has a higher moisture content that the atmospheric air. Therefore, a dehydration process might be happening in the tank. However, during winter, the dehydration potential is lower as the air getting into the tank is already carrying high levels of humidity while for the rest of the year the temperatures are expected to increase and therefore the dehydration efficiency.

As the case for the MobiSan, the moisture content was found to be higher than the 20% suggested in the literature. This was attributed to the misuse of the facility especially over weekends. The faecal sludge from children toilets has a highest MC that was partly attributed to the occurrence of diarrhoea and illegal disposal of night soil into the toilet.

Since the properties of the faecal sludge were found in line with those reported in the literatures the next phase of the study was to investigate the management of the faecal sludge produced by the MobiSan. The large volume of sludge withdrawn from the facility was collected using spade and rakes and packed into plastic bags. The handling of the faecal sludge was found to be not conforming with hygienic practices as workers were exposed to the faeces despite being considered sanitised.

There are various ways faecal sludge can be managed. The type of management will be dependent of the type of faecal sludge and its properties. In the case of the MobiSan, the faecal sludge produced was supposed to be used directly and no further treatment was required. However, given the reluctance of potential users based on the physical quality of the faecal sludge produced, this option was found not viable and yet have to found alternative. The alternative options suggested the bagging and infiltration into storm water sewer as management options.


Figure 4: Bagging of faecal sludge


Figure 5: Discharge of faecal sludge into stormwater drain

These two management options were found to be inadequate and not complying with established practices. The application of these alternative practices was attributed to the heterogenic properties of the faecal sludge withdrawn from different vaults of the MobiSan, the difficulties for handling and transportation compounded by the refusal of various wastewater treatment works to accept the faecal sludge.

CONCLUSIONS AND RECOMMENDATIONS

An understanding the properties of faecal sludge is fundamental to the identification of the management options and practices. The properties of faecal sludge influence the management process and practices and should be investigated prior to decide on the suitable option. The findings of this study show that the faecal sludge produced by the MobiSan is heterogenic and should be further analysed to determine its treatability.

Further, the faecal sludge produced by the MobiSan is not stable and is difficult to handle as it cannot be easily transported or pumped. The current management practices were found to be inadequate as it contributes to the pollution of natural water resources and increase vulnerability of workers.

In view of these issues, it is recommended that further treatment such as composting should be considered if the reuse option is envisaged. Alternative management options should be investigated and applied to prevent health risks and protect the general environment. Unless these issues are taken into consideration, the management of faecal sludge produced by the MobiSan will remain a hazard for both human and the general environment.

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REFERENCES

Austin, LM. & Duncker, LC., 2002. Urine diversion ecological sanitation systems in South Africa. CSIR and Construction technology, Pretoria, South Africa.

Austin, LM. & Van Vuuren, 2001. Sanitation, public health and the environment: looking beyond current technologies. Journal of the South African Institution of Civil Engineering, 43(1).

Austin, LM, Duncker, LC., Matsebe, GN, Phasha, MC and Cloete, TE., 2005. Ecological sanitation – literature review. Report to Water Research Commission, Pretoria, South Africa.

Cairncross, S., Hardoy, J.E., and Satterthwaite, D., (1990) The Urban Context. In Cairncross, S., Hardoy, J.E., and Satterthwaite, D., (eds). The Poor Die Young: Housing and Health in Third World Cities. Earthscan Publications Limited, London.

Hardoy, J.E., and Satterthwaite, D., (1990) The Future City. In Cairncross, S., Hardoy, J.E., and Satterthwaite, (eds). The Poor Die Young: Housing and Health in Third World Cities: Earthscan Publications Ltd, London.

Mels, A., Castellano, D., Braadbaarta, O., Veenstrac, S., Dijkstrac, I., Meulmand, B., Singelse, A., and Wilsenachf, J.A., 2008. Sanitation services for the informal settlements of Cape Town, South Africa. Journal of Desalination 251 (2010) 330–337.

Moser, C., and Satterthwaite, D., (2008) Towards Pro-poor Adaptation to Climate Change in the Urban Centres of Low-and Middle-income Countries. Human Settlements Discussion Paper Series Climate Change and Cities 3: Global Urban Research Centre, International Institute for Environment and Development.

Mosha, A.C., (1995) The Global Context of Housing Poverty. In Aldrich, B.C., and R.S., Sandhu (eds) Housing the Urban Poor: Policy and Practice in Developing Countries. London, Zed Books.

UN (United Nations), 2005. South Africa: Millennium Development Goals country report. United Nations, New York, USA.