AFTER THE PIT LATRINE IS FULL . . . WHAT THEN? EFFECTIVE OPTIONS FOR PIT LATRINE MANAGEMENT

D.A. Still

Partners in Development cc, PO Box 11431, Dorpspruit, 3206pidpmb@iafrica.com

SUMMARY

In rural areas the Ventilated Improved Pit Latrine (VIP) is considered as the basic RDP standard for sanitation. Large numbers of VIPs have even been constructed in urban areas where other sanitation options were not economically feasible. Pit filling times vary widely depending on factors such as numbers of users, soil type and pit lining methodology. Pits are also generally used for solid waste disposal, and this hastens the filling time.

This paper looks at the following aspects of pit latrine sludge management:

i) published data on pit latrine filling rates;
ii) methods employed in South Africa and elsewhere for the emptying of pit latrines;
iii) observations regarding the decomposition of pit latrine sludge;
iv) costs of pit latrine emptying and sludge disposal;
v) designing for emptying - what should be done;
vi) options for the disposal of pit latrine waste;
vii) alternative sanitation options for easier sludge management.

VIPs have not been with us long enough as an accepted part of the municipal services framework for local government to develop much of a response to the problem of the management of pit latrine waste. Particularly in the rural areas, where local government is stretched over huge areas, practical and economical solutions must be found. This paper describes an appropriate range of options.

1. INTRODUCTION

On-site sanitation, low flush septic tank systems (LOFLOS) and pit latrines in particular, are becoming more and more common in South Africa's peri-urban and rural areas. With an estimated 20 million people, roughly three million homes, still without access to basic sanitation, on-site sanitation is set to become the dominant form of sanitation in these areas. In most cases this type of sanitation is the most economical solution to sanitation provision. But how long will it be before the pit latrines fill up, and whose responsibility is it empty them?

Paper presented at the Biennial Conference of the Water Institute of Southern Africa (WISA) www.wisa.co.za
CD-ROM produced by: Water Research Commission (WRC), www.wrc.org.za
19 – 23 May 2002, Durban, South Africa
ISBN Number: 1-86845-844-X
Organised by: Conference Planners

2. SLUDGE ACCUMULATION RATES - PIT FILLING TIMES

Sludge accumulation rates in pit latrines and septic tanks are dependent on a variety of factors, the most important of which are the number of users, the degree to which the pit or tank is drained, and the degree to which the pit is used for disposal of other household waste. In practice sludge accumulation rates vary from as little as 10 litres per user per year to as much as 100 litres per user per year, with the median rate being in the 25 to 30 litre range. Tables 1 below shows a range of data from local and international experience.

The immediately noticeable thing about Table 1 is the difference between the filling rates at Bester's Camp, and those at the other locations. The higher rate of filling at Bester's can probably be explained by two factors: firstly, it is a very dense urban settlement, and users will thus be throwing more sullage and household waste in their latrines; and secondly, the latrines are not well drained.

Table 1: Observations of Filling Rates of Pit Latrines

Location	Reference	Age of Latrines	Number of Sites Monitored	Number of Visits	Avg. Pit Volume m^3	Range of Filling Rates Observed litres/capita/annum	Mean Filling Rate l/c/a
Soshanguve	WRC Report	approx. 3 years	11	14 over 28 months	1.96	13.1 to 34.0	24.1
Bester's Camp	City of Durban Report	four years	159	2 or 3 over 25 months	3.16	18.3 to 120.5	69.4
Mbila	Partners in Development Report	approx. 5 years	11	1	2.83	10.0 to 33.2	18.5
Gabarone, Dar es Salaam	WHO Paper, 1982	not stated	not stated	not stated	not stated	25 to 30	27.5 (implied)

One of the most interesting aspects of the Bester's Camp study was that the sludge build up rates decreased by more than 33% between the first visit, when the latrines were on average two years old, and the final visit, when the latrines were on average four years old. It is possible that the sludge volumes were consistently overestimated on the first visit, but it is more likely that the sludge build up rate does decrease with time due to the gradual increase of natural digestion processes in the latrine. There is evidence in the literature dealing with septic tanks that supports the latter conclusion.

In all cases it was observed that pits are also used, to a certain extent, for the disposal of household solid wastes such as rags, cloths, plastic and glass. An excavation of one old pit in the Mbila area indicated that this may contribute between 10 and 20% of the observed sludge accumulation rates. The use of newspaper for anal cleansing is most commonly observed, and this breaks down more slowly than soft tissue paper. The use of non-degradable anal cleansing materials, which is sometimes noted in the literature as a factor leading to more rapid pit filling, was not observed.

There is no widely accepted view as to whether sludge accumulation is faster when the wastes are retained in wet conditions or not. Franceys and Pickford (1992) include a table in their 1992 publication *A Guide to the Development of On-Site Sanitation*, which implies that the sludge accumulation rate in wet conditions will be approximately 33% slower than in dry conditions. However, they also include a disclaimer that little is known about the topic and that local data should preferably be used by planners. It is possible that the view that wet conditions reduce sludge accumulation is derived from the understanding of septic tanks, which is a much better researched field. When the wastes are under water natural biological reactions do convert the biodegradable fraction of faeces into carbon dioxide, methane and water. However, a pit latrine will only retain water on a continuous basis if the pit is partially or completely sealed, if the soil permeability is very low, or if it is built in an area with a very shallow groundwater table. Under these circumstances the pit latrine becomes effectively a cross between a conservancy tank and a poorly functioning septic tank. While the rate of solids accumulation will be similar to that in a septic tank, the retention of liquid can be so high that the pit latrine becomes effectively "full" long before it should be. Evidence of this problem is referred to by Rijnsburger in his report on sanitation in Dar es Salaam, *MAPET. A neighbourhood-based pit emptying service with locally manufactured handpump equipment in Dar es Salaam, Tanzania*. A South African example is the city of Grahamstown, where a number of pit latrines built in an area with poor drainage have to be emptied during wet times as frequently as once per week.

The data included in Table 1 above lend support to the contention that pit latrines fill more slowly in dry conditions. Whereas the Bester's Camp pits were built with concrete block lined pits in clayey soils, the Soshanguve pits were built without pit linings and the Mbila pits, though lined, are located in sandy soils and are thus well drained. It is also believed that a soil/sludge interface is beneficial to sludge reduction, as this facilitates the activities of insects and other biota which live in the soil, but which feed off the faeces.

The range of filling rates shown in Table 1 indicate that within a given area there is a high degree of variation in the rate of filling, and that moreover from one area to another there might be an even greater variation. When these per capita rates are compounded with the variation in the number of users per pit, and the volumes of the pits provided, it is seen that the filling time of pits within an area, and between areas, can be from as little as three years to as much as 20 years.

The rate of sludge accumulation in septic tanks and digestors is a topic better researched than the rate of filling of pit latrines. The WRC Report, *Sludge Build Up in Septic Tanks, Biological Digestors and Pit Latrines in South Africa* recommends that the filling rate of 29 litres/capita/annum is used as a design criteria for septic tanks, but quotes data from local and international experience which shows that filling rates vary from less than 10 litres per person per year to over 100 litres per person per year.

3. METHODS FOR PIT LATRINE EMPTYING

Pit latrines and septic tanks can both be emptied by vacuum tankers, and this is the preferred technology where access to the site and access to the inside of the pit or tank is not a problem. In the case of pit latrines the contents tend to be partially compacted and dried, and thus water must first be added and the contents must be agitated before a vacuum tanker can do its work.

Over the last decade small vacuum tankers have been developed for use in high density urban areas where access to sites is a problem. The 200 litre MAPET has been proven in Dar es Salaam, and the 500 litre Vacutug in Nairobi. The MAPET, short for MAnual Pit Emptying Technology, utilizes a handpump and a reinforced steel drum, which is mounted on a handcart. The Vacutug incorporates a 5.9 kW engine, and is self-propelled. In both cases (as in the case of all vacuum tankers) the suction is developed indirectly, so that no sludge comes into contact with any of the working parts of the pump. The MAPET and the Vacutug are both low cost appropriate technology solutions which would make it possible not only to provide an affordable service in remote areas, but they would also facilitate the entry of small businesses and entrepreneurs to this field. Including amortization and operating margins, the expected cost of pit emptying using these technologies is approximately R200 for a 2.0 m^3 pit. Neither device is, however, practical or economical if the sludge must be disposed of more than a kilometre from the source.

Pits can be emptied manually using either scoops or by flushing the contents through a hole in the lining into an adjacent pit. In the absence of a viable and affordable tanker service, these methods are the only options and are widely practised where the abandonment of the latrine is not considered an option due to space or cost concerns.

Figure 1: The MAPET, developed by the Dutch NGO WASTE, in action in Dar es Salaam (photograph by Jaap Rijnsburger**)**

Well-known practitioners of manual emptying are the aptly named *vyura* (frogs) of Dar es Salaam, who make their living emptying the pit latrines of the informal settlements in that city. The pits are very large, up to 10 m^3 in volume, and the men spend up to six hours in the pits in order to get the job done. Customers pay the *vyura* cash for their services, and the rate is for obvious reasons above the market rate for labour (the reported cost range per site was $30 to US $70 in 1989 - conversion to 2001 Rands gives a range of R235 to R550). Before the *vyura* can work a disposal pit is dug on-site near the latrine, the latrine structure is removed and the latrine slab is broken and removed. While this is a fascinating example of the resilience of the human spirit under very difficult circumstances, it is probably not one that South Africa should plan to emulate.

5. COSTS OF PIT LATRINE EMPTYING

In urban areas the cost of this service varies fom R200 to over R1000, depending on operational efficiencies and the volume of sludge to be removed. Costs of R100 per kilolitre of sludge and R7 per kilometre travelled are typical. Table 2 below compares the costs of the various pit emptying technologies which have been described in Section 4 above.

The table shows clearly that the manual excavation of the fully decomposed contents of an old pit latrine is an inexpensive operation (approx. R100). However, the use of a large vacuum tanker for the desludging of pit latrines in a rural location is prohibitively expensive.

It must also be stressed that only lined pits can be emptied using tankers.

Table 2: Typical costs of pit emptying

Methodology	**Source of Information**	**Cost (Range) for 2 m^3**
Manual excavation Old pit with fully decomposed contents	Standard Rates for Pit Excavation in Soil	R70 to R140
Manual scooping/flushing (Dar es Salaam) Handtools only	MAPET Report, SA Contractors	R50 to R110 (for *2*m^3, but reported pit size is 10 m^3)
MAPET (Dar es Salaam) Cart mounted 200 litre vacuum tank indirectly coupled to handpump	Jaap Rijnsburger, WASTE	R80 (but not covering capital or support costs)
VACUTUG (Nairobi) Self propelled 500 litre tank with motorised pump	Graham Alabaster UNCHS, Nairobi	R180
MINIVAC (Durban) Trailer Mounted, Tractor hauled 2000 litre tank	SA Contractors Lesotho	R200 to R600 low rate only applies for large scale scheduled work
VACUUM TANKER - URBAN 5 000 to 15 000 litres truck mounted tank	SA Contractors	R200 to R1000 depending on efficiencies R600 default
VACUUM TANKER - RURAL 5 000 to 20 000 litres truck mounted tank	SA Contractors	R7 to R15 per kilometre return e.g. 200 km return > R1 400

6. ALTERNATIVE SYSTEMS OF FAECAL WASTE MANAGEMENT

Emptying and removal of sludge is by no means the only option for the management of pit latrine waste. Other options include the Arborloo, the Alternating Pit Latrine, the Composting Latrine and the Urine Diversion Latrine. All of these options in some way recognise the very significant value of faecal waste as a soil conditioner or compost. By encouraging users to manage their own faecal waste, government can save the expense of pit emptying, while users can make productive use of the compost they produce.

One concept currently being promoted (Morgan, 1999) is the Arborloo, where the pit is deliberately made small (200 to 500 litres) and the latrine structure is made light. When the pit is full, a new pit is dug and the latrine is moved. Depending on the number of people using the latrine and the size of the pit the move interval can be from as little as three months to as much a two years. Ideally, after defecation, users should add a small quantity of sand or sandy soil to the pit, to improve the rate and the degree of conversion of the pit contents to a compost like humus. After the latrine is moved, the top thirty centimetres of the pit is filled with normal topsoil and a tree is planted.

The Arborloo will be of most benefit to those who have enough living space to permit their latrine to be moved repeatedly. However, if fast growing trees such as paw-paws are used, then a limited number of sites can be used with a repeating cycle.

The Ventilated Double Pit Latrine (VIDP) has two separate pits. The users only use one pit at a time, the second pit being sealed off to prevent accidental use. The pits are sized such that the pits are in service for at least two years, which means that the contents of a full pit will have that amount of time to decompose before the pit requires emptying.

It is important, however, that alternating pits are well separated - if seepage from the pit in use gets through to the sealed pit, then the contents will not be able to dry out and become inoffensive. VIDPs do not necessarily have to be constructed with the two pits adjoining (which is the standard detail given in the literature). Two alternating toilets will serve just as well, which means that any home could convert to the alternating pit latrine concept.

The emptying of a two year old sludge is a job which should be able to be tackled by hand relatively easily, which means that the logistics and the costs of pit emptying should not be onerous. Unfortunately South Africa has very little experience with the working of this system in practice.

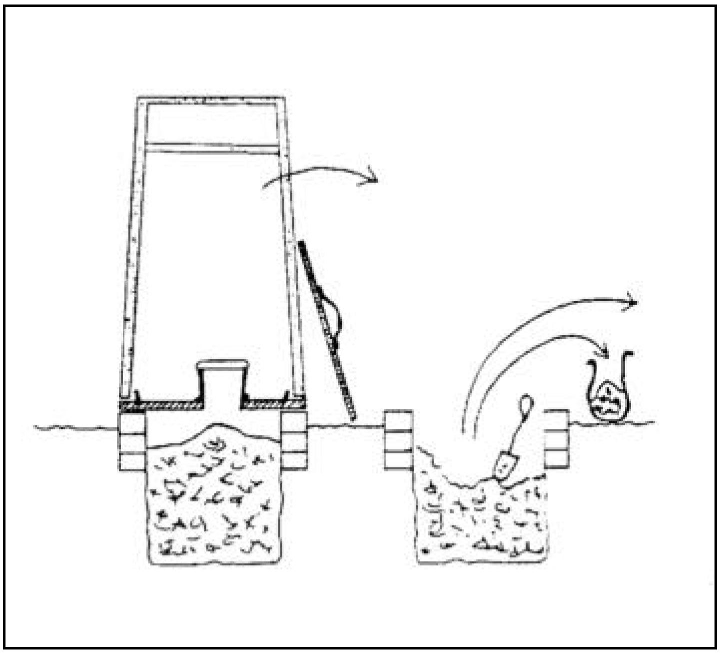


Figure 1: Schematic (from Morgan, 1999) of the Alternating Pit or *Fossa Alterna*. The pits are sized to fill in 3 to 6 months. When the pit is nearly full, the second pit's contents are emptied and put into compost bags. The latrine structure is moved, and the first pit is topped up with soil and covered. The process can be repeated indefinitely.

The only known case is the 1995 Mvula Trust/RSS pilot sanitation project at Thembalihle in the Eastern Cape. In that case the second chambers are only now becoming full, and thus the emptying of the first chamber must still be proven to be as simple as it is meant to be.

If soil, ash and kitchen wastes are added to the pit contents then decomposition proceeds more quickly, and smaller pits with shorter filling times can be used. Demonstrations in Harare have shown that such pits produce an inoffensive compost material after six months (Morgan, 1999). When two small pits are combined with a light and easily movable top structure, the combination is dubbed the *fossa alterna*, or alternating pit latrine.

The decomposed contents from a pit latrine are generally soil-like in composition, although a field trial on an old pit latrine carried out by Stephen Nash and Peter Morgan in December 2000 in northern KwaZulu-Natal did reveal that the decomposition of the contents of a larger lined pit was not complete, even after five years. More research will be needed to better understand the factors which might at times hinder the decomposition of the pit contents, but it is believed that a combination of anaerobic conditions and the sealing off of the contents from the surrounding soil do retard decomposition.

As pit latrine waste decomposes with time, a soil-like humus is formed. The evidence from the arborloo trials in Zimbabwe is that this humus is an effective compost. The use of faecal wastes for soil conditioning and for compost can be taken a step further with the composting latrine, which is a permanent structure. The composting latrine makes use of a shallow vault, instead of the deep pit common to pit latrines. The vault is aerated, and the faecal waste is well drained. The user adds soil and other organic waste to the pit (e.g. kitchen waste) to aid in the composting process. From time to time the user opens the vault from behind the latrine, and removes the older and more decomposed waste to be used as a compost or soil conditioner.

The composting latrine has been taken a step further with the concept of urine diversion (Austin, 2000). By far the greater part of the nutrients in human waste are contained in urine, and if one wishes to be able to remove decomposed faeces from the vault on a regular basis, then urine is not wanted in the vault. The idea then is that urine is separately collected from faeces. This is achieved in two ways. Firstly, men are asked to urinate into a separate receptacle, or funnel, which is mounted on the side of the latrine (which is very much like using a urinal). Secondly, the latrine is fitted with a urine separating pedestal, which is equipped with a baffle and a separate drain for urine. The act of sitting on the pedestal in order to defecate (or urinate) ensures that urine is separately collected.

Once the urine has been separated it can be diluted (10 to one with water) and used as a very effective plant fertilizer, or it can simply be disposed of into a soakpit. Meanwhile the separated faeces are sprinkled with ash, dry sand or sawdust to control flys and odours, and to help with moisture absoption. The dessicated and decomposed faeces can be removed from the vault within a relatively short period of time.

A number of pilot urine diversion projects are presently underway in South Africa, instigated by the Mvula Trust (in the Northern Cape) and by the CSIR (in the Eastern Cape). This very innovative concept makes compelling sense, but it needs social and cultural acceptance before it can be widely promoted. The pilot projects thus represent a critically important opportunity to monitor the success of urine diversion in the field.

7. DESIGN AND PLANNING CONSIDERATIONS FOR EMPTYING

The emptying of pit latrines and septic tanks can be made difficult or even impossible if access is not allowed for on site. Where vacuum tankers are used, *the key consideration is that the pit or tank cover slab level must not be more than two metres below the level of the nearest vehicle access point*. Furthermore a horizontal distance of more than 50 metres is impractical for a tanker, unless the tanker can be parked below the level of the pit (in which case the suction is assisted by gravity).

Where manual emptying is envisaged, the key consideration is that the hand scoops must be able to get into and out of the pit without obstruction. The best way of making this possible is to ensure that a section of the pit cover slab (or even the entire cover slab) can be removed.

Manual emptying is greatly facilitated if the pit contents have been allowed time to decompose into a soil like humus. This process is in turn aided if users regularly add sand, ash and organic waste to their pits. If the faecal waste is mixed with these other components, decomposition to an inoffensive material takes less than six months.

8. OPTIONS FOR FAECAL WASTE DISPOSAL

Regarding faecal waste **disposal**, by far the most economical option is to bury the contents on the site where they are generated. Where the contents must be removed due to a lack of space for on-site disposal, then municipalities have essentially three options:

i) the faecal waste can be disposed of at sewage treatment plants, although these plants must have enough capacity to handle the extra load (the volume of pit latrine sludge dumped per day should be small relative to the volume of ordinary sewage sludge processed per day);

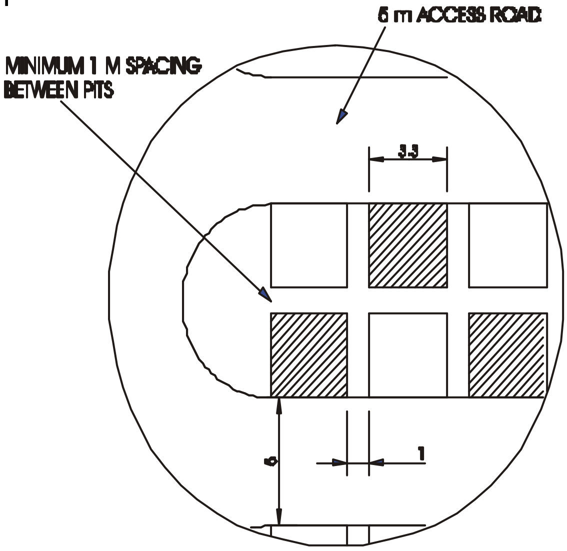
i) the waste can be composted by mixing with other organic waste and aerating;

ii) the waste can be buried at dedicated landfill sites designed for this purpose.

Of the above options, the most economical are (ii) and (iii), and the simplest to implement is (iii). It is estimated that the cost of a dedicated landfill disposal operation would be R7 per site served per month (Still, 2001).

Figure 3 illustrates a detail from a concept of a landfill site dedicated to pit latrine waste disposal. The full layout consists of 18 disposal beds, each 130 m long and 7.7 m wide. Each bed can accommodate 58 disposal pits, each 3.3 m by 3.3m and 1.5 m deep. Each pit is separated from adjoining pits by at least one metre of undisturbed soil. Each pit can be used to bury 10 m^3 of sludge, which is layered and covered with soil. The whole site can accommodate 10 440 m^3 of sludge, or the waste from over 5 000 pit latrines.

After sludge mixed with soil has been allowed to decompose for two or more years, the disposal pits can be re-used and the excess material can be removed and used for tree plantations.



A 10 m^2 pit, 1.5 metres deep, can hold 15 m^3 of material. Assuming that sludge is layered with soil (say 200 mm sludge to 100 mm soil), then such a pit can take five 2 m^3 tanker loads, or the contents of five pit latrines. Note that layering with soil is essential to ensure that each load of sludge is quickly covered to prevent odour and fly problems, and also to promote the full degradation of the sludge into a soil like humus. The soil provides a home for a host of biota which assist in the breaking down of the sludge, and thus full decomposition can occur. By comparison it has been found that a deep sludge in fully anaerobic conditions does not necessarily fully decompose (refer to Section 6 above).

Note that the site should be fenced off, screened with trees, and must be at least 500 m from the nearest dwelling. The site must be at least 200 m from the nearest river, dam or borehole. The ground must slope at less than 4% and the depth to the water table must be at least 5 metres. (WRC, 1997).

8. IMPACT OF PIT EMPTYING OBLIGATIONS ON LOCAL GOVERNMENT

In terms of the Water Services Act of 1997 and the Health Act of 1977, local authorities are responsible to ensure that affordable and workable systems are in place to manage faecal waste from on-site sanitation. Where the services provided are not affordable (and for poor areas a cost ceiling of R10 per family per month is a useful guideline), the council will have to subsidize the service from other income.

Due to problems with the collection of rates and levies in poor areas, most councils subsidize their pit emptying services so that users only pay a nominal charge of between R20 and R100. This means that councils are typically paying 80 to 90% of the cost of the pit emptying service, and it would thus be in their interest to develop technologies and systems which will bring down the cost of pit emptying. In this regard small-scale community-based options such as the MAPET and the Vacutug may prove useful. Alternately costs can be avoided altogether if users are encouraged to adopt one of the options to manage their own pit latrine waste (e.g. arborloo, alternating pit, fossa alterna, urine diversion or composting toilet).

ACKNOWLEDGEMENTS

The author wishes to thank the British Department for International Development (DFID) for funding this research, which was carried out in association with the Mvula Trust and the CSIR.

REFERENCES

AUSTIN, L.M.. and DUNCKER L. (2000). *Urine Diversion Technology in South Africa: Background and Case Study*. Boutek, CSIR

AUSTIN, L.M. and HOLDEN R. (2001). Study Report on Management of Faecal Waste from On-Site Sanitation Systems in South Africa. Report to the Department of Water Affairs and Forestry, prepared by Boutek, CSIR and The Mvula Trust.

BRANDES, M. (1978). *Accumulation Rate and Characteristics of Septic Tank Sludge and Septage.* Jour.Water Poll. Control Fed., 936-943.

CRANE, S.R. and MOORE, J.A. (1984). *Bacterial Pollution of Groundwater: A Review.* Department of Agricultural Engineering, Oregon State University, U.S.A. Water, Air and Soil Pollution 22, No. 1., D. Reidel Publishing Company.

DREWS, R.J.L.C. (1985). *A Guide to the Use of Septic Tank Systems in South Africa.* CSIR: Pretoria.

FRANCEYS, R., PICKFORD, J., and REED, R. (1992). *A Guide to the Development of On-site Sanitation.* World Health Organisation: Geneva.

GOTAAS H.B. (1956). *Composting: Sanitary Disposal and Reclamation of Organic Wastes.* Monograph Series 31. Geneva. World Health Organisation.

HAWKINS, P.M. (1982). *Emptying On-Site Excreta Disposal Systems in Developing Countries: an Evaluation of the Problems.* IRCWD News, WHO International Reference Centre for Wastes Disposal, Switzerland.

MORGAN, P. (1999). *Ecological Sanitation in Zimbabwe, A Compilation of Manuals and Experiences*. Harare.

MULLER, S. and RIJNSBURGER, J. (1988-1992). *MAPET. A Neighbourhood-Based Pit Emptying Service with Locally Manufactured Handpump Equipment in Dar es Salaam, Tanzania. Manual Pit-Latrine Emptying Technology Project Final Report.* WASTE, the Netherlands.

NaSCO, SANTAG, DWAF, DFID. (2000). *Legislation Affecting Basic Sanitation in South Africa.*

NORRIS, J.A. (2000). *Sludge Build-Up in Septic Tanks, Biological Digesters and Pit Latrines in South Africa.* WRC Report No. 544/1/00.

PEARSON, I. and LA TROBE, B. (1999). *Co-Disposal and Composting of Septic Tank and Pit Latrine Sludges with Municipal Refuse.* WRC Report No. 599/1/99.

STEWART SCOTT. (1998). *An Evaluation of the Enviro Loo Composting Latrine in an Informal Settlement Area in Greater Johannesburg.* WRC Report No. KV 112/98.

STILL, D.A.. (2001). *Guidelines for the Removal and Disposal of Faecal Waste from Pit Latrines and Septic Tanks*. Report prepared for the Mvula Trust and the Department of Water Affairs and Forestry.

STRAUSS, M. et al.. (1998). *On-Site Sanitation: When pits are full - Planning for Resource Protection in Faecal Sludge Management*. Conference on Water Sanitation and Health. WHO.

UNCHS (Habitat). (2000). *The Vacutug Development Project. A general purpose micro-exhauster developed for excreta and wastewater management.*

VAN RYNEVELD, M.B. and FOURIE, A.B. (1997). *A strategy for evaluating the environmental impact of on-site sanitation systems.* Department of Civil Engineering, University of the Witwatersrand. Water SA Vol. 23 No. 4.

WATER RESEARCH COMMISSION (1997). *Permissible Utilisation and Disposal of Sewage Sludge. dition 1.* WRC Report No. TT85/97.

WIEBELL, S.R., STRUB, C.P. and THOMAS, J.R. (1994). *Studies on household sewage disposal systems.* US Dept. of Health: Cincinnati, Ohio.