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The MobiSan approach: informal settlements of Cape Town, South Africa

A. Naranjo, D. Castellano, H. Kraaijvanger, B. Meulman, A. Mels and G. Zeeman

ABSTRACT

Pook se Bos informal settlement and the Cape Town Water & Sanitation Services Department are partnering on an urban sanitation project with a Dutch Consortium consisting of Lettinga Associates Foundation (LeAF), Landustrie Sneek and Vitens-Evides International. The aim of the project is to improve the basic sanitation services provided in informal settlements through the implementation of the MobiSan approach. The approach consists of a communal Urine-Diversion and Dehydration Toilet (UDDT) built in a former sea shipping container. The system is independent of water, electricity or sewerage connection and it is maintained by full-time community caretakers who also act as hygiene promoters. The project seeks to link sanitation services with hygiene promotion in informal settlements while enhancing user satisfaction and reducing costs in providing basic sanitation services. This paper describes the preliminary experiences and lessons learnt during the implementation and evaluation of the MobiSan prototype and discusses its potential for replication. The MobiSan has proved to be an appropriate option by means of dealing successfully with shallow groundwater table, land availability and high settlement densities. In addition it has been demonstrated to be cost-competitive in terms of operating cost compared to chemical toilets.

Key words | communal sanitation, dehydration toilets, informal settlements, resource-oriented, urine diversion

A. Naranjo
D. Castellano (corresponding author)
G. Zeeman
Lettinga Associates Foundation (LeAF),
Bomenweg 2,
6703 HD, Wageningen,
The Netherlands
E-mail: *aytor_naranjo@hotmail.com*;
david.castellano@wur.nl

A. Naranjo
H. Kraaijvanger
A. Mels
Vitens-Evides International,
Zwolle,
The Netherlands
E-mail: *Hans.Kraaijvanger@vitens.nl*;
Adriaan.Mels@vitens.nl

A. Naranjo
B. Meulman
Landustrie Sneek BV,
Sneek,
The Netherlands
E-mail: *b.meulman@landustrie.nl*

A. Naranjo
A. Mels
G. Zeeman
Environmental Technology Department,
Wageningen University,
Wageningen,
The Netherlands
E-mail: *Adriaan.Mels@wur.nl*;
Grietje.Zeeman@wur.nl

BACKGROUND

Cape Town as well as other cities in South Africa have experienced a huge increase in their number of informal settlements. Urban areas are growing rapidly as they are perceived as a potential income generation area and a way to make use of the centralised developments in the country. Cape Town currently has more than 240 informal settlements spread throughout the city with an estimated population of about one million. The inhabitants of these townships are characterised by low-income profiles, living under extreme poverty conditions, lacking the proper financial means and urban infrastructure to cover their basic needs. The Cape Town Water & Sanitation Services Department (WSSD) has a special division, the Water and Sanitation for Informal Settlement unit (WSIS), responsible for providing services to the informal settlements. With respect to sanitation, the municipal council of Cape Town intends to ensure access to basic sanitation services to at least 70% of all the informal settlements by 2010. This target will be difficult to achieve considering the already existing gaps in services' delivery and the socio-economic, cultural

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and environmental constraints in the informal settlements. They will also be extremely challenged by the constant flow of people immigrating from rural areas, poorer provinces and neighbouring countries. An additional challenge is that the city of Cape Town has agreed to provide basic water and sanitation services free of charge. A study conducted in 2007 on the sanitation situation in Cape Town's informal settlements (Mels *et al.* 2009) found that the main barriers for the implementation of proper sanitation systems were the unsuitable locations of many settlements (more than 40% of the sites are located on private land, wetlands and flood prone areas), the high settlement densities (55%), the non-permanent status of the informal settlements and the distance to existing sewerage networks.

Further evaluation, through a decision support tool developed for the selection of adequate sanitation systems (Castellano 2007), outlined that the more suitable technology to be applied under such circumstances was container and chemical toilets. However, due to the high operation and maintenance cost involved in container and chemical toilets, a partnership between WSSD and a Dutch Consortium was created to develop an alternative sanitation system. The Consortium involves Vitens-Evides International, Landustrie Sneek BV and Lettinga Associates Foundation (LeAF) and was started with the support of the Dutch government through Partners for Water (PvW) funding. In that respect, an innovative pilot project was launched based on the design, development and demonstration of a mobile ecological sanitation unit (MobiSan). It aims to increase service flexibility, reduce servicing costs, improve the delivery of emergency services, enhance user satisfaction and release some pressure from water resources and wastewater treatment works.

In April 2009 the MobiSan unit arrived from the Netherlands and was installed in Pook se Bos. It was monitored from April until September 2009. This project ended in October 2009 and the partnership-consortium is currently busy looking for funding to extend the research, implementation and follow up, because of the utmost importance perceived. In this sense some agreements are being worked out with the Water & Sanitation Services Department, local NGOs and Cape Peninsula University of Technology. This paper presents the experiences and lessons learnt during the implementation and evaluation of the first MobiSan unit installed in Pook se Bos informal settlement (Cape Town, South Africa) and discusses its potential for replication. This system is designed with the aim of assisting the Water & Sanitation Services Department to meet its ambitious goal with respect to sanitation coverage.

INTRODUCTION

Sanitation facilities that are shared among households – whether fully public or accessible to some – are not considered "improved" facilities, according to the definition used for the MDG indicator (WHO 2008). Some of the possible reasons for non-use of community toilets are listed as follows (UN-HABITAT India and Madhya Pradesh Government 2005):

- Lack of operation and maintenance (O&M)
- Poor construction and planning
- Lack in safety and security for women
- Insufficient funds for running or upgrading the system
- Lack of water supply
- Lacking in special provision to children and handicapped
- Lack of public health and hygiene education among poor sections of society

Several examples of shared toilets have been evaluated during this research such as the SPARC model in Mumbai (Burra *et al.* 2003), the Mukuru Biocentres in Nairobi informal settlements (Aubrey 2009) and the Ecotact's ikotoilets in Kenya (ecotact.org). The common feature of these public toilets is that the Municipality supports their activities and all rely on one or several community caretakers. In addition, these examples are closed at night, are based on a pay per use system and all are fixed structures. In the case of shared toilets in the informal settlements of Cape Town it is not possible to charge for basic water and sanitation services; and fixed structures are not allowed in private land without the owner's permission. In that respect, a robust-looking mobile structure (MobiSan) had to be designed and the full-time community caretaker role was implemented to avoid vandalism, promote hygiene and assure proper O&M.

Figure 1 | Blocked flush toilet.

It is common in the informal settlements of Cape Town to find overused toilets that look unhygienic regardless of the type of technology involved (Figure 1). The use of bulky anal cleansing material such as newspaper collected from the street-floor contributes to infections, especially in women and young girls, and also to rapid filling of sanitation systems. It also jeopardises waterborne systems due to frequent clogging (Castellano 2007).

The main sanitation technologies (>80%) used at the moment in Cape Town's informal settlements are chemical, container and flush toilets, as per the following Table 1.

Pit latrines are generally not in use due to the high water table found in the majority of informal settlements spread around Cape Town. Container toilets (removable 100 litres plastic bucket installed in a concrete cast superstructure containing 10 litres of chemicals to neutralise odours) or chemical toilets (similar to container toilets except that the plastic bucket is attached to the plastic superstructure) depend on cleaning services every two or three days which cannot control overuse, misuse and vandalism. Moreover, these systems do not promote any hand washing.

Table 1 | Sanitation technologies in informal settlements of Cape Town (Muller 2009)

Sanitation technology	Dwelling serving capacity (ratio)	Total number of units	Households serviced	% of households serviced	Cleaning cost/service. In South African Rands (VAT incl)
Container toilet	1:5	7,500	37,500	40.8%	22.10
Flush toilet	1:5	4,800	24,000	26.1%	29.78
Chemical toilet	1:5	3,600	18,000	19.6%	91.20
Other technologies (portapotties, UDT, conservancy tanks, etc)		8,111	12,323	13.5%	
Total		24,011	91,823	100%	

METHODS

The aim of this paper is to evaluate the MobiSan's technical feasibility and social acceptance as well as its potential for up-scaling, analysing different perspectives such as the social, technical, environmental, health and financial aspects, including the potential for reuse of end-products on-site and off-site. The gathered information was complemented by initial household survey, field observation and analytical measurement data as well as interviews with key informants from the public sector, academic and private field and community leaders. A portable measurement instrument (TESTO data logger) was used to collect quantitative data on humidity, temperature and air speed circulating through the ventilation pipes. This preliminary evaluation does not include extensive experimental results since the full cycle will only be finished by April 2010. However, samples are taken to the Cape Town's Scientific Department to analyse moisture content in the faeces (dehydration efficiency). At the end of this storage period samples will be taken to test for helminth eggs and *E. coli*.

The size of the settlement allowed using the population's 100% sample in order to get thorough data on the toilet distribution among the community as well as accurate information about the sanitation behaviour at night. The survey also compiled information on demographics and MobiSan acceptability information. The data obtained in the survey was validated through field observation and interviews.

The MobiSan (mobile sanitation)

The MobiSan pilot unit has been implemented in Pook se Bos, an informal settlement located in private land in an

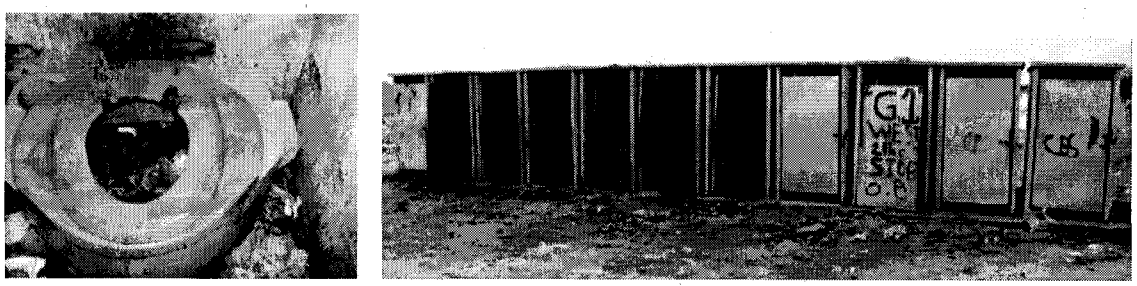

Figure 2 | Prevalent toilet conditions in Pook se Bos (container toilets).

industrial area, at 15 km from Cape Town's city-bowl. The "handmade" prototype implemented has been produced by Landustrie Sneek in Holland; however, the intention is to bring the MobiSan production to South Africa. The system consists of a communal sanitation unit built in a former sea shipping container. It is equipped with 13 toilets divided into seven toilets for women, three for men and three for children. It includes 12 waterless urinals "*Urimat Compact plus*" (see Figures 2–4) as well as hand washing facilities and a night soil disposal access. Toilets are based on urine diversion (UDDT) and faecal matter dehydration. Urine is collected in storage tanks for potential reuse and faecal matter is dehydrated within the MobiSan, resulting in reusable product. Pook se Bos informal settlement is characterised by an elevated prevalence of HIV/AIDS compared to other Western Cape areas. It accommodates a high rate of young population; sixty-two percent are under 30, out of which 28.5% are under 12 and only 3.5% are over 60. The existing sanitation in place before the MobiSan implementation was composed of 33 container toilets – only 23 were operative – organised in different rows and each toilet intended to be shared by five families. Some of those toilets (see Figure 2) were unlawfully locked for exclusively one/two family shared use, others were vandalised (without door or plastic container) and the rest overused, smelly, filthy and unhygienic.

Figure 3 | MobiSan unit.

Pook se Bos was selected because of its existing poor sanitation system, the physical and legal condition of the settlement (flood prone area, private land, high population density and the clustered arrangement of the settlement). Additionally, Pook se Bos could be entirely served with one single MobiSan unit, there was space available, and the community was keen to receive the unit and to collaborate in the testing. The pilot project is a work in progress as well as a learning process, with the intention to be used to test and monitor for further improvement and to get feedback from the community. All the lessons learnt from the implementation of the pilot unit can be used to improve the approach with the aim of replication in other settlements.

The MobiSan unit is designed to serve a community of about 500 people. It is understood that such a community has an average of ±25% of children and, even though informal settlements are characterised by high unemployment rates, some dwellers might use a toilet at work or at the school. For design purposes it has been calculated that in a community of 500 people only 70% use it full time and the minimum residence time of the faecal matter in the first chamber would be four to six months before being transferred to the second chamber for an extra four to six months of isolation. In case of larger communities more units could be distributed throughout the settlement.

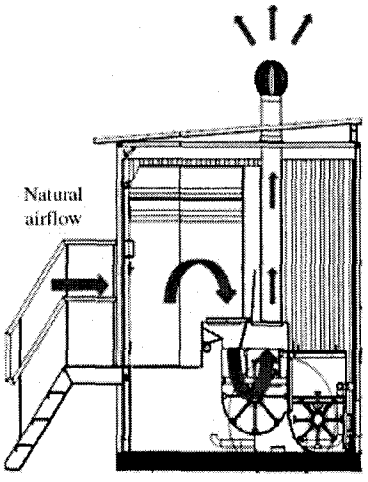

Figure 4 | Airflow recreation.

The aim of the MobiSan is to provide a proper basic sanitation service with a high hygiene and health standard to communities in the informal settlements, low lying areas, flood prone, temporary settlements, located in private land or where infrastructure is not present. MobiSan is independent of sewer networks, reliable water supply and energy sources. It is able to deal with higher toilet user rates and thus higher population density (Mels *et al.* 2009) compared to the ratio 1:5 used by the WSSD. It provides ease of implementation in poorly accessible as well as privately owned settlements. Finally the added value of its mobility – compared to fixed structures – facilitates the insertion, transfer or replacement in case of an emergency situation, a settlement's relocation or failure of the system.

The MobiSan unit is continuously staffed with local community caretakers (three per unit). The access is free of cost for the users, it also provides a small caretaker room and the facility is open from 5 am until 9 pm, seven days a week. Because of the risk of vandalism at night, the community asked for the MobiSan to be closed at night, lighted and fenced.

MobiSan is based on a double-vault system to avoid contact with fresh faeces in the final phase of the treatment process. Urine is diverted from the toilet pan and collected with the urinal flow in a separate storage tank of about 5.5 m^3. At the actual usage rate, urine is collected using a vacuum truck every six to eight weeks and disposed at the Wastewater Treatment Works (WWTW). It has been observed that many male dwellers urinate wherever they feel the need rather than walking to the toilet. If all the community urinated in the MobiSan the emptying frequency would be increased. In that respect, an extra storage tank would be required to reduce the emptying frequency rate. The faecal matter enters the first collection chamber by gravity and is mixed manually through a mechanical device or wheel. When the vault is full its content is transferred to the second chamber by lifting a separation panel (see Figure 5) and with the help of the mixing device, while the first one remains in use. In the second chamber the faecal matter is stored during 4–6 months for further hygienisation and improvement of the end product quality. The mixing device includes a gearbox (see Figure 5) to reduce the strength to be generated when turning, and, besides transportation, it contributes to the daily aeration and homogenisation of the contained faeces. Eleven black ventilation pipes are supplied to reduce smell and to reduce the moisture content of the faecal matter through air convection.

Figure 5 | Manual mixing device in caretaker room and second faeces chamber (separation panels can be seen in the left hand side).

In the first instance, the MobiSan offers an income opportunity for the community caretakers. Secondly, and this is the main difference from the other systems used in Cape Town, it provides a full time clean and hygienic toilet. Even though the full time community caretaker approach can be applied to any other sanitation system used in Cape Town, the MobiSan is the only one that uses this O&M approach and provides a caretaker room. This caretaker room was initially designed as a sanitation kiosk where toilet paper, nappies, condoms, soap and sanitary pads, among other items, could be supplied. However, during the initial phase it was preferred to concentrate just on the operation and cleaning activities. When the toilet is clean, there are no smells and it is safe, encouraging the use of the facilities. In addition, trained caretakers interact with the users in terms of proper use of the toilets, keeping a close monitoring of the process and raising awareness of hygiene behaviour. Moreover, neither users nor caretakers are in direct contact with excreta.

O&M remains crucial for any system to provide an acceptable level of service. Concerning container toilets, it is difficult for the WSIS to control and monitor the quality and frequency of the cleaning services provided by the private contractor (undertaking around 11,000 services/ week). Furthermore, part of the cleaning services are performed at night, which can make the control and monitoring even more difficult (Personal communication with Nashieta Leukes, Monitoring and Evaluation officer, WSIS 2009). The pilot project also supports capacity building within Cape Town Water Supply and Sanitation Department (WSSD) for the right enabling environment to facilitate large-scale implementation of these systems in the informal settlements.

FINDINGS AND DISCUSSION

The results highlighted in this section relate to the first phase of the implementation process in Pook se Bos informal settlement after six months of operation. At this stage the contents of the first collection chamber have been transferred to the second vault and kept isolated from fresh material for further processing. Even though the full cycle has not been completed (emptying of the second chamber), the lessons learnt during the initial MobiSan's M&E period are stressed in the following paragraphs. Daily interaction with the community, the caretakers and the municipality, combined with the consistent monitoring of the unit, has provided an overall encouraging outcome. As well, common in any working or learning process, some shortcomings have been identified and the actions taken or suggested to fix them are also described below. According to the methodology, the finding will be presented based on social, technical, environmental, health, finance and reuse aspects.

Social

In the initial phase of the implementation a household survey was conducted through the whole population of Pook se Bos (≈120 shacks). The results confirmed that the distribution of container toilets was uneven among the dwellers; therefore, the ratio 1:5 (one toilet per five families) applied by the City was not respected. This concept is particularly difficult to control due to constant human migration in the informal settlement as well as cohesion issues that may arise between dwellers sharing a toilet. This sometimes turns up in one household changing the lock of the toilet for its own use, making the sanitation coverage statistics not always reliable. In Pook se Bos, 36 shacks out of approximately 120 were using 16 container toilets out of 23. In other words, around 80 shacks were sharing seven container toilets whereas other toilets were shared by a single family (see Figure 6), consequently questioning the social justice of the ratio's concept. Therefore, the MobiSan offers equality in the service for everybody in

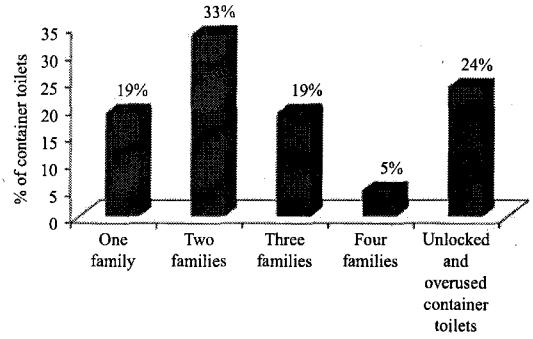

Figure 6 | Distribution of the previous container toilets in Pook se Bos.

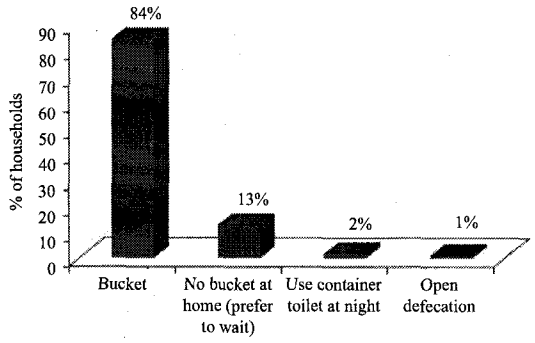

Figure 7 | Sanitation system used at night in Pook se Bos.

the settlement, no doors locked or shared with few households, everybody is allowed to use it, community as well as visitors and newcomers. Concerning the sanitation system used at night and its disposal method, it has been found that the bucket system is massively used in the community (84%). The main reason is that most people (98%) do not risk leaving the shack at night to walk to the nearest toilet, due to lack of light and, therefore, insecurity, especially for women and young girls. During the study, the settlement did not have electricity within their shacks or streetlight inside the settlement.

After nearly four months of operation, the night soil disposal access has rarely been used, due to the lack of promotion and the dwellers' common habit of disposing their night soil buckets in the marsh or anywhere closer. At the moment and based on field interviews, the dwellers do not feel comfortable walking through the settlement to the MobiSan carrying their buckets (Figure 7).

Acceptability

The community has been very supportive of the project and collaborated from the very beginning with the installation. Later on, a high level of acceptance has been found, mainly due to cleanliness, lack of smell and the safety provided by the system. The totality of the interviewed users declared being very satisfied with the safety and cleanliness of the unit. One-third of the total population was still using the old system because they had their own container toilet for their own use. After three months of operation, and in order to test the MobiSan at its full potential, the community committee was asked whether they would agree to remove the previous container toilets. This would allow one single MobiSan unit to provide service to everyone in the settlement. In addition, the WSIS would reduce the container toilet's operating cost in Pook se Bos. The community accepted to remove all toilets, which for some dwellers were located in front of their houses; even if they had to walk longer distances to the MobiSan (maximum distance within the settlement ≈ 100 m). This proved that the community was satisfied with the new system.

Technical

The unit has been tested during the worst case scenario, which is the winter season, when the temperatures are lower and the humidity is higher than in summertime. The major function of the first chamber is to contain the faeces and the second chamber is used to further dehydrate its contents through an extra four to six months storage, completely isolated from fresh input. The emptying of the final product is expected twice a year. Once the matter is transferred to the second chamber a source of carbon can be added to absorb extra moisture to improve dehydration or even, if preferred, to potentiate a composting process. Composting is not intended in the MobiSan, as it is a far more complicated process, which needs, besides monitoring devices, more care and attention than dehydration. However, during the monitoring wood shavings were added and mixed with the faeces and the temperature increased from 15 to 25 degrees Celsius, therefore indicating the starting of a composting process. Unfortunately, no follow up of the process was possible, but this could be readdressed in the future.

Despite the fact that winter climatic conditions do not contribute to an optimum dehydration process, the technical monitoring determined that the faeces tank was excessively humid without this being entirely due to the weather. The main reason turned out to be the urine separation channel being slightly too short, thus letting urine into the faeces tank, mainly in the women's toilets. This problem was generally not affecting the men's toilet, since men were using the urinals or the surroundings, and also because the existing urine separation channel measures were adapted to men. Although urine diverting measurements were used in compliance with existing UD toilets, this

did not match the sitting position of women, and therefore failed to provide a proper diversion.

Another issue is the high degree of humidity in the faeces, due to the general poor diet and health condition, as well as alcohol abuse among the dwellers. Visual inspections confirmed that a significant number of dwellers suffer from diarrhea. In addition, during the start-up of the project communication with the community failed to address the importance of the diversion system. In the initial survey 84% of the respondents using the MobiSan did not know that the unit was equipped with a urine diversion system. From that moment the caretakers started to interact with the users to educate them on the proper use of such toilets. Besides the lack of previous promotion, the users may have not known about the urine diversion device because it was not visible. The designers made the interior of the toilet bowl as dark as possible to prevent users from being confronted with the faeces tank underneath. This was one of the main community complaints in the case of chemical and container toilets.

In order to reduce the amount of liquid and to make the device visible, a red plexi-glass extension was added to the urine separation channel in all the women's toilets (see Figure 8) and it proved to be efficient. Additionally, three out of the seven women's toilets have been transformed into women's urinals by adding to the plexi-glass extension an extra six centimetres. These toilets have been signposted, the caretakers have briefed new users consistently, and women have assimilated the system.

It has been observed that the transfer to the second tank is not optimal when the moisture content of faeces is too high since the mixing device cannot transport the matter easily. Moreover, the mixing device has not provided an added value to the dehydration process. On the other hand, adding wood shavings in the tank has proved to absorb the excess of moisture efficiently and improves the transport. Wood shavings have generously been provided by Cape Firelogs Manufacturers cc., which will allow enough stock for the first year of operation. Field observation showed that the initial design overestimated the number of waterless urinals; four or five would have been enough.

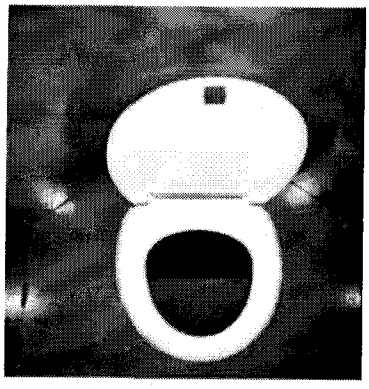

Figure 8 | Women's urinal.

Airflow and moisture removal

At the initial piloting of the MobiSan, and in order to evaluate the system's robustness against odours, no bulking agent was added after each visit. The natural airflow to the faeces tank follows the same pattern as the wind speed; it is not high (0.3 metres/second); however, it can be considered efficient as there are no smells within the cubicles. Concerning the moisture removal, a sensor probe was installed in one of the ventilation pipes to measure the moisture content of the natural airflow leaving the tank. This data has been compared with the relative humidity (rH%) obtained through the Cape Town International airport weather station, located ten kilometres away from the settlement. The results indicate that the natural airflow does remove some moisture; the process, nevertheless, could be more effective if the volume of air getting into the tank increases. To test the effectiveness of an increase of airflow, three electrical fans within the 12 ventilation pipes have been installed. They provide a higher and continuous airflow of 2.5 metres/second, which improves the dryness of the excreta mixture.

Accessibility

Although it was not compulsory, a concrete slab was built to assure the stability of the unit. Additionally, a crane was requested to locate the unit on top of the slab, raising the concern about the weight of the unit and its limited mobility.

The initial MobiSan design did not meet the needs of disabled people and children. The toilet bowls and urinals were designed for adults and the stairs were not suitable for

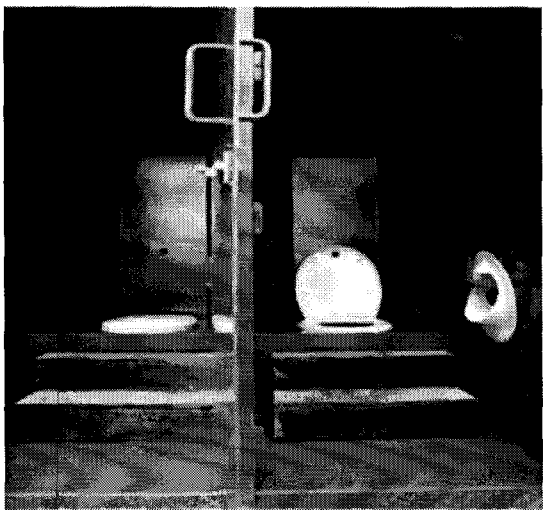

Figure 9 | Pedestal and potty.

people having mobility problems. The survey found that 8% of the users were not satisfied with the accessibility and 12% only reasonably satisfied; the rest (80%) were very satisfied. However, these issues were tackled by installing handrails, improving the access, as well as detachable potties to reduce the children's toilet bowl diameter, along with pedestals in the hand washing basins, urinals and children's toilets (see Figures 9–11). The MobiSan prototype does not allow wheelchair access but this can be improved by adding a ramp. However, no handicapped person in Pook se Bos is using a wheelchair.

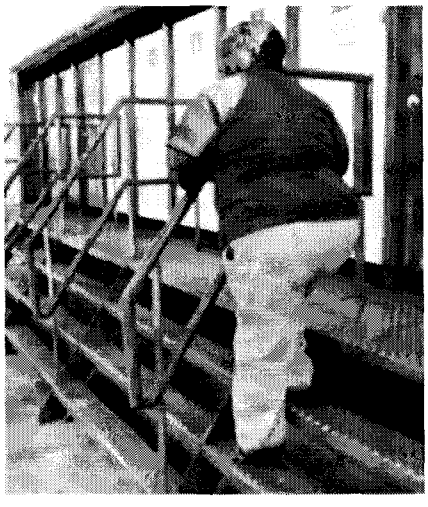

Figure 10 | Hand rails.

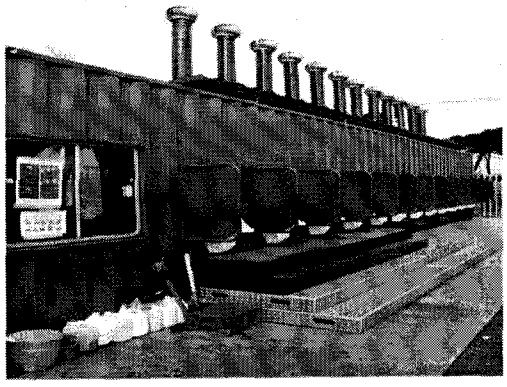

Figure 11 | Waterless urinals adapted to children.

Environment and health

Environment-wise, the MobiSan does not require any water, in contrast to flush toilets, contributing to City's water saving strategy. The hand-washing basins are connected to an existing stand post that drains to nearby marsh land. If water were not available a tank could be installed on top of the roof or rainwater harvested. Furthermore, with the MobiSan there is no potential pollution of surface and groundwater through sewer leakages and wastewater effluents. Observation on the servicing system of Pook se Bos container toilets has provided information on the contractor's servicing practices. On every service clean plastic containers replace the used ones, which are carried by hand and piled up, as per Figure 12 below, in a pick-up truck with its contents, fresh excreta, dripping on the street on the way to the Waste Water Treatment Works (WWTW). One important concern is that there are around 7,500 container toilets handled in the same way in informal settlements of Cape Town, causing a health and environmental concern. Also, a carbon intensive logistics is applied to chemical and container toilets since three emptying services/week are needed. In high density settlements the emptying might be required daily.

Open defecation has been another cause of environmental concern in Pook se Bos. In particular, children confirmed that they preferred to defecate in the open rather than in the previous filthy container toilets. In addition, the container toilets design is not children friendly. Compared to container toilets it has been found that children in the

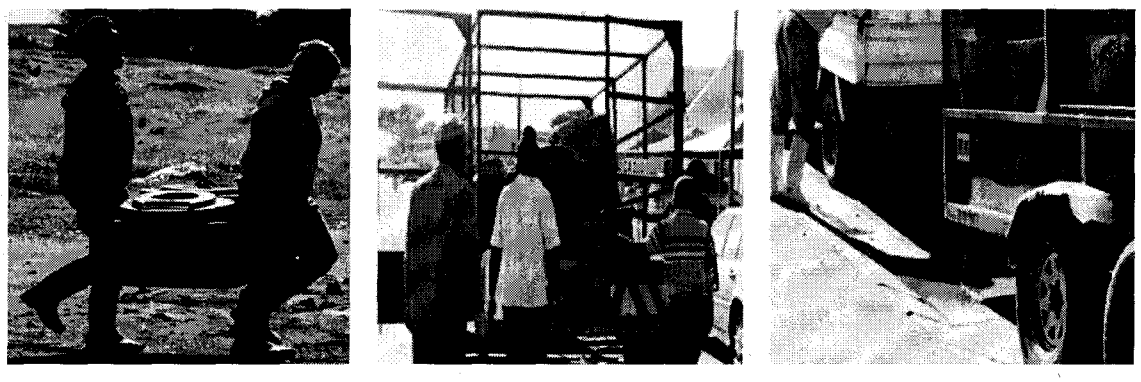

Figure 12 | Common container toilets servicing practice.

settlement are generally using the MobiSan because of the cleanliness, adaptability and lack of smell (Figure 13).

Health-wise, previous women's hygiene behaviour related to the cleansing (from back to front) using newspaper or other bulky material created vaginal and urine infections. A programme started to raise awareness to change this behaviour in collaboration with local health care officials and NGOs. The monitoring period also included a practical education programme to assist the children with personal hygiene (cleansing and hand-washing) supported by the *crèche* located in the settlement. Regarding promotion of toilet paper and soap, these basic items are provided free of charge to encourage a behavioural change. Although these basic items might not be provided for free in the long term, at present the demand is being created.

Figure 13 | Children defecating in Pook se Bos.

Reuse

In South Africa it is possible to market organic fertiliser containing treated human waste. Therefore, after further treatment, and the required microbiological and chemical analysis among other data, an organic compost registration license can be obtained. On-site and off-site options for final disposal/treatment are being explored. In the meantime dry faeces can be disposed with the primary sludge (at the WWTW) which is used by a local entrepreneur to make organic compost.

The present potential for the on-site reuse is currently low due to the dwellers' reluctance to reuse human excreta to fertilise edible products. Nevertheless, even if a secondary treatment is needed, once the storage cycle of the second chamber is finished, the community can be present during the emptying and, depending on the dehydration efficiency, the prevailing reluctance might diminish.

Despite many studies undertaken worldwide on the reuse of urine, it is not yet commonly practised. In that respect, the South African Council for Scientific and Industrial Research (CSIR) is piloting a project in Stellenbosch on the removal of nutrients from urine separation toilets (CSIR 2009). If the pilot succeeds, the process could be ready for up-scaling by the end of 2010 in a WWTW in Cape Town. In that case, urine from one or several MobiSan units could be treated separately from the regular waste stream, reducing the energy needed from the WWTW purification systems. Also environmental pressure on the surface water will be reduced and recovering nutrients will turn into agricultural resources, thus generating an income from informal settlements.

Table 2 | Comparison operating and capital cost (adapted from Moolan (2009))

Costs	Type of technology Container* (25 units = MobiSan unit)	Chemical	Flush†	MobiSan
Total operating cost/month	R 6,669	R 27,390	R 7,626	R 11,244‡
Total capital cost	R 80,336	N/A	R 137,350	N/A

*The environmental cost and impact of container toilets is not included.
†The operating cost of flush toilets does not include labour and petrol.
‡Around 90% consists of the caretakers' salaries.

Financial

The city of Cape Town is facing the challenge of providing basic water and sanitation services free of charge. As for the 2008 financial year, the WSIS unit spent almost R60M (€5.5 M) just in operating cost related to sanitation systems, the biggest part of such expenditure coming from the servicing of chemical toilets. This massive expenditure constrains the yearly budget that otherwise would be used for new infrastructure and upgrading of unplanned settlements. One of the problems the City council is facing with free basic services is that, despite heavier spending, users are not always satisfied. During 2009, this has been transmitted to the authorities in Cape Town through several strikes and public demonstrations for an improvement of the basic services in informal settlements, namely water, sanitation, electricity and housing.

Capital cost

The MobiSan project was granted €342,948 by the Dutch Government. This amount has been spent in the prototype design, construction, shipment from the Netherlands, installation, monitoring and evaluation. The major part of the prototype is produced in stainless steel, involving 800 hours of cutting, painting, welding and coating at Dutch labour rates. In order to be cost competitive compared to chemical, containers and flush toilets the MobiSan should be produced locally and the overall cost reduced considerably. An improved design is currently being developed and, therefore, the capital cost is not available yet. In the case of chemical toilets the capital cost is not considered as this system is rented by the city of Cape Town (R91.20/cleaning service/unit), contrary to container and flush toilets that are constructed by the City.

For this reason the main comparison is based on the operating cost; however, capital cost information, given in Table 2, gives an idea of a competitive breakeven point for a future MobiSan industrial design.

Operating cost

The monthly operating cost of the most common sanitation systems used in Cape Town (chemical, flush and container toilets) has been compared to the MobiSan. Further to the ratio 1:5 applied, it has been assumed that one MobiSan unit equals 25 toilets. These preliminary calculations including the collection, disposal and treatment of faeces and urine at the WWTW indicate that the MobiSan operating cost is over two times cheaper than chemical toilets, used as a quick and temporary solution for emergencies, but which unfortunately remain indefinitely.

Although the operating cost of flush and container toilets is relatively lower than in the MobiSan, they do not provide benefits in terms of acceptability, cleanliness, energy savings and hygiene promotion, besides the added value of the job creation through the caretakers' salary in a settlement suffering an elevated rate (64%) of unemployment (Naranjo 2009).

CONCLUSIONS & RECOMMENDATIONS

Looking back at the sanitation situation in Pook se Bos before the MobiSan implementation, it can be observed that the situation has undergone a tremendous positive change. This study considers that, when well managed, the MobiSan approach can be up-scaled in other informal settlements of Cape Town. It provides benefits such as a combination of dignity, equality and job creation, drinking water savings

and hygiene promotion as well as mobility of the system and a potential reuse of human waste as a resource. The communal facility fulfils the purposes it was conceived for, which are: to deliver a good and accepted service; to contain human excreta in a safe and hygienic way for users, caretaker and the environment; to comply with its designed technical requirements while reducing O&M cost as compared to chemical toilets; and being cost competitive with container and flush toilets.

Communal sanitation has proved to be an appropriate option, since physical, legal and social barriers, such as shallow groundwater table, land ownership, poverty, and high settlement densities, limit the implementation of individual sanitation. Likewise, the MobiSan approach addresses social justice issues by providing an attractive, clean and safe toilet that can be used by anyone in the settlement without restrictions. The opening of the MobiSan is limited to daytime to prevent the users, caretaker and the facilities being at risk. Therefore, bucket toilets at night are massively used due to insecurity, and unfortunately disposed into the environment. Ongoing discussions with the community are being held in order to promote the use of the night soil disposal facility available in the MobiSan. However, an alternative to the night bucket should be explored with the community (i.e. the *peepoo* bag, www.peepoople.com). A major weakness in the MobiSan is the lack of accessibility for disabled people that could be easily solved by adding a ramp or partially burying the unit.

Based on the experiences and lessons learnt during the implementation and evaluation of the MobiSan project, an improved approach and technical version is being drafted. Technologically, the overall weight needs to be reduced by using lighter materials and modular units that would also simplify transport and installation. It must take also into consideration access for disabled people and the mixing device should be removed as it does not provide a clear benefit. The future design could incorporate solar panels and rainwater harvesting tanks.

Final results for the Pook se Bos prototype (end of April 2010) including the quality of the final product will be crucial in order to assess the full potential of the dehydration process. To improve this efficiency a bulking agent could be added after each use. Nevertheless, it is acknowledged that further treatment will be required after the storage time in the MobiSan. Research is ongoing to make use of a local entity (Public and/or Private) to collect, transport and further treat and reuse the end products. Currently urine is disposed at the WWTW and therefore, reuse options are being explored. Due to the daily demand for firewood in the settlement, urine could be used on-site to fertilise fast growing trees such as Acacia. However, the community is yet reluctant to handle human excreta.

The preliminary evaluation shows that the O&M is less costly compared to the chemical toilets, which are by far the biggest Cape Town's on-site sanitation expenditure. Although the capital cost would depend on a future final design, in order to be competitive with container and chemical toilets, it should be produced industrially. The unit needs to be manufactured locally to reduce production costs and to create employment opportunities. Local partnerships are under evaluation; this includes further funding to set up an infrastructure for local production and operation and maintenance services of the system. Basic services in Cape Town are provided for free; however, this does not include shower services. The idea of its implementation is being evaluated with the community as a pay per use service. The income would contribute to the economic sustainability of the system.

For a replication initiative, this project recognises the importance of community involvement and participation, employment of local entrepreneurs, hygiene promotion activities and gender issues.

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