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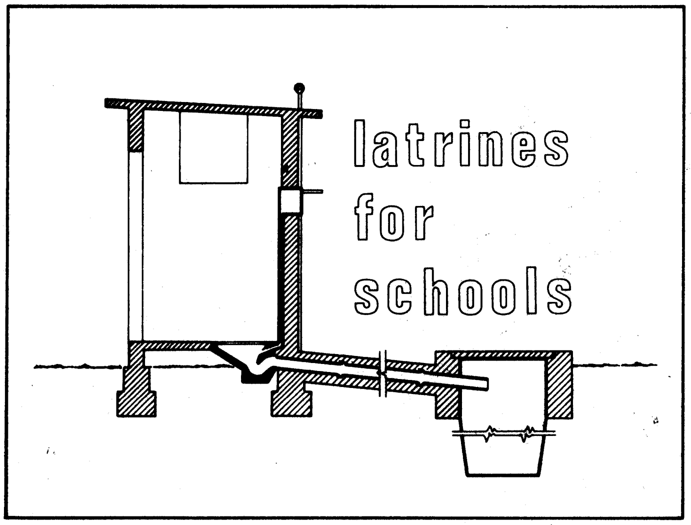

UNESCO REGIONAL OFFICE FOR EDUCATION
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Reprint Series No. E. 5

Educational Building Documents

LATRINES FOR SCHOOLS

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The Water-Seal Latrine*

by E.G. Wagner and J.N. Lanoix

Description

The water-seal latrine, also called the pour-flush unit, consists of an ordinary concrete slab into which a specially made bowl is incorporated, as shown in Fig. 1. Usual practices call for a seal 1.25–3.75 cm (0.5–1.5 in.) deep. Such a slab may be installed directly over or at a close distance to, a pit, bore-hole, or septic tank. In the case of the septic tank, the bowl is connected to the tank by a short length of pipe. One to three litres (or quarts) of water are sufficient to flush the contents into the pit. Because of the water seal, flies cannot gain access to the contents of the pit, and odours cannot escape.

Design and construction

The squatting plate

Various methods have been developed to cast the slab and bowl (see Fig. 2 and 3). Sometimes the trap assumes a P-shape or an S-shape, depending upon the location of the slab with respect to the pit.

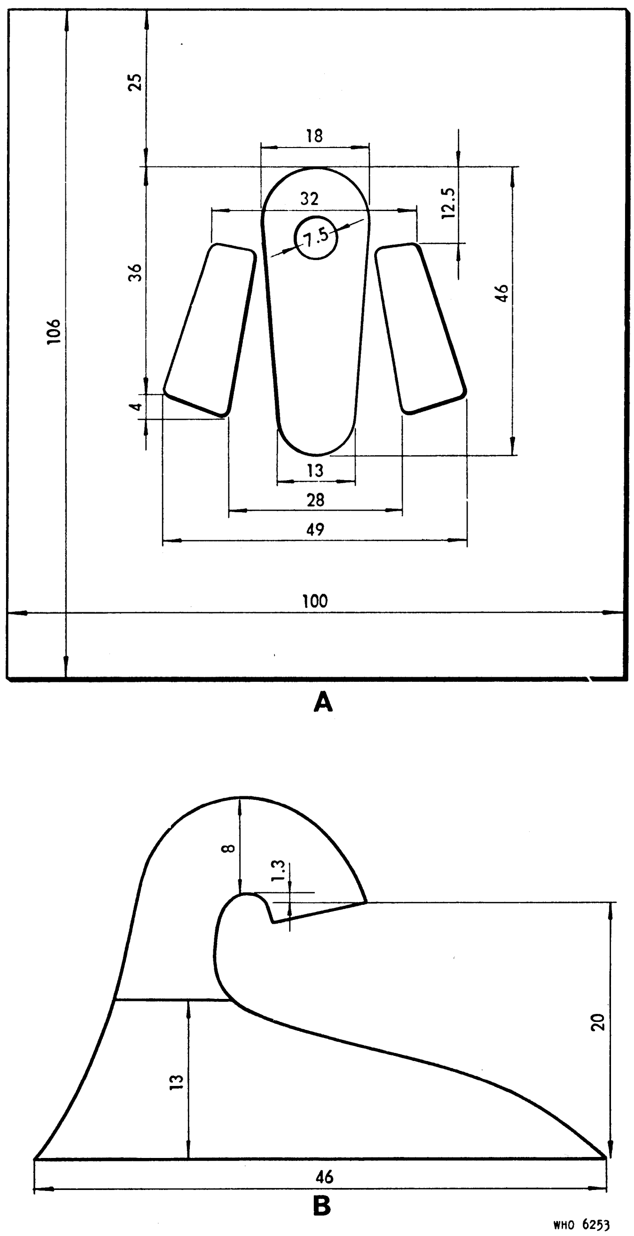
The following description is drawn from experience at Chiangmai, Thailand, where latrine bowls were formed from cement mortar and incorporated in concrete slabs. The Chiangmai technique, which is applicable everywhere, was found to be more practicable and to result in lower costs than most of the previous methods of casting. The dimensions given are intended merely as a guide, since the size and shape of latrine bowls and slabs are subject to local variations. In particular, the inclusion of raised foot-rests is a debatable point.

The general method of manufacture is as follows. A form is prepared in the shape of the interior of the bowl and trap; the form is plastered with a mixture of Portland cement and sand; and the bowl is left to harden and cure at the point of manufacture. The finished bowl is then transported to the latrine site; the latrine slab is cast, with the bowl forming an integral part of it; and the finished slab, after hardening, is lifted into place over the latrine pit.

A longitudinal profile of the form for the interior of the bowl is shown in Fig. 1B. Each form consists of two parts, the main portion being made of a rich cement mortar (two parts Portland cement to one part sand), or of solid wood, carefully finished and oiled; the other part of the form—for the interior of the trap—is made of clay. In Chiangmai, the wooden form costs the equivalent of US $ 3.40 and is much preferred to concrete, both because of its superior durability and because of the greater ease with which it allows the bowl to be removed.

The clay to be used in making the form for the interior of the trap is kept covered with water until needed. When it has been brought to a workable consistency by the addition of ash, it is moulded into a U-shaped roll in a curved pipe-mould. An essential part of the form is a shelf,

Fig. 1. Water-seal latrine

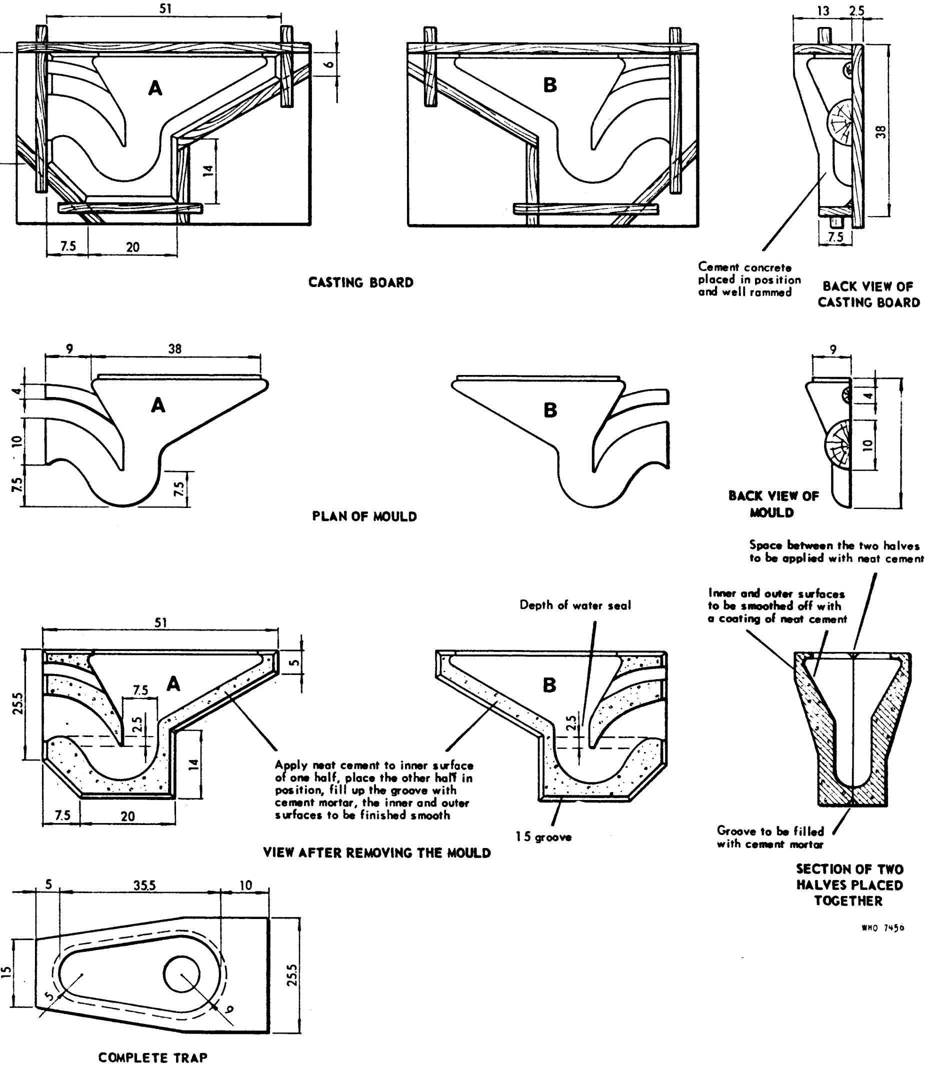


Measurements shown are in centimetres.

A = Plan
B = Form for casting water-seal bowl

* Reprinted from *Excreta disposal for rural areas and small communities* (WHO Monograph Series, No. 39) by E.G. Wagner and J.N. Lanoix. Permission given by World Health Organization.

Fig. 2. Method of casting water-seal slab in Ceylon



Measurements shown are in centimetres.

Details of casting

The casting boards A and B with the moulds fixed should be placed in position and cement concrete 1 : 2 : 2 (0.6 cm or 0.25 in. gravel) should be deposited into position and well rammed.

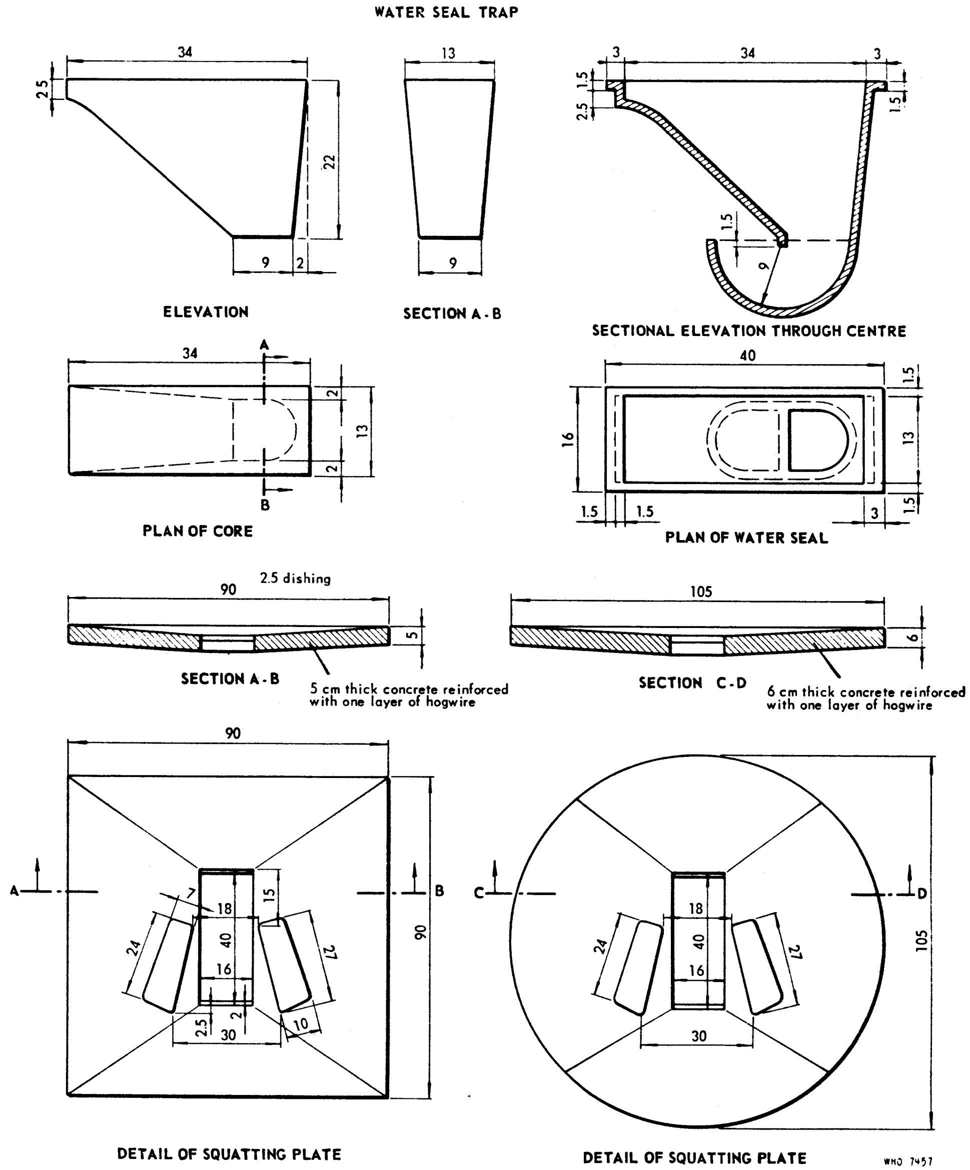
Twenty-four hours should be allowed for setting.

Remove the two halves and apply neat cement to the edge of one half and place the other half in position and fill up the groove with cement mortar.

The inner surface should be smoothed off with a coating of neat cement.

After completion, the trap should be cured in water for a period of at least one week.

Fig. 3. Water-seal trap and squatting plate



Measurements shown are in centimetres.

Siphons made of a cement-sand mixture (1 part cement to 1 part sand). Upper portions and lips 1 cm (1/2 in.) thick; lower portion, 0.9 cm (3/8 in.) thick. Finished weight about 26 kg (12 lb.). Cast inverted in one operation by plastering over core and expendable clay mould (for trap).

which is used to support one end of the U-shaped roll of clay; the other end of the clay roll rests upon the main part of the bowl form. The shelf is located 20 cm (8 in.) above the base of the main form. When the U-shaped roll is set in place, it is carefully smoothed to the main form with a small trowel, so that no irregularity is left on the interior surface of the finished bowl. The whole assembly is then oiled.

A thin cement-sand slurry is pressed over the form by hand, and dry cement is dusted on to provide the bowl with a dense, smooth interior surface. Finally, a stiff mortar, consisting of one part Portland cement to three parts sand, is pressed on by hand and trowelled smooth to a uniform thickness of 1.25 cm (0.5 in.). The bowl is left in place for 24 hours or longer, and is then removed from the form, taking the clay core with it. The operation of preparing the form and making one bowl requires about 25 minutes. After the bowl has hardened, the clay core is dug out of the trap with a small trowel, the entire surface is washed with a cement-water slurry, and the finished bowl is set aside and kept wet for about one week to cure. One 50-kg (110-lb.) bag of Portland cement, costing about US $1.50, is sufficient for 27 to 30 bowls.

One advantage of the Chiangmai bowl is that the trap discharges forward, beneath the mid-section of the bowl. Experience with traps that discharge towards the rear has shown that the back wall of the pit is liable to be washed away. Such a danger is minimized when the discharge is near the centre of the pit.

The details of the slab used at Chiangmai are shown in Fig. 1A. The size of the slab must be adapted to the dimensions of the pit. Whether or not a special foundation is needed to support the slab edges depends upon the nature of the soil. The finished bowl is transported to the site of the latrine and is cast into the squatting slab. A hole is dug, and the bowl is inserted so that its rim is level and 5 cm (2 in.) above the surface of the ground. Loose soil is packed around the bowl, and a wooden frame, 5 cm (2 in.) high, is set in place, with its upper edge level and 2.5 cm (1 in.) above the rim of the bowl. The ground inside the frame is then smoothed and tamped, so that it slopes downwards from the frame towards the bowl; thus a uniform thickness is preserved in the finished slab. Some kind of reinforcing material–chicken-wire, for example–is then laid, and 5 cm (2 in.) of concrete, made with one part cement, two parts sand, and four parts broken stone (not over 2 cm (0.75 in.) in diameter), is poured on and trowelled to a smooth finish from the upper edge of the form to the edge of the bowl. The slab must have an even finish to ensure easy drainage into the bowl. If foot-rests are required, separate small wooden forms may be used. It should be noted that casting on the bare ground eliminates the need for the heavy and expensive base-boards and ribs which are commonly used. After the slab has hardened, the pit is prepared, and the squatting plate is lifted by hand and set in place over the pit.

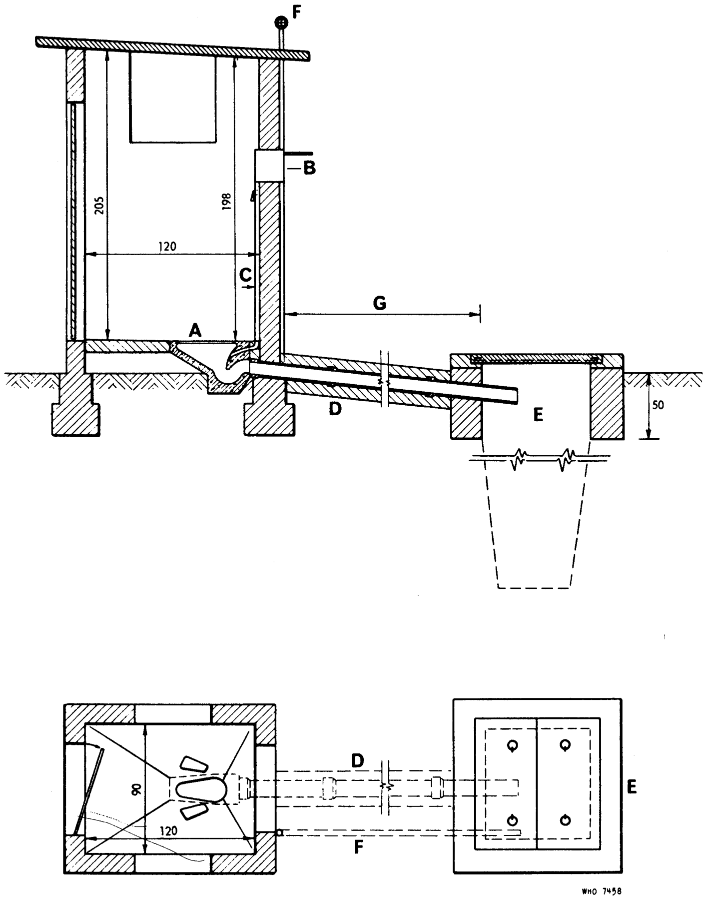
The cost of such a slab, based on 1955 prices, has been calculated in Chiangmai as follows:

Item	US $*
Bowl	0.25
Slab:	
cement (1/3 bag)	0.50
labour**	0.23
reinforcement	0.23
sand and gravel	0.14
Total	$ 1.35

* Exchange rate of 22 Baht to the dollar
** Daily wage of US $0.68

This estimate includes the overhead costs for casting bowls at a central plant, but not, of course, the cost of digging the pit or building the superstructure. According to Chiangmai experience, when a householder supplies the labour for these last two items, his total expenditure on materials for the squatting plate and the superstructure

Fig. 4. Water-seal latrine used in Ceylon



Measurements shown are in centimetres

A = Water-seal bowl with S trap
B = Water tank, filled by hand and provided with plug cock and overflow pipe
C = Water pipe leading from tank to bowl for flushing purposes
D = Drain pipe embedded in concrete leading to seepage pit
E = Seepage pit
F = Ventilation pipe for pit
G = Distance between bowl and pit should be as short as possible

amounts to approximately US \$2.30, that is, about one-sixth of the monthly income of the lowest paid worker.

The disposal system

When the squatting plate is placed over the disposal pit, the latter is designed and built in the same manner as for ordinary pit privies. If the squatting plate is installed inside the dwelling, the pit is dug outside and assumes the shape and design of a leaching cesspool, or of a bore-hole. In this case, the distance between the cesspool or bore-hole and the squatting plate should be as close as the building foundation permits; otherwise, the drainpipe becomes too long and tends to clog within a short time because of the small volume of water used to flush the faeces from the bowl (see Fig. 4). The drain pipe is usually 10 cm or 15 cm (4 in. or 6 in.) in diameter and made of cast iron or ordinary cement sewer pipe laid with a steep slope (not less than 5%). Because of the added expense and difficulty in laying this pipe, it is often preferable to place the squatting plate directly over the pit or bore-hole.

Another system makes use of a septic tank in lieu of a pit or bore-hole in areas where the ground water is high and interferes with the proper functioning of deep pits. This system is, of course, very expensive for ordinary rural areas and communities. It should be noted that,in addition, a subsoil disposal field is required in such systems for the effluent of the septic tank.

Location

If properly operated, latrines equipped with the water-seal-type slab fulfil all sanitary requirements and may be placed inside the dwelling itself. Some engineering factors governing the location of the disposal system often prevent such an ideal arrangement. However, even then it is possible to locate such latrines very close to the houses which they serve, a condition which ensures its daily use in bad as well as good weather.

Advantages and disadvantages

These may be summarized as follows:

Advantages

1. The water-seal (pour-flush) latrine, when properly operated and maintained, satisfies all sanitary and aesthetic criteria.

2. It can be installed near or inside the dwelling.

3. It minimizes contact with flies and vermin.

4. The odour nuisance is kept to a minimum.

5. It is entirely safe for children.

6. With improved construction techniques, it is simple to build and cheap for use in rural areas.

Disadvantages

1. It can be used only in areas where water is obtainable (a small volume will suffice) the year round.

2. It requires a period of intensive education in its proper use and cleaning and continued follow-up by sanitation authorities.

3. It costs slightly more than ordinary pit privies, but less than aqua privies.

4. In many rural areas of the world, it would require a change in customary use of cleaning materials.

5. It is not readily applicable in areas with impermeable soils.

6. It cannot be used in freezing climates.

In countries of South-East Asia, latrines with water-seal slabs have been used for more than 20 years, and appear to have been readily accepted by the rural people of the region, as they fit in well with their customs and religious patterns. Experience shows, however, that the water-seal latrine should be used only in family installations, that it is not suitable for use in public conveniences.

A Ventilated Pit Privy

by Peter R. Morgan, Blair Research Laboratory,
Salisbury, Zimbabwe-Rhodesia.

The deep pit latrine has distinct advantages in that it is cheap to build, easy to use and requires little maintenance, but it also has the disadvantage of acting as a perfect site for the transmission of flyborne disease. Some pit latrines are only one degree better than no sanitation at all, and under certain conditions may be worse! As a result they are often replaced by more complex waterborne systems of sanitation which can often be equally undesirable.

Many attempts have been made to overcome the offensive odours and fly breeding commonly associated with pit latrines. 'Solutions' here included the use of coverplates, fly traps and chemicals, but all these methods are far from foolproof and cannot be regarded as successful. Ventilation pipes had been tried, but with limited success[1] until the system described here was put into widespread use in Zimbabwe-Rhodesia in 1976 after two years of thorough testing[2,3]. The Blair Ventilated Privy, as it is known, provides almost complete protection against flies and odours emanating from the pit without the use of water, chemicals or coverplates. This makes it particularly useful where water is scarce or difficult to pipe to conventional waterborne sanitary devices, and it is safer and certainly more reliable than many waterborne methods of sanitation currently in use.

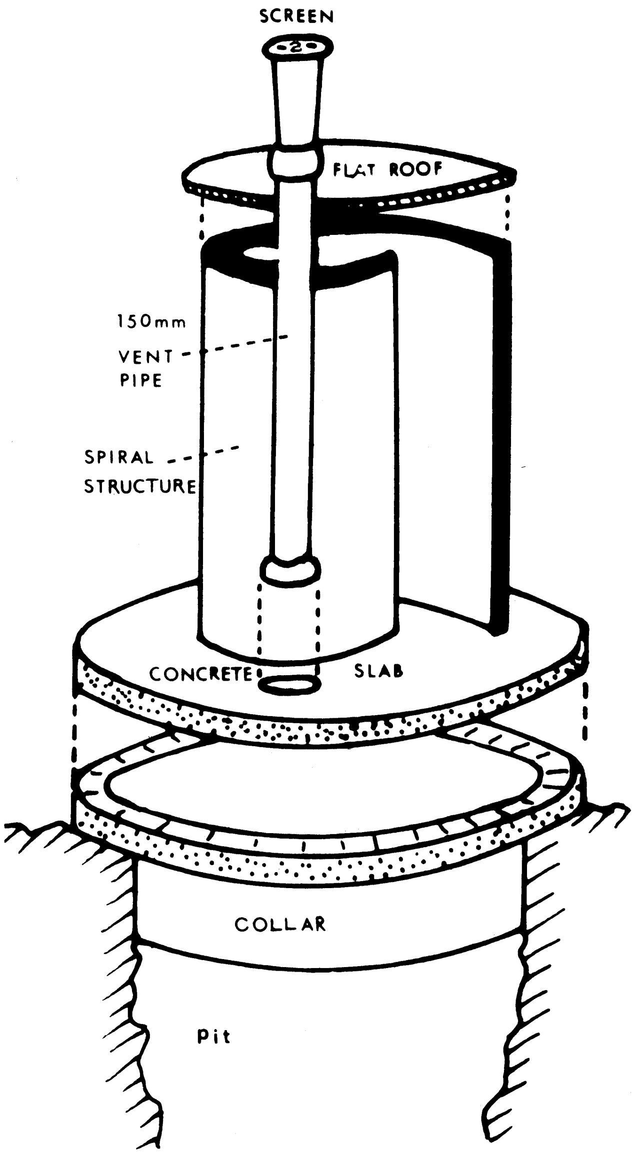


Fig. 2 Diagram of privy.

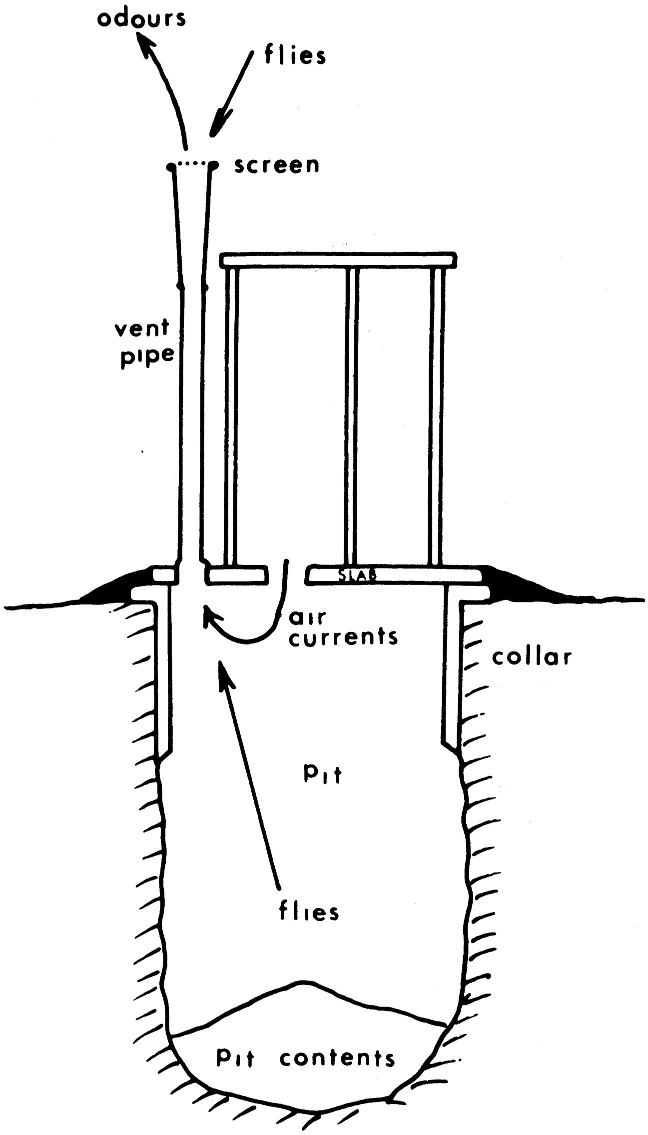


Fig. 2 Cross sectional diagram showing air currents and fly movements.

The system partly depends on the aerodynamic properties of an efficient fluepipe, 150 mm in diameter and about 2.5 m high. If this is fitted on to a concrete latrine slab over a sealed pit or tank the temperature difference between the inside and outside of the pipe will cause a convection updraught, drawing air and gases from the pit and thus causing a downdraught through the toilet aperture. Efficiency is increased by painting the pipe black and facing it towards the equator where it receives most sunlight. If there is a wind or noticeable air movement across the top of the pipe, air is drawn through the system even at night or in cold weather. The top of the pipe is elevated above the roof level and kept away from trees to reduce air turbulence which causes a loss of efficiency. The upper end of the pipe is cone-shaped and opens out to 200 mm and is fitted with a copper or fibreglass flyscreen (Fig.1).

When the latrine is in use, flies from outside are attracted to the odours passing up the pipe and tend to avoid the interior of the privy. Fly-breeding is thus reduced in the pit. Flies emerging from the pit travel towards the greatest light source and are attracted up the pipe, if the latrine structure is dark enough within. They are prevented from escaping by the screen and eventually die (Fig.2). The pipe thus performs three functions: it draws out odours, prevents much of the fly breeding and traps most of the flies that might emerge. It is essential that the pipe is large enough to enable the system to breathe efficiently and that it allows sufficient light to enter the pit to attract flies. 100 mm, 150 mm and 200 mm pipes were used in trials. The 100 mm pipe was ineffective and the 150 mm type was chosen because of its efficiency related to cost.

Basically, the privy consists of a reinforced concrete slab placed over a deep pit lined with bricks or plaster. Two openings are made in the slab, one outside the superstructure for the pipe, the other within the structure for the squatting hole. The structure itself must be darkened inside and the most successful are cast in a spiral form without a door (Fig.3). The structure can be built from bricks but a popular method of building consists of plastering a corrugated iron mould with a plaster mix using chicken wire as reinforcing.

Although the system works well without water, the privy can be built over a septic tank or seepage pit. This type of privy has been modified to produce biogas, and the pipe can also be designed to trap flies which have bred in other

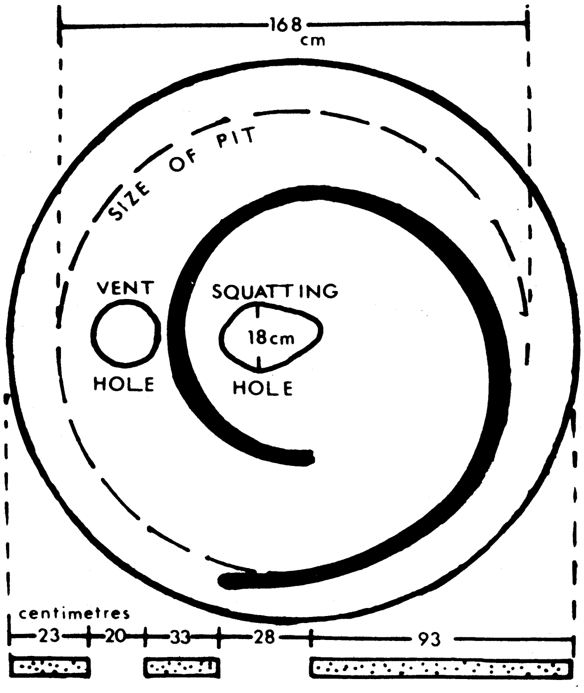


Fig. 3 Specifications of concrete slab.

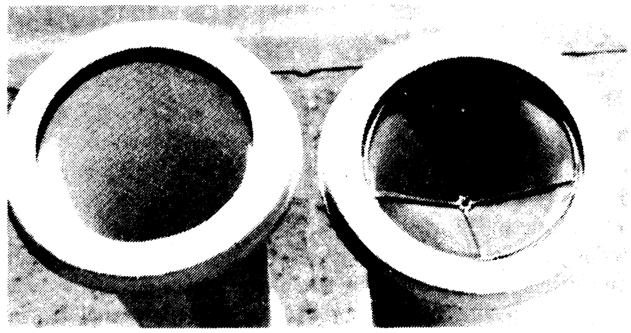


Fig. 4 Standard (left) and modified fly trapping screens.

places. This latter modification is particularly effective for reducing the nuisance of flies in compounds and other other living areas[4]. The ventilated privy works at its best when built as a single unit, with one pipe serving one squatting hole. Other combinations have been tried but are not as effective at reducing odours. An allowance is made for 0.087 cu.m. (3 cu. ft) per person per year when estimating the capacity of the pit. Pits are dug round and plastered in situ for strength, usually about three to five metres deep. The properties are retained even when the contents of the pit lie only 30 cm below the aperture.

The effectiveness of the unit has been tested thoroughly and one typical experiment serves as a good example. Four identical privies were built in a row, but only two were fitted with vent pipes. All the units were put into use for six months before the experiment. During the period October to December 1975 weekly counts of fly output were taken from one pair of structures (vented and unvented) whilst the other pair stabilised in use. The traps were moved from one pair of privies to the other at monthly intervals. During the period October 8 to December 24, 13,953 flies were trapped from the unvented structure, Fig. 4) whilst only 146 were trapped from the vented structures. The structures differed only in the presence or absence of the ventilation pipe.

The ventilated privy described in this article is very popular in Zimbabwe-Rhodesia and many thousands are now in regular use all over the country. Its success and acceptability can be ascribed to its simplicity and reliability and the fact that it does not necessarily need water to operate. It employs the forces of nature alone to overcome the passage of disease.

Acknowledgements

Sincere thanks are due to Mr Norman Johnston and Mr Ephraim Chinembiri who have contributed so much to the development of the Privy. Thanks are also due to the Director and staff of the Blair Research Laboratory, and also to the Secretary for Health for permission to publish this article.

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Excreta Disposal Without Water

Krisno Nimpuno, formerly at the Ministry of National Education, Dar es Salaam

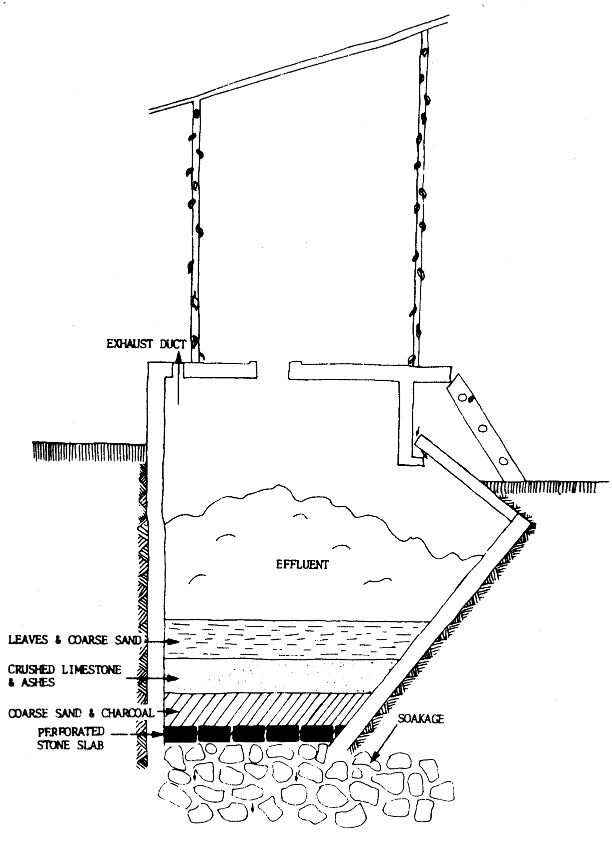
The shortcomings of the present sewage systems in East Africa are too obvious to be ignored. All the systems used in urban areas are expensive. The flushing system wastes very precious water in large quantities. The pollution caused by the water-borne systems is considerable. Therefore we simply feel that water-borne sewage systems are unsuitable. With all this in mind we have tried to devise a system which combines the best attractive aspects of the various systems illustrated in this article. The results of our efforts is the Biopot which we hope to be sufficiently flexible and effective to give an adequate answer to the most urgent urban and rural needs.

The Biopot is a closed system, does not contaminate the groundwater, the soil or the air and avoids the need for transporting offensive material. There are two stages of bio-chemical treatment involved: firstly an aerobic decomposition, secondly an anaerobic process which eliminates dangerous micro-organisms. Finally a chemical treatment takes place. As the main treatment is a composting process the additional advantage is that the bulk of the household garbage can be received and treated as well. The Biopot will thus yield very concentrated, rich manure. All the organic material can be used and instead of being a costly liability it becomes a valuable commodity. The system can be applied to existing neighbourhoods and the standard can vary according to the funds available.

The Biopot is a basically dry system. Although limited amounts of water may be used for flushing; there is no need for large quantities of water for the purpose of transporting the excreta. Little dilution of the raw sewage takes place and the volume which has to be treated is therefore significantly less. The system should be safe and cheap in operation. As long as the toilet is in use, ample oxygen is available inside the compartment. This ensures a rapid breakdown of the excreta in the same way as organic material in the open decomposes and changes into soil. The wastes will be broken down by micro-organisms in an aerobic process. The availability of alkaline material is important to neutralize the urine acids and for this reason it is necessary for ashes to be thrown into the vault daily. Paper and other household wastes will supply the cellulose which serves as a fuel in the decomposition process. When the vault is closed, a further decomposition will take place and complete the process. This involves anaerobic micro-organisms and it will be started by filling the pit with fresh green leaves. The temperature will now rise rapidly and remain at over 60°C for a prolonged period.

The sustained high temperature destroys all pathogenes, and the large organic molecules of the excreta successively break down into simple stable combinations, like nitrates and sulphates. It is essential that sufficient fluids are available in the deposited mass to reach such a level of humidity that the chemical process can be sustained. But it is of equal importance that excess fluids are drained away and that there is no standing water. The biochemical process takes several months and finally when the temperature has again reached normal level a homogenous compost remains. This material is now a completely inoffensive, odourless and dry black soil and it makes an excellent manure, rich in nitrogen and potassium.

Having built the biopot a filter is then put into it. The uppermost layer of the filter consists of leaves and coarse sand and aims at trapping the solid particles in the fluids. The next layer consists of calcium carbonate, for instance a combination of crushed limestone and ashes. This layer will neutralize the acids and the passing fluids will become alkaline. The third layer consists of coarse sand and charcoal and will trap the remaining organisms and particles. The filter rests on a perforated stone slab which is a permanent part of the construction. The neutralized fluid will have lost its smell after passing through the bottom plate into the soakage from where most will evaporate. At the end of the cycle the top part is removed and mixed with the other material and becomes part of the manure. The toilet house itself can be of any type of structure. It consists of one closet which is mounted over two vaults. Only one vault is used at a time, the other vault is closed by an airtight cover. The vault in operation has a flush bowl or a drop pipe with an automatic seal, and has such dimensions that it will take a family of six people nine to twelve months to fill it.



Biopot. Complete decomposition and pastorisation through high temperature composting. Chemical filter controls humidity even in humid tropical climate. Yields valuable manure.

The toilet has a conventional squatting plate. It is possible to flush the bowl with a very limited amount of water. It is therefore easy to keep the toilet clean and as the squatting plate is recessed, the floor can be kept dry. The flat floor drains towards the centre where one of the vault openings has a recessed squatting bowl with a seal, the other opening is closed by a slab almost level with the floor.

The seal or valve prevents odorous gases from entering into the room and eliminates the danger of flies and other insects entering into the space beneath but it still allows the easy disposal of paper, ashes and other wastes.

The fluids that pass through the disposable alkaline filter become completely harmless and finally seep into the last stage of the system. This stage will differ under various circumstances.

In areas with a low water table it can consist of a soakage trench. Then the infiltration takes place through a limestone and sand bed. If there is a very high water table another solution should be chosen. The fluids are collected in a tank which can be emptied if necessary.

The ventilation for the evaporation of the excess liquids from the tank or the soakage is promoted by the exhaust duct which is led through the fermentation oven, sucking in the colder air from outside into the tank. When the vault has been filled, it is closed hermetically. The fluids now drain slowly from the deposited mass and an anaerobic decomposition takes place, composting the material. After six months a cover in the vault can be opened and the then dry manure can be removed and a new cycle starts.

The choice of building material is primarily a question of costs and availability. In its simplest form it can approach a pit latrine. The superstructure may even be as simple as a screen of straw or branches. The vault can be constructed of sun dried mud blocks lined with a lime plaster. The seal can be omitted and a lid can cover the opening. All this can be done as self-help under supervision and the cost would be very small. If more money is available, the vault can be made of concrete blocks. The top slab and the vault cover can be made of concrete, and the water seal and squatting plate may be made of metal for instance, enamelled or galvanized and plastic treated iron. It is also possible to install a flusher but the quantity of flushing water should be limited to three to five litres at a time.

The significant differences compared with other systems are the following:

- All excreta remain in the toilet inaccessable to insects and animals;
- No handling of offensive material takes place and no water for transport is required. It is a self-contained system which can even solve the sewage problems in existing residential areas, urban as well as rural;
- The decomposition is complete and all pathogenes and larvae are destroyed, due to the high temperature. Fluids which have infiltrated into the earth or evaporated are likewise harmless and odourless;
- The alkaline filter neutralizes the acids rendering the system environmentally safe;
- As all other organic wastes can be deposited into the vault the problem of waste disposal is solved simultaneously. Only glass, tins and other indestructible material have to be carted away;
- The dry manure forms a valuable material which will help to make the system pay for itself;
- The system is cheap and its standard of construction can be adapted to the budget and standard of the rest of the building;
- Even if the filter is not properly handled the system is quite safe: the fluids entering the soakage will be more neutralized and harmless than the overflow water from septic tanks or aqua privies;
- If the seal is defective the toilet will still give less smell and insect problems than other latrines because the vault is kept dry and the contents will no longer be acidic.

It is important that the users be made aware of the nature of the system and that proper instructions are given. Field experience must be gathered to develop a reliable routine for the wider introduction and adoption of the system.

The Biopot system is under construction for a residential area in Dodoma, Tanzania. It is also planned to build a series in some villages in the same region. These projects will offer the first major testing areas and are intended to yield the information and experience needed for wider application. It will doubtless be necessary to conduct extensive tests in order to gain the experience necessary to determine suitable materials and construction details.

A great number of variations could be developed to suit different conditions in the country. If the Biopot fulfils its promises, new town planning possibilities will be available. The first version of the Biopot system has been described in a Swedish publication, *Sanitara Anglaggningar i Tropikarna,* Krisno Nimpuno, Goteburg 1972. Changes were made at the suggestion of Mr Ha Hong Hai of the Vietnamese Embassy in Dar es Salaam.

CRITERIA / TYPE	Health Criteria							Cost Criteria			
	No handling of fresh excreta	No pathogene survival	No ground water pollution	No surface pollution	No insect breeding	No odours	Full BOD digestion	Local materials and technology	Less than 10% of housing costs	Low water consumption	Valuable by-product.
Pit Latrine	●	●		●			●	●	●	●	●
Bored-hole Latrine	●	●		●		●	●	●	●	●	●
Methane Digester	●			●	●	●	●		●	O	●
Aqua Privy or Septic Tank	●			●	●	●	●	●	●		
W.C. with Treatment Plant	●	●	O	●	●	●	●				
Bucket Toilet			●	●	O			●	●	●	
Chemical Toilet	O		●	●	●	●		●	●	●	
Freezing Toilet	●		●	●	●	●				●	
Packing Toilet	●		●	●	●	●			●	●	
Recirculating Fluid Toilet	●	O	●	●	●	●				●	
Vacuum System & Lime Stabilization	●	●	●	●	●	●	●			●	●
Incinerating Toilet	●	●	●	●	●		●			●	
Compost Toilet	●	●	O	●	O		●	●	●	●	●
Mouldering Toilet	●	●	●	●	O	●	●	●	O	●	●
Vietnamese Toilet	●	●	O	●	●		●	●	●	●	●
Biopot Toilet	●	●	●	●	●	●	●	●	●	●	●
Pack - Freeze-Compost Toilet	●	●	●	●	●	●	●				●

● Criteria Fulfilled
O Criteria Fulfilled under certain conditions

The Vietnamese Toilet

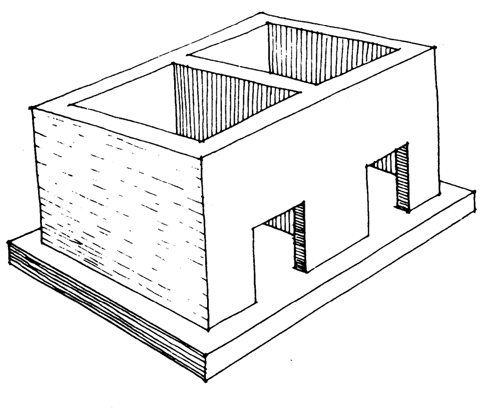
by Dr Krisno Nimpuno, 400 15 Gothenburg, Postbox 53 156, Sweden.

Many industrialized countries are now awakening to the drawbacks of water-carried disposal systems. Conventional sewerage has developed surprisingly little since its first application in 1842 in Hamburg, Germany, and some of its basic merits are now being questioned. Water is recognized as a valuable and limited resource, yet the average American, for instance, uses over forty tons of clean water each year to flush excreta — 25 kg of solids and 500 kg of fluids — out of his house. It is then mixed with industrial sewage and, after treatment, large quantities of sludge form mountains of horrific waste which cannot be used.

The search for adequate alternatives is therefore gaining recognition. Mouldering and composting methods have attracted much attention in recent years, and, in Northern Europe and North America, numerous attempts have been made to apply these methods to remote locations and in recreational areas. Both methods are based on the simple concept of the gradual breakdown (in the presence of oxygen) of organic matter in excreta by aerobic micro-organisms. Pathogens either die off during the long retention period, or because of the high temperatures that the composting process generates. However, when applied on a large scale, with less supervision, few systems prove to be sufficiently foolproof to be recommendable for general application.

Toilets which do not function properly are not only unhealthy but also unpleasant, and it is the emotional reaction of the user rather than consciousness about possible health risks which ultimately determines whether or not the toilet will be used. Nobody wants toilets with a foul smell where insects lurk and where laborious emptying and maintenance tasks are required.

The Vietnamese toilet was developed by a research team in the National Institute of Hygiene and Epidemiology in Hanoi under Dr Nguyen Dang Duc. The project started in 1956 and the first published report, appearing in *Vietnamese Studies*, used the name 'double septic tank'. Later, the term 'double septic bin' was used; in this article, it is simply called the Vietnamese toilet. The biological excreta treatments which do not use water to dilute and transport human waste, such as mouldering and composting, are all based on processing the mixture of urine and faeces. The sole exception is the Vietnamese system which treats the two separately in an anaerobic process, in the absence of oxygen. When urine is included, the large quantities of fluids, high acidity and the high nitrogen content complicate composting and require large quantities of carbon. The Vietnamese avoid this by separating urine and then opting for anaerobic composting. The process generates so much heat that adequate pasteurization takes place. After five days, a temperature of 45°C is reached and after 20 days, 52°C. Composting takes place in an hermetically sealed tank and does not require any inspection or handling during the process unlike mouldering toilets.



Two vaults are alternatively used.

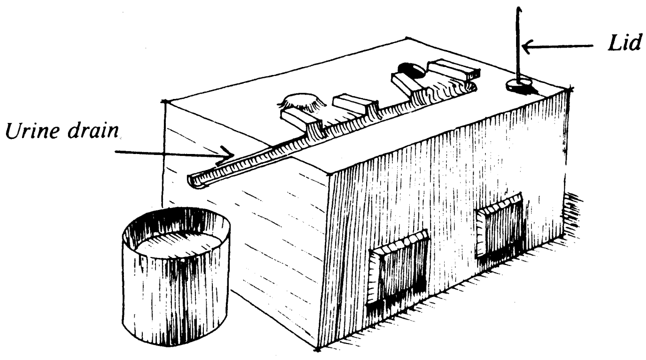


Figure showing squatting plate, urine drain and foot supports. One drophole is closed with a lid, the other has been sealed and dated. The drain leads the urine to a separate tank outside the building.

The urine is collected in a separate tank where it is either diluted with water or absorbed in soil and ashes. Very few diseases are transmitted through urine: one type of schistosomiasis (not found in Vietnam), leptospirosis, and occasionally typhoid. In comparison with the health risks related to faeces, these are very limited indeed. The Vietnamese hold that urine, after absorption in lime or ashes, can safely be used as fertilizer.

The use of the toilet

The Vietnamese toilet is a double vault system also known as a discontinuous toilet. There are two vaults: while one is used as a privy, the other is sealed and acts as a composting chamber for faecal matter. As mentioned before, faeces and urine are deposited in different containers. Although this may sound complicated to someone used to a flushing toilet, it is, in fact, very simple — no acrobatics are necessary! As established by the physionomic studies of Alexander Kira for the design of toilet seats, in the squatting position both men and

Dr Nguyen Dang Du showing visitors an example of the Vietnamese toilet.

women discharge urine forward and faeces downward. The Vietnamese observed the same and designed their squatting plate accordingly.

By using a faecal discharge opening of 14 cm diameter, the whole area between the foot supports can be shaped as a drainage bowl, leading the urine via a groove to a small tank outside the toilet building. With each use some lime or kitchen ashes are thrown on the fresh faeces, absorbing the smell and reducing humidity. Paper may also be dropped into the vault. The lid is carefully replaced after use to close the drophole. When the vault is full, the material is levelled off with a stick and covered with more ashes. The opening is then hermetically sealed with a cover, mortared over, and dated to help ensure an adequate treatment period. The compost from the other vault, which has now been treated for 45-60 days, is taken out and can be used as fertilizer. This vault is then cleaned out and its floor covered with a new layer of ashes. The drophole, which had been sealed with mortar, is opened and a tight lid fitted. The toilet is then ready for a new cycle.

Construction

The Vietnamese toilet is, in its present design and construction, a low-cost solution. As it was developed as part of rural health work, the whole effort was therefore geared towards bringing sanitation within reach of the poorest peoples. In the villages there is no problem in siting the toilet building, as in the cases of urban and suburban areas. The construction is quite a separate building.

The material used varies from place to place according to local building tradition and the availability of materials. Most common are burned brick constructions with floors made of concrete. Plastered adobe constructions are used in some areas, and even plastered bamboo. Many areas in Vietnam have a very high groundwater table and flooding is common. In such areas, it is necessary to build the whole toilet construction well above the surrounding ground level. The floor of the vaults should be at least 20 cm higher. The vaults measure 70 x 70 cm with a height of 60-70 cm, and three or four steps lead up to the toilet door. The vaults each have a 25 x 30 cm opening located in the back or front walls of the construction from which the compost can be extracted. These are closed with bricks and mortar after the vault has been emptied. The vaults are not ventilated, since ashes deposited on the excreta absorb odour adequately. The slab over the two vaults forms the squatting plate and the floor of the toilet, and has two openings with foot supports. One of these is sealed and the other has a lid. A urine drain in the slab leads the fluids to the urine tank.

Advantages

In summary, the advantages of the Vietnamese toilet are its simplicity, its efficient destruction of pathogens, the mineralization of organic matter, its safe use and handling, the absence of odour and pollution, low cost, the rich yield of fertilizer and its applicability in flood-prone areas. The system can still be improved, especially in its treatment of urine, but by and large all performance criteria for waste disposal systems are satisfied. The Vietnamese toilet can be successfully applied under difficult circumstances where other sanitation systems fail.

Urban applications

This toilet is universally used in North Vietnam in peri-urban and rural areas. Application in the South is not yet common. In the cities, however, sanitation facilities are still very poor: pit latrines and septic tanks are very common. Hanoi still has open sewers leading raw sewage to the agricultural communes around the town to irrigate rice fields which double as fish ponds. Although the sewage provides good nutrition for algae which in turn feed small fish, it has been established that intestinal diseases are spread to humans this way. Mr Tam of the Asian Institute of Technology reports that night soil from bucket latrines in Hanoi is collected and sold as manure.

It would be a logical step to do away with all these other methods and introduce the Vietnamese toilet to the towns. There is, however, resistance to this, seemingly reasons which bear little relation to the toilet itself. There seems to be the belief that whatever comes from the industrialized countries must be superior to indigenous solutions. There has been talk of a 'modern' sewage system although it seems difficult to believe that the limited water supply would allow this even if it were possible to dig sewers throughout the cities!

Bureaucratic independence may also play a role in rejecting rural solutions for urban planning, as two different

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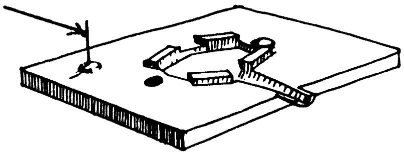
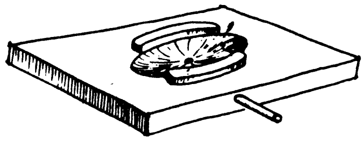
authorities deal with these matters and one may be reluctant to use solutions developed by the other. Another factor is certainly that the Vietnamese toilet was originally developed to serve the poorest people and used the cheapest construction materials which were not always the most durable. The unnecessary reputation of inferiority and structural weakness explains some of this hesitation for urban application. These factors, are, however, unrelated to the system and the process. Technically, there should be no difficulty in developing a suitable urban version of the Vietnamese toilet. In the meantime, other countries should profit from the excellent Vietnamese development work on excreta disposal to solve their own problems in planning and public health. ●



Squatting plate with central draining area.



Vietnamese proposal for a squatting plate where the removable drain closes one vault and leaves a drophole for the other vault. Now the urine tank can be placed inside the toilet base.

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A Simplified Approach to Aqua Privy Construction

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The aqua privy may be correctly described as the intermediate method for excreta disposal from the point of view of the pit latrine on one hand and the septic tank on the other. Figure 1 illustrates the differences and similarities between the pit latrine, the aqua privy and the septic tank systems.

The pit latrine is not popular among many people in the developing countries for many reasons. Many people cannot use the septic tank system because it is expensive to construct and to operate, for houses have to be connected to a constant water source for proper operation. In Table 1 the costs of the three systems are compared.

The aqua privy has great potential for use in the developing countries. If it is properly designed, well constructed and well maintained, it will function without odour and fly breeding – the two main objections to the pit latrine. Since it does not require water for flushing faeces into it, it can be operated satisfactorily in houses which obtain water from public stand taps, or houses in communities without pipe borne water supply. Since it does not involve much pipe system, materials like pieces of wood, cob of maize and objects other than toilet paper may be used for anal cleaning without blocking the system. Such solids, however, shorten the intervals between desludging the tanks.

Unfortunately, the aqua privy system is not as commonly used in many developing countries as the pit latrine and the septic tank. Investigations carried out by the author in many countries show that construction of the different components of both the pit latrine and the septic tank systems has been standardised and perfected. This cannot be said of the aqua privy, which is totally unknown in many communities that can benefit most from its use. The main reason why the aqua privy is not as common as it should be in many developing countries is because its construction, especially incorporating the drop pipe through the floor slab, has not been sufficiently simplified. The techniques suggested in many publications involve the use of complicated moulds which are not easy to produce (Wagner and Lanois, 1958; Macdonald, 1952). Some workers have used metal for the drop pipe (Vincent et al., 1961). But metal sheets which can be folded to form drop pipes are not readily available in areas where the aqua privy is most needed. Moreover, welding the metal to the correct shape requires qualified welders, who may also not be readily available.

There is therefore a need to simplify the construction of the aqua privy to enable any semi-skilled person to build it.

General features of the aqua privy

As shown in Figure 1, the aqua privy consists of four main components: the tank, the floor, the superstructure of the house and the soak-away or seepage pit. All these components, except the floor, are similar to the corresponding features in a septic tank system. The methods and materials employed for their construction for the septic tank can be adopted for the aqua privy system.

Aqua privy floor slab

The main difference between the floor slab of a pit latrine and that of the aqua privy is the inlet drop pipe which the latter carries. Once a simple method for incorporating the inlet drop pipe to the floor slab is available, the construction of the aqua privy floor slab becomes as simple and straightforward as the construction of the common pit latrine floor slab.

Construction methods

Three simple but related approaches have been employed for casting the floor slab for the aqua privy. These are:

a. the trench method
b. the hole method
c. the raised platform method.

For any of the three methods, materials like metal, wood, bamboo and asbestos cement may be employed for the inlet drop pipe. The two materials which the author has employed most are 15 cm diameter asbestos cement pipes and bamboos also of about 15 cm diameter. For individual construction of the aqua privy floor slab in the rural areas of the developing countries where asbestos cement pipe may not be readily available, bamboo is very useful indeed.

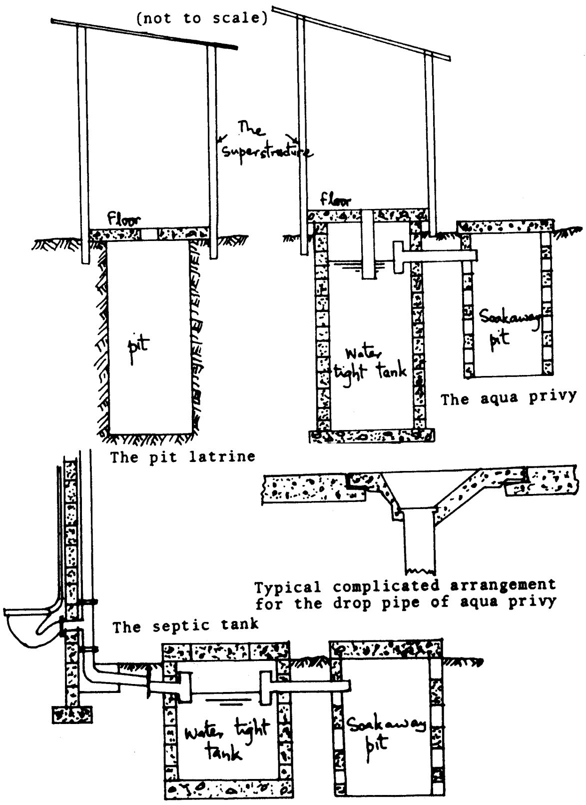

Fig. 1. Pit latrine, aqua privy and septic tank systems compared.

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The trench method

The sequence of four steps for this method is as follows (Oluwande, 1975):

i) A trench about 15 cm deeper than the length of the inlet pipe and 75 cm wide is dug (see Figure IIa). The length of the trench will depend on the number of floor slabs to be cast at a time. The length of the drop pipe recommended is 75 cm. This will ensure that the free end is sufficiently inside the water in the aqua privy tank and that the distance between the top water level and floor of the slab is enough to prevent water splashing on the users.

ii) Planks about 2.5 cm thick and 30 cm wide are cut into pieces one metre long. Four such pieces will be required for a floor slab 90 cm square. The pieces are placed side by side on the trench and a circular hole 20 cm in diameter is cut through the two pieces in the middle to accommodate the drop pipe (see Figure IIb).

iii) A piece 75 cm long is cut from a 15 cm diameter asbestos cement pipe or from bamboo. Four holes with diameters big enough for 10 cm long nails are made equally spaced on the circumference of the pipe. The centre line of the four holes must be about 2.5 cm from the end of the pipe. Nails 10 cm long are passed through the holes with their big ends inside the pipe (see Figure IIc).

iv) The platform planks are arranged over the trench and sheets of newspaper or cement bags are laid over them. The portion of paper over the middle hole is removed. The free end of the prepared drop pipe is passed through the central hole until the pipe is supported on the platform by the nails. The steel reinforcing rods for the floor slab are arranged so that they pass under the nails. A special wooden cover is made for the top end of the pipe. The main mould for the slab is placed in position. The whole arrangement is shown in Figure III. A concrete mix of 1:2:4 is used to cast the slab. In some cases, the aqua privy tank may serve as the trench but extra care must be taken when removing the platform planks later. Otherwise the floor may drop into the tank.

Fig. III Arrangement for slab casting.

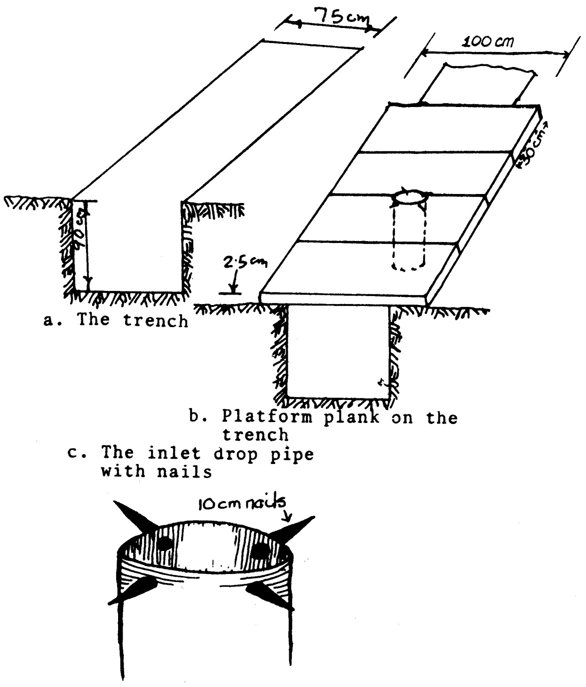


Fig. II. Sketches showing trench method of aqua privy floor slab construction.

The hole method

This is similar to the trench method except that a hole 20 cm in diameter replaces the trench. The depth of this hole should be about 3.8 cm shorter than the length of the drop pipe. The hole should be dug where the surface of the ground is level because platform planks are not necessary and the slab is to be cast on the surface. All other procedures are as described for the trench method (see Figure IVa). The number of holes will depend on the number of slabs to be cast at a time.

Raised platform method

This is also similar to the trench method except that the slab is cast on a raised platform instead of on the ground (see Figure IVb).

The choice of the three methods will depend on many factors such as the nature of the ground, the funds available and the availability of men to carry the slab. The hole method is the cheapest and simplest but requires at least four men to lift the slab from the hole. When bamboo or metal is used for the inlet drop pipe, it should be painted with tar or other anti-corrosion substance. The photographs of cast floor slabs are shown in Figure V and a

Fig. IV

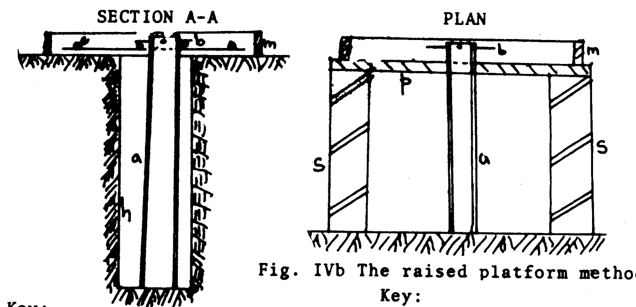


Fig. IVb The raised platform method

Key:
a. drop pipe
b. 10cm nails
c. reinforcing bars
h. the hole
m. main mould

Key:
p. platform plank
s. platform stand
a. drop pipe
b. 10cm nails
m. main mould

section through a typical slab is shown in Figure 6. The mould for casting the slab can be removed after 24 hours. The slab should then be covered with sand or other suitable material like sacking and cured for at least two days before it is placed over the aqua privy tank.

TABLE I
Costs of Pit Latrine, Aqua Privy and Septic Tanks Compared (1973)

Items	*Pit Latrine* ₦	*Aqua Privy* ₦	*Septic Tank* ₦
1. Labour for digging	16	30	30
2. Cement	2	30	30
3. Gravel	2	6	6
4. Sand	1	8	8
5. Bricklayer's Labour	4	18	24
6. Pipe fittings	–	6	35
7. Water closet flush tank and seat	–	–	42
8. Plumbers Labour	–	–	15
9. Super structure (if separate from house)	20.50	20.50	20.50
TOTAL	45.50	118.50	210.50

Note: ₦1 ≙ $0.70 (U.S.A.)

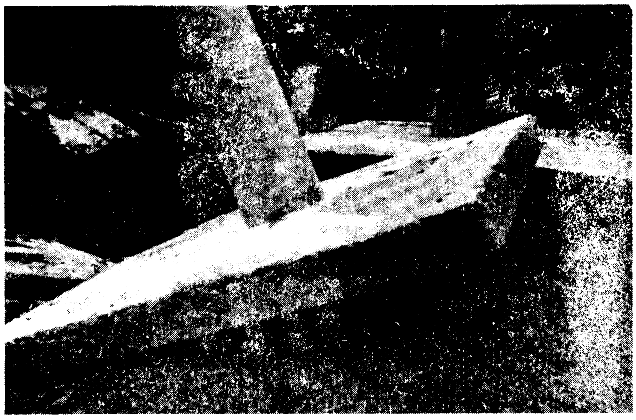
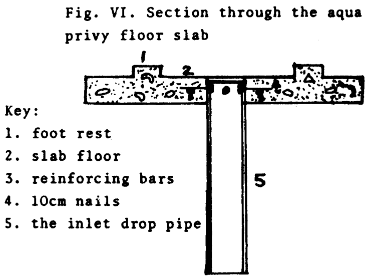


Fig. V. Photograph of the aqua privy floors with the inlet drop pipes after removal from the moulds.



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