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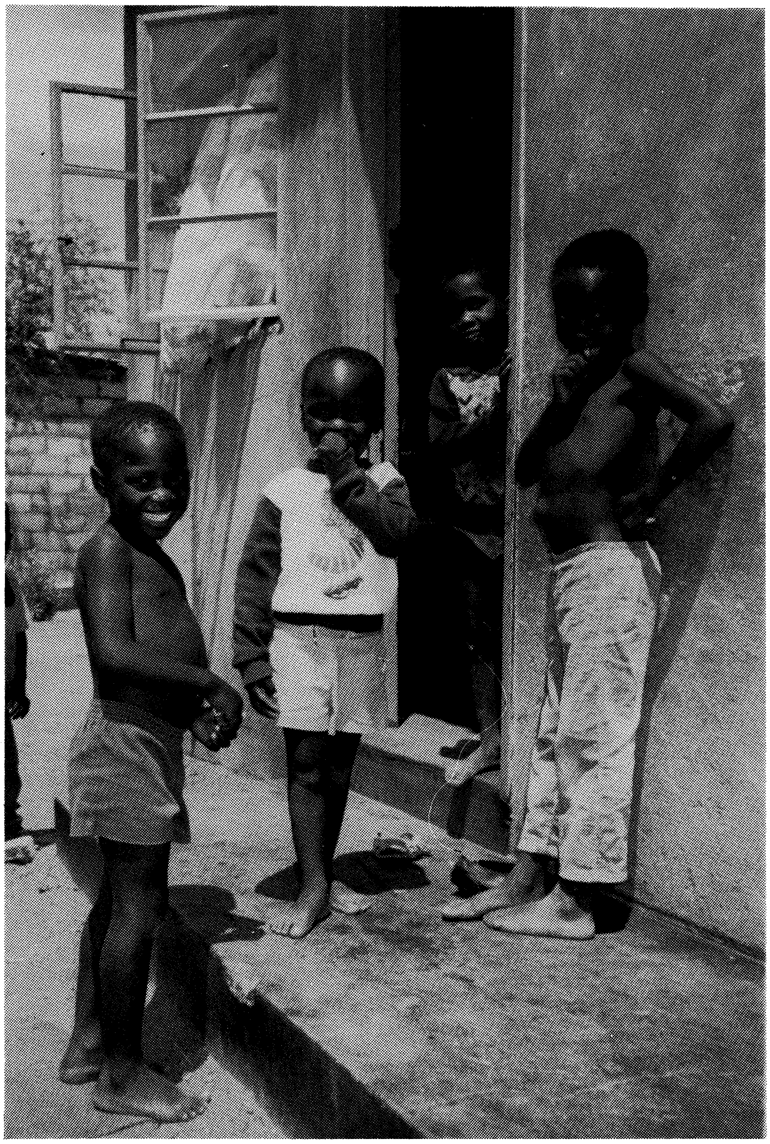
Health aspects of latrine construction

R F Carroll



A clean domestic environment helps to protect community health

Building Research Establishment
UNITED KINGDOM

International Division
Building Research Establishment
Garston, Watford WD2 7JR UK
Telephone 0923 894040
Telex 923200 Fax 0923 664010

SUMMARY
Safeguarding public health is the main objective of installing household sanitation systems. Cleanliness is important around dwellings, particularly in areas where children play, to reduce the transmission of diseases associated with infected human faeces. On-site systems are usually the only sanitation options available to most households in developing communities. Except for some main city centres, full sewerage is not generally possible, due to the high cost and lack of a reliable water supply.

There are particular aspects of latrine design and construction that can have considerable effects on insect populations breeding in latrines, eg flies, cockroaches and mosquitoes. Not only are they nuisance pests, they can also be carriers of serious diseases.

Attention to good construction and regular maintenance can control insect populations in latrines, without reliance on expensive insecticide treatments. Insecticides can kill off insects, but reinfestations are likely, unless access to attractive habitat in latrine pits and tanks is prevented.

A properly installed and maintained ventilation pipe in a pit latrine can greatly reduce the presence of odour, which is not only offensive to people but can be a great attraction to insects. Effective sealing of access covers and floors of latrines is a measure that can greatly reduce access by insects to stored excreta in on-site sanitation pits and tanks.

This Note discusses the problem of insects and disease, and describes effective construction features that can eliminate or drastically reduce insect populations in latrines.

CONTENTS

BIOGRAPHICAL NOTES

Ron Carroll has been involved with low-cost housing development since 1975. In particular he has led research and development projects on sanitation systems and sludge handling equipment for developing countries. More recently he has produced publications on health and housing in the Overseas Building Note and Overseas Information Paper series, to disseminate information produced by BRE's Overseas Division (now International Division).

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HEALTH ASPECTS OF LATRINE CONSTRUCTION

by R F Carroll C Eng M I Mech E

1 INTRODUCTION

The installation of household toilets (latrines) provides a way of helping to keep the ground clean around dwellings, by the collection and isolation of possibly harmful human excreta. Contact with such wastes by people, insects and animals can spread diseases if there are pathogenic organisms present.

For the majority of households in the growing semi-urban populations in the developing countries, forms of on-site sanitation are generally the only options available. Water-borne sanitation (sewerage) is only possible where there is a sufficient and reliable water supply. Other constraints on sewerage provision are the high initial cost and the ongoing service cost of sewage treatment and disposal.

Two forms of pit latrine[1,2], either dry pits (Figures 1 and 2) or pour-flush (Figures 3 and 4), predominate in most developing countries. Aqua privies[3] (Figure 5), which work as small septic tanks, are fairly common where sufficient water is available. However, because of frequent effluent soakaway problems, aqua privies are not now generally recommended.

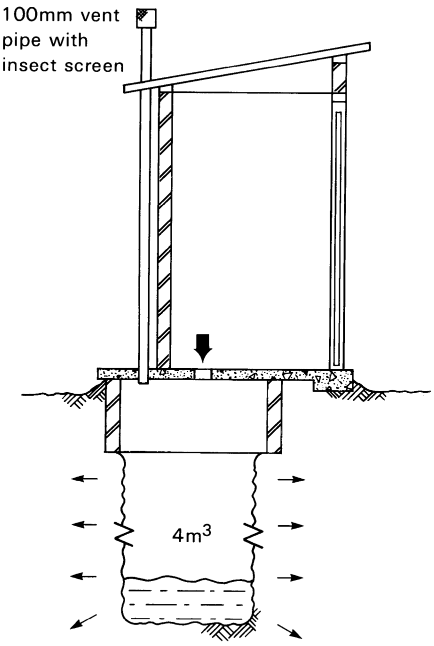

Figure 1 Ventilated improved Pit (VIP) latrine

Sanitation systems need to be selected to suit site conditions[4], be affordable and properly constructed. It is essential that users know how to maintain their system, and be motivated to do so.

The provision of latrines alone is not sufficient to control the transmission of diseases of faecal origin. Washing the hands after defecation and before eating is of prime importance in protecting family health. Small children commonly put possibly infected objects, as well as their fingers, into their mouths when playing.

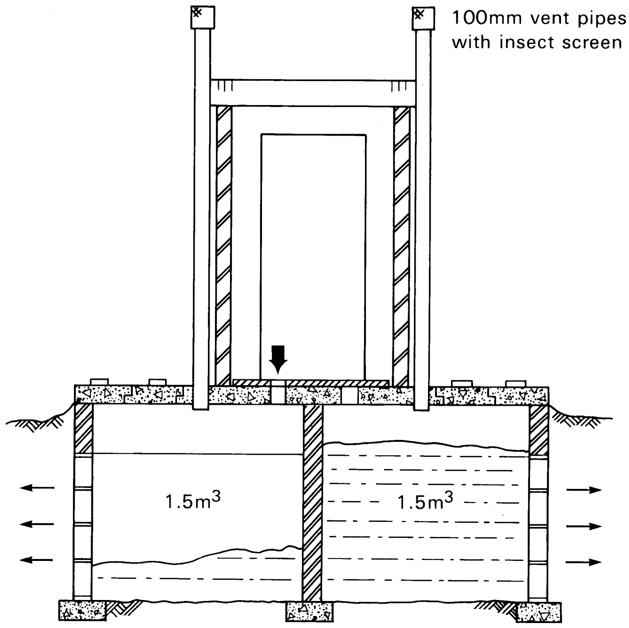

Figure 2 Ventilated Improved Double Pit (VIDP) latrine

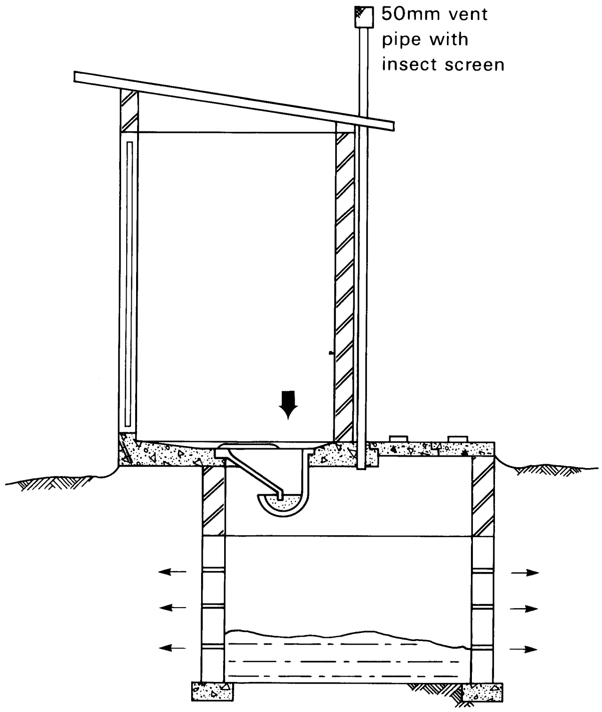

Figure 3 Pourflush latrine, single or double emptyable pit

Childrens faeces are more likely to be infected than those of adults, particularly with worm eggs.

This Note describes the common types of on-site sanitation system in developing countries, and highlights particular features that can have public health implications. Advice is given on ways of reducing infestations of insects that are not only nuisance pests, but may also be carriers of disease.

2 DISEASE AND SANITATION

It is not only for aesthetic reasons that household latrines are desirable. Direct contact by people with infected excreta is a likely way of spreading disease within the community. Insects and animals can be

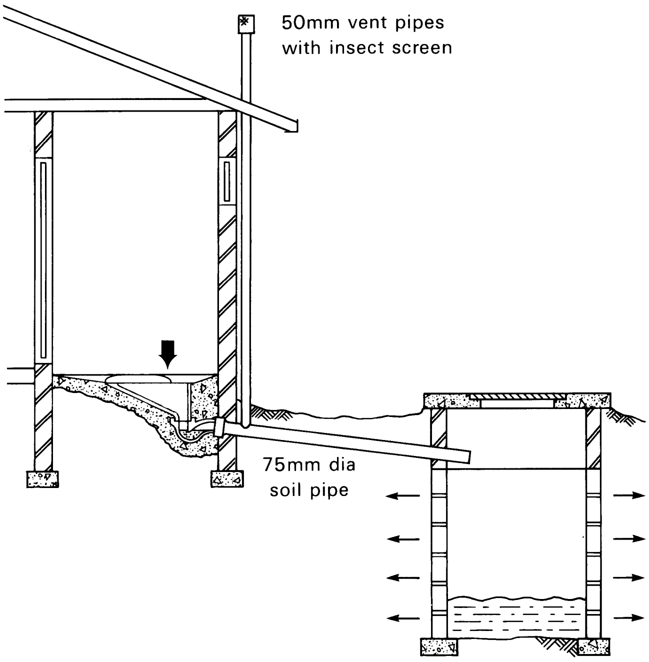

Figure 4 In-house pourflush latrine, single or double emptyable pit

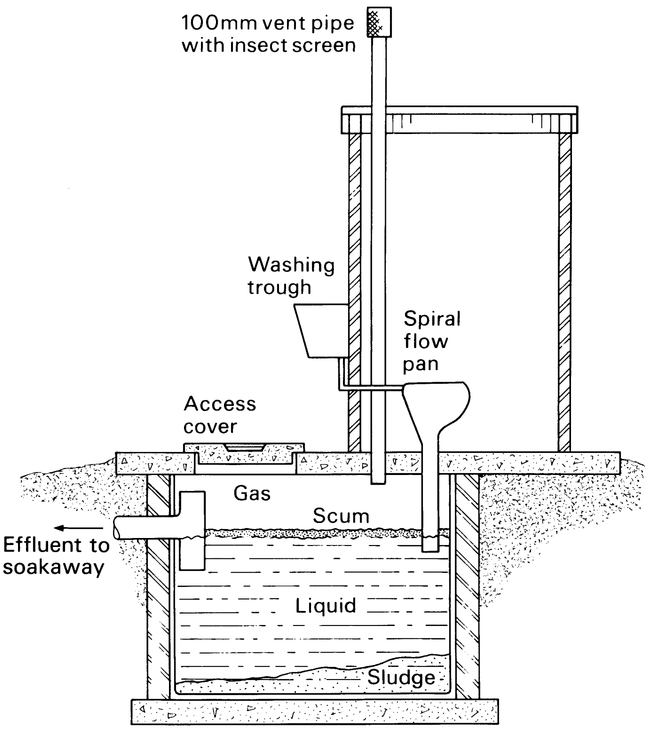

Figure 5 The Aqua privy. The type B, used in Botswana

carriers of disease and can pass on harmful organisms, by contaminating food and water supplies to be consumed by humans.

Mosquitoes can breed in latrines with accessible free water. They do not transmit excreted infections as do flies and cockroaches, but can carry other diseases which they can pass on, such as malaria and filariasis (elephantiasis), because they bite and take blood meals from humans who may already be infected.

2.1 Excreta related diseases

There are a range of bacteria, viruses, protozoa and worms that can be carried in human excreta. They occur widely in tropical developing countries[5,6]. Bacteria, viruses and protozoa are the cause of many diseases in humans, such as diarrhoeas, dysenteries, typhoid fever and cholera. The diseases caused by worms, such as hookworm and roundworm (ascariasis), are mainly debilitating and are very common in developing countries. Hookworms usually gain entry to the body by penetrating the skin of the feet. They can be found on faecally contaminated ground surfaces or latrine floors that are not kept clean. Ascaris eggs can find their way into the intestine via the mouth and unwashed hands.

2.2 Latrines and disease transmission

Transmission of disease-causing organisms from in or around a latrine, is due either to direct human contact with pathogen infected faeces or via infected insects and animals. Insects such as houseflies, blowflies and cockroaches inhabit and can breed in latrines that store human excreta. A wet or dry pit latrine is an ideal habitat, providing food, water and shelter. Transmission of pathogens by flies and cockroaches is by contact with man's food, and eating utensils and containers, either with their feet or body fluids.

Cockroaches, particularly the large American cockroach, are commonly found in unsealed pit latrines and sometimes in aqua privy tanks (Figure 6). The habitat is generally ideal and it is probably overpopulation that causes migration to other latrines, and into houses and other buildings that provide food, water, warmth and shelter. Stored foodstuffs can be contaminated by contact with cockroach faeces, deposited during feeding. A range of viable pathogens of human faecal origin can be found in a cockroach gut [7], and can be readily transmitted on food.

Figure 6 Cockroaches and fly larvae in poorly sealed aqua privy tank

Mosquitoes also will breed in latrines and tanks which have exposed free water (Figure 7). In areas where diseases such as filariasis and malaria are endemic, sealing or screening of pits and tanks against mosquitoes is important (see 3.3).

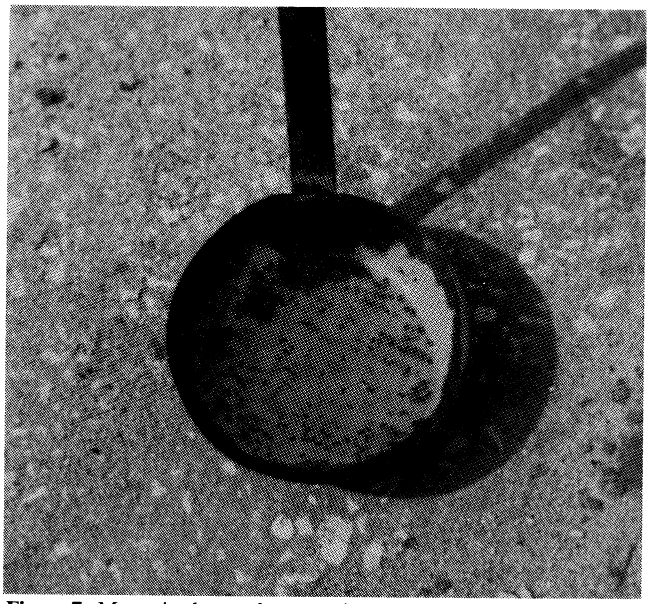

Figure 7 Mosquito larvae from septic tank soakaway (exposed water surface)

3 LATRINE CONSTRUCTION

The general design and construction of various latrine systems is well documented[1,2,3,5]. The choice of building materials for latrines is largely governed by what is available locally at an affordable price. However, whatever building materials are used, eg concrete block walls and galvanised sheet steel roof or mud walls and thatched roof, it is important that effective performance is achieved and maintained. Good latrine design and construction, coupled with proper use by the whole family and regular maintenance, are essential to safeguarding public health.

There are several aspects of construction that need particular attention, such as the provision of an effective screened ventilation pipe on latrines with inlets not fitted with a water seal. The ventilation pipe is necessary to eliminate odour, which is not only offensive to humans, but can also be an attraction to insects. Another important aspect is effective sealing of joints in floor slabs and access covers, so that insects cannot gain access to faecal material.

A form of pit latrine that does not need the ventilation pipe of VIP latrines and aqua privies, is the 'pour-flush latrine' (Figures 3 and 4), common in parts of the world where water is used for anal cleansing. It is a pit latrine that incorporates a low volume waterseal pan[1,5].The pan is flushed with only one to two litres of water from a hand-held container (hence the name 'pour-flush'). The waterseal prevents the passage of insects and odours between the toilet superstructure and the pit contents. However, great care is required to ensure insect-proof joints to prevent access to the pit contents.

3.1 Preventing insect infestations

The initial attraction for insects to seek entry to a pit latrine or aqua privy is probably odour. The main feature of VIP latrines is the ventilation pipe which is fitted to convey odorous gases away from the toilet compartment, to discharge outside and above the roof. The fitting of a ventilation pipe can remove or greatly reduce odours that could otherwise attract flies inside a latrine pit or tank.

Once a gravid fly enters a pit or tank, eggs are laid and subsequently hatch to produce a further generation. Flies hatching out in a pit will attempt to migrate toward the brightest light source, either the inlet hole if uncovered or the light visible through a vertical ventilation pipe. It is important therefore, to ensure that the inside of the toilet superstructure is normally in semi-darkness, in case the inlet hole is left uncovered. If the pipe outlet above the roof is covered with a fly-proof mesh, emerging flies are trapped and eventually die. It has been reported that 90% of flies hatching in a pit latrine have been killed in this way[8].

Hatching mosquitoes do not so readily fly toward the light. Experiments with unscreened ventilation pipes in Botswana and Tanzania showed that 67% of Culex mosquitoes emerged from a pit through the ventilation pipe, the remainder emerged from the inlet hole[8].

To combat emerging mosquitoes, in addition to a screened ventilation pipe, a mesh trap can be fixed over the inlet hole when the toilet is not being used (Figure 8)[5,6]. The latrine inlet hole should not be completely sealed, as that will greatly reduce the desirable upward flow of air and foul gases in the ventilation pipe. To maintain the ventilating effect, air must be allowed to enter a pit through the inlet hole.

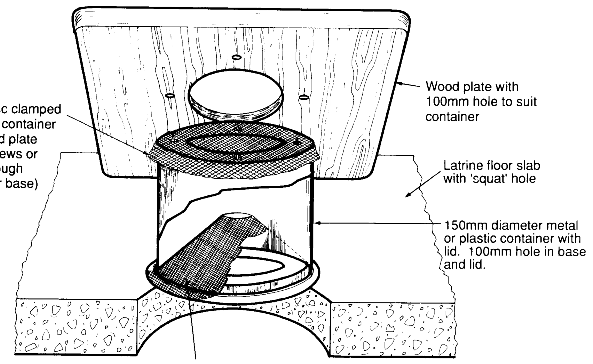

Figure 8 Mosquito and fly trap for latrine inlet hole (variation of pedestal insect trap— see reference 8)

Other mosquito breeding control measures, alternative to the mesh trap, have been found to be effective. A common measure is to float used engine oil onto the water surface, to cut-off the air supply to any mosquito larvae suspended in the surface film, and prevent subsequent egg laying[6]. Yet another method is to float expanded polystyrene beads, ideally a 20 mm thick layer of 2 mm diameter beads, onto the water surface to prevent egg laying [5].

An important aspect of the mosquito control measures described above, is that of ensuring the continuing presence of the selected barrier. The owners of the latrine system should understand the reasons for particular design features, and the need for regular inspection and maintenance.

Geckos (house lizards) are useful predators of both flies and mosquitoes. Their presence in and around pit latrines can help to control the numbers of these insects.

3.2 Ventilation pipes

The objective of installing a ventilation pipe and wall openings in a latrine superstructure, is to allow the wind blowing across the open pipe end above the roof, to generate an updraft in the pipe. This suction effect will slightly reduce the pressure inside the pit or tank which, in turn, will draw air in through the inlet hole. To assist the flow of air, it is important that the pressure inside the superstructure should be slightly higher than outside. This can be achieved by locating major wall openings to face the prevailing wind (see 3.4).

Ventilation pipes can be made of a variety of durable materials, eg plastics, asbestos cement, pitch fibre or rendered masonry. For a pipe with a smooth internal surface, such as UPVC, a 100mm diameter pipe is generally large enough. The pipe should discharge outside and about 500mm above the roof of the latrine superstructure, and the outlet end should be securely capped with an insect screen (see 3.3). For rougher surfaces, such as sand/cement rendered masonry, a 190mm square or 200mm diameter pipe should be a minimum to ensure an adequate upward airflow[9].

The ventilation pipe should be securely mortared into the base slab over the pit or tank (Figure 9), so that insects are unable to pass outside the pipe. Ventilation pipes should preferably be vertical, to maximise the effect of the wind blowing across the open end and dragging air and foul gases up the pipe. However, wind tunnel experiments at the Building Research Establishment have shown that 100 and 150mm, UPVC, ventilation pipes can be out of vertical by over 20 degrees before the wind induces a continuous downdraft in the pipe. Other reasons for installing ventilation pipes vertically, are to maximise the light visible from inside the pit and for good appearance. Therefore, to allow some construction flexibility while ensuring effective performance, it is recommended that the ventilation pipe should be no more than 10 degrees from vertical (Figure 10). Preferably, any inclination should be away from the prevailing wind.

3.3 Insect screens - materials and mesh sizes

Insect screens must be made of durable material. A screen must be securely fixed in position and be insect

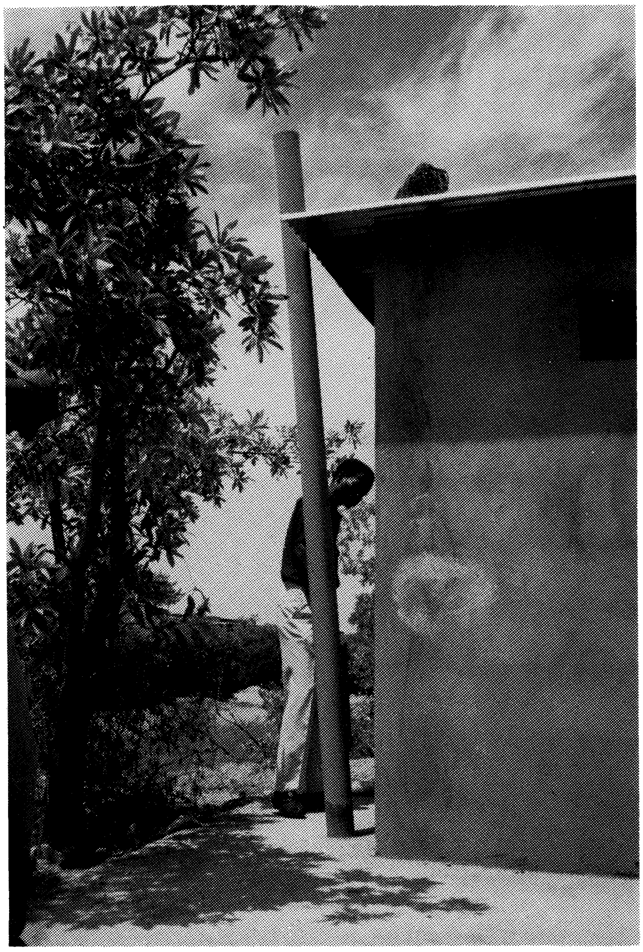

Figure 9 Ventilation pipe securely mortared into a pit latrine floor slab — insect proof joint

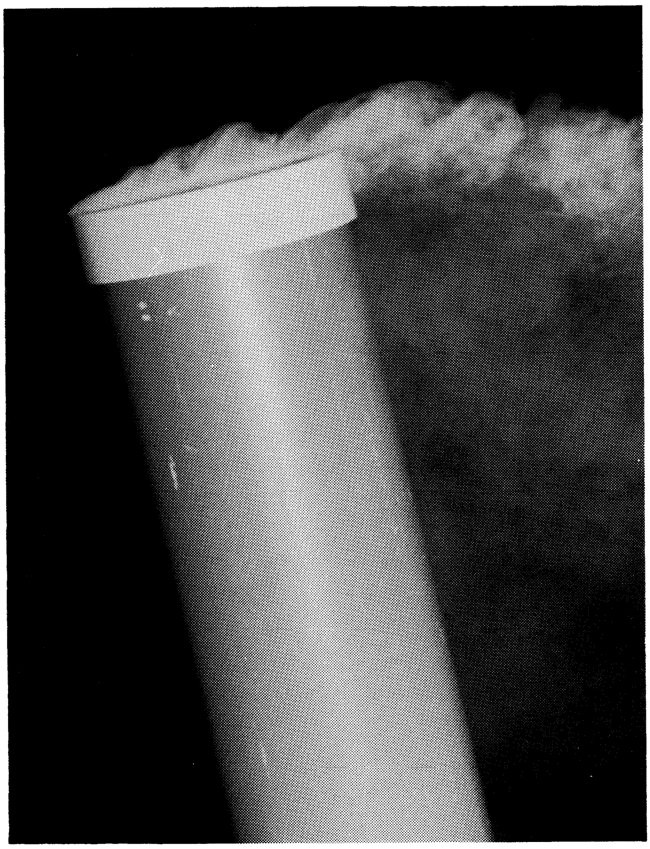

Figure 10 Smoke tracer drawn up inclined (10°) ventilation pipe due to wind across pipe end

proof (see Table for mesh sizes). Screen meshes should have a maximum open area, of the order of 60% or more, so that airflow through the screen is not excessively restricted. The ideal material is stainless steel woven wire mesh, which can last indefinitely. A cheaper material is PVC coated glass fibre woven mesh. This fabric mesh can have a life of several years where there is no risk of mechanical damage. Iron or steel meshes, even if zinc coated, are liable to corrode quickly when used to screen latrine ventilation pipes.

Mesh sizes to exclude insects:

Aperture length (sq)	Insects excluded
2.27 mm	Houseflies, blowflies
1.30 mm	Most mosquitoes
1.15 mm	All mosquitoes

Based on data from 'Insects and Hygiene'[10]

When UPVC or pitch fibre ventilation pipes are used, a stainless steel mesh disc can be fitted into a standard plastic cap fitting. If the disc is cut at least 5mm larger than the cap internal diameter, it will deform slightly into a shallow dome (Figure 11). The cap should be a tight fit on the pipe or be solvent welded in position. If a suitable standard cap is not available for a particular pipe material, stainless steel mesh or PVC coated glass fibre mesh can be wrapped over the pipe end and tightly bound with rust proof wire to secure it.

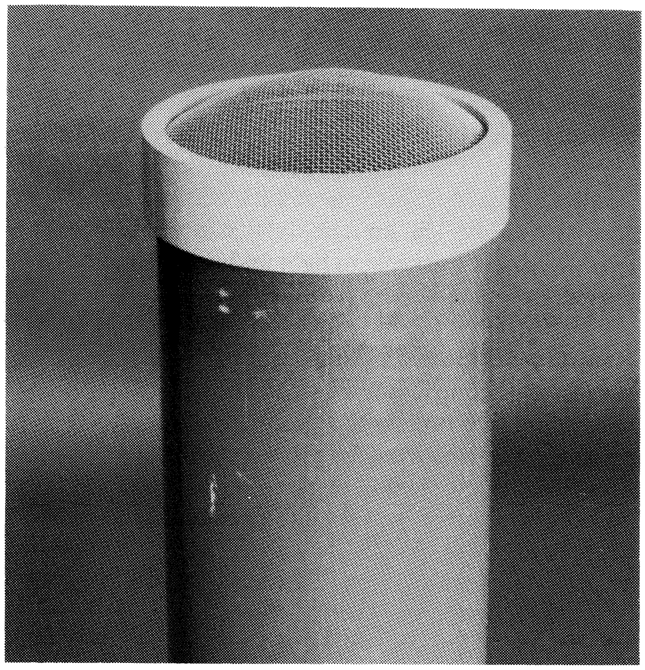

Figure 11 Insect screen — domed stainless steel mesh in standard 100mm UPVC pipe fitting

Whatever material is used for the insect screen, dirt fouling may eventually occur, particularly if birds are attracted by trapped flies to perch on the screen. Regular checking that the screen is intact is important. The mesh should be cleaned if the open area is obstructed, to maintain the ventilating airflow.

3.4 Wall openings

Latrine doors should be kept closed, to keep the inside in semi-darkness. Sufficient light for toilet users should be available through the wall openings. It is important that the brightest light visible from inside the pit or tank, should be seen through the ventilation pipe, to attract any emerging flies.

Wall openings in latrine superstructures can greatly affect ventilation pipe performance and therefore odour presence. Ideally the door should face the prevailing wind, so that if the door is accidently left open the wind will slightly pressurise the superstructure and prevent foul air from flowing back through the inlet hole. There should be a 75mm gap provided above the closed door to maintain a positive pressure in the superstructure. It is useful to have a vent of variable area (with a maximum area larger than the opening above the door) in the wall opposite the door, to be used if the wind direction produces a suction inside the toilet superstructure. This negative pressure would be indicated by the presence of offensive odour, caused by foul gases flowing back through the latrine inlet hole.

3.5 Sealing access covers and floor slabs

It is a common fault in latrine construction for gaps to exist between pit or tank linings, access covers and floor slabs (Figure 12). Flies, mosquitoes and cockroaches can often find easy access to faecal material through such gaps. Great care should be taken to seal all joints, particularly after access covers have been replaced after

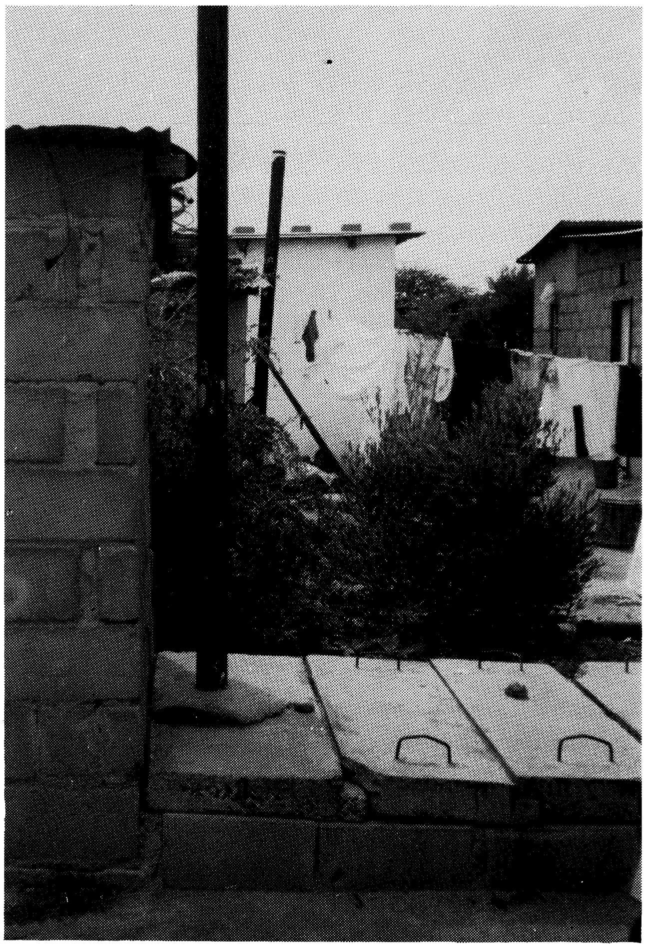

Figure12 Insect access through unsealed joints in coves of pit latrine

desludging. Damaged covers should be repaired or replaced. Sealing joints with weak cement:soil mortar (1:10 or 1:12 mix) is generally adequate. The mortar should not be too strong so that the joints can be purposely broken again when required for access.

Joint design between concrete cover slabs should be as simple and robust as possible. A simple vee joint (Figure 13), that can be easily sealed with weak mortar, can be quite adequate. Cover and floor slabs should be bedded in similar weak mortar onto the pit or tank lining. Where available and affordable, pit and tank access openings can be covered by cast iron or pressed steel covers in frames, that can more readily provide a reliable seal.

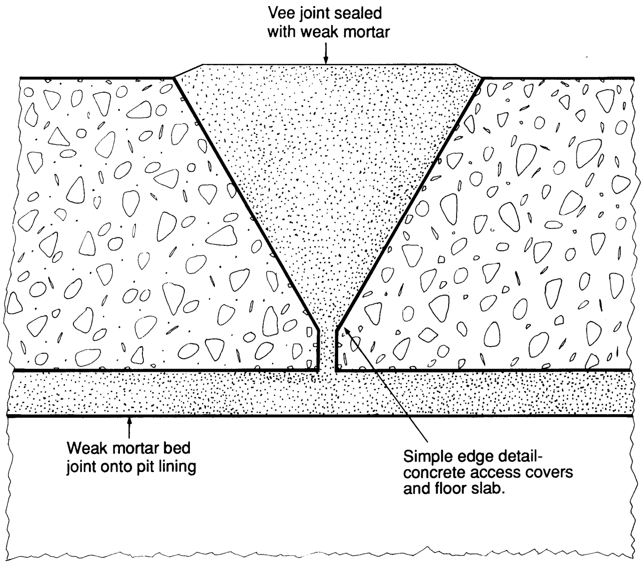

Figure 13 Vee joint between access covers and floor slabs of a pit latrine

Very basic and lowest cost pit latrines must also be carefully sealed to prevent access by insects. Pole floors, for example, can be made insect proof by plastering all gaps with mud, preferably stabilised with cement, lime or bitumen. The same insect screening recommendations for the ventilation pipe should apply, even though the ventilation pipe may have to be made from adobe masonry or other locally available material.

With effective sealing of joints, eliminating masonry cracks and fitting an insect screen and trap to ventilation pipe and inlet hole, almost complete elimination of insect access can be achieved.

4 INSECT CONTROL WITH INSECTICIDES

4.1 The use of insecticides

The regular use of insecticides to control infestations of flies and cockroaches in and around latrines is not recommended. It is usually more cost effective to reduce the initial attraction to insects, and the available habitat to prevent breeding, rather than rely on sprays and baits for control. However, occasional use of insecticides can be a useful way of reducing insect numbers, while at the same time taking steps to reduce habitat and attractions, such as odours, food supply and bodies of accessible polluted water.

Repeated applications of many insecticides can lead to insects aquiring resistance. Where repeated applications of insecticide are unavoidable, aquired resistance can be minimised by varying the type of insecticide used.

There can be harmful effects on operatives using insecticides, unless operatives are trained in their use and they wear protective clothing and masks. The choice of insecticide may be limited in some developing countries; the less preferred types may be the only insecticides available. Also, for domestic use, insecticides may not be affordable.

Great care is needed when using insecticides near watercourses and in the disposal of containers. All insecticides are particularly toxic to fish.

Where there are infestations of cockroaches in pit latrines, it is sometimes an option to spray ('fog') the pit when it is to be desludged. The inside surfaces should be sprayed immediately on opening the access covers, to cover as many insects as possible. This treatment will also eliminate fly larvae at the same time. Attention should be paid to more effective sealing if such infestations occur.

4.2 Types of insecticide[11]

The control of populations of flies, cockroaches and mosquitoes is usually with contact insecticides. They fall into two groups, non-residual and residual.

Non-residual insecticides. The best known non-residual insecticide is pyrethrum, which is a natural insecticide derived from pyrethrum flowers. An extract from the flowers is usually diluted with kerosine and used as an atomised spray. The insecticidal constituents of natural pyrethrum are unstable in light and air, and so have virtually no long-lasting (residual) effect.

Natural pyrethrum and some synthetic pyrethroids are very quick-acting and are useful for immediate alleviation of biting insects or to knock down cockroaches. However, larger insects such as cockroaches and blowflies, can recover from this 'knockdown' effect and so a killing agent is added to the spray formulation. Aerosol containers of insecticide are sometimes available and are convenient to knock down fast moving insects.

Residual insecticides. Residual contact insecticides are stable, organic chemicals which, when applied to a surface, remain toxic to insects for several months. However, many once-common residual insecticides are now known to be health hazards. They have been classified by the World Health Organisation (WHO) as being hazardous to humans in varying degrees, eg malathion is 'slightly hazardous', chlordane and DDT are 'highly hazardous', and dieldrin is 'extremely hazardous'. Use of these organochlorines, organophosphates and carbomates should only be used with strict control, and by trained and protected personnel. (See ref 11 for more complete information on insecticides, including types, names and applications).

Stable synthetic pyrethroids. Whereas all insecticides are toxic to humans to some degree, the synthetic pyrethroids have been mainly classed by the WHO as being 'unlikely to present an acute hazard in normal use'. Stable synthetic pyrethroids now exist with residual effects comparable with other conventional residual insecticides. Two examples of stable synthetic pyrethroids are permethrin and deltermethrin. They are very quick-acting, have longer-term residual effects and are effective killing agents for flies and cockroaches. They are commonly marketed as domestic sprays.

5 CONCLUDING COMMENTS

In this OBN, design and construction features of latrines have been highlighted that can greatly affect the health of users and the general community. The contamination of food by flies and cockroaches is not uncommon in communities that have on-site sanitation systems. A latrine that only serves to collect and store excreta, while probably improving the general cleanliness of the surroundings of houses, can also provide ideal insect breeding habitat. It is important to prevent access to a pit or tank by potentially disease carrying insects.

By properly constructing and maintaining a latrine, a great reduction in fly and cockroach populations can be achieved. However, care is required not to provide an attractive habitat inside a dwelling. Food should be covered to prevent contact by insects. Dampness and dirt should be discouraged, to reduce attractive habitat for insects. All these measures can benefit individual and community health.

Mosquito populations can also be reduced by improved latrine construction. However, this is unlikely to be so significant as for flies and cockroaches, unless other bodies of standing water are protected to prevent mosquito breeding.

6 ACKNOWLEDGEMENTS

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