



# overseas building notes

Information on housing and construction in tropical and sub-tropical countries

---

No 189

May 1982

## SANITATION FOR DEVELOPING COMMUNITIES

by R F Carroll



Open drains provide places for insect breeding as well as allowing access to polluted waste water for children and animals

## **BIOGRAPHICAL NOTE**

Ron Carroll is a chartered mechanical engineer and joined BRE in 1965 to work on mechanisation and industrialised building systems.

In 1976 he started the Overseas Division's programme of research on sanitation for developing countries. His work since then has involved several countries in collaborative research and advising on construction of sanitation systems, including the introduction of the double chambered pit latrine in Southern Africa.

---

## **OVERSEAS BUILDING NOTES**

---

Overseas Building Notes are prepared by the Overseas Division of the Building Research Establishment in order to provide information and advice on housing and construction in tropical and subtropical regions. They are distributed throughout the developing world to a wide range of organisations with a professional interest in building.

Further copies are available to other organisations and individuals with similar interests and can be obtained by writing to:

Distribution Unit  
Building Research Establishment  
Garston, Watford, WD2 7JR  
United Kingdom

© Crown copyright 1982

Limited extracts from the text may be produced provided the source is acknowledged. For more extensive reproduction, please write to the Head of the Overseas Division at the Building Research Establishment.

<b>CONTENTS</b>	<b>Page</b>
<b>1 INTRODUCTION</b>	1
<b>2 SANITATION, HEALTH AND NUISANCE</b>	1
2.1 Why sanitation	1
2.2 Transmission of disease	1
2.3 Some excreta related diseases	1
2.4 Nuisance	2
2.5 Information on health and disease	2
<b>3 POLLUTION OF SOIL AND GROUNDWATER</b>	2
3.1 Spread of contamination	2
3.2 Contamination of groundwater	2
3.3 Safe water supplies	2
<b>4 CRITERIA FOR SANITATION SYSTEMS</b>	2
<b>5 SANITATION SYSTEMS IN GENERAL USE</b>	2
5.1 Bucket latrine or nightsoil bucket	4
5.2 Overhung latrine	5
5.3 Pit latrine	5
5.4 Bored hole latrine	5
5.5 Ventilated improved pit (VIP) latrine	5
5.6 Reed odourless earth closet (ROEC)	7
5.7 Permanent improved pit (PIP) latrine	7
5.8 Vietnamese double septic bin	7
5.9 Compost or biological latrine	8
5.10 Pour-flush latrine	8
5.11 Vault and vacuum tanker	9
5.12 Septic tank	9
5.13 Aqua privy	9
5.14 Sewered self-topping aqua privy	10
<b>6 CONCLUDING COMMENTS</b>	10
<b>7 REFERENCES</b>	10

# SANITATION FOR DEVELOPING COMMUNITIES

by R F Carroll CEng MIMechE

## 1 INTRODUCTION

The generally poor health endured by large sections of developing communities is largely due to diseases carried by contaminated food and water. Enteric diseases spread by insanitary disposal of excreta and a polluted water supply are major causes of illness and death in the developing countries, particularly among children.

Effective sanitation is an important way of reducing the incidence of disease, but waterborne sanitation (full sewerage) based on the technology of developed countries is very costly and requires extensive water resources. The development and application of alternative systems, using little or no water, is therefore very important.

The objectives of sanitation technology for the disposal of human wastes can be summarised as 'providing means of collecting, retaining and rendering excreta harmless and inoffensive before discharge to the environment'.

On-site retention and treatment of excreta in a simple household pit latrine, for example, can be a very effective and minimum-cost system if proper care is exercised in initial design, construction, hygienic use and maintenance.

This note reviews sanitation systems, other than full sewerage, currently in use and gives guidance in design.

Two other notes in this series, No 174 Sewage treatment in hot countries<sup>1</sup> and No 187 The design of septic tanks and aqua privies<sup>2</sup>, are complementary to this review note. They contain respectively, information on waste stabilisation pond treatment of sewage in the tropics and the design and construction of septic tanks and aqua privies. An earlier Note, No 168 Sanitation without sewers — the aqua privy, also describes the aqua privy.

## 2 SANITATION, HEALTH AND NUISANCE

### 2.1 Why sanitation

The main reason why effective sanitation and access to an adequate and safe water supply are acknowledged to be so important is the need to safeguard human health.

Of the diseases afflicting man, many depend for their persistence on passing from the excreta of an infected person to the mouth of another, a new host. These diseases are mainly those due to viruses, bacteria, parasitic worms (helminths) and protozoa<sup>3</sup>.

The main causes of human mortality resulting from insanitary excreta disposal are the viruses and bacteria. Worms seldom cause death directly but debilitate their human host and can damage tissue and organs, encouraging further infection by other disease organisms.

The role of effective sanitation systems therefore, either full sewerage or the alternative systems described in this note, is to break the cycle of disease transmission, from man as the reservoir of disease to man as the new host.

The potential health hazards from excreta dictate the need for effective, properly operated latrines. An understanding of these factors is as important as the technical provision of the systems. Sanitation programmes in developing countries should therefore include an element of education for the community as users and for those who plan and provide the installations.

### 2.2 Transmission of disease

The main transmission routes for disease associated with human excreta disposal are by (a) direct oral ingestion of bacteria, viruses, protozoal cysts and helminth eggs from fingers or contaminated food and water, (b) penetration of the skin by helminth larvae (eg hookworm larvae through the soles of bare feet) and (c) insect vectors carrying pathogenic bacteria and viruses. In order to overcome the hazards of (a) a safe and sufficient water supply is essential, not only for direct consumption, but to allow adequate personal hygiene, particularly washing of the hands before preparing and consuming food and drink.

Under (b), hookworms are a major hazard on the surface of damp soil contaminated by infected excreta. To reduce this hazard the use of footwear should be encouraged and care taken to keep latrine floors clean.

The risk of disease transmission by vectors, (c), is mainly by insects that come into contact with food for human consumption, eg houseflies, blowflies, cockroaches, after having been in contact with excreta contaminated material.

### 2.3 Some excreta related diseases

Bacterial diseases include cholera, typhoid, bacillary dysentery, gastro-enteritis and diarrheas.

Viral diseases include infectious hepatitis, poliomyelitis and diarrheas. The range of diarrheas account for a major proportion of mortality in young children in developing countries.

Diseases caused by protozoa include amoebic dysentery and diarrhoea. Common worm infestations include roundworm, hookworm, whipworm, pinworm and tapeworm.

#### 2.4 Nuisance

Nuisance is subjective and individual tolerance to nuisance of all kinds varies from person to person. However, in the context of social acceptance of the need to build and use latrine systems, odour and insect nuisance play a large part. A foul-smelling latrine, infested by flies, is unlikely to be used if people can defecate in the open air, eg in fields, the bush or at the roadside, with the not so obvious attendant risks to community health.

#### 2.5 Information on health and disease

For further and detailed information on health and disease aspects of sanitation and water supply see references 3 and 4.

### 3 POLLUTION OF SOIL AND GROUNDWATER

Human excreta can be a source of infection from pathogenic bacteria, viruses and eggs of parasitic worms which are spread through the deposition of excreta from infected persons, passing on infection via the soil and groundwater. Great care is necessary in siting possible sources of pollution, such as pit latrines and soakage systems from septic tanks and aqua privies, to avoid pollution of the ground and water supplies by organisms and chemicals that are harmful to health.

#### 3.1 Spread of contamination

Only the soil close to faeces on the surface of the ground is likely to be contaminated, unless infection is carried further by surface water, or is picked up by flies or other insects and animals. It has been observed that hookworm larvae can be present around the openings to pit latrines with floor coverings that are difficult to clean. The larvae can infect humans through contact with the skin, usually bare feet. Hookworm eggs are known to survive up to five months in wet, sandy soil<sup>5</sup>. Pathogenic bacteria do not usually find the soil a suitable environment for multiplication and will die within a few days.

#### 3.2 Contamination of groundwater

A pit latrine in dry soil, Figure 1, ie above the water table, has little spread of contaminants, either bacterial or chemical, in a lateral direction and penetration vertically is not likely to exceed 3 metres. If the pit or disposal system has penetrated the groundwater, Figure 2, then bacteria or chemical contamination may travel downwards and laterally, transported by the groundwater; the lateral movement will always be in the direction of flow of the groundwater.

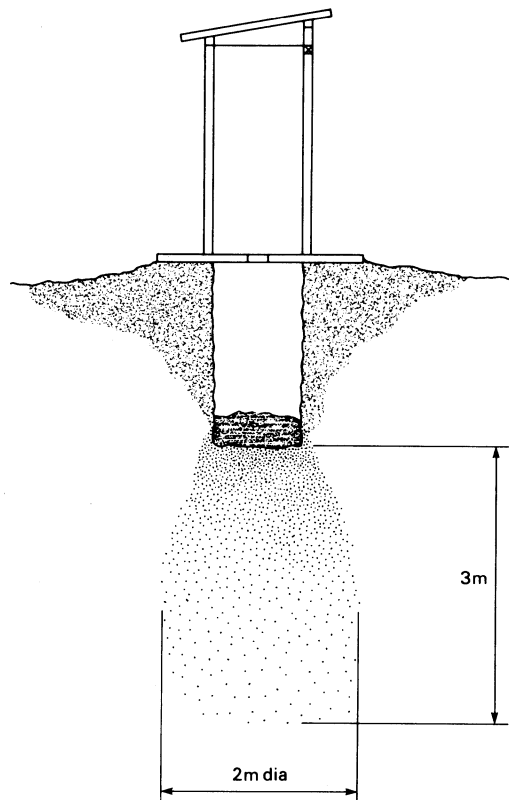


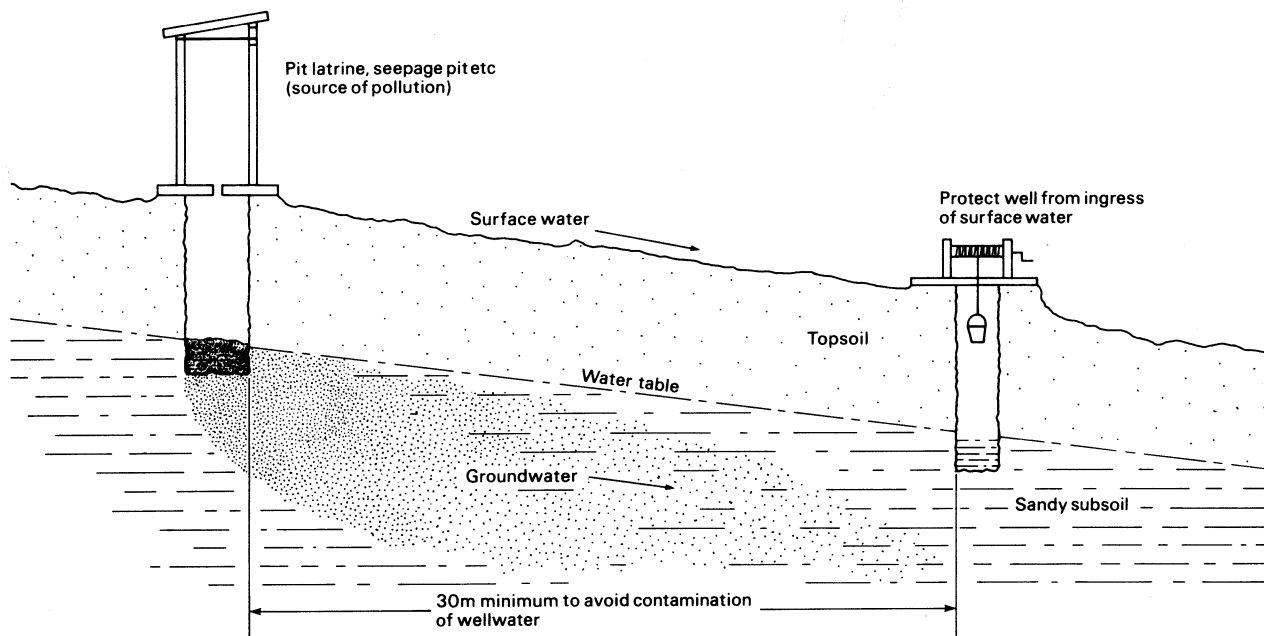
Figure 1 Spread of pollution in dry soil. There is little migration of bacteria and chemical substances, and hardly any lateral movement

When locating latrines, regard must be paid to sources of water supply to avoid the risk of pollution. There can be no arbitrary rule governing the minimum distance that is necessary between an excreta disposal pit and a source of water supply, since this will depend on the soil filtering effects and groundwater depth and flow, as well as the amount of pollutant. However it is important to locate a source of pollution, such as a pit latrine, downstream from a well or water source, to prevent contaminated groundwater from flowing into the well.

According to Macdonald<sup>6</sup>, bacteria rarely travel more than 3 metres downstream through soil, although chemical substances can travel up to 30 metres from the point of entry to the groundwater. However, where fissured rock occurs in the subsoil, as is common in limestone districts, contaminated water can travel considerable distances before being adequately filtered.

#### 3.3 Safe water supplies

Effluent from a septic tank or aqua privy can be as dangerous to health as raw sewage and therefore precautions to protect water supplies from contamination are also necessary for secondary treatment systems, such as soakage trenches and seepage pits. Macdonald<sup>6</sup> recommends the following rules governing location of pollution sources such as pit latrines, seepage systems, etc, relative to sources of water supply:



**Figure 2** Siting of latrines relative to water supplies. Latrines should be downhill from a water source. If they must be located uphill they should be at least 30 m from a well

- (i) In areas with limestone or other rock formations which may be fissured, disposal systems should be of the watertight septic tank type, either waterborne or aqua privy. They should be located at least 30 metres downhill from a water supply source; when this is not possible the septic tank effluent should be conveyed in close-jointed pipes to a secondary treatment, such as an aeration bed, and then to a final disposal point well clear of springs and wells.
- (ii) In areas that are free of fissured formations the disposal system (pit latrine etc) should be located downhill and at least 8 metres from any water supply source. If the latrine etc must be located uphill from the water source it should be at least 30 metres from the source and precautions should be taken to prevent surface water carrying contamination downhill to the water supply.
- (iii) On level ground where the direction of flow of the groundwater is not known accurately, or where its direction is liable to variation, the separation of disposal system from water source should be at least 30 metres.

Where the direction of flow of the groundwater is known, the recommendations at (ii), for sloping land, apply.

- (iv) In all situations the disposal system must be above flood level.

#### 4 CRITERIA FOR SANITATION SYSTEMS

The basic criteria for satisfactory excreta disposal systems that will be socially acceptable and effective in use will ensure:

- (i) no contact by humans with waste materials within the system
- (ii) no access to the waste materials for insects and animals
- (iii) no offensive odours or insect nuisance
- (iv) no unacceptable contamination of groundwater that may pollute springs or wells
- (v) no unacceptable contamination of surface water
- (vi) no unacceptable contamination of surface soil
- (vii) that the system will be simple and inexpensive to construct, use and maintain
- (viii) that the design will cater for modesty needs and personal cleansing practices of users.

In developing countries installations very often fall a long way short of these desirable objectives, due mainly to very limited resources but also to a lack of understanding of health hazards by the community itself. However, existing technology for simple low cost disposal systems can provide the required safeguards to health and the environment which should be the aims of all communities.

#### 5 SANITATION SYSTEMS IN GENERAL USE

Sanitation systems in general use are described below, with their advantages and disadvantages. In Table 1 a range of systems are compared for location suitability, cost, technology levels, water needs, health and nuisance risks. For further reading see references 4,5 and 7.

**Table 1 Some sanitation systems compared**

Sanitation system	General suitability*			Cost	Technology/skills	Water needs for flushing	Health hazards	Nuisance : odour, insects	Comments		
	Low density		High density								
	Rural	Urban	Urban	Initial	Ongoing	Construct	Maintain				
5.1 Nightsoil bucket and collection	Yes	Yes	Yes	Low	High	Very low	Low	None	High	High	Efficient management essential
5.2 Overhung latrine	Yes	No	No	Low	Low	Low	Low	None	High	Medium to high	Environmentally polluting
5.3 Pit latrine	Yes	No	No	Low	Low	Low	Low	None	Medium	Medium	Not permanent
5.4 Bored hole latrine	Yes	No	No	Low	Low	Low	Low	None	Medium	Medium	Not permanent
5.5 Ventilated improved pit (VIP)	Yes	Yes	No	Low	Low	Low	Low	None	Low	Low	Not permanent
5.7 Permanent improved pit (PIP)	Yes	Yes	No	Low	Low	Low	Low	None	Low	Low	Small double chambers, emptyable
5.9 Compost latrine	Yes	No	No	Low	Low	Low	Low	None	Medium	Medium	Extra user care required
5.10 Pourflush latrine	Yes	No	No	Medium	Medium	Medium	Low	Medium	Low	Low	Effective soakaway essential
5.11 Vault and vacuum tanker collection	Yes	Yes	Yes	Medium	High	Medium	Medium	Medium to high	Low to medium	Low to medium	Efficient management essential
5.12 Septic tank and soak-away	Yes	Yes	No	High	Medium	High	Medium	High	Low	Low	Effective soakaway essential
5.13 Aqua privy and soakaway	Yes	Yes	No	Medium	Medium	High	Medium	Medium	Low	Low	Effective soakaway essential
5.14 Sewered self-topping aqua privy	No	Yes	Yes	Very high	Medium	Very high	High	High	Low	Low	Treatment required, as for sewerage
Full sewerage	No	Yes	Yes	Very high	Medium	Very high	High	Very high	Very low	Very low	

\*Note: 'suitability' of a system for any particular location should take account of advantages and disadvantages described in the text.

### 5.1 Bucket latrine or nightsoil bucket

This system consists of a superstructure with seat or squatting plate positioned directly over a bucket or suitable container, which has to be emptied frequently. Emptying at night is a general practice, hence the term 'nightsoil', literally 'soil' collected at night. Water is not used for flushing and since the volume of waste is kept to a minimum because of the need to empty the bucket manually, the disposal of other waste materials, such as vegetable refuse and washing water, is not practicable by this system. The system attracts flies to the latrine and

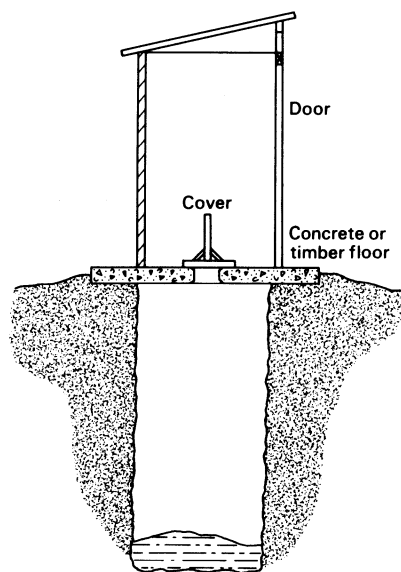
along the conveyance route to the disposal site; odour nuisance can be extreme and there are obvious health hazards through possible contact with raw excreta. The system is not necessarily cheap in the long run since the emptying service has to be paid for. In some parts of Asia the system is used to produce manure for agriculture. As a health protection measure, excreta should be composted to destroy harmful organisms before spreading on the land, as in the Indore process developed in India<sup>6</sup>.

## 5.2 Overhung latrine

This is simply a superstructure built over and discharging directly into water, either a river or the sea. The system produces little odour or fly nuisance and costs very little to construct. There are important pollution hazards to be considered, particularly the proximity of human habitation and the other uses for the receiving waters, such as community water supply. Generally this system is not recommended for community use.

## 5.3 Pit latrine

Figure 3. The basic pit latrine is widely used all over the world and consists essentially of a pit in the ground that receives and retains excreta which are biologically digested and eventually rendered harmless. The superstructure with either seat or squatting plate is built directly over a pit, generally about 1 m diameter or square, at least 2 m deep and often much deeper. The pit should be in permeable soil to allow slow seepage away of liquids. Unsuitable soils are those that are impermeable, and those that are too permeable, such as coarse gravel and fissured rock which can allow rapid movement of liquids through the ground, and possible bacterial pollution to travel considerable distances (see 3.2). Pits should be designed for a life of at least four years and preferably 10 years or more. A fill rate of 0.06 m<sup>3</sup>/head/year for pit sizing is generally adequate. Pits should be lined near the top, or even to full depth if necessary, to prevent caving in under the weight of the superstructure. When it is full to within 0.5 m of the ground surface, the pit should be topped up with soil. A new pit should then be dug nearby if there is sufficient space and the superstructure moved or rebuilt over it.



**Figure 3** A conventional pit latrine. Pits are often very deep to give several years use. When full a new pit is required. Typical pits are 1½ m dia and 3 m deep

The material in the old pit will reduce by digestion and after at least twelve months retention to reduce harmful organisms that could be in the raw excreta, the resulting 'compost' could be used as soil fertiliser; the emptied pit can then be used again.

Emptying of deep pits poses considerable problems, not least being the health hazards of handling possibly raw excreta in the top layers if an insufficient retention period has been allowed for the pit contents to digest.

For dry pits with well decomposed contents, hand emptying with shovels is possible, although not always socially acceptable. Suction emptying of wet pits is usually preferred, but most vacuum tankers are only capable of removing the water fraction over consolidated sludge and therefore the pit is only partially emptied. Specially developed suction appliances are required that will effectively remove pit contents in any condition. Work is in hand to develop such an appliance at the UK Building Research Establishment.

Odour and insect nuisance are common in simple unventilated pit latrines and this tends to discourage the fullest use of the installation where there are alternative places for defecation, such as in the open. Also little effort is made to keep squatting plates or seats clean in what is often regarded as an unclean place, making the problems of hygiene and nuisance worse. Improved forms of pit latrine are therefore to be recommended where pits are the only sanitation system affordable (see 5.5 and 5.7).

## 5.4 Bored hole latrine

In principle this is similar to the pit latrine, but utilises an augered hole of around 400 mm diameter by 4 to 8 m deep. Fouling of the sides of the hole is likely immediately below the opening and this increases the fly hazard and odour nuisance. For this reason the squatting plate opening should be centrally located over the bored hole, which itself must be vertical to minimise fouling. The augered hole should only be put down in soils that are permeable and firm enough not to collapse; large stones make boring difficult and slow. The capacity of the bored hole is much less than that of the usual pit latrine resulting in a shorter useful life. Due to its depth the hole often penetrates and pollutes the groundwater. When the hole is full emptying is difficult and therefore new holes are frequently required, at around 1 to 2 year intervals according to capacity and usage. Widely used in the Middle East and South East Asia.

## 5.5 Ventilated improved pit (VIP) latrine

By adding a screened ventilation pipe to the chamber of a basic pit latrine a great improvement in comfort can be achieved through reduced odour and insect nuisance. These latrines are generally known as VIP latrines.



An insect proof screen fitted over the ventilation pipe has been shown to trap a large percentage of flies breeding in the pit, as well as mosquitoes. Flies in particular attempt to leave the pit by way of the ventilation pipe, being attracted to the bright light visible through a straight length of vertical pipe.

Adequate ventilation of chambers can be provided by a pipe of around 100 mm diameter taken up well clear of the roof.

It is not essential to locate the ventilation pipe on the sunny side of the superstructure, since solar heat promoting an upward flow of air in the pipe is a relatively small benefit compared with wind effects. Wind flow over the pipe outlet will induce an

upward flow of air, drawing foul gases from the pit. This in turn will draw air in at the inlet hole thereby reducing odours in the latrine superstructure.

Figure 4, taken from a recorder chart, illustrates how insignificant the difference in air speed is in two pit ventilation pipes, one in full sun and one in shade. In contrast the peaks of air speed in the pipes correlate with wind gusts over the latrine roof (example is for very light wind conditions in UK with 6°C air temperature difference in the ventilation pipes).

Wind turbulence over a ventilation pipe can sometimes produce downdraughts in the pipe. The problem will be obvious because of the prevailing

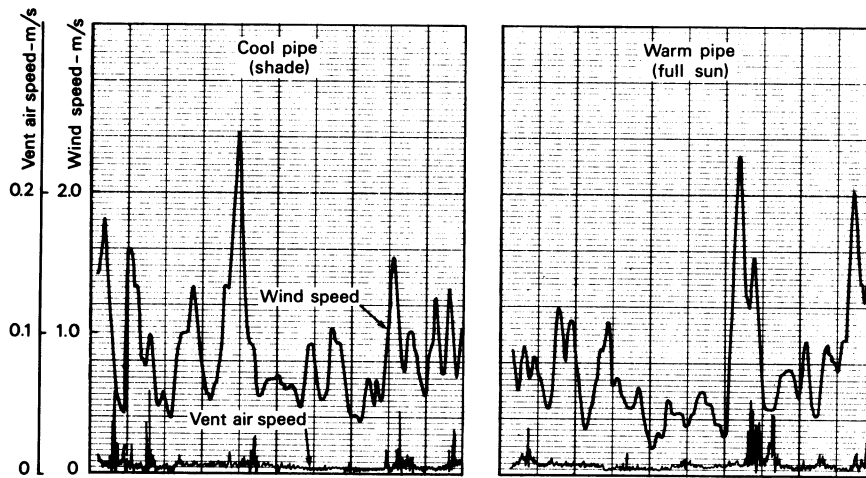


Figure 4 Extracts from a recorder chart, showing the minimal effect of sunshine and the large effect of wind on the ventilation air speed in two pit vent pipes

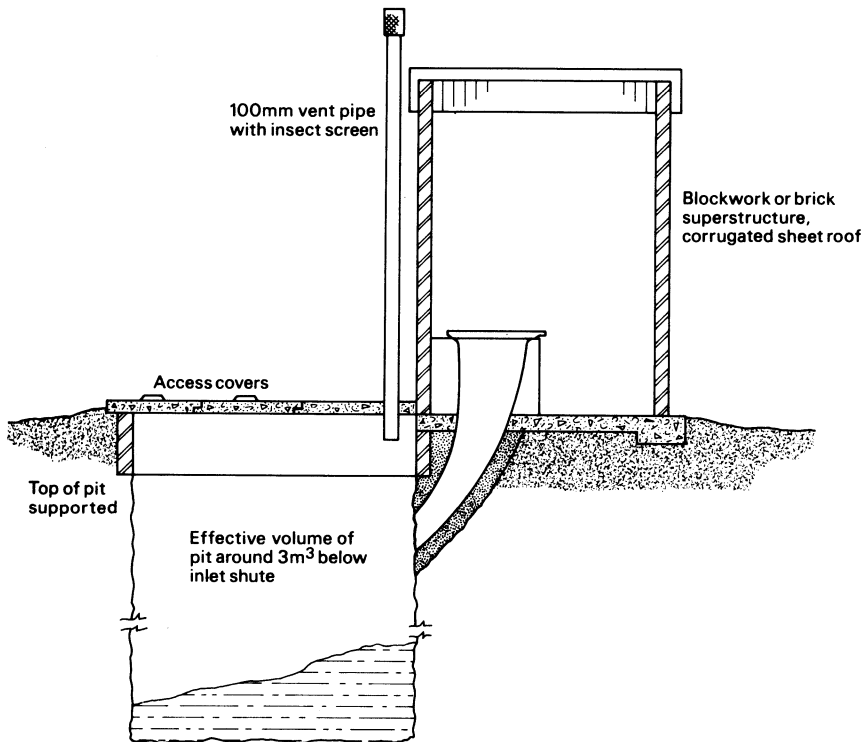


Figure 5 The Reed Odourless Earth Closet (ROEC) with proprietary prefabricated chute and seat with lid. (Similar to a design used in Botswana)

odour levels in the latrine and may be remedied by fitting a simple plate terminal over the ventilation pipe to prevent downdraughts.

### 5.6 Reed odourless earth closet (ROEC)

Figure 5. This is in effect an offset pit latrine with an exceptionally large pit, around 3 m<sup>3</sup> volume below the inlet chute. ROEC's have access covers so that the pit could be emptied from outside the superstructure. Like conventional pit latrines little information is available on emptying these pits but because of the large storage capacity something like 20 years of use could be expected for a single family.

The major drawback with this design is the inevitable fouling of the curved inlet chute. Recent experiences in Botswana have shown that special care with clearing this chute is essential to prevent fly nuisance due to this fouling. Venting and other design details are the same as for VIP latrines.

### 5.7 Permanent improved pit (PIP) latrine.

Figure 6. The PIP latrine<sup>9,10,11</sup> is a concept developed at the UK Building Research Establishment and consists of a double chambered, ventilated and emptyable pit. Design features include:

- (i) small ventilated and emptyable chambers, approximately 1.5 m<sup>3</sup> effective volume, around 1.7 metres deep and much less likely to penetrate and pollute the groundwater than traditional deep single pits
- (ii) a superstructure supported on a groundbeam that also serves as a liner to the top of the pit. Normally this should be around 0.5 metres deep but could be down to full depth if the pits are in unstable ground. A full depth lining should allow percolation, ie the vertical joints in the masonry should be left unfilled to allow liquids to seep away.

Currently this type of latrine system is being installed in parts of Southern Africa, mainly in Botswana where several thousand have been built and where they are called the Revised Earth Closet (REC).

The design and choice of materials for the superstructure can vary according to user preference and affordability. Typically brick or blockwork with a corrugated sheet roof or mud brick with thatch are used. PIP latrines need to be emptied at about three year intervals and this presents similar problems to traditional pits (5.3), except that PIP's are shallower and of much smaller capacity and have less material to be removed when they have to be emptied.

The contents of a PIP latrine are likely to be less compacted than the contents of large, long serving

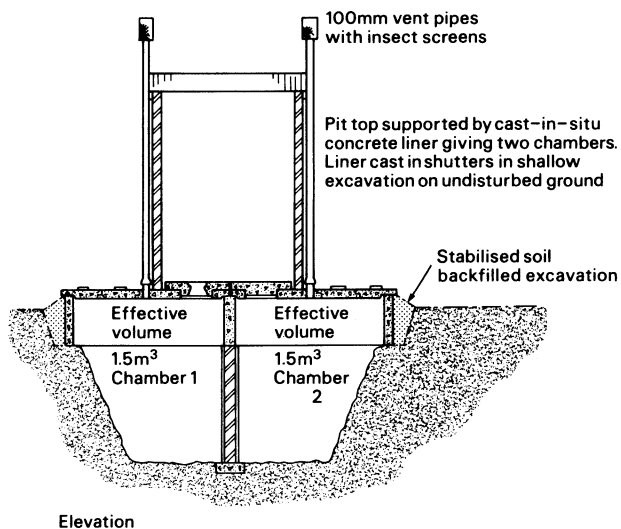
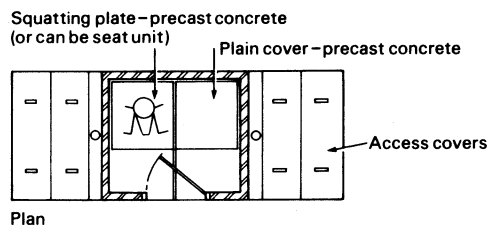


Figure 6 The Permanent Improved Pit (PIP) latrine

pits, so that suction emptying is more likely to be effective. Manual emptying with long handled shovels is feasible for these small chambers, where this task is socially acceptable. After a minimum of two years retention the excavated sludge can be used as a safe fertiliser in gardens.

### 5.8 Vietnamese double septic bin

This latrine system should not be confused with a 'septic tank', which is a settling tank for domestic sewage (5.12). The 'Vietnamese double septic bin' is a double vault, built on the ground with steps to reach the floor of the superstructure containing the inlet holes.

The vaults are very small, around 0.2 m<sup>3</sup> each, and are sized to suit the number of persons being served. Faeces drop directly into the vault in use and urine is channelled to a separate container for use directly as fertiliser. Since there are relatively few disease organisms likely in human urine this is probably why it is used untreated and separately to faeces on gardens as a fertiliser.

When the first vault is full of faeces it is sealed off and the second vault is brought into service. After each defecation wood ashes are sprinkled on the faeces to reduce odours. The faeces are allowed to decompose for about two months before removal and use as fertiliser.

It is claimed<sup>4</sup> that most pathogenic bacteria are destroyed during the two months retention, but

helminth removal requires further composting for between 45 and 60 days.

Little first hand information is available on the performance and social acceptability of this system, although it is reported to be widely used in Viet-nam in recent times. With such a short digestion period, 8 weeks, there may be health hazards from handling the 'compost' and using it as fertiliser without further composting, preferably aerobic to achieve high enough temperature to kill off the more persistent pathogens.

### 5.9 Compost or biological latrine

Figure 7. These are forms of composting originating in Scandinavia, where they were originally called 'Multrum' toilets, and are generally expensive and sophisticated installations. In the basic types, without special heating facilities, the temperature achieved during the retention period is not sufficient to destroy the harmful organisms likely to be present in the material being composted. Vegetable material as well as excreta are necessary for effective composting or more accurately 'mouldering' in temperate climates, and to ensure a safe product a long period of retention of from two to four years is advised, to reduce the number of harmful organisms before applying the compost to the land. Kitchen and human waste can be disposed of in this way, by a process not requiring a water supply. The system will be free from odour if a proper vent pipe is incorporated. It is a hygienic system as there is no contact with the decaying material during the process by humans, animals or insects.

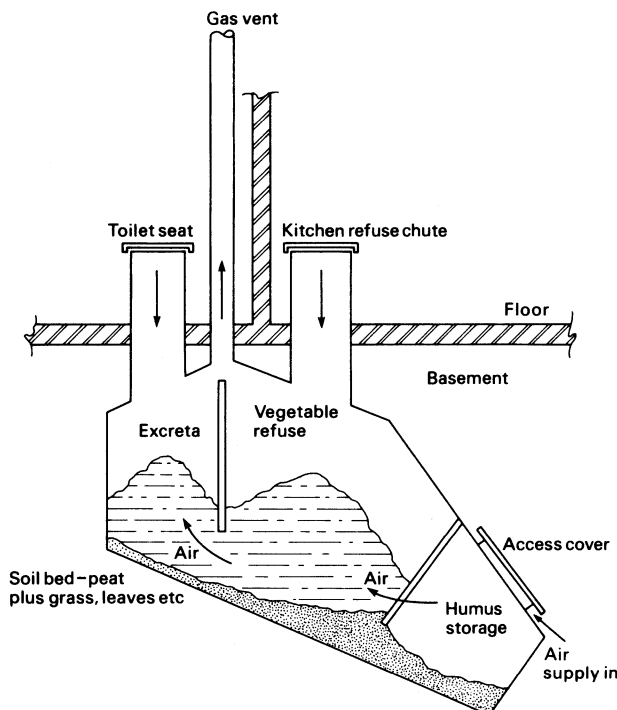


Figure 7 The compost latrine (Multrum toilet)

Climatic conditions can be much more favourable to the composting process in tropical countries where high ambient temperatures are conducive to rapid biological action within a composting chamber. High enough temperatures could be achieved during composting to destroy organisms harmful to humans. Research is in progress to see how effective this process can be in low-cost installations; recent reports suggest that much care is needed in operating and maintaining these installations to achieve hygienic conditions and effective decomposition.

### 5.10 Pour-flush latrine

In South-east Asia the pour-flush latrine is a complete system, comprising a shallow water seal pan integral with a squatting plate and discharging to a seepage pit. (Figure 8b). The pipe from pan to pit should be as short as possible, to reduce the risk of blockage due to the low volume of flush water. Because of the discharge of unsettled solids to the seepage pit, its life will be limited; solids and biological slime will tend to block the interstices of the soil, eventually preventing drainage of liquids;

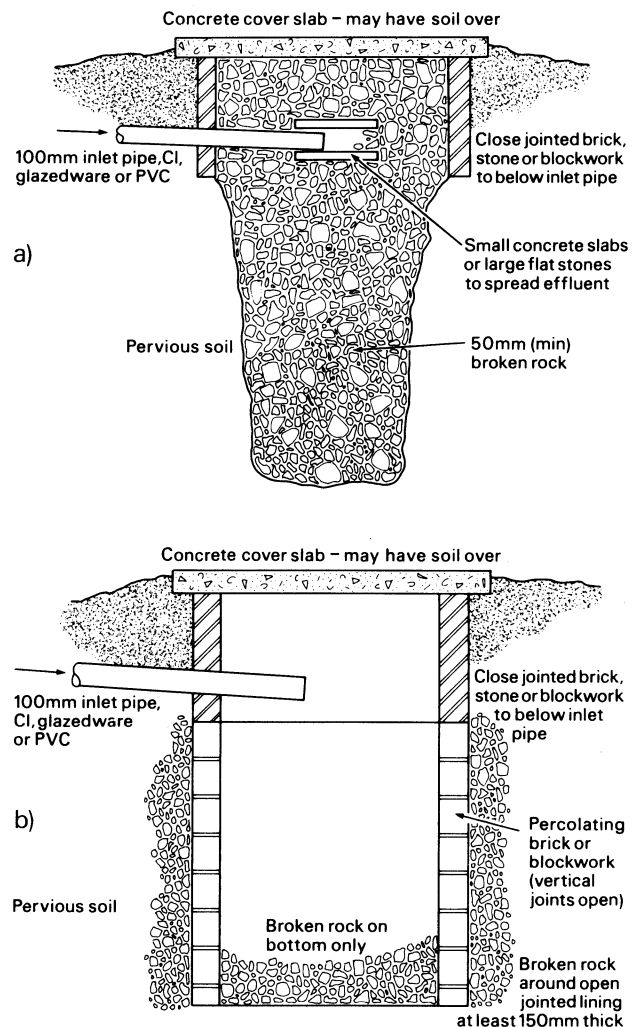
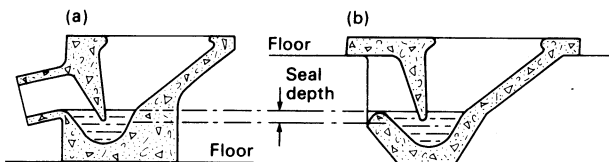


Figure 8 Seepage pits (soakaways). To be used only in pervious soil and above the water table. The pit volume should be at least that of the installation served. Pits are commonly 1.0 to 2.5 m dia and 2.0 to 5.0 m deep and can be in series

therefore the surface area of the seepage pit or trench should be as large as possible.

The term 'pour-flush' really refers to the type of water seal employed, Figure 9. This device can be used in a variety of sanitation systems, catering for users who normally use water for anal cleansing. It is similar to water seals used in developed countries except that it has a seal of around 25 mm, necessary because of a much smaller flush volume of less than 2 litres. Excreta are discharged through the seal to the disposal system and odours are prevented by the water seal from travelling back; the seal also prevents contact with excreta by flies.



**Figure 9** 'Pour-flush' water seal pans. These can be precast with neat cement internal surfaces to give a smooth finish for easier cleaning. (See Reference 3 for production details of similar devices.) 12 to 37 mm seal depth for low volume flush (1 to 2 litres). (a) Pedestal pan for pipe connection. (b) Squatting plate pan over pit or tank

### 5.11 Vault and vacuum tanker

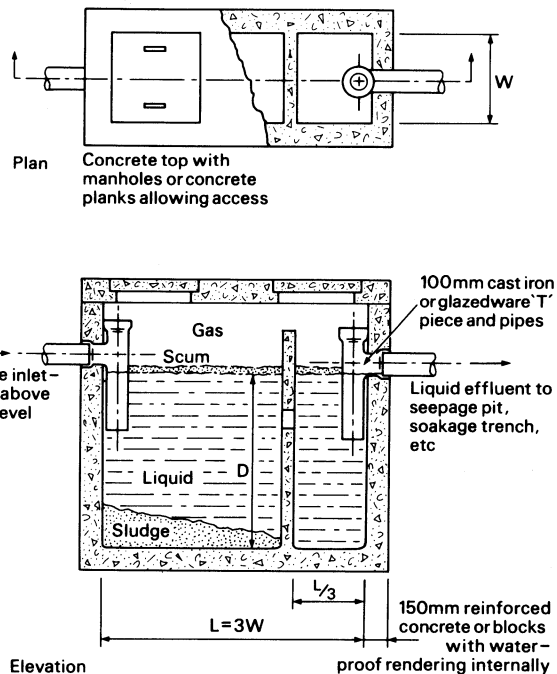
This system is simply a vault or cesspit storing excreta and waste water, resulting in sewage with probably less than 2% solids. The sewage can be sucked from the vault and transported for treatment by conventional vacuum tanker.

Generally this system is in use in more developed countries where large amounts of domestic water and a highly organised emptying service are available. It is not a low cost system because of the need to empty the vault every two or three weeks and the need for an adequate and reliable water supply.

### 5.12 Septic tank

Figure 10. The septic tank is part of a basic water-borne disposal system and is suitable for individual families or, on a larger scale, for whole communities in rural areas. The process can accept all domestic wastewater. It is a lot more expensive to construct than a simple pit or bored hole, but it is a permanent installation providing a high standard of hygiene and comfort. It requires little maintenance, other than sludge emptying at regular intervals.

A septic tank is effectively a sewage settlement tank, in which the solids are retained in a quiescent state long enough to be partly broken down by anaerobic bacterial action. The tank should be watertight and constructed of non-corrodible material. Raw sewage enters the tank at one end, bacteria digest and liquify some of the settled organic material and the resulting liquid effluent



**Figure 10** The Septic Tank. Typical tank for 10 persons: waste flow 120 litres/day/person, sludge storage capacity 150 litres/person.  $L = 3.0$  m,  $W = 1.0$  m,  $D = 1.1$  m, giving  $3.3 \text{ m}^3$  (3300 litres) effective volume

passes out of the other end to secondary treatment or disposal in a soakage trench or seepage pit (Figure 8). A suitable vent is required to allow the gases of decomposition to escape from the tank.

During retention insoluble particles accumulate as sludge on the bottom of the tank and a thick scum forms on the surface of the intermediate liquid layer, effectively excluding oxygen and creating anaerobic conditions. The effluent which flows out of the tank is drawn from the liquid layer and one of the criteria for an efficient septic tank is its ability to retain sewage solids, so that the effluent is relatively free of solid particles. Frequency of desludging can be of the order of from one to five years, depending on the efficiency of digestion and the sludge storage capacity in the tank.

Advice on the design of septic tanks and aqua privies is contained in BRE Overseas Building Note No 187<sup>2</sup>.

### 5.13 Aqua privy

Figure 11. This system is based on septic tank principles but is designed to accept human waste plus some cleansing water. It requires only sufficient water to clean the bowl or squatting plate and maintain the liquid level in the tank because of losses through evaporation; kitchen wastewater can be used for this purpose. In the type illustrated the spiral flow of water from the washing trough helps to clean the pan. Having less influent the tank requires less capacity than a septic tank in a water-borne system, thus saving on construction costs. There is a correspondingly reduced effluent flow, but with less dilution.

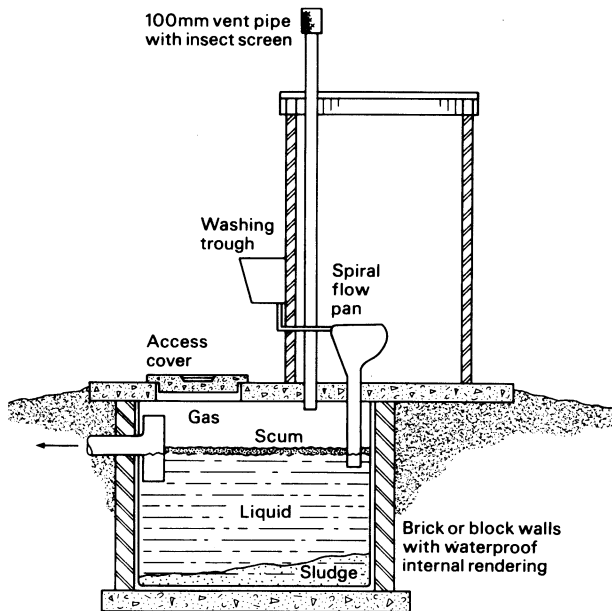


Figure 11 The Aqua privy. The type B, used in Botswana

The system uses a straight drop pipe into the tank for the excreta, the pipe discharging through the scum layer and beneath the surface of the liquid. To keep odour and fly nuisance to a minimum the bore of the drop pipe should be no larger than 150 mm; a 100 mm pipe is recommended by some sources for these reasons, plus the fact that scum does not form in a smaller pipe in regular use. A 150 mm pipe is less likely to block however, if larger items of refuse or personal cleansing materials are put into it.

Because of the small size of the aqua privy tank, there is a possibility of some of the influent getting to the outlet pipe before adequate settlement in the tank. This can be prevented by dividing the tank into connected compartments or by providing a baffle between inlet and outlet. A satisfactory secondary treatment can be provided by sub-surface irrigation.

#### 5.14 Sewered self-topping aqua privy

This is a medium to high cost system in which a conventional aqua privy has a pipe system to conduct settled effluent to a separate treatment system, such as waste stabilisation ponds. The tank is self-topping because kitchen wastewater is routed into it preferably via the excreta inlet, thereby also serving as flushwater to clean the appliance. Advantages<sup>12</sup> are low water use as compared with full sewerage and, because of settlement and part-digestion of the sewage in the tank, small bore pipes down to 100 mm can be laid to shallow falls to convey the liquid effluent, which has only finely suspended solids, to the treatment ponds.

## 6 CONCLUDING COMMENTS

Most of the alternatives to full waterborne sanita-

tion have been outlined in this note, with some advantages and disadvantages of each system. Further information is contained in the references.

Table 1, comparing a selection of systems commonly used around the world, is helpful in the preliminary selection of a likely system or systems for a particular location.

User acceptability and affordability cannot be tabulated, although they are factors of prime importance in final system selection.

Much experience has been accumulated around the world in the operation of the systems described. While research is progressing in many countries to try to develop more effective and economic systems, a lot can be done to improve present technology through a better understanding of sanitation principles, in order to achieve the fundamental objectives of improved public health and a better living environment.

## 7 REFERENCES

- 1 **Mara D D.** Sewage treatment in hot countries. *Overseas Building Note* No 174. Garston, Building Research Establishment, 1977.
- 2 **Pickford J.** The design of septic tanks and aqua-privies. *Overseas Building Note* No 187. Garston, Building Research Establishment, 1980.
- 3 **Feachem R G, Bradley D J, Garelick H and Mara D D.** *Health aspects of excreta and sullage management — a state of the art review.* Washington, World Bank, 1981.
- 4 **Pacey A (Ed).** *Sanitation in developing countries.* Chichester, John Wiley and Sons, 1978.
- 5 **Wagner E G and Laroix J N.** Excreta disposal for rural areas and small communities. *WHO Monograph Series* No 39. Geneva, World Health Organisation, 1958.
- 6 **Macdonald O J S.** *Small sewage disposal systems.* London, Lewis and Co (Distributors), 1951.
- 7 **Feachem R G and Cairncross A M.** Small excreta disposal systems. *Ross Institute Bulletin* No 8. London School of Hygiene and Tropical Medicine, 1978.
- 8 **Gotaas H B.** Composting. *WHO Monograph Series* No 31. Geneva, World Health Organisation, 1956.

- 9 **Carroll R F.** Improving the pit latrine. *Proceedings of Conference 'Water and waste engineering in Africa', Zaria 1980.* (Building Research Establishment reprint 1980).
- 10 **Wilson J G.** The PIP and REC II latrines. *Proceedings of workshop 'Sanitation in developing countries', Botswana 1980.* Ottawa, International Development Research Centre, 1981, pp 24 – 26.
- 11 **Bellard B.** Financing of low cost sanitation schemes in the urban areas of Botswana. *Proceedings of workshop 'Sanitation in developing countries', Botswana 1980.* Ottawa, International Development Research Centre, 1981, pp 131 – 134.
- 12 **Vincent L J, Algie W E and Marais G Van R.** A system of sanitation for low cost high density housing. *Proceedings of Symposium 'Hygiene and sanitation in relation to housing', Niamey 1961,* pp 135 – 172.

**OVERSEAS BUILDING NOTES — Titles available**

115	February 1967	Prefabricated low cost housing in Jamaica
132	June 1970	Admixtures in concrete
139	August 1971	Problems of concrete production in arid climates
145	August 1972	Durability of materials for tropical building
146	October 1972	Timber in tropical building
148	February 1973	The durability of metals in buildings
150	June 1973	The manufacture and use of concrete blocks for walls (J D McIntosh)
153	December 1973	Properties and production of concrete (J D McIntosh)
154	February 1974	Calcium silicate bricks (G E Bessey)
158	October 1974	Building for comfort
160	February 1975	Low cost housing in urban and peri-urban areas
161	April 1975	Production and use of lime in the developing countries (G E Bessey)
162	June 1975	Board linings to walls
163	November 1978 (rev)	Building research centres and similar organisations throughout the world
164	October 1975	The thermal performance of concrete roofs and reed shading panels under arid summer conditions (Adil Mustafa Ahmad)
165	December 1975	Buildings and the environment (Miles Danby)
166	February 1976	No-fines concrete
169	August 1976	Developments in paints and surface coatings
170	October 1976	Termites and tropical building
171	December 1976	Protection of steelwork in building
172	February 1977	Low cost housing in the Indian context (S K Misra)
173	April 1977	Bricks and mortar
174	June 1977	Sewage treatment in hot countries (Duncan Mara)
175	August 1977	Plastics for building
176	October 1977	Building materials in the Arabian Gulf (T R Allison)
177	December 1977	Avoiding faults and failures in building (G E Bessey)
178	February 1978	Village water supplies (A M Cairncross)
180	June 1978	Bitumen coverings for flat roofs (W Kinniburgh)
181	August 1978	The management of resources on construction sites (Roger A Burgess)
182	October 1978	Roofs in hot dry climates (Y A Mukhtar)
183	November 1979	Preservation of timber for tropical building (C H Tack)
184	February 1980	Stabilised soil blocks for building (M G Lunt)
185	April 1980	Current activities of the Overseas Division, BRE
186	June 1980	Fire protection and building regulations (R E H Read and H L Malhotra)
187	August 1980	The design of septic tanks and aqua-privies (John Pickford)
188	April 1981	Buildings and tropical windstorms (Keith J Eaton)
189	May 1982	Sanitation for developing communities (R F Carroll)