CHAPTER 9

THE SOUTH AFRICAN PILOT PROJECT

"If there is technological advance without social advance, there is, almost automatically, an increase in human misery."

Michael Harrington (American writer, 1962)

CHAPTER 9: THE SOUTH AFRICAN PILOT PROJECT

9.1 IDENTIFICATION OF COMMUNITIES

The author became aware of the potential of urine diversion technology during 1996. While still gathering basic research information, he was approached by the Eastern Cape Appropriate Technology Unit (ECATU), a parastatal of the Eastern Cape provincial government, with inquiries about the efficacy of these systems. ECATU had recently become interested in the technology and expressed a wish to implement some systems on an experimental basis. An agreement was reached on launching a pilot project whereby Boutek would direct the engineering and social research, while ECATU would be responsible for financing the building and supervisory work. Because ECATU worked closely with all the communities under its jurisdiction and thus knew them on a fairly intimate basis, it was agreed that this organisation should also assist Boutek with the required workshopping process.

ECATU indicated that they wished to implement the pilot project among certain of the rural communities, where poverty was rife and sanitation facilities either rudimentary or non-existent. The toilet units were to be fully subsidised. Boutek was initially opposed to this arrangement, as it was concerned about the sustainability of the project should there be no financial commitment from the communities. However, ECATU maintained that the technology was still unknown in South Africa, and that the communities were being expected to take part in an "experiment", so the acceptability of the toilet units was not necessarily a foregone conclusion. Boutek eventually agreed to this course of action, but with an increased determination to carry out the social process very thoroughly in an effort to ensure that the communities took complete ownership of the systems.

ECATU budgeted for a total of 45 toilet units over a two-year period. The intention was to provide fifteen units each in three selected villages, where the residents would be consulted about who the potential owners would be in each case. Due to constraints such as lack of experienced local builders as well as capacity within ECATU itself, it was decided to implement the systems in three phases of five each in communities only a short distance from Umtata. This would divide the project up into more manageable phases and making the logistics of material transport and supervision less taxing for the organisation. The villages identified by ECATU were Manyosini, Sinyondweni and Gwebinkundla, each approximately 30 minutes travel by road from Umtata. The villages were all in completely rural settings, despite their proximity to the city, and all had the same rolling topography and clayey soil. Most of the dwellings consisted of thatched-roofed mud huts, with the occasional brick and mortar house in evidence (see Figure 9.1). Availability of water was a major problem common to all three communities, the women and children having to walk long distances every day to fetch water from local streams. The few toilets that existed were ordinary pit latrines, mostly in a very poor and unsanitary condition. Residents generally relieved themselves in the veld, and the level of personal hygiene was observed to be low.

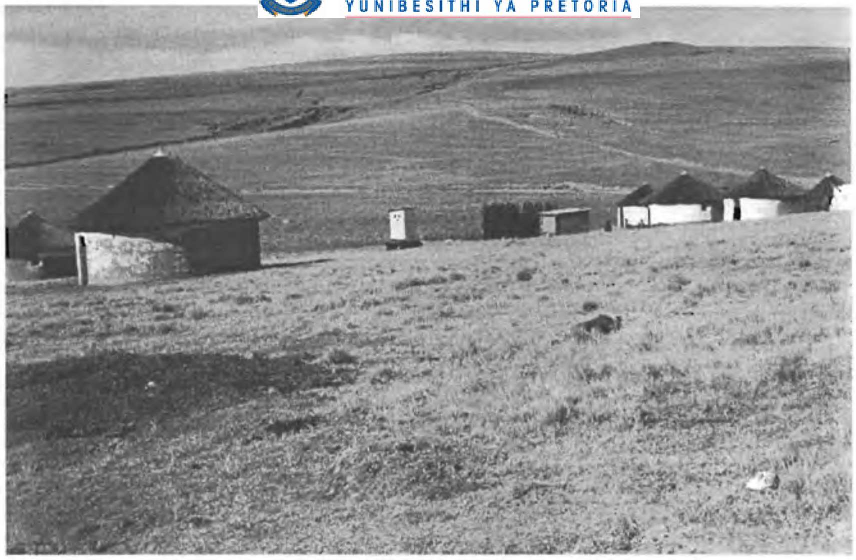


Figure 9.1: Typical views of the villages selected for the pilot project.
Top: Manyosini; middle: Sinyondweni; bottom: Gwebinkundla

9.2 THE COMMUNITY WORKSHOPPING PROCESS

Boutek's first task was for the author and an anthropologist (social scientist) to familiarise themselves with the three villages. They were accompanied by Ms Sybil Lila, ECATU's social worker, as well as the organisation's chief technician. Apart from getting to know the physical layout of the villages, it was important to understand the social structure and dynamics existing within the communities. Although the people were all Xhosas, each community had its own distinct characteristics, beliefs and behaviour. It was indeed an eye-opening event for the author, for whom this was the first time he was required to deal with project communities on an intimate, face-to-face level. Needless to say, the learning curve was extremely steep. However, having the assistance of an experienced social scientist to direct the proceedings facilitated the task enormously.

The community meetings had been arranged earlier by Ms Lila. The procedure in each village followed more or less the same pattern, with Ms Lila introducing the Boutek personnel (Figure 9.2) and explaining that ECATU and Boutek were there to talk about the possibility of implementing a new type of sanitation scheme for the community. She explained that it was a system being introduced into South Africa for the first time, which might seem foreign to them, and that only fifteen units in each village were going to be built initially. Volunteers would therefore be sought to take part in the project. These introductions were all conducted in Xhosa. The author, having been duly instructed in the correct procedure by Boutek's social scientist, was then required to take the floor and explain the concept of the new technology.

Speaking in English, with Ms Lila translating, the author made use of a fibreglass mock-up of a urine diversion pedestal to explain the basic operating principles of the system (Figure 9.3). The advantages of no pits being required, the desiccation process, the lack of odour if properly operated, the ease of emptying the faeces receptacle and the agricultural potential of the excreta were all explained to the villagers. A number of questions were asked and it was interesting to observe that, while much of the debating was done by the men, it was actually the women who prompted them to ask questions. The subservient role of the women in these particular societies was thus clearly illustrated.

While there were some sceptics who eventually decided not to participate further, the overall result of the introductory talks was generally positive. Most of the residents were generally quick to see that the proposed toilet systems, while being somewhat strange to them, were in actual fact superior to pit toilets in many respects. There was some difficulty, however, in understanding that only fifteen toilets were going to be built in each village, but ECATU's budgetary constraints were eventually accepted. The result was that there were more than enough volunteers to participate in the pilot project, and the communities indicated that they would democratically decide where the toilets were to be constructed. It was also interesting to note that, in the final list of fifteen people in each case, the village headman and sub-headman were always included.

The meetings were held either in the local school classroom or, if there were too many people present, outside the classroom (Figures 9.4 and 9.5).

Figure 9.2: ECATU's Ms Sybil Lila introducing the subject of the meeting

Figure 9.3: The author demonstrating the concept of the sanitation technology with the help of a fibreglass model of a urine diversion pedestal

Figure 9.4: Community workshop at Gwebinkundla School

Figure 9.5: Community workshop at Manyosini School

At Sinyondweni the residents were always particularly pleased to see the project team, and after each meeting they would sing as a way of showing their appreciation (Figure 9.6). The songs were usually traditional thanksgiving hymns to God.

Figure 9.6: Sinyondweni residents singing for the project team

Cultural taboos and beliefs which needed to be addressed during the implementation of the project were then discussed. For example, the necessity for keeping all foreign materials except ash or dry soil out of the faeces receptacle was the first problem to be overcome. It was brought to the attention of the project team that the people considered it unacceptable to burn the material used for personal cleansing because they believed they would get anal infections if they did so. This belief was taken care of in the project design by making available a plastic bucket next to the pedestal for storing the used cleaning material, which could then be buried at regular intervals. These buckets were fitted with lids, so flies or odour were not a problem.

Another important point was that the residents considered it unacceptable to collect and reuse the urine, although most of them were not opposed to the concept of utilising the desiccated faeces. This was an interesting development, as just the opposite was expected (i.e. that the reuse of human faeces would be more of a problem). While not opposed to using cattle manure to improve soil fertility, some cultures are opposed to the concept of "human manure". It was concluded that this aspect would need to be further researched among the various tribal people in the country in order to gain a better understanding of each culture's viewpoint on the issue. However, the fact that the residents were disinclined to reuse the urine was not considered to be a problem, and it was arranged to lead it into soakpits instead. The drainage pipes were arranged in such a way (see Figure 9.7) that the option of collecting the urine could still be adopted at a later stage should the residents decide to do so.

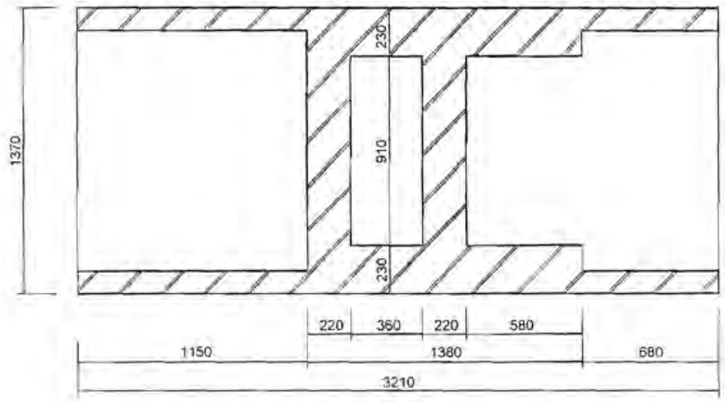
A further interesting aspect of social life in these villages was that it was considered unacceptable for a family's daughter-in-law to use the same toilet as her father-in-law. For the author, it was a further striking example of the massive gulf of ignorance existing in the civil engineering fraternity, which until fairly recently has assumed that all sanitation problems could be solved with technology alone. Fortunately, however, this specific social issue did not become a problem for the project, as the matter appeared to sort itself out among the families who eventually took part in the project.

Follow-up meetings developed into planning sessions, where the process of building the toilets was discussed. Options regarding the type of brick, colour of paint, type of faeces receptacle (i.e. plastic, wood, etc) and the type of urinal were all decided by the communities. The residents also indicated that they would point out exactly where, on their plots of land, they wished their toilets to be built. It was further agreed that each family would take responsibility for looking after all building materials delivered to their premises.

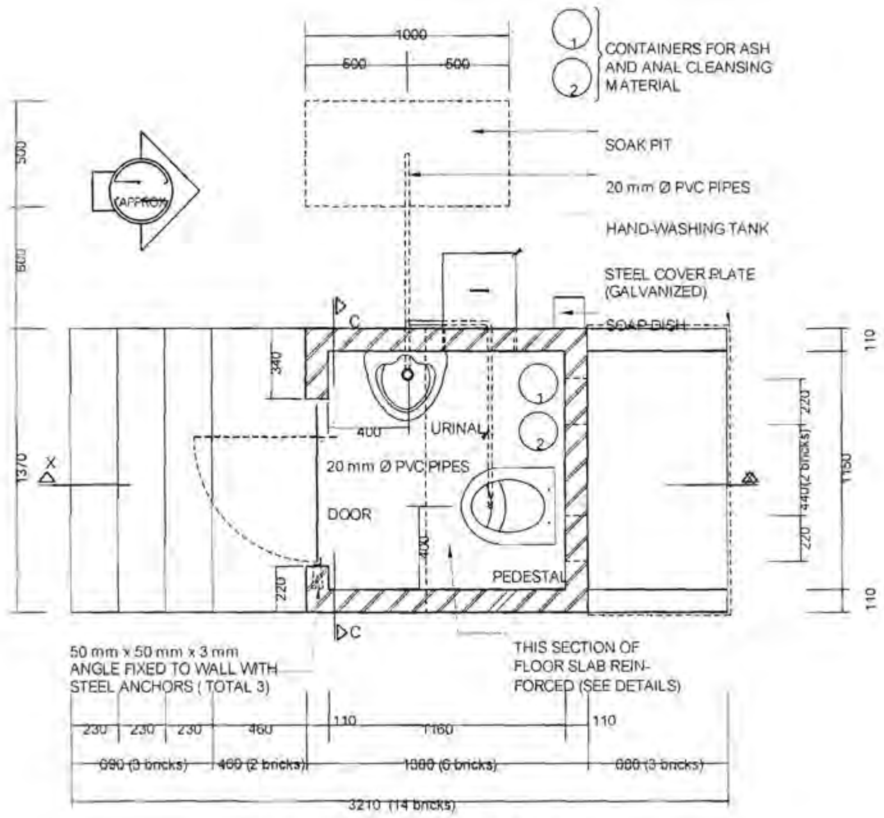
9.3 DESIGN OF THE TOILET UNITS

9.3.1 The superstructure

The entire process of designing the toilet superstructures, including all fittings except the urine diversion pedestals, was undertaken by a junior engineer in Boutek, working under the direct supervision of the author. The main aspects of the structures are illustrated in Figure 9.7. Details of fixings and fittings are not included here.



FLOOR PLAN ABOVE GROUND LEVEL



FLOOR PLAN ABOVE SLAB

Figure 9.7: General design aspects of the toilet units

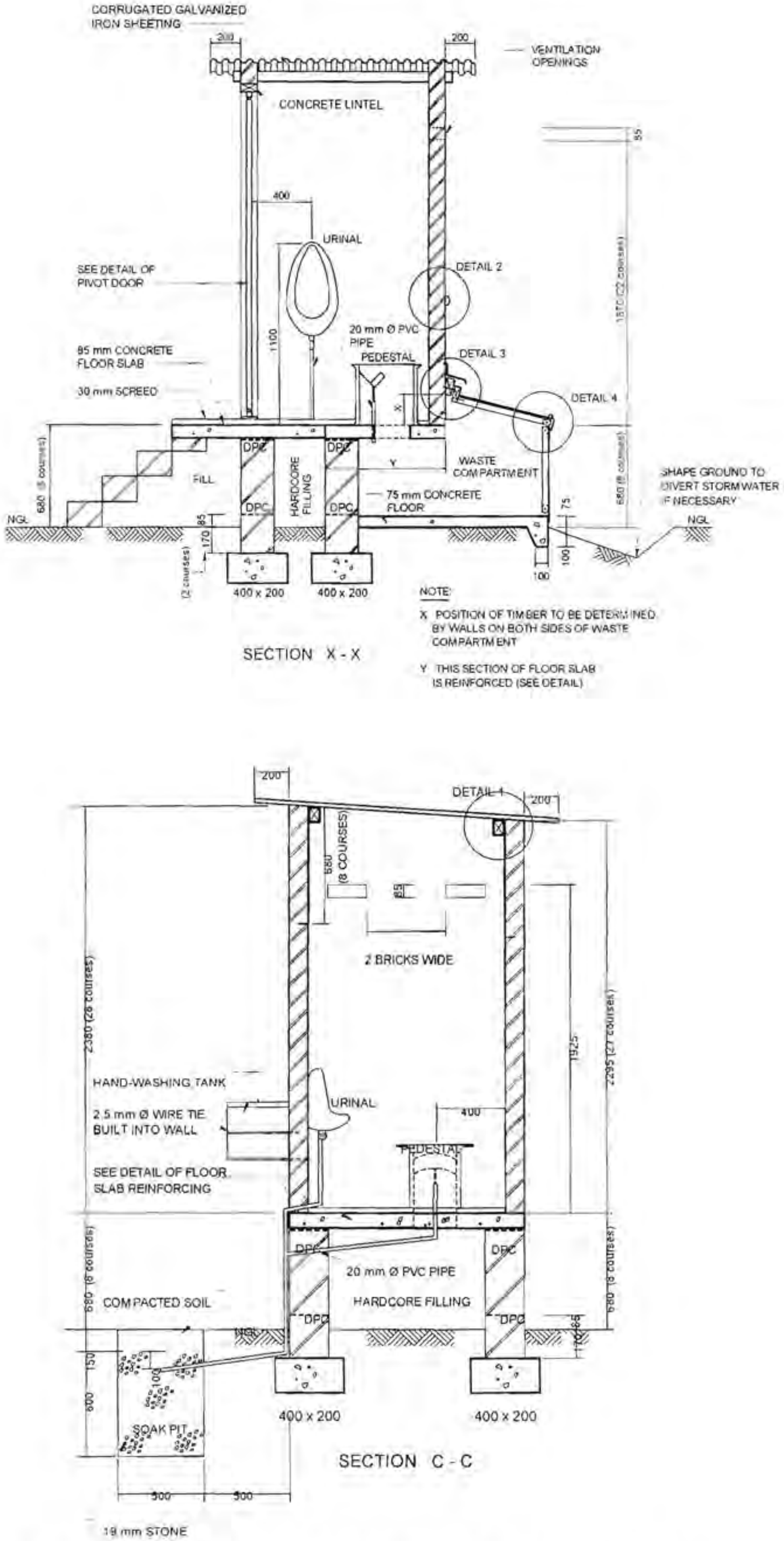
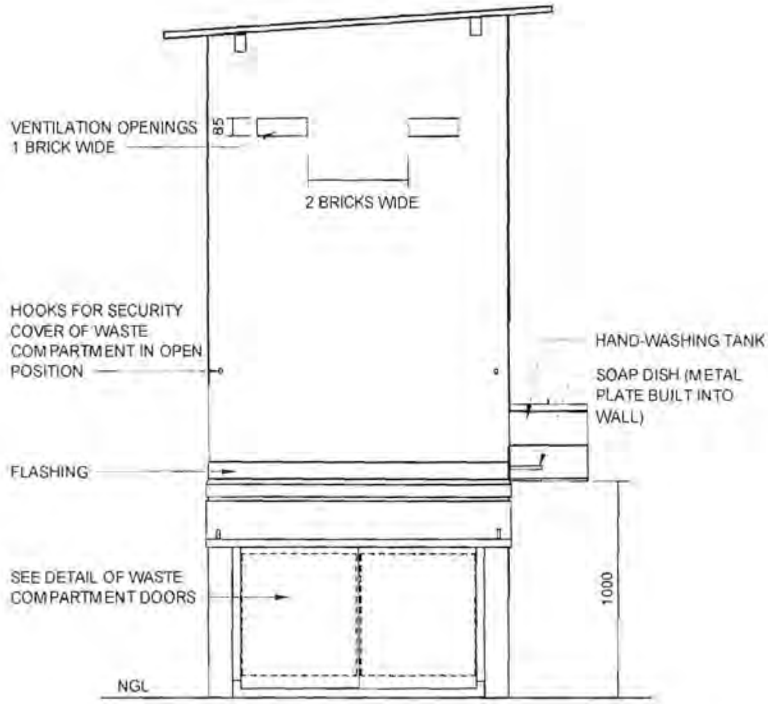
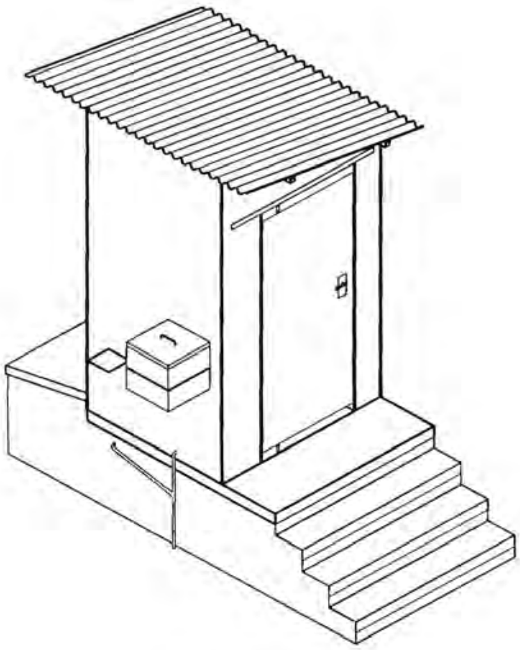


Figure 9.7 (cont): General design aspects of the toilet units



REAR ELEVATION



ISOMETRIC VIEW

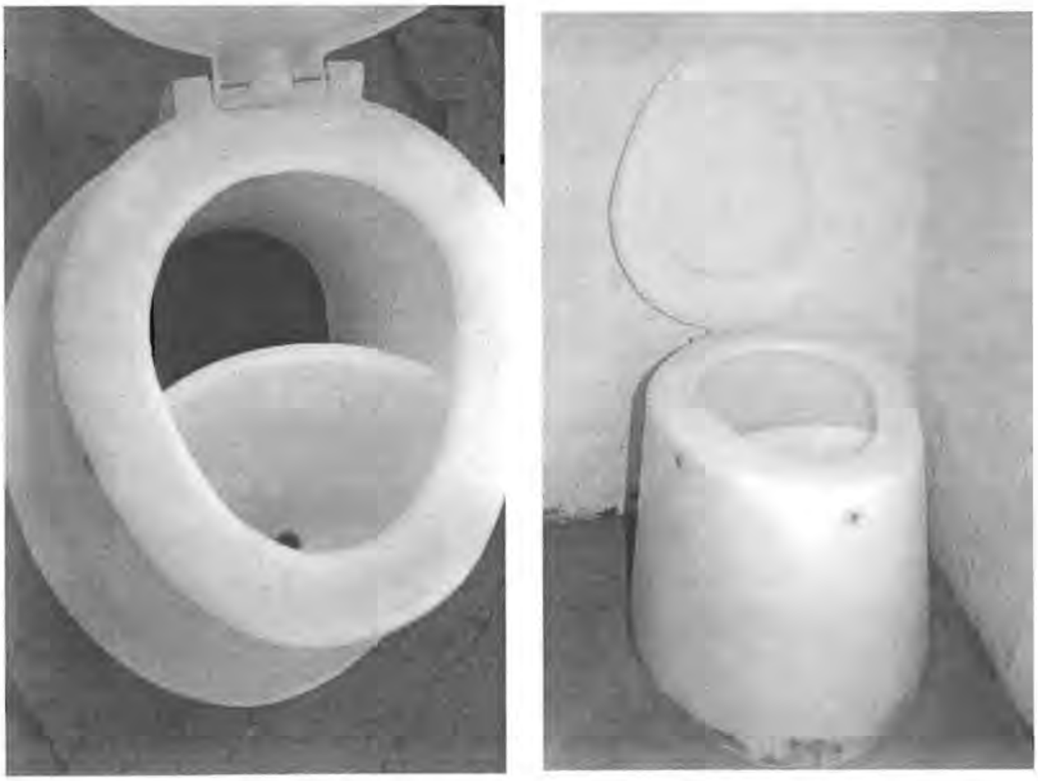
Figure 9.7 (cont): General design aspects of the toilet units

9.3.2 The urine diversion pedestals

The design of the pedestals was undertaken by the author. Based on measurements and photographs taken during a study trip to Sweden (see Figure 8.6(a), Chapter 8) the conceptual drawings were prepared and given to a plastics manufacturer in Pretoria for fabrication of the end product. Preliminary models were first made up for testing purposes.

The testing process involved some delicate negotiations with the author's wife and female colleagues, as well as much persuasion. As the correct positioning of the urine collection bowl is of vital importance for female users, it was essential that various women of different shapes and sizes test the model and provide constructive criticism on this aspect. As a result of the feedback obtained, the position of the bowl was adjusted up or down, back or forward, until a position was obtained which best suited the average woman.

Figure 9.8 illustrates the completed pedestal, fabricated in moulded plastic. The required number of pedestals for the project were transported to ECATU in Umtata.



(a) (b)

Figure 9.8: The plastic urine diversion pedestal designed by the author. (a) View showing the urine collection bowl; (b) pedestal installed in toilet unit (floor topping and final cleaning not completed yet).

9.4 HYGIENE EDUCATION IN THE COMMUNITIES

As explained previously (section 9.1), there was a low level of personal hygiene in the three villages. The residents were generally very poor, and water had to be fetched from muddy streams some distance away from their houses. For this project to be sustainable, and to uplift the standard of living of the people, it was essential for them to understand that the provision of proper sanitation facilities had to necessarily go hand in hand with an improvement in their personal hygiene habits.

Boutek's social scientist prepared a hygiene awareness training guide and explained to Ms Sybil Lila how to implement it. The main elements of the guide consisted of the following:

- The training should take place shortly before the handing over of the completed toilets to the families, and should be spread over a period of two to three days.
- Training should take place at a house in the community where the toilet had already been built.
- The purpose of the training programme should be explained to the people.
- The purpose of this specific type of toilet, as explained at the first community workshop, needed to be impressed again. Specifically, the separate collection and disposal of urine and faeces, and the reasons for this, were to be thoroughly understood.
- The proper operation and management of the toilets. This consisted of showing how the toilets in general, and the pedestals and urinals in particular, were supposed to be kept clean. Water could be used for rinsing the urinals and urine collection bowls. However, any soiling of the rear chute of the pedestal was not to be washed off but rather brushed clean with a damp toilet brush, as it was important to avoid adding unnecessary moisture to the faeces pile. Disposal of paper used for personal cleansing was also discussed and the people were once again reminded that this was not to be dropped into the faeces container. Finally, the necessity for sprinkling ash or dry soil over the fresh faeces was explained.
- The importance of personal cleanliness and the reasons for washing of hands, etc, was emphasised. The link between sanitation-related diseases, personal hygiene and food preparation was coupled to this aspect.
- The purpose of having two containers for faeces collection was explained. When the first container was full, it was to be kept to one side in the rear compartment of the toilet unit until proper desiccation had occurred, after which disposal could take place. For residents wishing to use the desiccated faecal matter on their vegetables and other crops, the necessity for allowing sufficient time for desiccation was explained. Otherwise it was to be simply buried. In both cases, however, the observance of personal hygiene was stressed. Ms Lila pointed out that the author would be returning at various intervals for the purpose of sampling the material to determine the rate of pathogen die-off. It was interesting to observe that the residents took this matter very seriously and would not empty the

containers "until the CSIR had said that it was all right to do so". Research into the rate of pathogen destruction is still continuing (see section 9.7).

- Time was to be allotted for questions and clarifications, and a "refresher course" was to be undertaken about a month after the toilets were handed over. The general condition of the toilets with regard to cleanliness was also to be checked at this time.

Matters not discussed:

- The question of storage time for urine did not arise. The communities were disinclined to reuse the urine as plant fertiliser, so all urine was led into soakpits, and not collected for reuse. No hygiene education was thus required for this aspect.
- The issue of possible HIV-AIDS transmission through handling of excreta was discussed with a medical doctor. Apparently this virus is very sensitive, and once it enters the human digestive tract, it is already under attack. The probability of it being excreted alive is, to quote the doctor, "small enough to be ignored", but should this happen (e.g. a woman's menstrual blood contaminating the urine), the hostile conditions encountered in any type of sanitation system will ensure its very rapid destruction. This aspect was therefore not considered to be of concern.

Generally speaking, the hygiene awareness training proved to be successful, with most residents scrupulously observing all that was taught them. There was an occasional need for Ms Lila to remind certain families about operational matters, the most common being the addition of sufficient ash to the faeces containers. Interestingly, the villages of Sinyondweni and Manyosini showed the best results, while Gwebinkundla residents needed the most attention. It was necessary for Ms Lila to do more follow-up work here than in the other two communities. When questioned as to possible reasons for this phenomenon, Ms Lila was of the opinion that the level of literacy in Gwebinkundla was generally lower than in the other two villages. This could not be proved at the time, though, and Boutek intends conducting a further research programme among the communities in order to scientifically establish whether there is indeed any connection between literacy and proper operation of the toilet units.

9.5 CONSTRUCTION AND HAND-OVER

9.5.1 The construction process

While very little in the way of building skills existed in the villages, the communities nevertheless offered to assist the builders appointed by ECATU wherever they were able to do so. This assistance generally took the form of helping with foundation excavations, mixing mortar and similar unskilled jobs. The standard of workmanship of the builders was initially very poor, and became a source of great frustration to the author. It quickly became clear that the problem of the dearth of experienced builders in the area was being seriously compounded by a lack of supervisory skills and capacity within ECATU. The result was that more trips to Umtata to inspect the progress of the work, as well as to offer general advice and assistance, had to be undertaken by the author. The initial project planning as regards timing of the various phases of the work was eventually discarded as worthless, and the author resorted (in desperation) to appeals to ECATU's top management to provide better staff and more commitment. These appeals were of necessity couched in terms which were actually thinly-veiled threats that Boutek would withdraw from the project, as the CSIR was not prepared to put its name to a scheme which was likely to become an embarrassment for all concerned. In addition to this cajoling, the author spent a great deal of time (far more than was initially thought necessary) in visiting all the building sites and pointing out simple and avoidable building errors and unacceptable quality of work.

Most of the problems, which could have been avoided through adequate supervision, were either overlooked or simply ignored, and were only attended to when the author demanded their rectification. As the building work progressed, however, the quality improved somewhat, because the builders came to understand what was required of them. By the time the first phase of 15 units had been completed, the builders had gained a lot of experience; this facilitated the progress of the second phase considerably, although quality still had to be carefully monitored.

As a result of the building problems experienced, as well as ECATU's lack of capacity, only two of the three phases had been completed at the time of writing, i.e. a total of 30 toilet units. Figure 9.9 illustrates various aspects of the completed units.

9.5.2 Handing over of completed units

On 31 July 1998 a large function was arranged at Sinyondweni School by the local communities to celebrate the completion of the first phase of the project. The occasion was marked with much pomp and ceremony, with many delegates from provincial government and semi-government institutions being invited. Speeches were given by

ECATU and various dignitaries, with the author also being required to make a speech on behalf of CSIR. The local schoolchildren entertained the dignitaries with song and dance, after which refreshments and a meal were served.

One of the toilet units at Sinyondweni was designated to represent the official opening of phase 1. A ribbon was tied around it and one of the dignitaries officially cut the ribbon and handed the keys of the toilet over to the proud owner.

Phase 2 was only completed in June 1999. The units were handed over to their owners as soon as they were completed.

(a) (b)

Figure 9.9: The completed toilet units.
(a) Front view; (b) rear view.

(c)

(d)

Figure 9.9 (cont): The completed toilet units.
(c) The ferrocement hand washing tank and urine drainage pipes from the urinal and pedestal.
(d) Resident illustrating the use of the hand washing tank. The small hole releases a thin stream of water out of the tank and is closed off with a twig.

Figure 9.9 (cont): The completed toilet units.
(e) An improved (and cheaper) hand washing arrangement incorporated into phase 2 units: the water is released and shut off by a simple nipple-type valve underneath the plastic container.

9.6 MONITORING OF PATHOGEN DESTRUCTION

9.6.1 Introduction

Chapter 8.3 sets out some health aspects of excreta reuse. Figure 8.11 in particular illustrates the importance of time and temperature in pathogen destruction. Because of the promotion of urine diversion technology as environmentally friendly sanitation, with the advantages of reusing the desiccated faeces as soil conditioner, it was considered essential to quantify the health aspects of handling the product under typical South African conditions. Obviously this single project is not regarded as being representative of all South African conditions, but it nevertheless does illustrate circumstances in a fairly wide range of climatic conditions. Summers in Umtata are mostly hot and humid, with a fairly high rainfall, while the winters may be extremely cold. When further projects are implemented in other areas, this aspect should be researched at the same time, in order to build up a reliable database of pathogen destruction conditions in the country as a whole.

Accordingly, samples were extracted from various toilet units at certain times (Figure 9.10). These were subjected to microbiological testing in the laboratories of the CSIR Division of Water, Environment and Forestry Technology (Environmentek) in Pretoria.

Figure 9.10: Extracting samples from the faeces containers for laboratory testing.

9.6.2 Results of microbiological tests

Table 9.1 indicates the results obtained from the microbiological tests on the desiccated faeces samples, while Table 9.2 shows comparative values in the natural soil around toilet unit E.

Notes on the use of indicator organisms:

It is impossible to test for all the possible organisms which could present a health risk. Indicator organisms are therefore used to give a general indication of water or effluent quality. No organism or group of organisms meets all these criteria, but the "coliform group" of organisms fulfills most of them. This group comprises organisms such as *Escherichia coli*, *Klebsiella pneumoniae* and *Enterobacter aerogenes*. *E.coli* are commonly found in the human intestine, but only some of them are pathogenic.

While coliforms are not an ideal indicator, they are still the most reliable indicators of the presence of faecal pollution. Faecal coliforms are indicative of faeces of warn-blooded animals, but do not distinguish between human and animal faecal contamination.

Faecal streptococci in water or effluent indicate faecal pollution and refer to those streptococci commonly found in human and animal faeces. They are useful as a supplementary bacteriological indicator and in locating the origin of faecal contamination in polluted water (the ratio of faecal coliform organisms to faecal streptococci is greater than 3:1 for human waste and smaller than 0,7:1 for animal waste). Faecal streptococci are usually more resistant to unfavourable environmental conditions than faecal coliforms.

The heterotrophic plate count is an additional screening step and is useful for monitoring changes in the bacteriological quality of water.

A coliphage is a virus hosting on the coliform bacteria. Coliphages have similar survival patterns as enteric viruses during water purification processes and although they do not provide an absolute indication of the presence of enteric viruses in all conditions, they may provide an acceptable indication of the presence of viruses in general.

The principal pathogenic parasites, protozoa and worms that may escape sanitary barriers in public water supplies include *Giardia* cysts and *Cryptosporidium* oocysts. These worms, cysts and oocysts are hardy; for example, they are not completely destroyed by chlorination, and require sedimentation and filtration.

The following guideline values do not relate to any standards for the desiccated sludge samples extracted from the toilet units, but are given for comparative purposes only, in order to facilitate an understanding of the degree of pollution of the various samples described. The symbol D indicates drinking water according to SABS 241:1984, while the symbol R indicates recreational water.

Indicator	Recommended limit	Max permissible limit
Heterotrophic plate count (D)	100 colonies per mℓ	not specified
Total coliforms (D)	0 per 100 mℓ	5 per 100 mℓ
Faecal coliforms (D)	0 per 100 mℓ	0 per 100 mℓ
Faecal streptococci (R)	40* per 100 mℓ	not specified
Coliphages (R)	50* per 100 mℓ; or 500** per 100 mℓ	not specified

* in 50 % of samples
** in 99 % of samples

9.6.3 Discussion of results

Unit E was always seen to have a higher moisture content in the faeces receptacle, usually due to insufficient ash being added. This was one of the units in Gwebinkundla where repeated visits were found to be necessary in order to monitor operation. It is seen that coliforms and coliphages are more viable at higher moisture contents.

The lack of parasites, especially Giardia, is somewhat surprising, as these organisms are often found in the water sources of poor communities.

The microbial population, with the exception of the heterotrophic plate counts, generally shows a good reduction over the sampling period. Temperatures measured in the faeces piles were never higher than 23 °C, however, and it is therefore only as a result of the passage of time, and not because of heat, that the pathogen destruction took place. It is surmised that the reason for this was that the piles were generally anaerobic, as the ash which was added was very fine, which therefore did not "bulk" the mixture and aerate it. Further experimentation with a coarser type of material needs to be carried out in order to determine the best method of keeping the pile aerobic, which would lead to higher temperatures. It may be necessary to turn the pile occasionally.

The heterotrophic plate count shows an increase over time. This is to be expected, as there are more nutrients available, in the form of rotten organic matter, for the bacteria to feed on. Bacteria multiply easily, and are not necessarily pathogenic.

The best results were repeatedly shown in unit C. This unit is in Sinyondweni, and is extremely well maintained, with the family showing the most commitment to the proper usage of the toilet.

The relatively high pH values recorded play an important role in pathogen die-off.

Table 9.2 reveals that even natural soil may have a relatively high microbial count, which may be due to bird droppings, cattle dung, worm castings, etc. Normal precautionary hygiene principles therefore also need to be observed after working with soil.

Table 9.1: Analytical results of laboratory testing
(Toilet units commissioned at the beginning of August 1998)

(a) Sample date: 4 February 1999 (± 6 months)

Sample ref	Heterotrophic plate count (per gram)	Total coliforms (per gram)	Faecal coliforms (per gram)	Faecal streptococci (per gram)	Sal-monella	Clos-tridia	Coli-phages (per gram)	Giardia cysts	Crypto-sporidium oocysts	Percent moisture	pH
A	60×10^6	50×10^4	15×10^2	47×10^2	+	+	300	ND	ND	22	
B	86×10^7	65×10^4	41×10^3	23×10^4	+	+	45×10^3	ND	ND	19	
C	80×10^5	165	115	655	+	+	600	ND	ND	35	
D	60×10^7	78×10^4	20×10^4	22×10^4	+	+	22×10^3	ND	ND	28	
E	26×10^7	48×10^6	33×10^6	13×10^5	+	+	75×10^4	ND	ND	60	

(b) Sample date: 9 June 1999 (± 10 months)

Sample ref	Heterotrophic plate count (per gram)	Total coliforms (per gram)	Faecal coliforms (per gram)	Faecal streptococci (per gram)	Sal-monella	Clos-tridia	Coli-phages (per gram)	Giardia cysts	Crypto-sporidium oocysts	Percent moisture	pH
A	14×10^8	24×10^2	25×10^2	40×10^2	+	+	0	ND	ND	11	9,4
B	29×10^8	12×10^4	18×10^3	13×10^3	+	+	200	ND	ND	15	8,6
C	64×10^7	52	0	14	+	+	0	ND	ND	21	9,6
D	11×10^8	98×10^2	10×10^2	69×10^2	+	+	45	ND	ND	4	9,2
E	19×10^8	11×10^6	55×10^5	11×10^4	+	+	14×10^3	ND	ND	40	9,4

Table 9.2: Analysis of natural soil around toilet unit E (sample date 9 June 1999)

Sample ref	Heterotrophic plate count (per gram)	Total coliforms (per gram)	Faecal coliforms (per gram)	Faecal streptococci (per gram)	Sal-monella	Clos-tridia	Coli-phages (per gram)	Giardia cysts	Crypto-sporidium oocysts	Percent moisture	pH
E	76×10^4	19×10^2	41	15	+	+	0	ND	ND		

\+ = "too high to count"
ND = "not detected"

9.7 RESEARCH CURRENTLY IN PROGRESS

9.7.1 Introduction

There are two main aspects of this project which are either currently being researched, or are scheduled for research in the near future. It is therefore not possible to include these ongoing research results in this dissertation, other than some preliminary observations and tentative conclusions. However, it is intended to publish these results as they become available, and also to include guidelines for implementing the technology in the Red Book.

9.7.2 Pathogen destruction

Although relatively good pathogen die-off was experienced, the faeces pile did not heat up as much as was expected or hoped. As already mentioned, it is thought that this may be as a result of the pile being anaerobic. It is therefore necessary to examine other options to increase the heat generated in the pile, and thereby speed up the process of pathogen destruction.

Experiments are currently being planned to let the faeces collect on the floor of the rear compartment instead of in a receptacle, so that the pile may be easily raked and turned with simple hand tools. It is expected that this action will contribute to the aeration of the pile and thus the heat generated, which in turn will accelerate the pace of pathogen destruction. The use of other mixing materials besides ash, for example coarse soil, will also be examined.

In the meantime, however, it has been possible to conduct a simple experiment to test the effect of increased aeration, temperature and desiccation on the rate of pathogen destruction. A sample of the faeces pile in unit E (the unit with generally the poorest results) was subjected to air drying and heat (sunshine) on the roof of Boutek's building. This was carried out in the middle of winter (July 1999) and the sample was therefore brought indoors at night. Temperature measurements were observed at 14:00 on certain days over this period. The ambient temperature varied between about 15 °C and 30 °C, while the temperature in the pile reached a maximum of 40 °C for a short time, but usually remained only a few degrees warmer than the ambient value (mostly due to the effect of cold winds).

The sample was tested after this period, with the following results:

Table 9.3: Sun-dried sample from unit E

Heterotrophic plate count (per gram)	Total coliforms (per gram)	Faecal coliforms (per gram)	Faecal streptococci (per gram)	Sal-monella	Clos-tridia	Coli-phages (per gram)	% mois t-ure
42×10^5	38×10^4	310	11×10^5	+	+	5	1,4

Discussion:

- The vast resistance of faecal streptococci towards unfavourable environmental conditions is evident.
- The other indicators, when compared with the previous results, show a reduction of around two to three orders of magnitude as a result of exposure to sunshine.
- It is likely that a higher rate of pathogen destruction will occur during the hot summer months.

Clearly, more research is needed on methods to increase the rate of pathogen destruction if it is intended to handle the desiccated faeces and use them for agricultural purposes. Alternatively, a longer storage period is required.

9.7.3 Community acceptance of the technology

Part of the follow-up research work planned in the near future is to conduct a thorough survey among the project participants in order to establish the general acceptability of this sanitation technology. Preliminary observations have indicated a very good acceptance, but in order to produce a sound, scientific treatise on the subject, it will be necessary to conduct a knowledge, attitude and practices (KAP) survey. This type of survey takes cognisance of various factors such as income level, literacy level, hygiene practices, attitude towards hygiene practices, acceptance of unfamiliar technologies, sanitation as a need, etc. In other words, the survey is not merely technology based. In this way, a good indication can be obtained of how the technology fits in with a specific culture.

9.7.4 A few preliminary observations

In general, the attitude of the residents towards the technology has been very positive. Many have stated that the new toilets are much better than pit toilets, or even VIP toilets. The lack of odours and flies, as well as the ease of maintenance, are particularly appreciated, while the secondary advantage of having a free agricultural resource available is welcomed by some people.

CHAPTER 10

SUMMARY AND CONCLUSIONS

"Furthermore, my child, you must realise that writing books involves endless hard work, and that much study wearies the body."

Ecclesiastes 12 : 12

CHAPTER 10: SUMMARY AND CONCLUSIONS

10.1 SANITATION – GENERAL ASPECTS DISCUSSED

A broad-based, yet fairly comprehensive, background to the general sanitation situation in South Africa and the developing world has been presented in this dissertation, with particular emphasis on the poorer population groups. It has been shown that existing systems and available resources are inadequate to deal with the serious problems which exist, and that the situation will not improve unless there is a significant change in the manner in which sanitation systems are chosen, designed and implemented.

Vast amounts of improperly-managed faeces and untreated sewage contaminate the living environments of millions of people worldwide. These environmental problems, in turn, undermine the process of development.

The myth that the only good sanitation technology in urban areas is waterborne sewerage is a factor which actually constrains the provision of efficient sanitation. While this technology has been widely successful in controlling the transmission of excreta-related diseases in most cities of industrialised countries, it has also created severe damage to ecosystems and natural water resources where the wastewater has been inadequately treated. It has furthermore been shown to be an unsustainable technology in many Third World cities where the required institutional capacity and skills are often lacking.

A large number of diseases are spread directly through contact with human excrement, indirectly via water, food and soil, or via carriers and vectors like flies, cockroaches and mosquitoes. The inability of existing sanitation systems to manage adequately the increasing volumes of human excreta is the main cause of the high incidence of infectious diseases in developing countries.

In many urban centres poorest groups face the most serious environmental hazards and the least possibility of avoiding them. The rapid population growth is furthermore putting severe strains on the water supply and sanitation services of the urban areas in developing countries. In Africa especially, lack of access to basic water supply and sanitation services lies at the root of many of the current health, environmental, social, economic and political problems.

The excreta of most urban dwellers in developing countries are disposed of through on-site sanitation systems such as pit toilets and septic tanks. A major problem which results is that faecal sludges collected from these systems are commonly disposed of untreated. The problem is growing, and over the next few decades most Third World urban growth will take place in peri-urban areas without access to basic services.

Very little progress has been made in improving sanitary conditions for much of the world's population. Without major changes in delivery mechanisms, the number of people without access to sanitary excreta management will remain above 3 000 million people, and mankind will not make any headway in its ability to dispose of wastes in a healthy, safe and ecologically sound manner. A revolution in thought and action is required – it is necessary to define principles, make priorities, create strategies and search for new technological, financial and institutional solutions.

In many of the developing regions, squatter areas and informal settlements of South Africa, the situation is much the same as in other poor regions of Africa and the world. Vast urban and peri-urban slums exist with no provision for excreta management of any kind, formal or informal. The situation is not confined to urban areas, however: the majority of rural households, schools and even clinics are also without adequate sanitation. An estimated 21 million South Africans, the vast majority belonging to the poorer sections of the population, do not have proper sanitation facilities.

The core problem in South Africa remains the fact that preventable diarrhoeal diseases continue, particularly in young children. The problem is related to socio-cultural, educational and institutional issues, with the lack of appropriate facilities and inadequate guidelines being a contributory factor. New approaches need to be initiated, and technologies which support alternative sanitation efforts should be developed. Sanitation is not simply a matter of providing toilets, but rather an integrated approach which encompasses institutional and organisational frameworks, as well as financial, technical, environmental, social and educational considerations. Because water supply and sanitation are both inextricably linked to the broader development process, the question of sanitation needs to be seen in the context of an integrated development strategy.

It has been shown that sanitation is an extremely complex issue, and that there is no single solution which can be universally applied to solve the problem. Improved sanitation is a **process**, and people must be seriously consulted and involved in sanitation programmes, from planning to implementation and follow-up. Innovative, low-cost sanitation facilities are needed, and it is wrong to promote one or two technologies as "the solution". More research and better designs are needed, in order to develop a range of systems applicable to differing cultural and environmental conditions.

Sanitation approaches based on flush toilets, sewers and central treatment plants cannot solve the problem. Pit toilets or septic tanks with soakpits are also not the solution in high-density urban areas. Certainly, "conventional" sanitation options may be suited to certain conditions. However, with the continuous growth of urban populations and the high incidence of low-income people living in slums and peri-urban squatter areas, there is no possibility of successfully increasing the overall sanitation coverage by these methods.

Sanitation systems must be appropriate for a particular project and circumstances. It has been shown that the appropriateness of a sanitation system depends on a number of circumstances, with the actual technology itself being, in most cases, less important than the socio-cultural factors involved. It is therefore important to look beyond the current restrictions for innovative ways and means of bringing adequate sanitation to the millions of people currently without access to this basic human right. Research and development for a wide range of cultural and environmental conditions is required, and a demand for systems which reuse or recycle human excreta should be created. Dependence on systems which use large amounts of potable water should be reduced, and systems should be promoted which are simple, reliable and easily maintained.

Excreta disposal, especially in rural areas, is far more complex socially than it is technically, and the introduction of on-site sanitation systems involves much more than the application of simple engineering techniques – it is an intervention that entails considerable social change. It is therefore necessary to understand how a society functions, including the communities and households within it, before embarking on a sanitation programme. Social issues have been shown to influence the choice of technology, and personal cleansing practices have direct technical consequences which have to be considered by the engineer.

It is essential that sanitation projects are not focused on purely numerical targets (i.e. how many toilet units have been built) but on ensuring that the projects are sustainable, and that the people are empowered with the necessary information and sense of ownership to effectively use and manage the facilities. Sanitation efforts must therefore incorporate more participatory methods. The development of a hygiene education strategy, in which women are included in the whole process of behavioural change, has a major impact on the sustainability of a project.

The choice of a sanitation technology is also heavily influenced by the type of institutional setup for delivery, operation and maintenance. All systems require a certain amount of institutional support, with the more complex technologies necessitating a level of funding and skills which may not be available in, for instance, rural areas. Due to the different stages of local government development in South Africa, institutional arrangements will vary in several ways, depending on the type of area involved. Operation and maintenance aspects play a major role in the success or failure of a sanitation project. Particularly in poor communities, it is essential to install robust, low-maintenance systems, where the total life-cycle costs are minimised without the environment being compromised in any way.

This dissertation has described the development of two new approaches to sanitation provision in which operation and maintenance aspects are greatly simplified. The first represents an improvement on an ordinary settled sewage scheme, which is a wet system, and the second an alternative to a VIP toilet, which is a dry system. A common problem associated with both of these existing technologies, as indeed it is with all on-site systems, is the removal and disposal of accumulated sludge and liquid effluent in a manner which is safe for humans and which does not put the environment at risk. It has been shown how the proposed technologies resolve this problem. The first method automatically flushes the sludge out of the interceptor tank and into the effluent pipeline, while the second avoids the need for a pit and dehydrates the faeces pile in an easily accessible compartment beneath the toilet pedestal, producing a product quite unlike pit toilet sludge. The difference is largely due to the fact that urine is not added to the faeces pile, but is diverted at source, thus keeping the pile relatively dry and assisting in the destruction of pathogenic organisms, as well as preventing the leaching of disease-carrying liquids into the surrounding ground.

The development of these two technologies, and the promotion of their use in South Africa, is likely to enhance the status of on-site sanitation systems. In some instances, on-site systems are regarded as inferior technologies because of the operation and maintenance aspects (for example sludge removal) associated with them.

10.2 THE "SLUDGE SIPHON" SELF-CLEANSING INTERCEPTOR TANK FOR SETTLED SEWAGE SYSTEMS

Septic tank technology which includes soakpits is well established virtually everywhere in the world. Settled sewage systems which reticulate the septic tank effluent for further treatment to off-site locations are less common, however. Most development has taken place in the United States, Australia and a few African countries, with South Africa being a relatively late starter some ten years ago. The operation of these systems has been described in this dissertation, and the principal advantage of soakpits not being required was emphasised. This has major environmental benefits, especially in densely populated urban areas, or where unfavourable geotechnical or geohydrological conditions are present. The major disadvantage has been shown to be the necessity for periodic desludging of the interceptor tanks. This is an unpleasant and sometimes difficult task to perform, which may even be impossible where access to the tanks is restricted.

Interceptor tanks in a settled sewage system must be designed to cater for various functions, namely solids interception, digestion of settled solids, and storage of digested solids. The rate of sludge accumulation depends on factors such as ambient temperature, living standard, diet, health of users, their occupations and working conditions, etc. Interceptor tanks are usually designed so that up to two-thirds of the volume may be taken up by digested solids (sludge), so the longer the anticipated interval between desludgings, the larger the tank has to be to cater for this. This is associated with an increase in capital costs, not only for the tank itself but also for labour and excavation. Consideration of these cost factors, as well as the problems involved in desludging of tanks, led the author to the conceptualisation and development of the "sludge siphon" as a solution.

Due to the fact that the sludge extracted from the interceptor tanks is usually deposited either in a nearby sewer manhole, or transported directly to the municipal sewage treatment works, the sludge eventually ends up in the municipal wastewater system in any case. The "sludge siphon" system eliminates the need for vacuum tankers and maintenance crews to physically empty an interceptor tank by siphoning the accumulated sludge out of the tank and flushing it, together with the normal effluent, into the settled sewage reticulation system. Once it has entered the pipeline, the sludge from a whole suburb or village can be hydraulically transported for an as yet undetermined distance, and can therefore either be taken to a single easily-accessible settling tank for uncomplicated collection, or perhaps even be transported all the way to a treatment works, where the sludge can be handled in the conventional manner.

Due to the fact that the sludge is automatically removed from the interceptor tank without intervention by a maintenance crew and without conscious thought by the householder, and then transported for some distance along the settled sewage pipe network, many savings can be achieved by both the householder and the local authority. There will be a vastly reduced need for vacuum tankers to gain access to individual interceptor tanks, so poor roads or densely built-up areas will be a lesser problem. Tanker fleets can be decreased and the operation and maintenance costs of a settled sewage scheme drastically reduced, with concomitant benefits for society.

It is thus seen that settled sewage schemes incorporating "sludge siphon" systems in the interceptor tanks result in savings in both initial capital costs as well as operational costs.

The concept of the "sludge siphon" is based upon the arrangement of the interceptor tank's outlet pipe in the form of a natural siphon. This siphon is activated by a rapid inflow of wastewater from either a washtub or a bath, with a certain minimum flow volume being required. The sludge siphon is suited to either an outside flushing toilet connected to a settled sewage system (the lowest level of service for which it is possible to operate the siphon) or a house with full water connections (highest level of service). The functioning of the siphon has been illustrated by Bernoulli's energy equation, which shows that the negative (gauge) pressure at the summit is responsible for its successful operation. Due to the low specific gravity of the sludge particles, they are easily kept in suspension by the effluent passing through the outlet siphon, and thus readily transported along the pipeline for as long as there is a sufficient volume of flow.

Initial experimentation was carried out in the laboratory, and was aimed at developing a method to initiate the flush by the simple addition of a quantity of water to the tank in which the siphon was installed. The method eventually perfected was based on, firstly, eliminating the inhibiting effect of the air bubble which formed naturally at the apex of the siphon, and secondly, reducing the volume of water needed to activate the flush. Once these problems had been overcome, experimentation was continued using sawdust to simulate digested sludge. It was found that the siphon intake did not extract the settled sawdust effectively and had to be modified in order to do so. A manifold-type of inlet with multiple inlet ports was then developed, which carried out the job successfully. Thereafter, actual septic tank sludge was used for further experimental work.

The physical properties of typical domestic septic tank sludge were analysed. Two sources of sludge were investigated, namely a middle income family and a poor community. As expected, it was found that the sludge emanating from the poor community's septic tank contained a much larger proportion of inorganic elements and dried solids, and the mean particle size was also considerably greater. This is generally due to the fact that poor communities often use sand and grit to scour pots and pans, and may also have more dirt particles in their clothing, which then end up in the wastewater. Scanning electron microscopy results showed further that the inorganic particles in sludge are so small, and the density so close to that of water, that the flow containing the particles is in all probability pseudohomogenous, with the mixture being of the non-settling type. The wide variety of particle shapes and sizes also indicated that very little of the work done to date on sediment transport theory and experimentation is actually applicable to the hydraulic transportation of septic tank sludge.

The siphon could be activated with a flow of about 21 litres of wastewater from the washtub. It was later possible to reduce this amount to about 16 litres by improving the design of the inlet compartment of the siphon. Flow behaviour was much as expected in terms of volume and velocity – the rate of flow became progressively less as the available head in the tank decreased, but there was no visible lessening of the sediment-carrying ability of the flow for the full duration of the siphon activation, even with a relatively small available head.

After successfully concluding the laboratory experimentation, the project team developed a prototype model of the sludge siphon system for installation under actual operating conditions on the CSIR campus at Scientia. The system was connected to the creche's outfall sewer, the flow being diverted through the tank which then operated as a conventional interceptor tank in a settled sewage system. The effluent outflow pipeline, with transparent sections to facilitate observation of the flow, was arranged in a zigzag pattern in order to produce friction losses at bends. The pipeline was laid above ground on adjustable supports, which facilitated the arrangement of different gradients for testing purposes. This included sections with a negative gradient in order to produce pressure flow, which is often a feature of settled sewage schemes. The siphon was activated by water flowing from a washtub installed near the tank, and this setup was used for further experimentation.

Various hydraulic and other factors which were thought may effect the performance of the system were then tested:

- Normally, the sludge equilibrium level would be at the height of the manifold ports. The sludge level was allowed to build up to about 150 mm above the level of the grille over the manifold, with insufficient retention time for full digestion to take place. The sludge thus contained small undegraded pieces of paper, food scraps and faeces. This did not result in any visible deterioration in the operation of the siphon, nor in the sludge-carrying ability of the flowing effluent. However, when the tank was hydraulically and biologically overloaded by increasing the wastewater inflow and being fed with materials such as large wads of paper towelling, sanitary pads, etc, the grille became blocked and whatever sludge formed was prevented from entering the manifold ports and being flushed out of the tank. This served to reinforce the fact that a sludge siphon sanitation system should be operated and cared for in the same manner as a conventional septic tank, where no problems are experienced if normal precautions are observed.
- Negative gradients were introduced into the effluent pipeline, which resulted in a "dam" of septage collecting at low points after normal flow had ceased. With subsequent flushes, the inertia of this standing septage had to be overcome before normal pipe flow could resume. This in turn caused a delay in activation of the flush, as more water was forced into the main chamber of the tank before

the water in the siphon could attain uniform flow. Additional water was then needed to activate the flush than what was normally the case – usually about 25 ℓ instead of the usual 16 ℓ. It was found by experimentation that, as long as a minimum distance of 12 m was maintained between the tank outlet and the first section of inverse pipe gradient, the siphon was able to activate normally and the energy of the full pipeline flow was sufficient to overcome the resistance of the standing septage.

- Tests were carried out to determine the effect of distance between the washtub (which activated the flush) and the tank. These were performed for varying horisontal as well as vertical distances. It is essential that the incoming wastewater enters the siphon compartment of the tank as rapidly as possible, otherwise the siphon will not activate at all or will require a greater volume of influent in order to do so. It was found that, at the shortest horisontal distance of 1,5 m between the washtub and the tank, a volume of only 16 ℓ was required to initiate the flush, while between 1,5 m and 6 m a volume of 25 ℓ was needed. At a distance of 7 m and beyond, a minimum of 35 ℓ had to be fed into the tank before the siphon activated. Vertically, it was found that raising the washtub higher than a nominal 950 mm above the crown of the siphon also resulted in additional water being required to initiate the flush. A volume of about 25 ℓ was needed in this case. This volume was thus adopted as the minimum required in order to ensure effective operation of the siphon, and the tank should be buried as close as possible to the plumbing fixture which activates the siphon. These results have been included in the guidelines in Appendix A.

10.3 URINE DIVERSION SANITATION SYSTEMS

The shortcomings of VIP toilets, particularly in high-density urban areas, have been explained. Apart from the obvious problems such as excavation of pits in difficult ground, negative factors are also to be found in operation and maintenance aspects, social perceptions and poor institutional support capacity. To address these shortcomings, it has been necessary to think beyond the limitations imposed by traditional methods of providing dry sanitation. This need has been substantiated by increasing awareness worldwide of the environmental issues associated with sanitation. Furthermore, pressure on land to produce more food to feed the ever-growing populations of developing countries has made it imperative to utilise natural resources, including human excreta, wherever possible. The concept of ecological sanitation, or "eco-san" as it is also known, is seen as an alternative solution to some of the problems associated with pit toilets, environmental degradation and food shortages.

Ecological sanitation systems are presently neither widely known nor well understood. They cannot be replicated without a clear understanding of how they function and how they can malfunction. However, long term economic factors are an attractive feature of these systems, for the following reasons:

- the entire structure is built above ground – there is thus no need for expensive digging and lining of pits;
- urine is diverted, no water is used for flushing and the volume of the processing vault is fairly small, as it is emptied periodically;
- emptying of the processing vault is easily carried out and does not require expensive equipment; and
- the contents of the processing vault are dry, which means that there is no need for expensive watertight construction methods.

The introduction of eco-san systems is thus bound to lower the total costs of urban sanitation in particular. This is an important consideration, especially for developing countries where public institutions have stringent financial limits.

It has also been shown that human excreta should not be regarded as a waste product, but rather as a valuable resource, as it (urine in particular) contains high percentages of plant nutrients such as nitrogen, phosphorus and potassium, with the added advantage of an organic fraction as well. The annual excretion of these plant nutrients by humans is enough to produce the 230 kg of crops they need each year, with an efficacy almost as good as, and in some cases better than, conventional chemical fertilisers. There are many reasons for recycling the nutrients in excreta. Recycling prevents direct pollution caused by sewage being discharged or seeping into water resources and ecosystems. A secondary benefit is that recycling returns nutrients to soil and plants, and reduces the need for chemical fertilisers. It restores good soil organisms to protect plants, and it is always available locally, wherever people live.

Examples of excreta reuse from many countries have been cited. In some countries the practice has been carried out for centuries, while in others it is a comparatively recent phenomenon. The benefits of this practice for subsistence farmers in particular has been pointed out.

Health aspects of excreta reuse have been dealt with in some detail, and it was seen that the health hazards associated with this practice are of two kinds: the occupational hazard to those who handle excreta, and the risk that contaminated products from reuse may subsequently infect humans or animals through consumption or handling. The main pathogenic organisms of interest in sanitation are viruses, bacteria, protozoa and helminths (worms). There are a number of different varieties of all these organisms. In developing countries especially, excreta-related diseases are very common, and the excreta contain high concentrations of pathogens that cause diseases in man. Sanitation systems designed for reuse of the excreta thus pose a special challenge to the engineer to design and develop technologies that will not pose unacceptable risks to public health.

As the death or survival of excreted pathogens is an important factor influencing transmission, these organisms need to be either destroyed or otherwise rendered harmless. Environmental factors of importance in the die-off rate of pathogens are high temperatures, low moisture contents and time. A high temperature, especially, is the most important consideration, as all living organisms, from the simplest to the most complex, can survive at temperatures only up to a certain level. Regarding moisture content, biological activity becomes severely restricted at moisture contents less than about 35 %, while pH is another important controlling factor, with a value above about 9 generally being lethal to most pathogenic organisms.

Some examples of urine diversion sanitation technology, as applied in various parts of the world, have been described. A common feature of the various examples was seen to be the ease of excreta disposal and the many possibilities for its reuse. The critical distinctions between desiccation, or dehydration, and composting were also explained, the chief variation being the difference in moisture content of the faeces pile. For desiccation to occur effectively, the diversion and separate processing of urine is imperative, except in very dry climates.

The basic requirement of a urine diversion sanitation system is a toilet pedestal (or squatting plate) which prevents urine and faeces from being mixed together. In the dry-box version, small amounts of ash, dry soil or sawdust are sprinkled on the faeces after each bowel movement; this serves to absorb the moisture which is an inherent part of fresh faeces and thus also to prevent odours. It is essential that the excreta remains as dry as possible and that moisture is prevented from entering the waste compartment. Paper and other material used for personal cleansing are not deposited in the receptacle but are stored in a separate container and disposed of by burning or burial. The urine can be collected in any suitable sealed container if its reuse for agricultural fertilizer is desired. Alternatively, it can be led into a soakpit. In the flushing version, the urine may be collected and stored in the same way, while the faeces are usually flushed into a conventional sewer system for further treatment.

A pilot urine diversion sanitation project in three rural villages near Umtata, Eastern Cape, was carried out by Boutek and the Eastern Cape Appropriate Technology Unit (ECATU). Boutek directed the engineering and social research while ECATU was responsible for the financial and construction aspects (the latter also under Boutek's supervision). The original intention was to build a total of 45 toilet units over a two-year period (15 units in each village). Due to capacity problems within ECATU, however, only 30 units were built during this time. The villages selected were Manyosini, Sinyondweni and Gwebinkundla, all in rural settings and with the same rolling topography and clayey soil. The residents of these villages were generally very poor, and availability of water was a major problem. The few toilets that existed were ordinary pit latrines, mostly in a very poor and unsanitary condition. Residents generally relieved themselves in the veld, and the level of personal hygiene was observed to be low.

Boutek's first task was for the author and an anthropologist (social scientist) to familiarise themselves with the physical layout of the villages, as well as the social structure and dynamics existing within the communities. Although the people were all Xhosas, each community had its own distinct characteristics, beliefs and behaviour. The proposed pilot project was thoroughly discussed with the residents and the basic aspects of the technology explained. While there were some sceptics who eventually decided not to participate further, the overall result of the introductory talks was generally positive. Most of the residents were generally quick to see that the proposed toilet systems, while being somewhat strange to them, were in actual fact superior to pit toilets in many respects.

Cultural taboos and beliefs which needed to be addressed during the implementation of the project were also discussed at this time. These included matters such as the disposal of personal cleansing materials, the collection and reuse (or disposal) of excreta, and various social issues affecting traditional family life in the various communities. Building options such as type of bricks, colour of paint, etc were further matters that required clarification and agreement.

The design of the toilet units was undertaken by Boutek. The author personally researched and designed the urine diversion pedestals, which were then fabricated by a plastics manufacturer in Pretoria and delivered to ECATU for installation in the completed structures.

For this sanitation project to be sustainable, and to uplift the standard of living of the communities, it was essential for the people to understand that the provision of proper sanitation facilities had to necessarily go hand in hand with an improvement in their personal hygiene habits. Accordingly, Boutek's social scientist prepared a hygiene awareness training guide which was implemented by ECATU's social researcher. This consisted generally of details such as proper operation and maintenance of the toilets, the importance of personal cleanliness, the link between hygiene and sanitation-related diseases, etc. Generally speaking, the hygiene awareness training proved to be successful, with only a few families needing repeat visits to ensure proper compliance with operational requirements.

Very little in the way of building skills existed in the villages, and the standard of workmanship was initially very poor. Compounding this problem was a lack of supervisory skills and capacity within ECATU. The result was that the author was required to spend a great deal of time (far more than was initially thought necessary) in visiting all the building sites and pointing out simple and avoidable building errors and unacceptable quality of work. As the building work progressed, however, the quality improved somewhat as the builders came to understand what was required of them.

After the owners had taken possession of their new toilets, the research project entered a very important phase. This was the monitoring of pathogen destruction in the faeces pile. Because of the promotion of urine diversion technology as environmentally friendly sanitation, with the advantages of reusing the desiccated faeces as soil conditioner, it was essential to quantify the health aspects of handling the product. Accordingly, samples were extracted from randomly selected toilet units at certain times, which were then subjected to microbiological testing at CSIR's laboratories in Pretoria. The results of the testing showed, inter alia, the following:

- Coliforms and coliphages are more viable in higher moisture contents.
- The microbial population generally displayed a good reduction over the sampling period. However, due to the relatively low temperatures experienced, this was due more to the passage of time rather than to heat.
- The low temperatures recorded in the faeces piles are thought to be due to conditions being anaerobic. It may be necessary to turn the pile occasionally in order to obtain aerobic conditions, which should then lead to higher temperatures and thus more rapid destruction of pathogens.
- The relatively high pH values (caused by the addition of ash) played an important role in pathogen die-off.

In general, the attitude of the residents towards the technology has been very positive. The lack of odours and flies, as well as the ease of maintenance, are particularly appreciated, while the secondary advantage of having a free agricultural resource available is welcomed by some.

10.4 CONCLUDING REMARKS

The majority of sanitation problems cannot be solved by the application of conventional engineering technologies. It is necessary to recognise toilets as being consumer products, which are subject to personal and community preferences. On-site technologies have, in many instances, been regarded as inferior or second-rate, often due to the operation and maintenance factors involved. While being true in certain cases, this is actually an incorrect generalisation. Some on-site technologies are able to offer a level of service very close to full waterborne sewerage, and for many poor communities especially, even a simple sanitation device is certainly a vast improvement to relieving onself in the veld.

The research and development of alternative on-site sanitation technologies described in this dissertation was aimed principally at tackling the most common operational problem associated with these systems, namely sludge disposal. Other benefits which accrue due to the application of these new technologies, for example certain environmental improvements, easy and safe reuse of excreta, or lower capital and operational costs, are additional advantages. By offering improved sanitation methods which reduce the operation and maintenance burdens on both users and local authorities, it is believed that a significant contribution has been made to improving the quality of human life across all sectors of society.

CHAPTER 11

RECOMMENDATIONS FOR FURTHER RESEARCH

CHAPTER 11: RECOMMENDATIONS FOR FURTHER RESEARCH

11.1 INTRODUCTION

In this chapter, comment will be restricted to the two technical issues covered in this dissertation, namely the sludge siphon and urine diversion technology. Many of the general sanitation and health issues discussed in the early chapters point to the requirement for sanitation approaches to be more human-centred, i.e. technologies should be responsive to human needs in an appropriate way. Using a toilet should not be an unpleasant experience and maintenance should also not be a burden. If it is, then users will tend to relieve themselves elsewhere, thus defeating the whole object of providing a toilet in the first place. This is where the development of appropriate technologies becomes so important. The promotion of good personal hygiene habits, especially among the poorest sections of the population, is inextricably linked to sanitation, and if the engineer has a basic understanding of the social issues involved, then the research and development of improved sanitation technologies will be correctly focused. In the interests of society as a whole, research needs to be concentrated on technologies which serve not only the user's interests but take into account the institutional capacity of local authorities as well.

11.2 FURTHER RESEARCH ON SLUDGE SIPHON TECHNOLOGY

The real challenge in using this technology is to get the suspended sludge transported for the maximum possible distance. This dissertation has been concerned with the development of an efficient siphon to automatically extract sludge from an interceptor tank in a settled sewage system, without conscious thought by the toilet user, and ensure its delivery into the effluent pipeline. While it has not been proved, it seems likely that the sludge could be carried in suspension for many kilometres. The ideal situation would be to transport the sludge from a whole suburb or town all the way to the treatment works without the need for intermediate settling tanks or the use of vacuum tankers. Thus the most important questions to be addressed in further research are:

- What is the maximum concentration of suspended sludge that can be efficiently transported in the effluent pipeline? This will ultimately determine the maximum number of users that can be connected to a single network.
- Allied to the first topic, what are the most hydraulically efficient pipeline sizes and gradients for various sludge concentrations? Here it will be necessary to examine not only suspended flow conditions but also the ability of the effluent flow to re-suspend sludge deposited on the pipeline invert.

- Will the inorganic particles in suspended sludge be responsible for undue pipeline wear? In other words, will it be necessary to specify a higher class pipe wall than would normally be necessary for pure hydraulic considerations? If this is the case, the savings achieved by implementing sludge siphon technology may be effectively negated.
- Is it possible to further refine the design of the siphon assembly such that the volume of wastewater needed to activate the siphon is reduced, irrespective of the distance or height difference between the activating fixture (washtub, bath, etc) and the interceptor tank? Due to the fact that Boutek holds a patent on the sludge siphon, this specific aspect will need to be researched by Boutek itself.
- Bearing in mind the composition of septic tank sludge, it is possible that a lighter duty sludge pump than what would normally be required for conventional sewage could be used, should a pumping station and rising main be required in the pipeline network. This aspect ought be investigated, as further savings could be achieved in such a case.

11.3 FURTHER RESEARCH ON URINE DIVERSION SYSTEMS

Most of the technical issues regarding design, operation and use of urine diversion sanitation systems have been thoroughly researched in other countries. However, the following aspects need to be further investigated for South African conditions, as at this stage the experience has been limited to a very narrow population and climatic sample:

- The social acceptability of these toilets in general (excluding the issue of excreta reuse for the purpose of this question) for all the various cultural groups in the country.
- Detail matters such as disposal of used personal cleansing material as well as desiccated faeces for the various cultural groups.
- The social acceptability of excreta reuse for agricultural purposes among the various cultural groups.
- The critical issue of pathogen destruction. While it is certain that the process will occur more rapidly in the hotter regions of the country, ways need to be found to accelerate the tempo of pathogen die-off under less favourable climatic conditions. Particularly, ways of ensuring that the faeces pile is kept aerobic are essential to the safe operation of these systems. In this respect, the use of bulking agents other than fine ash will probably play an important role. Otherwise, the feasibility of manually turning the pile occasionally (e.g. by raking) should be researched.
- Finally, a contribution to the nationwide issue of job creation and small business development can be made by examining ways of manufacturing the pedestals by communities themselves. The plastic pedestal used in the Eastern Cape pilot

project currently sells at just under R200 (1999 rands), but this may be too expensive for some very poor communities. The Mexican-type mortar pedestal described in chapter 7 is cheaper to produce, but its successful manufacture is highly dependent on factors such as local availability of good quality sand, the use of a suitable mortar mix, people's experience with working with mortar and moulds, etc. In addition, the fibreglass mould used for its manufacture is not easy to work with (assembly, stripping, etc) and its durability is a problem. Other materials and methods, and possibly even alternative designs, should be examined.