ON-PLOT SANITATION IN LOW-INCOME URBAN COMMUNITIES

A review of literature

Andrew Cotton, Richard Franceys,
John Pickford and Darren Saywell

September 1995

Water, Engineering and Development Centre
Institute of Development Engineering
Loughborough University of Technology UK

Institute of Development Engineering
Loughborough University of Technology
Leicestershire LE11 3TU UK

September 1995

ISBN Paperback 0 906055 44 X

Table of Contents

List of Tables and Figures

List of tables

List of figures

List of graphs

List of photographs

Glossary

Aqua privies
Latrine in which excreta fall directly through a submerged pipe into a watertight settling chamber below the floor, and from which effluent overflows to a soakaway or drain.

BOD
Biochemical oxygen demand: the mass of oxygen consumed by organic matter during aerobic decomposition under standard conditions, usually measured in milligrams per litre during five days; a measure of the concentration of sewage.

Excreta
Faeces and urine

Compost latrine
In this type of latrine, excreta fall into a watertight tank to which ash or vegetable matter is added.

Dry latrine

A latrine where users defecate into a bucket, basket or other receptacle that is regularly emptied.

Latrine
Place or building, not normally within a house or other building, for deposition, retention and sometimes decomposition of excreta

Overhung latrine
Latrine sited such that excreta falls directly into the sea or other body of water

Nightsoil
Human excreta, with or without anal cleaning material, which are deposited in a bucket or other receptacle for manual removal (often taking place at night).

Off-set pit
Pit that is partially or wholly displaced from its superstructure

On-plot sanitation
Sanitation systems which are contained with the plot occupied by the dwelling. On-plot sanitation is associated with household latrines, but also includes facilities shared by several households living together on the same plot.

On-site sanitation
Includes communal facilities which are self-contained within the site, in contrast to sewerage and dry latrines where excreta is removed from the site.

Pathogens
Organism that causes disease

Percolation rate
The rate at which liquids move through soil

Pit latrine
Latrine with a pit for accumulation and decomposition of excreta and from which liquid infiltrates into the surrounding soil

Pour flush latrine
Latrine with a small quantity of water is poured in to flush excreta through a water seal into a pit

Sanitation
The means of collecting and disposing of excreta and community liquid waste in a hygienic way so as not to endanger the health of individuals or the community as a whole

Septic tanks
Watertight chamber for the retention, partial treatment, and discharge for further treatment, of sewage

Sewage
Wastewater that usually includes excreta and that is, will be, or has been carried in a sewer

Sewer
Pipe or conduit through which sewage is carried

Sewerage
System of interconnected sewers

Soakaway
Soakpit or drainage trench for subsoil dispersion of liquid waste

Soakpits
Hole dug in the ground serving as a soakaway

Sullage
Wastewater from bathing, laundry, preparation of food, cooking and other personal and domestic activities that does not contain excreta

Superstructure
Screen or building of a latrine above the floor that provides privacy and protection for users

TACH
Total annual cost per household; includes capital (or investment) costs and recurrent costs

Vent pipe
Pipe provided to facilitate the escape of gases from a latrine or septic tank

VIP latrine
Ventilated improved pit latrine, pit latrine with a screened vent pipe and a partially dark interior to the superstructure

Water seal
Water held in a U-shaped pipe or hemispherical bowl connecting a pan to a pipe, channel or pit to prevent the escape of gases and insects from the sewer or pit

Wastewater
Sewage or sullage

Y-junction
Chamber in which liquid may be directed along either of two pipes or channels

Abstract

This document reports findings from Phase 1 (May - August 1992) of an Overseas Development Administration funded project (no. R4857) concerning on-plot sanitation in low income areas of urban Africa and Asia. Results from the project's two main tasks - a review of relevant literature and postal surveys (which were carried out simultaneously) are discussed.

More than three hundred documents were examined in the review and material relevant to on-plot urban sanitation has been summarized in sections dealing with technical, health and social, and management matters. Alternative technologies are critically reviewed, with special attention given to the relative advantages and disadvantages of each option. Many social and management factors that have influenced the success of projects and programmes have been noted. However, the literature search indicated that little has been written about the sustainability of on-plot sanitation nor its relevance to urban conditions. In particular, there is little evidence of an objective examination of performance, or whether operation and maintenance procedures were followed over a period of years.

The postal survey indicated what was known locally, but the answers to questions are in most cases based solely on the subjective impressions of the respondent. A summary of survey replies is provided, and information relevant to technology choice, absence of latrine, emptying practices, children's latrines, and household payments is briefly reviewed.

From information gained through the literature search, postal survey and investigator's observations in developing countries, seven topics which require more detailed investigation have been identified for Phase 2 of the project.

Part A: Introduction

During the International Drinking Water Supply and Sanitation Decade (1981-1990) sanitation coverage in developing countries worldwide increased from 46 to 54 per cent. However, UN statistics indicate that there were approximately 380 million urban people still without adequate sanitation in 1990 (United Nations, 1990), a figure that may still underestimate the true extent of the deficiency.

Although factors such as political will and shortage of trained staff affect the improvement of urban sanitation in low-income countries, financial considerations are the major constraint. Typically, the cost of conventional sewerage is excessive, sometimes requiring total annual expenditure in the order of a quarter of average household earnings. Considering the economic situation of many developing countries, there has been surprisingly high resistance to lower cost alternatives in towns and cities.

On-site sanitation includes communal facilities which are self-contained within the site, as against sewerage and dry latrines where excreta is removed from the site. *On-plot sanitation* refers to types of sanitation that are contained within the plot ('lot' in the United States) occupied by a dwelling. Commonly, on-plot sanitation is equivalent to 'household latrine', but also includes facilities shared by several households living together on the same plot - a situation found in many developing countries. 'Low cost' is of course a relative phrase, but for most low-income countries *low cost sanitation* is synonymous with some form of pit latrine.

A sewerage system has several advantages over on-plot sanitation systems: it is easy for the users to operate, there is little or no nuisance from odours and insects, and sullage and industrial wastewater can be discharged into the sewers. However, the disadvantages of sewerage are considerable. It is expensive and requires a piped water supply, (which most low-income people do not have, or supply is intermittent, and at low pressure).

Sewerage systems are rare in the major cities of developing countries despite assumptions to the contrary. Only 2 per cent of Bangkok's population is connected to sewers; Khartoum's municipal sewerage covers 5 per cent of the urban area; and Jakarta and Kinshasa have no sewerage at all (Hardoy et al, 1990).

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 providing sewerage to all the urban inhabitants who are now without adequate sanitation. Other systems have to be employed. Ideally they should provide the same health benefits as sewerage but remain affordable to those on low incomes. They must operate well without piped water and provide as great a convenience for users as possible. They must also be simple and reliable to operate and maintain.

Fortunately, a system that satisfies these requirements is available in most urban areas. It involves the use of some form of pit. Pit latrines are an appropriate technology for low-income people and are discussed in detail in this report. Typical costs per household are about one eighth of that of sewerage (Sinnatamby, 1990).

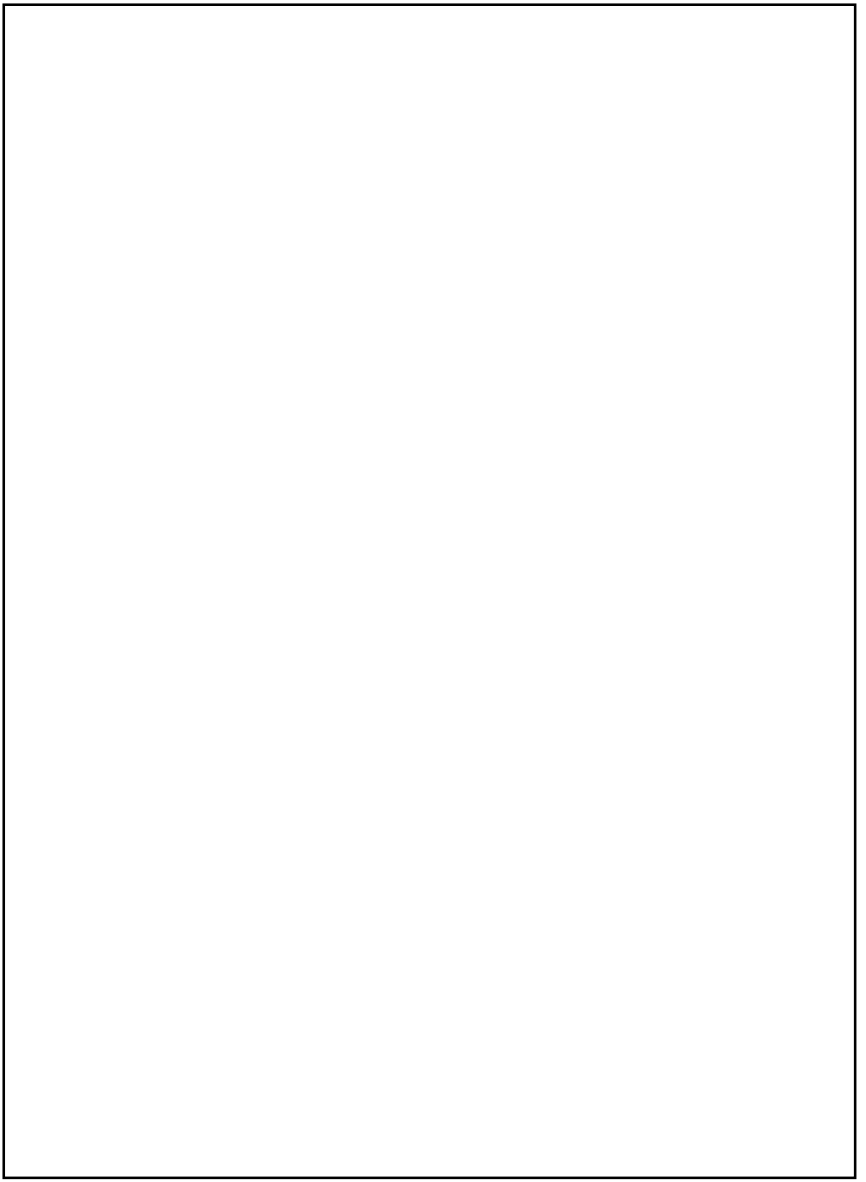
The objective of this booklet is to present a review of published information about latrines that have *proved in practice* to be suitable and sustainable for towns and cities. Phase 2 of the project will report on site investigations to determine the requirements and conditions for success.

Part B: Literature review

1. Publications reviewed

The review was wide in scope, covering all aspects of low cost sanitation so that what was relevant purely for urban areas could be abstracted. Few publications covered the problems of the sustainability of on-plot sanitation systems nor their relevance to urban conditions.

Valuable and comprehensive surveys have been undertaken in India (Sinha and Ghosh, 1990), Bangladesh (Chadha and Strauss, 1991) and Ghana (Whittington et al, 1992). Reports of achievements in the field that are particularly useful are those of Brandberg in Mozambique and Malawi and Morgan in Zimbabwe. There are numerous accounts of efforts to involve communities in rural areas, but little has been reported from towns and cities, apart from two *katchi abadis* in Karachi. However, in India Sulabh International has been instrumental in providing a very large number of new latrines and conversions of dry latrines to pour-flush pits.



Photograph 1: Pole and thatch superstructure to VIP latrine, Harare, Zimbabwe

2. Technical Matters

2.1 Key points

- The main advantages of pit latrines are their relatively low cost, acceptance of different anal cleansing materials and under certain conditions their satisfactory long term use

- Odour and insects are a common nuisance in pit latrines which do not have a waterseal. Possible ways of reducing these include: placing a tight-fitting lid over the squat hole; provision of a ventilation pipe for the pit; placing polystyrene beads inside pits containing water

- Single large pits should be used wherever possible in order to minimize maintenance in terms of the frequency of emptying

- Double (or 'twin') pits facilitate emptying if single large pits are not feasible

- Groundwater pollution can result from percolation of the liquid from pits; most micro-organisms of faecal origin are removed if two metres of sand or loam separate the bottom of the pit from the groundwater table

- There is little reported evidence on hygienic methods for emptying pits and disposing of their contents

- Regulations which proscribe the use of on-plot sanitation on plots smaller than a specified size do not appear to be based on evidence of unsatisfactory performance

2.2 Types of pit latrines

The principle underlying all types of pit latrines is that excreta and anal cleansing materials can be deposited in a hole in the ground. Its basic components, as seen in Figure 1, are a superstructure to provide user privacy, a hole or seat set into a slab which covers the pit, and a pit beneath the slab into which excreta is deposited.

Pit latrines receive only a small amount of water. Since the pit is not sealed, this liquid is allowed to seep from the pit into the surrounding ground. Excreta in the pit undergoes complex chemical and biological reactions which lead eventually to decomposition to innocuous, humus-like solids, water and gases. The remaining water and gases dissipate into the ground or air, leaving a solid residue in the pit. During decomposition, disease-causing pathogens are killed, a process which may take up to two years.

In most of Africa and in some other places solid material (such as newspaper in urban areas) is used for anal cleaning. The pit is normally beneath the latrine shelter, as shown in Figure 1. Variations are discussed in detail later in this report.

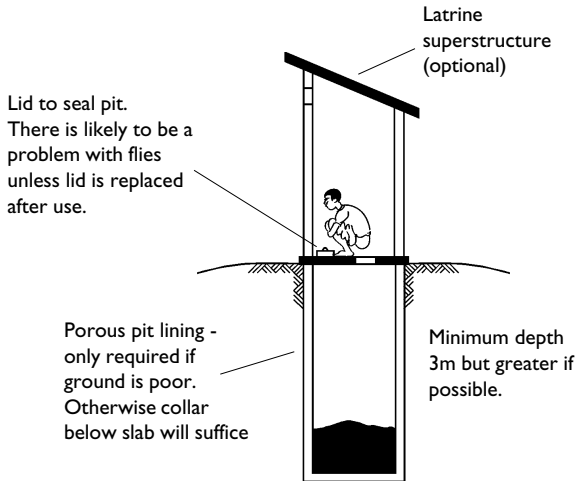


Figure 1: A simple improved pit latrine

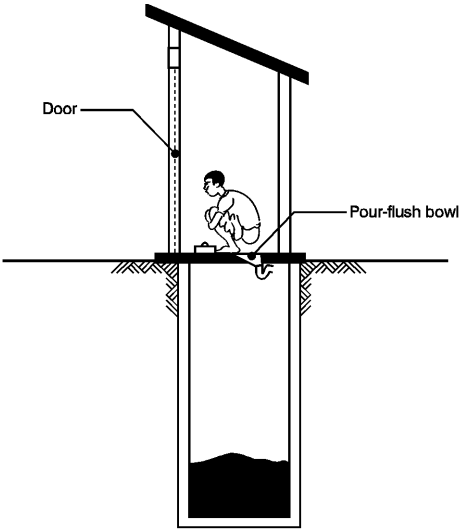
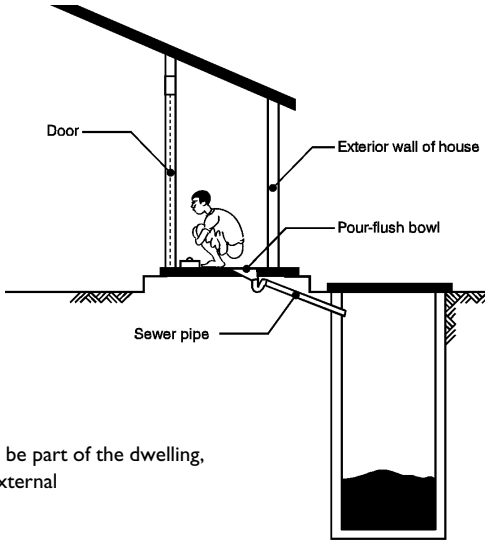


Figure 2: Pour flush latrine with pit beneath the superstructure



The toilet can be part of the dwelling, with the pit external

Figure 3: Offset pour flush latrine

Latrines with water seals are suitable where water is used for anal cleaning (this practice is widespread in south Asia). After defecation a small quantity of water is thrown down the pan, causing the excreta to pass to the pit (hence 'pour-flush latrines'). With a well-designed smooth-surface pan only a litre or two of water is required for cleaning, compared with nine litres or more commonly used in a cistern flushed WC. A pan with a water seal can be incorporated in a slab that acts as both a cover to the pit and as a floor of the latrine, with the pit immediately beneath the latrine shelter. More often the pit is offset, normally outside the latrine building. Floor and pan are supported on firm ground. The pan is connected by a short length of pipe or channel. Examples are shown in Figures 2 and 3.

At their best, when simple pit latrines are well designed, built and maintained they provide sanitary benefits as good as more sophisticated options. Their low cost, simple construction technology, upgrading by householders and acceptance of different anal cleansing materials make pit latrines a practical and widely used form of sanitation for many urban people. At their worst, however, pit latrines provide levels of sanitary hygiene little above open defecation.

2.3 Other alternatives to sewerage

There are also other alternatives to sewerage, which will be briefly considered before turning in more detail to pit latrines.

With '**dry latrines'**, users defecate into a bucket, basket or other receptacle that is regularly emptied. Poor operation or spasmodic and infrequent collection makes dry latrines malodorous and cause an insect nuisance. Nightsoil collection everywhere results in health hazards to collectors. Although widely condemned by users and authorities, millions of dry latrines still exist. In Delhi alone there were an estimated 500,000 in 1992. In Ghana, two-thirds of household bucket latrine users expressed satisfaction with them, as they provided reasonable privacy and convenience (Whittington et al, 1992).

Compost latrines allow for the recycling of a natural resource. When properly operated a compost latrine can provide material useful as a fertilizer. Unfortunately, most are not easy to operate. Compost latrine use is restricted to those nations where the practice is customary and the discipline of operation is observed (Hunt, 1986). The lack of an adequate composting period has resulted

in high levels of worm infection, a constraint which makes compost latrines only rarely suitable for urban areas.

Overhung latrines are built over water into which faeces fall. Only when the water has sufficient flow to carry excreta away and is not used by downstream people is the health hazard low enough for the latrines to be considered as satisfactory.

Septic tanks offer the same benefits to householders as sewerage (Pickford, 1980) and the same disadvantages - high cost and the need for piped water. Effluent from household septic tanks may be discharged to a soakaway or drainage field. This adds to the cost and requires low-density housing. An alternative is to discharge effluent to storm drains, but as septic tank effluent is highly charged with potentially pathogenic organisms, this practice involves obvious health risks.

Aqua-privies are watertight tanks located beneath latrines so that faeces fall into the tank. Effluent is discharged to soakpits. They have a reputation for poor operation and are seldom constructed now, except as communal latrines. The need for large quantities of water for cleaning the drop pipe has been given as another disadvantage of aqua-privies.

2.4 Controlling insects and odours

The literature review revealed that pit latrine use is not free from operational difficulty. Complaints about pit latrines most frequently mention odours and insect nuisance. There are few specific references to overcoming these nuisances in urban areas. However, the findings of other existing studies are likely to be relevant.

Whether a pit is dry or wet makes no difference to fly breeding, but for mosquitoes wet pits are essential as the larvae need water to swim in and a free liquid surface for the breathing siphon (Curtis and Hawkins, 1982).

Flies are a serious problem because they spread disease through feeding and breeding on faeces. Some types of mosquitoes (the *Culex* variety) breed in polluted water such as that in wet latrines and may carry the disease filariasis. Reduction of smells, flies and mosquitoes are therefore of the greatest importance.

A floating layer of polystyrene beads, through which female mosquitoes cannot lay eggs or larvae breathe, controls mosquitoes. Polystyrene is available as packing material or can be obtained as pellets. It has been found to remain in place for as long as four years. Tests in Zimbabwe when one kilogramme of 4 - 6 mm diameter polystyrene balls were added to a pit reduced the emergence of mosquitoes from about 1,500 to 65 a week (Morgan and Mara, 1982). In 1988 all pits known to contain water were treated with polystyrene beads in Makunduchi, Zanzibar. In the following year the biting population of mosquitoes had been reduced by 98 per cent (Curtis, 1991). No information on the durability or frequency of this kind of treatment is available.

2.5 Tight-fitting lids

In Maputo, Mozambique, Brandberg (1985) promoted a low-cost pit latrine which required only two-thirds of a bag of cement and no steel reinforcement. The thin circular dome shaped slab has a removeable lid cast in the squat hole to ensure that it fits tightly. Odour and insects cannot escape from the pit when the lid is placed over the squat hole. Although being used in a densely populated urban area, plot sizes were sufficient to allow a separate pit in a corner of the plot. To reduce costs further many latrines were constructed without any superstructure, except for a privacy screen made from local materials. This popular 'open-air' approach further reduced any odour problems.

A simpler version of this approach, known as the SanPlat, already promoted in urban Malawi and Kenya, uses a flat, unreinforced slab 600mm square and 50mm thick, again with a tight fitting lid. The slab rests on local materials of poles or scrap iron sealed with earth. The small slab reduces costs further but ensures a secure, washable and sealable slab. As for the domed slab, a superstructure is not required as part of the design.

Both these approaches are unsuitable for public, communal or institutional latrines as the handle becomes dirty (Brandberg, 1991b). An unreinforced domed slab is illustrated in Figure 4.

Lids are claimed to have been very successful in controlling flies in Mozambique, where fifty thousand household latrines with unreinforced domed slabs and concrete lids were built in the 1980s (Alvarinho, 1991). However, experience elsewhere has been mixed, with Wagner and Lanoix (1958) commenting on the problem of poor operation and maintenance.

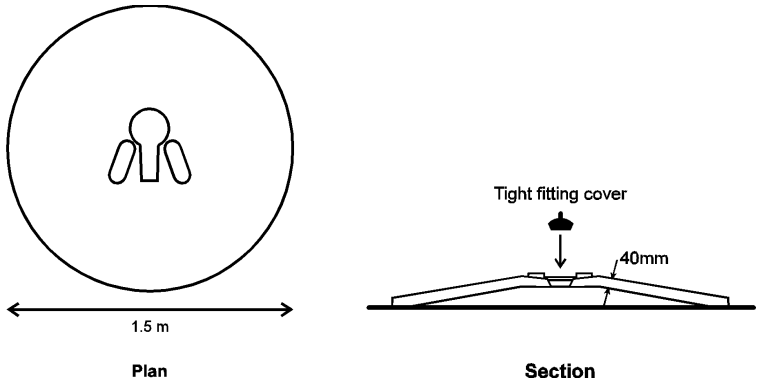


Figure 4: Unreinforced domed slab

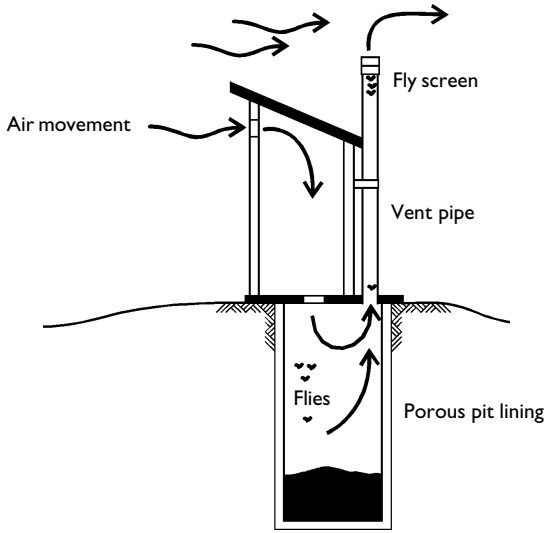


Figure 5: Ventilated improved pit latrine (VIP)

2.6 VIP latrines

The escape of odours and flies through a squat hole may be greatly reduced by providing a vertical vent from the pit (hence, Ventilated Improved Pit Latrine). Vents may be made from PVC, asbestos, cement, mud and split bamboo or built into the latrine superstructure. For maximum effect, flyproof netting should be fixed across the top of the vent and it should extend about 500 mm above flat or sloping roofs or to the apex of conical roofs to benefit from a draught passing across the pipe (Ryan and Mara, 1983). A VIP latrine is illustrated in Figure 5.

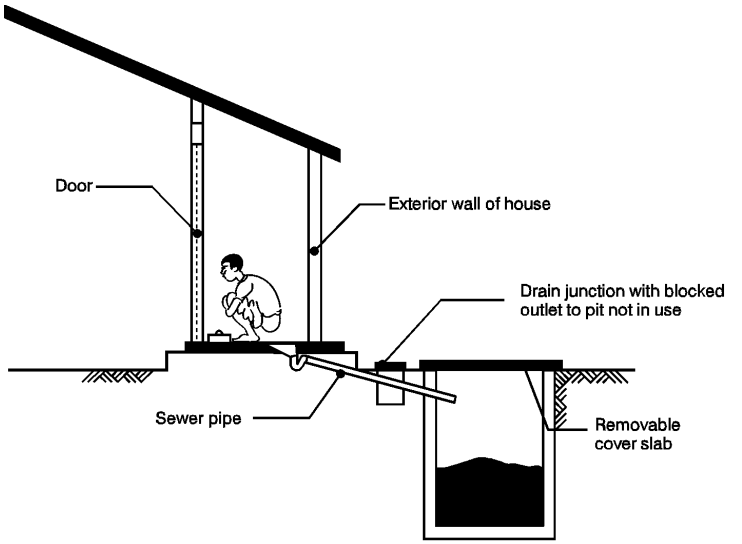
Fieldwork in Botswana and Zimbabwe indicated that the incidence of wind blowing across the top of the vent and into the latrine shelter was more important than the earlier idea that the pipe should be on the sunny side of the building and should be painted black, if not naturally black (pipe heating causes the air to rise and allows odours to escape).

Flies that hatch in the pit try to reach a source of light. If the superstructure is sufficiently dark the flies move towards the vent top (Curtis and Hawkins, 1982), are trapped by the flyproof netting and eventually die. The effectiveness of VIP latrines was demonstrated in Zimbabwe, where four pit latrines, two with vent pipes, two without were used equally for six months. 13,953 flies were trapped in the unvented pits, but only 146 in the vented ones during the subsequent two and a half month period (Morgan, 1977).

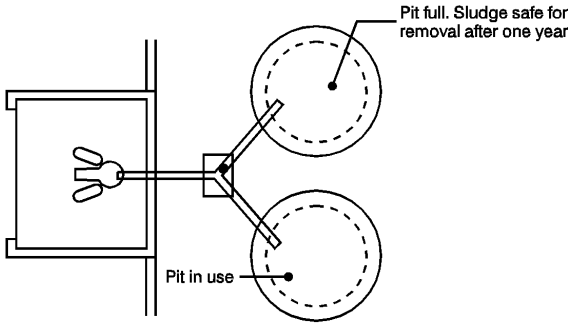
However, little consideration has been given to the urban context of latrines in which other buildings allow neither wind nor sunshine to reach the vent pipe. In particular, the effectiveness of ventilation pipes which do not protrude well above roof level in densely populated areas where local wind speed and direction is governed by the height and location of neighbouring buildings is unknown.

2.7 Pit size, single and double pits

Large pits have many advantages. Experience in East Africa (Duquehin, 1978 and Railton, 1978) showed that if pits are deeper than four metres they never fill up. A survey in Dar-es-Salaam (Harris et al, 1981) measured many pits which had served their households for more than twenty years and were still in use with no nuisance from smell or flies. As part of an upgrading scheme for urban areas in Malawi (Brandberg, 1988) the volume of pits was increased to one cubic metre per user. The lifetime of the pit was estimated to be between thirty and fifty years.



SECTION



PLAN

The toilet can be part of the dwelling, with the pit external

Figure 6: A pour flush double pit latrine

Pit latrines may have a double pit with each pit being used alternately. When one section is full it is 'rested' for two years, while the other section is in operation (see Figure 6). This resting period is long enough for all pathogens, including roundworm, to die. At the end of this period the accumulated solids can be safely removed.

VIP latrine pits may be slightly offset, with the vents and removable slabs located outside the buildings. Pits with a removable slab lining facilitate the pit emptying process. Latrines similar to the VIP have been constructed with pits completely outside of the latrine shelter. Chutes direct excreta to the pits from seats or squatting slabs inside the superstructure. Known as ROEC, latrines of this type were constructed in southern Africa in the late 1970s, but are no longer popular as the chute becomes fouled, attracting flies.

With pour-flush latrines two quite separate pits can be built. In a Y-junction the flow from the pan can be directed into either pit. One of the twin pits (or one chamber of a double pit) is used continuously for two or three years during which it fills to within half a metre or so of the top. Then the other pit or chamber is used for the same period. Whilst the possibility of using the decomposed contents as a fertilizer is frequently stated, it is important to note that this will not necessarily be an option for householders in urban areas. In fact, disposal of the contents often present problems.

However, in Kurunegela, Sri Lanka some householders failed to use twin pits properly (Cotton and Franceys, 1987) and there is anecdotal evidence from both Africa and Asia of poor operation. Frequently, both pits are used together and fresh solids are removed from both pits with attendant health hazards. Hoque et al (1994) reports on a survey of 214 households in Dhaka using double alternating twin pit latrines. Despite on-going health education programmes, 74 per cent of all families reported using only one pit, indicating that the routine of alternating pits was neither acceptable nor convenient to users in this context.

2.8 Solids accumulation and pit emptying

Pits gradually fill with accumulated solids and with liquid if the soil is not sufficiently permeable. Although little reliable information about solids accumulation is available, field observations near Calcutta in the Gangetic plain with high groundwater found that the rate of accumulation decreases with time (Adhya

and Saha, 1986). This study has reassessed their data, giving a best-fit curve with the following equation:

$A = 150 + 6y$, where A is the long-term accumulation in litres per person after y years, with y greater than two.

In a UNDP sanitation programme in Jakarta small pits (about 1000 litre volume) required repeated emptying within 300 days of being desludged once. This was assumed to be due to the clogging of the soil around the pit. Larger (4000 litre) pits did not experience the same problem (de Kruijiff, 1987)

Liquid in pits is derived from decomposition of faeces, urine, anal cleaning, latrine floor/pan cleaning, and sometimes from sullage tipped in the latrine. There are contrary views about whether sullage should be disposed of in pit latrines. Morgan (1989) and Feacham et al (1989) both advocate sullage disposal as an aid to promoting waste digestion. However, Harpham et al (1988) contrasts this view with studies taken from Addis Ababa. The percolation rate of liquid from the pit depends on soil conditions and the groundwater level relative to the liquid level in the pit.

Pits should be rested when they are filled to within half a metre of the top. If there is sufficient space on the plot a second pit may be dug. When full the first pit is topped up with soil and abandoned. A banana or other tree planted there grows well given the good supply of nutrients. In some places the floor slab and superstructure of the latrine are constructed in such a way that they can be moved to the new pit.

Alternatively a full pit may be emptied. Manual emptying of a recently filled pit is hazardous as the material may carry live pathogens. Emptying with a vacuum tanker (as used for septic tanks or street gullies) removes liquid, and some accumulated solids may be lifted by water jetting or agitation with the end of the suction hose. However, ordinary vacuum tankers are not powerful enough to completely empty pits. Carroll (1985) reports the use of tankers specifically designed for pit emptying, but they have been found to be expensive and cannot gain access to congested urban areas. Smaller, cheaper, slower and more manoeuvrable tankers have been developed (Coffey, 1988; Rijnsburger, 1991).

In Dar es Salaam, the Manual Pit Emptying Technology (MAPET) service has contributed to the improvement of environmental sanitaton in uplanned areas through effective and hygienic pit emptying services. The main components to

the service are the high manoeuverability of tankers in unplanned areas (handcarts are a maximum of 800mm in width), responsiveness to the demands and needs of residents, the creation of self-employment opportunities, and hygiene improvements to the working conditions of pit emptiers. The project was introduced in 1988 with seven teams in operation. In 1992, it was still running independently with five operational emptying teams (Muller & Rijnsburger, 1992)

In most places some of the problems of pit filling are overcome either by having very big pits or using alternating twin pits. Characteristically, twin pits are quite shallow (1.5 metres is usual), and are suitable on sites with groundwater or hard rock at shallow depth. With very shallow groundwater or rock the depth of excavation can be further reduced by raising the floor above ground level. The technique of allowing the full pit to 'rest' for about 2 years usually means that the contents can be manually dug out without presenting any significant health hazards.

2.9 Groundwater pollution

Liquid percolating into the soil from latrine pits contains large numbers of micro-organisms of faecal origin (including pathogens), nitrates and other salts. Therefore, groundwater under or near to pits may become polluted which may be a serious problem when it affects the quality of drinking water drawn from wells and boreholes. Water in leaky water pipes may also be contaminated if the pressure drops and polluted groundwater levels are above the pipes.

The literature on groundwater pollution has been thoroughly reviewed (Lewis et al, 1982). The key finding was that if there is two metres or so of sand or loam between the bottom of a pit or drainfield and the groundwater, virtually all bacteria, viruses and other faecal organisms are removed. Given the fact that in the soil above the groundwater there is little lateral movement of liquid, water may be safely abstracted from a well or borehole a few metres away from a latrine. This rule only applies where the groundwater level is lower than two metres below the bottom of the pit or drainfield *throughout the year*.

Wegelin-Schuringa (1991) suggest that wells can be safely sited within eight metres of the pit or drainfield if the soil is fine. In a two year study by Baskaran (1980) in West Bengal bacterial pollution of water samples from a pit latrine was found not to extend beyond three metres; 5-day BOD less than 1.5 metres; and at 4.5 metres, chemical pollution could not be distinguished from groundwater.

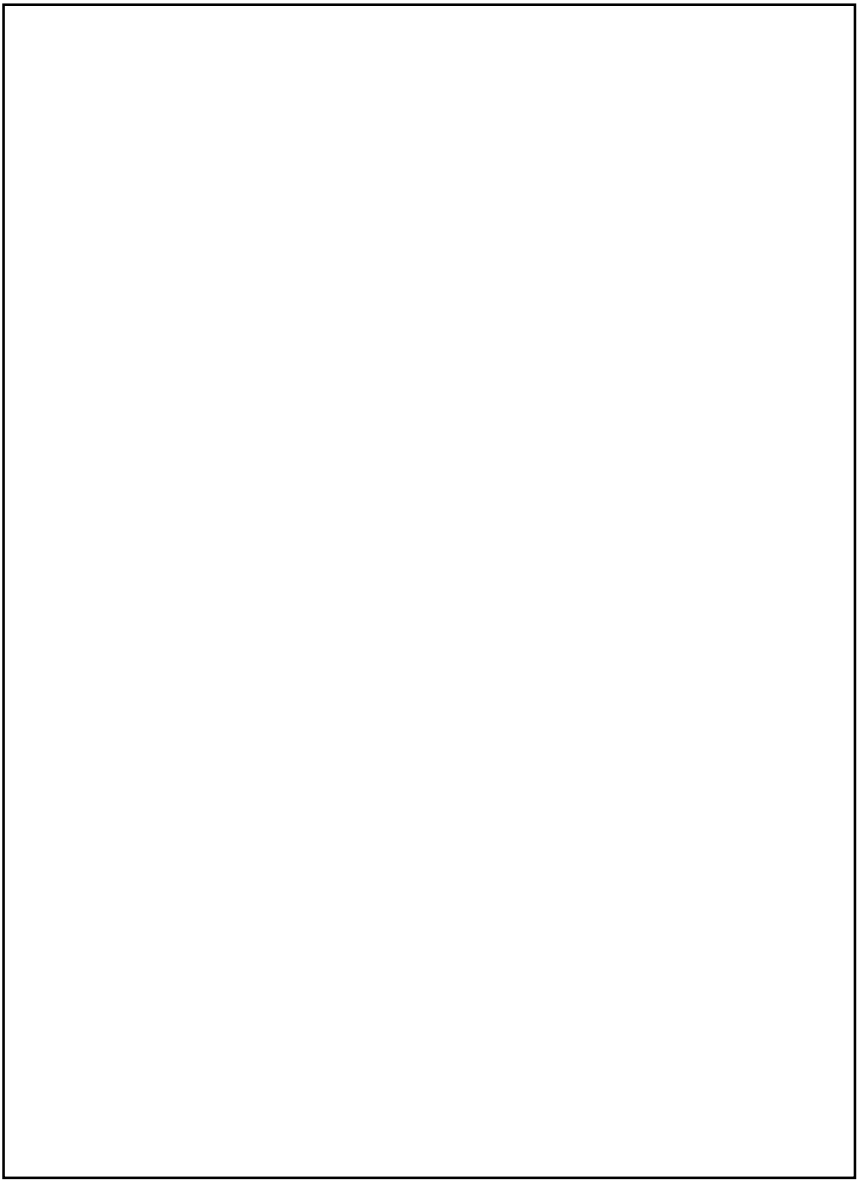
Chemical pollution extends much further than pollution by micro-organisms. With high pit latrine and septic tank densities, nitrate concentrations may build up to levels in excess of those recommended in WHO drinking water guidelines. The main health hazard from such concentrations is 'blue baby disease' if milk powder mixed with this water is fed to very young infants, and stomach cancer (although the evidence here is conflicting).

In some places overloading of soakpits can lead to a rise of groundwater with resultant overflowing, as in Teheran (UNCHS, 1980) and Riyadh (Pickford and Franceys, 1989). A particular problem in densely populated urban areas is the possible proximity of latrine pits and shallow wells on neighbouring plots. Whilst levels of service for water supply remain poor, many urban dwellers are likely to use a nearby shallow well if the groundwater table is sufficiently high. The lack of effective urban development planning control means that it is very difficult to regulate and enforce the relative location of latrines and wells on plots, even in formally developed areas.

2.10 Small plots and high-density population

Critics of pit latrines often claim that they are unsuitable for small plots in urban areas. In Jamaica, regulations prohibited pit latrine construction in areas where the density was higher than ten houses per acre (23 houses per hectare); in Indonesia, regulations state that areas with over 250 persons per hectare shall be classified as densely populated and shall not use on-plot excreta disposal (Alaerts and others, 1991). In a manual prepared for *Habitat* it is stated that the pit latrine system (except for VIPs) is 'unsuitable for use in even low density urban developments' (Roberts, 1987). The smallest plot size recommended for twin-pit pourflush latrines in India is 26 square metres (Ribeiro, 1985). None of the criteria used appear to be based on reasoned argument nor on evidence of performance.

Sinha and Ghosh (1990) surveyed 3,264 households in Bihar that had failed to convert dry latrines to pour-flush pits although funds were available for conversion. Only 0.9 per cent of respondents gave 'lack of space' as the reason for not taking advantage of the scheme.



Photograph 2: Improper siting and construction of VIP vent pipes can significantly reduce the effectiveness of this type of latrine

3. Health and Social Matters

3.1 Key points

- It is often difficult to prove direct cause-effect relationships between specific sanitation interventions and improvements in health, although several studies show positive indications.

- Low income people are rarely convinced of the benefits of sanitation by health statistics; status, convenience and privacy are all important perceived benefits of on-plot sanitation.

- Traditional latrines may be unsatisfactory, but careful attention should be paid to them as they reflect cultural and social preferences and a willingness to invest.

- A lack of attention to the ideas and perceptions of users in planning and implementation is unlikely to result in long term use of latrines.

- Limited surveys of latrine use and condition indicate a wide variety of problems linked to operation and maintenance which discourage their use.

3.2 Introduction

'. . . it is easier to change technology than to change behaviour, and it is more difficult to determine cultural acceptability than technical feasibility' (Elmendorf and Buckles, 1980).

It is often difficult to prove that latrines are beneficial to health. Positive evidence comes from a study of mortality among 2,500 infants in Bangladesh (Raman and others, 1985). Mortality amongst infants over 4 weeks old was 3.12 times higher in households not using latrines, compared with those who did use latrines. Silva & Athukorala (1991) showed that in four similar low income communities in Sri Lanka the only community in which people defecated in the open corresponded with the community with the highest incidence of diarrhoea.

As communities become larger, open defecation becomes more of a nuisance. In one year the police commissioner of Calcutta prosecuted one hundred and forty thousand people for 'creating a nuisance in a public place' (Pathak, 1985).

A survey was undertaken in five Nepalese urban centres to discover why people had built latrines outside the government subsidized programme. Only 28 per cent gave health as a reason; 43 per cent gave prestige, comfort, privacy or a combination of these (UNCHS, 1986).

A full discussion of the health implications of sanitation can be found in Cairncross & Feachem (1993). In general, it is difficult to disaggregate specific causes and effects. The combination of measures to improve personal and domestic hygiene, and the provision of adequate water supplies and safe excreta disposal lead to health benefits.

Maxwell and Curtis (1990) report that before a campaign to control mosquitoes was introduced in Zanzibar, Tanzania, it was estimated that each person in the town of Makunduchi received about twenty five thousand bites per year. Most of the mosquitoes bred in wet pit latrines. Half the population was infected with filariasis.

Low income urban people are seldom convinced by health statistics. Some like the status of having a latrine of their own (Franceys, 1988; UNCHS, 1986). For most the convenience of avoiding a long walk in driving rain on a dark night when suffering from diarrhoea is argument enough for having a household latrine. A good, well-built and well-maintained latrine can serve the family for as long as their house remains.

Existing, traditional latrines, even though unsatisfactory in many respects do reflect local sociological and cultural preferences and represent an investment by the people who built them. It may be possible to upgrade them to improve safety and hygiene (Wegelin-Schuringa, 1991). For example, Larbi (1990) reports that in Botswana the cost of a concrete slab, vent pipe, flyproof vent screen and squatting pan was one-seventh the cost of a new BOTVIP (the local name for VIP latrines).

3.3 Latrine use

'A number of projects report that latrine construction is easier to achieve than latrine use' (Burgers, Boot & Wijk-Sijbesma, 1988).

There is widespread evidence of the importance of involving householders in the planning and construction of latrines to ensure satisfactory maintenance. People's preferences should always be taken into account, even if these preferences refer to details which outsiders may consider irrelevant. Gibbs (1984) in a Bangladesh survey of latrines and people's perceptions found that the quality of the superstructure was more important than the type of technology used. Latrines were used more frequently (especially by adult women) if the superstructure was good and provided privacy. By contrast, children were typically unconcerned by privacy, defecating in the open where there was no fear of the dark or falling down the hole.

In Maputo, Mozambique, the quality of the superstructure was not significant from the user's point of view as long as there was privacy. It has been suggested that because people were used to defecating in the open air, either in the rural areas before moving to the city or on waste ground in the city before the latrine programme, they found the simple outdoor style a more acceptable superstructure than the 'tightly enclosed box' found in traditional designs (Brandberg, personal communication).

Cotton (1993) reports that in Cuttack, India the crucial factor affecting latrine use was the privacy afforded, particularly for women. A simple low cost latrine superstructure design is therefore an essential part of any sanitation package.
The importance of cultural behaviour and perception in latrine use was amply demonstrated in Kumasi, Ghana, when it was agreed to provide pit latrines after several master plans for sewerage were abandoned. The householder of the first

demonstration unit refused to use the latrine because he was a Moslem and the latrine faced the direction of Mecca (Kotalova, 1984).

The need for locating a latrine so that people can enter without being seen has been noted in some cultures in developing countries (Burgers et al, 1988). In some societies, it is acceptable to be seen going to have a bath (Morgan, 1990). Many people in Dar es Salaam like to take a bucket of water to the latrine and bath after defecation.

In the Baldia Soakpit project (Karachi) leaflets giving instructions about the use and maintenance of latrines were prepared. It was then realized that most women could not read. So some women with high school education were found and adult literacy classes were established. In 1987, a consultant surveyed pit latrines constructed in Baldia. For almost all the pits recorded as 'not in use', either the latrine outflow had been redirected to the street's open drain or an overflow from the pit discharged to the open drain (Bakhteari & Wegelin-Schuringa, 1992).

3.4 Nuisance

Smell is frequently cited as a nuisance. In Juba, Sudan, nearly half the pit latrine owners said 'smell' was their chief complaint (Nichols, 1982).

Harris et al (1981) reassessed a 1978 survey of 353 households with latrines in Dar es Salaam. Latrines were classed as satisfactory or unsatisfactory on the basis of cleanliness and freedom from unpleasant smells, mosquitoes and other insects. The poorest conditions were found when the owner did not live in the house and, surprisingly, when households had piped water connections. Latrines in the most satisfactory condition were recorded when excreta in the pit was more than 2 metres deep, and when latrines were cleaned by a male owner.

A more recent survey was carried out in India, with 100 households in Bihar and 149 households in Rajasthan. All had pour-flush latrines (Sinha and Ghosh, 1990). 7 per cent did not use their latrines because they were blocked, 8 per cent because the pits were full and had not been cleared, 2 per cent because of water shortage, 12 per cent because the latrine lacked a superstructure and 4 per cent because of poor latrine location. A further 23 per cent experienced problems such as overflowing, blockage or damaged pits. Of the latrines in use 37 per cent were cleaned less than once a week.

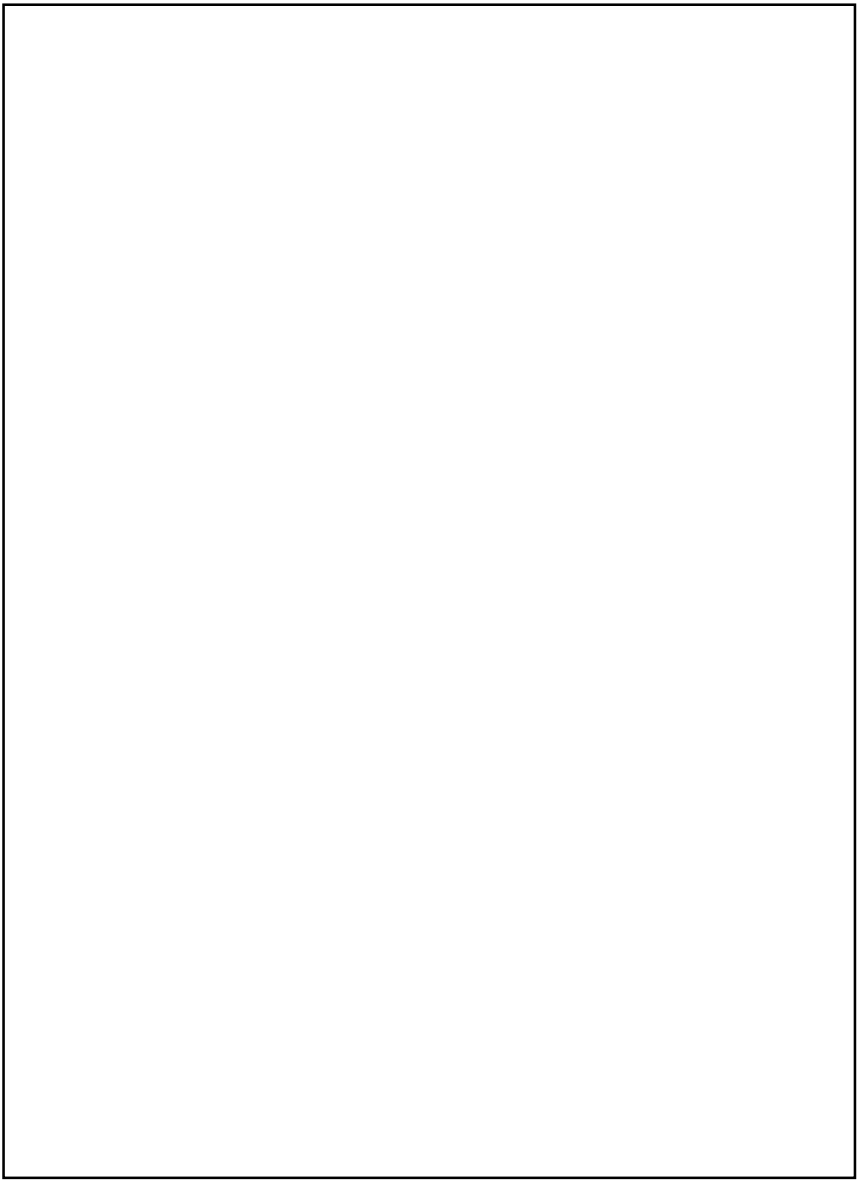
In a similar survey in unsewered parts of Cairo in the early 1980s it was found that the usual practice was to construct vaults that were emptied manually into tanks mounted on donkey carts. If sullage was put in the vault the proportion of satisfactory vaults was about twice that of vaults to which sullage was not added. 'Satisfactory' was assessed in terms of absence of smell, flies and mosquitoes. Large capacity vaults (measured as volume per user) were better than smaller vaults as regards smell, but the size of the vault made little difference to flies or mosquitoes. Offset vaults were better than vaults under the latrine in respect of smell, flies and mosquitoes.

3.5 Children and latrines

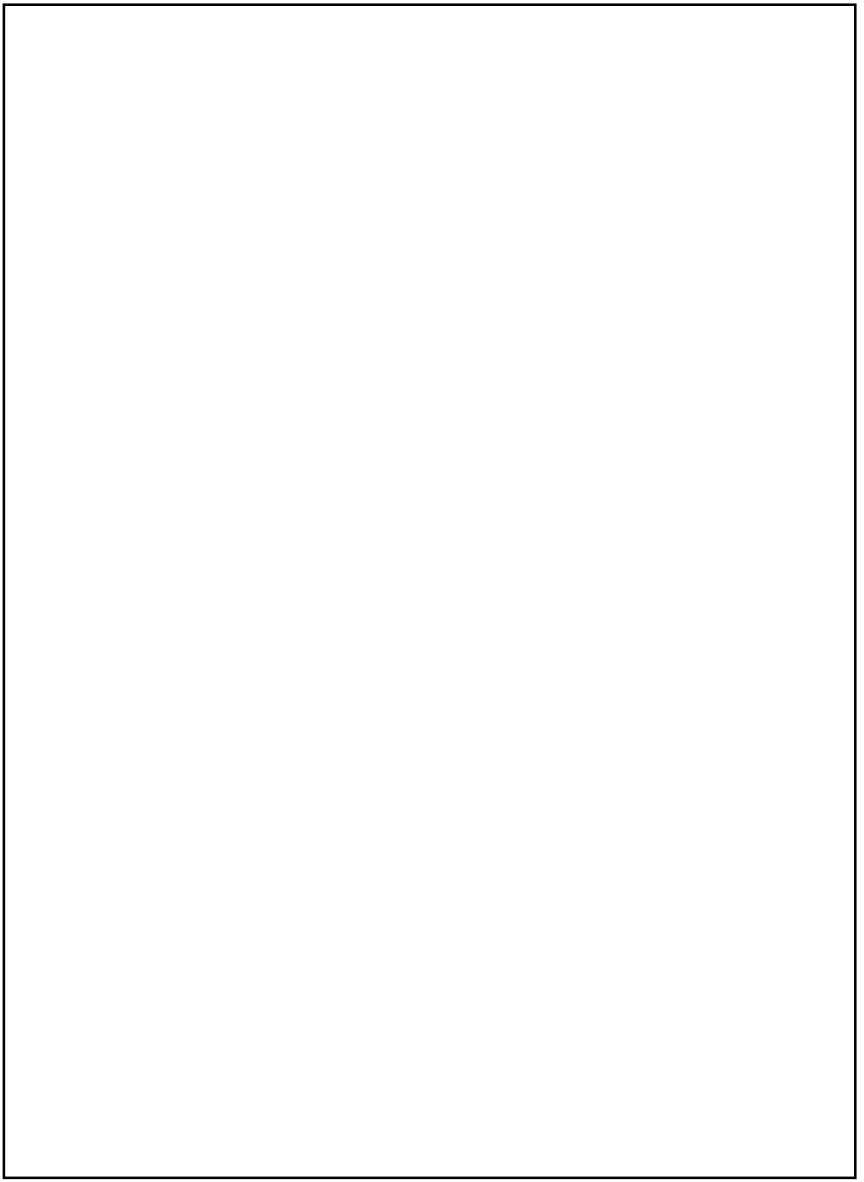
A WHO Expert Committee (WHO, 1951) noted that when insanitary latrines are found in schools children acquire poor hygiene habits which may be difficult to break. Similarly, well-built and operated pit latrines may be far safer and of greater fundamental value than a porcelain and tile WC which is allowed to become dirty and a nuisance.

A slum upgrading scheme surveyed in Madras, India, included separate children's latrines. The superstructure consisted of a wall about 600 mm high - high enough to give some privacy but low enough for a mother to lean over and attend to a small child. Where a children's latrine has a seat and a child is too short to reach it, a concrete block or stone can be put near the seat to put feet on (Mathebula, 1987).

Schoolchildren in Kenya mentioned the following fears when using latrines (UNCHS, 1986c): 86 per cent mentioned snakes and other animals, 56 per cent mentioned falling into the pit, 48 per cent mentioned smells, filth and insects, 35 per cent mentioned black magic and 14 per cent were afraid of being left alone.



Photograph 3: The thin, circular dome-shaped slab has a removable lid cast in the squat hole to ensure that it fits tightly. Odour and insects cannot escape from the pit when the lid is placed over the squat hole



Photograph 4: Cement screed VIP latrine, Harare, Zimbabwe

4. Management Matters

4.1 Key points

- Responsibility for construction, operation and maintenance usually rests with the owner or occupier of the plot.

- The proportion of urban households worldwide served by on-plot sanitation is increasing.

- Urban government has a crucial role to play in ensuring that its actions and regulations facilitate the use of on-plot sanitation.

- The adoption of a standard type of latrine by urban government in Ghana has impeded programme implementation because of the high unit cost.

- The total annual cost per household incorporates capital, operation and maintenance costs and is a useful cost indicator intra-nationally. International cost comparisons cannot realistically be made.

- A major survey in Kumasi, Ghana, revealed that willingness to pay is significantly affected by: income level; tenure status; existence of piped water supply; existing level of payment for sanitation services; and dissatisfaction with existing sanitary arrangements. Educational, socio-logical and cultural variations were not found to have a signifiacnt impact.

- In densely populated areas, for example in parts of Calcutta, latrines shared by several plots, with a clearly defined group of users, operate successfully.

- Communal latrines having unrestricted access are rarely maintained sufficiently well to give user satisfaction, unless urban governments or in a few cases non-public sector groups operate them satisfactorily.

4.2 Management and bureaucracy

On-plot sanitation is usually the responsibility of those who live or work on the plot, in this case the owner or occupier of the house (the 'householder'). Many latrine programmes which depend on central agency financial inputs do not receive the levels of political and financial backing needed to serve sizeable proportions of the urban poor (Harpham et al, 1988). Other than providing cash, governments and other agencies can support on-plot sanitation programmes through:

- 'motivation' - encouraging householders to construct latrines - often in conjunction with a health education programme;
- technical support through advice, training, preparation of leaflets and supervision of construction;
- resolving legal problems, including lack of land tenure in informal areas and inappropriate building regulations;
- making scarce materials available - cement, reinforcing steel and fly-proof netting are often difficult to obtain in the market; and
- prefabricating components such as slabs, pans and water seal traps.

Either independently, or in association with an external agency, a community may manage an on-plot sanitation programme, undertaking some of the activities listed above. For example, this may involve community organization and control of a revolving fund, using self-generated cash or a grant obtained from an NGO or external donor. It may also include a small community working together to dig pits for each member in turn.

The success of latrine programmes may be jeopardised by a bureaucracy applying too much persuasion. In Malawi prior to Independence, government officials ordered householders to dig latrines with the result that it became a sign of political integrity *not* to have a latrine. Lohani & Guhr (1985) report that in the Bhaktapur project, Nepalese householders 'choice' of latrine type was in fact limited because local conditions and subsidies favoured only the twin pit pour-flush variety.

Many politicians, administrators and engineers are ready to discount the value of pit latrines in favour of more 'modern systems'. Yet even in the 1970s, before the Water Decade promoted widespread consideration of options for sanitation other than conventional sewerage, the proportion of households being served

by pit latrines was steadily increasing. For example, the percentage of the urban population in Zambia served by various systems was as follows (Iwugo et al, 1978b).

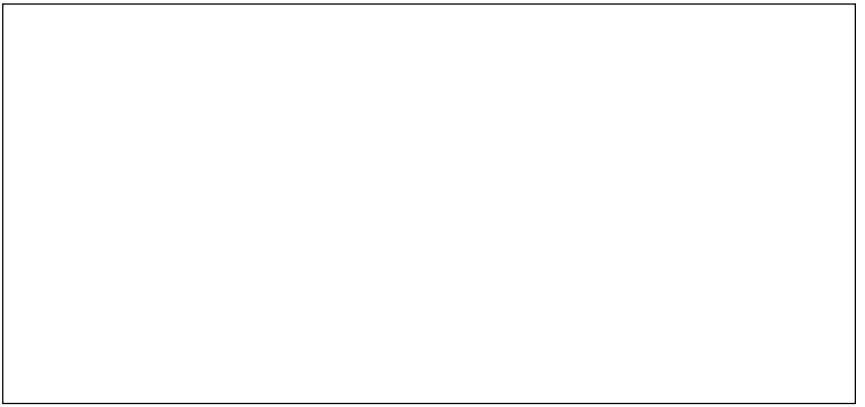


Table 1: Urban population in Zambia served by various types of sanitation system

The number of latrines in Mozambique increased twenty-fold between 1970 and 1984. Although Maputo city council provided 7,200 latrines free of charge in selected areas of their city, the programme was of limited success because of the latrine's short life span (three years) and because free issue did nothing to encourage latrine construction (Brandberg, 1983). More success was achieved through the formation of twelve co-operatives, each with eight trained people making a hundred slabs a month. Each slab had a life-long guarantee and bore the maker's signature, so that defective slabs could be identified and the maker retrained or boycotted.

A large *katchi abadi* in Karachi is Baldia, where under a 'soakpit' programme various types of pour-flush pit latrines were built. Between 1979 and 1985 the cost of 1,065 demonstration latrines was covered by UNICEF and other agencies. By 1985 about 14,000 households had soakpit latrines, with a ratio of total-to-demonstration latrines of 1:13 (Pasha and McGarry, 1989).

There is now a strong move towards a 'demand' or 'market driven' approach rather than the previously used 'supply' or 'product driven' approach of public works. This is largely in response to policy directives from major international institutions such as the World Bank and the IMF which perceive the inefficiency of a burgeoning public sector to be counter-productive to overall economic

development and restructuring (Fox, UMP paper No. ?, 1994). Alternatively, Raj (1991) suggests that this may be due to the government employee's greater job security, lack of incentive system, inflexible use of staff and lack of linkage between productivity and salaries. However, increasing private sector involvement may bring with it attendant unemployment, reductions in staff welfare and the neglect of unprofitable but socially desirable activities.

One approach is the creation of financially autonomous agencies for water supply and sanitation, as seen in Brazil and Tunisia (UNCHS, 1989). In practice, however, this financial autonomy is of limited value because any deficits are automatically paid by the state or national government. In other cases, there is enormous political pressure against proposed tariff increases.

4.3 Costs

A characteristic of appropriate on-plot sanitation systems is that most of the costs are for local material or labour. Imported supplies and equipment may have a range of prices, from low 'official' rates to ten or twenty times as much on the open market. Similarly, official conversion rates between local and 'hard' currency may be unrealistic. Consequently, attempts to give an international cost of different types of sanitation are of very limited value. To eliminate inter-country variations, financial statistics are often expressed in United States dollars, but this does not overcome the problems caused by the distortion of unrealistic exchange rates and date-specific costs. In addition, rates of inflation vary not only with time but also between different countries during the same period. Even allowing for shadow pricing, the costs of similar services show great variation. For example, the annual cost of providing a bucket latrine service in Kumasi, Ghana, in 1978 was four and a quarter times as much as in Ibadan, Nigeria, in the same year (Feachem et al, 1978).

The high cost of KVIP's in Ghana (where they were first introduced) has seriously impeded the implementation of urban sanitation programmes (Brown, 1985). Although both the government and the Ghana Water and Sewerage Corporation have adopted the KVIP as the 'approved' type of on-plot sanitation there has been a comparatively low rate of construction because of high costs. In Kumasi, conversion costs from a bucket latrine to KVIP were 60 per cent of the cost of a new KVIP. The savings made by sharing latrines can be seen from 1989 estimates which assumed that eight households would share one seat or squat hole (Whittington et al, 1992).

Table 2: Estimates of cost savings per household by sharing KVIP's

Comparison of the cost of conventional septic tanks and sewerage for houses that already have internal piped water supply in Malaysia showed that septic tanks dealing with all household wastewater are cheaper unless the population density is more than 150-180 persons per hectare. If a septic tank and soakaway only deal with WC wastes and sullage goes to roadside drains, sewerage only becomes cost-effective when population density exceeds about 350 people per hectare (Bradley, 1983).

In rehabilitation camps (for refugees) in Bangladesh a few latrines of various types were built for comparison. Costs compared with a simple pit lined with concrete rings and with a bamboo floor were as follows (Williams, no date):

Simple pit latrine	1.00
Ventilated improved pit latrine	1.28
Waterseal latrine	1.39
2-family aqua-privy	1.48
5-family aqua-privy	1.61
Double vault compost latrine	3.14

Somewhat similar comparisons were made from a comparison of alternative systems in Botswana in the late 1970s (Bellard, 1981), giving the following:

VIP latrine	1.00
ROEC	1.59
Double-pit latrine	1.59
Aqua-privy	2.46

The single most useful figure for comparing sanitation costs is the *total annual cost per household* (TACH). This includes capital (or investment) costs and recurrent costs adjusted to reflect real opportunity costs and averaged over time. Based on 1978 costs, a World Bank study (Kalbermatten et al, 1982a) found the proportion of the TACH to be as shown below in columns A and B. The financial requirements for different types of sanitation were expressed as a percentage of the income of an average low-income household, as shown in column C.

Although these figures have been used widely, their value is limited because of the limited number of observations, subsequent price increases in materials after 1978, and incorrect interest rate assumptions.

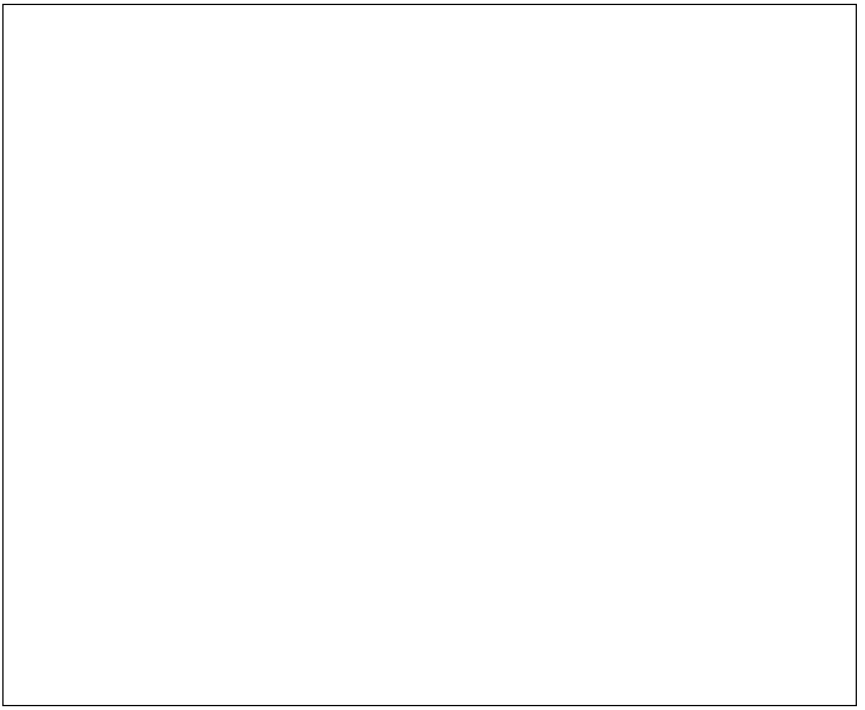


Table 3: Financial requirements for different types of sanitation system

The total cost of twin-pit VIP latrines in Lesotho was found to be almost the same as single pits over a twenty year period. This is because removal and disposal of sludge from single pits is more expensive. It also brings greater health hazards (Read, 1980). The break-down of the costs was as follows:

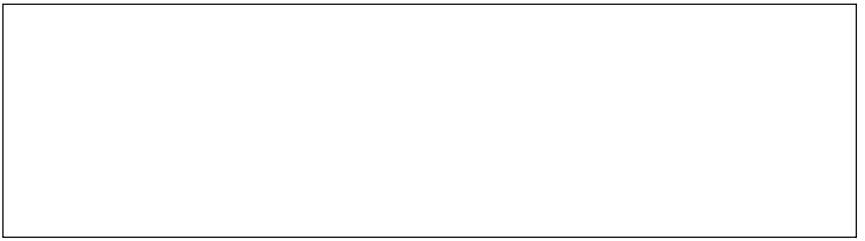


Table 4: Comparison of costs for single/twin pit latrines in Lesotho over 20 year period

4.4 Payment by householders, willingness to pay and cost recovery

Roy (1981) reports that the charges made to householders in India was based on household connection to electricity, piped water and ownership of a household latrine. If a household possessed two or three of these elements, the householders' share of conversion costs to a pour-flush pit latrine was by 100 per cent loan. If the household had one, 50 per cent loan, 50 per cent grant; if none, 25 per cent loan, 75 per cent grant.

Willingness to pay depends on other factors than the value householders place on sanitation. Tenure is critical. In Lima, Peru, it was found that with householders of similar socio-economic status those with tenure were willing to spend on average nine times as much on their dwelling as were those who had no tenurial rights (Soto, 1989).

In the 'willingness to pay' survey before the Kumasi Sanitation Project started (Whittington et al, 1992) the monthly sum householders would pay was almost the same for KVIPs ($1.47) as for WCs ($1.43) where there was already a water connection. The amount people were willing to pay for sanitation was affected by:

- Income: those with higher incomes were prepared to pay more;
- Tenure: owners were prepared to pay more than tenants;
- Those with piped water supplies would pay more;
- Those already paying a high sum for sanitation would pay more;
- Those most dissatisfied with existing sanitation would pay more; and
- Those living in single-storey houses would pay more for KVIPs than those in multi-storey apartments.

The study did not reveal any effects of the educational level, sociological and cultural variations on willingness to pay. The lack of willingness to pay for household latrines was crucially affected by cash-flow problems; for example, public latrines require only a daily payment, whereas monthly payments would be required for a household latrine. Identifiable household assets used in a household survey in Kumasi were radios, fans, sewing machines, cassette players, refrigerators and motorcycles (Whittington et al, 1992).

The subsidy (actual cost less 'willingness to pay') required in Kumasi was about one third of the cost of a new KVIP, based on three year repayment with 30 per

cent interest charges (Whittington et al, 1992). If repayment was made over twenty years with 10 per cent interest charges (the norm for public works) no subsidy would be required. For sewerage the required subsidy would be 80 per cent of the cost.

In Tegucigalpa (Honduras) loans up to $200 per family repayable in three years are offered to the urban poor through the Co-operative Housing Foundation and UNICEF. Although interest rates are high (17 per cent per year) and the Ministry of Health has a long standing policy of providing a free service, many people took up the option and built a sanitation unit with water tank, wash-board, shower and latrine (Aasen and Macrae, 1992).

Problems that hinder the establishment of full revenue recovery within organizations include:

- Political opposition to raising taxes and tariffs to appropriate levels;
- Deficiencies in the legal mandate to impose charges;
- Inefficient billing and collection procedures;
- Delayed or delinquent payments; and
- A general lack of civil compliance (UNCHS, 1989).

4.5 Public and community latrines

A brief survey of public and communal latrines is included because they are often the only existing form of sanitation in low income urban areas. Communal latrines as an alternative to household latrines in congested areas are rarely satisfactory. Wagner and Lanoix (1958) reported that 'in most instances communal latrines, irrespective of the type of design, proved to be failures'. With notable exceptions communal latrines are unpopular. In 1990, 71 per cent of those who used public latrines in Kumasi, Ghana, were not satisfied with them (Whittington et al, 1991).

It has been suggested that the two most important reasons for unsatisfactory communal latrines are cleanliness and lighting (Marais, 1973). When a communal latrine is fouled, subsequent users inevitably add to the fouling problem. Misuse is probable if adequate lighting is not provided at night in the latrine structure.

A 1988 study of a Madras slum-upgrading project that included construction of

latrines found that in one upgraded slum four out of the seven communal latrines built in 1980 were permanently out of order. As a result, 30 per cent of the slum population had again resorted to open defecation (Dewit and Schenk, 1989).

Overuse of public latrines is a common problem which is often made worse because authorities are disinclined to build more if the existing facilities already have a bad reputation. In Manila, a 1970s study found that one latrine which was originally intended for 200 people (four seats for women and four for men), was being used by 3,000 people daily (Ilustre, 1980).

More successful were the aqua-privy communal latrines built in Calcutta during the 1970s. Each had single chambers built for use by both men and women, and were planned at a rate of one for every 25 people (Maitra, 1978). The latrines were conveniently located within small groups of users, who were responsible for their cleanliness, an arrangement which proved to work on the evidence of unexpected inspections. The key issue seems to be the identification of a defined user group.

In Indonesia the 'Kampong' head makes a list of people selected by their families to clean and maintain the MCK during the next week (MCK: 'mandi' = bathing; 'cuci' = cleaning and 'kakus' = toilet). The Kampong head assesses the quality of the work. Families who participate can use the MCK free of charge. Money is collected from all families for desludging the septic tank.

In 1990 there were about 400 communal latrines scattered throughout Kumasi, used by about 40 per cent of households. All city centre public latrines and roughly half of the communal latrines elsewhere charged adults US$ 0.015 per visit. Children and the elderly are admitted free (Whittington et al, 1991). In 1992 the charge was 5 cedis (more or less US$ 0.015) for the old pan latrines, but was 10 cedis for better-kept KVIPs, and 20 cedis for new latrines with WCs. Fee collection is made at a ticket booth with an attendant who collects the money and gives each person a piece of newspaper for anal cleaning. A typical family in Kumasi relying on public latrines in 1990 paid about the same monthly amount for rent (US$ 1.51), water (US$ 1.26), sanitation (US$ 1.14) and electricity (US$ 1.63).

Operation by private sector contractors is often seen as a potential solution. An example are the latrines run by Sulabh International in India for the Patna Municipal Corporation near Gandhi Maidan in 1978, where operation and main-

tenance was covered by a pay-and-use contract. The Council covered water and electricity charges. The advantage of this system is that the contractor knows that his income from users will drop if the standard of cleanliness falls. For example when the piped water supply to the contractor of latrines in Chittagong, Bangladesh failed, the contractor had to hire men to carry water from a far distant source in order to maintain his income from users (Gibbs, 1986).

In Cuttack, India, the municipality operates 35 public latrines near to low income areas. The operation costs are funded from local taxation; whilst they are very popular with the users, there are far too few to cater for the increasing population, and the corporation cannot commit itself to constructing additional units. Operation of some of the latrines was contracted out, but the contractors performance was so poor that the corporation took back operation (Cotton, 1993). Contractors were also unable to make community latrines work successfully in some low income areas in Vishakapatnam. People were unwilling to pay and resorted to open defecation.

In Lagos the charge made for public latrines in the mid-1980s was sufficient to cover the costs of the attendant, toilet paper, soap and water for hand washing, and cleaning materials. Operation and maintenance of latrines by contractors was tried, but was not successful (Lochery and Adu-Asah, no date).

Part C: Postal survey

Methodology

Questionnaire A
During May 1991, this questionnaire was sent to 39 contacts in developing countries. The questionnaire consisted of a single sheet asking whether respondents would participate in a research programme. It carried four annexes dealing with pit latrines, septic tanks, multi-compartment latrines and sewerage and sewage treatment costs. Thirteen forms were returned of which only five possessed completed Annexes (although all promised to provide further information or participate in surveys if required). Two were in effect nil returns.

Questionnaire B
A single sheet questionnaire was therefore devised and copies sent out from March 1992. Most of the addressees were those who have attended WEDC courses at Loughborough. The response was much more positive, including a few forms completed by those who had previously been sent *Questionnaire A*.

By mid-July 1992 some of the main issues to be addressed in the project were becoming clear. The questionnaire was therefore revised and expanded, with payment for latrines and latrines for children introduced as new topics. A new form (*Questionnaire B2*) was prepared and sent to new addressees in late July and early August 1992.

A selection was made of countries to be covered in further studies and other nations were rejected from further work because of poor questionnaire representation, high GNP levels or language difficulties.

At the same time a *supplementary questionnaire* was sent to those who had completed and returned *questionnaire B*. This covered those additional items that were included in *questionnaire B2* but which were omitted in *questionnaire B*.

Most of the respondents were engineers, although there were a fair number of health staff. Some were fully involved in low cost sanitation, but the largest group were 'generalists' holding appointments like district water manager. In any case, low cost sanitation is often `nobody's job' as it is primarily a householder's responsibility.

Information obtained from the postal survey

The following are some of the deductions from the returned *questionnaire B* and *questionnaire B2*. Very few of the responses are based on surveys undertaken recently. Most were general impressions, which although providing conclusions which may be imprecise, do at least indicate major problem areas. For further information, refer to the pie-charts in Appendix 1. A summary of survey responses is as follows.

a. 38 per cent of household sanitation is by simple pit latrines, 11 per cent by VIP latrines, 25 per cent of households are served by WCs with waste to septic tanks; 12 per cent by WCs discharging to sewerage systems and the remainder by other types of latrine.

b. The most frequently expressed reason for householders failing to have a latrine is that they cannot afford the cost. Plots being too small is of less importance (although this may become more significant with more complete information from Asia).

c. Some pits are emptied. Most emptying is by vacuum tanker, although in some places the most common method is manual - digging out the sludge.

d. Few septic tanks discharge their effluent to open drains; some are desludged regularly, usually by tanker operated by the local authority.

e. Most children use the same latrines as adults. For those that do not, three quarters defecate indiscrimately, the rest use special children's latrines.

f. Nearly one third of the householders pay all the cost of household latrines, although many replies reported that householders pay nothing. When householders contribute to the cost they use their own savings, a negligible number obtain loans.

g. The most common type of multi-compartment latrines are simple pits, WCs to septic tanks and VIP latrines.

h. Most communal and public latrines are open 24 hours in the day; most

are cleaned by attendants; a few have electric lighting; at few is there a charge for admission.

Some interesting comments were received in response to questions without multi-choice answers.

a. Most of the 'other reasons' that account for the lack of household latrines were variations on the theme that people cannot afford them.

b. In most places disposal of pit contents and septic tank sludge either presents problems to the authorities or is carried out in a haphazard way involving considerable public health risks. One respondent simply described what seems to be the most common practice when he said these solids are 'thrown away'. Dumping in streams was referred to by severalrespondents and is a particularly undesirable practice in view of the frequency of downstream abstraction and the use of stream water for bathing, laundry and playing.

c. The intention of the section on latrines for children was to discover why children old enough to defecate on their own are so often seen openly defecating, sometimes in the immediate precincts of public or communal latrines. Some useful replies were received, but many other respondents seemed to have missed the point and referred to mothers holding a child over a squat hole or pan to 'potty training'. One or two differences of use between boys and girls were reported ('girls' latrines are cleaner' and 'boys urinate anywhere'). At this stage there was no report of discrimination against girls in the provision of facilities.

d. A few places encouraged cheaper latrine construction, particularly the use of local material for the shelter.

e General comments about multi-compartment latrines were as expected - that they quickly became fouled unless cleaners/attendants are constantly available.

Part D: Conclusions

The following key points emerge from the review of literature concerning on-plot sanitation in urban areas:

1 **Technical issues**

- The main advantages of pit latrines are their relatively low cost, acceptance of different anal cleansing materials and under certain conditions their satisfactory long term use

- Odour and insects are a common nuisance in pit latrines which do not have a waterseal. Possible ways of reducing these include: placing a tight-fitting lid over the squat hole; provision of a ventilation pipe for the pit; placing polystyrene beads inside pits containing water

- Single large pits should be used wherever possible in order to minimize maintenance in terms of the frequency of emptying

- Double (or 'twin') pits facilitate emptying if single large pits are not feasible

- Groundwater pollution can result from percolation of the liquid from pits; most micro-organisms of faecal origin are removed if two metres of sand or loam separate the bottom of the pit from the groundwater table

- There is little reported evidence on hygienic methods for emptying pits and disposing of their contents

- Regulations which proscribe the use of on-plot sanitation on plots smaller than a specified size do not appear to be based on evidence of unsatisfactory performance

2 Health and social issues

- It is often difficult to prove direct cause-effect relationships between specific sanitation interventions and improvements in health, although several studies show positive indications.

- Low income people are rarely convinced of the benefits of sanitation

by health statistics; status, convenience and privacy are all important perceived benefits of on-plot sanitation.

- Traditional latrines may be unsatisfactory, but careful attention should be paid to them as they reflect cultural and social preferences and a willingness to invest.

- A lack of attention to the ideas and perceptions of users in planning and implementation is unlikely to result in long term use of latrines.

- Limited surveys of latrine use and condition indicate a wide variety of problems linked to operation and maintenance which discourage their use.

3 **Management issues**

- Responsibility for construction, operation and maintenance usually rests with the owner or occupier of the plot.

- The proportion of urban households worldwide served by on-plot sanitation is increasing.

- Urban government has a crucial role to play in ensuring that its actions and regulations facilitate the use of on-plot sanitation.

- The adoption of a standard type of latrine by urban government in Ghana has impeded programme implementation because of the high unit cost.

- The total annual cost per household incorporates capital, operation and maintenance costs and is a useful cost indicator intra-nationally. International cost comparisons cannot realistically be made.

- A major survey in Kumasi, Ghana, revealed that willingness to pay is significantly affected by: income level; tenure status; existence of piped water supply; existing level of payment for sanitation services; and dissatisfaction with existing sanitary arrangements. Educational, socio logical and cultural variations were not found to have a major impact.

- In densely populated areas, for example in parts of Calcutta, latrines

shared by several plots, with a clearly defined group of users, operate successfully.

- Communal latrines having unrestricted access are rarely maintained sufficiently well to give user satisfaction, unless urban governments or in a few cases non-public sector groups operate them satisfactorily.

Details can be found in the appropriate section of the report.

No substantive information was found which relates to the following important issues for on-plot sanitation in urban areas:

- clear guidance about what were the key ingredients of sustainable on-plot sanitation programmes

- the effect and relevance of local legislation, for example in relation to plot size or groundwater pollution

- the effectiveness over time of operation and maintenance for various types of on-plot latrine (as opposed to an extensive literature on 'what ought to be done')

Recommendations for future work
It has not proved possible to produce a series of guidelines or recommendations regarding criteria for sustainable on-plot sanitation systems from the review of existing literature published up to August1992. The findings of the review suggest that the following areas merit more detailed investigation through a combination of desk, postal and field studies in order to obtain a clearer picture of systems which work.

Reasons for lack of household latrines
Objective: To investigate the reasons contributing to the success or failure of on-plot sanitation programmes, and to the absence of more widespread latrine construction outside of specific programmes.

Issues: • Influence of cost, technology choice and willingness to pay; • success/failure of highly promoted programmes; • unsupported initiatives.

User satisfaction
Objective: To investigate parameters of performance in relation to the percep-

tions of the users, which may impact on expansion of sanitation programmes.
Issues: • Perceived benefits of sanitation; • problems in use and maintenance;
• changes in attitude caused by problems in use and maintenance.

Effect of plot size
Objective: To determine which on-plot sanitation systems have been used successfully on small plots.

Issues: • Role of planning regulations and minimum plot size; • variations in systems used according to plot size and formal/informal development;
• operational problems resulting from small plot size.

Pit emptying
Objective: To identify satisfactory systems for the desludging of pits and tanks and the hygienic disposal of sludge.

Issues: • Assessment of current procedures and practices; • the extent to which desludging and disposal constitute long term operational problems.

Operation of double pit latrines
Objective: To investigate the extent of and reasons for incorrect operation of double pit latrines.

Issues: • construction-related problems; • inadequacy of support and education for users.

Groundwater pollution
Objective: To investigate the use and potential impact of guidelines which limit the provision of on-plot sanitation sytems.

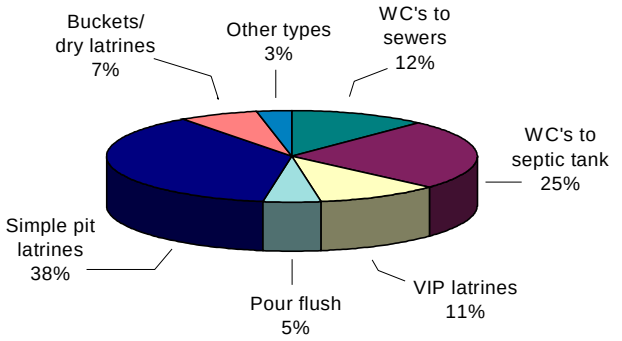
Issues: • Potential for and impact of groundwater pollution; • impact of proscribing on-plot technologies • the extent to which potential pollution should influence technology choice for on-plot sanitation systems.

Fly and odour control
Objective : To investigate the effectiveness of various measures for the control of nuisances caused by flies and bad odours.

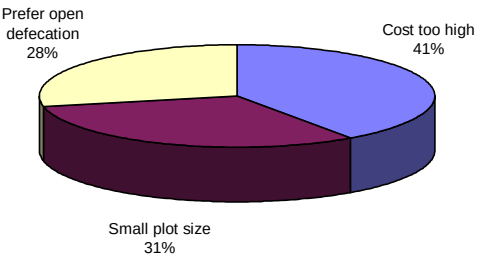
Issues : • effectiveness of latrine ventilation (VIP's) in areas of differing housing density; • effectiveness of tight-fitting lids without ventilation.

Appendices

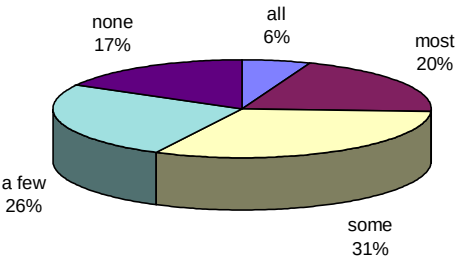
Appendix I: Survey responses



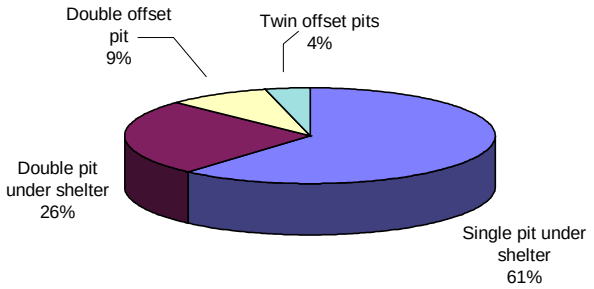
Graph 1: Latrine type



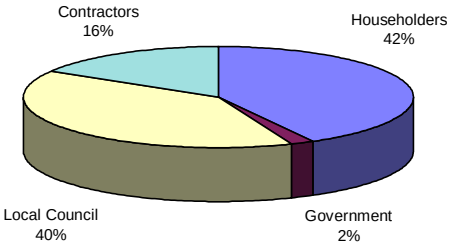
Graph 2: Reasons for no latrines



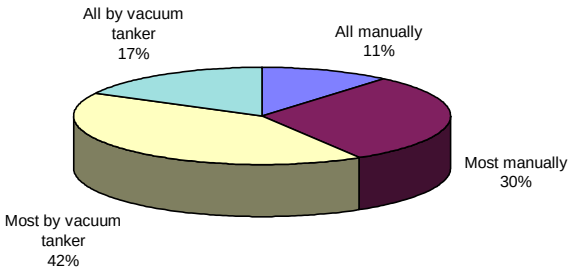
Graph 3: Households who empty pits



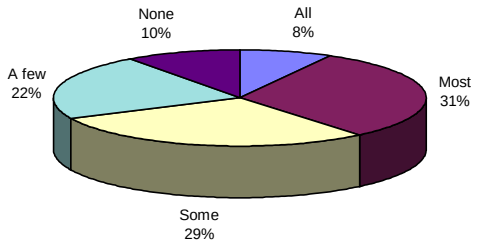
Graph 4:Types of pit emptied



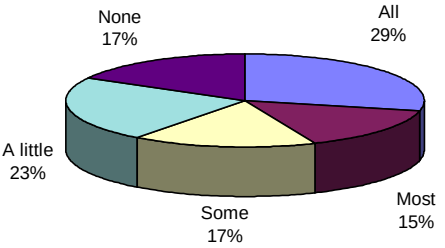
Graph 5:Who is responsible for emptying pits?



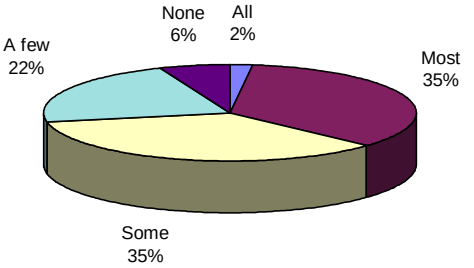
Graph 6: How latrine pits are emptied



Graph 7: Septic tanks desludged regularly



Graph 8: How many householders pay for their latrines?



Graph 9: For how many householders is latrine cost too high?

Appendix II: Low cost sanitation postal survey

Names and location of persons who provided information

1. John K Ackah, Enchi, Ghana
2. Daniel Lah Afari, Tema, Ghana
3. Ibrahim Al-Aldallah, Beirut, Lebanon
4. Mohamed Athman Ali, Malindi, Kenya
5. Salim M S Al-Mauly, Muscat, Oman
6. Robert Kweku Amo, Axim, Ghana
7. Steve A Anankum, Bolgatanga, Ghana
8. Mrs Eva Asare-Badiako, Kumasi, Ghana
9. John I Audi, Bauchi, Nigeria
10. U Win Aung, Yangon, Myanmar
11. Samuel Awamoah, Awaso, Ghana
12. Rev George Bagamuhunda, Kabale, Uganda
13. Bakri Osman Mohamed, Khartoum, Sudan
14. Margaret Nyoh T Besong, Younde, Cameroon
15. Dr Munir Ahmad Bhatti, Islamabad, Pakistan
16. Stephen Blighton, Tarkwa, Ghana
17. Sottie M Bomulama, Kampala, Uganda
18. J M Brew, Enchi, Ghana
19. Isrowandi Buonowikarto, Karachi, Pakistan
20. Stephen L Chavula, Blantyre, Malawi
21. Solomon D Chikom, Jos, Nigeria
22. Joram Chimedza, Bulawayo, Zimbabwe
23. Mark Daci, Jos, Nigeria
24. Manuela d'Angelo, Caracus, Venezuela
25. Ibrahim A Dibal, Tongsa, Bhutan
26. Stephen Dlamini, Mbabane, Swaziland
27. Alfred Duberry, Montserrat
28. Nader El-Khateeb, Bethlehem, West Bank (Israel)
29. Eyob Essatu, Wolaita-Aeeka, Ethopia
30. Edward Falana, Ibadan, Nigeria
31. Henry Olusigun Fawole, Osogbo, Nigeria
32. Zakka Fom, Jos, Nigeria
33. Dr (Mrs) Anuradha Gadkari, Nagpur, India
34. Dr J Stewart Gemmell (formerly Cairo, Egypt)
35. Charles S Githae, Kerugoya, Kenya
36. S I Green, Port Harcourt, Nigeria
37. Edward Cornelius Gomes, Dhaka, Bangladesh
38. Felicia Istifanus Gwet, Jos, Nigeria
39. Mrs Sadhana Hall, Thimphu, Bhutan
40. Syed Ziaul Hasan, Lahore, Pakistan
41. Dr Bilqis Amin Hoque, Dhaka, Bangladesh
42. Md Yakub Hossain, Dhaka, Bangladesh
43. S T Hulugh, Makurdi, Nigeria
44. Tiribo Iotia, Betio, Kiribati
45. Elibariki Asseri Kaaya, Dar es Salaam, Tanzania
46. Dismas Kalimwenjuma, Mbeye, Tanzania
47. Dr (Mrs) N Kamalamma, Gandhigram, India
48. C G Kamau, Nakuru, Kenya
49. M Zahir Ul Karim, Karachi, Pakistan
50. Kebede Ayele, Addis Ababa, Ethiopia
51. S A Kehinde, Abeokuta, Nigeria
52. Koronel M P Kema, Dodoma, Tanzania
53. Hassan Madu Kida, Jos, Nigeria
54. Dr Kamla Kumar, New Delhi, India
55. Mgunda M Kuruchumila, Tanga, Tanzania
56. Mamanding Kuyateh, Banjul, The Gambia
57. Dr Anthony M Land, Gaborone, Botswana
58. Hailay Lemma, Awassa-Sidamp, Ethiopia
59. Stephania Lwitakubi, Dar es Salaam, Tanzania

60. Peter M Macharia, Embu, Kenya
61. John M Machariah, Isiolo, Kenya
62. Enias Maramah, Chinhoyi, Zimbabwe
63. Anan Masri, Nablus, Israel
64. Ms Keiso Matashane, Maseru, Lesotho
65. Stephen Muthami Mbau, Kerugoya, Kenya
66. Godfrey I Mgbemena, Awka, Nigeria
67. Edward K Mokgotle, Kanye, Botswana
68. John Hezekiah Momo, Juba, Sudan
69. Yohana F M Monjesa, Lindi, Tanzania
70. John H M Msami, Dar es Salaam, Tanzania
71. Gideon E E Munduga, Entebbe, Uganda
72. Mathenge J Munene, Meru, Kenya
73. Steven A A Muninzwa, Karen, Kenya
74. Charles M Muniu, Kiambu, Kenya
75. Neumani J S Munuo, Moshi, Tanzania
76. Stephen S Mwaala, Monza, Zambia
77. H Y Mwalugoya, Njombe, Tanzania
78. Jonathan Naugle, Niamey, Niger
79. A A Nweackah, Sekondi, Ghana
80. Anthony I C Nwokocha, Owerri, Nigeria
81. Selben Harold Nyirenda, Mzuzu, Malawi
82. Vincent Orapeleng, Pitsane, Botswana
83. I F Oyewole, Osogbo, Nigeria
84. Nar Bahadur Pun, Kaski, Nepal
85. Md Abdul Quasem, Chittagong, Bangladesh
86. T L Ramaema, Maseru, Lesotho
87. Letty B Regonamanye, Masunga, Botswana
88. Dr Samia G Saad, Alexandria, Egypt
89. S A Sabuni, Morogoro, Tanzania
90. Sheela Samat, Meru, Kenya
91. George Saquee, Kenema, Sierra Leone
92. Mohammad Yousef Ali Sbeih, Ramallah, Israel
93. Hubadar K Seelal, St Joseph, Trinidad
& Tobago
94. Matiisetso Sehloho, Meseru, Lesotho
95. Ikram Abbas Shah, Sargodha, Pakistan
96. Abdillahy A Tawah, Singidaa, Tanzania
97. Dr Susan J Watts, Cairo, Egypt
98. Horatio Wright, Freetown, Sierra Leone
99. George K Yarngo, Monrovia, Liberia

Appendix III: References

The references listed in this section include those documents referred to in this report and a selection of publications from the original literature review which may obtained by professionals in developing countries.

AASEN Barnt and MACRAE Alexander, 1992. The Tegucigalpa model: water and sanitation through community management. *Waterfront*, Issue 1, February, 6

ADHYA A KALL G J, 1989. A permeable lining for seepage pits. *Waterlines*, **8**, 1, July, 30 - 32.

AGARWAL Anil, 1985. Taboos make hygiene difficult for women. *GATE*, No 4, p 29

AHMED Viqar, 1986. Lahore walled city upgrading project. In *Reaching the urban poor* (Ed Cheema). Westview Press, Boulder. Pages 45 - 60.

AKOWUAH E K O, 1985. Experiences and lessons from the operation of Monrovia sewerage system. In *Water and sanitation in Africa*. Proc 11th WEDC Conference, Dar es Salaam, 15 - 19 April 1985. WEDC, Loughborough. Pages 11 - 14

ALAERTS G J, VEENSTRA S, BENTVELSEN M, van DUIJL L A and others, 1991. *Feasibility of anaerobic sewage treatment in sanitation strategies in developing countries*. IHE Report Series 20. International Institute for Hydraulic and Environmental Engineering, Delft.

ANNAN Akweley, CROMPTON D W T, WALTERS D E and ARNOLD S E (Annan et al), 1986. An investigation of the prevalence of intestinal parasites in pre-school children in Ghana. *Parasitology*, **92**, 209 - 217.

APPLETON Judith, 1987. *Drought relief in Ethiopia: planning and management of feeding programmes: a practical guide*. Save the Children, London.

ASSAR M, 1971. *Guide to sanitation in natural disasters*. World Health Organization, Geneva.

BAKHTEARI, Quratul Ain and WEGELIN-SCHURINGA, Madeleen. (1992). *From sanitation to development, the case of the Baldia soakpit pilot project.* Technical Paper Series 31. IRC, The Hague

BALLHATCHET Kenneth and HARRISON John (Ed), 1980. *The city in South Asia: pre-modern and modern*. Curzon Press, London.

BANGLADESH RURAL WATER SUPPLY AND ENVIRONMENTAL SANITATION PROGRAMME (Bangladesh RWS&ESP), 1983. *User perceptions and observed use of latrines in Rahamaterpara*. Evaluation of Latrine Technology, Volume II. DPHE-UNICEF-WHO, Dhaka.

BARROW Nita, 1981. Knowledge belongs to everyone: the challenge in adult education and primary health care. *Convergence*, **14**, 2, 45 - 52.

BASAAKO Kebadire, PARKER Ronald, WALLER Robert B and WILSON James G (Basaako et

al), 1983. *Handbook for district sanitation co-ordinators*. TAG Technical Note No 9. The World Bank, Washington DC.

BASKARAN T R, 1980. Risk of pollution of water supplies from pit latrines. *Report of the International Seminar on low-cost techniques for disposal of human wastes in urban communities*. Calcutta, February. Annexure VI.

BELLARD Brian, 1981. Financing of low-cost sanitation schemes in the urban areas of Botswana. In *Sanitation in developing countries*. Proceedings of a workshop on training held in Lobatse, Botswana, 14-20 August 1980. IDRC, Ottawa. Pages 131 - 134.

BIELLIK Robin J and HENDERSON Peggy L, 1984. The performance of aquaprivies in Thai refugee camps. *Waterlines*, **3**, 1, July, 22 - 24

BLACKETT Isabel, 1988. Co-ordinating a national sanitation programme: the Lesotho way. *Waterlines*, **6**, 3, January, 12 - 13.

BLACKMORE Michael D, BOYDELL Robert A and MBERE Nomtuse (Blackmore et al), 1978. Choice of technology in Botswana. In *Sanitation in developing countries* (Ed Pacey). John Wiley & Sons, Chichester.

BRADLEY R M, 1983. The choice between septic tanks and sewers in tropical developing countries. *The Public Health Engineer*, **11**, 1, January, 20 - 28.

BRADLEY R M and RAUCHER R L, 1988. A technical and economic comparison of nightsoil and sewerage systems in urban areas. *Water S A*, **14**, 1, January, 49 - 57.

BRANDBERG Bjorn, 1983. *The latrine project, Mozambique*. IDRC-MR58e. International Development Research Centre, Ottawa.

BRANDBERG Bjorn, 1985. Why should a latrine look like a house? *Waterlines*, 3, 3, January, 24 26.

BRANDBERG Bjorn, 1991a. The SanPlat system: lowest cost environmental sanitation. In *Infrastructure, environment, water and people*. Proc 17th WEDC Conference, Nairobi, 19 - 23 August. WEDC, Loughborough. Pages 193 - 196.

BRANDBERG Bjorn, 1991b. *Planning, construction and operation of public and institutional latrines*. Hesawa Programme Management, Stockholm.

BRANDBERG B and JEREMIAS M, 1981. Housing sanitation, Mozambique. In *Sanitation in developing countries*. Proceedings of a workshop on training held in Lobatse, Botswana, 14-20 August 1980. IDRC, Ottawa. Pages 21 - 23.

BRISCOE J, FEACHEM R and RAHAMAN M M (Briscoe et al), 1986. *Evaluating health impact: water supply, sanitation and hygiene education*. International Development Research Centre, Ottawa, Canada.

BRITISH STANDARDS INSTITUTION (BSI). *Design and installation of small sewage treatment works and cesspools*. BSI, London.

BROWN, Ato, 1985. The task of renovation and operation of water supply and sanitation in Ghana. In *Water and sanitation in Africa*. Proc 11th WEDC Conference, Dar es Salaam, 15 - 19 April 1985. WEDC, Loughborough. Pages 15 - 18.

BUREN Ariane van, 1979 (Ed). *A Chinese biogas manual*. Translated from the Chinese by Michael Crook. IT Publications, London.

BUREN Ariane van, McMICHAEL Joan, CACERES Roberto and CACERES Armando (Buren et al), 1984. Composting latrines in Guatemala. *Ambio*, **13**, 4, 274 - 277.

BURGERS Lizette, BOOT Marieke and WIJK-SIJBESMA Christine van, 1988. *Hygiene education in water supply and sanitation programmes: literature review with selected and annotated bibliography*. Technical Paper No 27. IRC, The Hague.

CAIRNCROSS Sandy, 1988. *Small scale sanitation*. Ross Bulletin No 8. The Ross Institute, London.

CAIRNCROSS Sandy, 1989. Water supply and sanitation: an agenda for research. *Journal of Tropical Medicine and Hygiene*, **92**, 301 - 314.

CAIRNCROSS Sandy and FEACHEM Richard G, 1993. *Environmental health engineering in the tropics*. 2nd ed. John Wiley & Sons, Chichester.

CAMPBELL Dan, 1988. Data collection for the design of water and sanitation projects in Belize. *Waterlines*, **6**, 3, January, 26 - 28.

CARROLL R F, 1984. *BREVAC: a mechanised method of emptying sanitary chambers*. IP 1/84. Building Research Establishment, Garston, England.

CARROLL R F, 1985. Mechanised emptying of pit latrines in Africa. In *Water and sanitation in Africa*. Proc 11th WEDC Conference, Dar es Salaam, 15 - 19 April 1985. WEDC, Loughborough. Pages 29 - 32.

CARTER J C, 1938. The bored-hole latrine. *Bulletin of Hygiene*, **13**, 8, August, 591 - 600.
and SAHA S K, 1986. Filling characteristics of latrine pits. In *Water and sanitation at mid Decade*. Proc 12th WEDC Conference, Calcutta, 6-9 January 1986. WEDC, Loughborough. Pages 120 - 125.

CHADHA Skylark and STRAUSS Martin, 1991. *Promotion of rural sanitation in Bangladesh with private sector participation*. Swiss Development Corporation, Dhaka, Bangladesh.

CHARNOCK Gary, 1983. Patel promotes people participation. *World Water*, **6**, 12, December, 31 - 32.

COFFEY Manus, 1988. Low cost latrine emptying vehicle. In *Water and urban services in Asia and*

the Pacific. Proceedings of the 14th WEDC Conference, Kuala Lumpur, 11 - 15 April 1988. WEDC, Loughborough. Pages 77 - 80.

COTTON Andrew and FRANCEYS Richard, 1987. Sanitation for rural housing in Sri Lanka. *Waterlines*, **5**, 3, January, 9 - 11.

COTTON A P and FRANCEYS R W A, 1988. Urban infrastructure: trends, needs and the role of aid. *Habitat International*, **12**, 3, 139 - 147.

COTTON Andrew and FRANCEYS Richard, 1991. *Services for shelter*. Liverpool University Press, Liverpool.

COTTON Andrew, 1993. *Cuttack Slum Improvement Project: Infrastructure provision in the pilot slums*. Water,Engineering & Development Centre, Loughborough University of Technology

CHADHA Skylark and STRAUSS Martin, 1991. *Promotion of rural sanitation in Bangladesh with private sector participation*. Swiss Development Corporation, Dhaka, Bangladesh.

CROSS Piers, 1985. Existing practices and beliefs in the use of human excreta. *IRCWD News*, No 23, December, 2 - 4.

CURTIS Chris, 1982. Insect traps for pit latrines. *Appropriate technology*, **9**, 2, September, 11.

CURTIS Chris, 1991. New ideas in the control of mosquitoes. *Footsteps*, No 9, December, 10 - 11.

CURTIS C F and FEACHEM R G, 1981. Sanitation and *Culex pipiens* mosquitoes: a brief review. *Journal of Tropical Medicine and Hygiene*, **84**, 17 - 25.

CURTIS C F and HAWKINS P M, 1982, Entomological studies of on-site sanitation systems in Botswana and Tanzania. *Trans Royal Society of Tropical Medicine and Hygiene*, **76**, 1, February, 99 - 108.

CURTIS Donald, 1978. Values of latrine users and administrators. In *Sanitation in developing countries*. (Ed Pacey). John Wiley & Sons, Chichester. Pages 170 - 176.

DANISH INTERNATIONAL DEVELOPMENT AGENCY (DANIDA), 1991. *Village sanitation: survey of 629 households carried out in Matale District during April 1991*. Report No A21. Support to the rural water supply and sanitation sector in Matale, Polonnaruwa and Anuradhapura Districts for the National Water Supply and Drainage Board, Sri Lanka. Kampsax-Kruger, Copenhagen.

DE LEEUW C P, 1981. water supply and sewage disposal - experience in remote areas of Southern Africa. In *Appropriate technology in civil engineering*. Institution of Civil Engineers, London. Pages 43 - 45.

DEWIT Michael and SCHENK Hans, 1989. *Shelter for the poor in India: issues in low cost housing*. Manohar Publications, New Delhi.

DRAKAKIS-SMITH David, 1987. *The Third World city*. Routledge, London.

DUQUEHIN F L, 1978. *Personal communication*. (Now Jersey, Channel Islands; Kenya, early 1950s).

DWYER, D J. 1975. *People and housing in Third World cities*. Longman, London.

EL-KATSHA Samiha, YOUNIS Awatif, EL-SEBAIE Olfat and HUSSEIN Ahmed (El-Katsha et al), 1989. *Women, water and sanitation: household water use in two Egyptian villages*. The American University in Cairo Press, Cairo.

ELMENDORF Mary and BUCKLES Patricia, 1980. Sociocultural aspects of water supply and excreta disposal. Appropriate technology for water supply and sanitation, volume 5. The World Bank, Washington DC.

ENFO, 1992. Promotion of rural sanitation in Egypt. *Enfo*, **14**, 1, March, page 12.

ESRAY Steven A, COLLETT Jim, Miliotis Marianne D, KOORNHOF Hendrick A and MAKHALE (Esray et al), 1989. The risk of infection from *Giardia lamblia* due to drinking water and latrines among preschool children in rural Lesotho. *International J Epidemiology*, **18**, 1, 248 - 253.

ESRAY S A, FEACHEM R G and HUGHES J M (Esrey et al), 1985. Interventions for the control of diarrhoeal diseases among young children: improving water supplies and excreta disposal facilities. *Bulletin of the World Health Organization*, **63**, 4, 757-772.

ESRAY Steven A, POTASH James B, ROBERTS Leslie and SHIFF Clive (Esray et al), 1990. *Health benefits from improvements in water supply and sanitation: survey and analysis of the literature on selected diseases*. WASH Technical Report No 66. WASH, Arlington, Va, USA.

FEACHEM R, BRADLEY D, GARELICK H and MARA D (Feachem et al), 1983(a). *Sanitation and disease: health aspects of excreta and wastewater management*. John Wiley and Sons, Chichester.
FEACHEM Richard G, GUY Malcolm W, HARRISON Shirley, IWUGO Kenneth O, MARSHALL Thomas, MBERE Nomtuse, MULLER Ralph and WRIGHT Albert M (Feachem et al), 1983(b). Excreta disposal facilities and intestinal parasitism in urban Africa: preliminary studies in Botswana, Ghana and Zambia. *Trans Royal Society of Tropical Medicine and Hygiene*, **77**, 4, 515 - 521.

FEACHEM R G, MARA D D and IWUGO K O (Feachem et al), 1978. *Alternative sanitation technologies for the urban poor in Africa*. Energy, Water and Telecommunications Department, The World Bank, Washington DC.

FLANAGAN Donna, 1988. *Human resources development in water and sanitation programmes: case studies from Togo, Sri Lanka, Philippines, Zaire and Thailand*. Training Series No 3. IRC, International Water and Sanitation Centre, The Hague.

FORMAN David, 1987. Gastric cancer, diet and nitrate exposure, *British Medical Journal*, 28 February, 294, 528 - 529.

FRANCEYS Richard, 1986. Dry latrines. Technical brief No 9. *Waterlines*, **5**, 1, July, 15 - 18.

FRANCEYS Richard, 1990. Guide to sanitation selection. *Waterlines*, **8**, 3, January, 15 - 18. Also in *The worth of water; technical briefs on health, water and sanitation*. Intermediate Technology Publications, London. Pages 93 - 96.

FRANCEYS Richard and COTTON Andrew, 1988. Services by a support approach: infrastructure for urban housing in Sri Lanka. *Open House International*, **13**, 4, 43 - 48.

FRANCEYS, R., PICKFORD, J., REED, R. 1992. *A Guide to the Development of On-Site Sanitation*. World Health Organisation, Geneva, Switzerland. ISBN 92 4 154443 0.

GEARHEART Robert A, 1991. *Ghana rural water project start-up workshop: World Vision and Hilton Foundation: January 7-10, 1991*. WASH Field Report No 345. WASH, Arlington, Va.

GIBBS Ken, 1984. Privacy and the pit privy: technology or technique. *Waterlines*, **3**, 1, July, 19-21

GLENSVIG Leo and GLENSVIG Dorte, 1989. Pour-flush toilets and waste stabilization ponds in a refugee camp. *Waterlines*, **8**, 1, July, 2 - 4.

GOLLADAY Fredrick L, 1983. *Meeting the needs of the poor for water supply and waste disposal.* A World Bank Technical Paper. The World Bank, Washington DC.

GOYDER Catherine, 1978. Voluntary and government sanitation programmes. In *Sanitation in developing countries* (Ed Pacey). John Wiley & Sons, Chichester. Pages 162 - 167.

GUPTA Rajiv, 1983. Are community biogas plants a feasible proposition? *World Health Forum*, **4**, 4, 358 - 361.

HARDOY Jorge E, CAIRNCROSS Sandy and SATTERTHWAITE David (Hardoy et al), 1990. *The poor die young: housing and health in Third World cities*. Earthscan Publications, London.

HARPHAM Trudy, LUSTY Tim and VAUGHAN Patrick (Harpham et al), 1988. *In the shadow of the city: community health and the urban poor*. Oxford University Press, Oxford.

HARRIS R B, MASKELL A D, NJAU F Z and PICKFORD John *(Harris et al),* 1981. Dar-es-Salaam sewerage and sanitation study. In *Appropriate technology in civil engineering*. Institution of Civil Engineers, London. Pages 67-69

HARRISON Paul, 1987. *The greening of Africa: breaking through in the battle for land and food*. Grafton Books, London.

HINDHAUGH G M A, 1973. Night-soil treatment. *The Consulting Engineer*, September, 47, 49.

HOPCRAFT Arthur, 1968. *Born to hunger*. Pan Books, London.

HOQUE Bilqis A, HOQUE M M, ALI, N and COGHLAN Sarah E, 1994. Sanitation in a poor settlement in Bangladesh: a challenge for the 1990s. *Environment and Urbanization*, **6,** 2, October, 79-85

HOWARTH D A, 1983. The role of development banks in international funding. In *Water supply and sanitation in developing countries* (Ed Dangerfield). Water Practice Manuals, Volume 3. The Institution of Water Engineers and Scientists. Pages 47 - 63.

HUBLEY John, 1987. Communication and health education planning for sanitation programmes. *Waterlines*, **5**, 3, January, 2 - 5.

HUNT Steven, 1986. Lucrative latrines. *IDRC Reports*, **15**, 4, October, page 13.

INTERNATIONAL DEVELOPMENT RESEARCH CENTRE, 1983. *The latrine project, Mozambique*. IDRC-MR58e. IDRC, Ottawa. (Brandberg, 1983).

ISELEY Raymond B, FAIIA Scott, ASHWORTH John, DONOVAN Richard and THOMSON James (Iseley et al), 1986. *Framework and guidelines for Care water supply and sanitation projects*. WASH Technical Report No 40. WASH, Arlington, Va.

IWUGO Kenneth O, MARA D Duncan and FEACHEM Richard G (Iwugo et al), 1978a. *Sanitation studies in Africa*. A research study of the World Bank. Sanitation Site Report Number 1, Ibadan, Nigeria. The World Bank, New York.

IWUGO Kenneth O, MARA D Duncan and FEACHEM Richard G (Iwugo et al), 1978b. *Sanitation studies in Africa*. A research study of the World Bank. Sanitation Site Report Number 4, Zambia (Lusaka and Ndola). The World Bank, New York.

JEEYASEELEN S, LOHANI B N and VIRARAGHAVAN T (Jeeyaseelen et al), 1987. *Low-cost rural sanitation - problems and solutions*. ENSIC, Bangkok.

JOINT COMMITTEE ON MEDICAL ASPECTS OF WATER QUALITY (Joint Committee), 1984. *Advice on nitrate in drinking water in relation to a suggested cancer risk*. Department of Health and Social Security/Department of the Environment. HMSO, London.

KALBERMATTEN J M, JULIUS D S and GUNNERSON C G (Kalbermatten et al), 1982(a). *Appropriate sanitation alternatives: a technical and economic appraisal*. World Bank studies in water supply and sanitation 1. John Hopkins University Press, Baltimore.

KALBERMATTEN John M, 1991. Water and sanitation for all, will it become reality or remain a dream? *Water International*, **16**, 3, September, 121 - 126.

KAOMA J, 1981. Zambia's experience with aqua-privies. In *Sanitation in developing countries*. Proceedings of a workshop on training held in Lobatse, Botswana, 14-20 August 1980. IDRC, Ottawa. Pages 41 - 47.

KILAMA W and MINJAS J, 1985. The mounting Culex p. quinquefasciatus problem in urban East

Africa. In *Water and sanitation in Africa*. Proc 11th WEDC Conference, Dar es Salaam, April 1985. WEDC, Loughborough.

KINLEY David, 1992. Kumasi's people for better sanitation services. *Source*, **4**, 1, July, 4 - 9.

KOTALOVA J, 1984. *Personal and domestic hygiene in rural Bangladesh*. SIDA, Stockholm.

LACEY Linda and OWUSU Steven E, 1988. Squatter settlements in Monrovia, Liberia: the evolution of housing policies. In *Slum and squatter settlements in Sub-Saharan Africa: toward a planning strategy* (Ed. Obudho and Mhlanga). Praeger, New York.

LAVER Sue, 1986. Communications for low-cost sanitation in Zimbabwe. *Waterlines*, **4**, 4, April, 26 - 28.

LAVER Sue, 1988. Learning to share knowledge - a Zimbabwean case study. *Waterlines*, **6**, 3, January, 6 - 8.

LAWLESS Richard I and FINDLEY Allan M, 1981. Tunis. In *Problems and planning in Third World cities* (Ed Pacione). Pages 94 - 126.

LEA John P and COURTNEY John M (Ed), 1985. *Cities in conflict: studies in the planning and management of Asian cities*. World Bank, Washington, DC.

LEWIS W John, FOSTER Stephen S D and DRASAR Bohumil S (Lewis et al), 1982. *The risk of groundwater pollution by on-site sanitation in developing countries - a literature review*. IRCWD Report No 01/82. International Reference Centre for Wastes Disposal, Duebendorf, Switzerland.

LOCHERY Peter W S and ADU-ASAH Seth T, no date. *Building and operating multi-compartment VIP latrines*. Lagos, Nigeria.

LOHANI Kumar and GUHR Ingo, 1985. *Alternative sanitation in Bhaktapur, Nepal: an exercise in community participation*. GTZ, Eschborn.

LOWDER Stella, 1986. *Inside Third World Cities*. Croom & Helm, London.

McAUSLAN Patrick, 1985. *Urban land and shelter for the poor*. Earthscan, London.

McCOMMON Carolyn, WARNER Dennis and YOHALEM David (McCommon et al), 1990. *Community management of rural water supply and sanitation services*. UNDP-World Bank Water and Sanitation Program Discussion Paper Series, DP Number 4. World Bank, Washington, DC.

McMICHAEL Joan K, 1978. The double septic bin in Vietnam. In *Sanitation in developing countries* (Ed Pacey). John Wiley & Sons, Chichester. Pages 110 - 114.

MAI Sanan Na Chiang and KUKIELKA Boleslaw Jan, 1981. *Review of experiences with self-help family latrine project at Ban Khuan of Hang Chat District and possible application of these experiences in environmental health project*. Ref No N/55/27. Ministry of Public Health, Bangkok.

MAITRA M S, 1978. Sanitation for the urban poor in Calcutta. In *Sanitation in developing countries* (Ed Pacey). Wiley, Chichester. Pages 144 - 152.

MARA D Duncan, 1984. *The design of ventilated improved pit latrines*. TAG Technical Note No 13. The World Bank, Washington DC.

MARA Duncan, 1985. *Ventilated improved pit latrines: guidelines for the selection of design options*. TAG Discussion Paper No 4. The World Bank, Washington DC.

MARA D D and SINNATAMBY G S, 1986. Rational design of septic tanks in warm climates. *Public Health Engineer*, **14**, 4, 49 - 55.

MARAIS G v R, 1973. Sanitation and low cost housing. In *Water quality: management and pollution control problems* (Ed. Jenkins). Pergamon, Oxford. Pages 115 - 125.

MATHÉY Koste (Ed), 1991. *Beyond self-help housing*. Mansell Publishing, London.

MITRA H N, 1990. Housing and health in three squatter settlements in Allahabad, India. In *The poor die young* (Ed Hardoy et al). Earthscan Publications, London. Pages 89 - 108.

MOES W and ZWAGG R R, 1984. Low cost solutions often beat sewers. *World Water*, September, 56 - 57.

MOHANRAO G J, 1973. Waste water and refuse treatment and disposal in India. In *Environmental health engineering in hot climates and developing countries* (Ed Pickford). WEDC, Loughborough. Pages 69 - 86.

MORGAN Peter, 1977. The pit latrine - revived. *Central African J Medicine*, **23**, 1 - 4.

MORGAN Peter, 1990. *Rural water supplies and sanitation: a text from Zimbabwe's Blair Resarch Laboratory*. Macmillan, Basingstoke.

MORGAN Peter R and MARA D Duncan, 1982. *Ventilated improved pit latrines: recent developments in Zimbabwe*. World Bank Technical Paper No 3. The World Bank, Washington DC.

MORLEY David, ROHDE Jon and WILLIAMS Glen (Ed), 1983. *Practising health for all*. Oxford University Press, Oxford.

MORROW Richard H, 1983. A primary health care strategy for Ghana. In *Practising health for all* (Ed Morley, Rohde and Williams). Oxford University Press, Oxford. Pages 272 - 299.

MOSER Caroline O N, 1991. Women and self-help housing projects: a conceptual framework for analysis and policy-making. In *Beyond self-help housing* (Ed Mathéy). Mansell Publishing, London. Pages 53 - 73.

MOSER Caroline O N and PEAKE Linda, 1987. Women, human settlements, and housing. Tavistock Publications, London.

MOWFORTH K and AGGARWAL K K, 1985. Development of the Buguruni-type VIP. In Water and sanitation in Africa. Proc 11th WEDC Conference, Dar es Salaam, 15 - 19 April 1985. WEDC, Loughborough.

MULLICK M A, 1987. *Socio-economic aspects of rural water supply and sanitation: a case study of the Yemen Arab Republic*. The Book Guild, Lewes, Sussex.

NARAYAN-PARKER Deepa, 1989. *Goals and indicators for integrated water supply and sanitation projects in partnership with people*. PROWWESS/UNDP Technical Series. PROWESS/UNDP, New York.

NJAU Frederick Z, 1981. Sewerage and low-cost sanitation: a solution to sanitation problems in developing countries. In *Sanitation in developing countries*. Proceedings of a workshop on training held in Lobatse, Botswana, 14-20 August 1980. IDRC, Ottawa. Pages 56 - 58.

NOSTRAND John van and WILSON James G, 1983. *The ventilated improved double-pit latrine: a construction manual for Botswana*. TAG Technical Note No 3. The World Bank, Washington DC.

OBUDHO R A and MHLANGA Constance C (Ed), 1988. *Slum and squatter settlements in Sub-Saharan Africa: towards a planning strategy*. Praeger, New York.

OENDO A, 1983. *Sanitation, health and the community in Kibwezi*. AMREF, Nairobi

OTIS R, 1983. *Small diameter gravity sewers: an alternative wastewater collection method for unsewered communities*. Report prepared for the United States Environmental Protection Agency (USEPA). Municipal Environmental Research Laboratory, Office of Research and Development, USEPA, Cincinnati, USA.

OTIS R J and MARA D D, 1985. *The design of small bore sewer systems*. TAG Technical Note No 14. The World Bank, Washington, DC.

PACIONE Michael, 1981 (Ed). *Problems and planning in Third World cities*. Croom Helm, London.

PARLATO Ronald, 1984. *A monitoring and evaluation manual for low-cost sanitation programs in India*. TAG Technical Note No 12. The World Bank, Washington DC.

PASHA Hafiz A and Michael G McGarry (*Editors*), 1989. *Rural water supply and sanitation in Pakistan*. World Bank Technical Paper Number 105. The World Bank, Washington, DC.

PASTEUR D, 1979. The Ibadan comfort stations programme: a case-study of the community development approach to environmental health improvement. *Journal of Administration Overseas*, **18**, 1, 46 - 58.

PAWLOWSKI Z S, 1985. Ascariasis control. *World Health Forum*, **6**, 3, 254-256.

PEEL C, 1967. The problem of excremental disease in tropical Africa. *Journal of Tropical Medicine and Hygiene*, **70**, June, 141 - 152.

PESCOD M B, 1983. Low-cost technology. In *Water practice manuals. Volume 3: Water supply and sanitation in developing countries* (Ed Dangerfield). Pages 263 - 295.

PICKFORD John, 1977. *Indexed bibliography of publications on water and waste engineering for developing countries*. WEDC, Loughborough.

PICKFORD John, 1980. *The design of septic tanks and aqua-privies*. BRE Overseas Building Notes. No 187, September. Overseas Division, Building Research Establishment, Gartree.

PICKFORD John, 1984(a). Good hardware + appropriate software = successful implementation. *Waterlines*, **2**, 3, January, 2 - 4.

PICKFORD John, 1984(b). Training people to meet the global need. In *Water and sanitation: economic and sociological perspectives* (Ed Bourne). Academic Press, Orlando. Pages 199 - 219.

PICKFORD John, 1987. Waste disposal technology for households without piped water. *Trib Cebedeau* (Belgium), No 519, 41 - 48.

PICKFORD John, 1988. Sewerage. Technical Brief No 10. *Waterlines*, **6**, 4, April, 15 - 18. Also in *The worth of water: technical briefs on health, water and sanitation*. Intermediate Technology Publications, London, 1991. Pages 65 - 68.

PICKFORD John, 1990(a). Urgent urban water and waste problems. *Waterlines*, **9**, 1, July, 2 - 5.

PICKFORD John, 1990(b). Community and infrastructure in some Asian cities. In *Planning, shelter and services*. Proc 7th Inter-Schools Conference. WEDC, Loughborough. Pages 61 - 66.

PICKFORD John, 1991a. Public and communal latrines. Technical Brief No 28. *Waterlines* , **9**, 3, 15 - 19. Also in *The worth of water*. IT Publications, London, 1991. Pages 113 - 116.

PICKFORD John, 1992. Latrine vent pipes. Technical Brief No 31. *Waterlines*, **10**, 3, January, 15 - 18. Also in *The worth of water: technical briefs on health, water and sanitation*. Intermediate Technology Publications, London, 1991. Pages 125 - 128.

RAHMAN Mizanur, RAHAMAN M Mujibur, WOJTYNIAK Bogdan and AZIZ K M S (Rahman et al), 1985. Impact of environmental sanitation and crowding on infant mortality in rural Bangladesh. *The Lancet*, 6 July, ii, 28 - 31.

RAJESWARY I, 1992. Mahalapye's latrines sink no more. *Source*, **4**, 1, July, 10 - 13.

REED Bob and VINES Marcus, 1989. Reduced cost sewerage - does it work? In *Water, engineering and development in Africa*. Proceedings of the 15th WEDC Conference, Kano, Nigeria, 3 - 7 April 1989. WEDC, Loughborough. Pages 111 - 114.

REMEDIOS A P, 1981. Ecological balance in Goa. In *Appropriate technology in civil engineering*. Institution of Civil Engineers, London. Pages 46 - 48.

RIBEIRO Edgar F, 1985. *Improved sanitation and environmental health conditions: an evaluation of Sulabh International's low cost sanitation project in Bihar.* Sulabh International, Patna.

RIJNSBURGER Jaap, 1991. Emptying pit latrines: WASTE fills a vacuum in Dar es Salaam, Tanzania. *AT Source*, **18**, 2, 29 - 33.

ROBERTS Martin, 1987. Sewage collection and disposal. In *Affordable housing projects: a training manual: Readings*. Prepared for the United Nations Centre for Human Settlements (Habitat). Development Planning Unit, London.

ROBSON Emma, 1991. China's centuries-old recycling tradition gears for the future. *Source*, **3**, 4, December, 5 - 11.

ROSENHALL L, 1990. Water supply and sanitation in rural Burma - towards convergence. *Water Quality Bulletin*, **15**, 1, January, 46 - 51, 64, 65.

ROY A K, CHATTERJEE P K, GUPTA K N, KHARE S T, RAU B B and SINGH R S (Roy et al). *Manual on the design, construction and maintenance of low-cost pour-flush waterseal latrines in India.* TAG Technical Note Number 10. The World Bank, Washington DC.

RYAN Beverley A and MARA D Duncan, 1983. *Ventilated improved pit latrines: vent pipe design guidelines*. TAG Technical Note No 6. The World Bank, Washington DC.

RYBCZYNSKI Witold, POLPRASERT Chongrak and McGARRY Michael, 1978. *Low-cost technical options for sanitation: a state-of-the-art review and annotated bibliography*. IDRC-102e. IDRC, Ottawa.

SAGAR Gyan, 1983. A dwarf septic tank developed in India. *Waterlines*, **2**, 1, July, 22 - 23.

SCHERTENLEIB Roland and HAWKINS Peter, 1983. *Problems related to emptying on-site excreta disposal systems*. Paper presented at the International Seminar on Human Waste Management for Low Income Settlements, Bangkok, 16 - 22 January 1983.

SHUVAL Hillel I, ADIN Avner, FATTAL Badri, RAWITZ Eliyahu and YEKUTIEL (Shuval et al), 1986. *Wastewater irrigation in developing countries: health effects and technical solutions*. World Bank Technical Paper Number 51. The World Bank, Washington DC.

SHUVAL Hillel I, GUNNERSON Charles G and JULIUS DeAnne S (Shuval et al), 1981. *Nightsoil composting*. The World Bank, Washington DC.

SHUVAL H I, YEKUTIEL P and FATTAL B (Shuval et al), 1984. Epidemiological evidence for helminth and cholera transmission by vegetables irrigated with wastewater: Jerusalem - a case study. *Water Science and Technology*, **17**, 433 - 442.

SILVA Kalinga Tudor and ATHUKORALA Karunatissa, 1991. *The watta-dwellers: a sociological study of selected urban low-income communities in Sri Lanka*. University Press of America, Lanham.

SIMPSON-HEBERT Mayling, 1984. Water and sanitation: cultural considerations. In *Water and sanitation: economic and sociological perspectives* (Ed Bourne). Academic Press, Orlando. Pages 174 - 198.

SINHA Bakshi D and GHOSH Arun K, 1990. *Evaluation of low-cost sanitation: liberation, training and rehabilitation of scavengers*. Arnold Publishers, New Delhi.

SINNATAMBY Gehan, 1990. Low cost sanitation. In *The poor die young* (Ed Hardoy et al). Earthscan Publications, London. Pages 127 - 157.

SINNATAMBY G, MARA D and McGARRY M (Sinnatamby et al), 1986. Shallow systems offer hope to slums. *World Water*, 9, No 1, 39-41.

SKODA John D, MENDIS J Bertrand and CHIA Michael (Skoda et al), 1978. The impact of sanitation in Bangladesh. In *Sanitation in developing countries* (Ed Pacey). John Wiley & Sons, Chichester. Pages 33 - 34.

SOTO Harnando de, 1989. *The other path: the invisible revolution in the Third World*. Tauris, London.

SRIDHAR M K C and OMISHAKIN M A, 1985. An evaluation of the water supply and sanitation problems in Nigeria. *Journal of the Royal Society of Health*, **105**, 2, 68 - 72.

STRAUSS Martin, 1985. Health aspects of nightsoil and sludge use in agriculture and aquaculture: Part II:Survival of excreted pathogens in excreta and faecal sludges. *IRCWD News*, No 23, 49.

STRUYK Raymond, 1989. *Assessing housing needs and policy alternatives in developing countries*. Urban Institute Report 88-4. University Press of America.

SUBRAMANIUM S K, 1978. Biogas systems and sanitation. In *Sanitation in developing countries*. (Ed Pacey). John Wiley & Sons, Chichester. Pages 191 - 194.

THOLIN A L, 1971. The evolution of a master plan. In *Water supply and wastewater disposal in developing countries* (Ed Pescod and Okum). AIT, Bangkok. Pages 70 - 78.

TOBIN V, 1985. Sanitation training in Nepal. *Waterlines*, **4**, 2, October, 13 - 15.

TRAINER Edward S, 1985. Mass parasite control: a new beginning. *World Health Forum*, **6**, 3, 248-253.

TRUNEH Aragaw, 1981. Sanitary situation in Addis Ababa. In *Sanitation in developing countries*. Proceedings of a workshop on training held in Lobatse, Botswana, 14-20 August 1980. IDRC, Ottawa. Pages 52 - 55.

UNDP-WORLD BANK WATER AND SANITATION PROGRAM and PROWESS (UNDP-World Bank), 1990. *Rural sanitation in Lesotho: from pilot project to national program*. The World Bank, Washington DC.

UNICEF, 1991. *The state of the world's children 1991*. OUP, Oxford.

UNICEF, 1992. *The state of the world's children 1992*. OUP, Oxford.

UNITED NATIONS, 1990. *Report A/45/327 of the Secretary General of the Economic and Social Council to the UN General Assembly*. July 1990. United Nations, New York.

UNITED NATIONS CENTRE FOR HUMAN SETTLEMENTS (UNCHS), 1980. *Physical improvement of slums and squatter settlements*. Report of an Ad Hoc Expert Group Meeting held in Nassau, 31 January - 4 February 1977. CHS/R/80-1/S. UNCHS, Nairobi.

UNITED NATIONS CENTRE FOR HUMAN SETTLEMENTS (UNCHS), 1982. *Appropriate infrastructure services, standards and technology*. Report of the *ad hoc* expert working group meeting on appropriate services, standards and technologies for upgrading slums and squatter areas and rural settlements. Nairobi, 2 - 9 November 1981. HS/OP/82-10. UNCHS, Nairobi.

UNITED NATIONS CENTRE FOR HUMAN SETTLEMENTS (UNCHS), 1984. *A review of technologies for the provision of basic infrastructure in low-income settlements*. HS/40/84/E. UNCHS, Nairobi.

UNITED NATIONS CENTRE FOR HUMAN SETTLEMENTS (UNCHS), 1986a. *Sociocultural perspective of sanitation in Nepal: a survey report*. UNCHS, Nairobi.

UNITED NATIONS CENTRE FOR HUMAN SETTLEMENTS (UNCHS), 1986b. *The design of shallow sewer systems*. UNCHS, Nairobi.

UNITED NATIONS CENTRE FOR HUMAN SETTLEMENTS (UNCHS), 1986c. *Community participation in low-cost sanitation - training module*. UNCHS, Nairobi.

UNITED NATIONS CENTRE FOR HUMAN SETTLEMENTS (UNCHS), 1989. *The maintenance of infrastructure and its financing and cost recovery*. UNCHS, Nairobi.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA), 1984. *Handbook: Septage treatment and disposal*. EPA-625/6-84-009. USEPA, Cincinnati.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA), 1987. *Design manual: dewatering municipal wastewater sludges*. EPA/625/1-87/014. USEPA, Cincinnati.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA), 1991. *Manual:Alternative wastewater collection systems*. EPA/625/1-91/024. USEPA, Cincinnati.

UNRAU G O, 1978. Water seal pit latrines. In *Sanitation in developing countries*(Ed Pacey). John Wiley & Sons, Chichester. Pages 104 - 106.

URBAN EDGE The, 1987. India implements latrine program on a large scale. *The Urban Edge*, **11**, 10, December, 1 - 3.

VINES Marcus and REED Bob, 1990. Low-cost unconventional sewerage. *Waterlines*, **9**, 1, July, 26 - 29.

WAGNER E G and LANOIX J N, 1958. *Excreta disposal for rural areas and small communities*. World Health Organization, Geneva.

WANG L H and TAN T H, 1981. Singapore In *Problems and planning in Third World cities* (Ed Pacione). Croom Helm, London. Pages 218 - 249.

WATT Jim and LAING Richard O, 1985. Teaching aids for water and sanitation. *Waterlines*, **3**, 4, April, 25 - 27.

WEGELIN-SCHURINGA Madeleen, 1991. *On-site sanitation: building on local practice*. IRC, The Hague.

WHEELER D and CARROLL R F, 1989. The minimisation of microbiological hazards associated with latrine wastes. *Water Science and Technology*, **21**, 3, 35 - 42.

WHITE Alistair, 1981. *Community participation in water and sanitation: concepts, strategies and methods*. Technical Paper No 17. International Centre for Community Water Supply and Sanitation, The Hague.

WHITTINGTON Dale, Lauria Donald T, WRIGHT Albert M, CHOE Kyeongae, HUGHES Jeffrey A and SWARNA Venkateswarlu (Whittington et al), 1992. *Household demand for improved sanitation services: a case study of Kumasi, Ghana*. The World Bank, Washington DC.

WHYTE Anne V, 1984. Community participation: neither panacea nor myth. In *Water and sanitation: economic and sociological perspectives* (Ed Bourne). Academic Press, Orlando. Pages 221 - 241.

WIJK-SIJBESMA Christine van, 1979. *Participation and education in community water supply and sanitation programmes: a literature review*. Technical Paper 12. International Reference Centre for Community Water Supply and Sanitation, The Hague.

WIJK-SIJBESMA Christine van, 1985. *Participation of women in water supply and sanitation: roles and realities*. Technical Paper 22. International Reference Centre for Community Water Supply and Sanitation, The Hague.

WILLIAMS Chris, 1987. Choices in pit latrine emptying. In *Rural water and engineering development in Africa*. Proc 13th WEDC Conference, Lilongwe. WEDC, Loughborough. Pages 28 - 31.

WILLIAMSON J R, 1983. Towards community managed drinking water schemes in Nepal. *Waterlines*, **2**, 2, October, 8 - 13.

WINBLAD Uno, KILAMA Wen and TORSTENSSON K, 1985. *Sanitation without water*. Macmillan, Basingstoke.

WORLD HEALTH ORGANIZATION (WHO), 1982. *Benefits to health of safe and adequate drinking water and sanitary disposal of human waste: imperative considerations for the International Drinking Water Supply and Sanitation Decade*. EHE/82.32. WHO, Geneva.

WORLD HEALTH ORGANIZATION (WHO), 1987. *Evaluation of the strategy for health for all by the year 2000: Seventh report on the world health situation*. Volume 1, Global review. WHO, Geneva.

WORLD HEALTH ORGANIZATION (WHO), 1991. Surface water drainage for low-income communities. WHO, Geneva.

WORLD WATER, 1983. What is a pour-flush waterseal latrine? *World Water*, **6**, 12, December, p34.

WRIGHT A M, OWUSU S E and HANDA V K, 1978. Availability of latrines in a developing country. In *Sanitation in developing countries* (Ed. Pacey). Wiley, Chichester. Pages 4 - 10.

YOUNG B and BRISCOE J, 1987. *Water and health in rural Malawi: aspects of performance, utilization and health impact of the Malawi Self Help Rural Water Supply Project.* USAID, Washington DC.

ZACHER W, 1982. The significance of water and sanitation for primary health care workers in developing countries. *Internat J Hygiene Education*, **2**, 1, 21 -30.

ZAJAC Vincent, MERTODININGRAT Susanto, SUSANTO H Soewasti and LUDWIG Harvey F, *1984. Urban sanitation planning manual based on the Jakarta case study*. Technical Paper No 18. The World Bank, Washington DC.

Appendix IV - Bibliography

The following references were used in the compilation of Phase 1 of this project, but are considered to be difficult for professionals in developing countries to obtain or are only of marginal interest.

ALVARINHO Manuel, 1991. *Personal communication*. (Head of Department of Water Supply and Sanitation, National Directorate for Water Affairs, Maputo, Mozambique).

ANANKUM Steve, 1991. *WEDC Diploma coursework*.

ANNAN A, 1985. *The socio-economic determinants of malnutrition among pre-school children in Ghana*. Doctoral dissertation, Cornell University, Ithaca, New York.

BASKARAN T R, 1960. *A decade of research in environmental sanitation (1951-60)*. Special Report Series No 40. Indian Council of Medical Research, New Delhi.

BAWA E M, 1987. *WEDC MSc coursework*.

BEGAMUHUNDA George, 1991. *WEDC diploma coursework*.

BOMUKAMA Sottie, 1983. *WEDC MSc coursework*.

BOYDELL Robert Arthur, 1990. *The development of the rural water supply and sanitation sector in Zimbabwe between 1974 and 1987: the design and impact of donor supported projects*. PhD thesis. Loughborough University of Technology, Loughborough.

BRANDBERG Bjorn, 1988. Low-cost sanitation in Malawi - the urban to rural approach. In *Developing World Water*, Volume 3. Grosvenor Press International, London. Pages 28 - 30.

CARROLL R F and ASHCASSERLY M J P, 1978. *Personal communication.*

CENTRAL STATISTICAL ORGANIZATION, MYANMAR, (CSO) 1989. *Evaluation survey of latrine construction project.* Ministry of Planning and Finance, Yangon.

CLARE H C and WEINER D J, 1965. Costs of modern sewage treatment plants. *Public Works*, **96**,

CLINARD Marshall B, 1966. *Slums and community development: experiments in self-help*. Collier-Macmillan, London.

CROMPTON D W T, 1991. The challenge of parasitic worms. *Transactions of the Nebraska Academy of Sciences*, **18**, 73 - 86.

DE KRUIJFF Gerd Jan, 1987. A feasible sanitation alternative. In *Developing World Water*, Volume

2. Grosvenor Press International, London. Pages 52 - 53.

DEVELOPING WORLD WATER, 1988. Emptying latrines - the Lesotho experience. *Developing World Water* (Ed.Pickford). Volume 3. Grosvenor Press International, London.

DOOGAR R K, 1990. *WEDC diploma coursework*.

DREWS R J L C, 1983. *Pond systems for the purification and disposal of domestic wastewater from small communities: use, design, operation and maintenance*. CSIR Guide K15. National Institute for Water Research, Pretoria, South Africa

ENGLAND R, DE KRUIJFF G J and SONI P, 1980. *The pit latrines of Lamu: 600 years of 'illegal' sanitation*. Housing Research and Development Unit, University of Nairobi, Nairobi, Kenya.

ENVIRONMENT PROTECTION AGENCY (EPA), 1979. Comparison of sewerage and common effluent drainage for country townships. EPA Report No. 65/79. EPA, Melbourne, Australia.

ETHERTON David, 1980. *Water and sanitation in slums and shanty towns*. UNICEF report TRH 10. UNICEF, New York.

FELICIANO G and FLAVIER J, 1967. Strategy of change in the barrio: a case study of rural waste disposal. In *Communication and change in the developing countries* (Ed Lerner and Schramm). East-West Centre Press, Honolula, Haiwai.

FLINTOFF Frank, 1976. *Management of solid wastes in developing countries*. WHO Regional Publications, South-East Asia Series No 1. WHO, New Delhi.

FRANCEYS Richard, 1988. Low-cost sanitation in Juba. In *Developing World Water*. Volume 3. Grosvenor Press International, London. Pages 25 - 27.

GARBAN Yandi Ahmed, 1990. *WEDC Diploma coursework.*

GOETHERT Reinhart et al, 1979. Cluster layouts in high density urban situations. In *Human consequences of crowding* (Ed Gurkaynak and LeCompte). Plenum Press, New York.

GOVERNMENT OF INDIA (GOI), 1990. *People, water and sanitation: what they know, believe and do in rural India.* National Drinking Water Mission. GOI, New Delhi.

HABICHT J-P, DAVANZO J and BUTZ W P, 1988. Mother's mild and sewage: their interactive effects on infant mortality. *Pediatrics*, **81**, 3, 456 - 461.

HALL David and ADAMS Michael, 1991. *Water, sanitation, hygiene and health in the Qabane Valley, Lesotho: Report on a survey carried out by Sechaba Consultants for the water supply and sanitation programme of Tebellong Hospital Primary Health Care Department.* Sechaba Consultants, Qacha's Nek, Lesotho.

HARRIS Mollie, 1984. *Cotswold Privies*. Chatto & Windus, London.

HARRIS Mollie, 1990. *Privies galore*. Alan Sutton, Stroud, Gloucestershire.

HARRISON J B, 1980. Allahabad: a sanitary history. In *The city in south Asia* (Ed. Ballhatchet and Harrison). Curzon Press, London.

ILUSTRE Oscar I, 1980. Metro Manila sewerage and sanitation project. Report of the International Seminar on low-cost techniques for disposal of human wastes in urban communities. Calcutta, February. Annexure VII.

INDIAN STANDARDS INSTITUTION, 1986. *Code of practice for installation of septic tanks. Part 1: design criteria and construction. IS 2470 (Part 1)*. Indian Standards Institution, New Delhi. Subparagraph 3.1.3.

KAI Prem, 1990. *WEDC diploma coursework*.

KALBERMATTEN John M and JULIUS DeAnne S, 1978. Intermediate service levels in sanitation systems. In *Appropriate technology in water supply and waste disposal*. American Society of Civil Engineers. Pages 123 - 146.

KALBERMATTEN J M, JULIUS D S, GUNNERSON C G, and MARA D D (Kalbermatten et al), 1982(b). *Appropriate sanitation alternatives: a planning and design manual*. World Bank studies in water supply and sanitation 2. John Hopkins University Press, Baltimore.

KALBERMATTEN John M and LISTORTI James A, 1984. Issues related to financing water and sanitation for the developing countries. In *Water and sanitation: economic and sociological perspectives* (Ed Bourne). Academic Press, Orlando. Pages 136 - 150.

KARLIN Barry, 1961. *Thailand's water-seal privy program: a procedural and technical review*. USOM, Korot, Thailand.

KAWATA Kuzuyoshi, 1979. Of typhoid fever and telephone poles: deceptive data on the effect of water supply and privies on health in tropical countries. *Progress in Water Technology*, **11**, 1/2, 37 - 43.

KLEIN I, 1973. Death in India, 1871 - 1921. *J Asian Studies*, **32**, 4, 639 - 659.

KLIGLER I J, 1921. *Investigation on soil pollution and the relation of the various types of privies to the spread of intestinal infections*. Monograph No 15. The Rockfeller Institute for Medical Research, New York.

KUHLTHAU R H, 1979. *Country studies of appropriate sanitation alternatives*. Report No RES 21. The World Bank, Washington DC.

LARBI, 1990. Unpublished document

LAFFAN L A, 1978. *Personal communication*. (Now Benfleet, Essex, England; PWD, Malaysia, 1927 - 1955).

LAMBTON Lucinda, 1978. *Temples of convenience*. Gordon Fraser, London.

LANGSHAW C L, 1952. Sanitation in the West Indies. *Journal of the Institute of Sanitary Engineers*, **51**, 82 - 109.

McGARRY Michael G, 1977(a). Institutional development for sanitation and water supply. In *Water, wastes and health in hot climates* (Ed Feachem et al). John Wiley & Sons, London. Pages 195 - 212.

McGARRY Michael G, 1977(b). Waste collection in hot climates: a technical and economic appraisal. In *Water, wastes and health in hot countries* (Ed Feachem et al). John Wiley & Sons, London. Pages 239 - 263.

McNAMARA Robert S, 1973. *One hundred countries, two billion people: the dimension of development*. Pall Mall Press, London.

McNEIL G M, 1978. *Personal communication*. (Military Vehicles and Engineering Establishment, Christchurch, England).

MAJUMDER N, PRAKASAM T B S and SURYPRAKASAM M V (Majumdar et al), 1960. A critical study of septic tank performance in rural areas. *J Instn Engrs (India)*, **40**, 12, PH1, 743 - 761.

MAKWALI Saad R, 1992. *WEDC Diploma coursework*.

MARA Duncan, 1976. *Sewage treatment in hot climates*. John Wiley & Sons, London.

MARA Duncan, 1978. The influence of conventional practice on design capabilities. In *Sanitation in developing countries* (Ed Pacey). John Wiley & Sons, Chichester. Pages 75 - 81.

MARAMAH Enias, 1990. *WEDC Diploma coursework*.

MATHEBULA Mpho, 1987. Sanitation, hygiene and children. In *Developing World Water*, Volume 2. Grosvenor Press International, London. Pages 38 - 39.

MAXWELL Caroline A, CURTIS C F et al, 1990. *Control of Bancroftian filariasis by integrating vector control using polystyrene beads with chemotherapy*. Unpublished document.

MISRA D K, 1988. Cultural attitudes in rural sanitation. *Health for the millions* (Delhi), **14**, 4, August, 2 - 5.

MOHAMMED Kazi Noor, 1990. *WEDC Diploma coursework*.

MOORE Helen A, De LA CRUZ Enrique and VARGAS-MENDEZ Oscar, 1965. Diarrheal disease studies in Costa Rica: IV. The influence of sanitation upon the prevalence of intestinal

infection and diarrheal disease. *American Journal of Epidemiology*, **82**, 2, 162 - 184

MORGAN P R and CLARKE V de V, 1978. Specialized developments of pit latrines. In *Sanitation in developing countries* (Ed Pacey). John Wiley & Sons, Chichester. Pages 100 - 104.

MORISHITA K, 1980. In *Collected papers on the control of soil-transmitted helminthiases*, vol 1. Asian Parasite Control Organization, Tokyo, pp 223-236.

MULLER Maria and RIJNSBURGER Jaap. 1992. MAPET - Manual Pit Latrine Emptying Technology Project, 1988-1992: Final Report. Waste Consultants

MUNIR Amir, 1991. *WEDC diploma coursework*.

MWAYANGUBA Charles, 1991. *WEDC diploma coursework*.

MYINT Thein Maung and AYE U Ba, 1988. Evaluation of the health impact of tube well water supply in dry zone rural communities in Burma. Unpublished document. Department of Medical Research, Ministry of Health, Rangoon.

NAIPAUL V S, 1981. *Among the believers*. Penguin Books, Harmondsworth.

NENE Moses Nhlamhla, 1991. *WEDC diploma coursework*.

NICHOLS Paul, 1982. *Juba urban area sanitation survey: report of findings: sanitation facilities*. Unpublished report, Juba, Sudan.

NIELSON John Hebo and CLAUSON-KAAS Jes, 1980. *Appropriate sanitation for urban areas*. Cowiconsult, Virum, Denmark.

NWOKOCHA A I C, 1990. *WEDC diploma coursework*.

NYASALAND, various dates. *Annual reports of the Nyasaland Medical Department*.

OAKLEY H R, 1983. Urban sanitation and surface water drainage.

OLUWANDE P A, 1978. The potential of the aqua-privy: Nigerian experience. In *Sanitation in developing countries* (Ed Pacey). John Wiley & Sons, Chichester. Pages 88 - 91.

OO Saw and THWIN Khin Maung, 1987. *An evaluation study of household latrines in Burma*. UNICEF, Rangoon.

OWUSU S E, 1982. *Behavioural aspects of rural sanitation in Ghana*. National Workshop on Rural Sanitation in Ghana. Accra, 28 September - 1 October.

PACEY Arnold (Ed), 1978. *Sanitation in developing countries*. John Wiley & Sons, Chichester.

PATHAK Bindeshwar, 1985. *Personal communication*. (Founder and Chairman, Sulabh International).

PATHAK Bindeshwar, 1986. *Sulabh Shauchalaya: hand flush waterseal latrine: a simple idea that worked*. Pathak, Patna.

PICKFORD John and FRANCEYS Richard, 1989. *Arriyadh rising groundwater management study: domestic water conservation*. Report for the Arriyadh Development Authority. WEDC, Loughborough.

RAO J R N, 1976. *The new pour-flush privy: construction method and installation procedure*. Ministry of Health, Suva, Fiji.

RAILTON Frank A, 1978. *Personal communication*. (Now Porthcawl, Wales; East Africa, 1930 - 1953).

RAJ Mulkh, 1991. *Financing of urban infrastructure in India*. HUDCO, New Delhi.

RAWLINSON R, 1853. On the drainage of towns. *Minutes of Proceedings of the Institution of Civil Engineers*, 12, 25-109.

READ Geoffrey H, 1980. Aspects of low cost sanitation in Africa. *Report of the International Seminar on low-cost techniques for disposal of human wastes in urban communities*. Calcutta, February. Annexure IXfc.

REYBURN Wallace, 1989. *Flushed with pride : the story of Thomas Crapper*. Pavilion Books, London.

REYNOLDS Reginald, 1943. *Cleanliness and godliness*. George Allen & Unwin, London.

SAGAR Gyan and CHOURASIA H S, 1990. Design of biogas plant based on human excreta. Paper presented at the *International Conference on Water and Waste Water* Barcelona, 24 - 27 April.

SALE Charles, 1930. *The specialist*. Putman, London.

SELL Jack, 1981 (formerly UNICEF, Sudan). Personal communication to author.

SHAFIUDDIN and BACHMAN Sally, undated. *Vietnamese latrines at Gonoshasthaya Kendra*. Unpublished report. Gonoshasthaya Kendra, Savar, Dhaka, Bangladesh.

SOUTH AUSTRALIAN HEALTH COMMISSION (SAHC), 1986. *Common effluent drainage schemes*. Health Surveying Services, SAHC, Adelaide, Australia.

SSOZI Disan, 1991. *WEDC MSc coursework*.

SUNDARARAMAN Veena, 1986. *Social feasibility study in the role of women in rural development*. SNDT University, Bombay.

SYARIKAT GIBSON PERNIAGAAN, no date. *Gibson plastic water-seal latrine pan*. Manufacturer's leaflet. Kuala Lumpur.

SWAFFIELD J A and WAKELIN R H M, 1988. Low water use sanitation - the design and site evaluation of a three litre flush volume WC. In *Developing World Water*, Volume 3. Grosvenor Press International. Pages 351 - 353.

TANNAHILL J, 1966. Aspects of sewage disposal in Rhodesia. *Journal and Proceedings of the Institute of Sewage Purification*, No 5, 459 - 463.

TANZANIA, UNITED REPUBLIC OF, PRIME MINISTER'S OFFICE AND IRC (Tanzania), 1984. *Water, sanitation and village health: a community organization and participation approach in Tanzania*. Paper presented at the interregional seminar on women and the International Drinking Water Supply and Sanitation Decade, Cairo, Egypt, 12 - 16 March 1984. INSTRAW, Santo Domingo.

TURNER J A, 1914. *Sanitation in India*. The Times of India, Bombay.

UGBE Utiang P, 1990. *WEDC diploma coursework*.

UNITED NATIONS, 1956. *20th Report of the Administrative Committee on Coordination to the United Nations Economic and Social Council*. Annex III. Document E/2931. United Nations, New York.

UNIVERSITY OF ZIMBABWE DEPARTMENT OF LAND MANAGEMENT (University of Zimbabwe), 1982. *Environmental Study of the Sabi Valley, Manicaland*. University of Zimbabwe, Harare.

WEIR John M, WASIF Ibrahim Messack, HASSAN Farag Rizk, ATTIA Salah el Din Moh and KADER Mohamed Abdel (Weir et al), 1952. An evaluation of health and sanitation in Egyptian villages. *J Egyptian Public Health Association*, **27**, 55 - 122.

WIGGLESWORTH, Professor Sir Vincent B, 1978. *Personal communication*.

WILCOCKS C, 1965. *Medical advance, public health and social evolution*. Pergamon, London.

WILLIAMS David F, no date. *A report on family latrine trials at Tongi and Demra resettlement camps in Bangladesh*. Unpublished report.

WILSON H E, 1978. *Personal communication*. (Institute of Geological Sciences, London).

WORLD HEALTH ORGANIZATION (WHO), 1951. *Expert committee on school health services*. Technical Report Series No 30. WHO, Geneva.

WRIGHT Albert, 1982. *Report on mission to United Republic of Tanzania*. UNDP, New York.

WRIGHT A M, 1978. A review of rural excreta disposal systems. *Progress in Water Technology*, **11**, 1/2, 211 - 218.

WRIGHT Lawrence, 1960. *Clean and decent: the fascinating history of the bathroom and the water closet*. Routledge & Kegan Paul, London.