CHAPTER 1
INTRODUCTION AND BACKGROUND

1.1 SANITATION IN SOUTH AFRICA: POLICY AND PRACTICE

Flushing toilets are generally the most sought-after sanitation technology. However, inadequately maintained sewer reticulation systems in urban areas have caused adverse environmental impacts, most often as a result of leaking or blocked sewers, but sometimes also as a result of overloaded or inadequately maintained treatment works and failed pumping stations. In poor areas, especially, most of the operational difficulties are concentrated at the user end of the systems, where personal cleaning materials other than toilet tissue paper are used, and also because of a lack of education on the correct use of cistern flush toilets (Palmer Development Group 1993).

On the other hand, while many dry sanitation schemes have been successfully implemented utilising ventilated improved pit (VIP) toilets, it has been the author's experience (based on visits to numerous projects in South Africa) that others have been problematic, often because of poor design and construction practices. Furthermore, sufficient attention has not always been given to factors such as environmental impact, social issues or institutional capacity. The latter aspect, in particular the problem of desludging full pits, has prompted various local authorities to search for alternative dry sanitation technologies.

The sanitation policy of the South African government stresses that sanitation is not simply a matter of providing toilets, but rather an integrated approach that encompasses institutional and organisational frameworks as well as financial, technical, environmental, social and educational considerations (DWAF 2001). It is recognised that the country cannot afford to provide waterborne sanitation for all its citizens – nor, for that matter, should it necessarily aspire to do so. It is also acknowledged that, at all levels, the sanitation problem is related to socio-cultural, educational and institutional issues, with the lack of appropriate facilities and inadequate guidelines being contributory factors.

VIP toilets are generally considered to be the basic level of sanitation in South Africa, although the Department of Water Affairs and Forestry recognises various other systems. These include urine-diversion systems, septic tanks with soakpits, settled sewage systems, etc, and where appropriate, full waterborne systems. Urine-diversion toilets of various kinds have, in the last few years, become the systems of choice for a number of municipalities. However, due to some poor implementation practices, as well as some examples of poor design and construction, these have not always been successful. In some communities, operation and maintenance aspects are a matter of concern, particularly the need to periodically empty the vaults.

1.2 SANITATION, PUBLIC HEALTH AND THE ENVIRONMENT: THE CASE FOR URINE-DIVERSION ECOLOGICAL SANITATION SYSTEMS

Vast amounts of faecally contaminated material pollute the living environment of people, soils and bodies of water worldwide. Existing systems and available resources are often inadequate to deal with the associated social and behavioural factors. This has contributed much to the escalation in ecological problems. With rapid population growth, especially in urban areas, the situation will not improve unless there is a significant change in the manner in which sanitation systems are chosen, designed and implemented (Simpson-Hébert 1997). With uncontrolled urbanisation, as is seen in many areas today, sanitation problems result from poor, non-existent or reactive planning. There is an urgent need for pro-active sanitation planning, especially in urban areas.

It is predicted that, by early this century, more than half of the world's population will be living in urban areas. By 2025 this urban population could rise to 60%, comprising some five billion people. The rapid urban population growth is putting severe strain on the water supply and sanitation services in most major conurbations, especially those in developing countries (Mara 1996). In Africa today, over half the population is without access to safe drinking water and two-thirds lack a sanitary means of excreta disposal. Lack of access to these most basic services required to maintain health lies at the root of many of Africa's current health, environmental, social, economic and political problems. Hundreds of thousands of African children die annually from water- and sanitation-related diseases. More people are without adequate services today than in 1990, and at the current rate of progress full coverage will never be achieved (WSSCC 1998).

Water quality is deteriorating all over the world because of pollution. Some cities in developing countries treat only about 10% of their sewage (Björklund 1997). Even in South Africa, an alarming proportion of sewage waste in many towns and cities across the country does not reach treatment plants, but flows untreated into streams and rivers, with negative effects on the health of people reliant on these water resources (DWAF 1999). This is regarded as one of the most pressing water quality problems in the country. In many cases, even when sewage waste reaches the treatment plant, poor operation or a malfunctioning system means that partially treated sewage effluent is discharged into rivers (DWAF 1999).

Sanitation systems based on flush toilets, sewers and central treatment plants can therefore not solve the sanitation problem (Winblad 1996b). Methods of providing good sanitation without the concomitant use of large volumes of water should rather be sought. It has been shown that cistern flush toilets can use about 15 000 litres of (potable) water per person per year (Winblad 1996b), which South Africa can ill afford. This figure is based on a person using a conventional toilet flushing 8-10 litres of water 4 or 5 times a day. If one assumes that about 20 million people in the country have access to a waterborne sanitation system, it implies that 300 million m^3 of drinking water per annum are flushed into the sewers. According to DWAF (1997) the country will reach the limits of its economically usable, land-based fresh water resources during the first half of this century. The current maximum yield is some 33 290 x 10^6 m^3/year while the projected utilisation by 2030 is 30 415 x 10^6 m^3/year, leaving a surplus of only 2 875 x 10^6 m^3/year by this time. Sanitation strategies that support a conservation approach should therefore be followed.

However, the problem can also not be solved by systems based on various kinds of pit toilets (Winblad 1996b). These toilets are subject to various problems that may make implementation difficult, if not impossible. Geotechnical conditions, such as hard or rocky ground for instance, as are found in many areas of South Africa, may require additional expensive resources for excavation of pits, or the structure may need to be raised in order to minimize the volume of excavation. In other cases, non-cohesive soils (found for example in some coastal plains) will require a pit to be lined in order to prevent collapse of the structure. Pits should preferably also be avoided in areas where hydrogeological investigations indicate a potential for groundwater contamination. These toilets are also unsuited to densely populated urban or peri-urban areas, owing to the increased risk of environmental pollution. Full pits are a further problem, as emptying them is an expensive, unpleasant and unhealthy process, the burden of which often falls on local authorities that may be ill equipped for the job.

Some other solution should be sought in these cases. If a dry toilet is designed and constructed in such a way that that the faeces receptacle can be quickly and easily emptied, with minimal risk to human health, then one of the biggest operation and maintenance problems associated with these toilets will be obviated. If the excreta can also be productively and safely used for fertilizing crops and improving poor soils, the technology will become even more attractive.

According to Simpson-Hébert (1997), the approach to sanitation worldwide should be ecologically sustainable, i.e. concerned with protection of the environment. This means that sanitation systems should neither pollute ecosystems nor deplete scarce resources. It further implies that sanitation systems should not lead to degrading water or land and should, where possible, ameliorate existing problems caused by pollution. This argument is supported in the discussion above concerning South Africa. More research and better designs are needed. Human excreta can be rendered harmless, and toilet designs that do this in harmony with agricultural and social customs hold promise for the future (Simpson-Hébert 1996). It has been recommended (Simpson-Hébert 1997) that a demand should be created for sanitation systems that move increasingly toward use and recycling of human excreta.

Problems with conventional sanitation systems have been shown to include inadequate institutional capacity to deal with the sanitation process, a fixation with providing either a full waterborne system or a VIP toilet, the social acceptability of various systems, and the perception that dry, on-site sanitation systems are inherently inferior. The basic purpose of any sanitation system is to contain human excreta (chiefly faeces) and prevent the spread of infectious diseases, while avoiding damage to the environment. An alternative sanitation technology known as urine-diversion (UD) performs these functions with fewer operational and maintenance problems than those associated with conventional VIP toilets, and also provides a free, easily accessible and valuable agricultural resource for those who wish to use it. This technology represents one aspect of an approach, or philosophy, termed “ecological sanitation” (also known as “ecosan”). According to Esrey et al (1998) key features of ecosan are prevention of pollution and disease caused by human excreta, treatment of human excreta as a resource rather than as waste, and recovery and recycling of the nutrients. In nature, excreta from humans and animals play an essential role in building healthy soils and providing valuable nutrients for plants. Conventional approaches to sanitation misplace these nutrients, dispose of them and break this cycle.

UD technology has been used successfully for decades in countries such as Vietnam, China, Mexico, El Salvador, Ecuador, Guatemala, Ethiopia and, since 1997, also in Zimbabwe and South Africa (the author was responsible for implementing South Africa’s first UD project, near Umtata in Eastern Cape). Various Scandinavian and European countries have also implemented different UD schemes in the last few years. The most important characteristic of this technology is the low moisture content in the faeces receptacle. The urine is diverted at source by a specially designed pedestal and is not mixed with the faeces. A schematic representation is given in Figure 1.1, while a typical UD toilet pedestal is illustrated in Figure 1.2. A pit is not necessary, as the entire structure may be constructed above ground, or may even be inside the dwelling. Ash, dry soil or other suitable material is sprinkled over the faeces after defecation. This serves to absorb the moisture and control flies and odours. The generally dry conditions in the faeces receptacle facilitate the desiccation of the contents, which assists pathogen destruction. The desiccated faecal matter makes a good soil conditioner while the urine, when diluted with water, is an excellent fertiliser, being rich in the nutrients nitrogen, phosphorus and potassium.

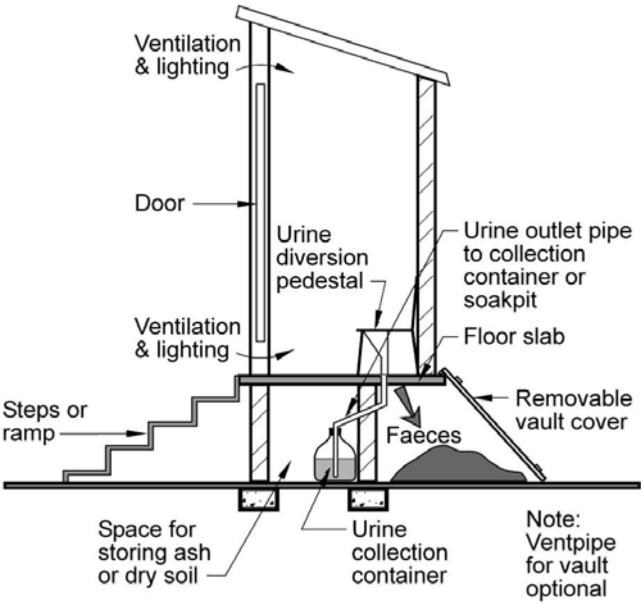

Figure 1.1: Schematic representation of a urine-diversion toilet

Figure 1.2: A typical urine-diversion toilet pedestal

1.3 BACKGROUND TO THIS INVESTIGATION

As mentioned above, UD systems have been successfully implemented in many countries, including South Africa where more than 60 000 (current figure, June 2007) of these toilets have been built since the implementation of CSIR's pilot project in 1997. However, despite much research having been carried out internationally and locally, various questions still remain, particularly on the health aspects of operation, maintenance, and excreta use or disposal. In contrast to composting, which is generally well understood, not enough is known about the dehydrating processes taking place inside the faeces vault, and there is still disagreement on safe retention periods and microbiological stability of the final product. The roles of dryness, pH, temperature and time in pathogen destruction also need to be further clarified. In addition, it is critically important that toilet users are able to operate and maintain their systems easily and safely, particularly while emptying the vaults and recycling or otherwise dealing with the contents. Engineers need to understand and take all these issues into consideration before they can properly design and implement sustainable UD sanitation systems.

It is therefore important to develop guidelines for sanitation practitioners that set out best practices for design and operation of UD toilets. Design recommendations are important because good design facilitates easy operation, and also promotes rapid pathogen destruction. Easy operation in turn directly influences the health risks associated with removing faecal material from the vaults by minimising contact with untreated material. The rate of pathogen destruction in a UD toilet is mainly dependent on temperature, dryness and pH, although detailed quantification of these parameters is still lacking and needs to be further researched. These parameters are also influenced by different types of bulking agents (e.g. ash, lime, sawdust, leaves, etc). If the interrelationship of these factors, together with time, could be determined and graphically illustrated, it would represent a valuable new tool for project implementers.

Handling of faecal material is an aspect inherent in the operation of UD ecological sanitation systems, because emptying of the vault is usually done using hand tools. If the faecal material is also used for agricultural purposes then further handling must of necessity take place. As such, there is a health concern, both for the person(s) handling the material and for the wider public who may be consumers of the fertilised crops. It is therefore necessary that these health concerns be quantified, in order that proper regulation may take place. These aspects are examined in more detail in chapter 2 (literature review), particularly section 2.6, as well as in chapter 4 (field trials on food crops). These two chapters form the basis of the rationale for the thesis, as set out in chapter 3.

This thesis is written from the perspective of an engineer, for engineers who are involved in the implementation of UD ecological sanitation systems. As such, it is not intended to be a microbiological treatise, but is concerned with health aspects that are, or should be, of concern to sanitary engineers. Proper implementation of UD toilets requires a working knowledge of the mechanisms of pathogen die-off in the toilet vaults, in order to ensure suitable design and construction methods aimed at enhancing this die-off, and also so that effective operation and management procedures may be put in place, particularly for handling, disposal and/or use of faecal material. The intention is to develop practical guidelines for this purpose, for both the designer and the regulator, and the microbiological aspects are thus dealt with only in detail sufficient for understanding the scope of the problem.