1

Introduction

1.1 THE NEED FOR SANITATION

Low-income communities which do not have adequate sanitation facilities are exposed to a high risk of infection with excreta-related diseases. Children under the age of 3 are particularly susceptible to diarrhoeal diseases. Older children and adults are likely to be infected with intestinal worms, most commonly the human roundworm (*Ascaris lumbricoides*) and the human hookworms (*Ancylostoma duodenale* and *Necator americanus*). This disease burden is generally very high in low-income periurban communities: Figure 1.1 shows that infant mortality in Bangladesh, for example, is higher in periurban areas than in rural areas; and Figure 1.2 shows that, both infant and adult mortality in urban Brazil is higher in poor areas than in non-poor areas.

There is an acute need for sanitation in poor periurban areas. Sanitation is the key infrastructure component which is required to reduce the unacceptably heavy toll of excreta-related disease. Yet sanitation coverage in urban areas is currently decreasing (Table 1.1), and urbanization – actually periurbanization – is increasing. In many (but obviously not all) periurban situations the sanitation technology of first choice is simplified sewerage. The two principal reasons for this, which are explained more fully in Section 1.2, are that it can be cheaper than on-site sanitation systems, and that it is often institutionally easier – that is to say, water and sewerage authorities accept it more readily than on-site systems simply because it is a sewerage system and therefore automatically part of their mindset.

Table 1.1 Urban Population (millions) Unserved with Sanitation, 1990 and 1994

Region	1990	1994	% Increase
Africa	71	108	**52.1**
LAC	52	94	**80.8**
Asia Pacific	316	371	**17.4**
World	453	589	**30.0**

Source: WHO (1996).

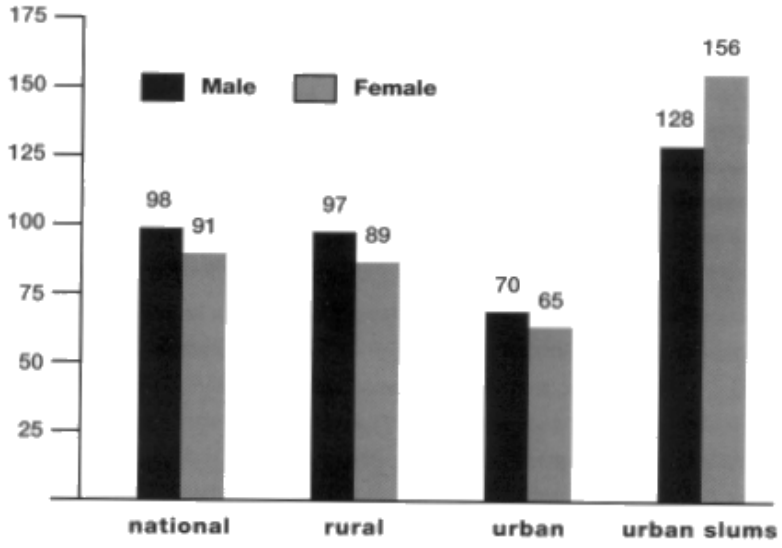

Figure 1.1 Infant mortality in Bangladesh in 1991. *Source*: UNICEF Bangladesh (1993), cited in Black (1994).

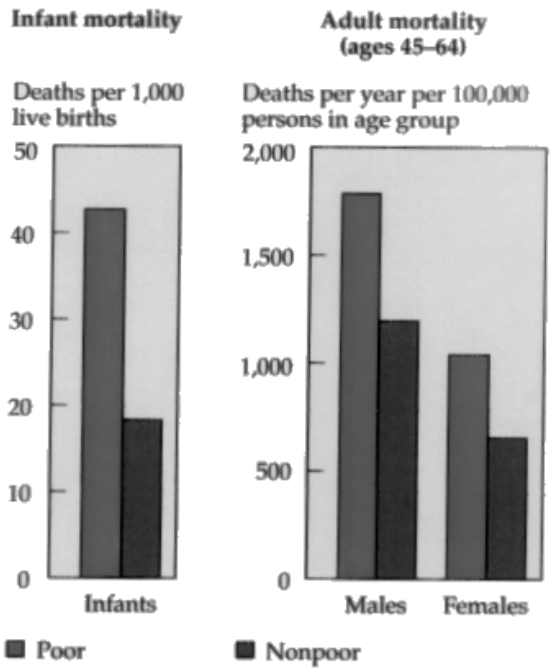

Figure 1.2 Infant and adult mortality in poor and non-poor areas of Porto Alegre in southern Brazil in 1980. *Source*: World Bank (1993).

1.2 SIMPLIFIED SEWERAGE

Simplified sewerage is an off-site sanitation technology that removes all wastewater from the household environment. Conceptually it is the same as conventional sewerage, but with conscious efforts made to eliminate unnecessarily conservative design features and to match design standards to the local situation.

Various approaches to reduced-cost sewerage have been developed in different parts of the world, often independently of each other. This Manual draws on the approach developed in the early 1980s by the CAERN, the Water and Sewerage Company of the northeastern Brazilian state of Rio Grande do Norte. The aim of CAERN was to develop a technically feasible and socio-culturally acceptable solution to the previously intractable problem of sanitation provision in high-density low-income peri-urban areas (de Andrade Neto, 1985; Guimarães, 1986; Mara 1996; de Melo, 1994; Sinnatamby, 1983 and 1986; Sinnatamby *et al*., 1986). The simplified sewerage approach is now widely used through Brazil (Box 1.1).

Key features of the system are as follows:

(a) **Layout**: in order to reduce costs, CAERN developed simplified sewerage as an *in-block* system (Figure 1.3), rather than – as with conventional sewerage – an in-road system. The key feature of an in-block system is that sewers are routed in private land, through either back or front yards. This in-block or back-yard system of simplified sewerage is often termed **condominial sewerage** in recognition of the fact that tertiary sewers are located in private or semi-private space within the boundaries of the `condominium'.

(b) **Depth and diameter**: simplified sewers are laid at shallow depths, often with covers of 400 mm or less (see Section 5.1.2). The minimum allowable sewer diameter is 100 mm, rather than the 150 mm or more that is normally required for conventional sewerage. The relatively shallow depth allows small access chambers to be used rather than large expensive manholes (see Section 5.1.5).

In-block systems of the type recommended by CAERN are not possible in all situations. For instance, there are many places where house construction extends to both the front and back of the plot, thus preventing a sewer from being routed though the plot. Even where this is not the case, householders may be reluctant to allow sewers to be routed through their plots. Other options have been developed in such situations to allow sewers to be laid at shallow depths. These include *lane sewers* laid in access ways that are too narrow to allow heavy traffic, and *pavement sewers* laid underneath pavements (sidewalks) to avoid the heaviest traffic loading (Figure 1.4). Most low-income areas do not have pavements. Where this is the case a variation in the form of *plot line sewers* may be appropriate. In essence, the principle is the same as that for the pavement sewer: the sewer is laid at shallow depth close to the front boundary of plots, which will often also be the building line.

Box 1.1 The development and dissemination of simplified sewerage in Brazil

Simplified sewerage – generally known as condominial sewerage in Brazil – was developed by the R&D Division of CAERN, the water and sewerage company of the northeastern State of Rio Grande do Norte, and its engineering consultant José Carlos de Melo, with technical assistance being provided by Professor Cicero Onofre de Andrade Neto of the department of Civil Engineering of the Federal University of Rio Grande do Norte. It was fieldtested in the low-income areas of Rocas and Santos Reis in Natal, the State capital in the early 1980s. The CAERN team presented its experience at the biennial Congress of the Brazilian Association of Sanitary and Environmental Engineering (ABES) held in Balneário Camboriú, Santa Catarina in November 1983, and also described the system in the ABES technical journal *Engenharia Sanitária* (de Andrade Neto, 1985; de Melo, 1985).*

CAERN's development of condominial sewerage in Natal was partially funded by the World Bank Medium Sized Cities project, which also saw the implementation of condominial sewerage in the city of Petrolina in the state of Pernambuco. In Natal the Brazilian Office of the World Bank/UNDP Technology Advisory Group (TAG) (project GLO/78/006, later INT/81/047) evaluated the Rocas and Santos Reis scheme. This led to the production of the Brazilian national design manual for simplified sewerage (Guimarães, 1986) and the formation of the ABES Low-cost Sanitation Committee (1984-1986), which in turn led to the adoption of a minimum sewer diameter of 100 mm in the revision of the Brazilian national sewerage design code (ABNT, 1986) (previously it was 150 mm). A further key feature in the development of simplified sewerage design in Brazil was the realisation by the late Brazilian sanitary engineer Eugênio Macedo that the sewer gradient should be based on the initial design flow and the sewer diameter on the final design flow – an important consideration (incorporated into the 1975 Brazilian national sewerage design code) as in low-income areas the latter may be up to five times the former.

Simplified sewerage schemes were then implemented by several of the Brazilian state water and sewerage companies (see Watson, 1995). SANEPAR and SABESP, the water and sewerage companies of the southern states of Paraná and São Paulo, introduced front-yard and pavement sewerage (laying the sewer in the front garden and sidewalk), rather than backyard (in-block) sewerage as used in the northeast of the country, and they changed the hydraulic design basis from minimum self-cleansing velocity to minimum tractive tension (Machado Neto and Tsutiya, 1985), a change which was also included in the 1986 Brazilian national sewerage design code.

CAESB, the water and sewerage company of Brasília and the Federal District, started implementing simplified sewerage in poor areas in 1991 and now it considers simplified sewerage as its "standard solution" for rich and poor areas alike (see Figure 1.6). CAESB has over 1,200 km of condominial sewers in operation – the largest example of simplified sewerage in the world. Average capital costs are around R$ 40-60 (US$ 22-34) per person (Luduvice, 2000).

Simplified sewerage is now used in many states in Brazil. Many schemes have been successful, and some have been failures – mainly due to poor construction and/or poor institutional commitment (see Watson, 1995), and especially due to poor maintenance. Whatever the successes and failures of individual projects, what can be said is that simplified sewerage has been successfully adopted into mainstream Brazilian sanitary engineering. The reasons for this success have been (1) the ease of dissemination of innovative technologies at the biennial ABES Congresses which are attended by all the state water and sewerage companies, (2) the relatively small number of leading Brazilian sanitary engineers who have been committed to, and have been excellent advocates of, the technology, and (3) the keen interest shown in the technology since its beginning by the World Bank and UNDP which has acted within Brazil to give the system a seal of international approval.

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* Dr Gehan Sinnatamby, then a doctoral student from the University of Leeds, England was part of the CAERN R&D team and this led to dissemination of condominial sewerage outside Brazil, including the production of the UNCHS Design Manual (see Sinnatamby, 1983 and 1986; Sinnatamby *et al*., 1986).

Figure 1.4 illustrates the way in which all these different types of sewer can be used. This is a theoretical example and it will be unusual for all the possible arrangements to be used together in the way shown in the figure. The key question to be answered by the designer and householders in the area to be sewered is which form (or forms) of condominial sewer will be most suitable for the local situation.

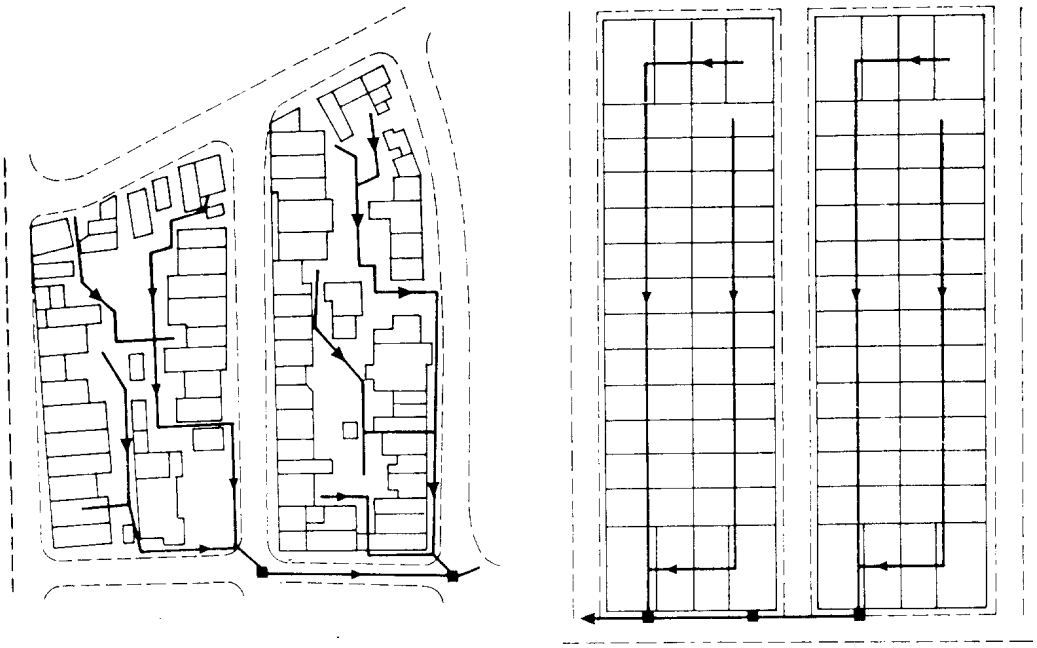

Figure 1.3 Layouts of in-block simplified (condominial) sewerage for unplanned and planned periurban housing areas. *Source*: Sinnatamby (1983).

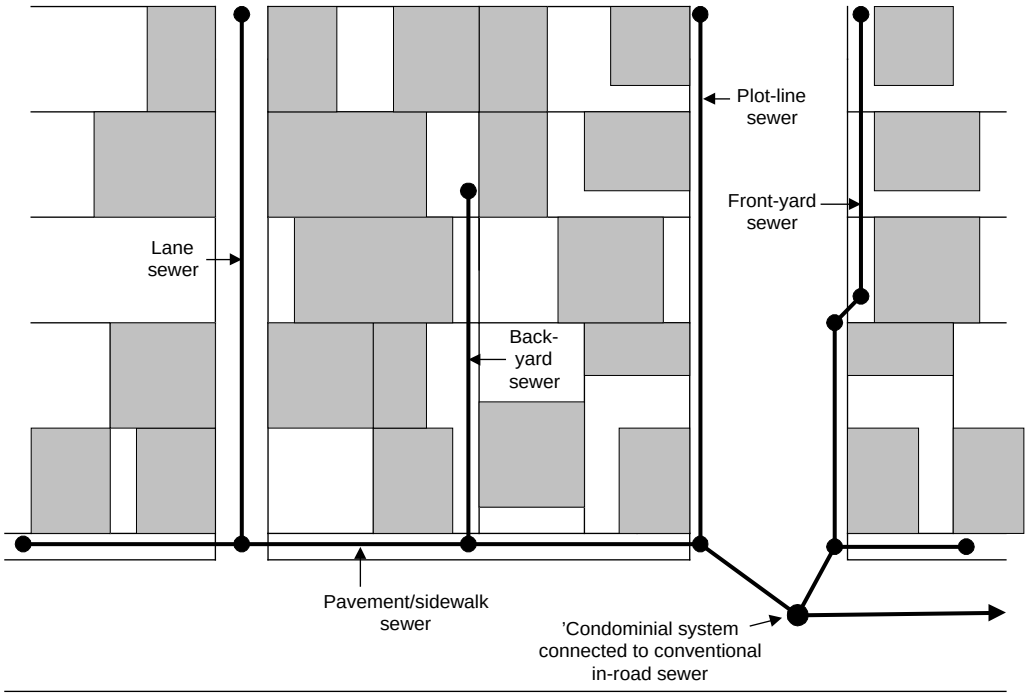

Figure 1.4 Alternative routes for simplified sewers.

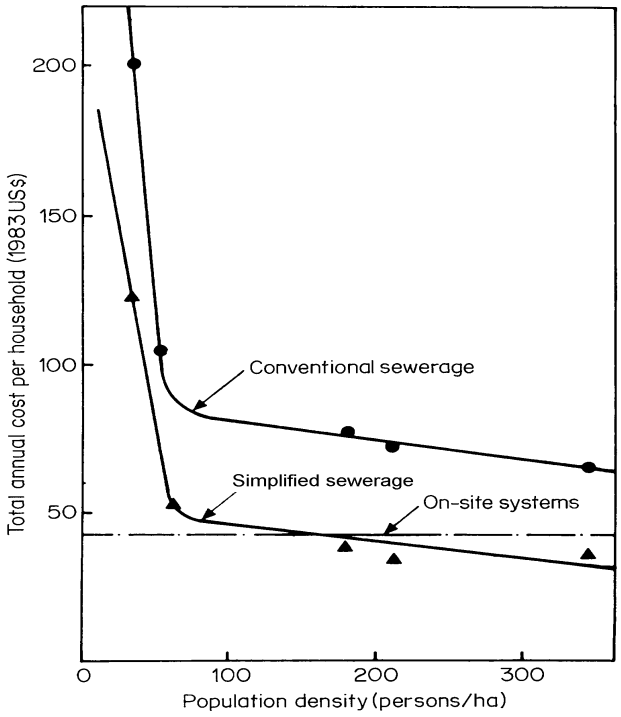

Figure 1.5 Costs of conventional and simplified (condominial in-block) sewerage, and on-site sanitation in Natal in northeast Brazil in 1983. *Source*: Sinnatamby (1983).

Figure 1.6 In-pavement (sidewalk) simplified sewerage being installed in the high-income area of Lago Sul in Brasília in 1999.

In-block sewerage, particularly back-yard sewerage, can significantly reduce the length of sewer required, thus reducing costs. Costs are further reduced by laying sewers at shallow depths away from heavy traffic loads. The results are illustrated in Figure 1.5, which shows that, as the population density increases, simplified sewerage can become cheaper than on-site sanitation systems. In Natal, the state capital of Rio Grande do Norte, this occurred at the relatively low peri-urban population density of 160 persons per hectare.

In Natal, the capital costs of simplified sewerage in 1980 were US$ 325 per household, compared with around US$ 1,500 per household for conventional sewerage. CAERN was able to recover its costs over a 30-year period by surcharging the monthly water bill by only 40%, rather than the 100% that was the norm for conventional sewerage. The monthly charge for water was US$ 3.75, the `minimum tariff', based on an assumed unmetered consumption of 15 m^3 per household per month. Thus, the cost of simplified sewerage to the householder was only US$ 1.50 per month.

Similar levels of cost saving have been recorded elsewhere. In Orangi, Pakistan, the cost of community-based sewerage installed with technical assistance from the Orangi Pilot Project (OPP) was found to be about one quarter of that of conventional sewerage provided by government agencies (see Reed and Vines, 1992*a*, *b* and Zaidi, 2000). At around $40 per household, the absolute costs of these sewers was much lower than in northeast Brazil. This was partly because of much lower construction costs and partly because the sewers were built by the users themselves. Regardless of the absolute cost, the important point is that simplified sewerage offers substantial costs savings over conventional sewerage and is thus more likely to be affordable to the urban poor.

The fact that simplified sewerage is low-cost does not mean that it can only be used in low-income peri-urban areas. CAESB, the water and sewerage company of Brasília and the Federal District in Brazil, now regards simplified sewerage as its standard solution for sanitation in rich and poor areas alike (Luduvice *et al*., 1999; see also Nigreiros, 1998). This preference for simplified sewerage must be seen in the context that rich areas of Brasília are very rich indeed (Figure 1.6).

Simplified sewerage has been successfully used in countries other than Brazil. In Latin America, for example, it is used in Bolivia, Colombia, Nicuagua, Paraguay and Peru (Guimarães, 2000). In Africa it has been implemented in a few trials in South Africa (Pegram and Palmer, 1999), and in Asia it has been very successfully used since the mid-1980s by the National Housing Development Authority in Sri Lanka, with over 20 schemes now in operation (Ganepola, 2000); it has also been used in Karachi, Pakistan (Sinnatamby *et al*., 1986) (Box 1.2) and Malang, Indonesia (Foley *et al*., 2000). In India, however, and despite the technology being included in the national sewerage and sewage treatment design manual (Ministry of Urban Development, 1995), it has not been used, even though its applicability is very high, especially in "slum networking" sewerage projects (see Diacon, 1997; see also Chaplin, 1999).

Interestingly condominial (back-yard) sewerage is not new: it was recommended in the United Kingdom 150 years ago (General Board of Health, 1852; Mara, 1999) (Figure 1.7).

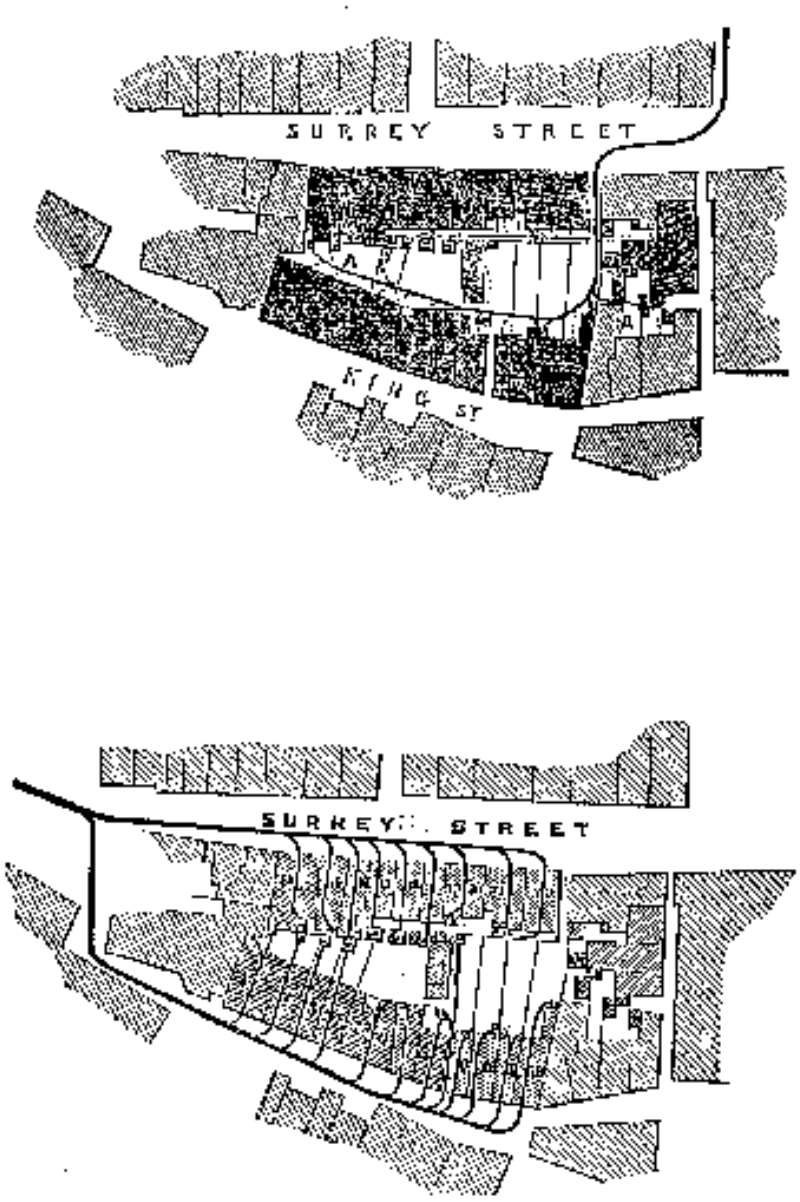

Figure 1.7 In-block sewerage (top) and conventional sewerage (bottom) in Victorian England. *Source*: General Board of Health (1852).

Box 1.2 The introduction of simplified sewerage into Pakistan

"Simplified sewers were introduced to Pakistan in early 1985. Christy Nagar, a low-income Bihari community on the outskirts of Karachi, was selected for a demonstration project. The population density is 193 persons per ha, and most households obtain an intermittent supply of water from public standpipes: water consumption is low, only some 27 litres per person per day. Simplified sewers, designed as in Brazil, receive the wastewater from manually flushed squat pans and also all the household sullage; a grit and grease trap is provided which acts as a focus for sullage collection and also serves as a preventive maintenance device. Despite the low flows, the system has functioned perfectly well for nearly a year: no blockages have occurred, showing that properly designed sewers do not need vast quantities of water for trouble-free operation. The investment cost per household was incredibly low – a mere $45, which covered the squat pan, grit and grease trap, house connection, street laterals, collector main and primary treatment."

Source: Sinnatamby *et al*. (1986).

1.3 PROMOTION OF SIMPLIFIED SEWERAGE

This Manual contains a considerable amount of information on simplified sewerage. More is available on the UNDP – World Bank Water and Sanitation Program's *Sanitation Connection* website.[1] However, even with all this information, how do you set about promoting and implementing simplified sewerage in a country with no previous experience of the technology?

Clearly, the first step is to identify a relatively small poor periurban area in which simplified sewerage appears to be a feasible solution to the community's sanitation needs.

Secondly, several things need to be done:

- discuss your ideas with senior management of the local sewerage authority,
- contact your local office of the UNDP – World Bank Water and Sanitation Program,[2]
- call a meeting of the community you have identified to present the technology.

If the local sewerage authority has been privatised and the privatisation contract requires the company to achieve 100 percent sanitation or sewerage coverage within (for example) five years, then this is in fact a very good opportunity for the promotion of simplified sewerage since there will generally be no alternative sanitation option that is as financially and technically appropriate as simplified sewerage.[3]

[1] http://www.sanigate.net (click on "information by topic", then on "Low cost Sewerage")
[2] For addresses (including email addresses), see http://www.wsp.org (or email info@wsp.org).
[3] See, for example, the El Alto project in La Paz, Bolivia (http://www.wsp.org/English/urban-elalto.pdf).

If, on the other hand, the local sewerage authority has not been privatised, then the problem of design standards may arise – national sewerage design codes, which are of course design codes for conventional sewerage, do not generally permit the use of 100 mm diameter sewers laid at a gradient of only 1 in 200.

The way forward here is to present to senior management the fundamentals of simplified sewerage as presented herein, with additional material obtained from the Sanitation Connection website,[4] and show how appropriate simplified sewerage is for the periurban community you have identified, and how – through simplified sewerage (plus, where appropriate, improved water supplies and hygiene education) – the sewerage authority can aid national objectives of overcoming urban poverty (see Alfaro, 1997). The idea is to obtain permission for a small pilot-scale (indeed, experimental) project to evaluate the local feasibility of simplified sewerage (see Section 3). Help will often be available from the UNDP – World Bank Water and Sanitation Program, from agencies such as UNICEF and the European Union, and from bilateral agencies such as DFID,[5] and for technical enquiries from the Sanitation Connection help desk.[6]

Finally, explain the technology to a meeting of the community you have identified (see Figure 1.8).

It will also be a good idea to present your ideas on simplified sewerage at a meeting of your local professional engineers association, and maybe persuade it to establish a Low-cost Sanitation Committee (as was done in Brazil – see Box 1.1). This committee could oversee the pilot-scale simplified sewerage project, and it could then recommend appropriate design standard changes to the national sewerage design code (this was also done in Brazil).

Figure 1.8. An engineer from the CAERN R&D Division explaining condominial sewerage to a residents' meeting in Rocas and Santos Reis in Natal, northeast Brazil (*cf.* Box 1.1).

[4] Including, for example, the poster on simplified sewerage available at: http://www.efm.leeds.ac.uk/CIVE/Sewerage/articles/simple_pas_.pdf
[5] Contact your local British Embassy or High Commission.
[6] http://www.sanigate.net/helpdesk (or email helpdesk@sanicon.net).